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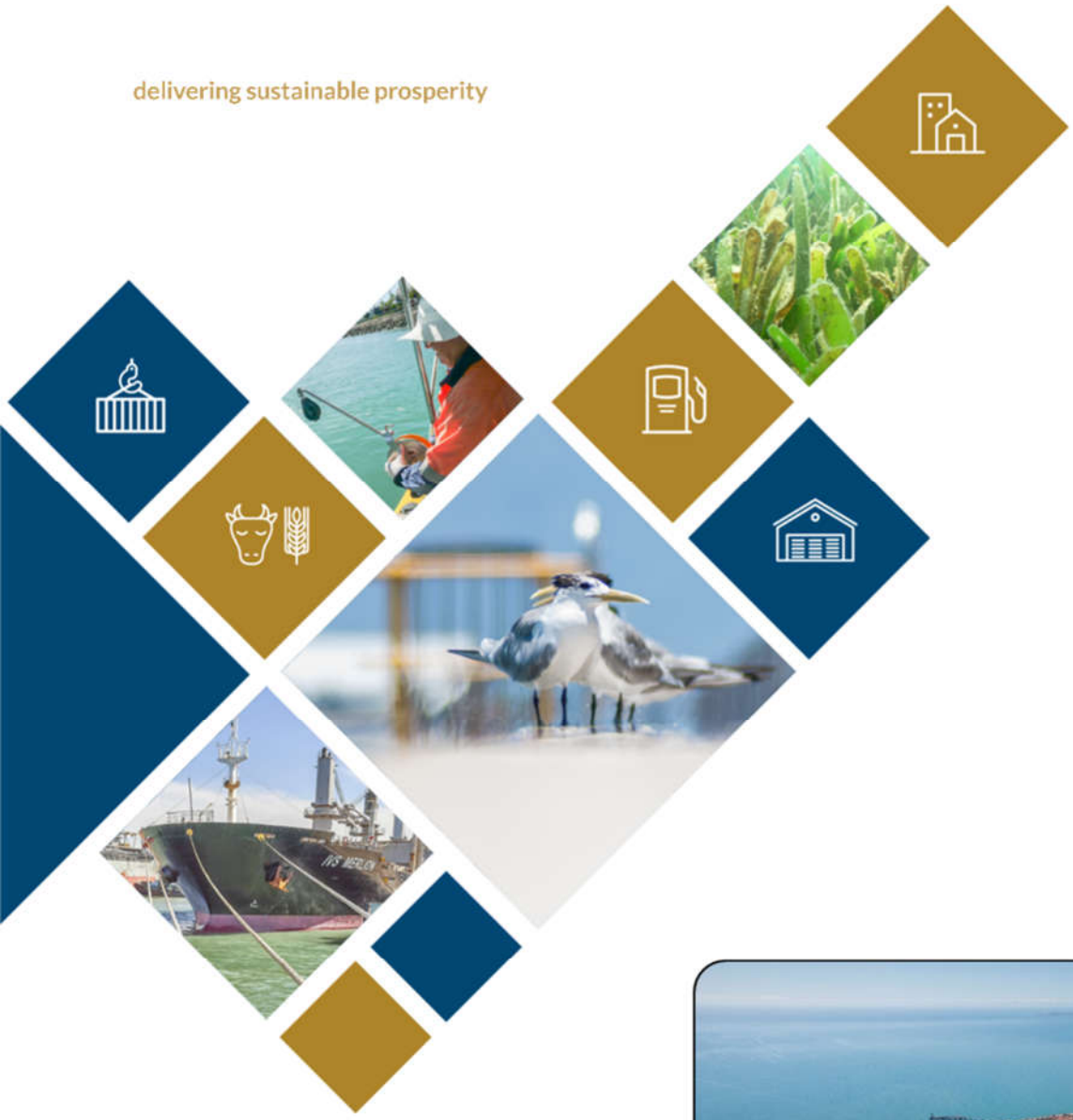

Port of Townsville Limited

Environmental and Social Values Surrounding the Port of Townsville

POT 1898

REVISION 1

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1	18/03/2020	Reformatting, minor changes, update Figure 4, add Saltmarsh section

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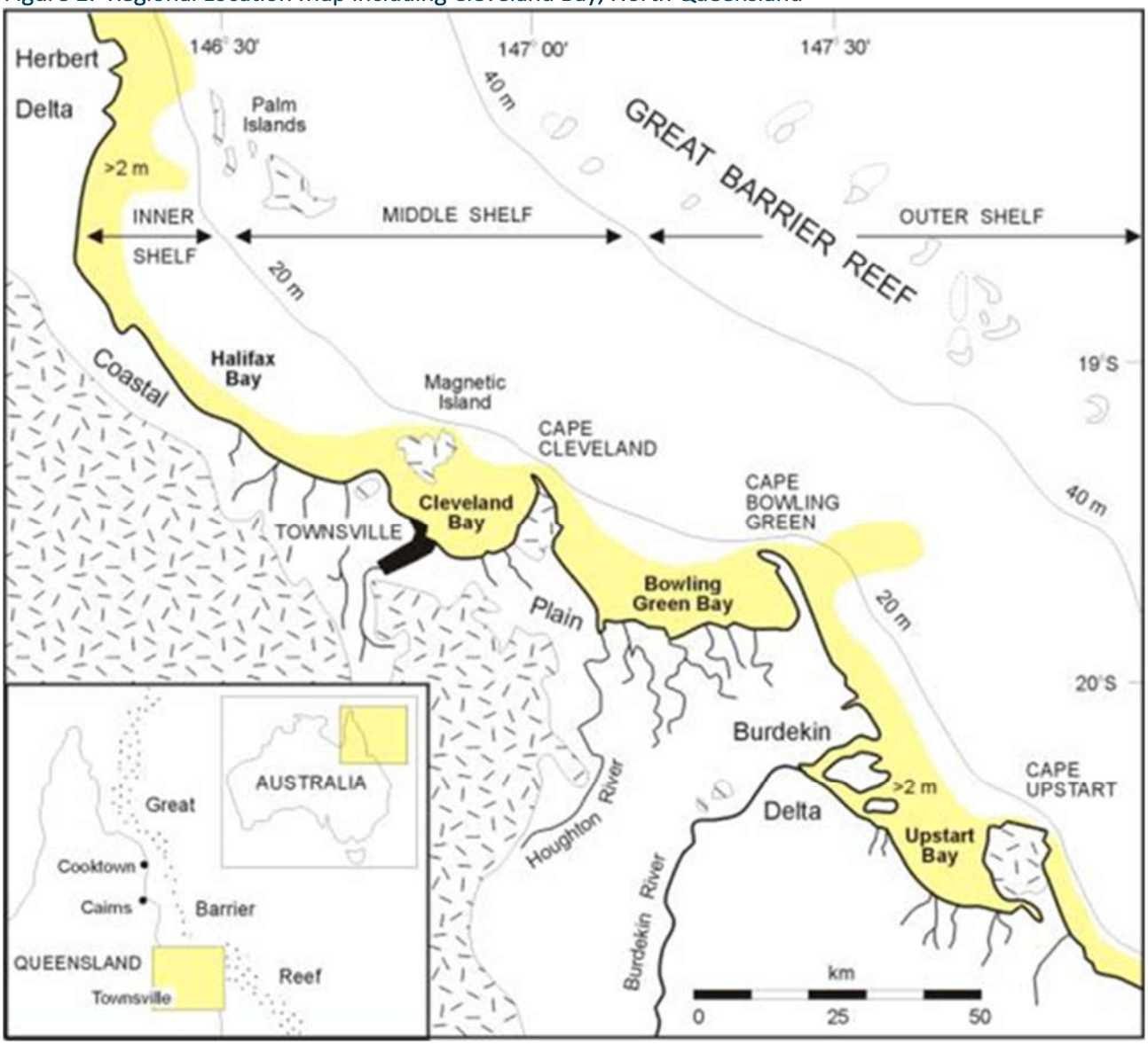
1 INTRODUCTION

The Port of Townsville (19°15'S, 146°50'E) is situated in the centre of the growing city of Townsville, the leading population centre in tropical North-East Queensland, approximately 1,359 kilometres north of Brisbane, Queensland's capital city. The Port is located in the south-west of Cleveland Bay, in between the mouths of Ross River and Ross Creek (Figure 1). Magnetic Island, a continental island located approximately 8km offshore, lies at the northern entrance to the bay.

Cleveland Bay is a naturally broad and shallow bay, bounded to the east and west by Cape Cleveland and Cape Pallarenda respectively, which are approximately 26km apart. As Cleveland Bay is north facing, it receives significant sediment loads from the Burdekin catchment and as such, it is a turbid water body that maintains significant sediment mobility through re-suspension. Dominant winds from south to east means the bay is relatively protected from prevailing breezes (Kettle *et al*. 2002).

Figure 1: Regional Location Map including Cleveland Bay, North Queensland



2 CLIMATE AND NATURAL DISASTER RISK

Located within a dry tropical region, Townsville is characterised by a tropical, seasonal wet and dry climate. High humidity and frequent storms, with occasional cyclones, typically occur during the wet season (November to April). The dry season (May to October) produces mild and moderate temperatures. The temperature ranges from a mean maximum of 31.6°C in December to a mean minimum of 13.7°C in July. Relative humidity is highest in the morning and monthly averages range between 60% during September/October and up to 75% in the wet season, peaking in February. Average annual rainfall in Townsville is approximately 1,136mm with the majority of the rainfall typically recorded during the wet season (BOM 2019).

Climate change projections indicate that the region's future climate is likely to be characterised by:

- Increased average annual temperature and increased number of days with maxima over 35°C;
- Decreased average annual rainfall, increased annual potential evaporation and more drought-like conditions;
- Increased average wind speeds;
- Increased number of severe tropical cyclones; and
- Elevated sea level and increased frequency and height of storm surge.

Careful planning of the potential effects of natural events, such as cyclones and floods including predicted climate change risks, are a key consideration in port planning, design and operations.

2.1 Wind

In Cleveland Bay, wind generates the ambient wave climate and storm waves. Wind speed is highest in the afternoon and is predominantly onshore, with south-east trade winds dominating the dry season, while the wet season brings winds typically from the north-east. Monthly afternoon average wind speeds vary between 18.1km/hr in June and 23.6km/hr in September (BOM 2019).

Wind driven waves and resuspension are important in Cleveland Bay. Wind will move sand, particularly fine to medium sized sand, off drying sections of the beaches to form dunes if there is sufficient undeveloped land between high water and coastal infrastructure. In 1995, the growth of a dune at Three Mile Creek, on the Rowes Bay-Pallarenda road, buried part of the old rock wall. However, there is little change at the Strand, due to the relatively coarse-grained sand.

2.2 Major Storm Events and Cyclones

The dry tropics are subject to marked intra-annual variability, but also monsoonal rainfall and cyclones. Tropical cyclones occur in Townsville resulting in significant spikes in wind speed and rainfall, leading to major flooding events and beach erosion. Tropical cyclones have the potential to develop from early December until late April. Since 1969, approximately 19 cyclones have passed within 100km of Townsville, three were

category 3, Cyclone Larry was a category 4 in 2006 and Cyclone Yasi in 2011 was a marginal category 5 (BOM 2019). The average frequency of cyclones affecting Townsville is estimated to be 1.9 events per season.

Storm surges often occur during the passing of a tropical cyclone, causing flooding of low-lying coastal areas and the potential for severe wave action to damage or modify on coastal structures. Storm surges can allow a beach to be degraded at a greater level than would occur from ambient waves as waves can readily remove sand. Where there is no dune, such as along The Strand, wave action causes significant turbulence at the seawall which again tends to exacerbate offshore sand transport. Sediment grain size also has a significant impact on the extent of offshore sand transport during storms, with coarser sand moving offshore at a much slower rate than finer materials.

3 MARINE COASTAL PROCESSES

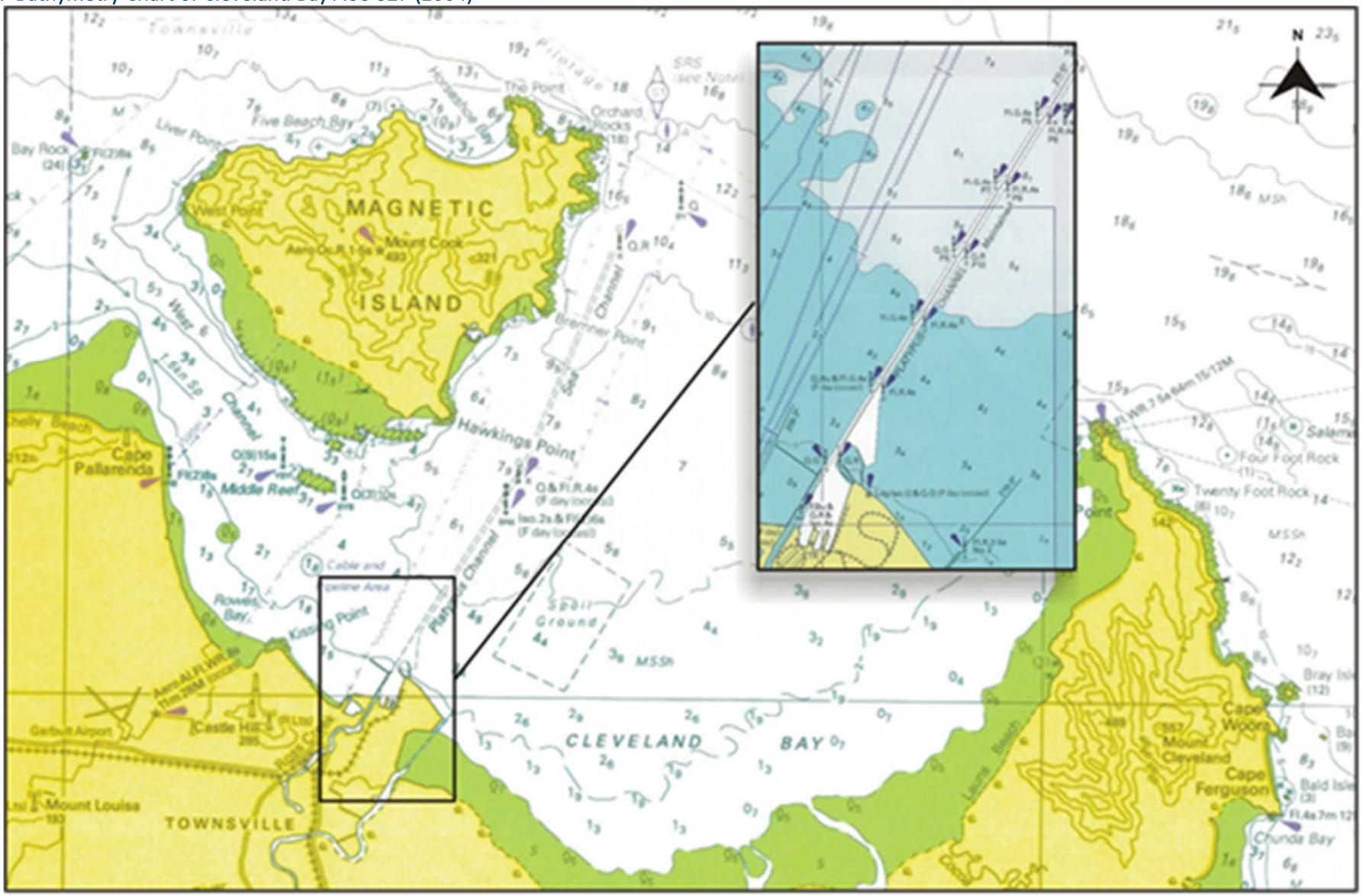
Cleveland Bay is a relatively low energy wave environment as it is sheltered from the predominant south-east waves by Cape Cleveland. Accumulated sediments make the bay relatively shallow, deepening to only 10 to 11m (below chart datum) along its northern aspect and averaging 2-6m across the bay. The coastline continues to be shaped by the prevailing waves at a slower rate, determined by the generally low energy waves and punctuated by the occasional higher energy cyclone waves that are able to penetrate across the bay onto the shoreline.

The Port of Townsville and surrounding coastal areas have been extensively modified over time. The port lands have been increased significantly by land reclamation and the placement of both maintenance and capital dredge material, dating back to the establishment of the port in 1864. The surrounding waterways have also been modified: Ross River has been dammed, along with the installation of three instream weirs; and Ross Creek has been shortened and no longer connects with Ross River. The Strand Beach is a significant coastal feature located immediately west of the Port. It is a man-made public area which was redeveloped in 2000, with the construction of five beach units separated by artificial rocky headlands, to control the natural longshore transport of sand. The Strand Beach has large grain-sized imported sands and steep beach fronts, again to minimise the loss of these constructed areas.

3.1 Bathymetry

The seabed of Cleveland Bay, to the offshore boundary that encompasses Magnetic Island, is approximately 325km^2. Water depths in most of the bay are generally <10m with a large section closer to shore of <4m (Figure 2). Port infrastructure is deeper with the Inner and Outer Harbours, Platypus and Sea Channels all dredged and maintained throughout the life of the Port.

Figure 2: Bathymetry Chart of Cleveland Bay AUS 827 (2004)



3.2 Ambient Wave and Current Conditions

South-easterly trade winds dominate the North Queensland coastline particularly in the dry season and are the driving force for waves within Cleveland Bay. Water-motion within Cleveland Bay is dominated by the effects of refracted south-easterly-generated waves (mostly 0.5-1.2m high, 4-6s period) and by semi-diurnal tidal currents, which reach speeds of 15-30cm/s during spring tides.

In Cleveland Bay, beaches respond seasonally to ambient wave climate. The plan view of a beach tends to be determined primarily by the ambient wave climate, but tropical cyclones also affect this form in Townsville. Geographically, a beach tends to align itself so that it lies parallel to the average inshore wave crests. At this alignment there is no net transport of sand along the beach. Sand along The Strand Beach tends to move from east to west and in Rowes Bay from south to north during the South-East Trade season (winter/dry). Sand moves in the opposite direction during summer, when north-east to north winds and waves prevail. Longshore currents are estimated to transport between 300,000t (Orpin *et al*. 1999) and 800,000t (Belperio 1978) of suspended sediment annually into Cleveland Bay from the Burdekin region, much of which is believed to settle within the bay. Shore parallel transport equates to a sediment export from the exposed portion of Bowling Green Bay equivalent to ~0.3mm/y. Moreover, assuming all this material is exported into Cleveland Bay to the north-west and is trapped there, then an accumulation rate of up to ~0.5mm/y could be produced assuming there is no sediment resuspension (Orpin *et al*. 1999).

A combination of the natural swell and wind-driven waves is capable of resuspending bed sediments and producing high turbidity conditions in the bay. Wave-induced bed stress is the most significant long-term contributor to sediment resuspension and elevated suspended sediment concentrations. Tidal, wind-driven, and three-dimensional currents alone do not resuspend bed sediments on a regular basis, but the interplay of these motions is fundamental to the dominant northward, shore parallel transport of suspended sediment along the inner shelf.

3.3 Tides

Tides at Townsville are semi-diurnal (2 tides per day). The maximum tidal range is 4.11m, with the mean spring tidal range being 2.34m. With the exception of significant tidal currents between Magnetic Island and the mainland via the west channel, tidal currents in the near-shore area are generally low because of the small tidal prism. The intertidal zone narrows along the northern Rowes Bay beaches and the tidal currents here may have a more significant impact on coastal processes. There is however a net east to west and south to north tidal flow along the Strand and Rowes Bay respectively. In the near-shore area this current is typically less than 0.1m/s. Such currents will not initiate sand movement, but may still affect sand, that has been mobilised by wave action.

Hydrodynamics in Cleveland Bay are driven by astronomical tide, direct forcing by wind stress at sea surface and influence from the East Australian Current. Nonlinear interactions, through bottom friction have a significant influence on the currents and therefore on the extent of particle movement. Movement of particles occurs in an anti-clockwise sense around Magnetic Island, except when the wind direction is from the north or north-west. Although this general description applies during the neap tides, additional effects are noted during spring tides:

- Non-linearities associated with the large spring tidal currents diminish the strength of the wind-induced currents and reduce the net movement of particles.
- The larger excursions associated with spring tidal currents can move particles into different current regimes of the bay, significantly altering their ultimate destinations.
- Spring tide causes increased shore-normal transport of water which can bring particles closer to sensitive areas like those surrounding Magnetic Island.

Cleveland Bay is a complex system impacted by a range of climatic and regional influences. Modelling of ambient conditions in BMT WBM (2014) typically show turbid conditions associated with stronger east-north-east wind periods with significant changes occurring to the structure of beaches and suspended sediments in a cyclone.

4 WATER QUALITY

Located between the mouths of Ross Creek and Ross River, the Port is situated on the south-western boundary of Cleveland Bay. The Ross Creek estuary has been extensively modified as a result of development in the near coastal river basin, particularly in the lower estuarine margins. Although extensively modified from its natural state, the Ross River estuary provides a contiguous aquatic habitat in its lower reaches. Catchment discharges from the Ross Creek and Ross River, typically after seasonal rainfall events, influence the ambient quality of inshore marine waters.

4.1 Water Column

Water quality in the bay is the result of a number of factors, particularly the source of incoming waters, which include the chemical and physical characteristics and the historic contamination of water bodies; stormwater discharge and runoff from the wider catchment; groundwater impacts; as well as product handling operations and accidental spillage, both at the Port of Townsville and from industries upstream of the bay. Townsville is a long-established township with a history of urbanisation and industrial activities in the Ross River and Ross Creek drainage systems. Contaminants liberated by industrial activities may be transported by stormwater to port areas and Cleveland Bay, particularly during the wet season. Areas of potential contaminants in Townsville include refineries, manufacturing and repair facilities, old rail sidings and industrial areas. Multiple industrial sites are licensed to discharge waste streams into Cleveland Bay east of Ross River (refineries, sewage treatment plant, meatworks etc.) and several landfills (both operating and rehabilitated) are also present in the Ross River catchment.

Ambient water quality in the bay is also strongly influenced by coastal process events with fine terrigenous sediments, characteristic of the seabed in the bay and delivered by river discharges, readily suspended by wind-driven waves and currents. In the shallow bay environment, at times, this results in high ambient turbidity levels. Flood and stormwater flows are also known to contribute sediment and contaminant loads into the waters of Cleveland Bay.

Water quality monitoring data, for example *Townsville Marine Precinct Project Environmental Impact Statement* (GHD 2009) and data collected by BMT WBM (2009), shows that the near-shore waters of Cleveland Bay are frequently turbid. In addition, elevated levels (compared to the relevant guidelines) of nutrients and certain contaminants have been recorded in the vicinity of the Ross River estuary.

4.2 Turbidity

Cleveland Bay has a relatively high natural turbidity that is spatially and temporally variable (Larcombe & Ridd 1994). The water clarity of outer bay waters, including in the vicinity of the existing offshore DMPA and further offshore as bathymetry deepens, is comparatively less turbid than near-shore waters. This is similarly the case for the Inner Harbour. Energy driven re-suspension of fine sediments does not occur as frequently in these areas as in inshore situations. Despite continually undertaking water quality monitoring programs in the bay over the past 40 years, no clear long-term trend for water clarity is evident, with Cleveland Bay showing significant variation, e.g. comparable results are not observed even with equipment placed 200m apart (POTL 2014a).

BMT WBM (Appendix K in AECOM 2009) has conducted water sampling at various locations in Cleveland Bay, over a period of approximately six months from September 2008, as part of baseline studies for planned developments in the area. During the study period (considered to be ambient levels), average soluble solids content varied from 11 to 30mg/L across sites in outer Cleveland Bay. At these outer Cleveland Bay sites, soluble solids content was >100mg/L and in few cases over 1,000mg/L, albeit only for short time periods. This was consistent with the observations by Larcombe *et al*. (1995), who measured near-bed soluble solids content in excess of 200mg/L caused by periods of strong south-easterly winds. Across all outer Cleveland Bay sites, 90% of all measurements were below 80mg/L. Therefore, soluble solids content measurements at these sites may be considered as representative for ambient soluble solids content in outer Cleveland Bay. Across these sites, average ambient soluble solids content was 22.4mg/L in outer Cleveland Bay.

In regard to inner Cleveland Bay, the average ambient soluble solids content varied from 35 to 126mg/L. The ambient soluble solids content for the Outer Harbour and the Strand (averaged across these sites) was 88.2mg/L. These results are consistent with the rest of the dataset and the current POTL monitoring program being conducted by the GHD.

5 SEDIMENT QUALITY

5.1 Seabed Sediments

The geology of the Townsville Region comprises Quaternary aged alluvium and colluvium sediments underlain by Late-Palaeozoic age granite. Sediments generally in Cleveland Bay are characterised as “slightly gravelly, muddy sand” and have a high content of fine fraction (silts and clay) material (Cruz Motta 2000). The soft, surface sediments are variable and are thought to arise from tidal and seasonal movement of the seabed sediments.

Previous characterisation of marine sediments (Golder Associates 2008) in the Outer Harbour basin and in the Platypus and Sea Channels identified the following broad material types:

- A surface layer of recent seabed sediments consisting of a mixture of very soft to soft silty clay to clayey silt with very loose and loose sand to silty sand to clayey sand. Shell fragments and organic materials commonly occur in this layer. The seabed sediments are easily identified by their dark hue and very soft and very loose nature. Preliminary investigations indicate that some of the surface materials are potential acid sulphate soils and, due to their soft and compressible nature, are generally unsuitable for use as reclamation fill or as the foundation material for structures.
- A subsurface layer of geologically older stiff to hard clays and sandy clays and medium dense to very dense clayey sands and sands. These materials are much lighter in colour than the seabed sediments. The subsurface material was not identified as potential acid sulphate soil and is considered suitable, although not ideal, as reclamation fill.

The surface layer has a thickness of approximately 1 to 1.5m in the Outer Harbour basin. A lesser thickness of the surface layer, typically in the order of 0.5 to 1m occurs in the Platypus and Sea Channels. This lesser thickness in the access channels is likely to be the result of regular maintenance dredging undertaken by POTL.

Sediment sampling undertaken in early 2017 (Geochemical Assessments 2017) found:

- Sediments in the Approach Channels were predominantly muddy with variable sand content and some gravel.
- Sediments in the Outer Harbour were predominantly muds and sandy muds. These sediments overlay clay and densely packed green sands.
- Sediments in the Inner Harbour were predominantly comprised of grey muds, with trace to minor amounts of sand, overlaying green/orange clay or sandy clay.
- Sediment textures in the Ross River, including the Marine Precinct were generally coarser (i.e. gravelly sands) in the up-river sections of the dredge area, and muds and sandy muds near the mouth of the Ross River.

5.2 Sediment Sources

Cleveland Bay is located about 50km north of the Burdekin River, about halfway between the Burdekin and Herbert Rivers which provide the dominant sediment supply to the central Great Barrier Reef coast (Belperio 1983; Moss *et al.* 1993). At the coast, bedload sediment (predominantly sand) from these rivers and from the much smaller Houghton and Ross Rivers, moves northwards along the shoreline by longshore drift processes. During summer floods, suspended loads of mud and fine sand are transported directly onto the inner shelf, where they either accumulate, or are adverted back into the tidal mangrove systems which fringe the coastal plain (Belperio 1978 and 1983; Larcombe & Ridd 1994; Larcombe 1995). Fabricius *et al.* (2014) demonstrated that river discharges significantly affect marine water clarity in shallow bays of the central

Great Barrier Reef region at intra- and inter-annual time scales and that fine river-derived sediments remain available for resuspension for years after floods.

The Cleveland Bay catchment incorporates an area of 1,770km^2 and there are several significant watercourses (Table 1) discharging stormwater into Cleveland Bay and supplying some sediment to the beach system and further offshore during floods. The main watercourses, all of which influence Cleveland Bay include:

- Ross River;
- Ross Creek;
- Three Mile Creek;
- Captains Creek;
- Sandfly Creek;
- Alligator Creek;
- Crocodile Creek; and
- Cocoa Creek.

Table 1: Drains and Creeks Discharging to Cleveland Bay (Townsville City Council Stormwater GIS Layer)

Cleveland Bay Section	Creeks	Drains
Rowes Bay / Pallarenda	2	12
Strand	-	7
East of Port to Cape Cleveland	12	-
Ross River / Ross Creek	-	131
Magnetic Island	9	12

5.3 Natural Sand Supply

Much of the land in the Cleveland Bay catchment has been cleared or modified of its remnant vegetation (GBRMPA 2014). The sediment yield of Ross River has been estimated at 330,000 t/y (Belperio 1983), but this amount fluctuates depending upon climatic conditions and input sources. Changes in catchment drainage due to urbanisation and agriculture may lead to an increase in runoff and in some cases soil erosion (Pringle 1989). It is noted that Ross River is heavily modified, which impacts the amount of material that is discharge into Cleveland Bay. Persson (1997) assessed anthropogenic activities disrupting the natural hydrodynamics and transport of coarse sediments and related effect on channel morphology and sediment supply to Cleveland Bay. This study found that the Ross River Dam and three downstream weirs have reduced the delivery of coarse sediments to the coast, but the outcome for finer sediments may not be similar as these sediments are entrained in suspension.

The Strand Beach can be considered as a “pocket” beach, except that it has an inadequate volume of sand within the headlands to maintain a beach along the full length of its foreshore. The existing alignment of

Rowes Bay is in general far from a state of equilibrium, with respect to zero net movement of sand along the beach. In order for these beaches to remain in equilibrium and not undergo long-term erosion, Townsville City Council undertake an ongoing beach monitoring and sand renourishment project to assist in the rehabilitation of beaches along Rowes Bay and Pallarenda.

5.4 Chemical Composition

Calcium carbonate rich sediments occur in the western section of the bay close to coral reef colonies formed on the fringes of Magnetic Island and Middle Reef, while the central section of the bay is characterised by terrigenous, muddy sand. Sources of terrigenous sediment to the bay include discharges of sediments from local creeks and rivers, as well as sediment from the Burdekin River from the eastern section of the bay.

Coastal sediments are generally uncontaminated even with the strong industrial and coastal history of Townsville. Some locations may contain detectable hot spots, albeit below published guideline limits under the National Assessment Guidelines for Dredging (NAGD 2009). Due to the nature of the soft sediments, there is potential for acid sulphate soils if oxidised. Results from POTL's long-term marine sediment monitoring indicate that the more industrialised areas of Ross Creek, the Port and Ross River show higher levels of contamination than the surrounding bay, with Ross Creek in particular, being an upstream diffuse source of contaminants (POTL 2014b).

6 MARINE ECOSYSTEM VALUES OF CLEVELAND BAY

Cleveland Bay supports numerous rich and diverse coastal habitats with varying ecological sensitivities, typically abundant in north-east Australia's coastal wet-dry tropics including:

- Corals which occupy only around 1% of the bay;
- Soft bottom communities, occupying over 85% of the bay;
- Intertidal and subtidal seagrass beds are present in about 10% of the bay;
- Mangrove communities;
- Saltmarsh/saltpan communities; and
- Forested, brackish and freshwater swamps.

There have been substantial previous investigations of marine ecology in Cleveland Bay and the surrounding Great Barrier Reef. The following sections provide a brief description of major aspects of the marine ecosystem values known in Cleveland Bay.

6.1 Reef Communities

Reef communities comprised of hard corals exist around Magnetic Island, at Middle Reef and at Virago Shoal located between Magnetic Island and Cape Pallarenda. A large number of hard corals have been recorded in these communities, including extensive areas of *Montipora digitata*. The distribution and abundance of coral species varies in the fringing reefs and is related to the physical characteristics of the substrate and energy environments.

Coral cover, species diversity and aesthetic quality is generally considered higher in the fringing reefs on the northern side of Magnetic Island (Horseshoe Bay) than in other fringing reefs. The Cockle Bay reefs, located on the south-western side of Magnetic Island, are characterised by species that are better adapted to high siltation and turbidity, with a general trend toward decreasing coral density in comparison to reef habitat in Geoffrey Bay, located on the south-eastern side of Magnetic Island (Bell & Kettle 1989). A previous study of the fringing reefs on the south-eastern side of Magnetic Island between Florence Bay (north) and Geoffrey Bay (south) indicates that these areas are qualitatively similar (Mapstone *et al.* 1989). Magnetic Island reefs also show more pronounced depth gradients compared with most other reefs of the Great Barrier Reef due to the high water turbidity in Cleveland Bay.

6.2 Benthic Communities

Soft sediment communities dominate the seabed of Cleveland Bay (Kettle, Dalla Pozza, & Collins 2001). The most common groups of benthic infauna present in the area include polychaetes, sipunculids, bryozoans and crustaceans such as amphipods and tanaids (Cruz Motta & Collins 2004). Benthic communities provide a significant food source for many species of fish, including higher order consumers, which are also targets for recreational fishing.

A number of additional baseline studies have been undertaken as part of the Port Expansion Project Environmental Impact Statement (AECOM 2009) to characterise the benthic environments in and around the Outer Harbour, the entrance channels and at the offshore dredge material placement area (DMPA). These studies characterised sediment type as well as epifauna and infauna communities in these areas.

The breakwaters and revetments of the Port provide hard substrates that support a range of algal and sponge dominated communities, as well as corals in more quiescent areas. Video-based surveys suggested that sparse and patchy epibenthic communities (i.e. organisms living on the seabed) occurred throughout the Port and surrounding areas. Mid-shore assemblages were comprised of occasional hydrozoans, sea pens, crinoids and ascidians. Channel assemblages were the most depauperate, with only one feather star (crinoid) recorded. Epibenthos assemblages at the nearshore control and Outer Harbour were structurally similar. Hydrozoans were the most abundant taxon in the nearshore areas, and were much less common in the DMPA, mid- and offshore control areas. Assemblages were dominated by plumulariid and sertularellid stinging hydroids, with occasional alcyonid soft corals, ascidians, and bryozoans.

Epibenthos assemblages in the DMPA were dominated by a type of burrowing goby. Of the 149 fish observed in video transects, 142 (95%) were burrowing gobies, and 124 of these were observed in the DMPA. Sea pens (Pennatulacea) were particularly common at the DMPA, but were only occasionally observed in the midshore

and Outer Harbour area and absent elsewhere. Bryozoans, sponges, polychaetes, ascidians (sea squirts), echiurans (spoon worms), hydrozoans and alcyoniid soft corals were occasionally observed. The small patches of rock in the DMPA provide habitat for reef-associated taxa such as sea pens, ascidians and some crinoids, and represent areas of locally higher biodiversity in the DMPA. In comparison to the DMPA, epibenthic assemblages were generally similar at other offshore areas, although sea pens and many hard substrate/gravel associated taxa recorded at the DMPA were not observed and very few Alcyonacea soft corals were recorded at the DMPA.

6.3 Seagrass Communities

Seagrass meadows occur in parts of Cleveland Bay and provide both important habitat and food resources for a range of species of conservation significance, including threatened dugong and turtles as well assisting in stabilising sediment and trapping and recycling nutrients (Roelofs *et al.* 2003) and providing a nursery for prawns. With the exception of the DMPA, seagrass is not known to occur in the existing port infrastructure, although shallow water and inter-tidal seagrass beds can occur nearby (e.g. near the Ross River mouth and along The Strand). Seagrass beds are extensive in the eastern portion of Cleveland Bay, away from almost all of the City's development. Smaller beds occur across the Strand, Kissing Point, Pallarenda Beach and some bays fringing Magnetic Island (Wells & Rasheed 2017). The seagrass habitats within this region are of high ecological significance and provide a regionally important foraging habitat for threatened species such as dugongs and turtles and economically important fishery species. The primary locations within Cleveland Bay for seagrasses tend to be in areas that are less than 4m in depth, between the mainland and Magnetic Island, and adjacent to Cape Cleveland (Lee Long *et al.* 1993).

A number of studies of spatial and temporal distribution of seagrass in Cleveland Bay have been undertaken over the years, but most recently baseline and annual surveys of seagrass, commissioned by Port of Townsville Limited (POTL), have been undertaken by James Cook University (JCU) since 2007 (Taylor & Rasheed 2009). The baseline surveys identified large and continuous seagrass meadows in Cleveland Bay, most commonly in lower inter-tidal and shallow sub-tidal areas. The best quality shallow seagrass meadows occur as shallow beds near Cape Cleveland, The Strand, Cape Pallarenda and around Magnetic Island. The dominant species in shallow waters include *Halophila ovalis*, *Halodule uninervis*, *Zostera muelleri*, and *Cymodocea serrulata* (Figure 3). The reef flats surrounding Magnetic Island support areas of *Thalassia hemprichii*.

The distribution, extent and density of seagrass assemblages in near-shore areas can show great variation over a range of temporal scales (particularly seasonally and inter-annually) in response to variations in a range of environmental factors. In particular, changes in the light availability, that result from wave-driven bed sediment remobilisation and turbidity associated with catchment discharges, are key drivers of temporal change in seagrass meadows (Taylor & Rasheed 2009). Previous surveys found that the near-shore seagrasses had also significantly diminished in biomass over the years since monitoring started. However, the most recent seagrass surveys conducted in Cleveland Bay (Bryant, Wells & Rasheed 2019) found that the area of seagrasses in Townsville continue to increase from the climate related losses that occurred leading up to 2011 and 2018 was the second largest spatial distribution since annual monitoring began in 2007 (Figure 4). Following the February 2019 flood event, seagrass density (biomass) at coastal meadows has not

returned to "typical" peak season levels, but the area of meadows is similar to that previously recorded (McKenna *et al*., 2020).

Cleveland Bay, including the DMPA, historically also contains ephemeral deep-water seagrass beds. These deep-water meadows are typically patchy (non-contiguous, fragmented beds) with a sparse cover and low species richness. The deep-water meadows also show seasonal and inter-annual variability, with the surveys from 2007 to 2016 showing a decline in biomass of these communities. However, the presence of a large deep-water meadow in the October 2019 indicates that later during that year conditions in Townsville were favourable for the germination and seasonal recruitment of *Halophila* species (McKenna *et al*., 2020). The restricted deep-water meadows suggest that either the light environment has not improved enough, or that some other factor is more influential in meadow recover in deeper habitats (Wells & Rasheed, 2017), including those attributed to effects derived from seasonal flooding. Regular maintenance dredging of the Port and channels in Townsville has been conducted for 150 years and the seagrasses currently within the Port are likely adapted to cope with this level of impact (Rasheed & Taylor 2008).

Figure 3: Seagrass Species found within Port Limits

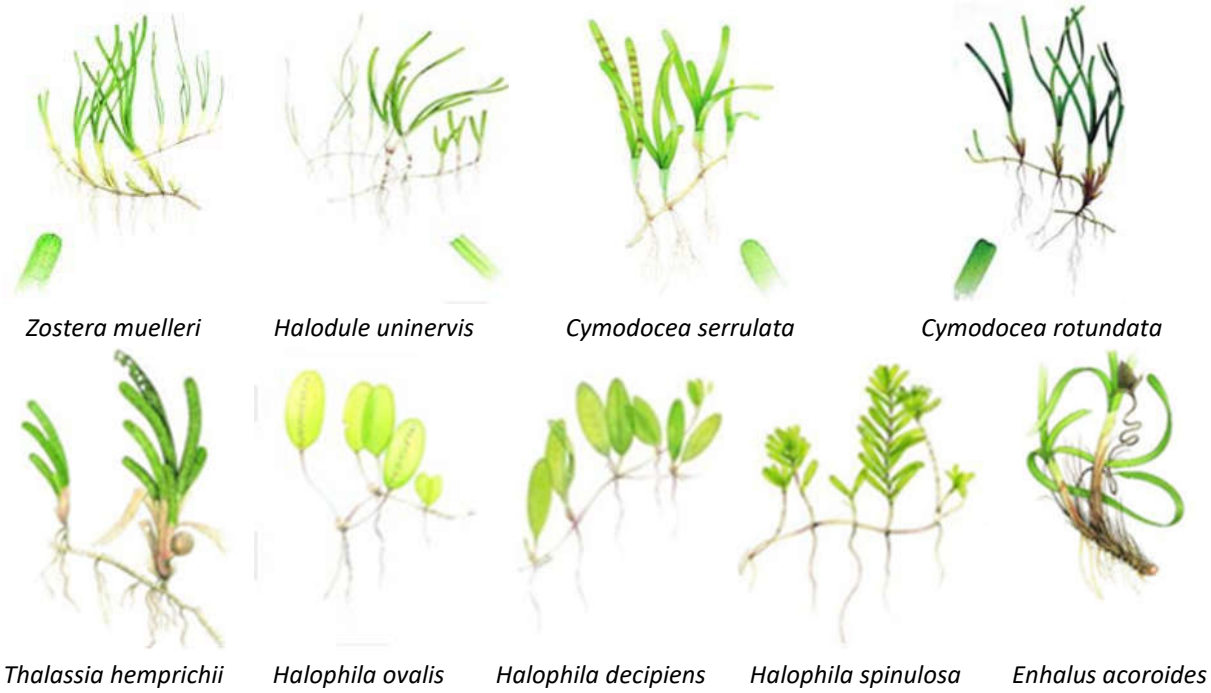
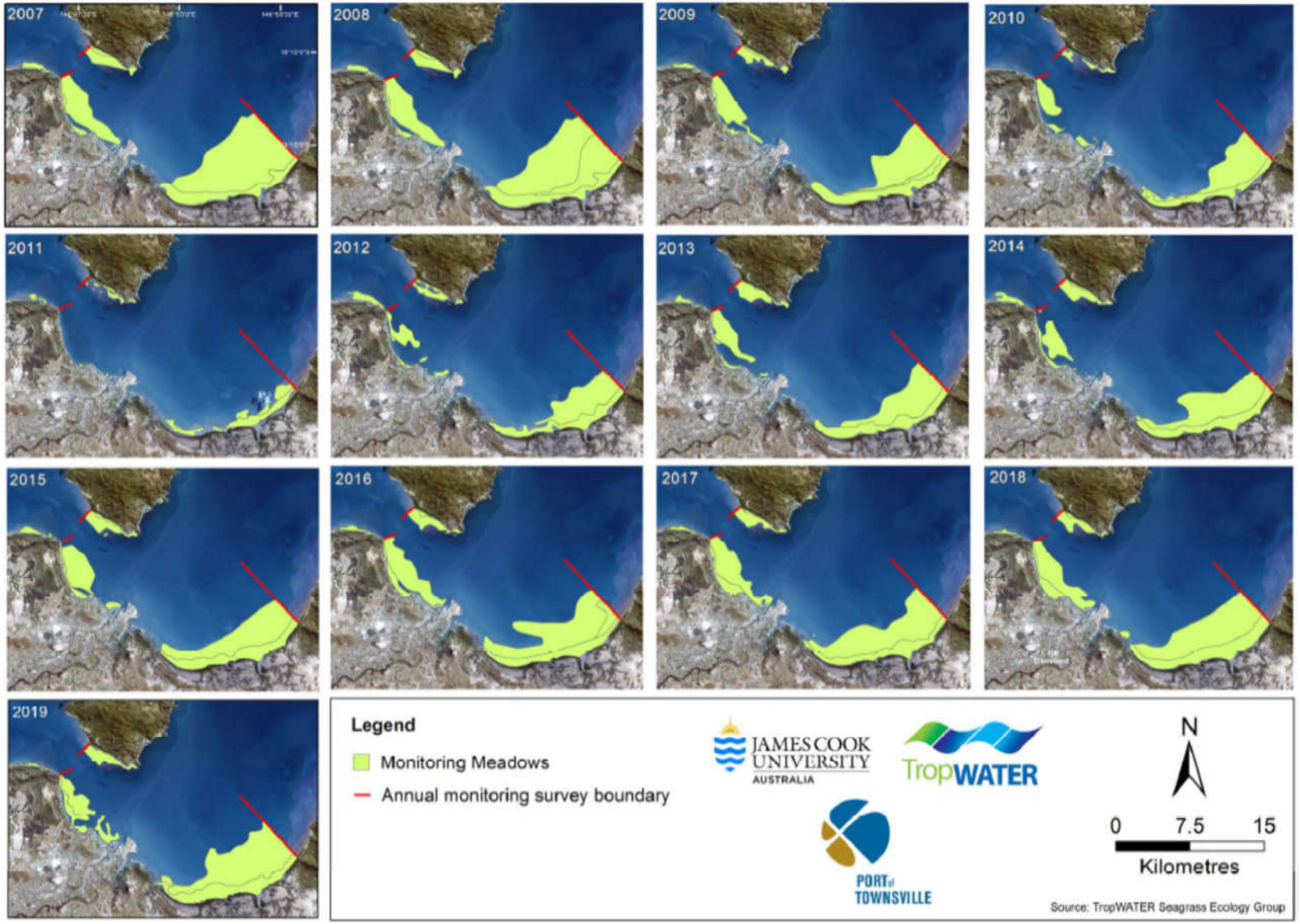


Figure 4: Seagrass Spatial and Temporal Distribution since October 2007



6.4 Mangrove Communities

Mangrove communities represent diverse communities growing in the intertidal zone of tropical to temperate coastal rivers, estuaries and bays (Lovelock 2003). They are most extensive in the southern portion of Cleveland Bay between Sandfly and Cocoa Creeks and in the Ross River, south of the Port. Smaller, structurally simpler mangrove stands occur in Rowes Bay and at Three Mile Creek. Predominant threats to mangrove ecosystems arise from land use conflicts and local effects on water quality.

The occurrence of particular mangrove species is dependent on environmental factors such as salinity (Sam & Ridd 1998), nutrient availability (Walker & O'Donnell 1981), oxygen levels in the sediment and wave energy (Brinkman *et al.* 1997). At least seven direct studies have been undertaken on the mangroves of Cleveland Bay and twelve species of mangroves have been recorded (Table 2).

Table 2: Mangrove Species within Cleveland Bay

Scientific Name	Common Name
Acrostichum speciosum	Mangrove fern
Aegialitis annulata	Club mangrove
Aegiceras corniculatum	River mangrove
Avicennia marina	Grey mangrove
Bruguiera exaristata	Small-leafed orange mangrove
Bruguiera gymnorrhiza	Large-leafed orange mangrove
Bruguiera parviflora	Small-leafed orange mangrove
Carallia brachiata	Freshwater mangrove, corkwood
Ceriops tagal	Yellow mangrove
Excoecaria agallocha	Blind your eye mangrove
Lumnitzera racemosa	White-flowered black mangrove
Rhizophora stylosa	Red mangrove

Mangrove communities are ecologically important as they provide habitat for a range of fauna, including mud crabs, prawns, fish, birds and saltwater crocodiles. Many fish and prawn species that are usually found offshore inhabit mangrove areas during part of their life cycle. In areas such as the southern shores of Cleveland Bay, where seagrass meadows are close inshore, they combine with the mangrove forests and wetlands to form a highly productive nursery habitat for commercial and recreational fish and crustacean species, including crabs, king prawns, barramundi, snapper, bream and mackerel. Other species, such as mud crabs, spend most of their lives in the mangroves and move to the open sea to spawn. They also provide roosting habitat for aerial animals such as birds and bats, insects, arboreal species of reptiles and gastropods.

Mangroves play an important role in preventing coastal erosion and provide vital protection from strong winds, tidal surges and heavy rainfall associated with cyclones, which occasionally affect this part of Queensland's coastline. By reducing current speed, the roots, pneumatophores and trunks of the mangroves trap sediments and nutrients and help to reduce siltation in adjacent marine habitats. Tides and currents

transport nutrients from the mangroves to seagrass beds and inshore coral reefs. These nutrients enrich the seagrass and reef environments which are important habitats for turtles, dugongs and fish.

6.5 Saltmarsh Communities

Cleveland Bay is also home to over 15 species of saltmarsh species (Table 3). Saltmarshes are ecologically important habitats, as they link the marine environment to the terrestrial, and provide habitat for both marine and terrestrial organisms (Goudkamp & Chin, 2006).

Table 3: Saltmarsh Species within Cleveland Bay

Scientific Name	Common Name
Sarcocornia quinqueflora	Bead weed
Tecticornia halocnemodies, T. indica and *T. pergranulata*	Glasswort
Tecticornia australasica	Grey samphire
Portulaca bicolor, P. oleracea and *P. pilosa*	Pigweed
Salsola kali	Prickly saltwort
Dysphania littoralis	Red crumbweed
Enchylaena tomentose var. glabra	Ruby saltbush
Suada arbusculoides and *S. australis*	Seablite
Sesuvium portulacastrum	Sea purslane
Dissocarpus biflorus	Twin flower saltbush
Phragmites australis	Common reed
Cynodon dactylon	Greencouch
Fimbristylis ferruginea and *F. polytrichoides*	Rusty sedge
Sporobolus virginicus	Saltcouch
Atriplex semibaccata	Creeping saltbush
Limonium solanderi	Native sea lavender

Saltmarsh communities tend to occupy the areas of low energy, intermittent, tidal inundation on sheltered soft substrates and often occur behind mangrove communities (Creighton, Gillies & McLeod 2015). Different saltmarsh community types produce different benefits to the ecosystem, including sediment trapping, nutrient cycling, dissipation of wave energy, fish and prawn nurseries, carbon sequestration, and feeding areas for birds (Creighton *et al*. 2015).

Distribution throughout the bay depends on the site microhabitat and seasonal influences from both land and sea direction. Saltmarshes play an important role in the ecosystem by providing organic matter, a rich supply of nutrients and supporting a great diversity of both marine and terrestrial life (adapted from RIVER Group 2004).

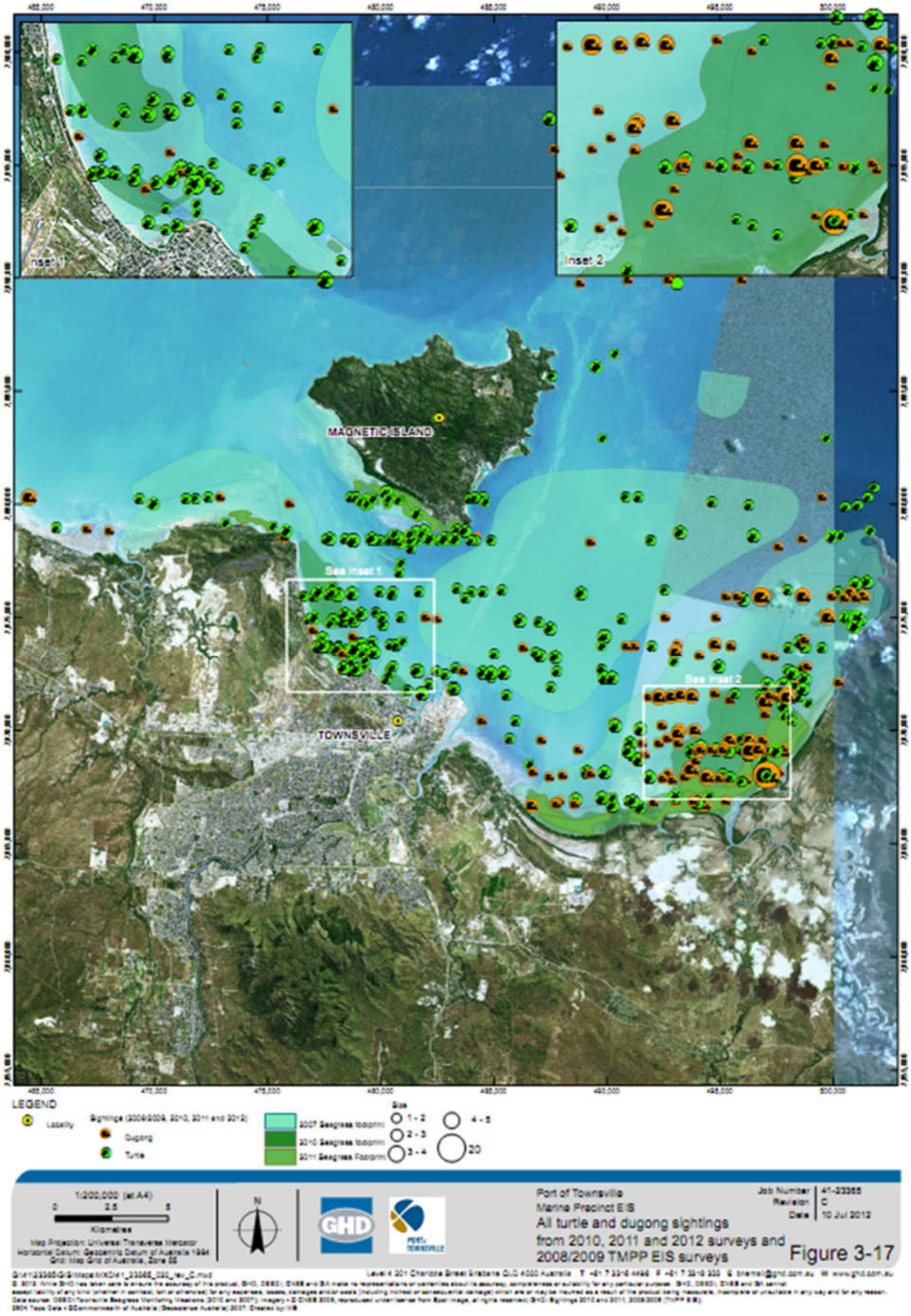
6.6 Marine Megafauna

Cleveland Bay is recognised as a key foraging area for the flatback turtle (*Natator depressus*) and a key feeding and nesting area for the green turtle (*Chelonia mydas*) (GHD 2011). The port footprint is not an area of high utilisation for turtles (Figure 5) (GHD 2012). However, the following marine megafauna species, listed under the *Nature Conservation (Wildlife) Regulation 2006*, have been observed within 2km of the Port:

- Endangered:
  - Loggerhead turtle (*Caretta caretta*)
  - Leatherback turtle (*Dermochelys coriacea*)
  - Olive ridley turtle (*Lepidochelys olivacea*)
- Vulnerable:
  - Dugong (*Dugong dugon*)
  - Green turtle (*Chelonia mydas*)
  - Hawksbill turtle (*Eretmochelys imbricate*)
  - Flatback turtle (*Natator depressus*)
- Near Threatened:
  - Australian snubfin dolphin (*Orcaella heinsohni*)
  - Indo-Pacific humpback dolphin (*Sousa chinensis*)

The waters of Cleveland Bay are entirely within a Declared Dugong Protection Area (DPA) and dugongs are known to be relatively abundant in the bay. Megafauna monitoring undertaken by GHD for the Townsville Marine Precinct and Port Expansion Projects (GHD 2009 & 2012) found that dugongs were found most often in areas with greater concentration of seagrass in Cleveland Bay, including the meadows near the southern and eastern shores of the bay (Figure 5). Boat-based and aerial marine megafauna surveys have been conducted in Cleveland Bay between 2008 and 2012. Turtles, dugongs, rays, sea snakes and dolphins were observed as part of these surveys. Both the Australian snubfin dolphin and the Indo-Pacific humpback dolphin were also observed as part of these surveys and were reported to be highly mobile and move in and out of Cleveland Bay.

Figure 5: Turtle and Dugong Sightings



6.7 Fish and Fisheries

The mangroves, seagrasses, reef and soft bottom benthic communities present in Cleveland Bay provide habitat for a variety of fish species. Fishing for target species is a common practice in Cleveland Bay, undertaken by Traditional Owner, commercial and recreational fishers within the tidal creeks and estuaries. Prawn trawling, coastal net setting and crab pot fishing occurs on a commercial scale, in and beyond Cleveland Bay. The net and crab pot fisheries target species such as mud crabs, barramundi, threadfin salmon, grunter and flathead. Target recreational fishing species include barramundi, threadfin salmon, queenfish, grunter, flathead and mud crabs.

Fish Habitat Areas (FHAs) have been established in Cleveland Bay, the nearby Bohle River and Bowling Green Bay. These areas provide protection and breeding grounds for target indigenous, recreational and commercially important species, including barramundi, grunter, mud crabs and prawns. While these species are highly mobile, it is recognised that the loss of important habitat such as for feeding or breeding, including seagrasses, reef and benthic habitats, may affect long-term stock levels and abundance. Commercial fishing has been restricted within parts of Cleveland Bay since the implementation of DPAs in 1998. Other limitations are placed on commercial and recreational fishing through the Great Barrier Reef Marine Park (GBRMP) boundaries and zoning maps and limited access within identified secure areas for shipping. No major aquaculture facilities are currently operating in the Cleveland Bay area.

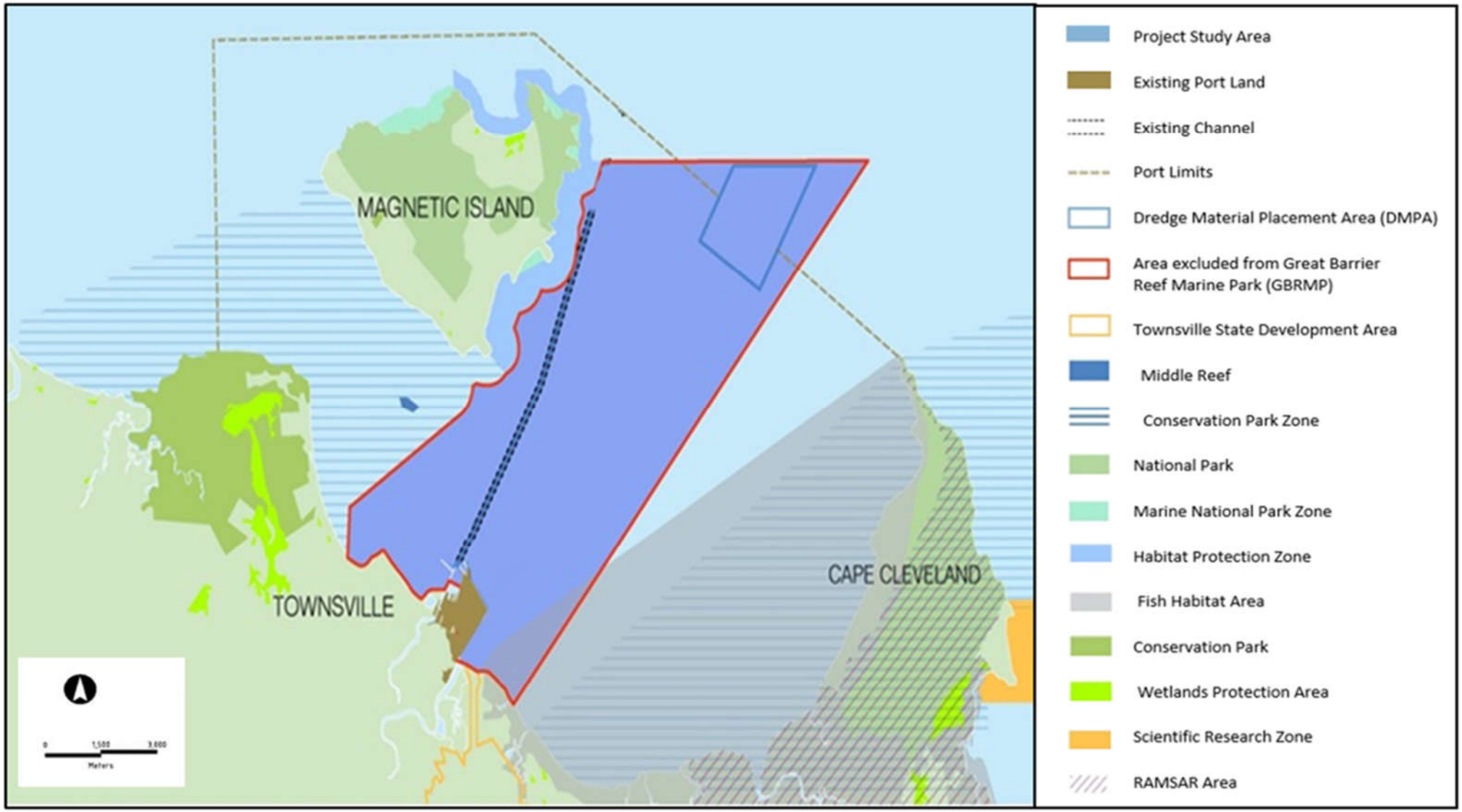
7 PROTECTED AREAS WITHIN CLEVELAND BAY

The Port of Townsville's sea jurisdiction is within the Great Barrier Reef World Heritage Area (GBRWHA), which is also a national heritage place. However, the Port and its marine infrastructure are in an exclusion area from the Central region of the Commonwealth GBRMP and the State Great Barrier Reef Coast Marine Park (Figure 6), with some port infrastructure abutting the marine park, e.g. the Sea Channel and the DMPA. Existing shipping channels accessing the Port of Townsville approach within approximately 1km of Bremner Point on Magnetic Island.

There are a range of marine conservation areas, declared in statutory notices, within or adjacent to Cleveland Bay. These areas are recognised as providing protection for communities such as hard corals, fringing reefs, seagrasses and mangroves and also forming part of the habitat requirements for a number of threatened species. Some of the key conservation areas as well as other features of the region (Figure 6) include:

- The GBRWHA, a world and national heritage place;
- The GBRMP and the State Great Barrier Reef Coast Marine Park (including a number of different zones of protection) noting the area depicted with a red boundary is the port exclusion area;
- Declared DPAs, in Cleveland Bay and around Magnetic Island;
- Declared FHA in the east of Cleveland Bay;
- The neighbouring Bowling Green Bay, a RAMSAR-listed wetland; and
- Magnetic Island National Park.

Figure 6: Coastal Habitats in and around Cleveland Bay



Note: DPA not shown as covers the entirety of Cleveland Bay.

7.1 The Great Barrier Reef World Heritage Area

The Great Barrier Reef extends for more than 2,000km along the coast of Queensland and covers an area of 348,000km^2. The area comprises diverse habitats including reefs, rocky reefs, sandflats, coastal lagoons, open ocean and the deep sea floor, mangroves, seagrass beds and beaches. It not only supports a huge and diverse array of wildlife, but is also used for recreation and commercial purposes. The GBRWHA was placed on the World Heritage List in 1981 and is also listed on the National Heritage List. The majority (99.3%) of the GBRWHA is contained within the GBRMP.

The Great Barrier Reef provides habitats for many diverse forms of marine life. There are an estimated 1,500 species of fish and more than 300 species of hard, reef-building corals. More than 4,000 mollusc species and over 400 species of sponges have been identified (CoA 2014). Other well-represented animal groups include anemones, marine worms, crustaceans (prawns, crabs etc.) and echinoderms (starfish, sea urchins etc.).

The extensive seagrass beds are an important feeding ground for the dugong, a mammal species internationally listed as vulnerable. The reef supports a wide variety of fleshy algae that are heavily grazed by turtles, fish, sea urchins and molluscs and contains nesting grounds of the vulnerable green and endangered loggerhead turtles, which are of world significance. It is also a breeding area for humpback whales that come from the Antarctic to give birth to their young in the warm waters. The islands and cays support several hundred bird species, many of which have breeding colonies there. Reef herons, osprey, pelicans, frigate birds, sea eagles and shearwaters are among the numerous sea birds that have been recorded.

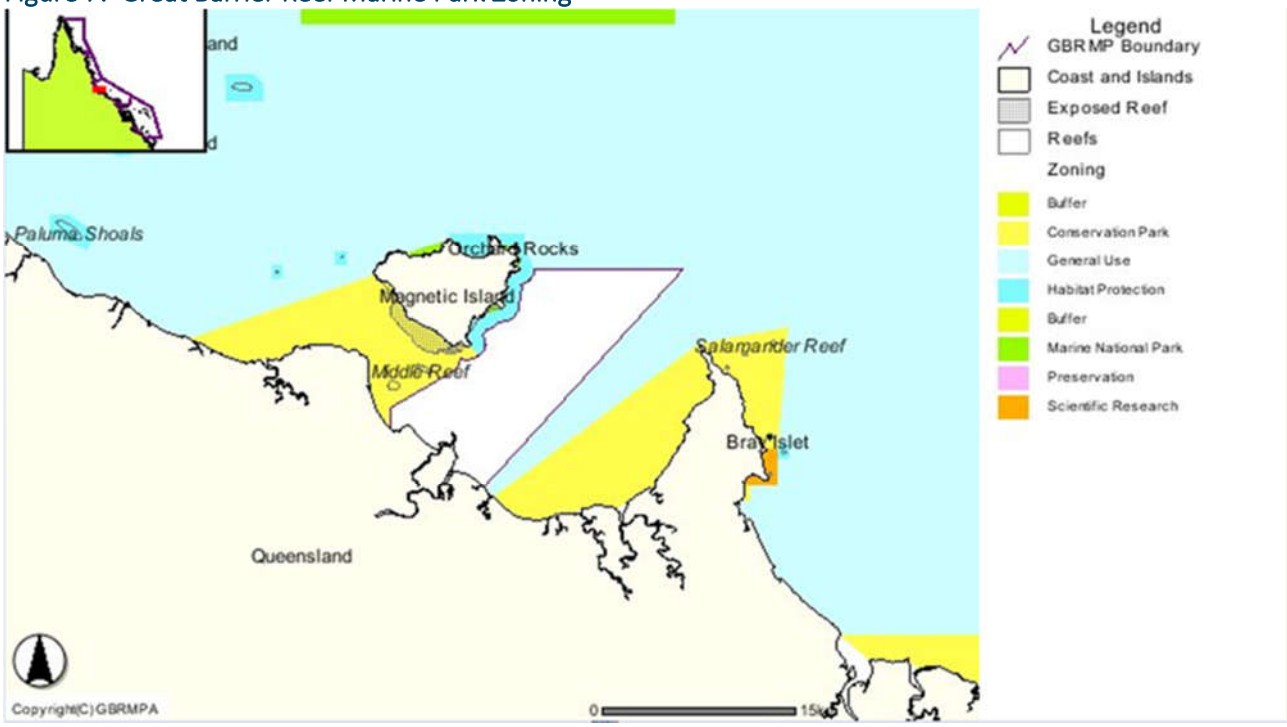
Cleveland Bay, including the Port of Townsville, is located within the GBRWHA, with all waters to low water mark along the coastline in the region included in the GBRWHA. It should be noted that the marine park boundaries and the GBRWHA boundary differ in Cleveland Bay.

7.2 The Great Barrier Reef Marine Park

The Commonwealth GBRMP was established in 1975 and covers 345,950km^2 and the State Great Barrier Reef Coast Marine Park runs its full length. The Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for the planning and management of the GBRMP, in conjunction with the National Parks section of Queensland's Department of Environment and Science (DES) who are responsible for the day-to-day management. The Townsville / Whitsunday Management Area of the GBRMP extends over approximately half the waters within the port limits. The State Marine Park complements the GBRMP through adopting similar zone objectives, and entry and use provisions. While the activities that can be carried out within the Great Barrier Reef Coast Marine Park and GBRMP are generally the same, there are some Queensland-specific provisions that may apply.

Existing port infrastructure is not contained within the GBRMP, however the approved DPMA and a portion of the Sea Channel is directly adjacent to the GBRMP. Under the GBRMP Zoning Plan, the areas immediately north and west of the Port are zoned Habitat Protection and Conservation Park and the area immediately to the east of the Port is zoned General Use with an area of Conservation Park further east (Figure 7).

Figure 7: Great Barrier Reef Marine Park Zoning

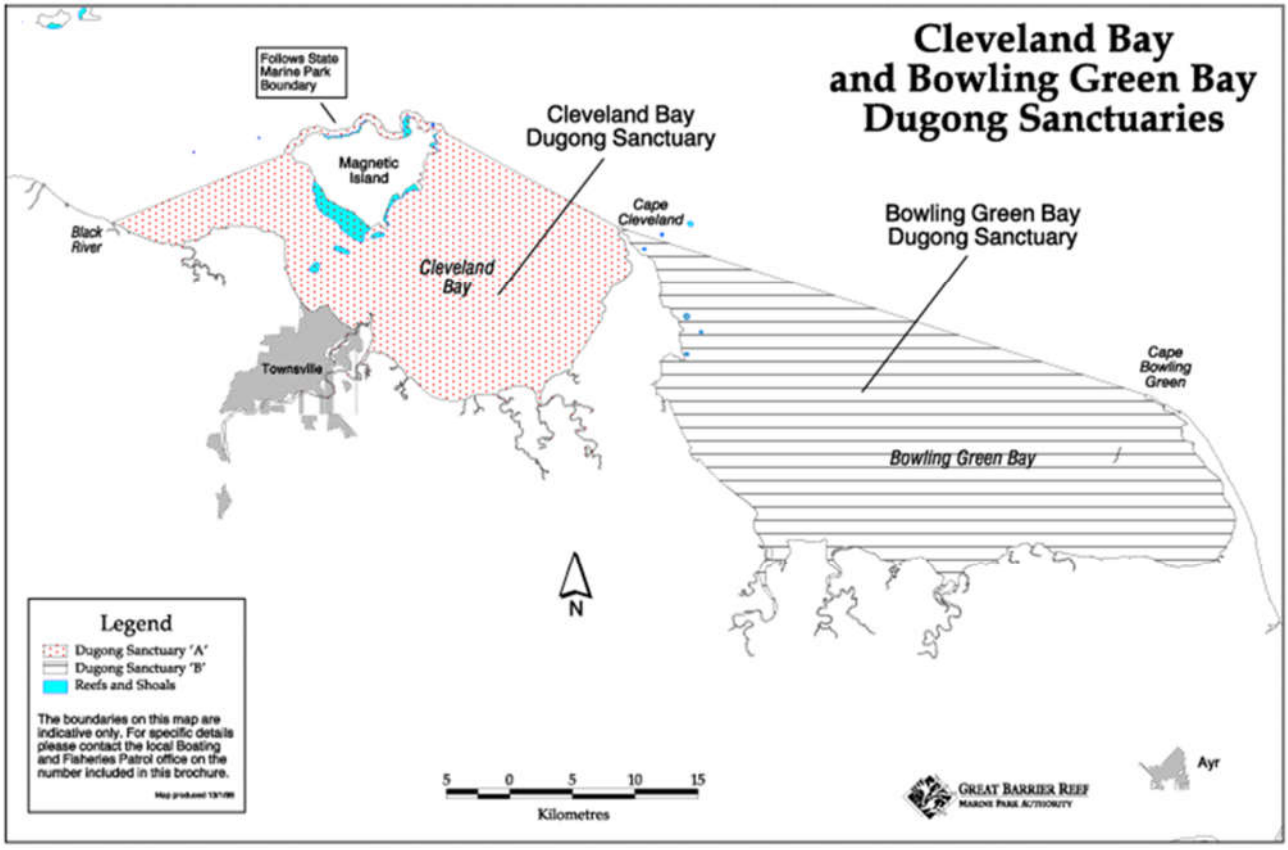


7.3 Dugong Protection Area

Dugong (*Dugong dugon*) are herbivorous mammals listed as marine and migratory under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and are listed as vulnerable internationally in Appendix 1 of the Conservation of the International Trade in Endangered Species. In 1997, the Australian and Queensland governments agreed to several measures aimed at arresting the decline of dugongs along the urban coast of Queensland. The most significant initiative was to establish a series of DPAs along the coastline, in which gill and mesh net fishing is restricted. DPAs are recognised under Queensland legislation as being areas of significant dugong habitat. The effective conservation of dugongs requires the protection of key seagrass habitats, including feeding and calving areas and migratory pathways.

A significant population of dugongs in the area has lead Cleveland Bay and all the waters around Magnetic Island to be declared as a DPA Zone A, with the adjacent Bowling Green Bay declared as a DPA Zone B (Figure 8).

Figure 8: Dugong Protection Areas

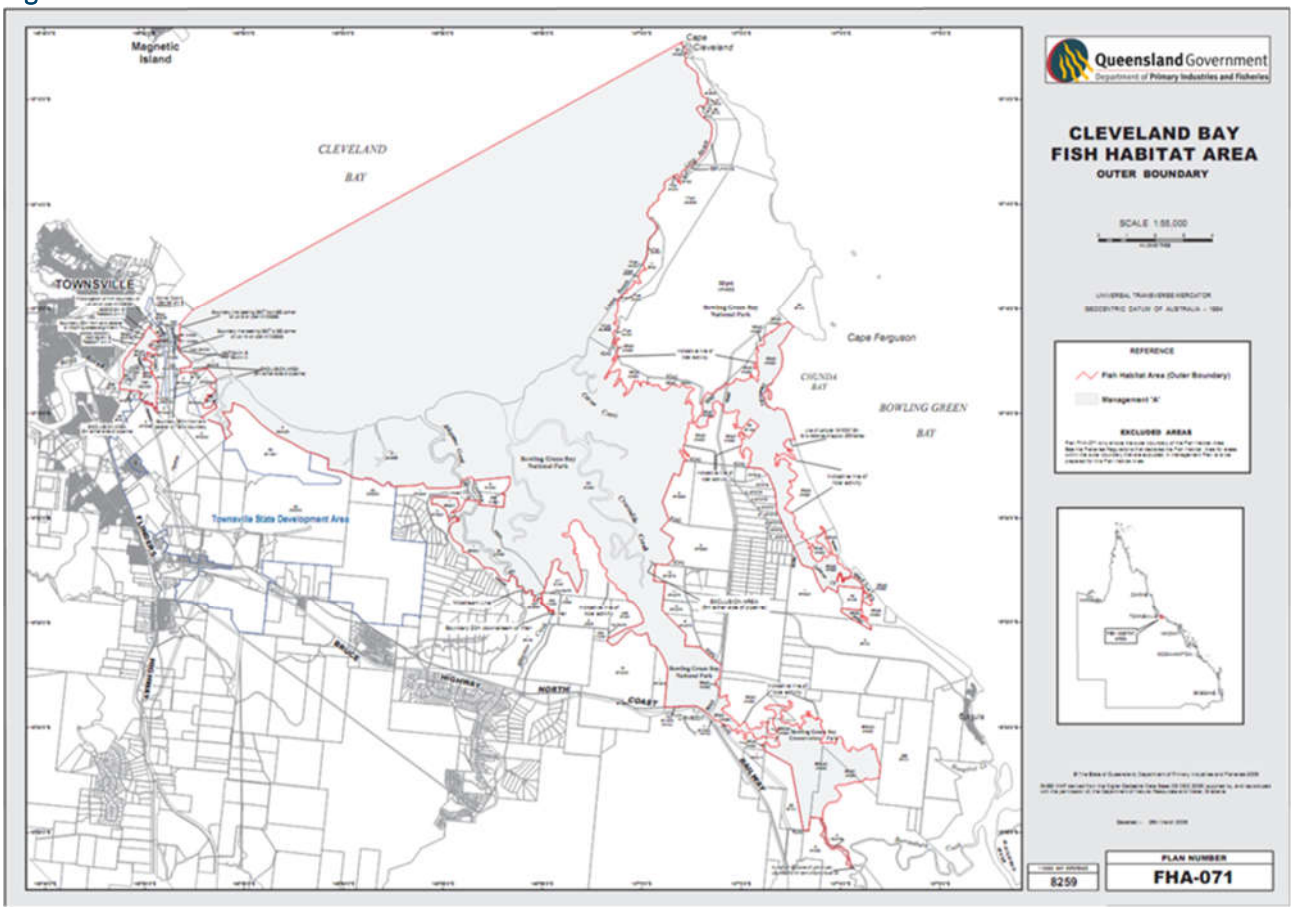


7.4 Fish Habitat Area

Declared FHAs are spatially defined areas containing key fish habitats that are vital to sustaining fish stocks and fisheries. These areas are declared and managed to protect the habitats from development-based impacts. A comprehensive network of over 70 Declared FHAs has been declared along the Queensland coast over the last 35 years. Examples of important fish habitats include fish spawning aggregation sites, seagrass beds and feeding grounds for larval and juvenile fish. Once an area is declared as a FHA, it protects all habitat types (e.g. vegetation, sand bars and rocky headlands) from direct physical disturbance and coastal development.

A management level 'A' FHA-071 was declared in Cleveland Bay in 2008, covering an area of 218.1km^2 (Figure 9), which affords the highest level of protection and limits allowable works to restoration works. No port infrastructure is within the Declared FHA.

Figure 9: Fish Habitat Area



7.5 RAMSAR – Bowling Green Bay

Located to the south of the Port of Townsville are the RAMSAR (internationally listed) Bowling Green Bay wetlands which are also listed on the Directory of Important Wetlands of Australia. Encompassing an area of 35,500 hectares, the site is significant for its extensive and diverse complex of coastal wetlands which are typical of the coastal wet-dry tropics of North Eastern Australia; the habitat it provides for wildlife including migratory birds; and its importance to commercial fisheries. The Bowling Green Bay wetlands are mostly coastal plain covered in tidal mudflats, mangrove forest and salt marshes, but the wetland complex is varied ranging from intertidal seagrass beds, mangrove woodlands and highly saline saltpan communities on the coast to brackish and freshwater wetlands inland. River channels and freshwater marshes also form part of this large wetland complex. Home to a rich and varied birdlife, the wetlands are also a nursery for fish and crustaceans and a feeding ground for rare and threatened wildlife such as the green turtle, dugong, little tern and eastern curlew.

Bowling Green Bay's mangrove communities provide vital protection from strong winds, tidal surges and heavy rainfalls associated with cyclones and also trap tide-borne sediments and help control coastal erosion. The varied floral communities in this wetland represent the major coastal communities of the North Australian tropics. Two plant species found here are classified as globally threatened. Nine species of mangrove grow in the wetland, providing a nursery and shelter for fish, mud crabs and prawns. Bowling Green Bay is an extensive baitfish breeding area and many commercial and recreational fish species feed

here, such as black marlin, sailfish and Spanish mackerel. The intertidal and subtidal seagrass beds of Cleveland and Bowling Green Bays provide a home for the vulnerable dugong and green turtle and are also a nursery for prawns. Juvenile barramundi breed prolifically in the area's swamps.

Rare and threatened animals which live in, or visit the wetlands, include the endangered loggerhead turtle, vulnerable green turtle, dugong, saltwater crocodile and little tern, and the rare painted snipe and eastern curlew. Brackish and freshwater wetlands behind Bowling Green Bay support a rich and abundant variety of waterbirds, including brolgas, magpie geese and sanderlings. More than half the migratory bird species listed in the Japan Australia Migratory Bird Agreement and China Australia Migratory Bird Agreement visit this wetland, including the threatened little tern. No port infrastructure is in or near the RAMSAR wetland with the closest point being the tip of Cape Cleveland which is approximately 6km from the offshore DMPA and the closest wetland on the coastline is approximately 12km away.

7.6 Magnetic Island

Magnetic Island (52km^2) is a mountainous island with 23 beaches and bays. It is separated from the mainland by the shallow (<15 m) west channel. The marine habitats of Magnetic Island are diverse and vary from wave-protected shallow, muddy environments on the leeward sides, to wave-exposed windward coastlines with clearer, deeper water. Associated with the high environmental diversity is a variety of marine communities, ranging from those tolerant of muddy, low light conditions to those that are typically found in less turbid environments (Fabricius & Brodie 2004).

Fringing reefs around high continental islands, like Magnetic Island, are quite different to offshore platform or ribbon reefs (Veron 1986). This is because of their relative youth in geological terms, and their exposure to natural freshwater, nutrient and sediment runoff from high continental islands onto the surrounding fringing reef. The coral reefs of Magnetic Island are shaped by high water turbidity and relatively storm-sheltered conditions from Cleveland Bay.

Marine turtles, sea snakes, several species of whales and dolphins and dugongs are regularly seen in the surrounding waters. Several Magnetic Island beaches are also known to be regular nesting sites for green turtles. Nests of ospreys and white-breasted sea eagles are well established on several headlands and their nesting sites have been continuously used for years if not decades. In addition, many bays are also seasonally inhabited by small flocks of Torres Strait Pigeons (now called Pied Imperial Pigeons) and regularly visited by frigate birds (Fabricius & Brodie 2004).

The Sea Channel is the closest piece of port infrastructure to Magnetic Island and is over 1km from Bremner Point at Geoffrey Bay.

7.7 Sensitive Receptors

Because the Port is located within an environmentally sensitive area of the coastline, ecological sensitivities are taken into account in all port planning and development activities. POTL recognises the regional ecological values identified throughout the Port and Cleveland Bay, which are summarised in Table 4.

Table 4: Sensitive Receptors in Cleveland Bay

Zone	Receptor	Description
Protected Areas	GBRWHA	Cleveland Bay is within the GBRWHA which is both a World and National Heritage Place.
	Marine Park	Cleveland Bay is within both the Central region of the Commonwealth GBRMP and the State Great Barrier Reef Coast Marine Park. Port infrastructure is in an exclusion area, but some infrastructure abuts the marine park.
	DPA	A DPA has been declared throughout Cleveland Bay, with a range of controls e.g. regulated speed limits etc. to minimise dugong strikes from vessels.
	FHA	A FHA (Cleveland Bay FHA-071) has been declared in the east of Cleveland Bay to sustain local and regional fisheries, outside the maintenance dredge areas and offshore DMPA.
	RAMSAR	A Declared RAMSAR wetland, Bowling Green Bay, is largely situated to the east of Cape Cleveland but also extends along the south-east coastline and tip of Cleveland Bay. The tip of Cleveland Bay is approximately 6km from the closest point of the offshore DMPA and the closest wetland on the coastline is approximately 12km away. However, the maintenance dredge areas and the offshore DMPA are located >9km from the RAMSAR wetland.
Marine	Coral	Coral reefs are present around Magnetic Island and between Magnetic Island and Townsville (e.g. Middle Reef). The closest point is Bremner Point in Geoffrey Bay which is >1km from the Sea Channel and 6km from the closest point of the offshore DMPA.
	Seagrass	Sparse ephemeral deep seagrass beds have been identified within Cleveland Bay, including some detected in the offshore DMPA in 2007 and 2008. Whilst mapping polygons include the channels, no surveys have detected seagrass in the channels.
	Fish Nurseries	Estuaries and sheltered bays are recognised fish nurseries for a number of species, including key commercial / recreational species (e.g. barramundi)
	Cetaceans	Dolphins and whales are commonly seen within Cleveland Bay, including snubfin dolphins (in and around Cleveland Bay and port infrastructure) and endangered blue whales (generally offshore).
	Dugong	Cleveland Bay is recognised as dugong habitat and is a Declared DPA.
	Sea Turtles	A number of species of sea turtles, including the endangered loggerhead, leatherback and olive ridley species, frequent Cleveland Bay and surrounding beaches. Green turtles are the most prolific.
	Sharks and Rays	A number of species of sharks and rays frequent Cleveland Bay
	Sea Snakes	A number of species of sea snakes frequent Cleveland Bay and surrounding beaches.
	Fish	Cleveland Bay has many species of fish which are protected by various mechanisms including a Declared FHA, zoning plans, licensing and catch limits.
	Crocodiles	Estuarine crocodiles frequent Cleveland Bay and its associated rivers.
	Sea Birds	A variety of sea birds are present in the marine areas, including sea eagles, ospreys and brown boobies.
	Benthic organisms	Common benthic flora and fauna are present in the marine areas.
Intertidal	Seagrass	Intertidal seagrass beds support dugong and turtle populations within Cleveland Bay, but routine monitoring of specific beds indicates that these beds fluctuate greatly over time depending on climatic conditions.

Zone	Receptor	Description
Intertidal	Mangroves	Substantial mangrove stands occur in Cleveland Bay and around Magnetic Island. These are protected by legislation, administered by the Department of Agriculture and Fisheries, and provide nursery habitat for many fish and invertebrate species as well as nesting habitat for birds and animals.
	Wetlands	Wetlands provide an important habitat for wading shorebirds and animals as well as removing nutrients from runoff and providing water retention areas.
	Wading Birds	Intertidal areas provide foraging habitat for many species of wading birds and migratory bird species listed in the Japan Australia Migratory Bird Agreement and China Australia Migratory Bird Agreement, particularly the east bank of Ross River.
	Benthic Invertebrates	The intertidal area is a key habitat for many species of invertebrates (e.g. crabs, shellfish, worms).

8 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The nine matters of national environmental significance protected under the EPBC Act are:

- World Heritage Properties;
- National Heritage Places;
- Wetlands of International Importance (listed under the RAMSAR Convention);
- Listed Threatened Species and Ecological Communities;
- Migratory species protected under international agreements;
- Commonwealth Marine Areas;
- The Great Barrier Reef Marine Park;
- Nuclear actions (including uranium mines); and
- A water resource, in relation to coal seam gas development and large coal mining development.

The Commonwealth marine area is outside the port limits and the last two Matters of National Environmental Significance are not located within the port area.

8.1 World Heritage Properties and National Heritage Places

Cleveland Bay is within the World Heritage Area and is a National Heritage Place. The bay, including the Port of Townsville, is located within the GBRWHA, with all waters to low water mark along the coastline in the region included in the GBRWHA.

8.2 Wetlands of International Importance

Cleveland Bay has one listed Wetland of International Importance on the eastern side of the bay. The Bowling Green Bay wetlands are listed under the RAMSAR Convention. No port infrastructure is in or near the RAMSAR wetland with the closest point being the tip of Cape Cleveland which is approximately 6km from the offshore DMPA and the closest wetland on the coastline is approximately 12km away. There are also three wetlands of national importance (listed in the Directory of Important Wetlands) located in the Townsville region, including the Burdekin-Townsville coastal aggregation, the Ross River Reservoir and the Townsville Royal Australian Air Force Base.

8.3 Listed Threatened Species and Ecological Communities and Migratory Species

A number of threatened species and migratory species use Cleveland Bay and the surrounding area. A protected matters search conducted on 21 January 2020 identified one listed terrestrial threatened ecological community outside the bay and 41 listed threatened species as potentially occurring within the bay and surrounding area (Table 5). It also identified 65 listed migratory species as potentially occurring within the bay and surrounding area (Table 6).

Table 5: Listed Threatened Species

Scientific Name	Common Name	Status	Type of Presence
Birds			
Botaurus pociloptilus	Australasian bittern	Endangered	Species or species habitat may occur within area
Calidris canutus	Red Knot, Knot	Endangered	Species or species habitat known to occur within area
Calidris ferrunginea	Curley sandpiper	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris	Great knot	Critically Endangered	Roosting known to occur within area
Charandrius leschenaultii	Greater sand plover, Large sand plover	Vulnerable	Roosting known to occur within area
Charadrius mongolus	Lesser sand plover, Mongolian plover	Endangered	Roosting known to occur within area
Erythrotriorchis radiatus	Red goshawk	Vulnerable	Species or species habitat known to occur within area
Fregetta grallaria	White-bellied storm-petrel (Tasman Sea)	Vulnerable	Species or species habitat likely to occur within area
Hirundapus caudacutus	White-throated needletail	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica bauera	Bar-tailed godwit (bauera), Western Alaskan bar-tailed godwit	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica menzbieri	Northern Siberian bar-tailed godwit, Bar-tailed godwit (menzbieri)	Critically Endangered	Species or species habitat may occur within area
Neochmia ruficauda	Star finch (eastern), Star finch (southern)	Endangered	Species or species habitat likely to occur within area
Numenius madagascariensis	Eastern curlew, Far eastern curlew	Critically Endangered	Species or species habitat known to occur within area

Scientific Name	Common Name	Status	Type of Presence
Poephila cincta	Southern black-throated finch	Endangered	Species or species habitat known to occur within area
Rostratula australis	Australian painted snipe	Endangered	Species or species habitat likely to occur within area
Tyto novaehollandiae kimberli	Masked owl (northern)	Vulnerable	Species or species habitat likely to occur within area
Mammals			
Balaenoptera musculus	Blue whale	Endangered	Species or species habitat may occur within area
Dasyurus hallucatus	Northern quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu]	Endangered	Species or species habitat known to occur within area
Hipposideros semoni	Semon's leaf-nosed bat, Greater wart-nosed horseshoe-bat	Vulnerable	Species or species habitat may occur within area
Macroderma gigas	Ghost bat	Vulnerable	Breeding likely to occur within area
Megaptera novaeangliae	Humpback whale	Vulnerable	Species or species habitat known to occur within area
Phascolarctos cinereus	Koala	Vulnerable	Species or species habitat known to occur within area
Pteropus conspicillatus	Spectacled flying-fox	Endangered	Species or species habitat likely to occur within area
Saccolaimus nudicluniatus	Bare-rumped sheath-tailed Bat, Bare-rumped sheathtail Bat	Vulnerable	Species or species habitat known to occur within area
Xeromys myoides	Water Mouse, False Water Rat, Yirrkoo	Vulnerable	Species or species habitat may occur within area
Plants			
Dichanthium setosum	Bluegrass	Vulnerable	Species or species habitat likely to occur within area
Marsdenia brevifolia		Vulnerable	Species or species habitat known to occur within area
Myrmecodia beccarii	Ant plant	Vulnerable	Species or species habitat likely to occur within area
Omphalea celata		Vulnerable	Species or species habitat likely to occur within area
Tephrosia leveillei		Vulnerable	Species or species habitat may occur within area
Reptiles			
Caretta	Loggerhead turtle	Endangered	Breeding likely to occur within area
Chelonia mydas	Green turtle	Vulnerable	Breeding known to occur within area
Dermochelys coriacea	Leatherback turtle, Leathery turtle	Endangered	Breeding likely to occur within the bay
Egernia rugosa	Yakka skink	Vulnerable	Species or species habitat may occur within area

Scientific Name	Common Name	Status	Type of Presence
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lepidochelys olivacea	Olive Ridley turtle, Pacific Ridley turtle	Endangered	Breeding likely to occur within area
Natator depressus	Flatback turtle	Vulnerable	Breeding known to occur within area
Sharks			
Carcharodon carcharias	White shark, Great white shark	Vulnerable	Species or species habitat may occur within area
Pristis	Freshwater sawfish, Largetooth sawfish, River sawfish, Leichhardt's sawfish, Northern sawfish	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron	Green sawfish, Dindagubba, Narrowsnout sawfish	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus	Whale shark	Vulnerable	Species or species habitat may occur within area

Table 6: Listed Migratory Species

Scientific Name	Common Name	Status	Type of Presence
Migratory Marine Birds			
Anous stolidus	Common noddy	Migratory	Species or species habitat likely to occur within area
Apus pacificus	Fork-tailed swift	Migratory	Species or species habitat likely to occur within area
Fregata ariel	Lesser frigatebird, Least frigatebird	Migratory	Species or species habitat known to occur within area
Fregata minor	Great frigatebird, Greater frigatebird	Migratory	Species or species habitat known to occur within area
Stern albifrons	Little tern	Migratory	Species or species habitat may occur within area
Migratory Marine Species			
Anoxypristis cuspidate	Narrow sawfish, Knifetooth sawfish	Migratory	Species or species habitat likely to occur within area
Balaenoptera edeni	Bryde's whale	Migratory	Species or species habitat may occur within area
Balaenoptera musculus	Blue whale	Endangered	Species or species habitat may occur within area
Carcharodon carcharias	White shark, Great white shark	Vulnerable	Species or species habitat may occur within area
Caretta	Loggerhead turtle	Endangered	Breeding likely to occur within area
Chelonia mydas	Green turtle	Vulnerable	Breeding known to occur within area
Crocodylus porosus	Salt-water crocodile, Estuarine crocodile	Migratory	Species or species habitat likely to occur within area
Dermochelys coriacea	Leatherback turtle, Leathery turtle, Luth	Endangered	Breeding likely to occur within area

Scientific Name	Common Name	Status	Type of Presence
Dugong dugon	Dugong	Migratory	Species or species habitat known to occur within area
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Lamna nasus	Porbeagle, Mackerel shark	Migratory	Species or species habitat may occur within area
Lepidochelys olivacea	Olive Ridley turtle, Pacific Ridley turtle	Endangered	Breeding likely to occur within area
Manta Alfredi	Reef Manta ray, Coastal Manta ray, Inshore Manta ray, Prince Alfred's ray, Resident Manta ray	Migratory	Species or species habitat likely to occur within area
Manta birostris	Giant Manta ray, Chevron Manta ray, Pacific Manta ray, Pelagic Manta ray, Oceanic Manta ray	Migratory	Species or species habitat likely to occur within area
Megaptera novaeangliae	Humpback whale	Vulnerable	Species or species habitat known to occur within area
Natator depressus	Flatback turtle	Vulnerable	Breeding known to occur within area
Orcaella heinsohni	Australian snubfin dolphin	Migratory	Species or species habitat known to occur within area
Orcinus orca	Killer whale	Migratory	Species or species habitat may occur within area
Pristis	Freshwater sawfish, Largetooth sawfish, River sawfish, Leichhardt's sawfish, Northern sawfish	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron	Green sawfish, Dindagubba, Narrowsnout sawfish	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus	Whale shark	Vulnerable	Species or species habitat may occur within area
Sousa chinensis	Indo-Pacific humpback dolphin	Migratory	Breeding known to occur within area
Migratory Terrestrial Species			
Cuculus optatus	Oriental cuckoo, Horsfield's cuckoo	Migratory	Species or species habitat known to occur within area
Hirundapus caudacutus	White-throated needletail	Vulnerable	Species or species habitat known to occur within area
Monarchis melanopsis	Black-faced monarch	Migratory	Species or species habitat known to occur within area
Monarcha trivirgatus	Spectacled monarch	Migratory	Species or species habitat known to occur within area
Motacilla flava	Yellow wagtail	Migratory	Species or species habitat likely to occur within area
Myiagra cyanoleuca	Satin flycatcher	Migratory	Species or species habitat known to occur within area
Rhipidura rufifrons	Rufous fantail	Migratory	Species or species habitat known to occur within area

Scientific Name	Common Name	Status	Type of Presence
Migratory Wetland Species			
Actitis hypoleucos	Common sandpiper	Migratory	Species or species habitat known to occur within area
Arenaria interpres	Ruddy turnstone	Migratory	Foraging, feeding or related behaviour known to occur within area
Calidris acuminata	Sharp-tailed sandpiper	Migratory	Roosting known to occur within area
Calidris alba	Sanderling	Migratory	Foraging, feeding or related behaviour known to occur within area
Calidris canutus	Red knot, Knot	Endangered	Species or species habitat known to occur within area
Calidris ferruginea	Curlew sandpiper	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos	Pectoral Sandpiper	Migratory	Species or species habitat known to occur within area
Calidris ruficollis	Red-necked stint	Migratory	Roosting known to occur within area
Calidris tenuirostris	Great knot	Critically Endangered	Roosting known to occur within area
Charadreius leschenaultii	Greater sand plover, Large sand plover	Vulnerable	Roosting known to occur within area
Charadrius mongolus	Lesser sand plover, Mongolian plover	Endangered	Roosting known to occur within area
Charadrius veredus	Oriental plover, Oriental dotterel	Migratory	Foraging, feeding or related behaviour known to occur within area
Gallinago hardwickii	Latham's snipe, Japanese snipe	Migratory	Roosting may occur within area
Gallinago megala	Swinhoe's Snipe	Migratory	Roosting likely to occur within area
Gallinago stenura	Pin-tailed Snipe	Migratory	Roosting likely to occur within area
Limicola falcinellus	Broad-billed sandpiper	Migratory	Foraging, feeding or related behaviour known to occur within area
Limosa lapponica	Bar-tailed godwit	Migratory	Species or species habitat known to occur within area
Limosa	Black-tailed godwit	Migratory	Roosting known to occur within area
Numenius madagascariensis	Eastern curlew, Far Eastern curlew	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus	Little curlew, Little whimbrel	Migratory	Roosting known to occur within area
Numenius phaeopus	Whimbrel	Migratory	Roosting known to occur within area
Pandion haliaetus	Osprey	Migratory	Breeding known to occur within area

Scientific Name	Common Name	Status	Type of Presence
Philomachus pugnax	Ruff (Reeve)	Migratory	Foraging, feeding or related behaviour known to occur within area
Pluvialis fulva	Pacific golden plover	Migratory	Roosting known to occur within area
Pluvialis squatarola	Grey plover	Migratory	Roosting known to occur within area
Tringa brevipes	Grey-tailed tattler	Migratory	Roosting known to occur within area
Tringa glareola	Wood sandpiper	Migratory	Foraging, feeding or related behaviour known to occur within area
Tringa incana	Wandering tattler	Migratory	Foraging, feeding or related behaviour known to occur within area
Tringa nebularia	Common greenshank, Greenshank	Migratory	Species or species habitat known to occur within area
Tringa stagnatilis	Marsh sandpiper, Little greenshank	Migratory	Roosting know to occur within area
Xenus cinereus	Terek sandpiper	Migratory	Roosting known to occur within area

8.4 Great Barrier Reef Marine Park

A component of Cleveland Bay is within the Commonwealth GBRMP and Great Barrier Reef Coast Marine Park. Existing port infrastructure is not contained within the GBRMP, however the approved DPMA and a portion of the Sea Channel is directly adjacent to the GBRMP.

9 TERRESTRIAL VALUES OF CLEVELAND BAY SHORES

9.1 Topography and Geology

Townsville is situated on a low-lying coastal landform bounded by Cleveland Bay and the Paluma and Hervey mountain ranges (DCILGPS 2000). This coastal plain, up to 7km wide, is present along the southern shoreline of Cleveland Bay and connects eastwards to the coastal plain of Bowling Green Bay further south. Otherwise, Cleveland Bay is fringed by rocky headlands, which rise to 497m on Magnetic Island, 557m on Cape Cleveland and 584m on Mt Stuart. The hinterland hills are comprised of late Paleozoic granitic intrusions, which intrude older Paleozoic volcanic and volcanoclastic rocks (Wyatt *et al*. 1970; Tresize *et al*. 1986; Bain & Draper 1997). The Port is constructed predominantly on reclaimed land using dredged material from the seafloor of the Outer Harbour basin.

9.2 Terrestrial Ecology

The landside port area is strategic port land, utilised for port operations and supporting industry and as such does not support terrestrial flora and fauna values, or have direct impacts on terrestrial ecology values. Avifauna (i.e. birds) may visit the coastal zone and use nearby shoreline and littoral habitats. Marine birds frequently occur at the Port, while feeding, resting or overflying from one area to another. Nearby inter-tidal shores are known for shorebird occurrence, providing a key roosting and feeding habitat. Many of those bird species that occur are listed as threatened or migratory species. The predominant areas of bird habitation are located on the sandspit on the eastern bank of Ross River.

On a broader scale, the Townsville region supports a number of wetland areas, including lacustrine (lake), palustrine (marsh), riverine, estuarine and marine wetland types. Such habitats support extensive and valuable bird populations, including the migratory birds that fly through the coastal plain on their annual journey along the East Australian Flyway. Bowling Green Bay is discussed above, but there are also three wetlands of national importance (listed in the Directory of Important Wetlands) located in the Townsville region, including the Burdekin-Townsville coastal aggregation, the Ross River Reservoir and the Townsville Royal Australian Air Force Base.

9.3 Visual Amenity

Castle Hill and Mount Stuart are key landform elements in the wider landscape rising above the urban areas of Townsville. The Port of Townsville is one of a number of visually dominant feature of both near-field and distant viewpoints, within the community; others include The Strand, Jezzine Barracks, Cape Pallarenda and Castle Hill. The most important designated landscape in the region is the coastal vista bounding the waters of the GBRWHA. This includes the Port of Townsville, which existed prior to the listing of the GBRWHA. The bowl-shaped landscape of Cleveland Bay, the two key headlands of Cape Pallarenda and Cape Cleveland, and Magnetic Island all constrain the scenic amenity of existing infrastructure on the wider World Heritage Area and parts of the marine park.

The natural character of this part of the GBRWHA is already influenced by the existing industrial development, in a context of productive human endeavours and urban and industrial establishments along the shores of Cleveland Bay and Magnetic Island.

10 CULTURAL HERITAGE

10.1 Indigenous Cultural Heritage

Land areas bounding Cleveland Bay contain tangible archaeological evidence for Aboriginal use and occupation. Cleveland Bay, Magnetic Island and the Townsville coastal plain are situated in a broad cultural landscape that retains significant Aboriginal cultural heritage values. Listed heritage values consist of both tangible and non-physical elements of Aboriginal cultural significance and Traditional Owners have expressed a view that both land and sea country remain as a component of the region's Aboriginal cultural landscape.

Areas of Ross River and Ross Creek are identified as integral components of the local Aboriginal creation story that explains the creation of the Halifax Bay and Cleveland Bay coastlines. Archaeological research in Townsville over the past two decades has recorded a diversity of Aboriginal archaeological sites, including shell middens, stone artifact scatters, rock shelters with paintings and cultural deposits, scarred trees, stone quarries, ceremonial places and burial sites. The area of Benwell Road Beach was noted as an important place that many local Aboriginal people still use for fishing, yabbying and collecting shellfish.

Two local communities, Gurambilbarra Wulgurukaba and Bindal, claim traditional ownership over Cleveland Bay. The cultural heritage values generally relate to those of protecting the natural environment. Recognition of Aboriginal cultural heritage values of the port area have been discussed through consultation with representatives of the Aboriginal parties. POTL is committed to working closely with the Traditional Owners and specific measures have been agreed to in order to mitigate potential indirect impacts of port operations, including the main navigation channel, as embodied in the Cultural Heritage Management Plan registered with the Department of Aboriginal and Torres Strait Islander Partnerships.

10.2 European and Natural Heritage

The Port of Townsville has played a significant role in the development of Townsville and, more broadly, of Northern Queensland. Established in 1864, the Port was created to service the newly settled hinterland to provide a harbour for trade vessels and service the demands of settlers north of the Burdekin River for a low risk flood locality. A jetty was originally constructed on Ross Island, between Ross Creek and Ross River, for goods and people to be loaded and unloaded after being discharged from vessels in the lee of Magnetic Island and transferred in lighters to Ross Island.

A historic cultural heritage study indicated that there were no listed places of historic European heritage significance in the Port (AECOM 2009). A search of the Townsville City Council's Local Heritage Database identified 143 properties of local significance in the adjoining suburbs of Townsville and South Townsville. A search of the National Heritage List, the Commonwealth Heritage List, the Register of the National Estate and the Queensland Heritage Register identified 55 places within approximately 3km of the Port. The GBRMP is the only place listed on the National Heritage Register, protected under the Environment Protection and Biodiversity Conservation Act 1999.

11 OTHER USES

An extremely diverse range of uses occurs in Cleveland Bay from ferry and barge services, commercial and recreational fishing, defence activities, diving and commercial marine tourism, recreational boating, research and educational activities and traditional use of marine resources, as well as port operations and shipping etc. These significant commercial industries and activities support employment and the livelihoods of many in coastal towns along the Townsville coast.

12 REFERENCES

AECOM 2009. Port Expansion Project Environmental Impact Statement. Prepared for Port of Townsville Limited. AECOM Australia Pty Ltd.

Bain JHC & Draper JJ 1997. North Queensland Geology. Australian Geological Survey Bulletin 240 and Queensland Department of Mines and Energy Queensland Geology 9, 600pp with 1:1 000 000 Geological Map 1:3 000 000 atlas.

Bell R & Kettle B 1989. The Coastal Resources of Magnetic Island, Townsville: report for Great Barrier Reef Marine Park Authority. Townsville

Belperio AG 1983. "Terrigenous sedimentation in the central Great Barrier Reef Lagoon: A model from the Burdekin region." Bureau of Mineral Resources Journal of Australian Geology and Geophysics 8: 179-190.

Belperio AG 1978. Recent paralic and continental shelf sediments adjacent to Townsville. Field Trip Guides: Third Australian Geological Convention, Townsville.

BMT WBM 2014. Assessment of Maintenance Dredging for 10 Year Permit. Prepared for Port of Townsville Limited.

BMT WBM 2009. Appendix K: Marine Ecology. Port Expansion Project Environmental Impact Statement. Prepared for Port of Townsville Limited.

BOM 2019. Climate Statistics for Australian Locations: Townsville Aero. Previous Tropical Cyclones. http://www.bom.gov.au/climate/averages/tables/cw_032040.shtml. http://www.bom.gov.au/cyclone/history/tracks/.

Brinkman RM *et al*. 1997. Surface wave attenuation in mangrove forests. Australasian Coastal Engineering and Ports Conference, Christchurch, New Zealand.

Bryant CV, Wells JN & Rasheed MA 2019. Port of Townsville Annual Seagrass Monitoring October 2018. Report No 19/01. James Cook University Publication, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), Cairns.

CoA 2014. EPBC Act referral guidelines for the Outstanding Universal Value of the Great Barrier Reef World Heritage Area. Commonwealth of Australia, 2014. (http://www.environment.gov.au/system/files/resources/e8e47508-5ea4-457b-adef-b9c1364e9bec/files/referral-guidelines-great-barrier-reef_0.pdf).

Creighton C, Gillies CL & McLeod IM (eds) 2015. Australia's saltmarshes: a synopsis to underpin the repair and conservation of Australia's environmental, social and economically important bays and estuaries. TropWATER Publication, James Cook University, Townsville (Report No. 15/61).

Cruz Motta JJ & Collins J 2004. Impacts of dredged material disposal on a tropical soft-bottom benthic assemblage. Marine Pollution Bulletin 48, 270-280.

Cruz Motta JJ 2000. Effects of the Dumping of Dredged Material of Townsville Port on the Soft-Bottom Benthic Community of Cleveland Bay. James Cook University, Department of Marine Biology, Townsville.

DCILGPS 2000. Townsville-Thuringowa Strategy Plan. Townsville: Queensland Department of Communication and Information, Local Government, Planning and Sport.

Fabricius, KE, Logan M, Weeks S & Brodie J 2014. The effects of river run-off on water clarity across the central Great Barrier Reef. Marine Pollution Bulletin 84: 191-200.

Fabricius KE & Brodie G 2004. World Heritage values of Magnetic Island: the marine system. Magnetic Island World Heritage Values - A Preliminary Assessment. Magnetic Island Community Development Association and Magnetic Island Nature Care Association.

GBRMPA 2014. The Great Barrier Reef Outlook Report 2014. Commonwealth of Australia Great Barrier Reef Marine Park Authority, Townsville.

GBRMPA 2009. The Great Barrier Reef Outlook Report 2009. Commonwealth of Australia Great Barrier Reef Marine Park Authority, Townsville.

Geochemical Assessments 2017. Sampling and Analytical Plan Implementation Report. Port of Townsville Limited, 2017 Maintenance Dredging Assessment.

GHD 2012. Appendix K4. Marine Megafauna. Port Expansion Project Environmental Impact Statement. Prepared for Port of Townsville Limited, July 2012.

GHD 2011. Port Expansion Project - Benthic Survey Results - Additional Sampling Sites. Technical Note prepared for Port of Townsville Limited, February 2011.

GHD 2009. Townsville Marine Precinct Environmental Impact Statement. Prepared for Port of Townsville Limited.

Golder Associates 2008. Summary of Geotechnical Testing Undertaken in the Port of Townsville Redevelopment Area. Unpublished report for AECOM Australia Pty Ltd. Golder Associates Pty Ltd, Brisbane.

Goudkamp K & Chin A 2006. Mangroves and Saltmarshes, Environmental Status. Great Barrier Reef Marine Park Authority (State of the Great Barrier Reef On-line).

Johns L 2010. Field guide to common saltmarsh plants of Queensland. Department of Employment, Economic Development and Innovation.

Kettle B *et al*. 2002. A Review of the Impacts of Dredging in Cleveland Bay, and Research Priorities for the next decade. James Cook University, Tropical Environmental Science & Geography, Townsville.

Kettle B, Dalla Pozza R, & Collins J 2001. New Directions, A Review of the Impacts of Dredging in Cleveland Bay and Research Priorities for the Next Decade. Report for Townsville Port Authority Dredge Spoil Disposal TACC, Townsville.

Larcombe P *et al*. 1995. "Factors controlling suspended sediment on inner-shelf coral reefs, Townsville, Australia." Coral Reefs 14(3): 163-171.

Larcombe P & Ridd PV 1994. Dry season hydrodynamics and sediment transport in mangrove creeks. Mixing Processes in Estuaries and Coastal Seas. C. Pattariatchi.

Lee Long W *et al*. 1993. Seagrasses between Cape York and Hervey Bay, Queensland, Australia. Australian Journal of Marine and Freshwater Research, 44, 19-31.

Lovelock C 2003. Field Guide to the Mangroves of Queensland. Australian Institute of Marine Science, Townsville.

Mapstone B *et al*. 1989. The Fringing Reefs of Magnetic Island: Benthic Biota and Sedimentation: A Baseline Study. Great Barrier Reef Marine Park Authority (Australia): 134.

McKenna S, Chartrand K, Van De Wetering C, Wells J, Carter AB & Rasheed M 2020, Port of Townsville Seagrass Monitoring Program: 2019, James Cook University Publication, Centre for Tropical Water & Aquatic Ecosystem Research (TropWATER), Cairns.

Moss AJ *et al*. 1993. A preliminary assessment of sediment and nutrient exports from Queensland costal catchments. Environmental technical report 5, Queensland Department of Environment and Heritage.

NAGD 2009. National Assessment Guidelines for Dredging. Commonwealth of Australia, Canberra.

Orpin AR *et al*. 1999. "Assessment of the relative importance of major sediment-transport mechanisms in the central Great Barrier Reef lagoon." Australian Journal of Earth Sciences 46: 883–896.

Persson A 1997. The influence of river regulation on downstream channel morphology and sediment delivery to the coast: the lower Ross River, North Queensland. James Cook University, School of Tropical Environment Studies and Geography, Townsville.

POTL 2014a. Cleveland Bay Water Quality Monitoring Review. Port of Townsville Limited, December 2014.

POTL 2014b. Contamination Management Audit. Port of Townsville Limited, December 2014.

Pringle A 1989. The history of dredging in Cleveland Bay, Queensland and its effects on sediment movement and on the growth of mangroves, corals and seagrass. Townsville, Great Barrier Reef Marine Park Authority (Australia): 177.

Rasheed M & Taylor H 2008. Port of Townsville Seagrass Baseline Survey Report 2007-2008. Department of Primary Industries and Fisheries, Commonwealth of Australia, Cairns.

Reichelt AJ & Jones GB 1994. "Trace metals as tracers of dredging activity in Cleveland Bay - field and laboratory studies." Australian journal of marine and freshwater research 45(7): 1237-1257.

RIVER Group 2004. Common Saltmarsh Plants of the Townsville Coastal Plains. Ross Island Volunteers Estuarine Research, Conservation volunteers Australia.

Roelofs AJ *et al*. 2003. Port of Weipa Seagrass Monitoring 2000 - 2002. EcoPorts Monograph Series No.22, Ports Corporation of Queensland, Brisbane.

Sam R & Ridd P 1998. "Spatial variations of groundwater salinity in a mangrove-salt flat system, Cocoa Creek, Australia." Mangroves and Salt Marshes 2(3): 121-132.

Taylor H & Rasheed M 2009. Port of Townsville Long-Term Seagrass Monitoring – 2009. Department of Employment, Economic Development and Innovation, Cairns.

Tresize DL *et al*. 1986. Townsville, Queensland (8259). 1:100 000 Geological Map Sheet and Commentary, Queensland Department of Mines.

Veron JEN 1986. Corals of Australia and the Indo-Pacific. Angus & Robertson, Sydney.

Walker TA & O'Donnell G 1981. "Observations on Nitrate, Phosphate and Silicate in Cleveland Bay, Northern Queensland." Australian Journal of Marine & Freshwater Research 32(6): 877-887.

Wells JN & Rasheed MA 2017. Port of Townsville Annual Seagrass Monitoring and Baseline Survey: September – October 2016. James Cook University Publication, Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), Cairns.

Wyatt DH *et al*. 1970. Geology of the Townsville 1:250 000 Sheet Area, Queensland. Bureau of Mineral Resources, Report 127.

13 DEFINITIONS AND ACRONYMS

DAWE	Department of Agriculture, Water and the Environment (Commonwealth)
DES	Department of Environment and Science (Queensland)
DMPA	Dredge Material Placement Area
DPA	Dugong Protection Area
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FHA	Fish Habitat Area
GBRMP	Great Barrier Reef Marine Park
GBRMPA	Great Barrier Reef Marine Park Authority
GBRWHA	Great Barrier Reef World Heritage Area
JCU	James Cook University
POTL	Port of Townsville Limited

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PORT OF TOWNSVILLE

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