Cobourg Peninsula Ramsar Site

Report to Department of Sustainability, Environment, Water, Population and Communities

20 January 2010

Research of key knowledge gaps in the ecological character of the Cobourg Peninsula Ramsar site, Northern Territory

Aquatic flora and fauna and physicochemical assessment

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Aquatic Flora and Fauna and Physicochemical Assessment

Prepared for

Department of Sustainability, Environment, Water, Population and Communities

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Acronyms

ALOS	Advanced Land Observation Satellite
ANZECC	Australian and New Zealand Environment and Conservation Council
AVC	Aquatic Vertebrate Carnivores
AVH	Aquatic Vertebrate Herbivore
BMT WBM	Environmental Consultant
BOD	Biochemical Oxygen Demand
BoM	Bureau of Meteorology (Australian Government)
CAMBA	China-Australia Migratory Bird Agreement
CPSMPB	Cobourg Peninsula Sanctuary and Marine Park Board
CR	Critically Endangered
DD	Data Deficient
DEWHA	Department of Environment, Water, Heritage and the Arts (now known as SEWPaC)
DSE	Victorian Department of Sustainability and Environment
EC	Electrical Conductivity
ECD	Ecological Character Description
ECM	Estuarine Coastal and Marine
EN	Endangered
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ETM+	Enhanced Thematic Mapper Plus
GDA	Geocentric Datum of Australia
IUCN	International Union for Conservation of Nature
JAMBA	Japan-Australia Migratory Bird Agreement
LR	Lower Risk
MIR	Mid infrared
MSS	Multispectral scanner
NATA	National Association of Testing Authorities
NDVI	Normalised Difference Vegetation Index
NE	Not Evaluated
NIR	Near infrared
NOx	Total Oxidised Nitrogen
NRETA	Northern Territory Department of Natural Resources, Environment and the Arts (now known as NRETAS)
NRETAS	Northern Territory Department of Natural Resources, Environment, the Arts and Sports
NT	Near Threatened
NTG	Northern Territory Government

NTU	Nephelometric Turbidity Unit
NVIS	National Vegetation Information System
PWCNT	Parks and Wildlife Commission of the Northern Territory (Northern Territory Government)
RIS	Ramsar information sheet
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
SCRSR	Sites of Conservation and Recreational Significance Register
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Australian Government)
SIMPER	Similarity percentage
SWIR	Shortwave infrared
TC	Tasselled Cap
TGI	Terrestrial Ground-foraging Insectivore
TKN	Total kjeldahl nitrogen
TLC	Tiwi Land Council
TM	Thematic Mapper
TN	Total nitrogen
TPWC Act	*Territory Parks and Wildlife Conservation Act*
TSSC	Threatened Species Scientific Committee
UPGMA	Unweighted Pair Group Method with Arithmetic Mean
USGS	United States Geological Survey
VU	Vulnerable

Executive Summary

AECOM Australia Pty Ltd (AECOM) was commissioned by the Australian Government Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) to research several key ecological and physicochemical knowledge gaps in the Cobourg Peninsula Ramsar site (Ramsar site). In order to research these gaps, the project aims were to:

- gain a detailed understanding of the location, extent and types of wetlands (following the Ramsar wetland type classification) present in the Ramsar site at the time of the site's listing as a Ramsar site in 1974, in addition to the present day wetlands
- gain an improved understanding of the key freshwater fauna (including invertebrates) and flora species currently present in the Cobourg Peninsula wetlands
- gain an understanding of the current physicochemical water properties in each wetland type.

The Ramsar site is located 163 km (570 km by road) northeast of Darwin within the Northern Territory of Australia.

Methods

Literature Review

A literature review was undertaken that focussed on identifying the representative range of wetland dependent flora and fauna (including invertebrates) that occur, or potentially occur, within or near to the Ramsar site. Observable threats to biodiversity in the Ramsar site were also identified. A range of literature and databases were reviewed. Database searches were focussed on the Cobourg Peninsula and surrounding islands (e.g. Croker Island).

Wetland Mapping

Preliminary identification and delineation of wetland types was undertaken by analysis of Landsat Enhanced Thematic Mapper Plus (ETM+), Advanced Land Observation Satellite (ALOS) and aerial (Google Earth Professional) imagery. Wetland types within the Ramsar site were then classified and divided into two broad categories, inland and marine/coastal, according to the Ramsar classification.

Wetlands identified during the preliminary assessment were verified through on ground studies which documented key physical characteristics at nominated representative sites from each wetland type expected to occur across the Ramsar site. Characteristics included physical water properties (e.g. pH, electrical conductivity, and dissolved oxygen), vegetation (e.g. algal, overhanging, emergent and trailing root), size of the wetland and connectivity to surrounding wetlands or the sea.

Aquatic and Wetland Dependent Flora and Fauna Survey

At least two representative sampling sites were selected within each wetland type expected to occur across the Ramsar site. This duplication aided in gaining an adequate understanding of the spatial variation in results across the Ramsar site. Twenty-one inland and marine/coastal sites within 14 wetland types were surveyed during the mid dry season survey (29 July to 3 August 2010). Thirty inland and marine/coastal sites within 16 wetland types were surveyed during the late dry season survey (3 to 5 October 2010).

The mid dry season survey consisted of sampling each site for:

- fish
- macroinvertebrates
- other wetland dependent fauna (e.g. water birds, water monitors)
- flora
- physicochemical water properties.

The biological study took into consideration species that are keystone, significant for trophic relationships, threatened or highly abundant.

The late dry season survey consisted of sampling for physicochemical water properties only. Opportunistic observations of any fauna were recorded.

Results

Wetland Types

The Cobourg Peninsula Ramsar site contains 10 marine/coastal and 10 inland wetland types (**Table 1**).

Table 1 Marine/Coastal and Inland Wetland Types (Ramsar Classified) that Occur in the Cobourg Peninsula Ramsar Site

Marine/Coastal Wetlands	Area (hectares)	Inland Wetlands	Area (hectares)
B – Marine subtidal aquatic beds; includes kelp beds, sea-grass beds and tropical marine meadows.	Not calculated	N – Seasonal/intermittent/irregular rivers/streams/creeks.	7,776
C – Coral reefs.	Not calculated	P – Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes.	359
D – Rocky marine shores; includes rocky offshore island, sea cliffs.	36.5 km*	Q – Permanent saline/brackish/alkaline lakes.	578
E – Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.	2,070	R – Seasonal/intermittent saline/brackish/alkaline lakes and flats.	169
F – Estuarine waters; permanent water of estuaries and estuarine systems of deltas.	7,592	Sp – Permanent saline/brackish/alkaline marshes/pools.	44
G – Intertidal mud, sand or salt flats.	6,212	Ss – Seasonal/intermittent saline/brackish/alkaline marshes/pools.	25
H – Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.	2,734	Tp – Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least of the growing season.	79
I – Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.	26,207	Ts – Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows and sedge marshes.	110
J – Coastal brackish/saline lagoons; brackish to saline lagoons with at least one relatively narrow connection to the sea.	1,314	Xf – Freshwater, tree-dominated wetlands; includes freshwater swamps, seasonally flooded forests, wooded swamps on inorganic soils.	770
K – Coastal freshwater lagoons; includes freshwater delta lagoons.	254	Y – Freshwater springs; oases.	302
Total	**46,383****		**10,212**

* This wetland type is linear and has been calculated as total length.
** The total area is an underestimate because the area of some wetland types that exist in the Ramsar site were not calculated.

Wetland Types (1973)

Analysis of 1973 imagery allowed the identification of only seven wetland types. Differences in wetland types from current wetland mapping are likely to be due to greater sophistication of today's imagery and analysis techniques.

Flora

A total of 913 flora species are recorded in the NT Flora Atlas for the Cobourg Peninsula Ramsar site.

Ninety-four terrestrial and aquatic plants were recorded at inland wetland sites. No species considered to be conservation significant was recorded. One species, *Nymphoides exiliflora*, listed as Data Deficient, was found at site I3. Three species (the palms *Carpentaria acuminata* and *Hydriastele ramsayi*, and *Corymbia porrecta* (Grey Bloodwood)) are endemic to the Northern Territory.

Twenty-one terrestrial and aquatic species of flora was recorded during the mid dry and late dry season surveys of marine/coastal wetland sites. One species, *Xylocarpus granatum*, listed as Near Threatened under the TPWC Act, was recorded at site M5.

Fauna

A total of 396 terrestrial vertebrate fauna species are recorded in the NT Fauna Atlas for the Cobourg Peninsula Ramsar site.

Thirty-eight species of fish was recorded during the mid dry and late dry season surveys of marine/coastal wetland sites. This includes:

- Giant Groper (*Epinephelus lanceolatus*): Data Deficient (TPWC Act)
- five conservation significant fish listed on the IUCN Red List (Blacktip Reef Shark (*Carcharhinus melanopterus*), Spot-tail Shark (*Carcharhinus sorrah*), Giant Groper (*Epinephelus lanceolatus*), Estuary Goby (*Glossogobius biocellatus*) and Lemon Shark (*Negaprion acutidens*)).

Five fish species were recorded during the mid dry and late dry season surveys of inland wetland sites.

A total of 1,125 individual benthic macroinvertebrates from 84 families were recorded during the mid dry season surveys of marine/coastal wetland sites. At least 222 species were identified from 56 (sub) families or higher taxonomic levels during the mid dry season surveys of inland wetland sites.

No frog species, seven reptile, 78 bird and five mammal species were recorded during the mid dry and late dry season surveys of marine/coastal wetland sites. This includes:

- four species of marine turtle (Green Turtle (*Chelonia mydas*), Hawksbill Turtle (*Eretmochelys imbricata*), and the Flatback Turtle (*Natador depressus*): all listed as Vulnerable (EPBC Act) and Loggerhead Turtle (*Caretta caretta*): Endangered (TPWC Act, EPBC Act and IUCN Red List))
- Saltwater Crocodile (*Crocodylus porosus*): Migratory and Marine (EPBC Act)
- thirty one EPBC Act-listed Migratory bird species and 38 EPBC Act listed-Marine bird species
- Indo-pacific Humpback Dolphin (*Sousa chinensis*): Migratory (EPBC Act), Near Threatened (IUCN Red List).

Seven species of frog, nine reptile, 77 bird and seven mammal species were observed during the mid dry and late dry season surveys of inland wetland sites. This includes:

- Northern Dwarf Tree Frog (*Litoria bicolor*): Data Deficient (TPWC Act)
- Saltwater Crocodile (*Crocodylus porosus*): Migratory and Marine (EPBC Act)
- Partridge Pigeon (*Geophaps smithii*): Vulnerable (EPBC Act)
- seventeen EPBC Act-listed Migratory bird species and 21 EPBC Act-listed Marine bird species
- Brush-tailed Rabbit-rat (*Conilurus penicilatus*): Vulnerable (TPWC Act and EPBC Act), Near Threatened (IUCN Red List)
- five introduced mammals.

Physicochemical Water Properties

Sampling was undertaken for physical and chemical properties from 18 marine/coastal wetland sites, including 14 sites during the mid dry season survey and 17 sites during the late dry season. At each site (except one), up to three samples were taken depending on the amount of water available.

Sampling was undertaken for physical and chemical properties from nine inland wetland sites, including six sites during the mid dry season survey and eight sites during the late dry season. Three of the 12 sites did not contain water during either survey. At each site, up to three samples were taken depending on the amount of water available.

Water temperature in wetland sites was generally lower in July than in October 2010, varying in relation to the type of system (e.g. low flowing water bodies such as lakes observed the highest increase in temperature, whereas the intermittent freshwater creek observed the smallest variation). Electrical conductivity was lower in

July than in October 2010 in all saline wetland environments. Turbidity was usually lower in July than in October in all inland and marine/coastal sites, with the change most apparent in the freshwater habitats. Dissolved oxygen varied between surveys and sites. In general the open marine wetlands recorded adequate concentrations; however the closed systems often recorded very low concentrations. pH levels tended to vary depending upon the systems surveyed, for example the pH readings for the inland springs were acidic while the marine wetlands were slightly alkaline.

The concentrations of total nitrogen, nitrate/nitrite (NOx) and ammonia were usually higher than the ANZECC 2000 guidelines. However, in order to accurately assess nutrient concentrations a much larger data set is required.

The data collected is still useful as it provides a snap shot of the conditions at the time of the surveys, thus increasing the understanding of the ecology of the differing wetland types. In general the nutrient concentrations were higher in the late dry season than the mid dry season. This is often the situation as water bodies dry out, however rainfall was recorded between the two surveys which will also influence the results as water is transferred from one wetland to another.

Threats

A range of threats to wetland integrity were identified during the mid dry and late dry season surveys of marine/coastal and inland wetland sites, including feral animals, weeds, extreme weather, saltwater intrusion into freshwater areas, fire and anthropogenic disturbances. Based on field observations, the most evident threat across the wetlands of the Cobourg Peninsula Ramsar site was disturbance from feral animals.

Summary of Discussion

The conclusions drawn from this study are summarised below.

Threats

- Most of the inland wetlands examined showed evidence (e.g. uprooted trees) of modification as a result of extreme weather events, including cyclones.
- Wetland systems are likely to have been subjected to similar forces in the past, and may be expected to undergo a slow transition back to pre-cyclone conditions and species assemblages as successive wet seasons progressively flush salt out of the system and salt-sensitive species regain dominance.
- It is reasonable to expect that flora and fauna assemblages are also in a state of flux.
- Evidence of changes in wetland condition can be derived from the literature. Previous flora and fauna studies undertaken in 1974 (Frith and Calaby, 1974) recorded large numbers of waterbirds at Gul Gul (lagoon) on Danger Point. Surveys of the same wetland during the present survey found significantly less water bird abundance.

Ecological Significance of Wetland Dependent Species

- Most wetlands support terrestrial wetland dependent species that may be significant in their influence over ecosystem health and functioning of the whole community. However, no species were observed during the surveys that could be regarded as ‘keystone’ species. Species that exert the greatest influence over communities are often the most abundant, although in some instances it is biomass, rather than abundance that may have the greatest influence.
- Including fish species sampled in the past and during the present survey, overall diversity is very low in a regional comparative sense.
- Apart from small isolated springs, other stream systems may dry out completely, or in large wetland sites, cyclonic disturbances are probably sufficiently frequent to result in periodic saltwater intrusion, which a large number of freshwater fish species will be intolerant of.
- There appears to be a lack of significant refugial freshwater sites for the majority of fish species to sustain viable populations through time.

Macroinvertebrates

- The negative correlation observed between macroinvertebrate species richness and degree of salinity of the inland water bodies, as well as the absence of fish in water bodies with high salinity, are direct indicators of the responses of the biota to cyclonic disturbances.
- There was substantial variability in macroinvertebrate assemblages across inland and marine/coastal wetland sites.

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by the Australian Government Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) to research several key ecological and physicochemical knowledge gaps in the Cobourg Peninsula Ramsar site (Ramsar site). Biosis (2009) identified a lack of detailed knowledge of a number of ecological features within the Ramsar site, including wetland types, freshwater dependent (including lacustrine, palustrine, spring and estuarine wetland systems) flora and fauna and physicochemical processes occurring primarily within freshwater (i.e. inland) wetland systems. Specifically, this project aimed to:

- gain a detailed understanding of the location, extent and types of wetlands (following the Ramsar wetland type classification) present in the Ramsar site at the time of the site's listing as a Ramsar site in 1974, in addition to the present day wetlands
- gain an improved understanding of the key freshwater fauna (including invertebrates) and flora species currently present in the Cobourg Peninsula wetlands
- gain an understanding of the current physicochemical water properties in each wetland type.

Within the constraints of timing and site access, this report provides data that will contribute to a site Ecological Character Description (ECD). Specifically, this report:

- details the approach taken, including a background review of targeted species
- details results acquired from field surveys
- outlines threats to ecosystems that were observed during the field surveys
- analyses data derived from field surveys in order to identify keystone flora and fauna, those species important for trophic relationships, community assemblages of freshwater species and their ecological importance in supporting the services of the wetland types
- includes a series of maps that present the extent and location of current wetland types, those from 1974 (i.e. the year that the Peninsula was listed on the Ramsar Convention) and seasonal variation in inundation and drying events across the Peninsula
- analyses and describes the primary physical and chemical characteristics of the sampled wetlands and extrapolates this across the Peninsula, where possible.

The field surveys undertaken during this study aimed to gather data on physicochemical properties and wetland dependent flora and fauna including those that are:

- specifically dependent on inland (e.g. lacustrine, palustrine, spring and estuarine systems) wetlands
- keystone species
- of conservation significance.

Two field surveys were undertaken. In the first survey (July 2010), flora, fauna and water chemistry data were collected from representative sites within each accessible wetland type. Confirmation of wetland types mapped during the desktop mapping exercise was also undertaken (i.e. ground-truthing). The second survey (October 2010) was designed to collect data relating to water chemistry properties only. These data were then used to assess the likely spatial and temporal variation in water quality throughout the Ramsar site. Fauna that was opportunistically observed was recorded from and between each site.

2.0 Background

Background information on the Cobourg Peninsula Ramsar site is provided in the following sections.

2.1 Location and Brief Description

Garig Gunak Barlu (pronounced *Gah-rig Goon-uk Bar-loo*) National Park was previously known as Gurig National Park and Cobourg Marine Park, and is located about 570 km (by road) to the northeast of Darwin on the Cobourg Peninsula. The park covers around 4,500 km^2 and includes the entire Peninsula, surrounding waters, including the Van Diemen Gulf and neighbouring islands. It consists of a diversity of land and marine areas including mangroves, rainforest, swamps, lagoons, beaches and dunes, sea grass meadows and other marine habitats.

The Cobourg Peninsula Ramsar site is an Australian listed Ramsar site and is protected within the larger Garig Gunak Barlu National Park. It comprises all wetlands of Cobourg Peninsula and the nearby Sir George Hope Islands, as well as surrounding intertidal marine areas to the low water mark. The Garig Gunak Barlu National Park also includes the Cobourg Marine Park, which extends seaward from the low water mark (DEWHA, 2010a).

The majority of the Cobourg Peninsula is freehold Aboriginal Land that has important social and cultural values for the Traditional Owners. The Park is managed jointly by the Traditional Owners and the Parks and Wildlife Commission of the Northern Territory (PWCNT). It is managed as a conservation reserve and is used for conservation, regulated tourism, hunting and Indigenous use. The waters surrounding the Cobourg Peninsula support commercial and recreational fisheries (NRETA and CPSMPB, 2007).

2.2 Designation as a Ramsar Site

The Cobourg Peninsula was declared a Ramsar site on 8 May 1974. The Protection of Ramsar Wetlands is also given under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

2.3 Legislative Obligations

The Cobourg Peninsula Ramsar site is managed under various laws and international agreements, including:

- the Ramsar Convention
- the EPBC Act
- *Cobourg Peninsula Aboriginal Land, Sanctuary and Marine Park Act 1981*
- *Territory Parks and Wildlife Conservation Act* (TPWC Act)
- *Fisheries Act 1988.*

2.4 Knowledge Gaps

This study will provide input into the Ecological Character Description (ECD) that is being developed for SEWPaC. The ECD will be used to update the Ramsar information sheet (RIS) for the Cobourg Peninsula Ramsar site. Knowledge gaps were identified by Biosis (2009). **Table 2** details these knowledge gaps and the methods used in this study to fill them.

Table 2 Knowledge Gaps Identified for the Cobourg Peninsula Ramsar Site

Component	Knowledge Gap	Methods Proposed to Fill Knowledge Gap
Ramsar wetland types	• wetland mapping according to Ramsar wetland classification	• distinguish and map wetlands, using existing maps, aerial, Landsat and Advanced Land Satellite Observation (ALOS) imagery • ground-truth
Hydrology	• quantitative data on the extent and duration of flooding during the wet season	• analysis of satellite imagery from successive seasons
Physicochemical water properties	• seasonal variability • information on estuarine and freshwater systems	• baseline physicochemical surveys in all wetland types during the mid dry and late dry season
Flora and vegetation communities	• key species • plant-animal relationships • seasonal dynamics	• baseline survey across all wetland types to include flora species list • a description of vegetation assemblages • observation of threatening processes
Invertebrates	• key species • abundance and diversity of invertebrates across all wetland types	• baseline survey across all wetland types
Fish	• freshwater fish abundance and diversity • knowledge of interactions between species	• baseline survey across all wetland types
Birds	• stability of waterbird breeding colonies	• opportunistic recordings during aquatic fauna survey
Other wetland dependent fauna	• abundance and diversity	• opportunistic recordings during aquatic fauna survey

3.0 Stages of the Study

The development of this study, from initial literature review and mapping, through to data analysis and final reporting, is outlined in **Table 3**. The methodology used at each step in the process of researching key knowledge gaps in the ecological character description of the Cobourg Peninsula Ramsar site will be discussed in detail in this section.

Table 3 Stages of the Study

Stage	Outputs
Desktop Literature Review	Wetland dependent flora and fauna likely to occur within the Cobourg Peninsula Ramsar site, including those species that are: • dependent on inland or estuarine wetland systems • of conservation significance • highly abundant.
Mapping of Wetland Types	• extent and location of wetland types across the Peninsula.
Site Selection for Field Surveys	• representative survey sites.
Mid Dry Season Survey (late July 2010)	• aquatic flora and fauna (including macroinvertebrates) • baseline physical and chemical water properties • opportunistic identification of other wetland dependent fauna (including migratory fauna).
Late Dry Season Survey (early October 2010)	• physical and chemical water properties • opportunistic identification of other wetland dependent fauna (including migratory fauna) • opportunistic identification of wetland flora at new sites.
Data Analysis	• determination of diversity and abundance of key wetland dependent flora and fauna and community assemblages, and their ecological significance to the Ramsar site • determination of physical and chemical water properties of the wetland types outlining the range and variability of individual properties where known.

4.0 Limitations

4.1 Project Delays

Due to delays in project inception, the first round of field sampling for aquatic flora and fauna was not undertaken until late July when conditions were not representative of the late wet season. The late wet season is generally regarded in northern Australia as that when diversity, in aquatic (freshwater) ecosystems at least, is greatest (Humphrey et al.,1990). As such, the first round of field sampling was considered to be during the mid dry season.

4.2 Targeted Flora and Fauna

This study has focussed on inland and coastal wetland systems. This includes all Ramsar classified wetlands in lacustrine, palustrine, estuarine, intertidal mud, salt and sand flat and shore areas. It excludes coral reefs and marine subtidal aquatic beds. While mapping and field surveys have been undertaken in all wetland types, data analysis, including information from the desktop literature review, includes only those species recorded, or likely to occur, in these systems. Flora or fauna (e.g. whales) known to occur in offshore (e.g. coral reefs and marine subtidal aquatic beds) systems are not mentioned in this study.

4.3 Site Selection and Access

The feasibility of examining the required number of wetland types within the allocated field duration was influenced by accessibility, tides, weather conditions and/or travel times. Consequently, pre-selected sites and wetland types expected to occur alter from those determined during field work.

Field sampling for fish and macroinvertebrates was proposed for representative sites across the Ramsar site (**Section 6.1**). Such sampling is labour intensive. Unfortunately and for cultural purposes, an unavoidable and last-minute restriction to the eastern side of the site (**Figure 34**) during the mid dry season surveys (i.e. when fish and macroinvertebrate surveys were undertaken) resulted in many sites becoming unavailable for sampling. Additionally, Indigenous staff from this area that were to be engaged for field assistance were unavailable and as a consequence each of the field teams was reduced from five to three workers. The reduced team completed the sampling program with limited local knowledge of the area.

During the late dry season survey, wind and sea conditions surrounding Sandy Island No. 2 were too dangerous to traverse. As such, sampling was not undertaken here. As an alternative, water samples were gathered from wetland sites near to Sandy Island No. 1, a closer and safer option. Sandy Island No. 1 contained similar wetland types and geomorphologic characteristics to Sandy Island No. 2.

4.4 Wetland Mapping

Wetland mapping is undertaken through analysis of satellite and aerial imagery and soil or vegetation mapping. A critical component of wetland mapping is ground-truthing, in which a set of wetlands are visited to confirm their physical and chemical properties. This study aimed to examine a subset of each of the expected wetland types. While it is not possible to visit all wetlands across the site, the methods used to map wetlands will give an accurate indication of wetland types expected to occur.

Mapping from 1973 shows fewer wetland types primarily because of the lower resolution of the available images and the difficulties in distinguishing boundaries and types of wetlands in such images. With larger pixel size, small wetlands are indistinct and mapping them is not possible or not accurate. However, this is not to say that those wetland types mapped as currently existing were not present in 1973.

4.5 Water Sampling

Water sampling undertaken in this study is limited and is very much a snapshot in time, given sampling occurred at each site on just two days of the year. For marine/coastal wetlands, physical and chemical properties will change over a spring neap cycle and within a flood (ebb tidal cycle). Other small scale influences on readings within tidally dominated systems and fluvial processes are possible sediment supply limitations. Temperature and conductivity readings can be influenced by localised effects of shallow waters moving over warm or salty substrates. This aside, the study does provide some basis for capturing typical values that will contribute towards a greater understanding of processes within these wetlands over time.

Ideally, water samples within a site would be collected in two seasons in order to attempt to determine seasonal variation. At several sites that were sampled in the mid dry season, primarily those that are ephemeral, water levels had receded significantly in the late dry season and it was not possible to collect water (i.e. sites I4, I5, I8). In several sites sampled during the late dry season only, some were dry (i.e. I13, M16) while another (site M19) presented a significant risk (i.e. presence of Banteng) to samplers and hence only one physical water quality measure was recorded (i.e. water chemistry samples were not collected).

Water levels in all accessible inland wetlands were shallow and water transparency readings could not be obtained with the use of a secchi disk. Turbidity was measured. As such, water transparency data are omitted from inland wetland site water quality results.

4.6 Fish Sampling in Marine Wetlands

Marine waters of the Ramsar site and the wider area have been the focus of numerous fish surveys undertaken in recent decades (e.g. Gomelyuk, 2003; Gomelyuk, 2008). The primary objective of this study was to survey for aquatic fish, macroinvertebrates and flora, and other wetland dependent fauna in inland and estuarine systems (i.e. not marine) and physicochemical properties in all marine/coastal and inland systems in representative sites across the Ramsar site. AECOM scientists also surveyed for fish, macroinvertebrates and other wetland dependent fauna in marine wetlands beyond the immediate estuarine zone (e.g. coral reefs, rocky marine shores and sand shores). While results of this additional sampling are presented in this report, the data are too meager to allow for the determination of 'keystone' species. A more comprehensive survey and examination of previous studies would be required for this. As such, in depth analysis of data produced from this study was not undertaken.

4.7 Electrofishing

Electrofishing is a method used to sample inland (freshwater) fish. The unit proposed (Smith-Root LR24) was not utilised at any sites due to the high readings of electrical conductivities (EC) of several wetlands, deeming the operation unsafe and ineffective. The malfunctioning of the unit also prevented its use at one site.

4.8 Analysis of Benthic Macroinvertebrates

Very few conservation significant macroinvertebrates (especially marine/estuarine) are listed at State or Commonwealth level. It is therefore difficult to discuss the significance of species or assemblages based on this. Analysis of macroinvertebrate data instead focused on using these assemblages as indicators of ecological health in the local ecosystems.

5.0 Wetland Types

5.1 Methods

5.1.1 1974 Wetland Distribution (Year of Designation)

The Cobourg Peninsula was designated as a Ramsar site on 8 May 1974. The most suitable satellite image from that time was from Landsat's Multispectral Scanner (MSS) platform. The closest available image dates were October 1973 and August 1973. Each image was acquired from United States Geological Survey (USGS, 2010).

The drawback of using such imagery is the limited spatial and spectral resolution. The sensor only records four bands of spectral data in the visible and infrared portions of the electromagnetic spectrum. The spatial resolution of this sensor is 60 m by 60 m with no panchromatic band to enhance the image.

To maintain consistency in visualising and mapping features, the two scenes were also optimised using Tasselled Cap (TC) transformations (**Figure 1**). However, the limited spatial and spectral resolution of the historical scenes restricted the number and extent of identifiable Ramsar classes across the Peninsula.

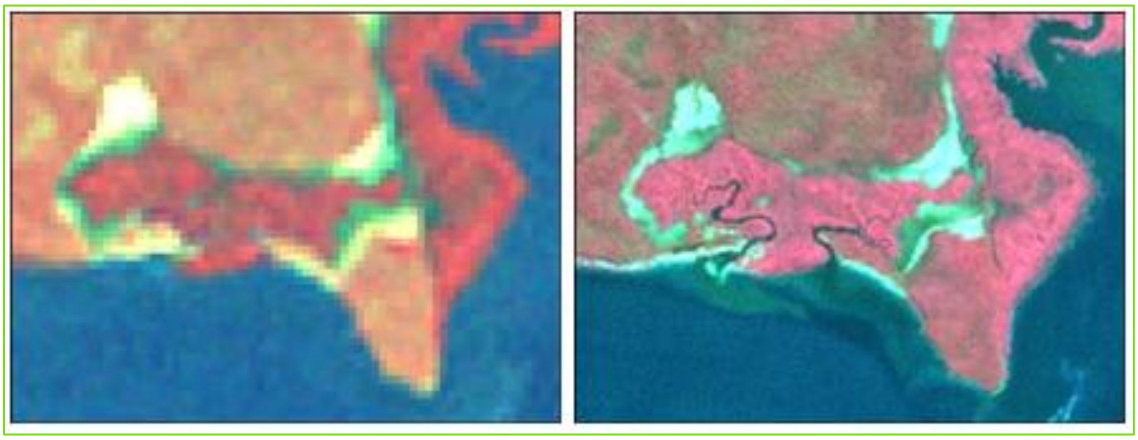


Figure 1 Comparison between Historical Landsat MSS Ground Detail and Pan-sharpened Landsat7 Ground Detail

5.1.2 2010 Wetland Distribution

5.1.2.1 Imagery Sources

Landsat Enhanced Thematic Mapper Plus (ETM+) images (Geoscience Australia) from 3 June 2000 and 9 June 2002 were used for the wetland delineation. Images were selected to represent the end of the northern wet season. Multi-date imagery enabled the differentiation between an above average rainfall wet season (2000) and a below average rainfall wet season (2002). These two years were selected based on comparison of the northern wet season total rainfall maps from 1998 onwards (BoM, 2010) (**Figure 2** and **Figure 3**). Additionally, daily rainfall data from Black Point, Seven Spirit Bay and Cape Don weather stations were checked to ensure the selected image dates reflected the total rainfall map data.

The Landsat ETM+ sensor records eight bands of spectral data in the visible, infrared and thermal portions of the electromagnetic spectrum. The spatial resolution of this sensor is 30 m by 30 m with a panchromatic band of 15 m by 15 m. The thermal band was excluded from the analysis due to its lower spatial resolution (60 m) and distortion due to cloud cover. Whilst more recent imagery was available from the Landsat Thematic Mapper (TM) sensor, the lack of a panchromatic band in this imagery does not allow the identification and mapping of features at a finer resolution.

In addition to the Landsat imagery, three scenes (sourced from Geoscience Australia) from ALOS were also analysed. Whilst the ALOS sensor has a higher spatial resolution of 10 m, it captures information in four spectral bands only (blue, green, red and near-infrared). The three scenes were captured between May and August 2008 and as such represent only a single snapshot in time. Hence, they were only used in the visual identification of features not clearly distinguishable in the Landsat imagery.

All the imagery was obtained with final radiometric correction and geometric rectification. The scenes were rectified to the Map Grid of Australia (Zone 53) using the Geocentric Datum of Australia 1994 (GDA94). Google

Earth Professional was used occasionally to interpret those features not distinguishable in both the Landsat and ALOS scenes.

5.1.2.2 Review of Existing Mapping Layers

The ecosystems of the Cobourg Peninsula have previously been mapped under several different projects. The resulting datasets were reviewed to determine their suitability to aid in the wetland mapping exercise for this project. The datasets consist of:

- estuarine, coastal and marine (ECM) habitat mapping (Mount and Bricher, 2008)
- National Vegetation Information System (NVIS; Version 3)
- vegetation community mapping for the Cobourg Peninsula and Garig Gunak Barlu National Park (Brocklehurst, 2010) which incorporates:
  - *The Cultural and Ecological Significance of Popham Creek* (Billyard, 1990)
  - *Melaleuca Survey of the Top End, Northern Territory* (Brocklehurst and Lynch, 2009)
  - *Methods for Monitoring the Abundance and Habitat of Northern Australian Mudcrab, Scylla serrata* (De Vries et al., 2002)
  - *Classification, Species Richness, and Environmental Relations of Monsoon Rainforest in Northern Australia* (Russell-Smith, 1991)
  - *The History and Natural Resources of the Tiwi Islands Northern Territory* (TLC, 1998)
  - *Vegetation Survey of the Northern Territory* (Wilson et al., 1990)
  - *The Land Resources of the Cobourg Peninsula* (Wood and Siverston, unpublished).

Other information sources used to aid in the mapping included:

- the RIS on the Cobourg Peninsula Ramsar site (PWCNT, 1998)
- land systems of Arnhem Land (Lynch and Wilson, 1998)
- Cobourg Marine Park Plan of Management (NRETA, 2007)
- OzCoasts geomorphic habitat mapping for the NT (Geoscience Australia, 2004).

The wetland definitions in available datasets used to aid in the wetland mapping did not align with those under the Ramsar wetland classification system (Ramsar, 2008). Further, conflicting boundaries and differing polygon attributes between available datasets made them unsuitable to be used as inputs into the mapping process. Nevertheless, the datasets were used in the preliminary assessment of the landscape units.

5.1.2.3 Image Enhancement and Analysis

The satellite imagery was processed using ERDAS Imagine® 2010 with a Microsoft® Windows XP Pro operating system. The images were sharpened using the panchromatic band to improve the ground resolution. The six TM bands (excluding band 6 (the thermal band)) were then optimized using Tasseled Cap (TC) transformations, which produce 3 bands of known characteristics: soil brightness, vegetation greenness and soil/vegetation wetness.

The Tasseled Cap transformation is a form of Principal Component Analyses, where the original spectral data is rotated to fully utilize the data range. It allows redundant data to be compacted into fewer bands. The Tasselled Cap transformations are specific rotations that optimize data viewing for vegetation studies.

Band combinations also aided in the interpretation of the landscape and in identifying the classes of interest. The combination of bands 5 (MIR), 4 (NIR) and 3 (Red) was used for the analysis of soil moisture and vegetation conditions. Band 5 of the Landsat sensor is sensitive to moisture variation in vegetation and soils.

In addition, band ratios such as the Normalised Difference Vegetation Index (NDVI) and the Normalised Difference Water Index (NDWI) were computed for both images to further identify areas of interest.

Ratios are used extensively to bring out small differences between features and can highlight differences that cannot be observed in the display of the original colour bands.

NDVI is computed using the Infrared (IR) and Red (R) spectral bands in the formula:

$(IR – R) / (IR + R)$

NDWI is computed using the Near-Infrared (NIR) and Short Wave Infrared (SWIR) spectral bands in the formula:

(NIR – SWIR) / (NIR + SWIR)

The proposed method using Density Slicing and a Normalised Difference Water Index was tested. However, it was concluded that the results of TC bands were more effective in differentiating between vegetation types and water-related features (**Figure 4**).

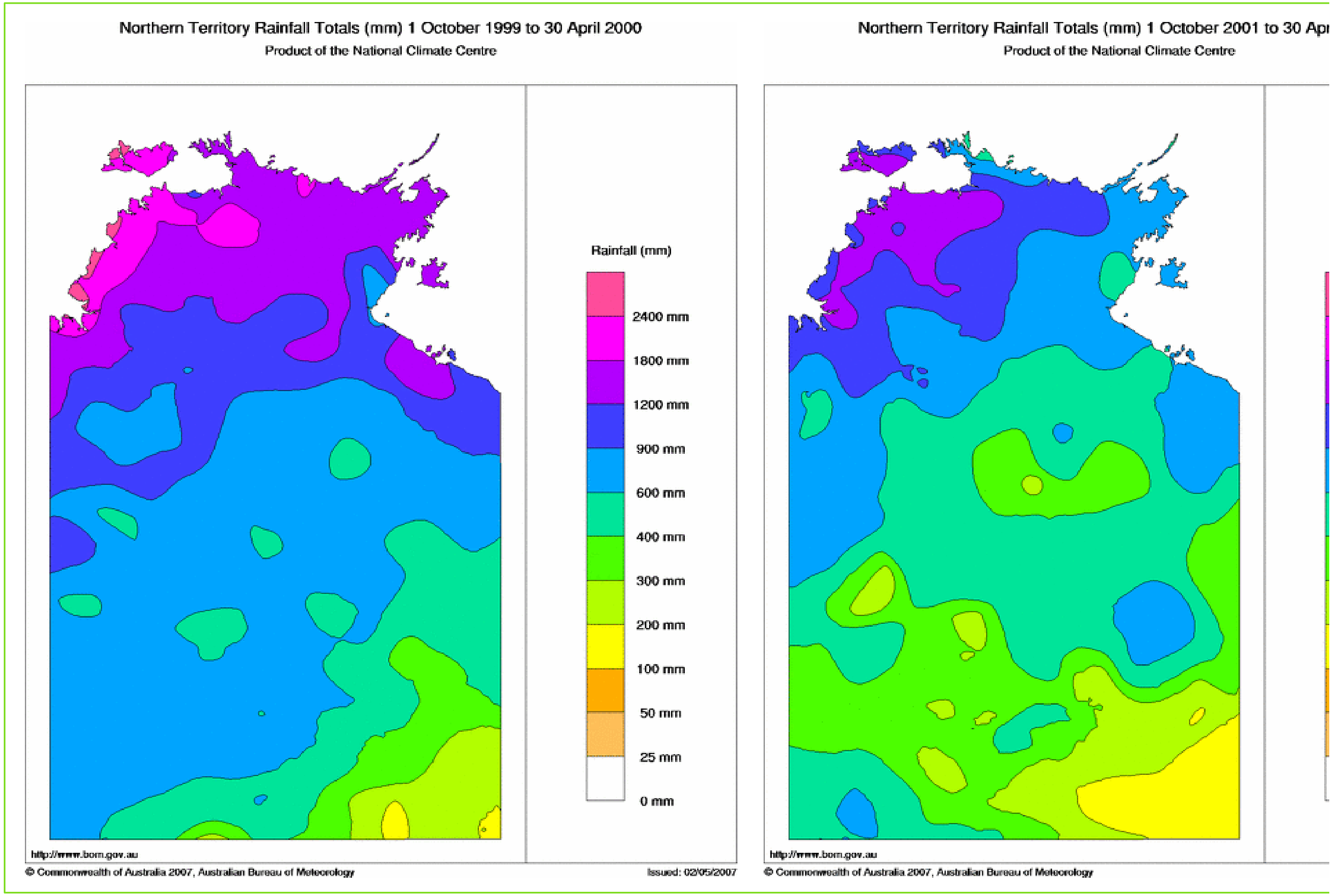


Figure 2 Northern Territory Wet Season Rainfall Totals from 1999 to 2000 and 2001 to 2002 (BoM, 2010)

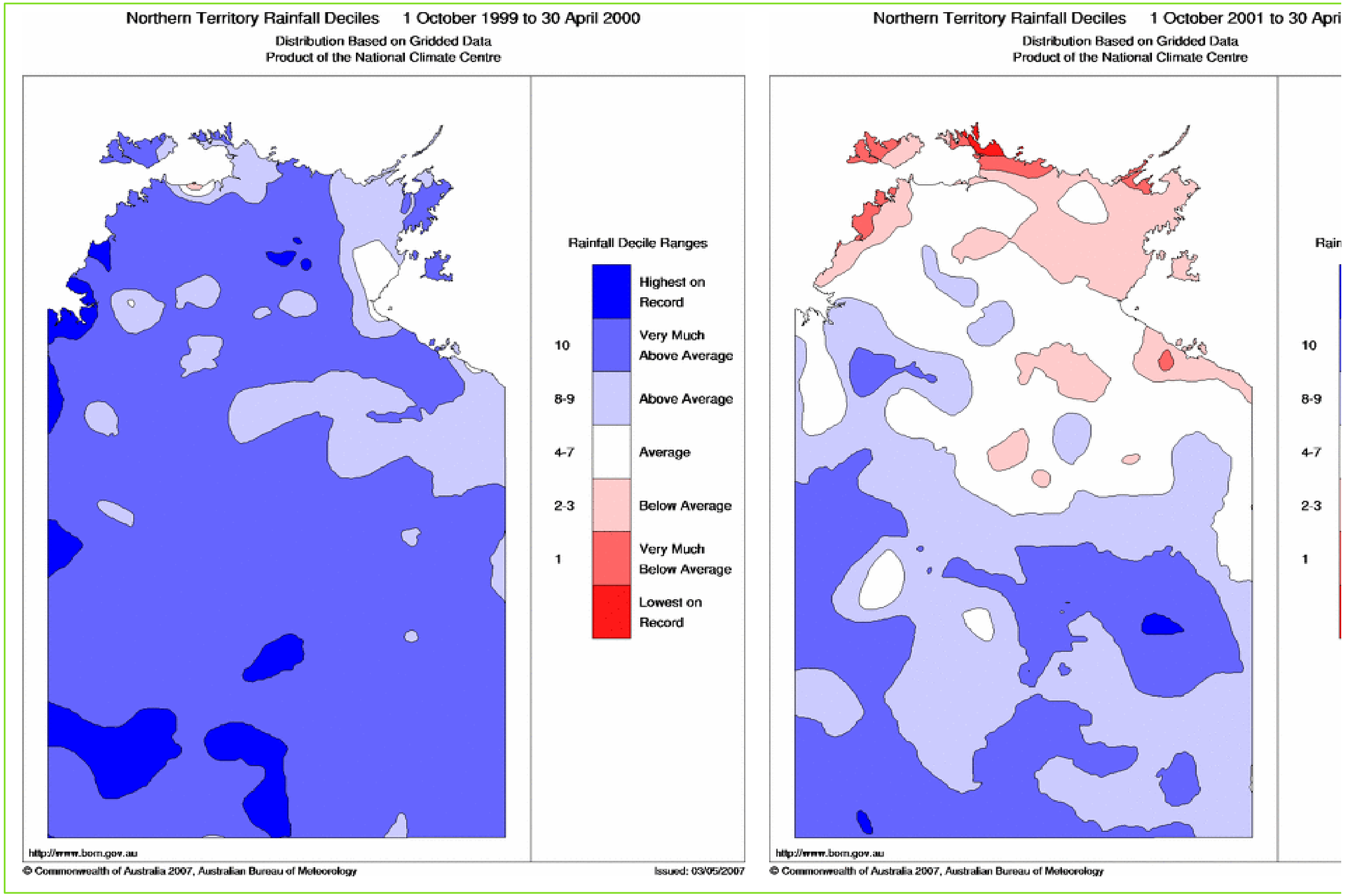
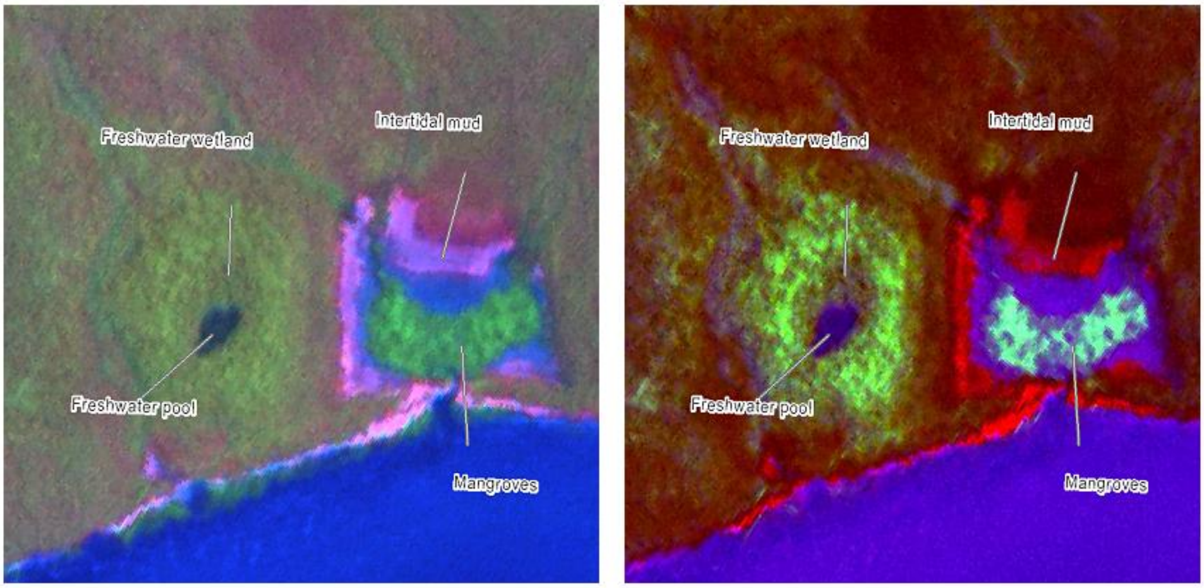


Figure 3 Northern Territory Wet Season Rainfall Deciles from 1999 to 2000 and 2001 to 2002 (BoM, 2010)



Landsat 2000 pan-sharpened image using Bands 5, 4 & 3. Vegetation appears green, water is blue and sand appears pinkish.

Contrast-stretched Tassel Cap bands 1, 2 & 3 of the Landsat 2000 pan-sharpened image. Note the clear distinction between the freshwater wetland & mangroves.

Figure 4 Comparison between an Unprocessed Satellite Image and Tasselled Cap Transformation

5.1.2.4 Mapping

Preliminary unsupervised classifications using 10, 25 and 50 classes were carried out on the June 2000 Landsat image to test the effectiveness of the process. Considering the number of Ramsar wetland types to be mapped, the resultant misclassification arising from mixed pixels suggested that the classification algorithms were not effective in mapping the numerous Ramsar units within the greater Cobourg Peninsula landscape.

Consequently the methodology adopted used the optimized TC components and contrast-stretched band combinations as a basis for image interpretation and digitising of the wetlands. The data were digitised in ESRI ArcMap 9.3.1 at a fixed scale of 1:10,000. Wet and dry images were analysed to assist in deciding best fit location of wetland polygon boundaries (**Figure 5**). Where required, Google earth images were used to assist in defining the wetland class boundaries.

The following wetland types could not be uniquely identified:

Aquatic seabeds – lack of confirmed sites and limited spatial/spectral resolution prohibited the identification and mapping of this wetland type.

Coral Reefs – while some sub-marine features were visible around the coastline, the available imagery was not able to categorically distinguish them as coral reefs from sand banks or other underwater topography.

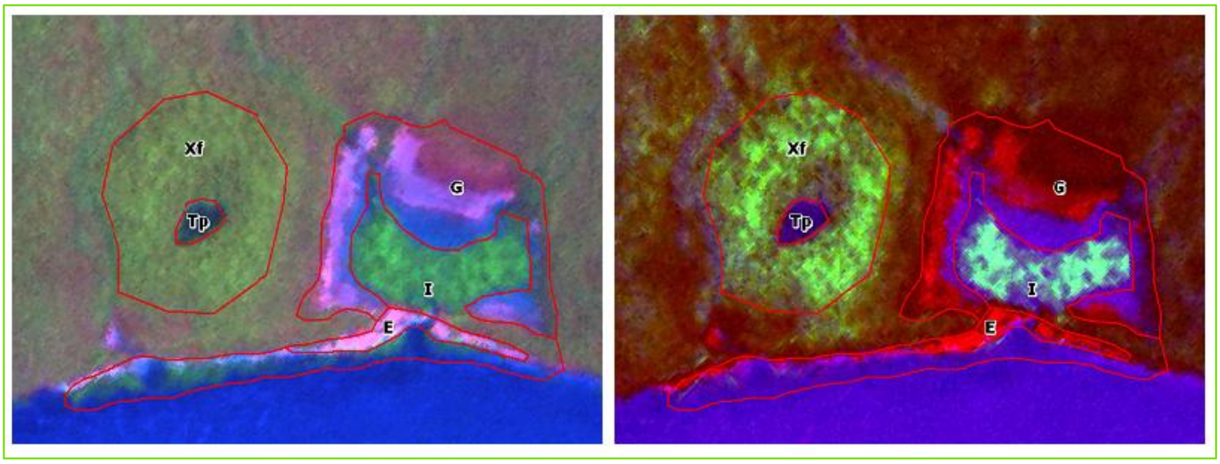


Figure 5 The Digitising Process Used to Determine Boundaries. E = Sand Shores, G = Intertidal Mud or Sand Flats, I = Intertidal Forested Wetlands, Xf = Freshwater, Tree-dominated Wetlands, Tp = Permanent Freshwater Marsh/Pool

5.1.3 Seasonal Variation in Inundation and Drying

To study the seasonal variability in the inundation of the Cobourg Peninsula Ramsar site, multi-temporal satellite images (from Geoscience Australia) were reviewed. Due to Landsat's limited return frequency, cloud cover and image distortion issues, the choice and number of images to represent a complete wet and dry season was restricted. The best available multi-temporal image set from the Landsat 5 archive was used to understand the seasonal variability in inundation (**Figure 6** and **Figure 7**).This consisted of eight images over a 12 month period from March 1992.

5.1.4 Image Enhancement and Analysis

The extent of flooding and the related fringing zone could not be mapped due to the following limitations:

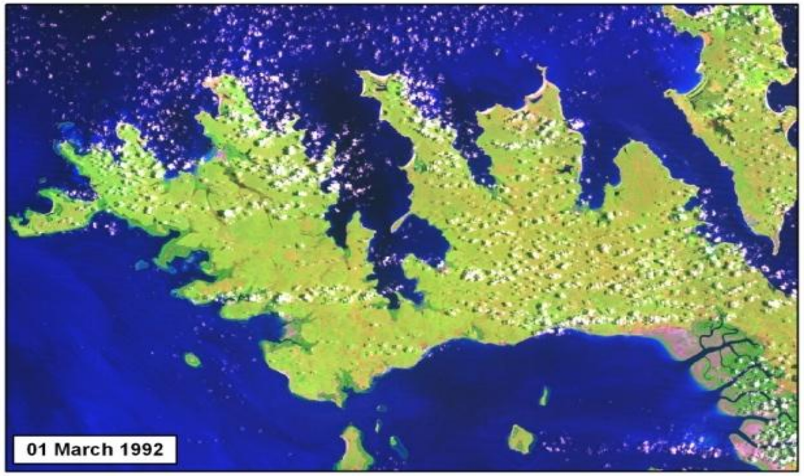
- Size of the study area and the large number of wetland systems to be analysed
- Limited spatial and temporal resolution of Landsat imagery
- Limited cloud-free imagery over a wetland system and the study area, especially after cyclones

However, the available imagery was used to analyse the change in moisture content within the wetland system, which relates the size and variability of the system to the quantity and quality of water present in the system through a wet/dry season.

To maintain consistency when comparing the mapped Ramsar wetland types from 2000 and 2002 (**Section 5.1.2**), the eight scenes were also optimized using the TC transformation. As the third component of the TC transformation related to wetness, it was used as the basis of moisture content for the Ramsar classes in each scene across the wet and dry seasons.

The wetness component contrasts the sum of the visible and near infrared bands (TM bands 1, 2, 3, and 4) with the longer infrared bands (TM bands 5 and 7) to determine the amount of moisture being held by the vegetation or soil. The longer infrared bands are the most sensitive to soil and plant moisture; therefore the contrast of visible and near-infrared bands with the longer-infrared bands highlights moisture levels within a scene.

The wetness component values were averaged for each Ramsar class across the eight scenes to return a temporal moisture signature.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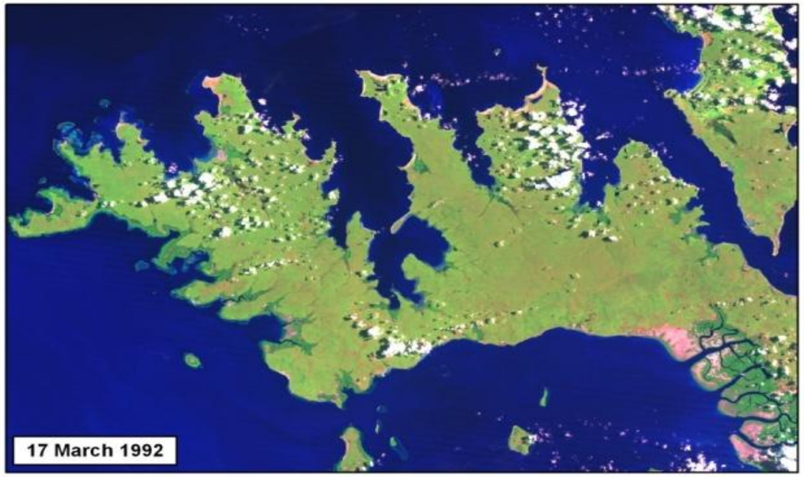

17 March 1992

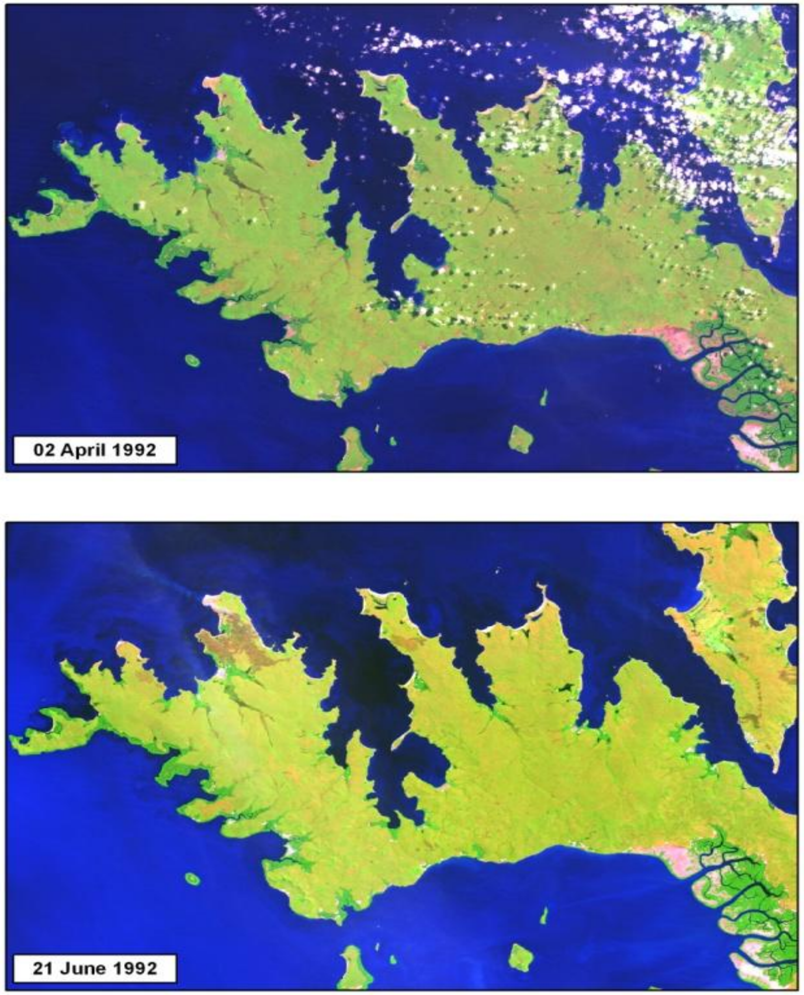
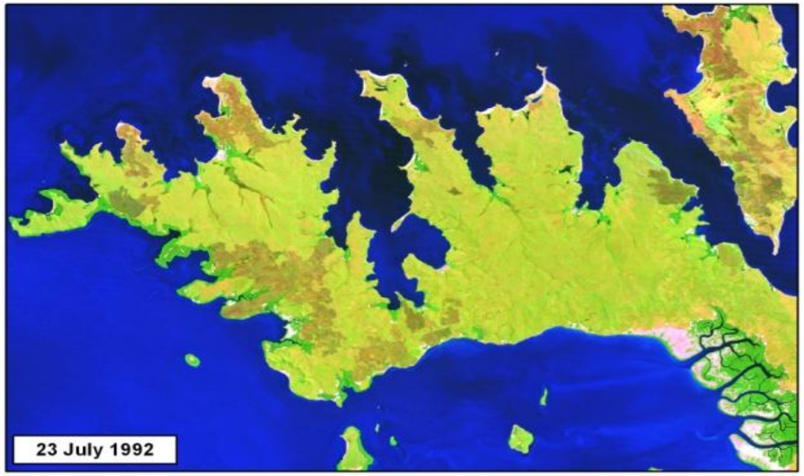
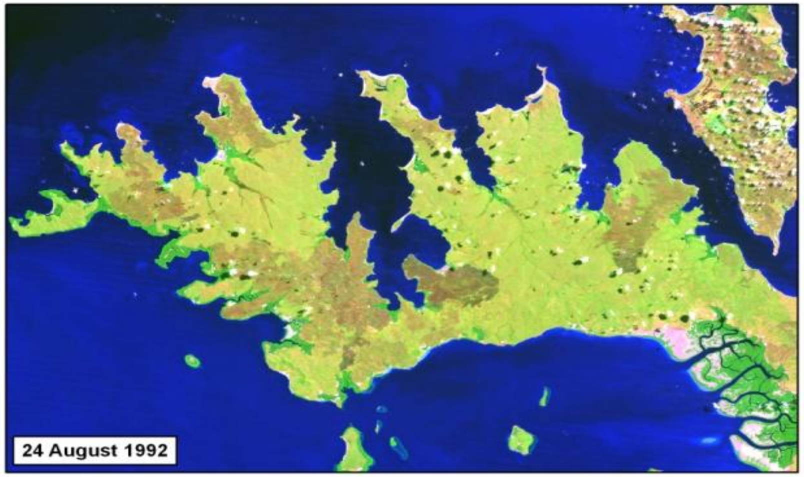


Figure 6 Landsat 5 Images Showing Seasonal Variability from March to June 1992


23 July 1992


24 August 1992

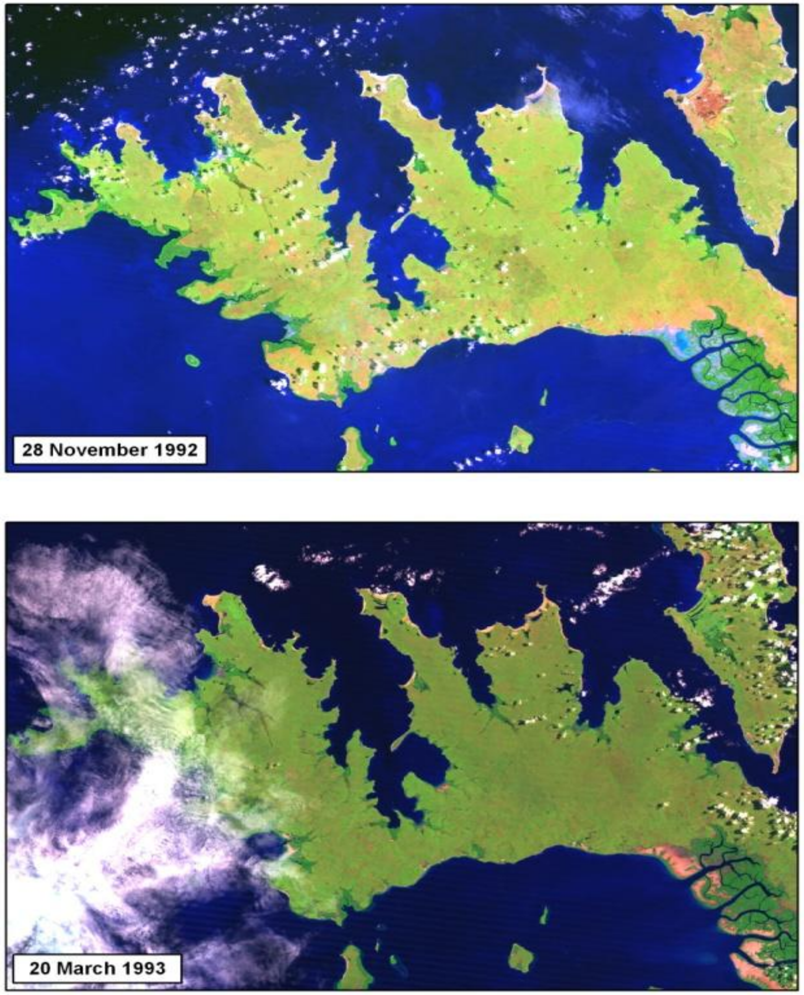


Figure 7 Landsat 5 Images Showing Seasonal Variability from July 1992 to March 1993

5.2 Results

5.2.1 1974 Wetland Distribution (Year of Designation)

The Cobourg Peninsula was designated a Ramsar site on 8 May 1974. The limited spatial and spectral resolution of the historical scenes restricted the number and extent of identifiable Ramsar classes across the Cobourg Peninsula. Seven Ramsar wetland types have been identified from 1973 mapping (**Table 4**, **Figure 8**).

Vegetation mapping produced in the 1974 RIS/nomination contained 5 wetland associated vegetation types (beach dunes, estuaries, mangroves, monsoon forest and forest with intermittent sedges); four of which are broadly similar in distribution and extent to that which we mapped from 1973. The fifth, monsoon forests, which are often associated with springs, have been mapped in the 1974 RIS/nomination in areas where we have mapped mangroves. Whilst we have not mapped any monsoon forest across the peninsula, we have mapped freshwater spring locations and seasonal creeks.

The 7 wetland types that we mapped from 1973 are all present in current mapping. These are the most obvious (i.e. larger) wetland types and the ones distinguishable in the imagery. These are also mostly marine/coastal wetlands. When overlaying the 1973 mapping with current mapping, the wetland extent is broadly similar. In many systems, the majority of the distribution of mangroves, intertidal mudflats, estuaries and beaches are similar. However, there appears to be some small-scale changes in the extent of marshes versus mangroves (i.e. where mangroves existed in 1973, marshes now exist and vice versa; for example in the southern end of Port Bremer). Where more complex wetland systems exist that contain several small wetlands, it is difficult to delineate individual wetlands from 1973 mapping.

Any potential change in distribution of inland wetlands in 1973 to current is not easily identifiable. In fact, only one inland wetland was identifiable from 1973 mapping (melaleuca wetlands). All others are simply not distinguishable. The 1973 Landsat mapping does not show enough detail to distinguish seasonal creeks, for example, from the surrounding topography.

Table 4 1973 Ramsar Wetland Types

Ramsar Wetland Type	Total Area (hectares)
A - Permanent shallow marine waters	12,086
E - Sand	4,431
F - Estuarine waters	3,194
G - Intertidal mud or salt flats	4,377
H - Intertidal marshes	1,869
I - Intertidal forested wetlands	26,593
J - Coastal brackish/saline lagoons	842
Xf - Freshwater tree-dominated wetlands	110

Figure 8 Historical (1973) Wetland Distribution in the Cobourg Peninsula Ramsar Site

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5.2.2 2010 Wetland Distribution

The Ramsar site is composed of a diversity of marine/coastal and inland wetland types (**Table 5, Figure 9**).

5.2.2.1 Marine/Coastal Wetlands

Table 5 Marine/Coastal Wetland Types and Representative Examples within the Ramsar Site

Ramsar Wetland Type	Representative Example	Number of Areas	Total Area (hectares)
A – Permanent shallow marine waters in most cases less than six metres deep at low tide; includes sea bays and straits.	Absent – site boundaries do not include subtidal areas.	-	-
B – Marine subtidal aquatic beds; includes kelp beds, sea-grass beds and tropical marine meadows.	Present – few sea grass communities exist along the northern coastline, including Blue Mud Bay and south of Cape Don.	2 (not confirmed)	Not calculated
C – Coral reefs.	Present – several coral communities exist on the northern coastline, including Sandy Island No. 1, Sandy Island No. 2 and Popham Creek.	4	Not calculated
D – Rocky marine shores; includes rocky offshore island, sea cliffs.	Present – predominantly found in Port Essington, rocky cliffs also exist in several locations along the southern coastline. Shoreline length approximately 36.5 km.	26	36.5 km*
E – Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.	Present – occurs in extensive areas mostly along the northern coastline.	49	2,070
F – Estuarine waters; permanent water of estuaries and estuarine systems of deltas.	Present – tidal sections of numerous large creeks.	20	7,592
G – Intertidal mud, sand or salt flats.	Present – occurs along the entire coastline. Extensive areas exist in the south east.	171	6,212
H – Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.	Present – occurs predominantly with intertidal forested wetlands (e.g. Shamrock Bay, Caiman Creek)	77	2,734
I – Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.	Present – extensive areas along the west coastline and south east (e.g. Ilamaryi River system)	112	26,207
J – Coastal brackish/saline lagoons; brackish to saline lagoons with at least one relatively narrow connection to the sea.	Present – scattered along the north coastline (e.g. Trepang Bay, Raffles Bay).	28	1,314
K – Coastal freshwater lagoons; includes freshwater delta lagoons.	Present – four recorded on the site including Mariah Lagoon and Spear Point.	4	254

Ramsar Wetland Type	Representative Example	Number of Areas	Total Area (hectares)
Zk (a) – Karst and other subterranean hydrological systems, marine/coastal.	Absent	-	-
Total marine/coastal wetland types	**10**	**491**	**46,383****

* This wetland type is linear and has been calculated in total length.
** The total area is an underestimate because the area of some wetland types that exist in the Ramsar site were not calculated.

Figure 9 Wetland Types in the Cobourg Peninsula Ramsar Site (Subset 1)

Figure 10 Wetland Types in the Cobourg Peninsula Ramsar Site (Subset 2)

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5.2.2.1.1 Marine Subtidal Aquatic Beds (Wetland Type B)

Representative Sites: none visited

Marine subtidal aquatic beds are represented within the site by at least one intertidal seagrass community. This wetland type is not included on wetland mapping conducted for this study as sites could not be confirmed. Consultation with local Indigenous residents and the NT Department of Natural Resources, Environment, the Arts and Sports (NRETAS) suggests that Blue Mud Bay (GDA94, Zone 53, E0158573, N8758316) contains seagrass. This area is a common hunting ground for Dugong and marine turtles (pers. comm. P. Fitzgerald). Dugong are also hunted on the southern side of Cape Don (PWCNT, 1995), which would suggest seagrass communities occur here also.

5.2.2.1.2 Coral Reefs (Wetland Type C)

Representative Sites: M3 (Kuper Point), M10 (Sandy Island No. 2), M14 (Sandy Island No. 1)

At least four coral reefs/communities exist in the Ramsar site, including at Kuper Point, Popham Creek, Sandy Island No. 1 and Sandy Island No. 2. Kuper Point is located on a rocky headland where corals have established. Popham Creek is a tidal channel system containing four coral communities (PWCNT, 1995). Both coral reef sites at Sandy Island No. 1 and Sandy Island No. 2 are located on exposed coastlines. Sandy Island No. 2 forms part of a coral fringed sand island. Gomelyuk (2008) identifies another coral reef within Port Essington and it is likely that numerous others exist within the site.

Figure 11 Coral Community (Site M3 (Kuper Point), October 2010) © Copyright, Robin Bir

5.2.2.1.3 Rocky Marine Shore (Wetland Type D)

Representative Sites: M8 (Observation Cliff), M12 (Smith Point)

Rocky marine shores are characterised mainly by rocky cliffs and rocky shores (**Figure 12**). Approximately 36.5 km of rocky shorelines are present in the Ramsar site, mostly in Port Essington and along the western coast of Cobourg Peninsula (**Figure 9**).

Figure 12 Rocky Marine Shore (Site M8 (Observation Cliff), July 2010) © Copyright, Will Riddell

5.2.2.1.4 Sand Shores (Wetland Type E)

Representative Sites: M9 (Observation Point), M11 (Sandy Island No. 2), M13 (Sandy Island No. 1)

This wetland type includes sandy islets, dune systems and humid dune slacks. The most common type of sand shore found along the mainland parts of the Ramsar site is an open coastline dune system (**Figure 13**). Islands to the north (e.g. Sandy Island No.1 and Sandy Island No. 2) also contain sand shores. Floral species common to this wetland type include *Casuarina equisetifolia* (Beach She-oak) and *Ipomoea pes-caprae* (Goat's Foot).

Offshore islands (such as Sandy Island No. 1 and Sandy Island No. 2) host important colonial breeding sites for relatively large numbers of nesting Terns, particularly Black-naped and Roseate Terns (Chatto, 2001). Crested Terns have been recorded in significant numbers (several thousand) on Sandy Island No. 2 (Frith and Calaby, 1974). Chatto (2001) reports Warla Island as the only island off the southern coast of the Ramsar site to contain Black-naped and Roseate Terns breeding colonies.

Figure 13 Sand Shore (Site M9 (Observation Point), July 2010) © Copyright, Will Riddell

5.2.2.1.5 Estuarine Waters (Wetland Type F)

Representative Sites: M1 (East Bay), M15 (Knocker Bay), M17

Estuaries are represented with the Ramsar site in several extensive areas, including in the south east (the Ilamaryi Creek system) and south west (Aiton Bay) (**Figure 9**). *Rhizophora stylosa* (Red Mangrove) is abundant at this wetland type, located along the coastline in the intertidal zone. A total of 20 estuaries were mapped, covering approximately 7,500 hectares (**Table 5**).

Figure 14 Estuarine Waters (Site M1 (East Bay), July 2010) © Copyright, Will Riddell

5.2.2.1.6 Intertidal Mudflats (Wetland Type G)

Representative Sites: M4 (Barrow Bay), M16

Intertidal mudflats are comprised of deposited mud or sand within the intertidal zone (**Figure 15**). They are submerged and exposed approximately twice a day. They occur in most of the estuarine systems throughout the Ramsar site, often interdispersed with mangroves, such as *Rhizophora stylosa* (Red Mangrove), *Avicennia marina* (Grey Mangrove) and *Sonneratia alba* (White Mangrove) (**Figure 9**). Over 6,000 hectares of intertidal mud, sand or salt flats were mapped within the Ramsar site. A large proportion of this is found in the Ilamaryi River in the south east of the Ramsar site.

Intertidal mudflats observed in the Ramsar site are generally devoid of flora. On an outgoing tide, organic debris (e.g. leaf litter) from estuaries provides food for bacteria. Small invertebrates such as worms, crustaceans and molluscs feed on this bacteria and detritus (decaying plant and animal matter). In turn, these animals are an important food source for fish and birds, especially seabirds (e.g. terns) and shorebirds (e.g. knots and curlews). Waterbirds such as Great, Eastern Reef and Little Egrets, Great-billed Heron, Common Terns, Little Terns and Black-necked Storks and raptors such as Whistling Kites, Brahminy Kites and Ospreys are regularly observed.

Figure 15 Intertidal Mudflat (Site M4 (Barrow Bay), July 2010) © Copyright, Will Riddell

5.2.2.1.7 Intertidal Marshes (Wetland Type H)

Representative Sites: None visited

Intertidal marshes cover an area of approximately 2,700 hectares in the Ramsar site according to wetland mapping conducted for this study. They generally inhabit sheltered intertidal mud or salt flats and fringe the lower and mid estuarine sections of channels, often interdispersed with mangroves (**Figure 9**). There are typically few flora species that occur in intertidal marshes in northern Australia (Russell-Smith 1995). Species include the succulent shrubs *Tecticornia indica* (Shrubby Samphire), *T. australasica* (Grey Samphire) and *Sesuvium portulacastrum* (Shoreline Purslane).

5.2.2.1.8 Intertidal Forested Wetland (Wetland Type I)

Representative Sites: M2 (East Bay), M5 (Barrow Bay), M18 (Popham Creek)

Intertidal forested wetlands are represented by mangrove communities within the Ramsar site (**Figure 16**). Wetland mapping for this study indicates that over 26,000 hectares of mangroves occur in the Ramsar site (**Table 5**). They occur in sheltered areas along much of the southern coastline and tidal areas of nearly all estuarine systems. There are also isolated pockets in small bays (e.g. Knocker Bay). This represents approximately 6.5% of the entire 400,000 hectares of mangroves found along the Northern Territory coastline (NTG, 2002). An extensive area of mangroves occurs around Ilamaryi Creek in the south east of the Ramsar site. This area is among the most important in Australia for Radjah Shelduck nesting (Chatto, 2006).

Studies by Wightman (1989) have indicated that there are 48 flora species that regularly occur in NT mangrove communities. Common species found in mangrove communities in the Ramsar site include *Sonneratia alba* (White Mangrove), *Rhizophora stylosa* (Red Mangrove), *Avicennia marina* (Grey Mangrove), *Bruguiera exaristata* (Orange Mangrove) and *Aegialitis annulata* (Club Mangrove).

Mangrove communities are highly productive and used by a wide range of marine and terrestrial fauna for breeding, roosting and foraging. Those commonly found include molluscs, crustaceans, fish, crocodiles, insects, snakes, frogs, mammals (e.g. possums and flying foxes) and birds. In Darwin Harbour, 128 bird species have been recorded (Dames and Moore, 1988). Fish use mangroves during high tide. The dense root structures provide ideal nursery and spawning habitat.

Mangroves also protect the coastline from erosion and storm surge (NTG, 2002).

Figure 16 Intertidal Forested Wetland (Site M18 (Popham Creek), October 2010) © Copyright, Robin Bir

5.2.2.1.9 Coastal Brackish/Saline Lagoon (Wetland Type J)

Representative Sites: M6 (Barrow Bay), M7 (Gul Gul), M19 (Araru Point)

Coastal brackish/saline lagoons are linked to the sea by at least one relatively narrow connection and separated by a barrier sand dune (**Figure 17**). Twenty-eight of these lagoons have been mapped as part of this study (**Table 5**). All occur along the northern coastline of the Ramsar site (**Figure 9**).

Plants commonly found fringing the lagoons include the trees *Thespesia populnea*, *Acrostichum speciosum* (Mangrove Fern), *Lumnitzera littorea* (Black Mangrove), *Fimbristylis ferruginea*, the sedge *Schoenoplectus litoralis*, and the herb *Utricularia chrysantha* (Sun Bladderwort).

Fauna species commonly found in coastal brackish/saline lagoons include raptors (e.g. Whistling Kite, Osprey, and White-bellied Sea-eagle) and numerous seabirds and shore birds, including Brolgas, Red-capped Plovers and Lesser Sand Plovers.

Figure 17 Coastal Saline Lagoon (Site M19 (Araru Point), October 2010) © Copyright, Mihkel Proos

5.2.2.1.10 Coastal Freshwater Lagoons (Wetland Type K)

Representative Sites: M20 (Mariah Swamp)

This wetland type is uncommon within the Ramsar site. Only one site was located (Mariah Swamp). This lake is located in relatively close proximity to the coast. The majority of the lake is dominated by Bulkuru Sedge (*Eleocharis dulcis*). The margins have extensive forests dominated by *Melaleuca* sp. in the north and west and little (i.e. often less than 10 m wide) or no riparian areas in the south. At least three freshwater springs feed into the wetland from the west, while mangrove presence in the east indicates tidal influence.

Wetland dependent fauna is characterised by a wide range of birds and reptiles, including abundant waterbirds such as Egrets, Ducks, Magpie Geese, Cormorants and Jacanas. Fauna typically found in the riparian areas include Rainbow Bee-eaters, Forest Kingfishers and Lemon-bellied Flycatchers.

Figure 18 Coastal Freshwater Lagoon (Site M20 (Mariah Swamp), October 2010) © Copyright, Robin Bir

5.2.2.2 Inland Wetlands

The Ramsar site has a diversity of inland wetland types (**Table 6, Figure 9**). The following sections contain a general description of sites within each inland wetland type.

Table 6 Inland Wetland Types and Representative Examples within the Cobourg Peninsula Ramsar Site

Ramsar Wetland Type	Representative Examples	Number of Areas	Total Area (ha)
L – Permanent inland deltas.	Absent	-	-
M – Permanent rivers/streams/creeks; includes waterfalls.	Absent	-	-
N – Seasonal/intermittent/irregular rivers/streams/creeks.	Present – Widespread in upper reaches of all catchments	111	7,776
O – Permanent freshwater lakes (over 8 ha); includes large oxbow lakes.	Absent	-	-
P – Seasonal/intermittent freshwater lakes (over 8 ha); includes floodplain lakes.	Present – Several sites exist mainly within the Smith Point and Wanaraij Point areas.	14	359
Q – Permanent saline/brackish/alkaline lakes.	Present – Relatively uncommon, represented inland from Smith Point.	8	578
R – Seasonal/intermittent saline/brackish/alkaline lakes and flats.	Present – Uncommon on the site, represented inland from Knocker Bay and Raffles Bay.	7	169
Sp – Permanent saline/brackish/alkaline marshes/pools.	Present – Uncommon on the site, represented inland from Trepang Bay, Minto Head and the far east.	5	44
Ss – Seasonal/intermittent saline/brackish/alkaline marshes/pools.	Present – Uncommon on the site, represented inland from Kennedy Bay and Popham Bay.	5	25
Tp – Permanent freshwater marshes/pools; ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least of the growing season.	Present – Uncommon on the site, represented inland from Trepang Bay, Coral Bay and Raffles Bay.	11	79
Ts – Seasonal/intermittent freshwater marshes/pools on inorganic soils; includes sloughs, potholes, seasonally flooded meadows and sedge marshes.	Present	17	110
U – Non-forested peatlands; includes shrub or open bogs, swamps and fens.	Absent	-	-
Va – Alpine wetlands; includes alpine meadows, temporary waters from snowmelt.	Absent	-	-
Vt – Tundra wetlands; includes tundra pools, temporary water from snowmelt.	Absent	-	-

Ramsar Wetland Type	Representative Examples	Number of Areas	Total Area (ha)
W – Shrub-dominated wetlands; shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.	Absent	-	-
Xf – Freshwater, tree-dominated wetlands; includes freshwater swamps, seasonally flooded forests, wooded swamps on inorganic soils.	Present – several relatively extensive areas exist including inland from Trepang Bay, Reef Point and the far east coastline.	16	770
Xp – Forested peatlands; peatswamp forests.	Absent	-	-
Y – Freshwater springs; oases.	Present – occurs at the upper reaches of several catchments e.g. Ferny Springs, Wolf Claw Springs.	22	302
Zg – Geothermal wetlands.	Absent	-	-
Zk (b) – Karst and other subterranean hydrological systems, inland.	Absent	-	-
Total	**10**	**216**	**10,212***

* The total area is an underestimate because the area of some wetland types that exist in the Ramsar site were not calculated.

5.2.2.2.1 Seasonal Creeks (Wetland Type N)

Representative Sites: I3 (Irgul Road), I13 (East Bay)

This wetland type is typically lined with riparian vegetation communities though the extent and structure of these may vary significantly according to the type of system and the influence of seasonality. Common riparian flora includes Weeping Tea Tree (*Leptospermum longifolium*), Broad-leaf Paperbark (*Melaleuca leucadendra*), Grey Bloodwood (*Corymbia porrecta*) and Spiral Pandanus (*Pandanus spiralis*) (**Figure 19**).

Figure 19 Seasonal Creek (Site I3 (Irgul Road), October 2010) © Copyright, Robin Bir

5.2.2.2.2 Permanent Brackish/Saline Lakes (Wetland Type Q)

Representative Sites: I2 (Campsite No. 2 Billabong)

This wetland type is uncommon within the Ramsar site. Patches of dead mature Broad-leaf Paperbarks (*Melaleuca leucadendra*) and juvenile Red-flowering Black Mangroves (*Lumnitzera littorea*) suggests that this lake contained freshwater until relatively recently (see **Section 7.2** for further discussion).

Dominant aquatic emerging vegetation includes *Eleocharis* sp. though large areas of open water exist. Dominant riparian flora includes Broad-leaf Paperbark (*M. leucadendra*) and Red-flowering Black Mangrove (*L. littorea*).

Wetland dependent fauna is characterised by a wide range of birds and reptiles, including abundant waterbirds such as Egrets, Ducks, Magpie Geese, Cormorants and Jacanas. Fauna typically found in the riparian areas include Rainbow Bee-eaters, Forest Kingfishers and Lemon-bellied Flycatchers. Saltwater Crocodiles (*Crocodylus porosus*) were observed. Evidence of Feral Pigs (diggings) and Banteng (tracks) was prevalent.

Figure 20 Permanent Saline/Brackish Lake (Site I2 (Campsite No. 2 Billabong), October 2010) © Copyright, Robin Bir

5.2.2.2.3 Seasonal Brackish/Saline Lakes (Wetland Type R)

Representative Sites: I1 (Wuwurdi Swamp)

This wetland type was observed at a single site (Wuwurdi Swamp; **Figure 21**). The amount of water present in the swamp and the period over which it remains wet is likely dependent on seasonal factors. The swamp is known to fill with freshwater runoff during the wet season and is likely to have limited groundwater inflow (since it periodically dries).

Dominant aquatic emerging vegetation includes *Eleocharis* sp. though areas of open water exist. Dominant riparian flora includes Broad-leaf Paperbark (*Melaleuca leucadendra*).

Wetland dependent fauna is characterised by a wide range of birds, reptiles and frogs, including abundant waterbirds such as Egrets, Ducks, Magpie Geese, Cormorants and Jacanas. Fauna typically found in the riparian areas include Bar-breasted Honeyeaters, Rainbow Bee-eaters, Forest Kingfishers and Lemon-bellied Flycatchers. Evidence of Feral Pigs (diggings) and Banteng (tracks) was prevalent.

Figure 21 Seasonal Brackish/Saline Lake (Site I1 (Wuwurdi Swamp), July 2010) © Copyright, Greg Calvert

5.2.2.2.4 Seasonal Brackish/Saline Pools (Wetland Type Ss)

Representative Sites: I12 (Araru Point)

This wetland type was located at Araru Point in close proximity to the coast (**Figure 22**). Wetland mapping across the Ramsar site identified four other seasonal brackish/saline pools, mostly inland from Kennedy Bay and Popham Bay (**Figure 9**). The amount of water present in the pool and the period over which it remains wet is likely dependent on seasonal factors. Historic aerial photos show the pool containing no water during the late dry season. Emerging freshwater-dependent vegetation at one end of the pool suggests that the pool may have some groundwater inflow.

Very little emergent aquatic vegetation existed throughout the majority of the pool. The benthic layer was covered by algae. Values of the habitat in and around the pool for wetland dependent vertebrate fauna was limited, though dense grass covered banks may provide good shelter and foraging habitat for reptiles and small birds. Fauna observed included White-breasted Woodswallows and a Whistling Kite. Whilst no feral animals were observed in the immediate vicinity, Banteng were observed in similar habitats within a kilometre of the pool and it is likely that they utilise this pool.

Figure 22 Seasonal Brackish/Saline Pool (Site I12 (Araru Point), October 2010) © Copyright, Mihkel Proos

5.2.2.2.5 Permanent Freshwater Pools (Wetland Type Tp)

Representative Sites: I10 (Coral Bay)

This wetland type includes ponds less than eight hectares in area, as well as marshes and swamps on inorganic soils with emergent vegetation that is waterlogged for at least most of the growing season. Within the Ramsar site, this wetland type is relatively uncommon and represented by 11 sites with a total area of approximately 79 hectares. Parts of the wetlands are commonly dominated by grass or sedges (**Figure 23**).

Representative sites occur inland from Trepang and Coral Bays and to the north west of Raffles Bay (north of Mariah Swamp). At the latter, a series of freshwater systems occur, including permanent freshwater pools (**Figure 9**). Wetland types surrounding or adjoining this site include freshwater tree-dominated wetlands (type Xf) and seasonal freshwater marshes/pools (type Ts). Permanent freshwater pools regularly adjoin these wetland types.

Permanent freshwater pools provide important dry season refuge for many species of wetland dependent flora and fauna. They are often fringed with *Melaleuca*, *Barringtonia*, *Livistona* and *Pandanus* tree species (Cowie et al., 2000).

Figure 23 Permanent Freshwater Pool (Site I10 (Coral Bay), October 2010) © Copyright, Will Riddell

5.2.2.2.6 Seasonal Freshwater Marshes/Pools (Wetland Type Ts)

Representative Sites: I5 (Ingrid's Waterhole)

This wetland type comprises seasonal/intermittent freshwater marshes and pools on inorganic soils and includes seasonally flooded meadows and sedge marshes. According to mapping undertaken for this study, it occurs in 17 relatively small, isolated and scattered locations across mainly inland from the northern coastline (**Figure 9**), covering a total area of approximately 110 hectares (**Table 6**).

Fluctuations of the tropical wet-dry climate are very evident in seasonal wetlands such as seasonal freshwater marshes/pools where there is a regular flooding and drying cycle. Seasonal freshwater marshes/pools are typically dominated by herbaceous vegetation that has adapted to cope with seasonal drying of the pools including grasses such as *Dichanthium sericeum*, *Elytrophorus spicatus* and *Ophiuros exaltatus* (Cowie et al., 2000). The seasonal pools also play an important role in key phases of life cycles of wetland dependent flora and fauna.

Fauna observed in fringing riparian vegetation included Rufous-throated Honeyeaters, Lemon-bellied Flycatchers and Whistling Kites. Site I5 exhibited widespread damage by feral animals, mostly Feral Pigs.

5.2.2.2.7 Freshwater, Tree-dominated Wetlands (Wetland Type Xf)

Representative Sites: I4 (Danger Point), I8 (Friarbird Swamp)

This wetland type is composed of freshwater, tree-dominated wetlands including freshwater swamp forests, seasonally flooded forests and wooded swamps on inorganic soils (**Figure 24**). A total of 16 of these wetlands have been identified according to mapping undertaken for this study, covering an area of approximately 770 hectares (**Table 6**, **Figure 9**). Extensive areas of *Melaleuca* swamp forest occur inland from Trepang Bay, Reef Point and Irgul Point. Wetlands of this type are expected to become at least partially inundated each wet season.

Dominant flora species found in these swamp forests include the trees *Melaleuca leucadendra* (White Paperbark) and *Melaleuca viridiflora* (Broad-leafed Paperbark), the herbs *Eriocaelon cinereum, Dentella dioeca* and *Ammannia multiflora*, and the grasses *Cyperus aquatilis* and *Pseudoraphis spinescens*. Fauna observed included Varied Sittella, Forest Kingfisher, Northern Fantail, Lemon-bellied Flycatcher and Varied Triller. There was significant damage from feral animals, including Banteng and Feral Pigs, which included loss of almost all emergent vegetation (*Eleocharis* sp.).

Figure 24 Freshwater, Tree-dominated Wetland (Site I4 (Danger Point), July 2010)
© Copyright, Dave Wilson

5.2.2.2.8 Freshwater Springs (Wetland Type Y)

Representative Sites: I6 (Ferny Springs), I7 (Wolf Claw Spring), I11

Twenty-two freshwater springs are identified from wetland mapping as part of this study (**Table 6**, **Figure 9**). Most of these freshwater springs support dense wetland vegetation including riparian or monsoon rainforest communities dominated by species of *Melaleuca*, *Hydristele* and *Pandanus spiralis* (**Figure 25**, **Figure 26**). Fauna commonly observed included Varied and Red-collared Lorikeets, Yellow Oriole, Brush Cuckoo and Pheasant Coucal. No evidence of feral animals was observed within the waters of the springs though Banteng and Feral Pigs were regularly observed on the margins of the monsoon rainforests and the woodland.

Figure 25 Freshwater Spring (Site I6 (Ferny Springs), October 2010) © Copyright, Robin Bir

Figure 26 Freshwater Spring (Site I7 (Wolfs Claw Spring), July 2010) © Copyright, Dave Wilson

5.2.3 Seasonal Variation in Relative Moisture of Wetlands

5.2.3.1 Tidal Influence

As the inundation cycle is influenced by tides, the hourly sea levels for Darwin were obtained from the Bureau of Meteorology's Australian Baseline Sea Level Monitoring Project (ABSLMP) (BoM, 2010a). Due to Landsat's fixed return frequency, all images were captured at 1000 hours (approximately). By using the offsets for Two Hills Bay (plus 84 minutes), Cape Don (minus 23 minutes) and Port Essington (minus 102 minutes) it was evident that all but the August scene were captured at either sides of a high tide. Whilst the August scene should have been excluded, the limited date range and the broad averaging of the analysis warranted the inclusion of the August scene in the analysis (**Figure 27**).

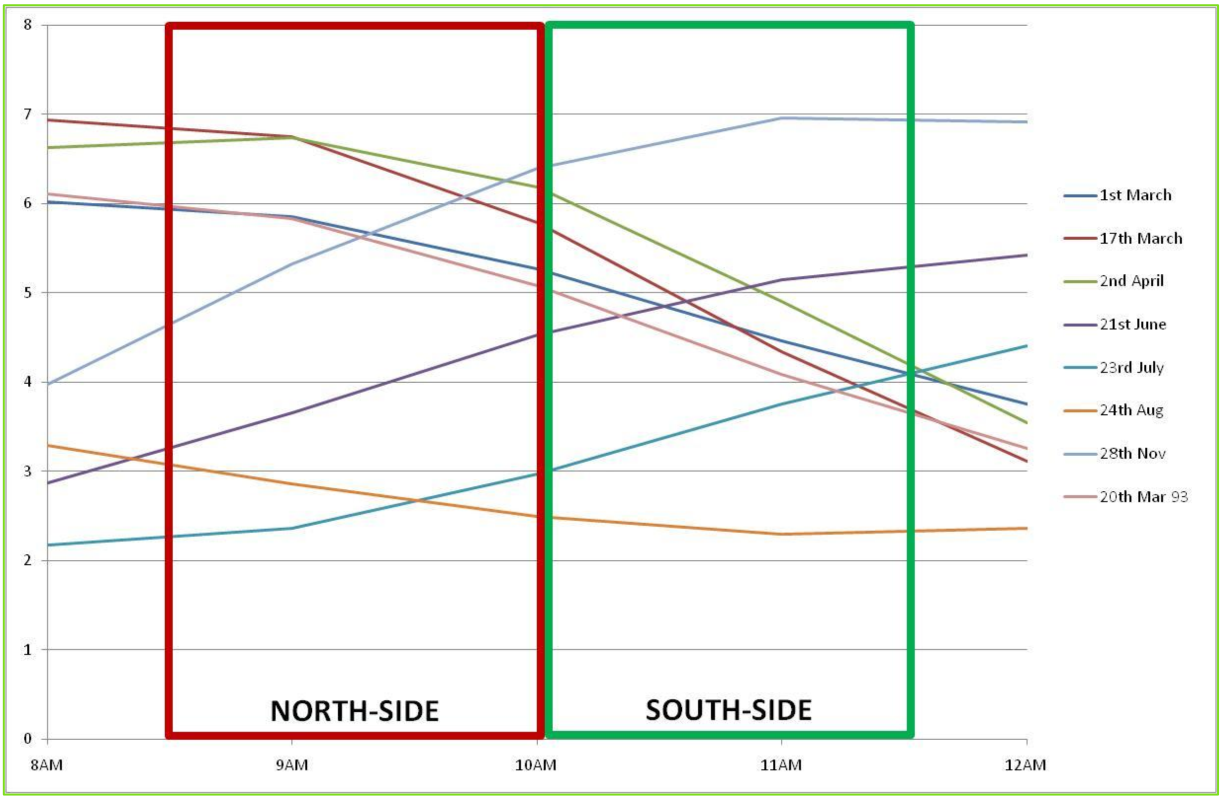

Figure 27 The Inundation Cycle at 1000 hours from the North and South Sides of the Ramsar Site

5.2.3.2 Seasonal Variation in Relative Moisture

The values for this component were averaged to return a temporal moisture signature (**Figure 28**, **Figure 29**). Interpretation of these signatures is given in **Table 7**. To simplify the analysis and interpretation of the different Ramsar classes, they have been split into marine/coastal and inland systems.

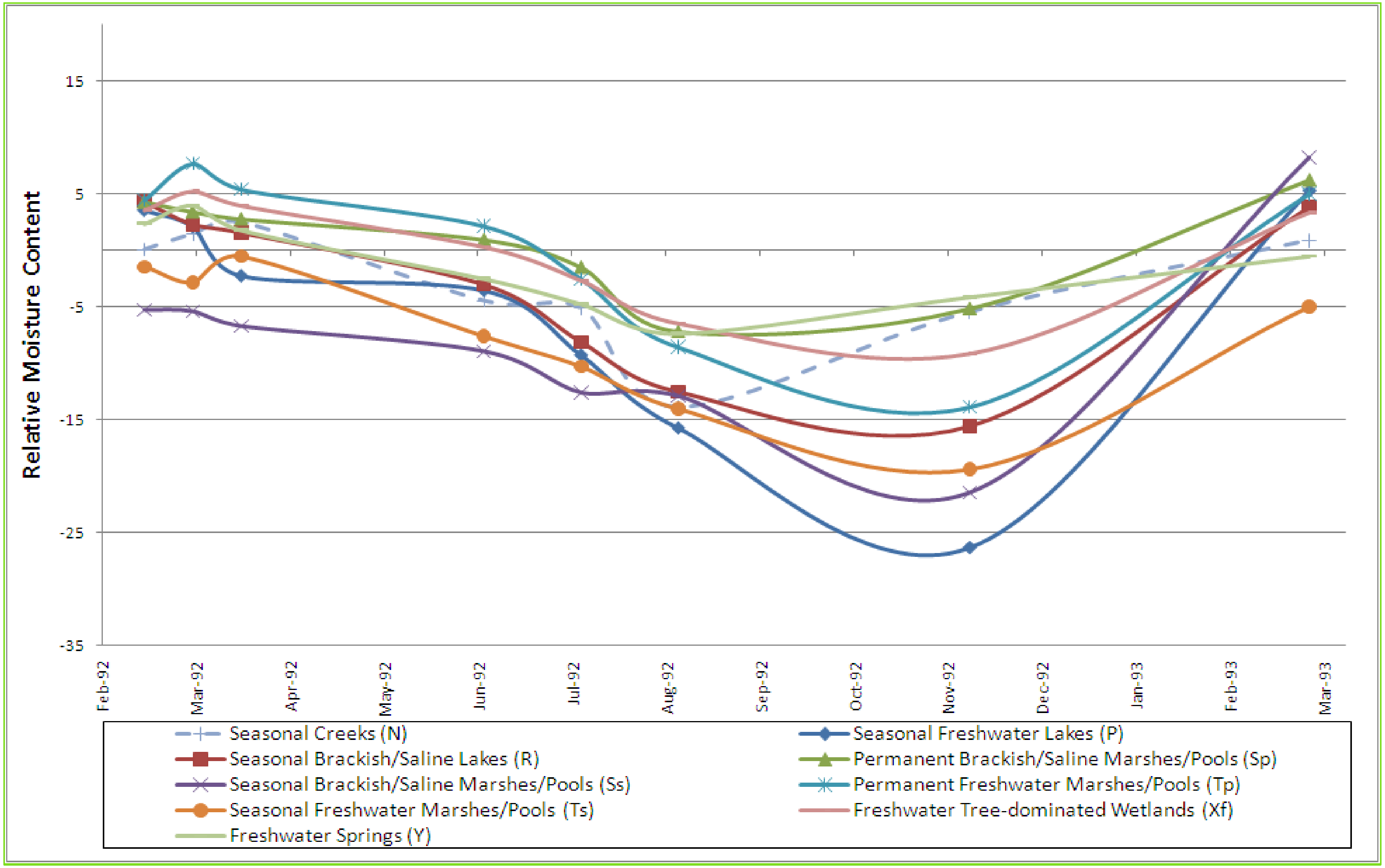

Figure 28 Seasonal Variation in Relative Moisture Content of Marine/Coastal Wetlands

Figure 29 Seasonal Variation in Relative Moisture Content of Inland Wetlands

Table 7 Description of Seasonal Variation in Relative Moisture of Wetlands within the Ramsar Site

Wetland Type	Code	Description of Seasonal Variation in Relative Moisture
Marine/Coastal Wetlands (Figure 28)		
Sand Shores	E	Sand shores present a low moisture profile. Generally, moisture content of beaches and dunes decrease in a landward direction (OzCoasts, 2010). Changes in average seasonal moisture content in the sand shores are likely influenced by rainfall and run-off.
Intertidal Mud or Sand Flats	G	Intertidal mud or sand flats contain high seasonal variation in moisture content. They recharge early in the dry season due to the proximity to rivers and mangroves.
Intertidal Marshes	H	Intertidal marshes show a similar pattern to mangroves as they are typically located between mangroves and land. A plateau in moisture content during the late wet season indicates steady presence of water.
Intertidal Forested Wetlands (Mangroves)	I	Mangroves do not show much variation in moisture content between wet and dry seasons. They are the first wetland type to show recharge after the wet season, most likely due to rivers feeding water from springs. Also, tidal influence minimizes any significant loss.
Coastal Brackish/Saline Lagoons	J	Coastal brackish/saline lagoons within the Ramsar site have relatively narrow connections to the sea. As such, tidal influence is less evident and recharge from rivers causes them to maintain a high signature.
Coastal Freshwater Lagoons	K	Coastal freshwater lagoons show a plateau effect during the late wet season indicating steady inflows of water. During the dry season, they are dependent on streams for maintaining moisture content. They do not show rapid loss during the dry season, possibly due to recharge from creeks.
Inland Wetlands (Figure 29)		
Seasonal/Intermittent Creeks	N	Seasonal creeks maintain moisture content into the dry season for a longer period than most other wetland types. While the drop in moisture content is not as pronounced as the other systems, they appear to recover earlier than the other systems, implying recharge from springs and aquifers.
Seasonal Freshwater Lakes	P	Seasonal freshwater lakes are able to collect more water during the wet season (and hence avoid run-off). Their open structure causes them to lose most of it during the dry season.
Permanent Brackish/Saline Lakes	Q	Permanent saline lakes have an almost identical signature to seasonal saline lake.
Seasonal Brackish/Saline Lakes	R	Seasonal saline lakes show less moisture loss than freshwater lakes due to tidal influence.
Permanent Brackish/Saline Marshes/Pools	Sp	Permanent brackish/saline pools are commonly observed at the landward side of mangrove systems. The reduction in water content is likely to be dependent on the size of the associated mangrove system.
Seasonal Brackish/Saline Marshes Pools	Ss	Seasonal brackish/saline pools are commonly observed at the landward side of mangrove systems though periodically dry out during the late dry season.
Permanent Freshwater Marshes/Pools	Tp	Permanent freshwater marshes/pools have a higher water signature during the dry season than lakes which may be attributed to their smaller size and associated vegetation.
Seasonal Freshwater Marshes/Pools	Ts	Seasonal freshwater marshes/pools have a higher water signature during the dry season than seasonal lakes which may be attributed to their smaller size and associated vegetation.
Freshwater, Tree-	Xf	Freshwater, tree-dominated wetlands show a plateau effect during the wet

Wetland Type	Code	Description of Seasonal Variation in Relative Moisture
dominated Wetlands		season but do not show rapid loss during the dry season, possibly due to recharge from rivers and creeks.
Freshwater Springs	Y	Freshwater springs show the least reduction in the dry season.

5.2.3.3 Understanding Seasonal Variability within Inland Wetland Types

While the wetland profiles in **Figure 28** and **Figure 29** show the separation between the different wetland types, they do not completely explain the seasonal variability that is expected in inland wetland systems. To understand the change across the wet and dry season, analyses of the standard deviation between key fluctuating wetland types was carried out.

Only inland wetland types have been analysed because tides and canopy cover in many marine/coastal wetland types will influence moisture content and will result in inaccurate values. The inland wetland systems most prone to fluctuations in spatial extent and spectral signature are lakes and pools. Also, inland freshwater lakes/pools were separated from the saline lakes/pools for easier interpretation.

Initially, the average standard deviations were plotted for each of the wetland types (**Figure 30** and **Figure 31**). From preliminary analyses of the data, it appears that the increase in the difference between the wetland types relates to the transition from wet season through to the dry season. This implies that the increase in standard deviation across the dry season relates to the decrease in water content, with the smaller systems showing greater variation than the larger lake systems. Therefore, it is the difference in standard deviation that will help interpret and understand the seasonal variability. The graphs below represent the difference in standard deviation between the bigger lake systems from the smaller pools.

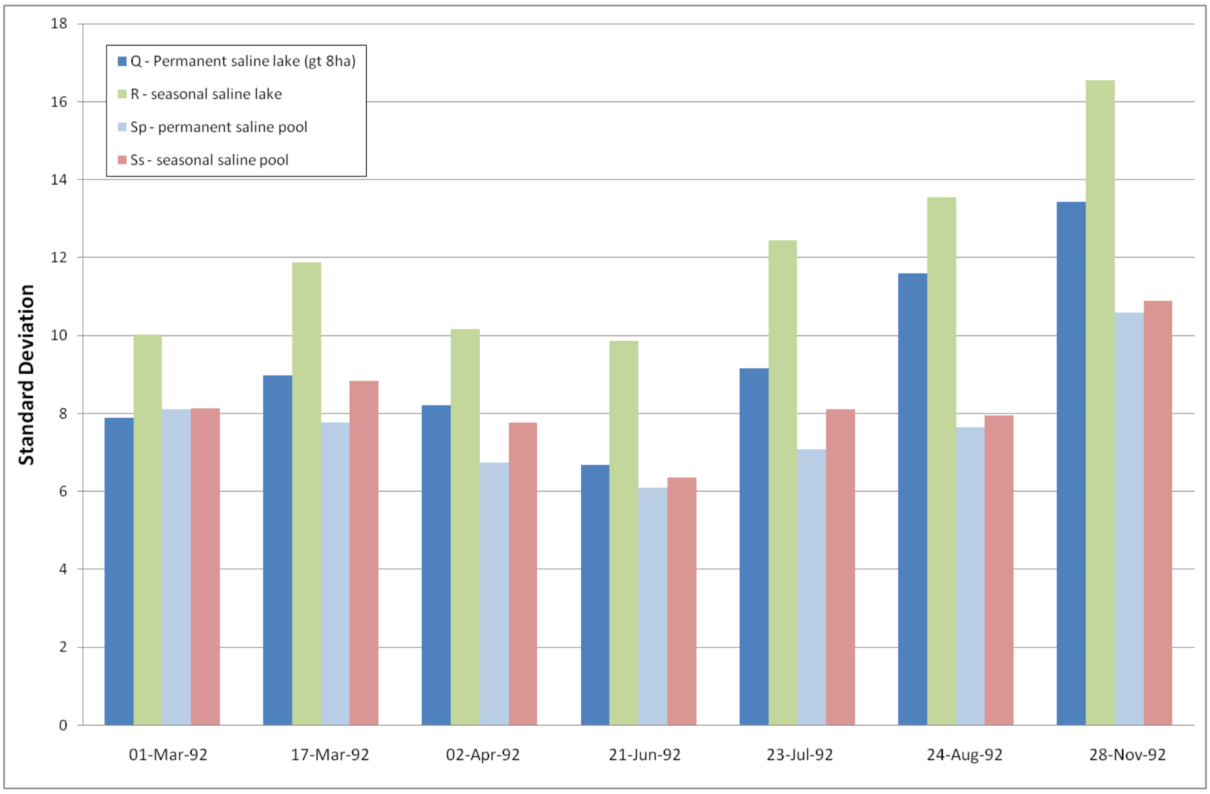

Figure 30 Standard Deviation of Relative Moisture in Inland Saline Wetland Types

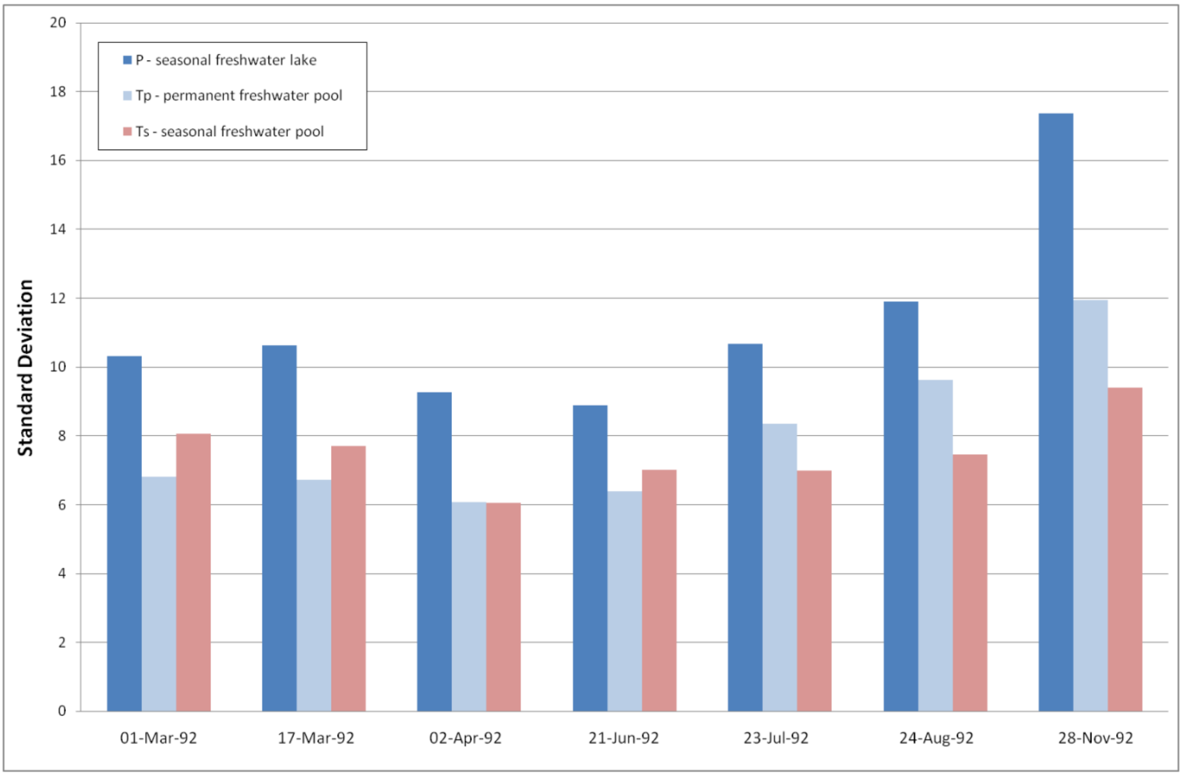

Figure 31 Standard Deviation of Relative Moisture in Inland Freshwater Wetland Types

In **Figure 32**, the solid blue line represents the difference between freshwater lakes and permanent freshwater pools. When compared to the dotted blue line (freshwater lakes minus the seasonal freshwater pools) it appears that the variation in the seasonal pools not only increases a lot sooner but also at a steep rate of increase. However, the permanent pools eventually show the same rate of increase as the seasonal pools at the end of the dry season.

In **Figure 33**, there is a difference between permanent saline lakes and seasonal saline lakes (solid blue line). It does not show the extreme variations as the other two.

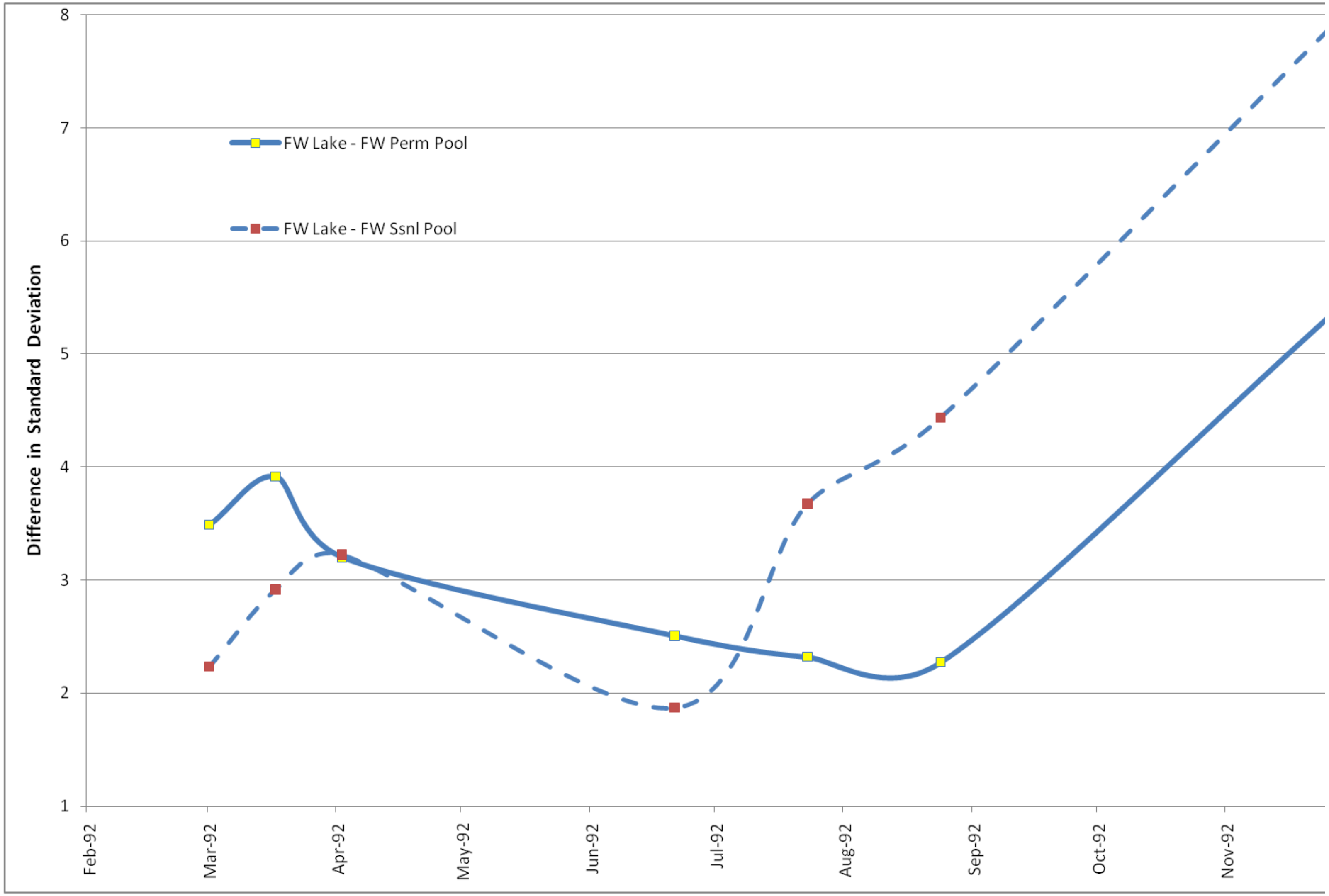

Figure 32 Difference in Standard Deviation Between Inland Freshwater Wetlands

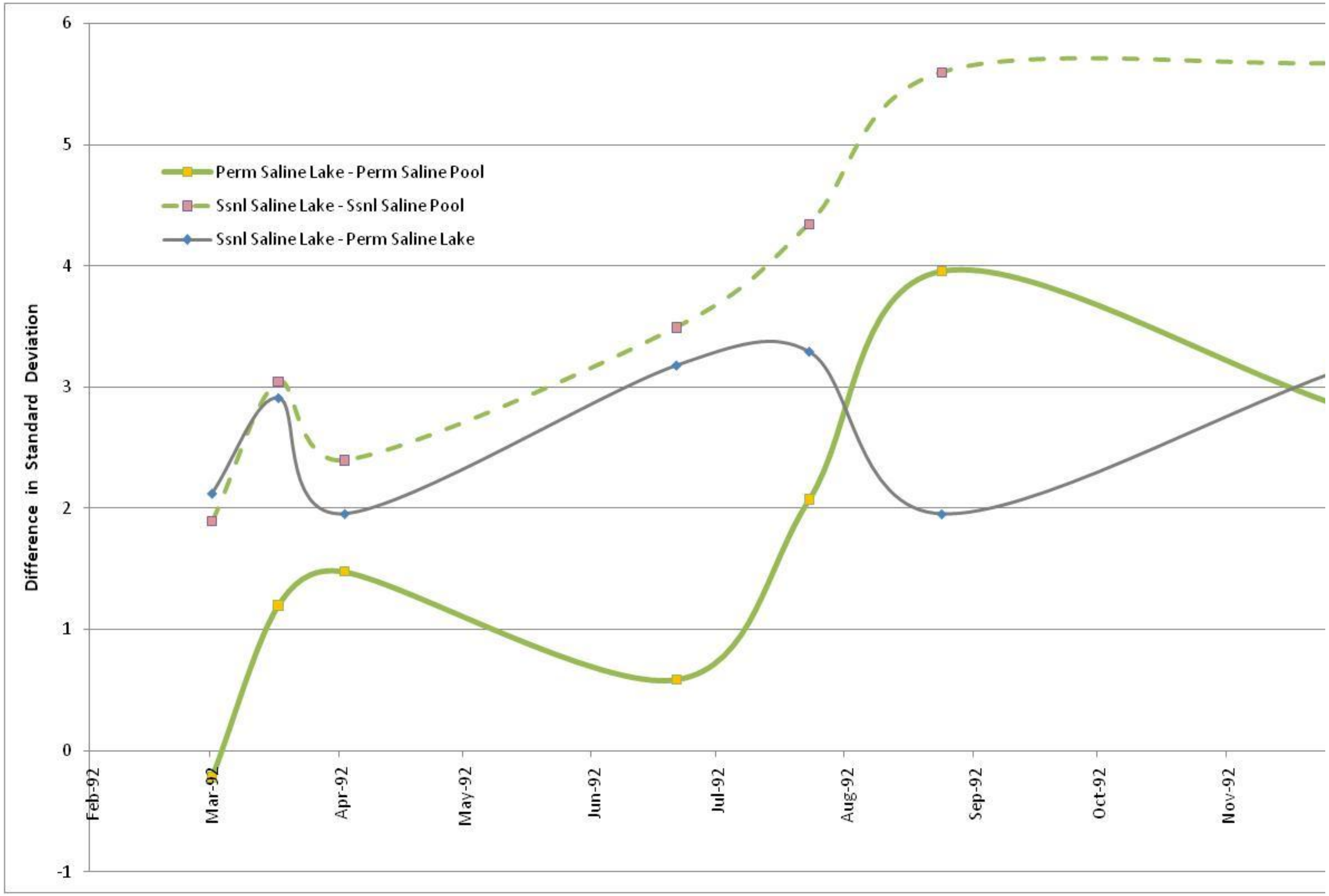

Figure 33 Difference in Standard Deviation Between Inland Saline Wetlands

6.0 Wetland-dependent Flora and Fauna

6.1 Methods

6.1.1 Desktop Literature Review

Desktop literature review provides an opportunity for assessment of existing ecological knowledge relating to the Cobourg Peninsula Ramsar site in relation to the knowledge gaps listed in **Table 2**. The literature review focussed on identifying the representative range of inland and coastal wetland dependent flora and fauna (including invertebrates) that occur, or potentially occur, within or near to the Cobourg Peninsula Ramsar site. Additionally, observable threats to Cobourg Peninsula biodiversity were also identified through the literature. A range of literature and databases were reviewed prior to conducting field surveys. Database searches focused on Cobourg Peninsula and included surrounding islands (e.g. Croker Island). Databases include:

- EPBC Act Protected Matters Database
- NRETAS NT Flora and Fauna Atlas
- Fish Atlas of North Australia
- FishBase (a Global Information System on fishes)
- Western Australian, Northern Territory, Queensland and Australian Museum fish databases.

Three groups of aquatic and terrestrial wetland dependent flora and fauna were targeted for this review:

- species that are dependent on inland or estuarine wetland systems
- species of conservation significance
- species that are highly abundant.

Inland and coastal wetland systems include all Ramsar classified wetlands in lacustrine, palustrine, estuarine, intertidal mud, salt and sand flat and shore areas. It excludes coral reefs and marine subtidal aquatic beds. The desktop literature review includes only those species recorded, or likely to occur, in these systems. Any flora or fauna (e.g. whales) known to occur in offshore systems (e.g. coral reefs and marine subtidal aquatic beds) are not mentioned in this study.

Wetland dependent flora and fauna includes species that are:

- completely dependent on aquatic environments (e.g. fish and yabbies)
- partially dependent on aquatic environments (e.g. terrestrial snakes or raptors that hunt in wetlands)
- dependent on vegetation that is associated with aquatic areas (e.g. birds that live in riparian areas)
- listed as a Marine species under the EPBC Act.

Fauna recorded during the literature and database review that are not considered wetland dependent (based on habitat preferences) were also noted (**Appendix A**).

Conservation significant species include those that are listed as Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) or Lower Risk (LR) under the TPWC Act, EPBC Act or the International Union for Conservation of Nature (IUCN) Red List.

Species listed as Data Deficient (DD) are those for which available information, such as total population size, limits of geographic range, rate of change of populations, etc., is too meagre to allow a confident assessment of their risk of extinction. These species are not considered as conservation significant in this study. The risk of extinction for species listed as Not Evaluated (NE) has not been assessed, so these species are also not considered as conservation significant in this study.

An assessment of the likelihood of occurrence for wetland dependent conservation significant flora and fauna not previously recorded in inland or coastal systems in the Northern Territory was undertaken. Each assessed species was placed in one of three categories (**Table 8**). Species that are 'possible' or 'likely' to occur within the site were subsequently targeted during field surveys.

Table 8 Likelihood of Occurrence Definitions

Likelihood	Definition
Unlikely	The species has not been recorded in the site or region and no suitable habitat for the species exists within the site.
Possible	The species has not been recorded in the site or region though potentially suitable (i.e. marginal) habitat exists within the site.
Likely	The species has not been recorded in the site or region though suitable habitat exists within the site.

6.1.2 Mid Dry Season Survey

Field survey one (mid dry season survey) was undertaken from 27 July to 3 August 2010. It consisted of flora, fish, macroinvertebrates, other wetland dependent fauna, and physical and chemical water property sampling.

6.1.2.1 Site Selection

Selection of representative sites within inland and marine/coastal wetlands involved a two-step process. Initially, wetland types and potential survey locations across the Cobourg Peninsula Ramsar site were assessed and selected ('preliminary' selection (**Section 6.1.2.1.1**)) from aerial photographs and Landsat imagery in consultation with:

- NRETAS
- SEWPaC
- BMT WBM
- Northern Land Council
- relevant Traditional Owners
- North Australian Expeditions Pty Ltd.

Immediately prior to the mid dry season survey, access to the western section of the Peninsula was restricted and wetland sites were available only from Port Essington eastward (**Figure 34**). Consequently, some wetland types became under-represented and a re-analysis of wetland types and potential sites in the eastern section was required (**Section 6.1.2.1.2**).

6.1.2.1.1 Preliminary Selection

Eight marine/coastal and five inland Ramsar wetland types were initially expected to occur within the Ramsar site (**Table 9**). Within these wetland types, 17 marine/coastal sites and 15 inland sites were selected as being suitable for surveying (**Figure 34**, **Table 9**). Where possible, the identification of more sites per wetland type than necessary for the purposes of the survey allowed contingency for sampling in the case of unforeseen events where sites could not be sampled (e.g. wetland types were incorrectly identified in the preliminary site selection, sites became inaccessible, wetlands were dried out etc.). Sites were selected to obtain a geographical spread across the Peninsula and based on proximity to roads for ease of access. Access to parts of the Ramsar site is also restricted due to being sacred to local residents and Traditional Owners.

Only one marine subtidal aquatic bed (wetland type B) and coastal brackish/saline lagoon (wetland type J) could be identified prior to field sampling. No sites within estuarine waters (wetland type F) were chosen as it was assumed they could be easily located without the need for prior consultation (i.e. sites could be located while in the field). This was based on advice given by PWCNT staff.

Table 9 Inland and Marine/Coastal Wetland Types and Representative Sites Selected during Preliminary Assessment

Wetland Code	Wetland Type	Expected to Occur	Representative Sites
Marine/Coastal Wetlands			
A	Permanent	✗	-
B	Marine subtidal aquatic beds	✓	M7
C	Coral reefs	✓	M3, M8, M10
D	Rocky marine shores	✓	M11, M12
E	Sand, shingle or pebble shores	✓	M10, M11, M12, M13
F	Estuarine waters	✓	*
G	Intertidal mud, sand or salt flats	✓	M1, M2
H	Intertidal marshes	✗	-
I	Intertidal forested wetlands	✓	M4, M5, M6, M13
J	Coastal brackish/saline lagoons	✓	M9
K	Coastal freshwater lagoons	✗	-
Zk(a)	Karst and other subterranean hydrological systems, marine/coastal	✗	-
Inland Wetlands			
L	Permanent Inland Deltas	✗	-
M	Permanent rivers/streams/creeks	✗	-
N	Seasonal/intermittent/irregular river/streams/creek	✓	I3, I7, I8
O	Permanent freshwater lakes (over 8 ha)	✗	-
P	Seasonal/intermittent freshwater lakes (over 8 ha)	✗	-
Q	Permanent saline/brackish/alkaline lakes	✗	-
R	Seasonal/intermittent saline/brackish/alkaline lakes and flats	✗	-
Sp	Permanent saline/brackish/alkaline marshes/pools	✗	-
Ss	Seasonal/intermittent saline/brackish/alkaline marshes/pools	✗	-
Tp	Permanent freshwater marshes/pools	✓	I5, I12, I15
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils	✓	I1, I7, I8, I14
U	Non-forested peatlands	✗	-
Va	Alpine wetlands	✗	-

Wetland Code	Wetland Type	Expected to Occur	Representative Sites
Vt	Tundra wetlands	✗	-
W	Shrub-dominated wetlands	✗	-
Xf	Freshwater, tree-dominated wetlands	✓	I2, I6, I9, I10, I11
Xp	Forested peatlands	✗	-
Y	Freshwater springs	✓	I4, I7, I8, I12, I13
Zg	Geothermal wetlands	✗	-
Zk(b)	Karst and other subterranean hydrological systems, inland	✗	-

* Estuarine survey sites were not pre-selected as potential sites were abundant and on-ground selection was considered more appropriate.

6.1.2.1.2 Final Selection

As stated above, immediately prior to the mid-dry season survey, access to the western half of the Peninsula was restricted for cultural reasons and wetland sites were available only from Port Essington eastward (**Figure 35**). This reduced the original 32 sites selected during the preliminary assessment to 23 survey sites (11 inland and 12 marine/coastal). Five inland and seven marine/coastal wetland types were expected to occur in the eastern half of the Ramsar site. Consultation with PWCNT Rangers and other local residents was undertaken during the surveys to locate additional representative sites within wetland types now under-sampled (i.e. wetland types N and Y). Based on advice from PWCNT staff, no sites within estuarine waters (wetland type F) and intertidal mud, sand or salt flats (wetland type G) were chosen prior to the field survey. No marine subtidal aquatic beds (wetland type B) are known from the eastern section of the Peninsula (pers. comm. P. Fitzgerald).

Poor (i.e. dry) site conditions and site accessibility resulted in eight inland and 13 marine/coastal sites within 14 wetland types being sampled in the eastern half of the Ramsar site during the mid-dry season survey (29 July to 3 August 2010, **Table 10**, **Figure 35**). Three wetland types (permanent freshwater lakes (O), permanent saline/brackish/alkaline lakes (Q) and seasonal/intermittent saline/brackish/alkaline lakes and flats (R)) were anticipated not to occur during the preliminary assessment but were identified in the field and sampled (**Table 10**). Two of these, wetland types Q and R, were misidentified during preliminary assessment as wetland types Xf (freshwater tree-dominated wetlands) and Ts (seasonal/intermittent freshwater marshes/pools on inorganic soils), respectively. Water chemistry sampling within two sites (I1 and I2) revealed that the water contained within the wetlands contained elevated electrical conductivities indicating elevated levels of salt (**Section 7.2**) and so these sites were reclassified.

With the exception of marine subtidal aquatic beds (wetland type B), flora and fauna sampling occurred in representative sites across the full range of accessible marine/coastal wetlands expected to occur in the Ramsar site (**Table 10**).

Site M20 was originally classified in the 'inland' wetland category (i.e. as site 'I9'). Analyses of data have included this site as an inland wetland type even though subsequent categorisation placed this site into the marine/coastal wetland type class.

Table 10 Wetland Types and Representative Sites Sampled during the Mid Dry Season Survey (July to August 2010)

Wetland Code	Wetland Type	Site Name	Local Wetland Name**	Location	Easting*	Northing*	Date Visited (day.month. year)	Time of Day Visited (hours)
Marine/Coastal Wetlands								
C	Coral reefs	M3	Wahwaldi	Kuper Point	197006	8762844	2.08.2010	1330
		M10	-	Sandy Island No. 2	203542	8771712	30.07.2010	0930
D	Rocky marine shores	M8	-	Observation Point	193233	8751406	28.07.2010	1000
		M12	-	Smith Point	186978	8768806	31.07.2010	1450
E	Sand, shingle or pebble shores	M9	-	Observation Point	193494	8751758	28.07.2010	1300
		M11	-	Sandy Island No. 2	203659	8771080	30.07.2010	1200
F	Estuarine waters	M1	-	East Bay	195633	8736602	31.07.2010	0910
G	Intertidal mud, sand or salt flats	M4	-	Barrow Bay	198215	8744376	29.07.2010	0930
I	Intertidal forested wetlands	M2	-	East Bay	195252	8737452	1.08.2010	0830
		M5	-	Barrow Bay	197828	8743818	29.07.2010	1600
J	Coastal brackish/saline lagoons	M6	-	Barrow Bay	198708	8749626	1.08.2010	1145
		M7	-	Gul Gul	208272	8764990	2.08.2010	1745
K	Coastal freshwater lagoon	M20	Mariah Swamp	Danger Point Road	212410	8755863	3.08.2010	1220
Inland Wetlands								
N	Seasonal/intermittent/ irregular river/streams/creek	I3	-	Irgul Road	232773	8740209	30.07.2010	1000
Q	Permanent saline/brackish/ alkaline lakes	I2	Campsite No. 2 Billabong	Smith Point	190853	8766490	29.07.2010	1550

Wetland Code	Wetland Type	Site Name	Local Wetland Name**	Location	Easting*	Northing*	Date Visited (day.month. year)	Time of Day Visited (hours)
R	Seasonal/intermittent saline/brackish/ alkaline lakes and flats	I1	Wuwurdi Swamp	Black Point	188089	8765533	29.07.2010	0800
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils	I5	Ingrid's Waterhole	Danger Point	210890	8765177	31.07.2010	1500
Xf	Freshwater, tree-dominated wetlands	I4	-	Danger Point	209872	8766610	31.07.2010	1130
		I8	Friarbird Swamp	Main Road	210028	8738712	2.08.2010	0855
Y	Freshwater springs	I6	Ferny Springs	Danger Point Road	212204	8742879	1.08.2010	1030
		I7	Wolf Claw Spring	Black Point Road	204181	8743352	1.08.2010	1320

* Datum: Geocentric Datum of Australia 1994 (GDA1994); Zone 53.

** Where known

Figure 34 Results of Preliminary Selection of Survey Sites

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Figure 35 Inland and Marine/Coastal Sites Sampled during the Mid Dry Season Survey (July and August 2010)

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6.1.2.2 Flora Surveys

Surveys, targeting those species considered to be important components of the wetland ecosystems, were undertaken once at each site for terrestrial and aquatic flora (**Section 6.1**). Botanical diversity and structure was distinctly different outside the wetland ecosystem and these areas were not surveyed. The wetland flora was defined as being that which was dependent on the aquatic environment.

Targeted conservation significant plant species have been identified previously in NRETAS (2009). Generally, identification was undertaken in the field, however, where this was not possible, a specimen was collected and lodged with the NT Herbarium.

Each species was assigned an abundance status for the wetland in which it occurs – abundant, common, uncommon or rare, depending on the numbers and average spacing of individuals. Notes were kept on the growth habit of each species, divided into the following ten categories:

- tree (T)
- shrub (Sh)
- herbaceous (H)
- grass/ grass like (including sedges) (G)
- epiphyte (Ep)
- floating (F)
- emergent (from water) (E)
- submerged (S)
- parasite (P)
- vine / scrambler (V)

Aquatic emergent grasses and sedges were assigned to the E category rather than the G category.

6.1.2.3 Fish Sampling

Systematic fish surveys occurred during the mid dry season survey only. A range of fish survey techniques was utilised (**Table 11**, **Table 12**). Fish sampling was undertaken under Special Permit No. 2010/S17/3026 issued by the NT Department of Resources.

6.1.2.3.1 Marine/Coastal Wetland Sites

Thirteen marine/coastal wetland sites were surveyed for fish.

Gill Nets

Three monofilament nylon gill nets, each with a diagonal mesh size of three, four or five inches, were deployed at nine sites (**Table 11**). Gill nets could not be deployed effectively at three sites (M6, M3 and M7) that were accessed by land. Each net was 23 m long and 2.5 m high. A lead-lined rope at the base, supplemented by three 1.4 kg weights at each end, allowed the base of each net to rest on the substrate. A float line along the top of the net, supplemented by 150 mm diameter floats at each end, allowed each net to span the water column at each site. Nets were placed perpendicular to the shore at each site. Entangled fish were removed from the net, identified and then released. Nets were monitored for approximately one hour before being retrieved.

Trawl Net

A weighted beam trawl net with a 1.5 m diameter opening was trawled for a distance of approximately 100 m at each site exhibiting soft sediments. The net was trawled at a variety of depths at each site. The trawl net was deployed in six sites (**Table 11**), however was not used in sites where sub-surface obstacles were expected, such as coral reefs.

Visual Observation

Opportunistic sightings of fish were recorded at each of the 13 sites (**Table 11**) and incidentally between sites, regardless of whether positive identifications could be made.

Seine Nets

Due to physical limitations and the safety hazard posed by Saltwater Crocodile (*Crocodylus porosus*), seine netting was undertaken at one site only (**Table 11**). A 10 m seine net was anchored at one end and swept in an arc with the use of a boat.

Table 11 Fish Survey Techniques Used at Marine/Coastal Wetland Sites

Site	Wetland Type	Fish Survey Method				
		Gill Nets	Trawl Net	Visual Observation	Seine Net	Trawled Lure*
M1	Estuarine waters	✓	✓	✓	×	✓
M2	Intertidal forested wetland	✓	✓	✓	×	✓
M3	Coral reef	×	×	✓	×	×
M4	Intertidal mud flat	✓	✓	✓	×	×
M5	Intertidal forested wetlands	✓	✓	✓	×	×
M6	Coastal brackish/saline lagoon	×	×	✓	×	×
M7	Coastal brackish/saline lagoon	×	×	✓	×	×
M8	Rocky marine shore	✓	✓	✓	×	×
M9	Sand shore	✓	✓	✓	✓	×
M10	Coral reef	✓	×	✓	×	×
M11	Sand/shingle beach	✓	×	✓	×	×
M12	Rocky marine shore	✓	×	✓	×	✓
M20	Coastal Freshwater Lagoon	×	✓	✓	×	×

* Opportunistic method

6.1.2.3.2 Inland Wetland Sites

Six inland wetland sites were surveyed for fish. Sampling techniques utilised at the inland sites are outlined in the following sections

Visual Inspection

An inspection of the water body at each site was made upon arrival and during the water quality sampling process (**Section 6.4**). The water quality sampling process creates a level of disturbance that draws a number of fish species from cover, including more common species such as Rainbowfish (*Melanotaenia* spp.), as they forage on the disturbed material that is resuspended in the water column.

Dip/Sweep Netting

Dip/sweep netting was utilised wherever a visual inspection and assessment of the water quality parameters indicated fish species may be present. Samples were collected using a D-shaped frame pond net (pond net) of mesh size 250 µm with a combination of techniques, according to the habitats available.

Kick-sampling

Where water was flowing, a kick-sample method was used to collect samples. The pond net was placed on the streambed and the sediment just upstream of the net disturbed vigorously with the feet. Small fish were carried downstream by the current into the net. Fish were then identified and immediately released.

Net Sweeping

Edge habitats were sampled by disturbing the area with the foot, net frame or other implement, then sweeping the net through the water directly above the disturbed area a number of times. Open areas were sampled by disturbing the bottom sediment and similarly repeatedly sweeping the net through the water column above the disturbed area.

To sample macrophyte beds, the pond net was used to disturb the plants, starting at the base of the plants on the bed of the waterbody, and working upwards to the surface of the water, sweeping the net through the water column at the same time, to collect fish.

Cast Netting

Cast netting was utilised wherever a visual inspection and assessment of the water quality parameters indicated fish species may be present. A cast net is a circular mesh net with weights attached to the edge, drawn in at the centre where it is attached to a rope. It is thrown from the bank over the water such that it opens into a circle shape in the air, hits the surface of the water, then sinks to the bottom. Once it settles the centre of the net is drawn up slowly by the rope, drawing the weights together along the substrate, trapping the fish in the knitted mesh. The net is then pulled out of the water, spread out on the ground and the fish removed. This technique is best applied in fairly open water, with minimal emergent and submerged macrophytes. The cast net used had a 2 m diameter with a 10 mm mesh size. Fish were then identified and immediately released. No voucher specimens were collected.

Table 12 Fish Sample Techniques Used at Inland Wetland Sites

Site	Sample Techniques Used		
	Visual Inspection	Dip Netting	Cast Netting
I1	✓	×	×
I2	✓	×	×
I3	✓	✓	×
I4	✓	✓	×
I5	N/A	N/A	N/A
I6	✓	✓	✓
I7	✓	✓	✓
I8	N/A	N/A	N/A

6.1.2.4 Macroinvertebrate Sampling

As with the other biota apart from birds, systematic macroinvertebrate sampling occurred during the mid dry season survey only. Nineteen sites (six inland and 13 marine/coastal wetland sites) were sampled for macroinvertebrates.

6.1.2.4.1 Marine/Coastal Wetland Sites

Invertebrates were sampled using a combination of grab sampling and handpicking. Individuals were identified in the laboratory following field work.

Grab Sampling

Most samples were collected with a 15 cm^3 Ekman grab, which was lowered to the substrate by rope. At each site, 15 samples were collected and combined to give a single sample representing an area of 0.3375 m^2.

Handpicking

A spade was used instead of the grab sampler in some shallow locations within sites. Samples collected with the spade represented a similar area of substrate to that collected with the grab sampler.

Sample Processing

Directly after collection, grab samples were washed through a 1 mm mesh sieve and the retained fraction stored in a polyethylene container. At the end of each day, samples were fixed and preserved in borax buffered sea-water formalin.

In the laboratory, macrobenthos was extracted by washing the samples through a 1 mm mesh sieve until all fine sediment had been washed away. The remaining material was then sorted under a dissecting microscope. Fauna was sorted to major taxon and then specimens identified to the lowest possible taxon and enumerated for each sample. Identifications were made by Aquateco Consulting Pty Ltd. Each sample was sub-sampled so that quantitative estimates of the entire sample could be made via extrapolation of data for those samples with greater than 300 individuals.

Data Analysis

The statistical package Primer-E v6 was used to perform Bray Curtis similarity analysis on square root transformed macroinvertebrate data. The square root transformation of the dataset is a commonly used approach for ecological data where assemblages are strongly dominated by a small number of taxa (Clark and Warwick, 2001) and reduces the influence of dominant taxa to reveal the influence of less common taxa. A cluster analysis was performed on the macroinvertebrate assemblages between sites and has been depicted as a dendogram. Differences between sites were assessed at the 30% similarity level. This similarity level identifies similarities at the 30% level or greater (within the Bray-Curtis similarity matrix) of macroinvertebrate communities between sites.

6.1.2.4.2 Inland Wetland Sites

Macroinvertebrates were collected with a D-shaped frame pond net (pond net) of mesh size 250 µm, using a combination of techniques including kick-sampling and net sweeping, similar to sampling fish (**Section 6.1.2.3**). The location of the seven sampling sites is shown in **Figure 35**. At each site, two samples were collected. Each comprised a composite totalling 10 m, collected across the range of habitat types available at the site (e.g. riffles, edges, macrophytes in open water, etc.).

Field and Laboratory Processing

Once collected (using the methods outlined in **Section 6.1.2.3**), each composite sample was passed through a 250 µm mesh size sieve to remove fine sediment and other unwanted material. Large particulate matter such as sticks and leaves were thoroughly flushed with water (over the sieve) to remove any organisms adhering to their surfaces and visually inspected before being discarded. Each sample was placed in a uniquely labelled container with two waterproof labels and preserved with 90% ethanol. Containers were sealed with Parafilm® to prevent leakage during transportation.

Samples were processed in the laboratory by pouring the contents of the sample container into a 250 µm mesh size sieve and thoroughly flushing with tap water to remove excess sediment. Because the samples invariably contained large amounts of sediment or very high numbers of individuals, subsamples were taken and sorted using a microscope under ten or 16 times magnification. At least 200 individuals were retrieved from the sample. The contents of the whole sample were then transferred to a white sorting tray and invertebrates observed by eye were removed using forceps. Generally, invertebrates were identified to the lowest taxonomic level possible using available keys. These keys or other taxonomic references are listed in **Section 9.0**.

Sampling dates and laboratory subsampling details for macroinvertebrates are detailed in **Table 13**.

Table 13 Date of Collection of Inland Macroinvertebrate Samples and Percent of the Whole Sample Processed in the Laboratory

Site code and duplicate	Date sampled	% sub sampled
I1 Duplicate 1	29 July 2010	1
I1 Duplicate 2	29 July 2010	1
I2 Duplicate 1	29 July 2010	3
I2 Duplicate 2	29 July 2010	3
I3 Duplicate 1	30 July 2010	5
I3 Duplicate 2	30 July 2010	7
I4 Duplicate 1	31 July 2010	10
I4 Duplicate 2	31 July 2010	11
I6 Duplicate 1	1 August 2010	100
I6 Duplicate 2	1 August 2010	2
I7 Duplicate 1	1 August 2010	3
I7 Duplicate 2	1 August 2010	2

6.1.2.5 Other Wetland Dependent Fauna Survey

Surveys were undertaken at each site for terrestrial and aquatic fauna, particularly for those species considered to be dependent on wetlands. Targeted fauna included amphibians, reptiles, birds, and mammals (**Section 6.1**). Abundance was recorded only for species that are conservation significant or Migratory (under the EPBC Act).

Targeted fauna included conservation significant species. Conservation significant fauna that have been recorded on the Cobourg Peninsula are listed in NRETAS (2009) and the NT Fauna Atlas (**Appendix B**).

Bird surveys attempted to identify all species present, however, the focus was on those listed as Migratory under the EPBC Act and those defined as 'water birds' (ecologically dependent on wetlands) under the Ramsar Convention (1971), including:

- grebes (Podicipediformes)
- wetland related pelicans, cormorants, darters and allies (Pelecaniformes)
- herons, bitterns, storks, ibises and spoonbills (Ciconiiformes)
- swans, geese and ducks (Anseriformes)
- wetland related raptors (Accipitriformes and Falconiformes)
- wetland related cranes, rails and allies (Gruiformes)
- wetland related jacanas, waders (or shorebirds), gulls, skimmers and terns (Charadriiformes)
- coucals (Cuculiformes)
- wetland related owls (Strigiformes).

An assessment was made regarding the value of different wetlands as a waterbird breeding site, however, stability of these sites as waterbird breeding colonies would only be possible through long term monitoring.

As part of the assessment into threatening processes, the presence of feral animals (e.g. Cane Toads, Feral Pigs, Buffalo and Banteng) and their observable impacts on the various wetlands were also recorded.

Survey techniques employed included visual identification of fauna, identification of bird and frog calls, and identification of animal traces including tracks, feathers, droppings, sloughed skins, bones, scats and nests. Although conservation significant mammals such as the Brush-tailed Rabbit-rat (*Conilurus penicillatus*) and Northern Quoll (*Dasyurus hallucatus*) have been recorded on the Cobourg Peninsula, these species are not considered to be ecologically dependent on wetlands and were not targeted for survey. Echolocation calls of microchiropterans ('microbats') were recorded with an 'Anabat' recorder at one site only.

The results of the terrestrial vertebrate fauna survey were combined with results of the survey of wetland flora, fish and macroinvertebrates in order to determine potential trophic relationships, classify species into various trophic levels and highlight those considered to be 'keystone' species. The Ramsar definition of 'keystone' species is those whose loss from an ecosystem would cause a greater than average change in other species populations or ecosystem processes (i.e. those whose continued well-being is vital for the functioning of a whole community).

6.1.3 Late Dry Season Survey

The late dry season survey was undertaken from 3 to 5 October 2010. It involved sampling for physical and chemical water properties only. Observations of all other fauna, especially those considered wetland dependent, were recorded, however systematic sampling was not undertaken.

6.1.3.1 Site Selection

Thirteen inland wetland sites within nine wetland types, and 17 marine/coastal wetland sites within seven wetland types, were visited during the late dry season survey (3 to 5 October 2010) (**Table 14**,**Figure 36**). Access to the western half of the Cobourg Peninsula was available during this survey period

Table 14 Wetland Types and Representative Sites Sampled during the Late Dry Season Survey (October 2010)

Wetland Code	Wetland Type	Site Name	Local Wetland Name**	Location	Easting*	Northing*	Date Visited (day.month.year)	Time of Day Visited (hours)
Marine/Coastal Wetlands								
C	Coral reefs	M3	Wahwaldi	Kuper Point	197006	8762844	4.10.2010	0800
		M14	-	Sandy Island No. 1	192462	8769814	4.10.2010	0900
D	Rocky marine shores	M8	-	Observation Point	193233	8751406	3.10.2010	1520
		M12	-	Smith Point	186978	8768806	4.10.2010	0945
E	Sand, shingle or pebble shores	M9	-	Observation Point	193494	8751758	3.10.2010	1550
		M13	-	Sandy Island No. 1	192872	8769394	4.10.2010	0845
F	Estuarine waters	M1	-	East Bay	195633	8736602	3.10.2010	1215
		M15	-	Knocker Bay	186126	8743526	4.10.2010	1115
		M17	-	Araru Point Road	195577	8730744	5.10.2010	1415
G	Intertidal mud, sand or salt flats	M4	-	Barrow Bay	198215	8744376	3.10.2010	1000
		M16	-	Araru Point Road	195630	8731257	5.10.2010	1030
I	Intertidal forested wetlands	M2	-	East Bay	195252	8737452	3.10.2010	1250
		M5	-	Barrow Bay	197828	8743818	3.10.2010	1030
		M18	-	Popham Creek	156816	8751413	5.10.2010	1330
J	Coastal brackish / saline lagoons	M6	-	Barrow Bay	198708	8749626	3.10.2010	0910
		M7	-	Gul Gul	208272	8764990	4.10.2010	1350
		M19	-	Araru Point	159466	8761592	5.10.2010	1500

Wetland Code	Wetland Type	Site Name	Local Wetland Name**	Location	Easting*	Northing*	Date Visited (day.month.year)	Time of Day Visited (hours)
K	Coastal freshwater lagoon	M20	Mariah Swamp	Danger Point Road	212410	8755863	4.10.2010	1430
Inland Wetlands								
N	Seasonal/intermittent/ irregular river/streams/creek	I3	-	Irgul Road	232773	8740209	6.10.2010	0840
		I13	-	East Bay	196086	8736081	5.10.2010	0900
Q	Permanent saline/brackish/alkaline lakes	I2	Campsite No. 2 Billabong	Smith Point	190853	8766490	3.10.2010	0715
R	Seasonal/intermittent saline/brackish/alkaline lakes and flats	I1	Wuwurdi Swamp	Black Point	188089	8765533	3.10.2010	0645
Sp	Permanent saline pool	I12	-	Araru Point	159144	8761153	5.10.2010	1100
Tp	Permanent freshwater pool	I10	-	Coral Bay	178847	8759816	4.10.2010	1350
Ts	Seasonal/intermittent freshwater marshes/pools on inorganic soils	I5	Ingrid's Waterhole	Danger Point	210890	8765177		
Xf	Freshwater, tree-dominated wetlands	I4	-	Danger Point	209872	8766610		
		I8	Friarbird Swamp	Main Road	210028	8738712	3.10.2010	1420
Y	Freshwater springs	I6	Ferny Springs	Danger Point Road	212204	8742879	3.10.2010	1305
		I7	Wolf Claw Spring	Black Point Road	204181	8743352	3.10.2010	1105
		I11	-	Araru Point Road	183062	8740372	5.10.2010	0850

* Datum: Geocentric Datum of Australia 1994 (GDA1994); Zone 53.

Figure 36 Inland and Marine/Coastal Wetland Sites Sampled During the Late Dry Season Survey (October 2010)

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6.1.4 Data Analysis

Data collected during field surveys were analysed to determine variability in species abundances and community assemblages and to identify those species that are likely to be:

- keystone species
- important for understanding trophic relationships.

For both inland and marine/coastal macroinvertebrate data, the statistical package Primer-E v6 was used to perform Bray Curtis similarity analysis on square root transformed data. The square root transformation of the dataset is a commonly used approach for ecological data where assemblages are strongly dominated by a small number of taxa (Clark and Warwick, 2001) and reduces the influence of dominant taxa to reveal the influence of less common taxa. Cluster analyses were performed on the similarity matrices derived from the macroinvertebrate assemblage data from amongst sites and (for inland data) duplicates, and are depicted as dendograms. Differences amongst sites were assessed at the 30% similarity level. This similarity level identifies similarities at the 30% level or greater (within the Bray-Curtis similarity matrix) of macroinvertebrate communities between sites. For inland macroinvertebrate data, multivariate pattern was also assessed using Multi-Dimensional Scaling (MDS) ordination. The ordination was depicted as a two-dimensional plot based on the site by site (including duplicate) similarity matrix. For the primary inland groups identified from the cluster analysis at the 30% similarity threshold, diagnostics of taxa responsible for group separation (i.e. defining taxa for the classification groups) was performed using the SIMPER routine from Primer.

For all statistical analyses of inland macroinvertebrate information, data for microcrustaceans were omitted because these groups were not sorted from every sample.

6.2 Results

6.2.1 Literature Review

Results from the desktop literature review are detailed in the following sections.

6.2.1.1 Flora

A total of 913 flora species are recorded in the NT Flora Atlas for the Ramsar site (**Appendix C**). This includes species not dependent on wetlands.

6.2.1.1.1 Conservation Significant Species

Seventeen conservation significant flora species are recorded in the NT Flora Atlas for the Ramsar site (**Appendix C**). This includes species considered not to be dependent on wetlands. Literature review reveals a further three species considered to be wetland dependent that may occur (**Table 15**). The likelihoods of occurrence of these three species are assessed in **Appendix D** with the summary of results shown in **Table 15**.

Table 15 Likelihood of Occurrence of Wetland Dependent Conservation Significant Flora not Previously Recorded in the Ramsar Site

Family	Species	Conservation Status		NT Flora Atlas	Likelihood of Occurrence
		TPWC Act	EPBC Act		
Arecaceae	*Arenga australasica*	DD	VU	×	Unlikely
Lauraceae	*Cryptocarya hypospodia**	EN	-	✓	Possible
Lentibulariaceae	*Utricularia dunstaniae*	VU	-	×	Possible

Key: DD = Data Deficient; VU = Vulnerable; EN = Endangered. * species has been recorded on nearby Croker Island.

6.2.1.1.2 Endemic Species

The NT Flora Atlas contains records of 50 flora species from the Ramsar site endemic to the NT (**Appendix C**). Two of these species (*Zornia oligantha* and *Cyclophyllum schultzii f. schultzii*) are endemic to the Cobourg Peninsula (NTG, 2008). Three of these species (*Zornia oligantha, Cyclophyllum schultzii f. schultzii* and *Spermacoce protrusa*) are endemic to the Tiwi Cobourg bioregion (NTG, 2008).

6.2.1.1.3 Wetland Species

A range of flora known to inhabit particular wetland types exist across the Ramsar site and the Top End.

Thirty-five species of mangrove flora (wetland type I) have been recorded on the Ramsar site (NRETA, 2007; Brocklehurst, 2010). Of importance is the Mangrove Palm (*Nypa fruticans*), which is known from only three locations in the NT, including Trepang Bay (NRETA, 2007). Mangrove communities are generally found on saline mudflats along intertidal coastal and river margin areas, including river mouths (NRETA, 2007; Chippendale, 1974). Common species found near river mouths include *Rhizophora mucronata* and *R. stylosa* while *Avicennia marina* var. *resinifera* occurs behind (Chippendale, 1974). Mangroves are also found in some protected bays (Chippendale, 1974). The mangrove communities that exist in the Ramsar site are:

1. *Rhizopora stylosa* low closed forest
2. *Ceriops tagal, Bruguiera* spp. low closed forest
3. Mixed species mid closed forest
4. *Sonneratia alba* low open forest/woodland
5. *Ceriops tagal, Avicennia marina* low open forest
6. *Ceriops tagal, Avicennia marina* and *Lumnitzera racemosa* low open forest
7. *Avicennia marina, Ceriops tagal, Bruguiera* spp. low open forest.

Sixteen flora species were recorded during surveys in the Popham Creek (west of Port Essington) mangroves in 1994 (PWCNT, 1995). Eight are typical of much of the Top End coast, two are considered uncommon (*Lumnitzera littorea* and *Ceriops tagal*) and the Frangipani (*Cerbera manghas*) is locally rare (PWCNT, 1995). Behind the mangrove communities surrounding saline lagoons (wetland type J) contain species such as the fern *Acrostichum speciosum* (Chippendale, 1974). Adjacent to the site, the Murganella Creek area contains tidal estuarine plains (a series of channels) that lead into seasonal creeks that commonly contain species such as Wild Rice (*Oryza rufipgon*) and the sedge *Eleocharis dulcis* (Chippendale, 1974).

Seasonal creeks (wetland type N) within the site are dominated by plants typical of the Top End. Vegetation includes common flora such as *Pandanus* spp., *Melaleuca* spp., *Banksia dentata* and *Tristania lactiflua* (Chippendale, 1974). Common plants within seasonal freshwater marshes (wetland type Ts) include *Grevillea pteridifolia* and the sedge *Leptocarpus spathaceus* (Chippendale, 1974).

Small patches of monsoon forest (often associated with wetland type Y (freshwater springs)) occur in the Ramsar site (Chippendale, 1974). Common species include *Buchanania obovata*, *Alstona actinophylla*, *Vitex glabrata*, *Sterculia quadrifida*, *Canarium australianum*, *Parinari corymbosum* and *Tamarindus indica* (Chippendale, 1974). The climbing fern *Stenochlaena palustris* is common in most of the monsoon forests (Chippendale, 1974). Monsoon forests near freshwater lagoons often contain flora such as *Ficus* spp., *Abrus precatorius*, *Pongamia pinnata*, *Cupaniopsis anacardioides*, *Strychnos lucida* and *Trema amboinensis* (Chippendale, 1974).

6.2.1.1.4 Weeds

Seventy-one species of introduced flora have been recorded within 10 km of the Ramsar site (**Appendix C**). Ten of these are declared as Schedule A or B (under the NT *Weed Management Act*).

6.2.1.2 Fauna

A total of 396 fauna species have been recorded in the Ramsar site in the NT Fauna Atlas, including 174 species (44% of the total) considered not to be wetland dependent (**Appendix A**). Review of literature reveals an additional ten wetland dependent species have been recorded in the Ramsar site (**Appendix B**).

6.2.1.2.1 Fish

There is a general deficiency of data available for freshwater and estuarine fish in northern Australia, with no fish from the Ramsar site having been recorded in the NT Fauna Atlas (**Appendix B**). Difficulties associated with accessing and surveying remote rivers and past misidentification of species have led to many species only being recorded relatively recently (Thorburn et al., 2004). Only two documented surveys targeting sharks and rays have been undertaken in the NT (Taniuchi et al., 1991; Thorburn et al., 2004) (**Table 17**). Very few ad hoc surveys have reported any sharks and rays (Thorburn et al., 2004) (**Table 17**).

Whilst the Fish Atlas of North Australia, compiled under the North Australian Freshwater Fish project, has redressed information gaps for freshwater fishes substantially (NAFF, 2008), it includes no records for Cobourg

Peninsula. For reference, 70 species have been recorded in the freshwaters of the adjacent East Alligator River catchment (NAFF, 2008).

Nevertheless, Cobourg Peninsula is the type location for two Australian freshwater fish species, the Black-lined Rainbowfish (*Melanotaenia nigrans*) and the Purple-spotted Gudgeon (*Mogurnda mogurnda*), and there are records for another species, Mouth-almighty (*Glossamia aprion*). The collective results are from surveys undertaken on the Peninsula in the 1800's. These references are as follows:

- Black-lined Rainbowfish (*Melanotaenia nigrans*)
  - Richardson J. 1843. Contributions to the ichthyology of Australia (continued). Annals and Magazine of Natural History (New Series) v. 11 (nos. 67-8, 71-2): 22-28, 169-182, 352-359, 422-428. [Continued from v. 10, p. 34, and continues in Suppl. to v. 11, p. 489.]
- Purple-spotted Gudgeon (*Mogurnda mogurnda*)
  - Richardson J. 1844-48. Ichthyology of the voyage of HMS Erebus & Terror. In: J Richardson and JE Gray. The zoology of the voyage of HHS "Erebus & Terror," under the command of Captain Sir J. C. Ross during 1839-43. London. Ichthyology of the voyage of HMS Erebus & Terror, v. 2 (2): i-viii + 1-139, Pls. 1-60. [1844: 1-16; 1845: 17-52; 1846: 53-74; 1848: i-viii + 75-139 (see Bauchot et al., 1982:66).]
- Mouth-almighty (*Glossamia aprion*)
  - Richardson J. 1842 (for Mar.) Contributions to the ichthyology of Australia. Annals and Magazine of Natural History (New Series) v. 9 (no. 55): 15-31.

Another record of a freshwater (or more precisely, euryhaline) fish species from the Ramsar site was obtained from the Museum and Arts Gallery of the Northern Territory (MAGNT) (the Ox-eye Herring, *Megalops cyprinoides*; pers. comm. Gavin Dally).

Seven conservation dependent estuarine/marine fish species may occur in the site, according to the relative close proximity of records to the Ramsar site (**Appendix B**). Further analyses based on their ecology and regional distribution reveals that four of these possibly, or are likely to occur on the Peninsula (**Table 16**, **Appendix E**).

A total of 465 species of fish, including sharks, manta rays and stingrays, have been recorded in the Cobourg Marine Park (NRETA, 2007). Many of these occur in the intertidal zone and the inshore waters on rocky and coral reefs (NRETA, 2007). The Marine Park is also the type locality for 21 species of fish that were collected between 1838 and 1849 (NRETA, 2007).

Approximately 118 species of elasmobranches (sharks and rays) are known to occur in estuarine areas and the lower reaches of rivers in Australia (Thorburn et al., 2004). Five of these (one ray, one sawfish and three sharks) penetrate further into the upper reaches of rivers (Thorburn et al., 2004). The Freshwater Sawfish, *Pristis microdon*, and the ray, *Himantura chaophraya*, are reported to occur in estuarine and fresh waters, with the former also occurring in coastal marine waters (Thorburn et al., 2004). None have been recorded on the Cobourg Peninsula.

The Speartooth Shark (*Glyphis garricki* (formerly *G.* sp. A)) and Northern River Shark (*Glyphis glyphis* (formerly *G.* sp. C)) are known to inhabit freshwater or marginally saline waters (Thorburn et al., 2004). The Bull Shark (*Carcharhinus leucas*) occurs in both marine and freshwater habitats (Thorburn et al., 2004).

Table 16 Likelihood of Occurrence for Conservation Significant Fish not Previously Recorded in the Ramsar Site

Species	Common Name	Conservation Status			Likelihood of Occurrence
		TPWC Act	EPBC Act	IUCN	
Glyphis garricki	Northern River Shark	EN	EN	EN	Unlikely
Glyphis glyphis	Speartooth Shark	VU	CR	CR	Possible
Pristis clavata	Dwarf Sawfish	VU	-	CR	Possible
Pristis microdon	Freshwater Sawfish	VU	VU	CR	Possible
Pristis zijsron	Green Sawfish	VU	-	CR	Possible

Species	Common Name	Conservation Status			Likelihood of Occurrence
		TPWC Act	EPBC Act	IUCN	
Carcharias taurus	Grey Nurse Shark	DD	VU	-	Possible

Table 17 Northern Territory Records for Conservation Significant Freshwater Sharks and Rays (Thorburn et al., 2004)

Author	Survey Year	*Glyphis* sp.	*Glyphis glyphis*	*Glyphis garricki*	*Pristis microdon*	*Himantura chaophraya*
Whitley	1945				No river specified	
Midgley (in Larson, 1999)	1981				Keep River	
Bishop et al., 1986	1986				Alligator River	
Taniuchi et al., 1991	1989	Adelaide, West Alligator Rivers				
Larson, 1999	1999				Keep River	
Larson, 2000	1999	East, West, South Alligator Rivers				
Pers. comm. Berra, in Thorburn et al., 2004	2001		Adelaide River	Adelaide River		
Last, 2002	2002			South Alligator River		Alligator River
Thorburn et al., 2004 (includes records from MAGNT)	2002			Adelaide and East Alligator Rivers	Adelaide, Daly, Roper, McArthur, Wearyan, Robinson, East Alligator and Goomadeer Rivers	Daly and Roper Rivers

6.2.1.2.2 Macroinvertebrates

There are no records of freshwater or marine/coastal invertebrates in the NT Fauna Atlas for the Ramsar site (**Appendix B**). Very few invertebrate species are listed on State or Commonwealth threatened species lists (pers. comm. G. Vinall, 2010). There is a paucity of information on wetland dependent invertebrates that occur in freshwater (including lacustrine, palustrine, spring and estuarine) wetlands of the Cobourg Peninsula. As such, discussion will focus on data collected in the field and using the identified community assemblages as ecological indicators rather than the conservation status of individual taxa.

Several species of bivalve were recorded in mangrove areas in Popham Bay during surveys in 1994 (PWCNT, 1995). Mud Crabs (*Scylla serrata*) are abundant in the intertidal zones (NRETA, 2007).

Whilst not a focus of this study, a marine/estuarine invertebrate fauna inventory of Cobourg Marine Park includes approximately ten to 15 species of bryozoans, 300 species of annelids, 75 species of crustaceans, 331 species of molluscs and 100 species of echinoderms, all described (Blackburn, 1974; NRETA, 2007). Many other collected specimens are yet to be described. Marcia Clams (*Veneridae*) and Wedge Shells (*Donacidae*) are found in inshore coarse clean sands (wetland type A) in Popham Bay (PWCNT, 1995). Mud Creepers (*Potamididae*, *Cerithiidae*) and Comb Starfish (*Luidiidae*) are found in inshore muddy sands (wetland type A) in Popham Bay (PWCNT, 1995).

The habitat of the inshore waters of the Marine Park between Vashon Head and Danger Point (Gul Gul), including Port Bremmer and the bays of Port Essington, has been surveyed. Of the areas surveyed, the fringing rocky and coral reefs, and oyster beds have been studied in detail. The structure of the rocky and fringing coral reefs within the Marine Park is typical of northwest inshore waters.

6.2.1.2.3 Amphibians

The NT Fauna Atlas contains records of 18 species of amphibians from the Ramsar site (**Appendix B**). Three of these, Giant Frog (*Litoria australis*), Northern Dwarf Tree-frog (*Litoria bicolor*) and the Northern Territory Frog (*Austrochaperina adelphe*), are listed as Data Deficient under the TPWC Act. Cogger and Lindner (1974) recorded 13 amphibians, of which one, *Sphenophryne robusta*, is only known from Queensland. This specimen is possibly *Austrochaperina (Sphenophryne) adelphe*, though has not been included due to the uncertainty of the record. No conservation significant amphibian species have been recorded.

6.2.1.2.4 Reptiles

The NT Fauna Atlas contains records for 29 species of wetland dependent reptiles from the Ramsar site (**Appendix B**). This includes one crocodile, six marine turtles, two freshwater turtles, one dragon, three monitors, four colubrids (rear-fanged snakes), two pythons and ten sea snakes. Nine conservation significant reptile species have been recorded on the site (**Table 18**).

Cogger and Lindner (1974) recorded 43 reptiles in the Port Essington area. This includes ten that are considered wetland-dependent (**Appendix B**).

Saltwater Crocodiles are abundant in the Ramsar site, though population counts have not been undertaken (NRETA, 2007).

Table 18 Wetland Dependent Reptiles Species of Conservation Significance Known to Occur in the Ramsar Site

Species	Common Name	Conservation Status			NT Fauna Atlas
		TPWC Act	EPBC Act	IUCN	
Caretta caretta	Loggerhead Turtle	EN	EN	EN	✓
Chelonia mydas	Green Turtle	LC	VU	EN	✓
Dermochelys coriacea	Leatherback Turtle	VU	VU	CR	✓
Eretmochelys imbricata	Hawksbill Turtle	DD	VU	CR	✓
Lepidochelys olivacea	Olive Ridley	DD	EN	VU	✓
Natator depressus	Flatback Turtle	DD	VU	DD	✓
Varanus panoptes	Floodplain Monitor	VU	-	-	✓
Varanus indicus	Mangrove Monitor	NT	-	-	✓
Varanus mertensi	Mertens' Water Monitor	VU	-	-	✓

6.2.1.2.5 Birds

The NT Fauna Atlas contains records of 153 species of wetland dependent bird species in the Ramsar site (**Appendix B**). Review of literature reveals a further four species have been recorded in or near the site (this includes the wetlands of Murganella and Salt Water Creeks outside the Ramsar site) (Frith and Hitchcock, 1974; Chatto, 2006). Frith and Hitchcock (1974) recorded 99 bird species in the Ramsar site. All are typical of sub-coastal areas of the NT.

Seven conservation significant species (under the TPWC Act, EPBC Act or the IUCN Red List) have been recorded (**Table 19**). There are no large numbers of waterbirds or significant aggregations of shorebirds known from the site (Chatto, 2003; 2006). The mangrove system between Minimini Creek and Ilamaryi Creek is reported to be among the most important breeding sites for Radjah Shelduck in Australia (SCRSR, undated, in Chatto, 2006).

Table 19 Wetland Dependent Bird Species of Conservation Significance Known to Occur in the Ramsar Site

Species	Common Name	Conservation Status			NT Fauna Atlas
		TPWC Act	EPBC Act	IUCN	
Acrocephalus australis	Australian Reed-Warbler	NT	-	LC	✓
Esacus magnirostris	Beach Stone-curlew	LC	-	NT	✓
Ephippiorhynchus asiaticus	Black-necked Stork	LC	-	NT	✓
Limosa limosa	Black-tailed Godwit	LC	-	NT	✓
Numenius madagascariensis	Eastern Curlew	LC	-	VU	✓
Calidris tenuirostris	Great Knot	LC	-	VU	✓
Amaurornis moluccana	Pale-vented Bush-hen	NT	-	LC	✓

6.2.1.2.6 Mammals

The NT Fauna Atlas contains records for 16 wetland dependent mammal species recorded in inland or estuarine systems in the Ramsar site (**Appendix B**). Review of literature reveals an additional two species have been recorded. Of the total, six are conservation significant (in the TPWC Act, EPBC Act or the IUCN Red List) (**Table 20**). Three wetland dependent introduced mammal species have been recorded.

Dugongs are found in most areas of the Cobourg Marine Park, especially between Aiton Bay and Wurgurlu Bay, and surrounding Greenhill Island (NRETA, 2007). Estimated densities range up to 20 individuals per square kilometre with a total population of over 1000 (NRETA, 2007). The Cobourg Marine Park is considered to be one of the most significant areas for Dugong in the NT (NRETA, 2007).

Cetaceans are common within the Cobourg Marine Park, though little is known about their distribution, abundance and genetic composition (NRETA, 2007).

A study conducted from 1965 to 1966 (Calaby and Keith, 1974) recorded 25 native and six introduced mammal species. This includes species that may not be relevant to this study (i.e. those not wetland dependent).

Table 20 Wetland Dependent Mammal Species of Conservation Significance Known to Occur in Inland or Coastal Wetland Systems in the Ramsar Site

Species	Common Name	Conservation Status			NT Fauna Atlas
		TPWC Act	EPBC Act	IUCN	
Bos javanicus	Banteng	INT	-	EN	✓
Conilurus penicillatus	Brush-tailed Rabbit-rat	VU	-	NT	✓
Dugong dugon	Dugong	NT	Mig, Mar	VU	✓
Orcaella heinsohni	Australian Snubfin Dolphin	LC	-	NT	✓
Sousa chinensis	Indo-Pacific Humpbacked Dolphin	LC	Mig	NT	✓
Xeromys myoides	Water Mouse	DD	VU	VU	✓

6.3 Flora and Fauna Survey

Sampling undertaken during the mid dry season targeted flora, fish, macroinvertebrates, birds and physicochemical water properties (**Table 3**). Surveys undertaken during the late dry season targeted physicochemical water properties only. Other wetland dependent fauna (e.g. mammals, reptiles) were opportunistically recorded during each survey period.

6.3.1 Flora

6.3.1.1 Marine/Coastal Wetlands

Twenty-one species of flora was recorded during the mid dry and late dry season surveys of marine/coastal wetland sites (**Appendix F**). One species, *Xylocarpus granatum*, listed as Near Threatened under the TPWC Act, was recorded at site M5.

6.3.1.2 Inland Wetlands

Ninety-four terrestrial and aquatic plants were recorded at inland wetland sites (**Appendix F**). No species considered to be conservation significant were recorded. One species, *Nymphoides exiliflora*, listed as Data Deficient, was found at site I3. Three species (the palms *Carpentaria acuminata* and *Hydriastele ramsayi*, and *Corymbia porrecta* (Grey Bloodwood)) are endemic to the NT. The greatest number of species recorded were at site I7 (34 species) followed by site I3 (27 species) and site I6 (26 species). The lowest plant species diversity was at site I4 (six species).

Arranged by growth habit, plant species diversity was as follows:

- 27 tree species
- eight shrub species
- 22 herbaceous species
- ten grass/grass like species
- one epiphyte species
- two floating species
- nine emergent (from water) species
- three submerged species
- two parasite species
- ten vine/scrambler species.

Each of the freshwater wetlands were either dominated or fringed by a *Melaleuca* tree species. Four of the sites were also dominated by an *Eleocharis* or *Schoenoplectus* sedge species. The two spring-fed wetlands (I6 and I7) had a dense wet monsoon forest community where trees were the dominant life form. Floating macrophytes were generally rare or uncommon and were absent from four of the nine sites. Submerged macrophytes were also absent at most sites. The only common occurrence of a submerged plant was at site I2 (permanent saline lake), where the algae *Chara* (stonewort) was dominant, but covered in unidentified microalgae. At sites I1 (seasonal brackish lake) and I2 (permanent saline lake), large areas of the open water were covered in a floating mat, consisting of a freshwater sponge (80%), *Chara* sp. (algae) (15%) and other algae species (5%).

6.3.2 Fish

6.3.2.1 Marine/Coastal Wetlands

Thirty-eight species of fish were recorded during the mid dry and late dry season surveys of marine/coastal wetlands (**Appendix G**).

6.3.2.1.1 Mid Dry Season

Thirty-five fish species were identified from 199 individuals either captured or observed during the mid dry season surveys of marine/coastal wetlands (**Appendix G**). Twenty of these species are in addition to those recorded by Gomelyuk (2003; 2008).

Due to constraints associated with time and the fish survey methods available, relatively low numbers of fish and diversity of fishes were recorded. Consequently, it is likely that the species listed in **Appendix G** reflect only a fraction of those species utilising the habitats sampled. Nevertheless, important ecological information was

obtained on a number of fish species, including those likely to be considered keystone species in the Cobourg Peninsula.

No conservation significant species listed under the TPWC or EPBC Acts were recorded. One species (Giant Groper (*Epinephelus lanceolatus*)) listed as Data Deficient under the TPWC Act was recorded at site M1 (estuarine waters). Five conservation significant fish listed on the IUCN Red List were recorded (**Table 21**).

The Talang Queenfish (*Scomberoides commersonnianus*) comprised 15% of the catch in this study. Due to its large size, the Talang Queenfish also represents a significant part of the fish biomass encountered.

Table 21 Conservation Significant Fish Recorded during Mid Dry Season Surveys of Marine/Coastal Wetland Sites

Species Name	Common Name	Conservation Status		
		TPWC Act	EPBC Act	IUCN Red List
*Carcharhinus melanopterus**	Blacktip Reef Shark	LC	-	NT
Carcharhinus sorrah	Spot-tail Shark	LC	-	NT
*Epinephelus lanceolatus^*	Giant Groper	DD	-	VU
Glossogobius biocellatus	Estuary Goby	NE	-	LR / NT
*Negaprion acutidens**	Lemon Shark	LC	-	VU

* = recorded previously in Port Essington in sandy bank, rock reef or coral reef by Gomelyuk (2008); ^ = recorded previously in at Black Point area and adjacent water of Garig Gunak Barlu National Park in Gomelyuk (2003); LC = Least Concern; NT = Near Threatened; DD = Data Deficient; NE = Not Evaluated; LR = Lower Risk; VU = Vulnerable.

6.3.2.1.2 Late Dry Season

Nine fish species were opportunistically recorded during the late dry season surveys of marine/coastal wetlands (**Appendix G**). This includes the Blacktip Reefshark (*Carcharhinus melanopterus*) listed as Near Threatened on the IUCN Red List.

6.3.2.2 Inland Wetlands

Five fish species were recorded during the mid dry season surveys of inland wetland sites (**Table 22**). None were recorded during the late dry season surveys. Sites I5 and I8 were dry and could not be sampled for fish. Sites I1 and I2 contained saline/brackish water (**Table 22**) and no fish were recorded. The high salinity of these waters (even if seasonal or intermittent) would inhibit the recruitment of many freshwater fish species and the majority would not be expected to be present.

At I3, the Empire Gudgeon (*Hypseleotris compressa*) was found to be common, but no other species was observed or captured. Extensive dip netting of several wallows at I4 failed to capture any fish. Cast and dip netting of the freshwater spring site, I6, captured numerous Poreless Gudgeons (*Oxeleotris nullipore*) and a single specimen of a Swamp Eel (*Ophisternon guttural*). The remaining freshwater spring site, I7, was the richest site with three fish species observed. Black-striped Rainbowfish (*Melanoteania nigrans*) and Poreless Gudgeons (*Oxeleotris nullipore*) were both abundant, and easily observed and captured by dip and cast netting. The Spotted Blue Eyes (*Pseudomugil gertrudae*) were uncommon, with only a few individuals observed. The high density of *Eleocharis* in the littoral zones of site M20 (~90% areal cover) prevented access to the central open waters, and meant that only dip netting could be undertaken. While, no fish were observed and nor captured, it cannot be assumed that fish did not occur in the more favourable open waters at the site.

The three dominant fish species found in the springs, *M. nigrans, O. nullipora* and *P. gertrudae* are small-bodied planktivores that are intolerant of saline conditions (Pusey et al., 2004). Given this observation, none of the species would be expected to occur at sites I1 and I2. The Swamp Eel can tolerate brackish conditions and can also survive short periods out of water (Allen et al., 2002). The sole fish species found in the small stream, *H. compressa*, is common in the lower reaches of rivers and can tolerate salinity equal to sea water (Allen et al., 2002). The tiny fry form part of the plankton community in estuaries and as they mature, the adults form schools that migrate inland to freshwater (Schmida, 1984).

Table 22 Abundance of Fish Species and Mean Electrical Conductivity Recorded during the Mid Dry Season Survey of Inland Wetlands

Site	Mean Electrical Conductivity (mS/cm)	Species	Abundance
I1	7.9	None	n/a
I2	21.6	None	n/a
I3	0.1	*Hypseleotris compressa*	Common
I4	2.3	None	n/a
I5	Dry	None	n/a
I6	0.0	*Oxeleotris nullipora* *Ophisternon gutturale*	Common Rare
I7	0.0	*Melanoteania nigrans* *Oxeleotris nullipora* *Pseudomugil gertrudae*	Abundant Abundant Uncommon
I8	Dry	None	n/a

6.3.3 Macroinvertebrates

6.3.3.1 Marine/Coastal Wetlands

A total of 1,125 individual benthic macroinvertebrates from 84 families were recorded during the mid dry season surveys of marine/coastal wetland sites (**Appendix I**). The location of the 12 marine sampling sites is shown in **Figure 35**.

There was a substantial variability in total abundance and family richness in sites sampled across Cobourg Peninsula (**Figure 37**). Total abundance ranged from three to 257 individuals. The number of families ranged from three to 24.

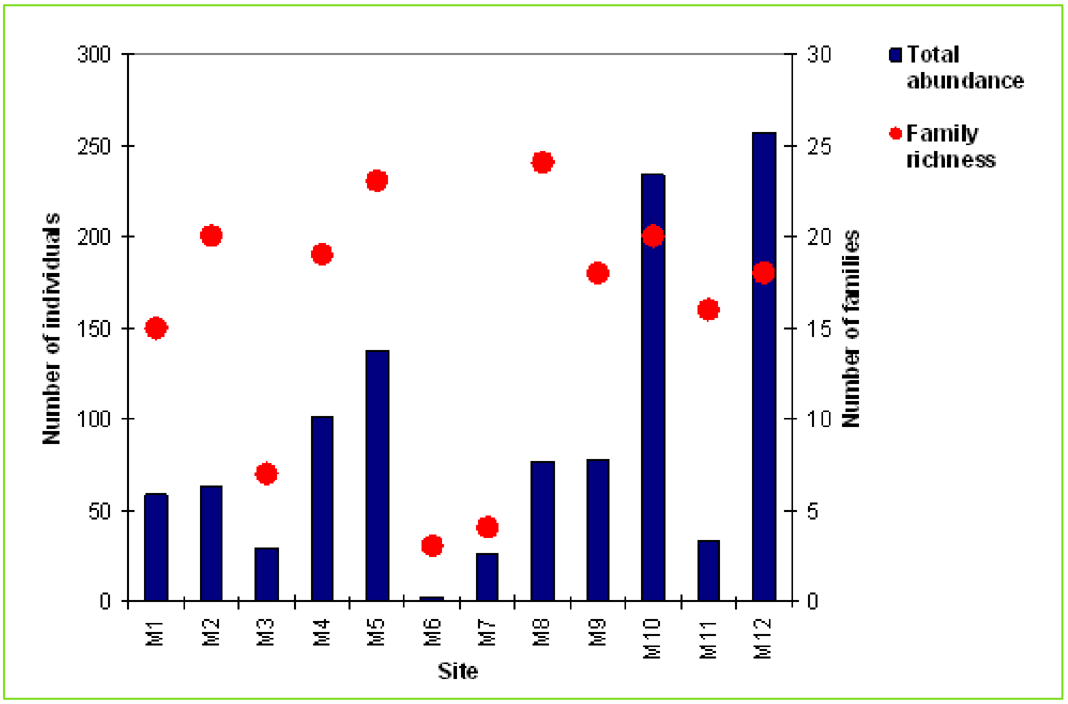

Figure 37 Abundance of Benthic Macroinvertebrates and Family Richness in Marine/Coastal Wetland Sites

6.3.3.2 Inland Wetlands

Macroinvertebrates were subsampled, sorted and identified from duplicate samples representing each of six of the nine inland wetland sites sampled in the July and August 2010 survey. Sampling dates and subsampling details are shown in **Table 13**. At least 222 species were identified from 56 (sub) families or higher taxonomic levels (**Appendix J**). Estimated total abundance in the samples varied substantially, from 460 to over 47,000 (**Figure 38**). Sites I2, I3 and I4 recorded particularly low sample abundances relative to other sites which may correspond to the disturbed nature of sites 2 (affected by saltwater intrusion) and 4 (high turbidity) or the seasonal nature only of surface waters at site 3. A large amount of variation (60%) in taxa richness (**Figure 39**) could be accounted for by salinity; thus, for log transformed electrical conductivity (EC) data (derived from **Table 49**) a highly significant negative correlation was observed between taxa richness and log EC (Pearson correlation -0.775, P<0.01) (**Figure 39**). Similar (negative) responses of invertebrates to high EC have been recorded for locations in inland Australia affected by dryland salinity (e.g. Mitchell and Richards 1992).

Macroinvertebrate community patterns and indicator species are discussed in **Section 6.4**.

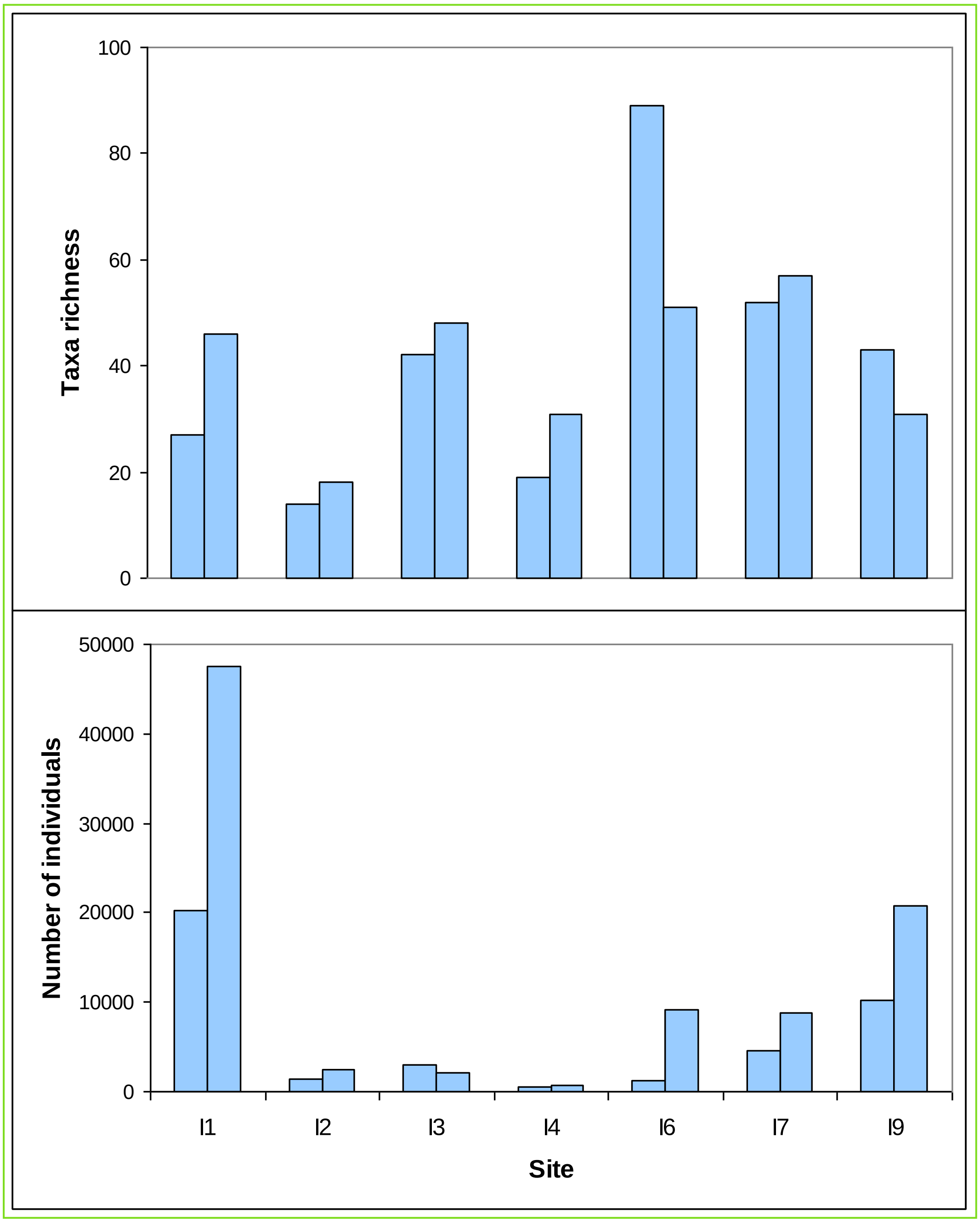

Figure 38 Abundance and Taxa Richness of Benthic Macroinvertebrates from Inland Wetland Sites

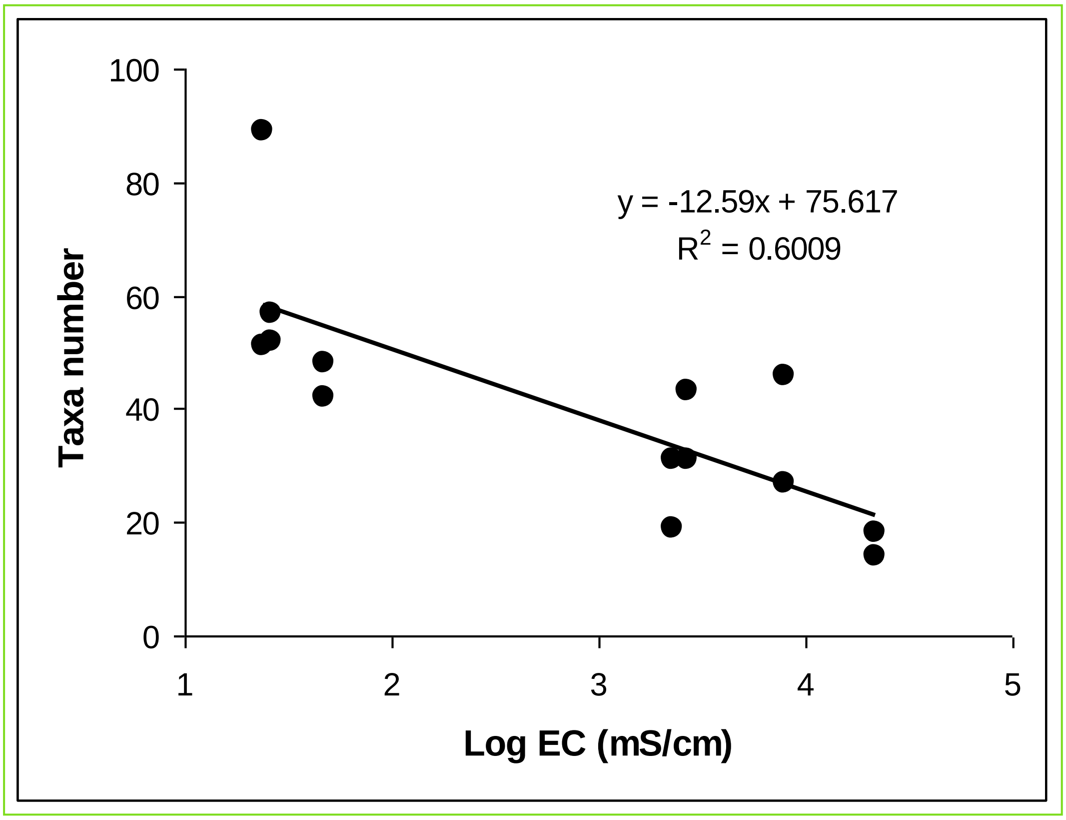

Figure 39 Relationship Between Taxa Richness of Benthic Macroinvertebrates from Inland Wetland Sites and Corresponding Electrical Conductivity of the Surface Waters

6.3.4 Amhibians

6.3.4.1 Marine/Coastal Wetlands

No amphibians were recorded during the mid dry and late dry season surveys of marine/coastal wetland sites.

6.3.4.2 Inland Wetlands

Seven species of amphibian were observed during the mid dry and late dry season surveys of inland wetland sites (**Appendix H**). This includes the Data Deficient species, *Litoria bicolor*. No conservation significant amphibian species were recorded.

6.3.5 Reptiles

6.3.5.1 Marine/Coastal Wetlands

Seven reptile species were recorded during the mid dry and late dry season surveys of marine/coastal wetland sites.

6.3.5.1.1 Mid Dry Season

Six reptile species were recorded during the mid dry season surveys of marine/coastal wetland sites (**Appendix G**). This includes three marine turtle species (Green Turtle (*Chelonia mydas*), Hawksbill Turtle (*Eretmochelys imbricata*), and the Flatback Turtle (*Natador depressus*)), one crocodile species (Saltwater Crocodile (*Crocodylus porosus*)), one skink species (Striped Rainbow Skink (*Carlia munda*)) and one dragon species (Two-lined Dragon (*Diporiphora bilineata*)).

6.3.5.1.2 Late Dry Season

Two reptile species were recorded during the late dry season surveys of marine/coastal wetland sites, potentially reflecting a lower survey effort compared to the mid dry season survey. This included the Saltwater Crocodile (*Crocodylus porosus*), listed as Migratory under the EPBC Act, and the Loggerhead Turtle (*Caretta caretta*), listed as Endangered, Marine and Migratory under the EPBC Act.

6.3.5.2 Inland Wetlands

Nine species of reptiles were recorded during the mid dry and late dry season surveys of inland wetland sites (**Appendix H**).

6.3.5.2.1 Mid Dry Season

Nine reptile species were recorded during the mid dry season surveys of inland wetland sites (**Appendix H**). This includes one listed Migratory and Marine species listed under the EPBC Act (Saltwater Crocodile (*Crocodylus porosus*)). One introduced reptile species was recorded (Asian House Gecko (*Hemidactylus frenatus*)).

6.3.5.2.2 Late Dry Season

Three reptile species were recorded during the late dry season surveys of inland wetland sites (**Appendix H**). One introduced reptile species was recorded (Asian House Gecko (*Hemidactylus frenatus*)).

6.3.6 Birds

6.3.6.1 Marine/Coastal Wetlands

Seventy-eight bird species were recorded during the mid dry and late dry season surveys of marine/coastal wetland sites (**Appendix G**).

6.3.6.1.1 Mid Dry Season

Fifty-six bird species were recorded during the mid dry season survey of marine/coastal wetland sites (**Appendix G**). No conservation significant terrestrial species listed under the EPBC Act or TPWC Act were recorded. Twenty two EPBC Act listed Migratory bird species and 28 EPBC Act listed Marine bird species were recorded (**Table 23**). Thirteen species are protected under international Migratory Bird Agreements, including the Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

Table 23 Bird Species listed as Migratory (Mig) or Marine (Mar) or Protected under International Migratory Bird Agreements Recorded during the Mid Dry Season Survey of Marine/Coastal Wetland Sites

Species	Common Name	Mig	Mar	J*	C*	R*
Ardea alba modesta	Great Egret	✓	✓	✓	✓	
Ardea intermedia	Intermediate Egret		✓			
Calyptorhynchus banksii macrorhynchus	Red-tailed Black-cockatoo	✓				
Charadrius ruficapillus	Red-capped Plover	✓	✓			
Coracina papuensis	White-bellied Cuckoo-shrike		✓			
Egretta garzetta	Little Egret		✓			
Egretta sacra	Eastern Reef Egret	✓	✓		✓	
Esacus neglectus	Beach Stone-curlew		✓			
Falco berigora	Brown Falcon	✓				
Fregata ariel	Lesser Frigatebird	✓	✓	✓	✓	✓
Grus rubicund	Brolga	✓				
Haliaeetus leucogaster	White-bellied Sea-Eagle	✓	✓		✓	
Haliastur Indus	Brahminy Kite	✓	✓			
Haliastur sphenurus	Whistling Kite	✓	✓			
Larus novaehollandiae	Silver Gull		✓			
Merops ornatus	Rainbow Bee-eater	✓	✓			
Numenius phaeopus	Whimbrel	✓	✓	✓	✓	✓
Nycticorax caledonicus	Nankeen Night Heron		✓			
Pandion haliaetus	Osprey	✓	✓			
Pelecanus conspicillatus	Australian Pelican		✓			
Pluvialis squatarola	Grey Plover	✓	✓	✓	✓	✓
Sterna albifrons	Little Tern	✓	✓	✓	✓	✓
Sterna anaethetus	Bridled Tern	✓	✓	✓	✓	
Sterna bergii	Crested Tern		✓	✓		
Sterna hirundo	Common Tern	✓	✓	✓	✓	✓
Sula leucogaster	Brown Booby	✓	✓	✓	✓	✓
Threskiornis molucca	Australian White Ibis		✓			
Todiramphus sanctus	Sacred Kingfisher		✓			

Species	Common Name	Mig	Mar	J*	C*	R*
Xema sabini	Sabine's Gull		✓			

* Protected under International Bird Agreements: (J) Japan-Australia Migratory Bird Agreement, (C) China-Australia Migratory Bird Agreement, (K) Republic of Korea-Australia Migratory Bird Agreement

6.3.6.1.2 Late Dry Season

Fifty-one bird species were recorded during the late dry season survey in marine/coastal wetlands. No conservation significant species were recorded. Eighteen Migratory species and 25 Marine species, listed under the EPBC Act, were recorded. Fourteen species are protected under international Migratory Bird Agreements, including the Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

Table 24 Bird Species listed as Migratory (Mig) or Marine (Mar) or Protected under International Migratory Bird Agreements Recorded during the Late Dry Season Survey of Marine/Coastal Wetland Sites

Species	Common Name	Mig	Mar	J*	C*	R*
Actitis hypoleucos	Common Sandpiper	✓	✓	✓	✓	✓
Anseranas semipalmata	Magpie Goose		✓			
Ardea intermedia	Intermediate Egret		✓			
Arenaria interpres	Ruddy Turnstone	✓	✓	✓	✓	✓
Calidris tenuirostris	Great Knot	✓	✓	✓	✓	✓
Charadrius leschenaultii	Greater Sand Plover	✓	✓	✓	✓	✓
Charadrius mongolus	Lesser Sand Plover	✓	✓	✓	✓	✓
Chroicocephalus novaehollandiae	Silver Gull		✓			
Egretta sacra	Eastern Reef Egret	✓	✓		✓	
Esacus neglectus	Beach Stone-curlew		✓			
Fregata ariel	Lesser Frigatebird	✓	✓	✓	✓	✓
Gelochelidon nilotica	Gull-billed Tern	✓				
Haliaeetus leucogaster	White-bellied Sea-Eagle	✓	✓		✓	
Haliastur Indus	Brahminy Kite	✓	✓			
Haliastur sphenurus	Whistling Kite	✓	✓			
Merops ornatus	Rainbow Bee-eater	✓	✓			
Numenius madagascariensis	Eastern Curlew	✓	✓	✓	✓	✓
Nycticorax caledonicus	Nankeen Night Heron		✓			
Pandion haliaetus	Osprey	✓	✓			
Pluvialis fulva	Pacific Golden Plover	✓	✓	✓	✓	✓

Species	Common Name	Mig	Mar	J*	C*	R*
Sterna albifrons	Little Tern	✓	✓	✓	✓	✓
Sterna bergii	Crested Tern		✓	✓		
Sula leucogaster	Brown Booby	✓	✓	✓	✓	✓
Threskiornis molucca	Australian White Ibis		✓			
Todiramphus macleayii	Forest Kingfisher		✓			
Xenus cinereus	Terek Sandpiper	✓	✓	✓	✓	✓

* Protected under International Bird Agreements: (J) Japan-Australia Migratory Bird Agreement, (C) China-Australia Migratory Bird Agreement, (K) Republic of Korea-Australia Migratory Bird Agreement

6.3.6.2 Inland Wetlands

Seventy-seven bird species were observed during the mid dry and late dry season surveys of inland wetland sites (**Appendix H**).

6.3.6.2.1 Mid Dry Season

Sixty-four bird species were recorded during the mid dry season survey (**Appendix H**). One species of conservation significance and 13 species listed as Migratory under the EPBC Act were recorded (**Table 25**). The Whistling Kite was encountered at the greatest number of sites (seven sites), followed by the Rainbow Bee-eater (four sites). Only one of the nine sites visited did not contain any Migratory species. The abundance of Migratory species across the site was generally low. The greatest abundance of Migratory species was found at site I2 (seven species).

Three Partridge Pigeons (Vulnerable (EPBC Act) were seen at site I3 drinking from the water's edge. The Chestnut-backed Button-quail was seen while commuting between sites, but the location suggests that this species is not wetland dependent.

Table 25 Bird Species listed as Migratory (Mig) or Marine (Mar) or Protected under International Migratory Bird Agreements Recorded During the Mid Dry Season Survey of Inland Wetland Sites

Species	Common Name	Mig	Mar	J*	C*	R*
Accipiter cirrhocephalus	Collared Sparrowhawk	✓				
Anas superciliosa	Pacific Black Duck	✓				
Ardea alba	Great Egret		✓			
Ardea intermedia	Intermediate Egret		✓			
Ardea modesta	Eastern Great Egret	✓	✓	✓	✓	
Aviceda subcristata	Pacific Baza	✓				
Dendrocygna arcuata	Wandering Whistling-Duck	✓	✓			
Ducula bicolor	Pied Imperial Pigeon		✓			
Falco berigora	Brown Falcon	✓				
Fregata ariel	Lesser Frigatebird	✓	✓	✓	✓	✓
Grus rubicunda	Brolga	✓				
Haliastur indus	Brahminy Kite	✓	✓			
Haliastur sphenurus	Whistling Kite	✓	✓			
Merops ornatus	Rainbow Bee-eater	✓	✓	✓		
Plegadis falcinellus	Glossy Ibis	✓	✓		✓	
Stiltia isabella	Australian Pratincole		✓			
Tadorna radjah	Radjah Shelduck	✓	✓			
Threskiornis molucca	Australian White Ibis		✓			
Todiramphus macleayii	Forest Kingfisher		✓			
Todiramphus sanctus	Sacred Kingfisher		✓			

* Protected under International Bird Agreements: (J) Japan-Australia Migratory Bird Agreement, (C) China-Australia Migratory Bird Agreement, (K) Republic of Korea-Australia Migratory Bird Agreement

6.3.6.2.2 Late Dry Season

Forty bird species were recorded during the late dry season survey of inland wetlands. Ten species listed as Migratory under the EPBC Act were recorded. The Great Egret, Whistling Kite and White-bellied Sea-eagle were all encountered at three sites, the most of any migratory species. The Great Egret was the most abundant encountered (five individuals). The greatest abundance of Migratory species was found at site I2, with eight individuals recorded comprising four species.

Table 26 Bird Species listed as Migratory (Mig) or Marine (Mar) or Protected under International Migratory Bird Agreements Recorded During the Late Dry Season Survey of Inland Wetland Sites

Species	Common Name	Mig	Mar	J*	C*	R*
Accipiter fasciatus	Brown Goshawk	✓				
Anseranas semipalmata	Magpie Goose	✓	✓			
Ardea alba	Great Egret	✓	✓	✓	✓	
Ardea intermedia	Intermediate Egret		✓			
Dendrocygna arcuata	Wandering Whistling Duck	✓	✓			
Dicrurus bracteatus	Spangled Drongo		✓			
Gelochelidon nilotica	Gull-billed Tern		✓			
Grus rubicunda	Brolga	✓				
Haliaeetus leucogaster	White-bellied Sea-eagle	✓	✓		✓	
Haliastur sphenurus	Whistling Kite	✓	✓			
Himantopus himantopus	Black-winged Stilt		✓			
Plegadis falcinellus	Glossy Ibis	✓	✓		✓	
Tadorna radjah	Radjah Shelduck	✓	✓			
Threskiornis molucca	Australian White Ibis		✓			
Todiramphus macleayii	Forest Kingfisher		✓			
Todiramphus sanctus	Sacred Kingfisher		✓			
Tringa stagnatilis	Marsh Sandpiper	✓	✓	✓	✓	✓

* Protected under International Bird Agreements: (J) Japan-Australia Migratory Bird Agreement, (C) China-Australia Migratory Bird Agreement, (K) Republic of Korea-Australia Migratory Bird Agreement

6.3.7 Mammals

6.3.7.1 Marine/Coastal Wetlands

Five species of mammal were recorded during the mid dry and late dry season surveys of marine/coastal wetland sites (**Appendix G**). This includes one species (Indo-pacific Humpback Dolphin (*Sousa chinensis*)) listed as Migratory under the EPBC Act and Near Threatened under the IUCN Red List.

6.3.7.2 Inland Wetlands

Seven species of mammal were recorded during the mid dry and late dry season surveys of inland wetland sites (**Appendix H**). This includes the Brush-tailed Rabbit-rat (*Conilurus penicilatus*) which is listed as Vulnerable under the TPWC Act and EPBC Act and as Near Threatened under the IUCN Red List. Five introduced mammals were recorded.

6.4 Trophic Levels and Significant Processes, Species, Populations and Communities

Most of the inland wetlands examined showed evidence of modification as a result of extreme weather events (e.g. tropical Cyclone Ingrid in 2005). These modifications include tree fall, influx of saline water (possibly through storm surge), and tree death from increased salinity levels and possibly increased permeability of the wetland, reducing its ability to retain water. The negative correlation observed between macroinvertebrate species richness and degree of salinity of the inland waterbodies, as well as the absence of fish in waterbodies with high salinity, are direct indicators of the responses of the biota to such cyclonic disturbances. These wetland systems are likely to have been subjected to similar forces in the past, and may be expected to undergo a slow transition back to pre-cyclone conditions and species assemblages as successive wet seasons progressively flush salt out of the system and salt-sensitive species regain dominance. It is reasonable to expect that flora and fauna assemblages are also in a state of flux.

Evidence of changes in wetland condition can be derived from the literature. Previous flora and fauna studies undertaken prior to 1974 (Frith and Calaby 1974) recorded large numbers of waterbirds at Banteng Lagoon on Danger Point, now known as Gul Gul. This included:

- Pied Heron (nine seen in 1961)
- Great Egret (‘scores’ in 1961)
- Australian White Ibis (50 in 1968)
- Glossy Ibis (20 in 1961)
- Magpie Goose (5000 in 1961, 1000 in 1968)
- Green Pygmy Goose (10 in 1968)
- Wandering Whistling Duck (150 in 1961)
- Radjah Shelduck (20 in 1961)
- Pacific Black Duck (50 in 1961)
- Brolga (30 in 1961, 50 in 1968).

Surveys of the same wetland during the present survey found the situation had substantially changed. There was a marked absence of submerged and emergent wetland plants, and the fringing vegetation showed numerous dead *Melaleuca* trees and an abundance of young mangroves. Birds were scarce, and those species present (e.g. Black-necked Stork, Lesser Sand Plover, Silver Gull, Gull-billed Tern and Caspian Tern) are often associated with marine environments. No individuals were observed of any of the waterbirds recorded in the 1961 and 1968 surveys.

Notwithstanding these transitions, plant-animal interactions and interactions between fauna species continue, and most wetlands support species that could be regarded as being ‘keystone’ species in their influence over ecosystem health and functioning of the whole community. Species that exert the greatest influence over communities are often the most abundant, although in some instances it is biomass, rather than abundance that may have the greatest influence.

Some generalisations regarding the nature of food webs in the wet-dry tropics of northern Australia were made by Douglas et al. (2005), who made five broad generalisations:

(1) the seasonal hydrology is a strong driver of ecosystem processes and food web structure
(2) hydrological connectivity is largely intact and underpins important terrestrial- aquatic food web subsidies
(3) river and wetland food webs are strongly dependant on algal production
(4) a few common macroconsumer species have a strong influence on benthic food webs
(5) omnivory is widespread and food chains are short.

Not all of these generalisations are necessarily true for the freshwater wetlands on the Cobourg Peninsula.

6.4.1 Flora

6.4.1.1 Threatened Species

A range of threatened plant species were assessed for their likelihood of occurrence within the Cobourg Peninsula Ramsar site (**Appendix D**). A number of threatened species known to occur in Garig Gunak Barlu National Park (**Appendix C**) are not dependant on wetlands, so will not be discussed any further.

6.4.2 Fauna (Excluding Fish and Macroinvertebrates)

Wetland-dependent fauna observed in the Ramsar site were analysed according to trophic levels and subsequent ecological significance

6.4.2.1 Coastal Freshwater Lagoon (Wetland Type K)

Representative Sites: M20 (Mariah Swamp)

6.4.2.1.1 Trophic Levels and Keystone Species

This wetland was water-filled at the time of visit, though it was evident that water levels were falling. Twenty-six vertebrate fauna species were identified in this wetland type. Considering many species occupy several different positions in the food web, the fauna assemblage consisted of ten levels (**Table 27**). All trophic groups were detected from this site, however, there were no trophic groups with significantly more species present than other trophic levels.

Due to the large size of the lake and difficulties in accessing the site, it was not possible to bring a boat or to sample in the interior portions of the lake. As such, it is not known if fish species occupy the site; however, the number of insectivorous/carnivorous egrets suggests that there may be.

The heterogeneity of vegetation along the extensive perimeter of this lake suggests that multiple trophic pyramids may occur on site. Numbers of water birds were lower than expected for a wetland of this size, suggesting that preferred food resources are scarce. The simplified floristics of the aquatic vegetation may be a response to a sudden increase in salinity which would in turn explain the reduced abundance of waterbirds.

The highest number of species were flying insectivores (eight species), emphasising the importance of arboreal invertebrates in the food web. In particular, Lemon-bellied Flycatcher and Rainbow Bee-eaters were prominent flying insectivores.

6.4.2.1.2 Ecological Significance

This is the largest inland wetland in eastern Cobourg Peninsula. It is therefore unique in all of its parameters. The hydrology of the site is highly complex and this in turn is reflected in the highly heterogeneous nature of the terrestrial fringing vegetation. Due to time constraints, not all of these vegetation communities could be closely assessed, but were instead characterised from distant examination with binoculars. It is likely that a multitude of trophic pyramids exist on site, depending on the salinity tolerance of primary producing species. It should be noted though that the aquatic vegetation (primarily *Eleocharis dulcis*) was fairly consistent throughout the wetland. While this may suggest water quality homogeneity across the wetland, it is more likely to reflect the broad range of environmental tolerances of this sedge species. If elevated salinity levels are the result of a cyclonic event, then monitoring the transition back to a more freshwater system would allow a greater understanding of the types of impacts and influences that could be expected with rising sea levels and increased cyclonic activity as a consequence of global warming.

6.4.2.2 Seasonal Creeks (Wetland Type N)

Representative Site: I3 (Irgul Road)

6.4.2.2.1 Trophic Levels and Keystone Species

Seventeen vertebrate fauna species were identified at this wetland type. Considering many species occupy several different positions in the food web, the fauna assemblage consisted of ten trophic levels (**Table 27**). The absence of any freshwater specialist fish species reinforces the status of this creek as being ephemeral; however, water is obviously present for long enough periods to establish water dependant plants and fauna. Of all wetlands visited this type had the most ground foraging insectivores, mostly amphibians and lizards. The skink *Carlia munda* was common in the area and would be an important insectivore species, as well as prey item for larger carnivores. Half of the trophic levels identified were represented by just a single species. The overall fauna was relatively depauperate, however, this was a snapshot view and there are likely to be other species present within each of the identified trophic pyramids. The water body was too small to provide habitat for waterbirds such as ducks and cormorants, but was still attracting some water dependant species such as Brahminy Kites (a predator of aquatic species) and the Partridge Pigeon, a species that needs to drink fresh water once or twice a day. Most of the fauna observed were bird species utilising resources in the tree canopy rather than in the water itself, however the tree fauna was wetland dependant so even tree foraging bird species were being influenced by the wetland. No species present at this wetland could be regarded as ‘keystone species’. It would require additional data analysis to identify these, if indeed clear candidate species actually exist.

6.4.2.2.2 Ecological Significance

This wetland type had a high abundance of wetland dependant plants and allows for the presence of wetland dependant fauna such as the Javelin Frog, the Brahminy Kite and the Partridge Pigeon which requires daily access to freshwater. Additional freshwater dependant fauna species may be located with additional fauna surveys. The Cobourg Peninsula is generally characterised by a low availability of fresh water, particularly since Cyclone Ingrid modified many of the coastal lakes, pools and marshes. For freshwater dependant species, this wetland type allows their species to persist on the Peninsula until additional rainfall events restore the freshwater values of other salt-impacted wetlands.

6.4.2.3 Permanent Saline Lakes (Wetland Type Q)

Representative Site: I2 (Campsite No. 2 Billabong)

6.4.2.3.1 Trophic Levels and Keystone Species

Twenty-five vertebrate fauna species were identified at wetlands of this type. Considering many species occupy several different positions in the food web, the fauna assemblage consisted of ten trophic levels (**Table 27**). This wetland appears to have originally been freshwater but has since become increasingly saline. There were no fish detected and surprisingly few birds. Bulkuru Sedge (*Eleocharis dulcis*) dominated the water. Brolgas and Feral Pigs were observed using this habitat. Most other vertebrates appeared to be restricted to the fringing lines of *Melaleuca* and young mangroves. Nine bird species could be described as waterbirds, but were in generally low abundance. Intermediate Egrets and Australasian Grebes were the most common waterbirds, but these were scarce considering the size of the water body. This is likely due to an absence of fish and other significant prey items. Thirteen species prey on invertebrates, suggesting they are a major contributor to the food web at this location. There is a high degree of resource partitioning of this food resource amongst vertebrates present. For example, some bare areas were present adjacent to the wetland and Australian Pratincoles were seen utilising this specialised habitat.

The highly brackish nature of the water reduced the attraction of the wetland to mammals such as Agile Wallabies and Feral Pigs, though both were present in small numbers. Estuarine Crocodiles were noted to be using this wetland, but only in the more marine dominated areas to the north. The largest individual (approximately 4.2 m) was noted to move regularly between this wetland and the ocean, though a smaller individual seemed to be a more permanent resident of the wetland. It was unknown whether this was because the wetland could not provide enough food resources or if the wetland provided a sanctuary from rough seas. No evidence of crocodiles was present in the larger wetland area.

Most trophic levels showed a degree of redundancy, though frugivores were noticeably uncommon. Ground foraging insectivores were not recorded, though it is likely that more intensive searching or trapping would identify several lizard species. Similarly, terrestrial carnivores were only represented by Feral Pigs; however, unobserved species such as Dingoes, pythons and other predatory snakes are likely to be present. No species present at this wetland could be regarded as ‘keystone species’. It would require additional data analysis to identify these, if indeed clear candidate species actually exist.

6.4.2.3.2 Ecological Significance

This wetland, though currently species-poor, is unique on Cobourg Peninsula for its high abundance of macrophytic algae (*Chara* sp.). The brackish water, *Melaleuca* dieback and absence of fish are likely to be the cause of low abundance of vertebrates. Additional fauna surveys may be required to reveal if other specialised fauna species are present.

If elevated salinity levels are the result of a cyclonic event, then monitoring the transition back to a more freshwater system would allow a greater understanding of the types of impacts and influences that could be expected with rising sea levels and increased cyclonic activity as a consequence of global warming.

6.4.2.4 Seasonal Brackish/Saline Lakes (Wetland Type R)

Representative Site: I1 (Wuwurdi Swamp)

6.4.2.4.1 Trophic Levels and Keystone Species

Thirty-eight vertebrate fauna species were identified at this wetland type. The bulk of fauna present at this wetland type were invertebrates. Considering many species occupy several different positions in the food web, the fauna assemblage consisted of 11 trophic levels (**Table 27**). All trophic levels present were represented by multiple species, with the exception of ground foraging carnivores, represented only by Feral Pigs. Other species such as

snakes, goannas and Dingoes would likely be present but were not recorded. The most abundant vertebrate recorded was the Northern Dwarf Tree Frog (*Litoria bicolor*). It is a ground foraging insectivore that was abundant amongst *Eleocharis* sedges. Amongst the *Melaleuca* trees on the dry bank, the Northern Water Dragon (*Lophognathus temporalis*) was the dominant insectivore, though it is only one of 25 vertebrate species recorded that utilise this resource. The most common terrestrial insectivorous birds are Lemon-bellied Flycatchers and Leaden Flycatchers. Pied Cormorants and, to a lesser degree Intermediate Egrets, should be considered to be an important aquatic insectivore and carnivore (of amphibians and fish). Pied Imperial Pigeons and Rose-crowned Fruit Dove are amongst the few frugivores dispersing fruit. Peaceful Doves and Bar-shouldered Doves were both abundant species, providing a food resource for carnivores such as Boobook Owls. Boobook Owls were the only large predator recorded. Pythons and tree snakes would also be predators of birds though none were observed. No species present at this wetland could be regarded as ‘keystone species’.

Melaleuca sp. dominated the banks and through their shade, they exert a strong influence on understorey species. Feral Pigs also exert a significant influence over understorey vegetation, but in a destructive manner. While Agile Wallabies influence grass growth and disperse seeds, they were not in any abundance that would have a significant influence over the community.

6.4.2.4.2 Ecological Significance

This small wetland has recently undergone a demonstrated transition from wetland type Ts (seasonal/intermittent freshwater marshes/pools on inorganic soils) to wetland type R (seasonal/intermittent saline/brackish/alkaline lakes and flats). The Black Point Ranger Station used to draw drinking water from this wetland but is currently too saline to be drinkable.

If elevated salinity levels are the result of a cyclonic event, then monitoring the transition back to a more freshwater system would allow a greater understanding of the types of impacts and influences that could be expected with rising sea levels and increased cyclonic activity as a consequence of global warming.

The cause and ecological function of the floating sponge and algal mats is still to be determined and may be the focus of further ecological studies. The high abundance of filter feeder organisms reveals that there is a high abundance of micro-organisms that are too small to be detected in this study. Their role in the ecology of this wetland is yet to be understood.

6.4.2.5 Seasonal Freshwater Pools (Wetland Type Ts)

Representative Sites: I5 (Ingrid’s Waterhole)

6.4.2.5.1 Trophic Levels and Keystone Species

This wetland was dry at the time of the visit so any purely aquatic component of the trophic pyramid was absent. However, a relatively diverse vertebrate fauna was recorded. Eighteen vertebrate fauna species were identified at this wetland type. Considering many species occupy several different positions in the food web, the fauna assemblage consisted of nine trophic levels (**Table 27**). Since there was no water present, there were no representative species of aquatic vertebrate insectivore (AVI) or aquatic vertebrate herbivores (AVH). The single aquatic vertebrate carnivore was the Northern Long-necked Turtle (*Macrochelodina rugosa*) which was identified by its eggs. Its current ability to persist in the waterhole where it was identified is in doubt due to the lack of water.

Terrestrial flying insectivores were the most abundant vertebrate trophic level with 19 species, followed by terrestrial flying nectivores (eight species) and terrestrial flying frugivores (seven species). All of these functional groups are highly reliant on the tree canopy, emphasising their role in the food web in these locations. The most commonly seen bird species was the Silver-crowned Friarbird which represents all three of these trophic levels. This bird was present in large numbers and its aggressive manner possibly reduced the number of other bird species observed at this wetland. While the terrestrial ground foraging insectivores were not represented by a large number of species, they were represented by a large number of individuals, particularly Striped Rainbow Skink (*Carlia munda*) and Swanson's Snake-eyed Skink (*Cryptoblepharus cygnatus* syn *plagiocephalus*). Predation was observed with a Whistling Kite taking a Cane Toad. Though Cane Toads are widely implicated in the decline of many carnivorous species, anecdotal reports from Kakadu National Park (pers. comm. G. Calvert) suggest that Whistling and Black Kites regularly predate on Cane Toads without ill effect. No fauna species present at this wetland could be regarded as ‘keystone species’. It would require additional data analysis to identify these, if indeed clear candidate species actually exist.

6.4.2.5.2 Ecological Significance

Compared to many other costal freshwater wetlands, there was evidence of only minor saltwater intrusion and no evidence of salt-induced tree dieback. As such, this site remains a good example of this wetland type on inorganic soils, particularly if feral animal control was undertaken. As an intact system, this wetland type would likely support a broad range of freshwater-dependant flora and fauna, including threatened species such as Partridge Pigeons that require regular access to fresh water.

This site was dry at the time of visit and showed significant influence from Cyclone Ingrid. It had a large number of dead *Melaleuca* trees in the lowest topographic basin. These areas had visible levels of salt crusting on the surface. In other areas of the same wetland the tree canopy remains intact and there are significant levels of native tree recruitment in the understorey.

6.4.2.6 Freshwater Tree-dominated Wetland (Wetland Type Xf)

Representative Sites: I4 (Danger Point), I8 (Friarbird Swamp)

Only two examples of this wetland type were encountered in eastern Cobourg Peninsula. These sites had an extensive forest cover of *Melaleuca* but the understorey was almost absent due to the destructive impacts of Feral Pigs and Banteng. The water had contracted to several small pools and although water quality was tested and collected, its condition was significantly reduced by feral animals. A large group of Feral Pigs were observed wallowing and feeding in the mud and water, which was green with algae, presumably as a consequence of eutrophication.

6.4.2.6.1 Trophic Levels and Keystone Species

This wetland was mostly dry at the time of visit, and remaining water was in a highly degraded condition so aquatic components of the trophic pyramid were significantly reduced. Similarly, damage and habitat modification by Feral Pigs was so extensive that native ground foraging vertebrates were also reduced. Seventeen vertebrate fauna species were identified at this wetland type. Considering many species occupy several different positions in the food web, the fauna assemblage consisted of eight trophic levels (**Table 27**). Trophic groups not detected at this site include aquatic vertebrate insectivores and carnivores and terrestrial flying nectivores. The trophic levels of terrestrial ground foraging herbivores and carnivores were represented only by feral animals. Terrestrial flying frugivores was represented only by a single species (Varied Triller). The Varied Triller is a secondary frugivore, deriving most of its nutrition from invertebrates. The most abundant trophic group were the flying insectivores with 10 species which heavily utilised the *Melaleuca* canopy. An unexpected fauna component was an abundance of tadpoles of Roth's Tree Frog (*Litoria rothii*). In the tadpole stage, they fill an AVH trophic niche however upon metamorphosis would be classified as a terrestrial ground foraging insectivore (TGI). No adult frogs were seen. Other TGI included Swanson's Snake-eyed Skink (*Cryptoblepharus cygnatus*) and Two-lined Dragon (*Diporiphora bilineata*). These species were far less abundant at site I4 (Danger Point) than at site I8 (Friarbird Swamp), the latter containing considerably less damage from Feral Pigs. Feral Pigs are having a profound impact on this wetland, potentially limiting its use to other vertebrate species including threatened fauna. Although they currently dominate this system, they cannot be regarded as a keystone species as their continued well-being is not vital for the functioning of a whole community. No species present at this wetland could be regarded as 'keystone species'. It would require additional data analysis to identify these, if indeed clear candidate species actually exist.

6.4.2.6.2 Ecological Significance

At site I8 there is evidence that water levels were consistently at approximately 1.5 m high as evidenced by flood debris and pronounced adventitious root growth from *Melaleuca* at this height. However, the area was dry when visited and with a high degree of grass and herb cover in the understorey. There was no evidence of recent pooling of water. The understorey was littered with large numbers of uprooted *Melaleuca* trees, presumably from Cyclone Ingrid. It is hypothesised that this uprooting has increased the permeability of the basin and has effectively reduced the ability of the basin to retain water. It is predicted that over time that silt will eventually restore the impermeable layer and that wetland functions will be restored.

6.4.2.7 Freshwater Springs (Wetland Type Y)

Representative Sites: I6 (Ferny Springs), I7 (Wolf Claw Spring), I11

Freshwater springs are potentially numerous in the Ramsar site, possibly occurring anywhere in valleys or gullies beside areas of higher topography. Water percolates through weaknesses in rock, expressing in shallow soaks or pools of clear fresh water. These wetlands are generally small in nature and not easily observed from aerial photography or spectral analysis except where patches of monsoon forest become established in response to

water availability. Two sites (I6 and I7) were sampled, both well known to local Indigenous people. Both sites had distinctive vegetation communities readily separated from adjacent woodland communities on imagery. A third site (I11) was visited but not sampled.

6.4.2.7.1 Trophic Levels and Keystone Species

All sites were wet at the time of visit with a slow water current perceptible. The water was clear with low turbidity and surrounded by plant species with high water requirements. Thirty-five vertebrate fauna species were identified at this wetland type. Considering many species occupy several different positions in the food web, the fauna assemblage consisted of nine trophic levels (**Table 27**). The only trophic group not detected at this site were AVC and terrestrial flying nectivores. The trophic levels of terrestrial ground foraging herbivores and carnivores were represented only by feral animals. Terrestrial flying frugivores was represented only by a single species (Varied Triller). The Varied Triller is a secondary frugivore deriving most of its nutrition from invertebrates. Aquatic trophic levels were filled by fish species. Freshwater springs are one of only two freshwater wetlands that contained freshwater fish on the Cobourg Peninsula at the time of sampling. Although specialised aquatic carnivores were not recorded at these sites, some carnivorous bird species such as the Azure and Sacred Kingfishers would be expected to predate on fish species. The most abundant trophic group were the flying insectivores with ten species which heavily utilised the *Melaleuca* canopy. Generally, most trophic levels were represented by several species. With this degree of ecological redundancy, it is not possible at this stage to identify any single fauna species as being a 'keystone' species. It would require additional data analysis to identify these, if indeed clear candidate species actually exist.

6.4.2.7.2 Ecological Significance

These springs are permanent allowing for the evolution and maintenance of freshwater dependant species. This wetland type was the only one that contained fish species that were strictly freshwater species. They support a high abundance of flora species that in turn encourages a high diversity of fauna and trophic interactions. Their permanent supply of fresh water no doubt provides refugial nodes for freshwater dependant fauna to retreat to during drier years and the springs are therefore likely to be essential to the continued persistence of a range of fauna species within the Ramsar site.

Table 27 Fauna Assemblages within Trophic Levels for Wetland Dependent Vertebrate Fauna in Inland Wetlands

	Wetland Type Code						
Trophic Level	**K**	**N**	**Q**	**R**	**Ts**	**Xf**	**Y**
Aquatic							
Vertebrate Insectivore	6	1	5	3	0	1	4
Vertebrate Herbivore	2	0	4	2	0	0	2
Vertebrate Carnivore	5	1	4	3	1	0	0
Terrestrial							
Ground Foraging Herbivore	3	2	3	4	4	2	3
Ground Foraging Insectivore	2	4	0	8	5	3	3
Ground Foraging Carnivore	3	1	1	1	2	1	2
Flying Insectivore	8	4	8	0	19	10	15
Flying Frugivore	3	1	1	3	7	7	6
Flying Herbivore	6	5	4	5	4	2	8
Flying Carnivore	3	1	4	4	4	4	6
Flying Nectivore	0	2	3	3	8	0	0
Total Number of Trophic Levels	10	10	10	10	9	8	9

Key: Coastal Freshwater Lagoons (K), Seasonal Creeks (N), Permanent Brackish/Saline Lakes (Q), Seasonal Brackish/Saline Lakes (R), Seasonal Freshwater Marshes/Pools (Ts), Freshwater, Tree-dominated Wetlands (Xf), Freshwater Springs (Y).

6.4.3 Fish

6.4.3.1 Overall Observations on the Importance of Inland Fish Communities

Overall diversity is very low in a regional comparative sense, including fish species sampled in the past and during the present survey. For example, eight species were collectively observed on the Peninsula compared with 48 species recorded in the freshwaters of the adjacent East Alligator River catchment (Press *et al* 1996; with two species additions from ERISS, unpublished data). Notwithstanding access difficulties at one site in the current survey (M20), the low species richness appears to be associated with the general lack of permanent and connecting fresh surface waters on the Peninsula. Apart from small isolated springs, other stream systems may dry out completely, or in large (lentic) wetland sites, cyclonic disturbances are probably sufficiently frequent to result in periodic saltwater intrusion, of which a large number of freshwater fish species will be intolerant. It is notable that three of the eight species that have been recorded on the Peninsula (Ox-eye herring (*Megalops cyprinoides*), Swamp Eel (*Ophistemon guttural*) and Empire Gudgeon (*Hypseleotris compressa*)) are tolerant of brackish waters or waters of a salinity equivalent to sea water. Hence, there appears to be a lack of significant refugial freshwater sites for the majority of fish species to sustain viable populations through time.

More meaningful and relevant diversity comparisons could be made by considering similar-sized catchments or regions across coastal northern Australia that have, similarly, diffuse and short watercourses with general lack of permanent freshwaters and/or systems that lack connectivity to adjacent larger rivers and streams. Unfortunately, the survey focus of the Fish Atlas of North Australia (NAFF, 2008) was upon larger rivers in the coastal drainages. Regions of similar type for comparison, including Cape Leveque coast in the Kimberley region of WA or the Tiwi Islands or Groote Eylandt in the NT, have no published freshwater fish records. However, the effect upon fish species diversity caused by geographical isolation and lack of connectivity to mainstream rivers that flow to the

sea is evident in watercourses of the Arnhem Land plateau above major escarpment waterfalls. Despite the presence of permanent waterholes in these plateau streams, the diversity of fishes is often restricted to just a very small number of highly-mobile or upland-specialist species, including *Mogurnda mogurnda* (Northern Trout Gudgeon) and *Melanotaenia exquisita* (the Exquisite Rainbowfish) respectively (Bishop et al 1990)..

6.4.3.2 Life Histories and Trophic Relations of Freshwater Fishes Sampled or Previously Recorded from the Ramsar Site

6.4.3.2.1 Melanotaeniidae (Rainbowfish)

***Melanotaenia nigrans* (Black-lined Rainbowfish)**

This species occurs in Australia in three disjunct populations:

- the eastern Kimberley around Napier Broome Bay
- the northern most areas of the NT and around into the Gulf of Carpentaria including Groote Eylandt
- on the northern tip of Cape York including Prince of Wales Island (Allen et al., 2002).

Within these populations schools of *M. nigrans* are commonly seen moving amongst aquatic vegetation growing on gravely or sandy substrates in clear freshwater streams, billabongs and smaller pools (Schmida, 2004). They can also be found in the slack water of some larger rivers (Allen et al*.,* 2002). They generally occur within 40 km of the sea (Larson and Martin, 1989) however they have been collected up to 130 km inland (Allen et al*.,* 2002) and are abundant in escarpment habitats through Alligator Rivers region (Walden and Pidgeon, 1998, Bishop et al*.,* 2001). The species is common in the streams of the East Alligator catchment (Humphrey et al., 2006) and has been observed in Cooper Creek (Bishop et al*.,* 2001).

M. nigrans are a slender Rainbowfish, grey-brown sometimes with a silver or bluish tinge above and white below with a prominent black mid-lateral band (Allen et al*.,* 2002) which extends through the eye (Larson and Martin, 1989). The species is known to be sexually dimorphic and breeding males develop a black margin and reddish tinge on the second dorsal and anal fins (Allen et al 2002). Commonly around 6 cm in length, some may grow up to 8.5 cm (Allen et al*.,* 2002).

They are opportunistic omnivores which tend to feed on aquatic and terrestrial insects, as well as algae, across the substrate and in surface waters (Bishop et al*.,* 2001).

The wild breeding biology of this species is not well known (Larson and Martin, 1990); however Bishop et al. (2001) showed that in the Alligator Rivers region this species has a bimodal spawning pattern for any given year. Bishop et al (2001) showed that their peak spawning period occurred in the late dry/early wet season (November to December), a period with typically warmer water temperatures and at the beginning of seasonal creek flows. Spawning is reported to occur around thick aquatic vegetation with eggs attaching via tiny filaments until hatching (Larson and Martin, 1990). In aquaria breeding can occur all year, most likely due to controlled conditions. The breeding behaviour of Rainbowfish involves the male displaying ‘flashing’ vivid colours to initiate spawning. The pair then swim amongst aquatic vegetation and release eggs and milt with a vigorous shudder of the body (Ivantsoff et al*.,* 1988; Allen et al*.,* 2002).

6.4.3.2.2 Apogonidae (Cardinalfish)

***Glossamia aprion* (Mouth Almighty)**

Glossamia aprion is a purely freshwater species from a predominantly marine family. Its distribution includes the drainage systems of the north-east coast, Gulf of Carpentaria and Timor Sea (Bishop et al., 2001). It is found in still or gently flowing waters of streams, pools, lakes, swamps and reservoirs, rarely venturing more than 20 cm from some sort of cover (Bishop et al*.,* 2001; Allen et al*.,* 2002).

Generally a small to moderate sized fish it can reach sizes up to 200 mm in total length but is more common less than 80 mm total length (Larson and Martin, 1990). *G. aprion* is usually distinguished by a relatively large cavernous mouth (Allen et al, 2002), which has given it the name ‘Mouth Almighty’.

As the name suggests it is a carnivorous species feeding primarily on fish, aquatic insects and macrocrustacea (Pusey et al*.,* 2004). It is an ambush predator remaining motionless within and around structure where it imitates leaves. Bishop et al. (2001) classified the feeding nature of *G. aprion* in the Alligator Rivers region as a macrophagic carnivore.

Bishop et al. (2001) suggested this species may breed over a range of seasons but primarily in the late dry/early wet season (November to December). Spawning, though not confirmed, is believed to occur at night due to the

primarily nocturnal habit of this species. Pairs mate in still water to enable the transfer of eggs from the female to the male (Bishop et al., 2001; Pusey et al., 2004). Males are buccal incubators and exhibit parental care. The incubation period ranges from two to five weeks. They reach maturity sometime between 60 mm and 70 mm (Bishop et al., 2001).

6.4.3.2.3 Eleotridae (Gudgeons)

***Hypseleotris compressa* (Empire Gudgeon)**

Hypseleotris compressa is a widespread species in Australia, occurring from the Murchison River in the Pilbara region of Western Australia throughout the NT, Queensland and south to the Towamba River in southern New South Wales (Larson and Martin, 1990; Bishop et al., 2001; Pusey et al., 2004). In the NT they are found in most coastal draining systems and can tolerate brackish water (Larson and Martin, 1990). They are often abundant in floodplain lagoons and creeks where water flows are mild with plenty of instream cover (Larson and Martin, 1990; Pusey et al., 2004).

Their diet is varied and is regarded by Bishop et al. (2001) as microphagic (feeding on microscopic organisms) opportunistic carnivore, sometimes omnivorous, feeding on the benthic organisms and from the mid-water zones of the water bodies.

It can complete its life cycle in freshwater and has been bred in captivity. It has also been observed in spawning aggregations in estuarine areas but it is unclear if it actually spawns in these areas (Pusey et al., 2004). Spawning appears to be over an extended period from summer to autumn in northern and eastern Australia (Pusey et al., 2004) but in the Alligator Rivers region peak spawning was estimated as occurring during the mid wet season (Bishop et al., 2001).

***Oxeleotris nullipora* (Poreless or Dwarf Gudgeon)**

The Poreless, or Dwarf Gudgeon as it is sometimes called, occurs in southern New Guinea and in two geographically separate populations in Australia, one across the Top End from Darwin to Cape Arnhem in the NT, the other encompassing the westerly flowing drainages of northern Cape York, Queensland (Allen et al., 2002). In the Top End they have been captured in shallow billabongs in the South and East Alligator River catchments (Humphrey et al., 2006). They are typically found in the still waters of billabongs and swamps, as well as the backwater areas of smaller rivers and streams with a preference for areas with dense aquatic vegetation (Larson and Martin, 1989).

O. nullipora is a tiny, cryptic species of gudgeon that reaches a length of 3 to 4 cm and is cylindrical in shape with a protruding jaw and dorsally flattened head (Allen et al., 2002). It is generally brown above and lighter below and this colouration makes it extremely difficult to observe in the wild, even when captured in tends to lie very still and blends in with any mud or organic matter. A distinguishing characteristic of this species of *Oxyeleotris* species is the lack sensory pores on top of the head, giving it the common name Poreless Gudgeon.

Very little is known of the biology of the species in the wild, probably largely due to its highly cryptic nature. In captivity it is carnivorous (Larson and Martin, 1989).

Females lay around 30 relatively large eggs which are guarded by the male until they hatch about eight days later (Allen et al., 2002).

***Mogurnda mogurnda* (Northern Trout Gudgeon)**

Mogurnda mogurnda is found from north-western Australia to Cape York Peninsula, possibly extending further south in north-eastern Queensland (Allen et al., 2002; Pusey et al., 2004). It has also been recorded from southern New Guinea (Allen et al., 2002). All species of this genus are restricted to freshwater (Bishop et al., 2001). Bishop et al. (2001) found *M. mogurnda* in most lowland sandy creek bed habitats and in escarpment streams however they are most abundant in the upper reaches of streams where other fish species cannot penetrate. This species has been reported by Bishop et al. (2001) climbing vertical wet surfaces around waterfalls suggesting it has the ability to climb higher into the catchments than other fish species.

M. mogurnda is an opportunistic carnivore, eating insects, crustaceans and possibly small fish (Bishop et al., 2001).

Spawning occurs during the wet season from November to March (Bishop et al., 2001; Allen et al., 2002). Bishop et al. (2001) noted a slight increase in reproductive development during the early wet season. Females produce batches of eggs that are deposited on rocks or logs, where the male fans or guards the eggs until hatching after

eight to ten days (Allen et al., 2002). In captivity however, egg masses have frequently been found to hatch after approximately three days (pers. comm. A. Hogan).

6.4.3.2.4 Megalopidae

***Megalops cyprinoides* (Tarpon or Ox-eye Herring)**

Megalops cyprinoids are common in coastal seas of tropical northern Australia and as far south as northern New South Wales. Its entire range encompasses a vast area from east Africa, south-east Asia, Papua New Guinea and Tahiti (Bishop et al., 2001; Allen et al., 2002; Pusey et al., 2004). It is essentially a marine species, though smaller specimens inhabit estuaries and are regularly found in freshwater rivers and creeks well above tidal influence (Bishop et al., 2001; Allen et al., 2002). In Australia it is found in freshwaters in the far north (Bishop et al., 2001; Pusey et al., 2004). *M. cyprinoids* life history is complex and involves a variety of different habitats at different life stages. Its complex life history makes it susceptible to changes in flooding regimes, movement and habitat for juveniles.

In the Alligator River region its diet was found to have been dominated by fish and aquatic insects and was regarded as a macrophagus carnivore/piscivore, feeding predominantly in surface and mid-waters (Bishop et al., 2001).

Detailed aspects of reproduction are lacking as this species moves out of freshwater to near-shore marine or estuarine environments (Pusey et al., 2004). Bishop et al. (2001) recorded mature males at the end of the dry season and spent females moving back upstream during the mid wet season indicating *M. cyprinoids* spawns in the summer.

6.4.3.2.5 Synbranchidae (Swamp Eels)

***Ophisternon gutturale* (Swamp Eel)**

The One-gilled or Swamp Eel (*Ophisternon guttural*) is commonly found in the Timor Sea and Gulf of Carpentaria Drainage Basins of northern Australia and southern New Guinea and has also been recorded in the Mossman River near Port Douglas (Bishop et al., 2001; Allen et al., 2002). In the Alligator Rivers region it has been observed in billabongs in the South and East Alligator River catchments (ERISS, unpublished data). It is a cryptic nocturnal species which is usually found in the soft bottom sediments of estuaries, freshwater swamps and the lower reaches of freshwater rivers where they favour areas of slack water with thick vegetative cover (Schmida, 2008; Larson and Martin, 1989; Bishop et al., 2001). During the wet season juveniles of the species are sometimes seen moving through Darwin drains at night, elsewhere they can be observed by spotlighting at night (Larson and Martin, 1989).

Though not a true eel *O. gutturala* are eel like in appearance, they are reported to reach up to 60 cm though more commonly found up to 20 cm. Their colour is variable, usually brown to green, sometimes with spots or mottling and are usually darker dorsally (Allen et al., 2002), their eyes are small and sometimes reddish and they have large fleshy lips (Larson and Martin, 1989).

Details of reproduction and dietary habits of this elusive species are not well known and are presently assumed to resemble that of related species such as *Ophisternon bengalense* (Bishop et al., 2001). The Swamp Eel is known to survive short periods out of water (Larson and Martin, 1989) a characteristic which would be beneficial in an area such as Cobourg Peninsula where the freshwater habitats reduce to a few isolated areas as the dry season progresses.

6.4.3.2.6 Pseudomuguilidae (Blue-eyes)

***Pseudomugil gertrudae* (Spotted Blue Eye)**

The Spotted Blue-eye is widespread across northern Australia and the Trans-Fly region of southern New Guinea (Allen et al., 2002) and a number of islands in the region Aru, Melville and Groote Eylandt (Pusey et al., 2004). In Australia they are found in the Timor Sea and Gulf of Carpentaria Drainage Basins, on the east of Cape York and as far south as the Herbert River catchment (Pusey et al., 2004). Locally the species was recorded in low abundances in Gadjarrigamarndah Creek in the Cooper Creek catchment (Pidgeon and Boyden, 1995) and the Magela Creek catchment (ERISS, unpublished data). Although the species has a reasonably broad geographic range, populations tend to be isolated and patchy; this isolation has likely led to the distinct geographic variation in the appearance that is observed in the species (Allen et al., 2002; Pusey et al., 2004). The species is restricted to lowland, low elevation areas across a range of habitats including small sandy creeks, shaded rainforest streams, isolated pools and the edge habitats in the main channels of large rivers, however they are most commonly

observed in *Pandanus* and *Melaleuca* dominated swamps and streams (Pusey et al., 2004). Pusey et al. (2004) state that the species generally occurs in waterbodies of good water quality showing a preference for well oxygenated waters and that they are tolerant of warm, tannic, highly acidic waters.

P. gertrudae is a tiny slender fish, commonly around 2.5 cm but up to 3 cm in length. It has a whitish body, sometimes with a golden sheen and features distinctive delicate black spotting. It has three black lines starting from the tail that fade to spots anteriorly, dorsal, caudal and anal fins are pale yellow with black spots. In adult males the middle rays of the first dorsal and anterior rays of the pelvic fin are elongated and breeding males tend to have longer fins and heavier spotting than females (Larson and Martin, 1989).

The diet consists mainly of algae, microcrustacea and some other aquatic insects (Larson and Martin, 1989).

According to Pusey et al. (2004) nothing is known of movement biology of wild *P. gertrudae* or their reproductive biology though they suggest that spawning may occur at any time of year, with the highest recruitment occurring during the wet season. Larson and Martin (1989) also suggest that breeding most commonly occurs during the wet season, and that spawning sites are unknown.

6.4.4 Macroinvertebrates

A wide diversity of both inland and marine/coastal habitats was sampled for benthic macroinvertebrates across Cobourg Peninsula. There is a broad variability in benthic macroinvertebrate assemblages amongst sites sampled. Significant variability observed in inland waterbodies could be accounted for by natural disturbance, particularly the degree of salinity of the surface waters. At most sites family diversity and abundances of benthic macroinvertebrates were high, suggesting a healthy system.

6.4.4.1 Classification of Marine/Coastal Community Types and Ecological Role

There was substantial variability in macroinvertebrate assemblages across marine/coastal wetland sites in the eastern Cobourg Peninsula (**Figure 40**). There were six clusters that contained a similarity of less than 30%, of which only two comprised more than a single site. The largest cluster contained six sites (half of the total number of sites sampled). The benthic macroinvertebrate communities in this cluster (M1, M2, M4, M5, M10 and M11) were sampled from a range of habitat types (estuary, mangroves, coral reef, intertidal flats and sandy shore) and across the eastern Peninsula. These sites were comparable in containing a high diversity (53% of all families identified) and abundance (80% of all individuals counted) of polychaete worms reflecting the nature of the sediments (sand and silt) from which they were sampled.

The second biggest cluster contained two sites (M8 and M9) which are located in close proximity to each other in the central west of the Peninsula. The habitat type at sites M8 and M9 was rocky and sandy shore respectively. Samples from these sites contained a high diversity (35% of all families identified) and abundance (65% of all individuals counted) of polychaete worms, but had a greater proportion of crustaceans (35% of all families identified 24% of all individuals counted) than sites within the largest cluster.

The remaining four clusters contained only a single site each. Site M3 (coral reef) differed from the other sites largely due to the low diversity and abundance of individuals. This may have been due to the higher levels of algal cover at this site than at any other site (between 35 to 65% cover of substrate). Site M12 (rocky marine shore) contained large numbers of attached bivalves particularly Mytillidae (mussels) and Ostreidae (oysters). Sites M6 and M7 were located in saline lagoons and had a low diversity and abundance of benthic macroinvertebrates typical of a highly variable environment.

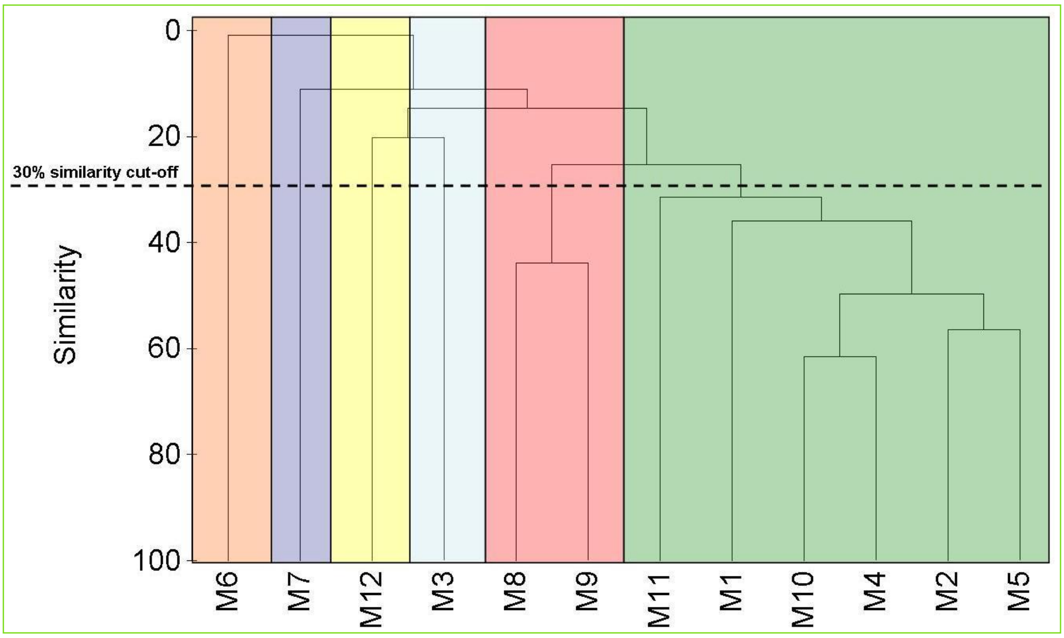

Figure 40 Classification Analysis of Benthic Macroinvertebrate Communities for the Cobourg Peninsula Ramsar Site based on Similarities Calculated from Abundance Data. The Six Different Clusters with Bray-Curtis Similarities less than 30% have been Identified Using Different Colours.

6.4.4.2 Classification of Inland Community Types and Ecological Role

There was considerable variability in macroinvertebrate communities sampled from inland wetland sites of the eastern Cobourg Peninsula. In particular and in multivariate ordination space (where the proximity of samples in the two-dimensional space indicates the similarity or otherwise of representative communities), sites I2, the wetland under marine influence and I4, the seasonal pools, were well separated from one another and from other wetlands (**Figure 41**). The associated cluster analysis (**Figure 42**) identified four clusters that contained a similarity of less than 30% of which two comprised more than a single site. The largest cluster contained three sites and two wetland types and represented spring (sites I6 and I7) and seasonal stream (I3) sites. The second largest cluster contained two sites and also two wetland types, representing slightly brackish (I1) and freshwater (M20) lakes. The ordination appeared to support the separation of sites into four quite distinct clusters.

Similarity percentages (SIMPER) analysis was used to distinguish characteristic taxa contributing to the clusters. The most influential taxa and in descending order of importance, are listed in **Table 28**. By common names of the macroinvertebrate taxa, the following summary may be made:

- The permanent saline/brackish lake (site I2) was dominated by biting and non-biting midge larvae, a species of freshwater snail, amphipod crustaceans, mosquito larvae and mites.
- The seasonal freshwater pool (site I4) was dominated by ‘backswimmer’ bugs, biting and non-biting midge larvae, mites, mayfly nymphs and segmented worms.
- Springs or seasonal streams (sites I6, I7 and I3) were dominated by mites, biting and non-biting midge larvae, beetles, and segmented and non-segmented (nematode) worms.
- Fresh/brackish water lakes (sites I1 and M20) were dominated by mites, mayfly nymphs, biting and non-biting midge larvae, other fly larvae, segmented worms and nymphs of a common damselfly species.

A feature of the fauna of inland wetlands of Cobourg Peninsula was the virtual absence of any taxa strongly associated with flowing waters. Even for the flowing springs or seasonal stream sites (I6, I7 and I3), no flow-dependant taxa were found amongst the taxa most influential in distinguishing this classification group from other wetland types. Rather, the taxonomic list (**Appendix J)** is dominated by species typically associated with still waters. Unsurprisingly given the seasonal nature of most of the inland wetlands and waterbodies sampled, the fauna also appears to lack any locally endemic species. This is consistent with the observation made by Finlayson et al. (2006) that the highly seasonal and climatically and geomorphologically dynamic, conditions of the lowland environments in northern Australia (including Cobourg) have selected for generally cosmopolitan and vagile aquatic invertebrate species

At least 222 species were identified from the seven Cobourg inland locations surveyed. These locations represent a diversity of habitats, including fresh and brackish lagoons and small freshwater streams and springs. Apart from the Kakadu region, very few species-level inventories have been compiled for invertebrates of inland waters over comparably-sized regions or catchments of the wet-dry tropics. By way of comparison, Finlayson et al. (2006) estimated that there were over 600 freshwater macroinvertebrate species from freshwater habitats in the Kakadu region of the NT, across flowing and still-water habitats on sandstone plateau, lowlands and lower floodplains. Considering that the Kakadu inventory represents a summary of collections made over two decades and from a larger number and diversity of habitats and sites, and that there appears to be a low diversity of flow-dependant taxa on Cobourg Peninsula (from above), the taxa list for the (eastern portion of the) Peninsula would appear to represent a comparable diversity for the habitats investigated.

Oribatid and acarinan mites, microcrustaceans (cladocerans, copepods and ostracods), nematode and oligochaete worms, biting and non-biting midge larvae (ceratopogonids and chironomids respectively) and baetid mayfly nymphs were numerically dominant in the invertebrate samples. Presumably these and other invertebrates are important in aquatic and terrestrial food webs, making energy and nutrients available to other invertebrates, fish, semi-aquatic vertebrates and birds. However, detailed ecological studies would be required to quantify this further, and to identify species pivotal ('keystone'), if at all, in associated food webs.

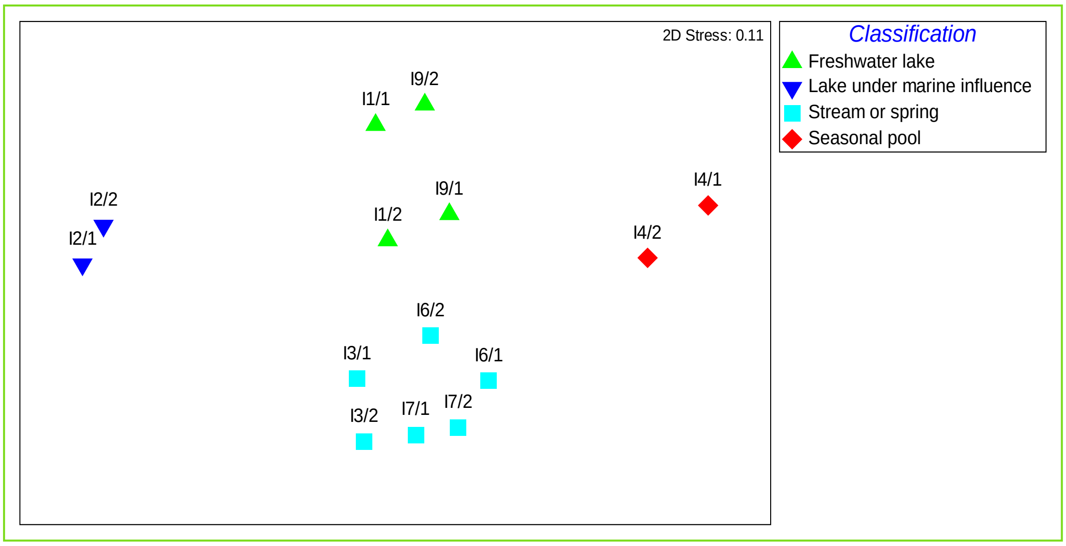

Figure 41 Two-dimensional MDS Ordination of Macroinvertebrate Community Structure Data from Inland Sampling Sites (and Duplicates), according to Classification Group Identified in the Associated Cluster Analysis

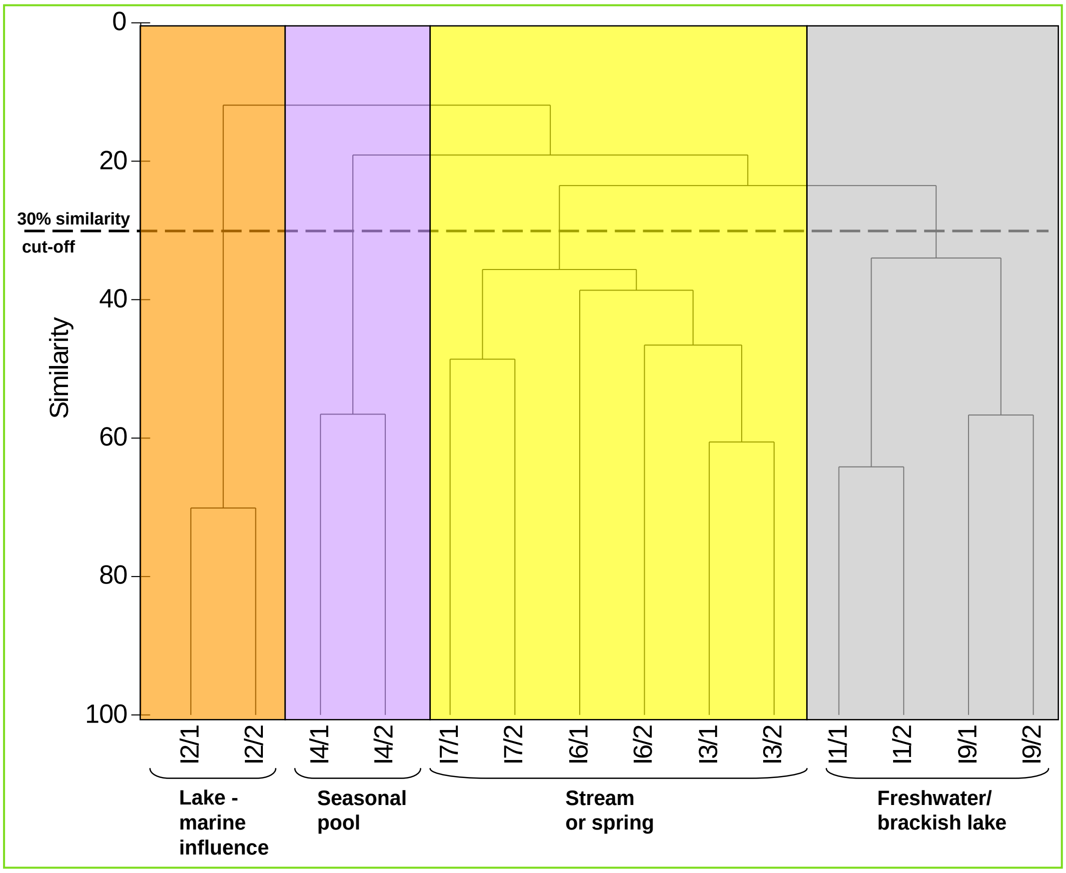

Figure 42 Unweighted Pair Group Method Analysis (UPGMA) Classification of Macroinvertebrate Community Structure Data from Inland Sampling Sites (and Duplicates). The Four Clusters with Bray-Curtis Similarities less than 30% are Denoted using Different Colours

Table 28 Important and Characteristic Macroinvertebrate Taxa (in Descending Order of Influence, Identified by SIMPER) Distinguishing those Inland Wetland Classification Groups (i) Identified a Priori and (ii) Arising from Cluster Analysis

Wetland Type (Wetland Code)	**Permanent Saline/ Brackish Lake (Q) (Site I2)**	**Seasonal Freshwater Marshes/Pools (Ts) (Site I4)**	**Freshwater Springs (Y) (Sites I6, I7)**	**Seasonal Stream/Creek (N) (Site I3)**	**Seasonal Saline/ Brackish Lakes and Flats (R) (Site I1)**	**Permanent Freshwater Lakes (O) (Site M20)**
Wetland Type from Cluster Analysis	**Permanent Saline/ Brackish Lake**	**Seasonal Freshwater Marshes/Pools**	**Springs or Seasonal Streams**		**Fresh/Brackish Water Lake**	
Indicator taxa	Ceratopogoninae sp. (L)	Notonectidae spp.	Oribatida spp.		Oribatida spp.	
	Gabbia sp.	*Chironomus februarius* group (L)	Ceratopogoninae sp. (L)		Baetidae spp	
	Amphipoda spp.	Acarina spp.	*Hydrochus radjiei*		*Larsia albiceps*	
	Aedes sp. (L)	Baetidae spp.	*Procladius paludicola* (L)		*Odontomyia* sp.	
	Oribatida spp.	*Anisops* sp.	Nematoda spp.		Ceratopogoninae sp.	
	Culicidae spp.	*Kiefferulus barbatitarsis* (L)	Paramerina spp.		Tanypodinae spp.	
	Procladius paludicola (L)	Ceratopogoninae sp. (L)	Acarina spp.		Oligochaeta spp.	
	Ceratopogoninae sp. (P)	Oligochaeta spp.	Oligochaeta spp.		*Chironomus februarius* group	
		Enithares sp. CBG01	*Polypedilum convexum* (L)		*Austroagrion watsoni*	
		Anisops nasutus	*Polypedilum* K3		*Tanytarsus nr. bispinosus*	

7.0 Physicochemical Water Properties

7.1 Methods

The objective of the water sampling was to gain an understanding of the current physicochemical water properties in each wetland type. To do this, two field surveys were undertaken; the first in July/August 2010 (mid dry season) and the second in October 2010 (late dry season). The number of sites sampled during each survey varied due to access restrictions and water availability.

7.1.1 Sampling sites and timing

Water samples were collected from 20 marine/coastal sites, including 13 sites during the mid dry season survey and 18 sites during the late dry season survey (**Table 29**).

Water samples were collected from nine inland sites, including six sites during the mid dry season survey and eight sites during the late dry season (**Table 29**). Three of the 12 inland sites did not contain water during either survey.

Table 29 Sites Visited during the Mid Dry (MD) and Late Dry (LD) Season Surveys

Wetland Type (Wetland Code)	Site Name	Water Present	
		MD	LD
Marine/Coastal Wetland Sites			
Coral Reefs (C)	M3	✓	✓
	M10	✓	×
	M14	×	✓
Rocky Marine Shore (D)	M8	✓	✓
	M12	✓	✓
Sand Shores (E)	M9	✓	✓
	M11	✓	×
	M13	×	✓
Estuarine Waters (F)	M1	✓	✓
	M15	×	✓
	M17	×	✓
Intertidal Flats (G)	M4	✓	✓
	M16	×	✓
Intertidal Forested Wetlands (I)	M2	✓	✓
	M5	✓	✓
	M18	×	✓
Coastal Brackish/Saline Lagoon (J)	M6	✓	✓
	M7	✓	✓

Wetland Type (Wetland Code)	Site Name	Water Present	
		MD	LD
	M19	×	✓
Coastal Freshwater Lagoon (K)	M20	✓	✓
TOTAL	**20**	**13**	**18**
Inland Wetland Sites			
Seasonal Creeks (N)	I3	✓	✓
	I13	×	×
Permanent Brackish/Saline Lakes (Q)	I2	✓	✓
Seasonal Brackish/Saline Lakes (R)	I1	✓	✓
Seasonal Saline Pool (Ss)	I12	×	✓
Permanent Freshwater Pool (Tp)	I10	×	✓
Seasonal Freshwater Pool (Ts)	I5	×	×
Freshwater Tree-dominated Wetland (Xf)	I4	✓	×
	I8	×	×
Freshwater Springs (Y)	I6	✓	✓
	I7	✓	✓
	I11	×	✓
TOTAL	**12**	**6**	**8**

7.1.2 Physical Properties

Physical parameter readings were undertaken at each wetland site (where water was present) using a Hydrolab Sonde or a TPS 90FL-MV. All readings were recorded once the unit had stabilised. The probes were calibrated every three days with standard solutions. The parameters measured were:

- pH
- temperature
- electrical conductivity (EC)
- dissolved oxygen (DO)
- turbidity

Profiling was undertaken at a number of locations within each marine/coastal wetland site given the dynamic nature of marine processes at work and thus the potential for variation at each sampling location. This contributed to a better understanding of temporal conditions at each site.

Multiple profiling was not undertaken at inland sites as generally:

- freshwater tropical wetlands are not as dynamic as the marine environment
- access to spatially different parts of the freshwater wetlands was time consuming and limited field time was available

- the depth of water sampled in these fresh water systems was relatively shallow.

Light attenuation was estimated using a secchi disk where adequate water depth was available for the method.

An understanding of the tidal conditions during sampling is important in the interpretation of data collected. Sampling in intertidal wetlands was mostly undertaken during a spring tide period (i.e. higher overbank tides) when access was possible by boat. Consequently, any freshwater signals in those systems that are 'tide-dominated' from a geomorphic perspective (e.g. mangrove creek systems) may be dampened, as tidal energy will be strongest at this time. Other site specific data was recorded quantitatively including estimates of wind intensity and direction, wave action and shelter.

7.1.3 Chemical Properties

At each site where water was present, three water samples were collected across a range of habitats, such as riffles, edges and macrophyte beds approximately 10 cm below the water's surface. The samples were then put on ice and cooled before transport to the laboratory with more ice. The suites of analysis undertaken by a National Association of Testing Authorities (NATA) accredited laboratory on each of the water samples were:

- alkalinity
- chloride
- major ions (sulphate, sodium, magnesium, calcium, potassium)
- nitrogen speciation (ammonia, nitrate, nitrite, total oxidised nitrogen, total kjeldahl nitrogen and total nitrogen)
- biochemical oxygen demand (BOD).

For quality control purposes, a duplicate sample was collected amongst every ten primary samples.

7.1.4 Analysis of Water Properties

In the absence of local guidelines, physical and chemical water properties were assessed against guideline values in the ANZECC water quality guidelines for tropical Australia (ANZECC/ARMCANZ 2000) in slightly disturbed systems. Where default trigger values for physical and chemical stressors for tropical Australia (inland waters) were available, these were utilised. Where there was an absence of guidelines for the protection of aquatic ecosystems, the guidelines for Primary Recreation were used. The ecosystem types for guideline values used in this assessment reflected the wetland type (according to the Ramsar classification system) only where it comprised a matching vegetation community. Otherwise a more general ecosystem type was used. Generic guideline values provide a general baseline against which to compare collected data and assess water quality. They are used to highlight areas that may require more detailed examination to determine if the exceedences of the guideline values are the result of natural processes or are an indication of non natural processes such as anthropogenic inputs.

For the marine and estuarine sites a mean and range from the lateral replicates were computed and presented in tabular format at the differing profile depths ie 0.1m, 1.0m, 2.0m,3.0 m for each wetland site. As no profiles were taken of the inland sites the means and range of the replicates are presented at one depth, 0.1m. A comparative snapshot of the mean physical water parameters for the marine and estuarine sites was computed using both vertical and lateral data for each wetland type.

Electrical conductivity values are indicative of saline conditions as outlined in **Table 30**. Analysis of results also includes the lateral and vertical mixing of properties. Where a column is well mixed, the biota is likely to be the same throughout, varying according to sunlight intensity. A well mixed water column can act to buffer thermal pollution and dilute other contaminants within aquatic and marine environments.

Table 30 Electrical Conductivity Values Used for Saline Condition Assessment

Electrical Conductivity Values (in millisiemens/cm) (mS/cm)	Saline Conditions
0 to 0.8	Fresh water
0.9 to 1.5	Marginally fresh water
1.6 to 5	Brackish water
6 to 55	Saline water

Electrical Conductivity Values (in millisiemens/cm) (mS/cm)	Saline Conditions
>55	Hyper saline water

7.2 Results

The unprocessed water quality results are presented in **Appendix K** for the marine and coastal wetlands and in Appendix L for the inland wetlands. Processed physical and chemical data is presented in this section for each wetland type along with a brief description of the results.

7.2.1 Marine/Coastal Wetlands

Between approximately 1,100 mm and 1,300 mm of rain fell across the Cobourg Peninsula in the 12 month period (1 August 2009 to 31 July 2010) prior to the mid dry season survey ((Black Point and Cape Don and Seven Spirit Bay Met Stations) BoM, 2010). The long term average (1965 to 2010) annual rainfall is 1,247 mm (BoM, 2010). Black Point recorded the following climatic variations from July to October 2010 (BoM, 2010b):

- Daily maximum temperature increased from 28.5 degrees Celsius in July to 31.9 degrees Celsius in October.
- Rainfall was 0.8 mm in July, 0.4 mm in August and 2.0 mm in September.

Site specific conditions at each site including location, tidal stage and a qualitative assessment of sea state and meteorological conditions are presented in **Table 31**. **Table 32** provides a comparative snapshot of physical parameters between wetland types in the Cobourg Peninsula Ramsar site. Individual data for each of the wetland types are presented in the following sections

Table 31 Temporal Sampling Conditions for Marine/Coastal Wetland Sites during the Mid Dry Season Survey

Site	Wetland Type (Code)	Location of Sampling Sites Within Wetland	Stage of the Tide	Sea State Conditions
M3	Coral reef (C)	Landward edge of reef flat	End of ebb tide (low water)	Fresh breeze from south east, exposed coastline, small wavelets in reef fleet
M10		Top of reef located at depth	Flood tide	Moderate breeze from south east, exposed coastline, small wavelets (some sheltering)
M8	Rocky marine shore (D)	Adjacent to rocky outcrops	Ebb tide/flood tide	Slight breeze from south east, small ripples, sheltered site
M12		30 m offshore from rocky headland	Flood tide	Moderate breeze from north east, small waves
M9	Sand shore (E)	15 m offshore of beach	End of ebb tide (Low water)	Slight breeze from south east, small wavelets, sheltered site
M11		Toe of beach on western side of island	Start of ebb tide (low water)	Moderate breeze from south east, sheltered on western side
M1	Estuarine waters (F)	Along tidal channel in mangrove creek	Start of ebb tide (high water)	Calm
M4	Intertidal mud flats (G)	50 m seaward from mangrove fringe	Start of ebb tide (high water)	Light breeze, small wavelets, sheltered site
M2	Intertidal forested wetlands (I)	Along seaward mangrove fringe	Ebb tide	Light breeze from north east
M5		Along seaward mangrove fringe	Flood tide	Slight breeze from south east, small wavelets, sheltered waters
M6	Coastal saline lagoons (J)	Along western shore of lagoon	Ebb tide (3 hours before low water)	Very slight breeze from south east, small ripples, sheltered waters
M7		Along northern shore of lagoon	High water	Fresh breeze from south east, small ripples, relatively sheltered waters
M20	Coastal freshwater lagoons (K)	Along southern (MD) and northern (LD) shore of lagoon	NA	NA

.

Table 32 Mean Physical Water Property Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Marine/Coastal Wetlands

	Number of Sites Containing Water	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)*		Dissolved Oxygen (%)	
Wetland Types		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
Coral Reefs (C)	3	27.1	31.3	43.7	53.4	^	8.4	2.9	4.6	119.0	93.0
Rocky Marine Shores (D)	2	27.1	30.3	44.0	53.2	6.2	7.0	2.4	6.6	105.5	108.0
Sand Shores (E)	3	26.7	30.1	49.9	53.9	^	7.9	1.7	2.7	103.2	123.5
Estuarine Waters (F)	3	27.0	31.0	50.0	57.6	^	6.7	7.5	18.6	44.6	67.3
Intertidal Mudflats (G)	1	26.4	30.3	48.6	52.5	^	7.9	5.6	16.2	80.0	85.5
Intertidal Forested Wetlands (I)	3	28.3	30.6	46.2	52.4	8.7	8.0	16.9	38.4	85.5	93.8
Coastal Brackish/Saline Lagoons (J)	2	29.0	36.5	43.6	61.6	^	8.8	4.1	9.3	109.5	104.0
Coastal Freshwater Lagoons (K)	1	26.7	42.4	2.7	0.0	7.5	7.7	1.9	38.2	33.3	54.0

Key: ^ no reading as meter malfunctioned.

7.2.1.1 Coral Reefs (Wetland Type C)

Representative Sites: M3 (Kuper Point), M10 (Sandy Island No. 2), M14 (Sandy Island No. 1)

The results of the sample analysis are provided in **Table 33** and **Table 34**.

Physical Setting

The three sites sampled represent different geomorphic settings for corals. Site M10 (Sandy Island No. 2) and M14 (Sandy Island No. 1) form part of coral fringed sand islands as opposed to site M3 (Kuper Point) which is a rocky headland on the Peninsula where corals have established. All three sites are located on exposed coastlines. Sampling was undertaken in very shallow waters at site M3 and over the top of the coral reef at sites M10 and M14.

Physical Processes

The physical parameters measured at M10 and M14 sites indicate that the water is well mixed by wave action; this is indicated by the relatively low variability in temperature and salinity at those sites. At Site M3 a greater range of EC and temperature was measured during the mid-dry season and may be indicative of lower mixing at Kuper Point. Lower EC values were recorded at Site M3 (Kuper Point) compared to site M10 (Sandy Island No. 2) during the mid dry season survey. This may indicate some nearby mainland freshwater influence. This is also supported by fluctuations in conductivity at site M3 when compared with those at site M10.

pH was only measured during the late dry at site M3 and M14. Elevated measurements were recorded at site M3 (8.3 – 9.2) while M14 was within the ANZECC range. Turbidity was lower than the ANZECC guideline values at Site M10 in the Mid Dry season and within the range 1 – 20 NTU at all other sites. The water was adequately oxygenated at M3 and M10.

Chemical Processes

Elevated concentrations of NOx, total nitrogen and ammonia were recorded at most sites during both the mid and late dry surveys. Nesting sea bird colonies were present at Site M3 which may have influenced the nutrient concentrations. Elevated sodium and sulphate concentrations at this wetland type are indicative of the estuarine nature of coastal systems in the Ramsar site.

Natural Variation

The overall differences in parameters between the three sites are attributed to their different geographic locations.

Seasonal Variation

Site M3 was the only site which was sampled seasonally allowing a comparison. The temperature recorded in the water in the late dry increased along with the salinity which resulted in decreased in dissolved oxygen concentrations. The temperature increase did not have the same effect on conductivity levels as seen in other wetland types. This may be due to the offshore location of the coral reef allowing greater mixing of the water column through wave action.

Table 33 Physical Ranges and Mean Values for Mid Dry (MD) and Late Dry (LD) Season Surveys of Coral Reef Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		No value		8.0 - 8.4		1 - 20		90 – no data	
Site M3 (Kuper Point)											
Mean	0.1	27.5	35.0	38.3	51.7	^	8.9	5.5	5.6	128	93
Range (lowest - highest)	0.1 - 0.1	27.0 - 28.9	34.2 - 35.6	34.4 - 47.6	51.0 - 52.9	^	8.3 - **9.2**	2.7 - 8.6	1.3 - 10.5	123 - 136	112 - 118
Site M10 (Sandy Island No. 2)***											
Mean	0.1	26.6	/	49.1	/	^	/	0.2	/	109	/
	1.0	26.6	/	49.0	/	^	/	0.4	/	105	/
	2.5	26.5	/	49.1	/	^	/	0.3	/	106	/
Range (lowest - highest)	0.1 - 2.5	26.4 - 26.7	/	48.9 - 49.3	/	^	/	0 - 0.5	/	99 - 117	/
Site M14 (Sandy Island No. 1)***											
Mean	0.1	/	29.5	/	55.1	/	7.8	/	3.6	/	/
	1.0	/	29.3	/	54.8	/	7.8	/	2.3	/	/
Range (lowest - highest)	0.1 - 1.0	/	29.4 - 29.8	/	54.4 - 55.6	/	7.5 - 7.9	/	1.6 - 3.4	/	/

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. *** = Site sampled during one survey only. ^ = No reading as meter malfunctioned. / = Readings not taken

Table 34 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Coral Reef Sites

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site M3 (Kuper Point)				
Alkalinity –total (mg/L)		MD	113.7	111 – 116
		LD	116	113 – 119
Chloride (mg/L)		MD	19266.7	19200 – 19300
		LD	18666.7	18600 – 18700
Calcium (mg/L)		MD	427	424 – 432
		LD	436.7	432 – 444
Magnesium (mg/L)		MD	1123.3	1120 – 1130
		LD	1353.3	1340 – 1370
Sodium (mg/L)		MD	11700	11600 – 11900
		LD	10966.7	10800 – 11100
Potassium (mg/L)		MD	338.3	333 – 343
		LD	454.7	448 – 467
Sulfate (mg/L)		MD	2693.3	2640 – 2740
		LD	3233.3	3200 – 3280
Nitrogen – total (mg/L)	0.10	MD	0.3	0.3 – 0.3
		LD	800	100 – 1200
Ammonia (µg/L)	1 - 10	MD	0.07	0.04 – 0.10
		LD	16.67	10 – 30
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	0.04	0.03 – 0.05
		LD	0.02	0.01 – 0.03
TKN (mg/L)		MD	0.25	0.25 – 0.25
		LD	1.1	1.1 – 1.2
BOD (mg/L)		MD	1	1 – 1
		LD	16.3	14 – 18
Site M10 (Sandy Island No. 2)				
Alkalinity –total (mg/L)		MD	115.3	115 – 116
		LD	-	-
Chloride (mg/L)		MD	19900	19800 – 20000
		LD	-	-
Calcium (mg/L)		MD	423.9	427 – 431
		LD	-	-
Magnesium (mg/L)		MD	1346.7	1340 – 1350
		LD	-	-
Sodium (mg/L)		MD	10700	10600 – 10900
		LD	-	-
Potassium (mg/L)		MD	425.3	423 – 429
		LD	-	-
Sulfate (mg/L)		MD	2923.3	2910 – 2940
		LD	-	-
Nitrogen – total (mg/L)	0.10	MD	0.6	0.3 – 1.0
		LD	-	-
Ammonia (µg/L)	1 - 10	MD	0.03	0.02 – 0.04

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
		LD	-	-
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	0.05	0.03 – 0.07
		LD	-	-
TKN (mg/L)		MD	0.6	0.3 – 0.9
		LD	-	-
BOD (mg/L)		MD	1.0	1.0 – 1.0
		LD	-	-
Site M14 (Sandy Island No. 1)				
Alkalinity –total (mg/L)		MD	-	-
		LD	117.3	116 – 120
Chloride (mg/L)		MD	-	-
		LD	18800	17000 – 21200
Calcium (mg/L)		MD	-	-
		LD	429.3	410 – 446
Magnesium (mg/L)		MD	-	-
		LD	1380	1320 – 1430
Sodium (mg/L)		MD	-	-
		LD	10700	10400 – 11300
Potassium (mg/L)		MD	-	-
		LD	442.7	440 – 447
Sulfate (mg/L)		MD	-	-
		LD	3153.3	3120 – 3190
Nitrogen – total (mg/L)	0.10	MD	-	-
		LD	566.7	200 – 1100
Ammonia (µg/L)	1 - 10	MD	-	-
		LD	31.67	5 – 80
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	-	-
		LD	0.04	0.01 – 0.08
TKN (mg/L)		MD	-	-
		LD	0.5	0.1 – 1.1
BOD (mg/L)		MD	-	-
		LD	8	1 – 13

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). - = Sampling not undertaken.

7.2.1.2 Rocky Marine Shores (Wetland Type D)

Representative Sites: M8 (Observation Cliff), M12 (Smith Point)

The results of the sample analysis are provided in **Table 35** and **Table 36**.

Physical Setting

The two rocky shore sites (M8 and M12) sampled represent slightly different geomorphic conditions. Smith Point (site M12) is a rocky cliff headland located at the entrance to Port Essington and thus is directly exposed to the open waters of the Timor Sea. At the time of sampling a visible turbid plume appeared to be trapped behind the most western extremity of the outcrop. The rocky habitat adjacent to Observation Point (site M8) is located on an open part of the coastline of Port Essington, which is a semi-enclosed water body.

Physical Processes

Wave action is the dominant physical marine process at these two sites. Salinity stratification was recorded at SM12 (Smith Point), where a steady increase from 33.4 (mS/cm) to 43.4 (mS/cm) was recorded. This change in salinity may be attributed to groundwater influence from the nearby large dune/ swale wetland system located near Smith Point.

Analysis of the physical parameters at Site M8 (Observation Point) indicates that the water is well mixed laterally and vertically. Fluctuations in pH were recorded at both sites, with some measurements lower than the ANZECC guidelines. The water at both sites was well oxygenated and turbidity was occasionally elevated at Site M8.

Chemical Processes

Total nitrogen and NOx where above guideline values at both sites and during each survey period, with ammonia elevated at Site M8 in the late dry. Elevated sodium and sulphate concentrations at these wetlands are indicative of the estuarine nature of coastal systems in the Ramsar site.

Natural Variation

Natural variation within rocky marine shore sites is more likely to be influenced by the sites proximity to large scale geomorphic features. As a consequence this means that large scale water circulation patterns may have a greater influence on natural variation which is driven seasonally. In the eastern Cobourg Peninsula, rocky shores tend to be located in wave-dominated environs and as a result they are not covered by finer sediment that is accumulating as a function of lesser energy processes. The salinity stratification recorded indicates that groundwater flow may be influencing water quality near Smith Point. Small scale variations in physical properties were recorded in surface waters between the flood and ebb tides at Observation Point.

Seasonal Variation

Water temperature increases were recorded at both sites during the late dry possibly reflecting warmer ambient temperatures. An increase in salinity and a decrease in dissolved oxygen were recorded at Site M12 in the late dry. This was not duplicated at Site M8 where EC, pH, turbidity and dissolved oxygen measurements were similar during both surveys.

Table 35 Physical Ranges and Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Rocky Marine Shores

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		No value		8.0 – 8.4		1 - 20		90 – No Data	
Site M8 (Observation Cliff)											
Mean	0.1	26.2	31.0	52.1	51.7	**6.4**	**7.5**	0.9	2.4	95	120
	2.0	26.2	31.0	52.0	51.6	**6.1**	**6.0**	7.9	18.4	/	117
	3.0	26.2	/	52.0	/	**6.1**	/	6.1	/	93	/
Range (lowest - highest)	0.1 - 3.0	26.1 - 26.4	30.8 - 31.4	51.6 - 52.5	50.7 - 52.3	**5.8 - 7.9**	**4.7 - 7.9**	**0.0 - 36.8**	1.9 - **40.1**	93 - 106	113 - 126
Site M12 (Smith Point)											
Mean	0.1	27.8	29.6	33.4	55.0	^	8.0	**0.4**	1.9	111	97
	1.0	27.8	29.7	36.5	54.6	^	6.5	**0.1**	3.6	112	98
	2.0	27.8	/	38.3	/	^	/	**0.4**	/	111	/
	3.0	28.0	/	43.4	/	^	/	**0.7**	/	111	/
Range (lowest - highest)	0.1 - 3.0	27.6 - 28.1	29.6 - 29.8	32.8 - 46.9	54.5 -55.2	^	5.6 - 8.1	**0** - 5.9	1.1 - 5.5	110 - 117	95 - 139

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. *** = Site sampled during one survey only. ^ = No reading as meter malfunctioned. / = Readings not taken.

Table 36 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Rocky Marine Shores

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site M8 (Observation Cliff)				
Alkalinity – total (mg/L)		MD	120	119 – 121
		LD	114.7	113 – 116
Chloride (mg/L)		MD	19666.7	19400 – 20100
		LD	16866.7	16800 - 16900
Calcium (mg/L)		MD	442	438 – 448
		LD	421	419 - 424
Magnesium (mg/L)		MD	1180	1170 – 1190
		LD	1313.3	1310 - 1320
Sodium (mg/L)		MD	12000	11800 – 12400
		LD	10266.7	10100 - 10400
Potassium (mg/L)		MD	360	355 – 364
		LD	419.7	418 - 421
Sulfate (mg/L)		MD	2916.7	2890 – 2960
		LD	3036.7	3020 - 3050
Nitrogen – total (mg/L)	0.10	MD	**0.5**	0.3 – 0.6
		LD	**200**	100 – 300
Ammonia (µg/L)	1 - 10	MD	0.07	0.03 – 0.12
		LD	**73.3**	40 - 110
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	**0.03**	0.01 – 0.04
		LD	**0.05**	0.03 – 0.08
TKN (mg/L)		MD	0.45	0.25 – 0.60
		LD	0.17	0.10 – 0.20
BOD (mg/L)		MD	1	1 – 1
		LD	1	1 - 1
Site M12 (Smith Point)				
Alkalinity – total (mg/L)		MD	115.3	115 – 116
		LD	-	-
Chloride (mg/L)		MD	19633.3	18900 – 21000
		LD	-	-
Calcium (mg/L)		MD	426.7	426 – 427
		LD	-	-
Magnesium (mg/L)		MD	1130	1120 – 1140
		LD	-	-
Sodium (mg/L)		MD	11700	11300 – 12400
		LD	-	-
Potassium (mg/L)		MD	341.3	340 – 343
		LD	-	-
Sulfate (mg/L)		MD	2743.3	2740 – 2750
		LD	-	-
Nitrogen – total (mg/L)	0.10	MD	**0.6**	0.3 – 1.2
		LD	-	-
Ammonia (µg/L)	1 - 10	MD	0.05	0.03 – 0.06
		LD	-	-

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	**0.06**	0.04 – 0.10
		LD	-	-
TKN (mg/L)		MD	0.5	0.3 – 1.1
		LD	-	-
BOD (mg/L)		MD	1	1 – 1
		LD	-	-

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). - = Sampling not undertaken.

7.2.1.3 Sand Shores (Wetland Type E)

Representative Sites: M9 (Observation Point), M11 (Sandy Island No. 2), M13 (Sandy Island No. 1)

The results of the sample analysis are provided in **Table 37**and **Table 38**.

Physical Setting

The three sand shore sites represent relatively different geomorphic conditions. The first chosen site (M9) forms part of an open coastline dune system to the north of Observation Point and represents one of the most common types of sandy shore found in the Cobourg Peninsula. Site M11 (Sandy Island No. 2) forms part of small coral-fringed islands located approximately 5 km offshore from Danger Point. A macroalgal bloom was present on the western side of Sandy Island No. 2 and in relatively close proximity to the sample site. Site M13 (Sandy Island No. 1) is located approximately 1 km offshore and is surrounded by relatively shallow waters.

Physical Processes

Wave action is the dominant physical marine process at each site. Depth profiling of physical parameters at each site indicated that the water column is well mixed both laterally and vertically. Periodic algal accumulation in parts of the shallow sheltered lagoon at site M11 may occur which will influence chemical processes. All physical parameters measured where within or close to ANZECC guideline values.

Chemical Processes

Elevated concentrations of TN and NOx were recorded at Sites M9 and M11 in the mid dry survey, and elevated concentrations of TN, NOx and ammonia at Site M9 and M13 were recorded in the late dry survey. Elevated sodium and sulphate concentrations at this wetland type are indicative of the estuarine nature of coastal systems in the Ramsar site.

Natural Variation

The three sites appeared to function in a similar manner with little variation between sites. The increased nutrients at site M11 (Sandy Island No. 2) may be attributed to guano from the nesting seabird colony.

Seasonal Variation

A small increase in temperature was recorded between the mid and late dry surveys at M9 as well as 10% increased in dissolved oxygen.

Table 37 Physical Ranges and Mean Values from the Mid Dry (MD) and Late Dry (LD) Season Surveys of Sand Shore Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		No value		8.0 – 8.4		1 - 20		90 - 120	
Site M9 (Observation Point)											
Mean	0.1	27.1	30.8	50.1	51.8	^	**7.6**	2.4	2.0	104	125
	1.0	/	30.9	/	51.6	^	**7.9**	/	3.2	/	122
	2.0	26.8	/	50.5	/	^	/	2.2	/	102	/
	3.0	26.7	/	50.6	/	^	/	2.5	/	102	/
Range (lowest - highest)	0.1 - 3.0	26.8 - 28	30.6 - 31.2	46.6 - 50.9	51.4 - 52.1	^	**7.1 - 8.0**	1.5 - 3.0	1.6 - 3.4	107 - 110	120 - 132
Site M11 (Sandy Island No. 2)*											
Mean	0.1	26.3	/	49.2	/	^	/	**0.6**	/	104	/
	0.5 - 1.0	26.4	/	49.2	/	^	/	**0.6**	/	104	/
Range (lowest - highest)	0.1 - 1.0	26.2 - 26.4	/	48.2 -49.8	/	^	/	**0.1** - 1.5	/	102 - 105	/
Site M13 (Sandy Island No. 1)*											
Mean	0.1	/	29.2	/	56.4	/	8.0	/	2.0	/	/
	1.0	/	29.3	/	55.7	/	8.0	/	3.7	/	/
Range (lowest - highest)	0.1 - 1.0	/	28.8 - 29.6	/	55.0 - 57.0	/	**7.8** - 8.2	/	1.3 - 6.0	/	/

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). *Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. *** Site sampled during one survey only. ^ No reading as meter malfunctioned.

Table 38 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Sand Shores

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site M9 (Observation Point)				
Alkalinity – total (mg/L)		MD	119.7	118 – 122
		LD	118.3	117 - 120
Chloride (mg/L)		MD	20433.3	20300 – 20600
		LD	19966.7	17100 - 21900
Calcium (mg/L)		MD	435.7	434 – 438
		LD	436.3	434 - 438
Magnesium (mg/L)		MD	1390	1360 – 1440
		LD	1393.3	1350 - 1420
Sodium (mg/L)		MD	10933.3	10700 - 11100
		LD	11133.3	10500 - 11500
Potassium (mg/L)		MD	431.3	429 - 434
		LD	451.7	444 - 457
Sulfate (mg/L)		MD	2946.7	2940 – 2950
		LD	3276.7	3160 - 3340
Nitrogen – total (mg/L)	0.10	MD	**0.25**	0.25 – 0.25
		LD	**766.7**	200 - 1500
Ammonia (µg/L)	1 - 10	MD	0.04	0.02 – 0.08
		LD	**86.7**	50 - 120
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	**0.04**	0.03 – 0.05
		LD	**0.02**	0.01 – 0.03
TKN (mg/L)		MD	0.25	0.25 – 0.25
		LD	0.8	0.2 – 1.5
BOD (mg/L)		MD	1	1 - 1
		LD	1	1 - 1
Site M11 (Sandy Island No. 2)				
Alkalinity – total (mg/L)		MD	114	113 – 115
		LD	-	-
Chloride (mg/L)		MD	18866.7	18700 – 19000
		LD	-	-
Calcium (mg/L)		MD	421	416 - 424
		LD	-	-
Magnesium (mg/L)		MD	1100	1090 - 1110
		LD	-	-
Sodium (mg/L)		MD	11533	11200 - 11800
		LD	-	-
Potassium (mg/L)		MD	330	327 – 334
		LD	-	-
Sulfate (mg/L)		MD	2660	2620 – 2680
		LD	-	-
Nitrogen – total (mg/L)	0.10	MD	**0.5**	0.3 – 0.9
		LD	-	-
Ammonia	1 - 10	MD	0.10	0.05 – 0.16

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
(µg/L)		LD	-	-
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	**0.03**	0.02 – 0.04
		LD	-	-
TKN (mg/L)		MD	0.05	0.3 – 0.9
		LD	-	-
BOD (mg/L)		MD	1.7	1 – 2
		LD	-	-
Site M13 (Sandy Island No. 1)				
Alkalinity – total (mg/L)		MD	-	-
		LD	115.7	115 – 117
Chloride (mg/L)		MD	-	-
		LD	18333.3	16500 - 20500
Calcium (mg/L)		MD	-	-
		LD	418	415 - 421
Magnesium (mg/L)		MD	-	-
		LD	1330	1320 – 1350
Sodium (mg/L)		MD	-	-
		LD	10533.3	10200 – 10900
Potassium (mg/L)		MD	-	-
		LD	430.7	411 – 444
Sulfate (mg/L)		MD	-	-
		LD	3120	3030 - 3170
Nitrogen – total (mg/L)	0.10	MD	-	-
		LD	**366.7**	200 - 600
Ammonia (µg/L)	1 - 10	MD	-	-
		LD	**83.3**	60 - 100
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	-	-
		LD	**0.05**	0.04 – 0.06
TKN (mg/L)		MD	-	-
		LD	0.3	0.1 – 0.6
BOD (mg/L)		MD	-	-
		LD	1	1 - 1

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). - = Sampling not undertaken.

7.2.1.4 Estuarine Waters (Wetland Type F)

Representative Sites: M1 (East Bay), M15 (Knocker Bay), M17

The results of the sample analysis are provided in **Table 39** and **Table 40**.

Physical Setting

Estuarine waters within the Cobourg Peninsula Ramsar site are likely to be seasonally present as a function of the pronounced wet-dry climate and the lack of substantial fluvial systems. Creeks found on the Peninsula are known to be fed by groundwater and springs outside of the wet season. Sampling during the mid dry season survey (site M1) was undertaken at a tidal mangrove creek in East Bay close to freshwater springs. The tidal mangrove creek is typical of many small mangrove creek systems found in the eastern Cobourg Peninsula. Profiling was undertaken along the length of this tidal mangrove creek. Sampling during the late dry season survey also included site M15 (Knocker Bay) and M17 (adjacent to a large salt flat along the southern coastline).

Physical Processes

Tidal currents are the main physical controlling processes in each of these systems due to the morphology of the channels. EC values in site M1 during the mid dry season survey indicate a vertical increase in salinity in the channel. This suggests some minor freshwater influence is present. Further, EC values were lower towards the head of the system. Turbidity increased towards the substrate as would be expected from tidal current re-suspension. During the late dry season surveys, there was no apparent change in EC at depth indicating that the water column was well mixed vertically. Similar values were obtained at site M15 (Knocker Bay) during the late dry season survey. pH values were occasionally lower than the ANZECC guidelines at all sites. The dissolved oxygen concentration at M1 was well below the recommended ANZECC guidelines during both the mid and late dry season surveys.

Chemical Processes

Typical conditions exist in this Site M1 wetland for mid dry season, with elevated concentrations of NOx and total nitrogen. Nitrogen is a limiting nutrient in saline waters and exceedences slightly above the applicable guidelines is reflected in the limited amount of algal growth in this wetland type. Decreased DO concentrations and low temperatures are indicative of the moderate level of foliage cover and moderate turbidity caused by erosion.

The concentrations of TN, NOx and ammonia were much higher during the late dry survey at Site M1 with although a green colour in the water column possibly indicating a low level of algae growth. Water collected from M15 and M17 also recorded elevated concentrations of these nutrients. Elevated sodium and sulphate concentrations at this wetland type are indicative of the estuarine nature of coastal systems in the Ramsar site.

Natural Variation

Variations in salinity concentrations within estuarine waters are driven by the interaction between marine processes and freshwater runoff / groundwater influences. Small variations between sites were recorded during the late dry period, which is probably influenced by the differences in water depth.

Seasonal Variation

At site M1 all the comparable parameters increased between the mid-dry and late dry season surveys.

Table 39 Physical Ranges and Mean Values during Mid Dry (MD) and Late Dry (LD) Season Surveys of Estuarine Waters

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		No value		70 - 8.5		1 - 20		80 - 120	
Site M1 (East Bay)											
Mean	0.1	27.1	30.7	45.6	57.9	^	7.4	4.9	7.1	**45.6**	**70**
	1.0 -1.5	27.0	30.3	51.4	58.2	^	7.3	7.4	10.6	**46.1**	**63**
	2.0 - 3.0	27.0	30.0	53.1	57.2	^	**5.4**	10.1	24.2	**42.1**	**69**
Range (lowest - highest)	0.1 - 3.0	26.4 - 27.7	29.6 - 30.9	36.9 - 57.7	54.7 - 60.8	^	**4.3** - 7.5	**0.7** - 17.2	5.6 - **40**	**33.9 -59.4**	**46 - 89**
Site M15 (Knocker Bay)* **											
Mean	0.1	/	31.1	/	56.9	/	8.1	/	4.9	/	?
	1.0	/	31.0	/	56.5	/	**5.4**	/	10.2	/	?
Range (lowest - highest)	0.1 - 1.0	/	30.6 - 31.4	/	56.4 - 57.0	/	**5.3** - 8.2	/	3.4 - 14.0	/	?
Site M17 (southern coastline) * **											
Mean	0.1	/	32.6	/	59.0	/	6.7	/	**54.7**	/	?
Range (lowest - highest)	0.1 - 0.1	/	32.0 - 33.3	/	57.9 - 60.0	/	**5.8** - 7.4	/	23.5 - **93.2**	/	?

Note: Values in bold are outside ANZECC trigger values for estuarine ecosystems. * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. *** = Site sampled during one survey only. ^ = No reading as meter malfunctioned. / = Readings not taken.

Table 40 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Estuarine Waters

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site M1 (East Bay)				
Alkalinity – total (mg/L)		MD	154	143 - 160
		LD	111	67 – 155
Chloride (mg/L)		MD	25533.3	24800 – 27000
		LD	20500	20000 - 21000
Calcium (mg/L)		MD	508.7	505 – 514
		LD	531	514 – 548
Magnesium (mg/L)		MD	1300	1290 – 1310
		LD	1635	1580 – 1690
Sodium (mg/L)		MD	13833.3	13400 - 14200
		LD	12350	12000 – 12700
Potassium (mg/L)		MD	394.3	391 – 399
		LD	534	507 – 561
Sulfate (mg/L)		MD	3136.7	3130 - 3140
		LD	4000	3680 – 4320
Nitrogen – total (mg/L)	0.25	MD	**0.5**	0.3 – 0.7
		LD	**300**	200 – 400
Ammonia (µg/L)	15	MD	0.2	0.1 – 0.5
		LD	**50**	40 – 60
Nitrate/Nitrite (mg/L)	0.003	MD	**0.07**	0.04 – 0.10
		LD	**0.03**	0.02 – 0.04
TKN (mg/L)		MD	0.5	0.3 – 0.6
		LD	0.3	0.2 – 0.4
BOD (mg/L)		MD	1	1 - 1
		LD	1	1 - 1
Site M15 (Knocker Bay)				
Alkalinity – total (mg/L)		MD	-	-
		LD	123.7	122 – 126
Chloride (mg/L)		MD	-	-
		LD	22383	21450 – 23000
Calcium (mg/L)		MD	-	-
		LD	447.3	444 - 452
Magnesium (mg/L)		MD	-	-
		LD	1448.3	1430 – 1465
Sodium (mg/L)		MD	-	-
		LD	11600	11500 – 11700
Potassium (mg/L)		MD	-	-
		LD	475.3	468 – 480
Sulfate (mg/L)		MD	-	-
		LD	3326.7	3300 – 3360
Nitrogen – total (mg/L)	0.25	MD	-	-
		LD	**883.3**	350 – 1300
Ammonia	15	MD	-	-

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
(µg/L)		LD	**53.3**	5 – 85
Nitrate/Nitrite (mg/L)	0.003	MD	-	-
		LD	**0.01**	0.01 – 0.03
TKN (mg/L)		MD	-	-
		LD	0.9	0.4 – 13
BOD (mg/L)		MD	-	-
		LD	7.7	4 - 13
Site M17 (Southern Coastline)				
Alkalinity – total (mg/L)		MD	-	-
		LD	148.3	147 – 150
Chloride (mg/L)		MD	-	-
		LD	20433	18000 – 21700
Calcium (mg/L)		MD	-	-
		LD	475.3	470 – 478
Magnesium (mg/L)		MD	-	-
		LD	1446.7	1420 – 1470
Sodium (mg/L)		MD	-	-
		LD	11833.3	10900 – 12400
Potassium (mg/L)		MD	-	-
		LD	444.3	438 – 455
Sulfate (mg/L)		MD	-	-
		LD	3366.7	3360 – 3370
Nitrogen – total (mg/L)	0.25	MD	-	-
		LD	**2300**	300 – 4800
Ammonia (µg/L)	15	MD	-	-
		LD	**883.3**	40 – 1560
Nitrate/Nitrite (mg/L)	0.003	MD	-	-
		LD	**0.06**	0.05 – 0.07
TKN (mg/L)		MD	-	-
		LD	2.3	0.2 – 4.8
BOD (mg/L)		MD	-	-

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore).

7.2.1.5 Intertidal Mud Flats (Wetland Type G)

Representative Sites: M4 (Barrow Bay), M16

The results of the sample analysis are provided in **Table 41** and **Table 42**.

Physical Setting

The only accessible intertidal mudflat site (site M4) was sampled at the front of a small mangrove creek system within Barrow Bay. The intertidal flat was devoid of any visible marine flora where sampled and was composed of very soft mud. Nine locations were sampled over a distance of approximately 500m.

Physical Processes

The main physical processes affecting water parameters on these intertidal mudflats were identified as:

- periodic exposure of the substrate during tidal cycles
- resuspension of the substrate by tidal currents and wave action
- flocculation of suspended sediment in the water column
- export of leaf litter (i.e. nutrients and carbon) from nearby mangrove creek systems on the ebb tide
- extensive bioturbation and burrowing by invertebrates.

The water was laterally mixed with little variation in physical parameters. There was little evidence of freshwater influence.

Chemical Processes

The main chemical process identified for the intertidal flats is denitrification of the substrate (consisting of anoxic mud). DO levels during the mid dry season survey, whilst still able to support healthy ecosystems were noticeably lower (at high tide) than those of the more open sandy and rocky shorelines.

The concentrations of Total Nitrogen and NOx at this site were elevated when compared the guideline values for both the mid dry and late dry. During the late dry survey elevated concentrations of ammonia where measure in the water samples. The water was also green in colour during the late dry survey which may due to algae growth in the water column. Elevated sodium and sulphate concentrations at this wetland type are indicative of the estuarine nature of coastal systems in the Ramsar site.

Seasonal Variation

Temperature, conductivity and turbidity increased in concentration between August and October. The total nitrogen and ammonia concentrations in the water samples were significantly higher in the late dry season.

Table 41 Physical Ranges and Mean Values from the Mid Dry (MD) and Late Dry (LD) Season Surveys of Intertidal Mudflat Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		No value		8.0 - 8.4		1 - 20		90 – no data	
Site M4 (Barrow Bay)											
Mean	0.1	26.4	30.5	48.6	52.3	^	**7.9**	5.6	4.7	**80**	90
	1.0	/	30.1	/	52.7	^	**7.9**	/	**27.6**	/	81
Range (lowest - highest)	0.1 - 1.0	25.9 - 26.6	20.9 - 30.9	36.9 - 50.9	51.2 - 53.3	^	**7.8 -** 8.0	2.2 - 9.0	2.8 - **35.4**	80	69 - 94

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. *** = Site sampled during one survey only. ^ = No reading as meter malfunctioned. / = Readings not taken.

Table 42 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Intertidal Flats

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site M4 (Barrow Bay)				
Alkalinity – total (mg/L)		MD	128	127 – 130
		LD	122.3	122 – 123
Chloride (mg/L)		MD	20133.3	20100 – 20200
		LD	20033.3	17800 – 21300
Calcium (mg/L)		MD	444.7	441 – 447
		LD	450	446 – 456
Magnesium (mg/L)		MD	1166.7	1150 – 1180
		LD	1416.7	1400 – 1440
Sodium (mg/L)		MD	11966.7	11800 – 12200
		LD	11633	10900 – 12100
Potassium (mg/L)		MD	347.7	343 – 351
		LD	431	420 – 450
Sulfate (mg/L)		MD	2790	2770 – 2810
		LD	3260	3230 – 3290
Nitrogen – total (mg/L)	0.10	MD	**0.25**	0.25 – 0.25
		LD	**1166.7**	600 – 2200
Ammonia (µg/L)	1 – 10	MD	0.08	0.05 – 0.13
		LD	**356.7**	40 – 950
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	**0.03**	0.02 – 0.04
		LD	**0.04**	0.02 – 0.05
TKN (mg/L)		MD	0.25	0.25 – 0.25
		LD	1.1	0.6 – 2.1
BOD (mg/L)		MD	1	1 – 1
		LD	1	1 – 1

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore).

7.2.1.6 Intertidal Forested Wetlands (Wetland Type I)

Representative Sites: M2 (East Bay), M5 (Barrow Bay), M18 (Popham Creek)

The results of the sample analysis are provided in **Table 43** and **Table 44.** Note that sites M2 and M5 were sampled on different stages of the tide, with site M5 (Barrow Bay) sampled on a flood tide and the M2 (East Bay) system sampled on an ebb tide.

Physical Setting

During the mid dry and late dry season surveys, two mangrove creek systems (sites M2 and M5) of similar size and geomorphic type were sampled. Within these systems there is considerable variation in the position of the mangroves ranging from the exposed open coast setting at the front of a system to more sheltered areas at the back of the system (as demonstrated by the range of species present). Water sampling was undertaken from the safety of a small boat in the seaward fringe of mangroves adjacent to the intertidal mudflat area at both sites. Site M18 (Popham Creek) was sampled during the late dry season survey only.

Physical Processes

The main physical processes affecting water parameters were identified as:

- tide-dominated water movement in and out of system resulting in periodic exposure of the substrate
- resuspension of the substrate by tidal currents and wave action in the mangrove fringe area
- flocculation of suspended sediment in the water column
- partial stratification present in the East Bay system due to possible seasonal groundwater influence
- extensive bioturbation and burrowing by invertebrates ensuring the substrate receives water through large openings.

Turbidity and dissolved oxygen measurements were outside the ANZECC guidelines at Site M2.

Chemical Processes

Mid season concentrations of total nitrogen and NOx were elevated above ANZECC guidelines at Site M2 and M5 (M18 was not surveyed). During the late dry all three wetlands were surveyed and elevated concentrations of total nitrogen, NOx and ammonia were recorded.

The main chemical process identified for the wetland is denitrification of the substrate (consisting of anoxic mud). There is a significant amount of detrital organic material (from mangroves) in and on the substrate. Elevated sodium and sulphate concentrations at this wetland type are indicative of the estuarine nature of coastal systems in the Ramsar site.

Natural Variation

During the mid dry season survey, EC values at site M5 (Barrow Bay) were typical of seawater values while within site M2 (East Bay) EC readings indicated a freshwater influence. A vertical increase in salinity measurements with small spatial changes in salinity along the wetland fringe were recorded at Site M2 in the mid dry. DO levels were also significantly lower in the water leaving the mangrove wetland on the ebb tide. Lower temperatures and salinity but higher pHs were recorded at Site M18 compared to M5 and M2.

Seasonal Variation

All the comparable parameters increased between the mid dry and late dry season surveys at Site M2. This is expected with the increase in rainfall across the area. Similar physical measurements were recorded at Site M5 during both seasons.

Table 43 Physical Ranges and Mean Values from the Mid Dry (MD) and Late Dry (LD) Season Surveys of Intertidal Forested Wetlands

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		No value		8.0 - 8.4		1 - 20		90 – no data	
Site M2 (East Bay)											
Mean	0.1	26.8	31.6	37.9	54.3	/	7.8	6.5	**24.6**	**72**	90
	0.5	26.9	/	44.1	/	/	/	**23.0**	/	**62**	/
	1.0	26.7	31.2	41.0	54.6	/	**7.9**	7.1	**156**	**68**	**82**
Range (lowest - highest)	0.1 - 1.0	26.0 - 27.8	30.5 - 32.1	12.3 - 51.9	53.5 - 55.1	/	**7.8** - 8.2	1.4 **- 51.9**	**21.6 - 225**	62-68	**71** - 94
Site M5 (Barrow Bay)											
Mean	0.1	30.0	30.7	51.4	53.0	**8.7**	**7.9**	18.4	6.5	106	103
	0.4 - 0.6	29.6	/	51.4	/	/	/	17.9	/	104	/
	1.0	30.0	30.1	51.2	52.8	/	**7.9**	**28.3**	6.9	101	100
Range (lowest - highest)	0.1 - 1.0	26.2 - 31.1	29.3 - 31.1	50.9 - 51.9	52.7 - 53.4	**8.6 - 8.9**	**7.8 - 7.9**	11.6 - **84.6**	4.9 - 7.4	101-106	98 - 108
Site M18 (Popham Creek)*											
Mean	0.3	/	29.4	/	47.2	/	**8.7**	/	1.7	/	/
Range (lowest - highest)	0.3 - 0.3	/	29.3 - 29.4	/	46.1 - 48.2	/	**8.7 - 8.7**	/	0.9 – 4.0	/	/

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. *** = Site sampled during one survey only. ^ = No reading as meter malfunctioned. / = Readings not taken.

Table 44 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Intertidal Forested Wetlands

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site M2 (East Bay)				
Alkalinity – total (mg/L)		MD	119.3	109 – 129
		LD	124.3	123 – 127
Chloride (mg/L)		MD	20866.7	19600 – 21700
		LD	20900	18100 – 26200
Calcium (mg/L)		MD	452	428 – 468
		LD	469.7	465 – 473
Magnesium (mg/L)		MD	1443.3	1390 – 1490
		LD	1503.3	1440 – 1610
Sodium (mg/L)		MD	11300	10900 – 11700
		LD	11866.7	11100 – 13300
Potassium (mg/L)		MD	445.3	421 – 460
		LD	486.3	478 – 499
Sulfate (mg/L)		MD	3063.3	2900 – 3180
		LD	3463.3	3340 – 3610
Nitrogen – total (mg/L)	0.01	MD	**0.7**	0.3 – 1.0
		LD	**1366.7**	700 – 2600
Ammonia (µg/L)	1 – 10	MD	0.06	0.03 – 0.11
		LD	**60**	30 – 120
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	**0.05**	0.04 – 0.06
		LD	**0.02**	0.01 – 0.03
TKN (mg/L)		MD	0.6	0.3 – 0.9
		LD	1.4	0.7 – 2.6
BOD (mg/L)		MD	1	1 – 1
		LD	1	1 - 1
Site M5 (Barrow Bay)				
Alkalinity – total (mg/L)		MD	127.3	126 – 129
		LD	121.3	121 – 122
Chloride (mg/L)		MD	20033.3	19900 – 20200
		LD	17633.3	17500 – 17700
Calcium (mg/L)		MD	448.3	446 – 452
		LD	451.3	446 – 456
Magnesium (mg/L)		MD	1186.7	1180 – 1200
		LD	1400	1390 – 1410
Sodium (mg/L)		MD	12066.7	11600 – 12400
		LD	10933	10900 - 11000
Potassium (mg/L)		MD	357.7	356 – 359
		LD	461.7	460 – 463
Sulfate (mg/L)		MD	2893.3	2880 – 2910
		LD	3326.7	3270 – 3390
Nitrogen – total (mg/L)	0.01	MD	**0.4**	0.3 – 0.6
		LD	**733.3**	600 – 900
Ammonia	1 – 10	MD	0.06	0.03 – 0.09

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
(µg/L)		LD	**63.3**	30 – 100
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	**0.03**	0.01 – 0.05
		LD	**0.04**	0.01 – 0.08
TKN (mg/L)		MD	0.4	0.3 – 0.6
		LD	0.7	0.5 – 0.9
BOD (mg/L)		MD	1.3	1 – 2
		LD	1	1 - 1
Site M18 (Popham Creek)				
Alkalinity – total (mg/L)		MD	-	-
		LD	120	119 – 121
Chloride (mg/L)		MD	-	-
		LD	18550	18500 – 18600
Calcium (mg/L)		MD	-	-
		LD	444	443 – 445
Magnesium (mg/L)		MD	-	-
		LD	1365	1360 - 1370
Sodium (mg/L)		MD	-	-
		LD	10750	10600 – 10900
Potassium (mg/L)		MD	-	-
		LD	463	449 – 477
Sulfate (mg/L)		MD	-	-
		LD	3300	3270 – 3330
Nitrogen – total (mg/L)	0.01	MD	-	-
		LD	**300**	200 - 400
Ammonia (µg/L)	1 – 10	MD	-	-
		LD	**12.5**	5 – 20
Nitrate/Nitrite (mg/L)	0.002 – 0.008	MD	-	-
		LD	**0.01**	0.01 – 0.01
TKN (mg/L)		MD	-	-
		LD	0.3	0.2 – 0.4
BOD (mg/L)		MD	-	-
		LD	14	11 - 17

Note: Values in bold are outside ANZECC trigger values for marine ecosystems (inshore). - = Sampling not undertaken.

7.2.1.7 Coastal Brackish/Saline Lagoons (Wetland Type J)

Representative Sites: M6 (Barrow Bay), M7 (Gul Gul), M19 (Araru Point)

The results of the sample analysis are provided in **Table 45** and **Table 46**.

Physical Setting

Coastal saline lagoons in the Ramsar site are typically connected to the ocean through a small tidal channel that is fringed with mangroves. Three sites with relatively different geomorphic expression were sampled. Site M7 (Gul Gul) is a lagoon that is associated with a typical large beach ridge system (wave-dominated system) common on the Peninsula. Site M6 (Barrow Bay) is associated with typical chenier ridge / salt flat morphology that is more commonly associated in tide-dominated systems. Site M19 (Araru Point) is relatively small with a short (50 m) connection to the ocean.

Physical Processes

The main physical and chemical processes affecting water parameters in these coastal brackish/saline lagoons were identified as:

- poor flushing of the system with marine waters (given the size of the lagoons relative to the tidal channel)
- freshwater influence was present at sites M6 (Barrow Bay) and M19 (Araru Point) as reflected by the lower EC values
- evaporation which created hypersalinity conditions at site M7 (Gul Gul) and deposits of salt on elevated parts of the lagoon shore
- resuspension of substrate by surface waves on lagoon
- bioturbation by limited species of invertebrates
- reduced substrate at depth with anoxic sediment present.

Chemical Processes

Mid season concentrations of total nitrogen and NOx were elevated above ANZECC guidelines at Site M6 and M7. During the late dry survey in both wetlands elevated concentrations of total nitrogen, NOx and ammonia were recorded. A high level of organic matter in the substrate and disturbance from feral animals contributed to the elevated nutrient levels. Elevated sodium and sulphate concentrations at these wetlands were measured.

Natural Variation

Variation in salinity conditions within the Barrow Bay (site M6) system is driven by the interaction between marine processes and freshwater runoff / groundwater influences. Based on limited sampling, site M7 (Gul Gul) does not appear to be as influenced by freshwater.

Seasonal Variation

Increases in salinity for Sites M6 and M7 were the most noticeable change between the mid dry and late dry surveys.

Table 45 Physical Ranges and Mean Values from the Mid Dry (MD) and Late Dry (LD) Season Surveys of Coastal Brackish/Saline Lagoons

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		No value		7.0 - 8.5		1 - 20		80 - 120	
Site M6 (Barrow Bay)											
Mean	0.1	29.9	30.5	21.9	70.1	^	7.7	0	8.4	108	92
Range (lowest - highest)	0.1 - 0.1	29.4 - 30.2	30.4 - 30.7	19.4 - 20.7	69.7 - 70.4	^	7.4 - 7.9	0	7.4 - 10.1	101 - 115	81 - 104
Site M7 (Gul Gul)											
Mean	0.1	28.1	41.5	65.2	76.7	^	**9.3**	4.1	4.3	111	116
Range (lowest - highest)	0.1 - 0.1	27.7 - 28.3	41.4 - 41.6	60.3 - 66.9	76.3 - 77.0	^	**9.3 - 9.4**	8.5 - 8.6	2.3 - 7.6	109 - 114	109 - 120
Site M19 (Araru Point)											
Mean	0.2	/	37.4	/	38.0	/	9.5	/	15.1	/	/
Range (lowest - highest)	0.2 - 0.2	/	^^	/	^^	/	^^	/	^^	/	/

Note: Values in bold are outside ANZECC trigger values for estuarine ecosystems. * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. ^ = No reading as meter malfunctioned. ^^ = Only one reading taken at this site. / = Readings not taken.

Table 46 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Coastal Brackish/Saline Lagoons

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site M6 (Barrow Bay)				
Alkalinity – total (mg/L)		MD	0.5	0.5 – 0.5
		LD	107	101 – 111
Chloride (mg/L)		MD	9780	9720 – 9810
		LD	32566.7	32000 – 33000
Calcium (mg/L)		MD	241.3	241 – 242
		LD	641.7	637 – 645
Magnesium (mg/L)		MD	670	665 – 673
		LD	2063.3	2030 – 2090
Sodium (mg/L)		MD	5220	5200 – 5230
		LD	16633.3	16400 – 16900
Potassium (mg/L)		MD	174	172 – 176
		LD	592	590 – 594
Sulfate (mg/L)		MD	1650	1630 – 1660
		LD	4673.3	4600 – 4740
Nitrogen – total (mg/L)	0.25	MD	**0.25**	0.25 – 0.25
		LD	**1233.3**	1200 – 1300
Ammonia (µg/L)	15	MD	0.29	0.26 – 0.32
		LD	**480**	270 – 740
Nitrate/Nitrite (mg/L)	0.003	MD	**0.04**	0.02 – 0.05
		LD	**0.04**	0.02 – 0.08
TKN (mg/L)		MD	0.25	0.25 – 0.25
		LD	1.2	1.2 – 1.2
BOD (mg/L)		MD	1.7	1 - 3
		LD	4	4 - 4
Site M7 (Gul Gul)				
Alkalinity – total (mg/L)		MD	153.3	152 – 155
		LD	133	132 – 134
Chloride (mg/L)		MD	32566.7	32200 – 32800
		LD	40700	37200 – 43000
Calcium (mg/L)		MD	602	599 – 604
		LD	696	686 – 706
Magnesium (mg/L)		MD	1956.7	1920 – 1990
		LD	2473.3	2380 - 2530
Sodium (mg/L)		MD	16433.3	16200 – 16700
		LD	21100	19900 – 22000
Potassium (mg/L)		MD	603	600 – 607
		LD	853.7	844 – 868
Sulfate (mg/L)		MD	4043.3	4040 - 4050
		LD	5466.7	5380 – 5580
Nitrogen – total (mg/L)	0.25	MD	**1**	0.3 – 2.0
		LD	**1400**	1100 – 1800
Ammonia	15	MD	0.63	0.28 – 1.23

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
(µg/L)		LD	**623.3**	560 - 660
Nitrate/Nitrite (mg/L)	0.003	MD	**0.04**	0.03 – 0.05
		LD	**0.02**	0.02 – 0.03
TKN (mg/L)		MD	1	0.3 – 2.0
		LD	1.4	1.1 – 1.8
BOD (mg/L)		MD	3	1 – 5
		LD	1	1 - 1

Note: Values in bold are outside ANZECC trigger values for estuarine ecosystems.

7.2.1.8 Coastal Freshwater Lagoon (Wetland Type K)

Representative Site: M20 (Mariah Swamp)

The results of the sample analysis are provided in **Table 47** and **Table 48**.

Physical Setting

Mariah Swamp (site M20) is a large freshwater lagoon system located in relatively close proximity to the coast. There appears to be three creeks through which freshwater is sourced. The lake edge is thickly vegetated with *Eleocharis* sp. but contains a large area of open water.

Physical Processes

The system is marginally fresh to brackish and influenced by some saltwater intrusion. The conductivity of water sampled in one of the creeks entering the system during the mid dry season survey was found to be 0.05 mS/cm. Periodic breakout of the system to the marine environment, when the system is full, is likely to occur. Dissolved oxygen was lower than the ANZEC guidelines. Surface wind waves would be responsible for resuspension of lake edge sediments given the size of the water body. Low DO is indicative of reduced freshwater flows at the site.

Chemical Processes

Mid and dry season concentrations of total nitrogen, NOx and ammonia were elevated above ANZECC guidelines at Site M20.

Natural Variation

Natural variation within this wetland may be small and dependent on the amount of rainfall which falls during the wet season.

Seasonal Variation

DO, turbidity and temperature increased between the mid and late dry season survey, with temperature showing a marked change. pH remained constant over the two sample dates, whilst conductivity decreased slightly. The increase in DO and turbidity, and decrease in conductivity is likely to be due to the rainfall that occurred between sample date, causing increased flow and wetland retention and deposition.

Table 47 Physical Ranges and Mean Values from the Mid Dry (MD) and Late Dry (LD) Season Surveys of Coastal Freshwater Lagoon Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		0.09 - 0.90		6.0 - 8.0		2.0 - 200.0		90 - 120	
Site M20											
Mean	0.1	26.7	42.4	**2.7**	**0.0**	7.5	7.7	1.9	38.2	**33.3**	**54**
Range (lowest, highest)	0.1, 0.1	25.2 - 28.3	39.2 - 44.5	**2.6 - 2.7**	**0.0 -0.0**	7.4 - 7.5	7.0 -8.0	1.5 - 2.3	16.7 - 80	**25.2 -41.0**	**10** - 92

Note: Values in bold are outside ANZECC trigger values for freshwater lakes. *Due to the temperature being so variable in Australia ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile.

Table 48 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Coastal Freshwater Lagoons

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site M20				
Alkalinity – total (mg/L)		MD	34.7	2 – 51
		LD	241	222 – 251
Chloride (mg/L)		MD	579	14 – 866
		LD	6033.3	5780 – 6270
Calcium (mg/L)		MD	10.2	0.5 – 15.0
		LD	128	120 – 133
Magnesium (mg/L)		MD	30.5	0.5 – 46.0
		LD	391.3	359 – 414
Sodium (mg/L)		MD	314	8 – 474
		LD	3386.7	3180 – 3600
Potassium (mg/L)		MD	12.5	0.5 – 19.0
		LD	117.7	111 – 123
Sulfate (mg/L)		MD	36.7	1 – 55
		LD	457.3	450 – 469
Nitrogen – total (mg/L)	0.35	MD	**533.3**	400 – 600
		LD	**1600**	1400 – 1800
Ammonia (µg/L)	10	MD	**90**	10 – 140
		LD	**38.3**	5 – 70
Nitrate/Nitrite (mg/L)	0.01	MD	**0.06**	0.05 – 0.08
		LD	**0.05**	0.04 – 0.06
TKN (mg/L)		MD	0.5	0.3 – 0.6
		LD	1.5	1.4 – 1.7
BOD (mg/L)		MD	1.3	1.0 – 2.0
		LD	5	1 - 13

Note: Values in bold are outside ANZECC trigger values for freshwater lake ecosystems.

7.2.2 Inland Wetlands

Appendix L summarises the water chemistry of inland wetland sites during the mid dry and late dry season surveys. **Table 49** provides a comparative snapshot of physical water parameters between inland wetland types in the Cobourg Peninsula Ramsar site.

Table 49 Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Inland Wetlands

	Number of Sites Containing Water	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
Wetland Types		**MD**	**LD**	**MD**	**LD**	**MD**	**LD**	**MD**	**LD**	**MD**	**LD**
Seasonal Creeks (N)	1	25.6	26.6	0.1	0.1	6.0	6.0	1.1	117	59.7	18.0
Permanent Brackish/Saline Lakes (Q)	1	30.9	37.8	21.6	41.4	8.9	8.0	2.8	117	150	55.0
Seasonal Brackish/Saline Lakes (R)	1	24.6	22.9	7.9	22.6	8.7	7.4	2.5	231	22.2	11.4
Seasonal Brackish/Saline Pools (Ss)	1	/	40.0	/	11.3	/	9.8	/	36.1	/	6.3
Permanent Freshwater Pools (Tp)	1	/	32.7	/	0.4	/	6.1	/	28.0	/	4.8
Seasonal Freshwater Pools (Ts)	0	/	/	/	/	/	/	/	/	/	/
Freshwater, Tree-dominated Wetland (Xf)	1	29.9	/	2.3	/	7.6	/	1206	/	75.1	/
Freshwater Springs (Y)	3	26.4	32.2	0.0	0.0	5.1	5.5	4.7	290.4	36.6	30.3

Key: / = water sampling not undertaken at this site during this period.

7.2.2.1 Seasonal Creeks (Wetland Type N)

Representative Sites: I3 (Wahwaldi), I13 (East Bay)

The results of the sample analysis for site I3 are provided in **Table 50** and **Table 51**. No water was present in site I13 when visited.

Physical Setting

Situated in the eastern part of the Peninsula, site I3 is thought to be supplied by spring waters from one of its tributaries. The creek was flowing in the low flow channel and there was evidence of past human activity around the site.

Physical Processes

The main physical process affecting site I3 appears to be changes to volume in the channel which is supplied by both runoff and spring waters. The EC values during the mid dry season survey indicate that water sampled in the channel is fresh and likely to be supplied at the time of sampling by spring waters. The pH of the water was on the lower side of the ANZECC guidelines, however not quite as low as that sampled for spring waters. Turbidity measurements were elevated in the water during the late dry season survey. Dissolved oxygen concentrations were lower than the ANZECC guidelines.

Chemical Processes

Mid and late dry season concentrations of total nitrogen and NOx were elevated above ANZECC guidelines at Site I3. Late dry concentrations of ammonia were also elevated. The mid dry season conditions at site I3 included high freshwater inflow and high foliage cover. These factors may have combined to reduce the nutrient levels in the water column, limiting algae growth and maintaining acceptable DO levels. The occurrence of a creek crossing at this site may be contributing to the slightly elevated turbidity levels.

In the late dry season, conditions changed significantly at site I3. The freshwater inflow was significantly less and water was pooling at the site causing stagnancy. The stagnant water, the occurrence of the road crossing and Feral Pigs frequenting the location combined to increase the nutrient loading in the water column.

Natural Variation

Larger turbidity variations were recorded in the late dry sampling survey.

Seasonal Variation

Increases in turbidity and decreased in dissolved oxygen concentrations were measured in the late dry sampling survey than the mid dry survey.

Table 50 Physical Ranges and Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Seasonal Creek Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		0.02 - 0.25		6.0 - 8.0		2.0 - 15.0		85 - 120	
Site I3 (Irgul Road)											
Mean	0.1	25.6	26.6	0.1	0.1	6.0	6.0	**1.1**	**117**	**59.7**	**18.0**
Range (lowest, highest)	0.1, 0.1	25.6 - 25.6	25.9 - 27.1	0.1 - 0.1	0.1 - 0.2	6.0 - 6.0	**5.7** - 6.5	**0.1** - 2.0	**19.0 - 297**	**55.6 - 63.8**	**14.0 - 21.0**

Note: Values in bold are outside ANZECC trigger values for lowland river ecosystems. * = Due to the temperature variability, ANZECC recommends deriving trigger values on a site specific basis using the 80^{th} and 20^{th} percentile.

Table 51 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Seasonal Creek Sites

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site I3 (Irgul Road)				
Alkalinity – total (mg/L)		MD	4	4 - 4
		LD	10	5 – 15
Chloride (mg/L)		MD	9.5	7 – 12
		LD	24	22 – 26
Calcium (mg/L)		MD	0.5	0.5 – 0.5
		LD	0.8	0.5 – 1.0
Magnesium (mg/L)		MD	0.5	0.5 – 0.5
		LD	2.3	2.0 – 2.5
Sodium (mg/L)		MD	6.5	4 – 9
		LD	18.8	18.5 – 19.0
Potassium (mg/L)		MD	0.5	0.5 – 0.5
		LD	0.6	0.5 – 0.8
Sulfate (mg/L)		MD	0.5	0.5 – 0.5
		LD	5.8	5.5 – 6.0
Nitrogen – total (mg/L)	0.2 – 0.3	MD	**0.25**	0.2 – 0.3
		LD	**800**	700 - 900
Ammonia (µg/L)	10	MD	0.12	0.01 – 0.23
		LD	**47.5**	40 – 55
Nitrate/Nitrite (mg/L)	0.01	MD	**0.02**	0.01 – 0.02
		LD	**0.04**	0.01 – 0.07
TKN (mg/L)		MD	0.25	0.2 – 0.3
		LD	0.75	0.7 – 0.8
BOD (mg/L)		MD	1.5	1 – 2
		LD	1	1 - 1

Note: Values in bold are outside ANZECC trigger values for lowland river ecosystems.

7.2.2.2 Permanent Brackish/Saline Lakes (Wetland Type Q)

Representative Site: I2 (Campsite No. 2 Billabong)

The results of the sample analysis are provided in **Table 52** and **Table 53**.

Physical Setting

Site I2 is located in close proximity to the coast and forms part of the larger dune-swale system located in the vicinity of the Black Point / Smith Point area. A number of large swamps make up the dune-swale system that is seasonally connected by small channels when filled with freshwater runoff received during the wet season. The larger dune /swale system does periodically break out to the marine environment when filled. Flora species observations of mature melaleuca dieback and juvenile mangroves (*Lumnitzera* sp.) in the lake sampled may suggest a relatively recent change in salinity conditions within this system.

Physical Processes

The main physical processes affecting water parameters at Site I2 were identified as:

- Resuspension of lake edge sediments by wind action due to the size of the water body.
- Inundation by seawater during cyclones. Cyclone Ingrid may have been the cause of saline conditions recorded given that the waters appear to be fed by runoff /groundwater.
- The substrate at depth is reduced with anoxic sediment present, as well as algal mats.

Chemical Processes

Mid and late dry season concentrations of total nitrogen and NOx were elevated above ANZECC guidelines at Site I2. Late dry concentrations of ammonia were also elevated. Elevated concentrations of sodium and sulphate are consistent with the saline/brackish nature of the wetland.

Natural Variation

The greatest natural within wetland variation may be attributed to changes due to large cyclonic events.

Seasonal Variation

Temperature, conductivity and turbidity increased between the mid dry and late dry survey. Dissolved oxygen concentrations were above the ANZECC guidelines during the mid dry survey but well below when the water was sampled in the wet dry survey. Algal mats were present in the wetland which may have influenced the turbidity and oxygen levels.

Table 52 Physical Ranges and Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Permanent Brackish/Saline Lake Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	ED	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		0.09 - 0.9		6.0 - 8.0		2 - 200		90 - 120	
Site I2 (Campsite No. 2 Billabong)											
Average	0.3	30.9	37.8	**21.6**	**41.4**	**8.9**	7.5	2.8	117	**150**	**55**
Range (lowest, highest)	0.1 - 0.4	30.6 - 31.2	36.9 - 38.8	**21.6 -21.6**	**37.1 - 44.8**	**8.6 - 9.0**	7.8 - **8.4**	**0.9** - 5.5	**0 - 341**	**131 -161**	**5 - 83**

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems. * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile.

Table 53 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Permanent Brackish/Saline Lakes

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site I2 (Campsite No. 2 Billabong)				
Alkalinity – total (mg/L)		MD	88.3	81 – 100
		LD	110	95 – 133
Chloride (mg/L)		MD	7703.3	7430 – 7860
		LD	19400	18600 – 20500
Calcium (mg/L)		MD	383	366 – 393
		LD	940	909 – 977
Magnesium (mg/L)		MD	468	461 – 472
		LD	1366.7	1280 – 1460
Sodium (mg/L)		MD	3870	3720 – 3960
		LD	10370	9710 – 11000
Potassium (mg/L)		MD	137.7	128 – 143
		LD	352.3	331 – 369
Sulfate (mg/L)		MD	1586.7	1470 – 1650
		LD	4753.3	4600 – 4870
Nitrogen – total (mg/L)	0.35 – 1.20	MD	**1.2**	0.8 – 1.9
		LD	**2300**	1600 – 3400
Ammonia (µg/L)	10	MD	0.74	0.03 – 1.80
		LD	**160**	100 – 220
Nitrate/Nitrite (mg/L)	0.01	MD	**0.03**	0.02 – 0.05
		LD	**0.03**	0.03 – 0.04
TKN (mg/L)		MD	1.2	0.8 – 1.9
		LD	2.3	1.6 – 3.4
BOD (mg/L)		MD	24	2 – 67
		LD	2.3	1 - 5

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems.

7.2.2.3 Seasonal Brackish/Saline Lakes (Wetland Type R)

Representative Site: I1 (Wuwurdi Swamp)

The results of the sample analysis are provided in **Table 54** and **Table 55**.

Physical Setting

Wuwurdi Swamp (I1) is situated in close proximity to the coast near Black Point, in a slight depression on the boundary between the tertiary weathered surface and extensive coastal sediments found to the north. The substrate contains a high content of organic matter.

Physical Processes

The amount of water present in the swamp and the period over which it remains wet is likely dependent on seasonal factors. EC readings indicate that the water is saline. There are no obvious direct links to the ocean through which saline waters can enter. The pH levels indicate alkaline conditions slightly above the ANZECC guidelines. The swamp is known to fill with freshwater runoff during the wet season and is likely to have limited groundwater inflow (since it periodically dries) and low dissolved oxygen 5-32%, well below guideline concentrations.

Chemical Processes

Mid and late dry season concentrations of total nitrogen and NOx were elevated above ANZECC guidelines at Site I1. Late dry concentrations of ammonia were also elevated. Elevated sodium concentrations are consistent with the type of wetland (seasonal and saline).

Natural Variation

TKN values recorded in this swamp are significantly higher than in other wetlands sampled in the Eastern Cobourg Peninsula. The reason for high nutrients cannot be determined at this stage, however the swamp is located in close proximity to the Black Point settlement, is frequented by feral animals and does contain a significant amount of organic debris. DO levels are significantly lower than found in other brackish/freshwater wetlands sampled. Floating algal mats were present at the site.

Seasonal Variation

Natural variation within this wetland will depend on the amount of rainfall during the wet season. As conditions dry significant changes in wetland water quality may occur. The most obvious change between the seasons were higher salinity and turbidity values in the late dry survey compared to the mid dry survey.

Table 54 Physical Ranges and Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Seasonal Brackish/Saline Lake Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		0.09 - 0.9		6.0 – 8.0		2.0 - 200.0		90 - 120	
Site I1 (Wuwurdi Swamp)											
Mean	0.3	24.6	22.9	**7.9**	**22.5**	**8.7**	7.4	2.5	**231.1**	**22.2**	**11.4**
Range (lowest, highest)	0.1 - 0.4	23.4 - 25.7	17.6 - 32.0	**7.7 - 8.1**	**19.8 - 27.3**	7.9 - **9.9**	7.2 - 7.6	**0.3** - 4.1	**0 - 622**	**5.8 - 34.1**	**0.3 - 32.0**

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems. * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile

Table 55 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Seasonal Brackish/Saline Lake Sites

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site I1 (Wuwurdi Swamp)				
Alkalinity – total (mg/L)		MD	183	120 – 215
		LD	332.7	188 – 435
Chloride (mg/L)		MD	2976.7	2920 – 3020
		LD	9236.7	8450 – 10400
Calcium (mg/L)		MD	236	230 – 239
		LD	724.7	631 – 772
Magnesium (mg/L)		MD	141.3	140 – 142
		LD	524.7	456 – 588
Sodium (mg/L)		MD	1400	1380 – 1410
		LD	3930	3530 – 4420
Potassium (mg/L)		MD	44.3	41 – 47
		LD	130.7	122 – 145
Sulfate (mg/L)		MD	209.3	182 – 262
		LD	154.3	32 – 374
Nitrogen – total (mg/L)	0.35 – 1.20	MD	**1.4**	1.3 – 1.5
		LD	**10933**	5500 – 21800
Ammonia (µg/L)	10	MD	0.14	0.01 – 0.25
		LD	**666.7**	140 – 1680
Nitrate/Nitrite (mg/L)	0.01	MD	**0.03**	0.03 – 0.04
		LD	**0.01**	0.01 – 0.02
TKN (mg/L)		MD	1.4	1.3 – 1.5
		LD	10.9	5.5 – 21.8
BOD (mg/L)		MD	3	2 - 4
		LD	9	1 - 25

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems.

7.2.2.4 Seasonal Brackish/Saline Pools (Wetland Type Ss)

Representative Site: I12 (Araru Point)

The results of the sample analysis are provided in **Table 56**and **Table 57** .

Physical Setting

Site I12 is situated in close proximity to the coast near Araru Point, in a slight depression on the boundary between the tertiary weathered surface and extensive coastal sediments along the northern coastline of Araru Point. The pool is relatively small (< 1 ha) and contains grassy banks with occasional trees. The late dry season survey revealed some water contained within the pool, however, historic aerial photos show the pool being dry in some years.

Physical Processes

The amount of water present in the pool and the period over which it remains wet is likely dependent on seasonal factors. This site was accessed only during the late dry season. EC readings indicate that the water is saline (11 mS/cm) with no direct links to the ocean through which saline waters can enter. The pH levels indicate alkaline conditions (9.8) outside the guideline range of 6.8 while turbidity was within the guideline values. Emerging freshwater-dependent vegetation at one end of the pool suggests that the pool may have some groundwater inflow.

Chemical Processes

Site I12 was only surveyed during the late dry season. Concentrations of total nitrogen, NOx and ammonia recorded were elevated above ANZECC guidelines.

Seasonal Variation

Natural variation within this wetland will depend on the amount of rainfall during the wet season. As conditions dry significant changes in wetland water quality may occur.

Table 56 Physical Ranges and Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Seasonal Brackish/Saline Pool Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		0.09 - 0.9		6.0 – 8.0		2.0 - 200.0		90 - 120	
Site I12 (Araru Point)											
Mean	0.1	/	40.0	/	**11.3**	/	**9.8**	/	36.1	/	/
Range (lowest, highest)	0.1 - 0.1	/	38.4 - 41.1	/	**11.0 - 11.7**	/	**9.8 - 9.8**	/	**1.0** - 99.0	/	/

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems. * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. / = Readings not taken.

Table 57 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Seasonal Saline Pool Sites

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site I12 (Araru Point)				
Alkalinity – total (mg/L)		MD	-	-
		LD	573	566 – 578
Chloride (mg/L)		MD	-	-
		LD	3596.7	3560 - 3640
Calcium (mg/L)		MD	-	-
		LD	28	28 – 28
Magnesium (mg/L)		MD	-	-
		LD	263	255 – 269
Sodium (mg/L)		MD	-	-
		LD	2233.3	1990 – 2410
Potassium (mg/L)		MD	-	-
		LD	93	87 – 100
Sulfate (mg/L)		MD	-	-
		LD	362.7	342 - 384
Nitrogen – total (mg/L)	0.35 – 1.20	MD	-	-
		LD	**4033.3**	3900 – 4200
Ammonia (µg/L)	10	MD	-	-
		LD	**10**	5 – 20
Nitrate/Nitrite (mg/L)	0.01	MD	-	-
		LD	**0.01**	0.01 – 0.02
TKN (mg/L)		MD	-	-
		LD	4	3.9 – 4.2
BOD (mg/L)		MD	-	-
		LD	11.3	1 - 21

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems. - = Sampling not undertaken.

7.2.2.5 Permanent Freshwater Pools (Wetland Type Tp)

Representative Site: Site I10 (Coral Bay)

The results of the sample analysis are provided in **Table 58** and **Table 59**.

Physical Setting

Site I10 is located inland from Knocker Bay, near to the Seven Spirit Bay resort.

Physical Processes

The amount of water present in the pool is likely dependent on seasonal factors. This site was accessed only during the late dry season. There is potential for inundation of the pool by seawater during cyclones. Patches of dead *Melaleuca* trees and the recruitment of young *Melaleuca* trees may indicate the results of such an event. The substrate at depth is reduced with anoxic sediment present, as well as algal mats.

Chemical Processes

Site I10 was only surveyed during the late dry season. Concentrations of total nitrogen, NOx and ammonia recorded were elevated above ANZECC guidelines.

Seasonal Variation

Natural variation within this wetland will depend on the amount of rainfall during the wet season. As conditions dry significant changes in wetland water quality may occur.

Table 58 Physical Ranges and Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Permanent Freshwater Pool Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		0.09 - 0.90		6.0 – 8.0		2.0 - 200.0		90 - 120	
Site I10 (Coral Bay)											
Mean	0.4	/	32.7	/	0.4	/	6.1	/	28.0	/	/
Range (lowest, highest)	0.3 - 0.5	/	29.7 - 36.3	/	0.1 - **1.0**	/	**5.0** - 6.9	/	2.6 - 69.5	/	/

Note: Values in bold are outside ANZECC trigger values for fresh water lake and wetland ecosystems. * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. / = Readings not taken.

Table 59 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Permanent Freshwater Pool Sites

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site I10 (Coral Bay)				
Alkalinity – total (mg/L)		MD	-	-
		LD	2.7	2 – 3
Chloride (mg/L)		MD	-	-
		LD	27.7	24 – 30
Calcium (mg/L)		MD	-	-
		LD	0.5	0.5 – 0.5
Magnesium (mg/L)		MD	-	-
		LD	0.8	0.5 – 0.10
Sodium (mg/L)		MD	-	-
		LD	22.3	20 – 25
Potassium (mg/L)		MD	-	-
		LD	0.5	0.5 – 0.5
Sulfate (mg/L)		MD	-	-
		LD	3.7	2.5 – 6.0
Nitrogen – total (mg/L)	0.35 – 1.20	MD	-	-
		LD	**3533.3**	600 - 7400
Ammonia (µg/L)	10	MD	-	-
		LD	**43.3**	30 – 60
Nitrate/Nitrite (mg/L)	0.01	MD	-	-
		LD	**0.03**	0.01 – 0.05
TKN (mg/L)		MD	-	-
		LD	3.5	0.6 – 7.4
BOD (mg/L)		MD	-	-
		LD	3.7	1 - 7

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems. - = Sampling not undertaken.

7.2.2.6 Seasonal Freshwater Pools (Wetland Type Ts)

Representative Site: I5 (Ingrid's Waterhole)

There was no water present at site I5 during the mid dry or late dry season surveys.

7.2.2.7 Freshwater, Tree-dominated Wetlands (Wetland Type Xf)

Representative Sites: I4 (Danger Point), I8 (Friarbird Swamp)

The results of the sample analysis are provided in **Table 60** and **Table 61**.

Physical Setting

Site I4 is *Melaleuca* dominated with seasonal freshwater flow. It is located in a shallow depression feature on a narrow isthmus with dark clay soils. Water sampling was undertaken in a number heavily impacted of pools/wallows containing green algae. Less than 5% of the wetland area contained water at the time of sampling.

Physical Processes

The main physical processes affecting water parameters are identified as:

- seasonality of freshwater flow to the wetland balanced by evaporative processes during the dry season
- major disturbance to and pollution by feral animals.

The parameters measured during the mid dry survey indicate that the water was brackish and dissolved oxygen was below guideline concentrations while turbidity was elevated.

Chemical Processes

Site I5 was only surveyed during the mid dry season. Elevated concentrations of total nitrogen and NOx were recorded above ANZECC guidelines.

Seasonal Variation

Variation in water quality within these systems is seasonally driven. Turbidity and water clarity within these waters are also affected by the disturbance of the substrate by feral animals.

Table 60 Physical Ranges and Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Freshwater, Tree-dominated Wetland Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		0.09 - 0.90		6.0 – 8.0		2.0 - 200.0		90 - 120	
Site I4 (Danger Point)											
Mean	0.1	29.9	/	**2.3**	/	7.6	/	**1206**	/	**75.1**	/
Range (lowest, highest)	0.1, 0.1	28.7 - 30.8	/	**2.3 - 2.4**	/	7.4 - 7.8	/	**386 - 2664**	/	**59.5 -89.4**	/

Note: Values in bold are outside ANZECC trigger values for fresh water lake and wetland ecosystems. * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80th and 20th percentile. / = Readings not taken.

Table 61 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Freshwater Tree-dominated Wetland Sites

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site I4 (Danger Point)				
Alkalinity – total (mg/L)		MD	66	58 – 72
		LD	-	-
Chloride (mg/L)		MD	758.7	751 – 770
		LD	-	-
Calcium (mg/L)		MD	39.3	39 – 40
		LD	-	-
Magnesium (mg/L)		MD	34.7	34 – 35
		LD	-	-
Sodium (mg/L)		MD	395	388 – 403
		LD	-	-
Potassium (mg/L)		MD	21.7	21 – 22
		LD	-	-
Sulfate (mg/L)		MD	16	14 – 17
		LD	-	-
Nitrogen – total (mg/L)	0.35 – 1.20	MD	**2.5**	1.6 – 2.9
		LD	-	-
Ammonia (µg/L)	10	MD	0.9	0.52 – 1.48
		LD	-	-
Nitrate/Nitrite (mg/L)	0.01	MD	**0.02**	0.01 – 0.03
		LD	-	-
TKN (mg/L)		MD	2.5	1.6 – 2.9
		LD	-	-
BOD (mg/L)		MD	6.3	3 – 10
		LD	-	-

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems. - = Sampling not undertaken.

7.2.2.8 Freshwater Springs (Wetland Type Y)

Representative Sites: I6 (Ferny Spring), I7 (Wolf Claw Spring), I11

The results of the sample analysis are provided in **Table 62** and **Table 63** .

Physical Setting

Three freshwater springs were sampled (Ferny Spring (I6), Wolf Claw (I7) and a third of unknown name (I11)). All contain dense wetland vegetation with high organic matter on the substrates and tannin present in the waters. Each site contains a number of different pools and separated by higher ground.

Physical Processes

The water that was sampled within all three springs was fresh. Water levels within the spring are likely to be regulated by groundwater height, which is influenced by local annual rainfall and infiltration rates. All of the springs surveyed contained significantly lower pH values than wetlands sampled elsewhere which is not unusual. Dissolved oxygen concentrations where below guideline concentrations and turbidity was above the ANZECC guidelines.

Chemical Processes

Sites I6 and I7 were sampled in both seasons while Site I11 was only surveyed in the late dry season. Concentrations of total nitrogen, NOx and ammonia were elevated above ANZECC guidelines in the late dry at all sites and NOx was elevated at I6 and I7 during the mid dry survey.

Natural Variation

The variation between the three sites was mainly with respect to temperature, dissolved oxygen and turbidity. Turbidity may have been influenced by the presence of feral animals.

Seasonal Variation

In the longer term, changes in the annual rainfall patterns may affect the health of these systems by changes through changes in groundwater supply. The water column has remained relatively constant between the surveys, except for an increase in temperature and turbidity. The high range in turbidity is likely to be due to animal interaction with the spring, churning up sediment whilst bathing and drinking the water.

Table 62 Physical Ranges and Mean Values from Mid Dry (MD) and Late Dry (LD) Season Surveys of Freshwater Spring Sites

	Depth (m)	Temperature (deg C)		Electrical Conductivity (mS/cm)		pH		Turbidity (NTU)		Dissolved Oxygen (%)	
		MD	LD	MD	LD	MD	LD	MD	LD	MD	LD
ANZECC Trigger Value	NA	*		0.09 - 0.9		6.0 – 8.0		2.0 - 200.0		90 - 120	
Site I6 (Ferny Spring)											
Mean	0.1	25.2	35.0	**0.0**	**0.0**	**5.6**	**5.4**	4.5	**765**	**37**	**53**
Range (lowest - highest)	0.1 - 0.1	25.1 - 25.3	34.8 - 35.1	**0.0 - 0.0**	**0.0 - 0.0**	**5.4 - 5.8**	**5.2 - 5.6**	**1.5** - 7.5	50 - 1700	**13 - 60**	**37 - 62**
Site I7 (Wolf Claw Spring)											
Mean	0.1	27.5	32.9	**0.0**	**0.0**	**4.5**	**5.9**	4.8	90.8	**36**	**10**
Range (lowest - highest)	0.1 - 0.1	27.3 - 27.6	32.6 - 33.2	**0.0 - 0.0**	**0.0 - 0.0**	**4.4 - 4.5**	**5.5 - 6.2**	2.4 - 7.3	5.4 - **253**	**30 - 42**	**6 - 12**
Site I11											
Mean	0.1	/	28.7	/	**0.0**	/	**5.3**	/	15.0	/	**28**
Range (lowest - highest)	0.1 - 0.1	/	28.1 - 29.2	/	**0.0 - 0.1**	/	**5.0 - 5.5**	/	3.9 - 34.1	/	**58 - 85**

Note: Values in bold are outside ANZECC trigger values for fresh water lake and wetland ecosystems. * = Due to the temperature variability in Australia, ANZECC recommends deriving trigger values on a site specific basis using the 80^{th} and 20^{th} percentile. / = Readings not taken.

Table 63 Chemical Ranges and Mean Water Quality Values from Mid Dry (MD) and Late Dry (LD) Season Surveys for Freshwater Spring Sites

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Site I6 (Ferny Spring)				
Alkalinity – total (mg/L)		MD	3.3	3 – 4
		LD	3	2 – 4
Chloride (mg/L)		MD	6.3	5 – 7
		LD	6	6 – 6
Calcium (mg/L)		MD	0.5	0.5 – 0.5
		LD	0.5	0.5 – 0.5
Magnesium (mg/L)		MD	0.5	0.5 – 0.5
		LD	0.7	0.5 – 1.0
Sodium (mg/L)		MD	3.7	3 – 4
		LD	6.7	6 – 8
Potassium (mg/L)		MD	0.5	0.5 – 0.5
		LD	0.5	0.5 – 0.5
Sulfate (mg/L)		MD	0.8	0.5 – 1.0
		LD	2.5	2.5 – 2.5
Nitrogen – total (mg/L)	0.35 – 1.20	MD	0.2	0.2 – 0.3
		LD	**866.7**	600 – 1400
Ammonia (µg/L)	10	MD	0.15	0.02 – 0.25
		LD	**40**	30 – 50
Nitrate/Nitrite (mg/L)	0.01	MD	**0.1**	0.1 – 0.1
		LD	**0.07**	0.04 – 0.09
TKN (mg/L)		MD	0.2	0.1 – 0.2
		LD	0.8	0.5 – 1.4
BOD (mg/L)		MD	4.3	1 – 11
		LD	9	8 - 10
Site I7 (Wolf Claw Spring)				
Alkalinity – total (mg/L)		MD	3	3 – 3
		LD	5	4 – 6
Chloride (mg/L)		MD	6.7	6 – 7
		LD	9.7	7 – 14
Calcium (mg/L)		MD	0.5	0.5 – 0.5
		LD	0.5	0.5 – 0.5
Magnesium (mg/L)		MD	0.5	0.5 – 0.5
		LD	0.5	0.5 – 0.5
Sodium (mg/L)		MD	3.7	3 – 4
		LD	6	4 – 9
Potassium (mg/L)		MD	0.5	0.5 – 0.5
		LD	0.5	0.5 – 0.5
Sulfate (mg/L)		MD	0.7	0.5 – 1.0
		LD	1	0.5 – 2.0
Nitrogen – total (mg/L)	0.35 – 1.20	MD	0.2	0.1 – 0.2
		LD	**566.7**	500 – 700
Ammonia (µg/L)	10	MD	0.01	0.01 – 0.01
		LD	**340**	220 – 520

Analyte	ANZECC Trigger Value	Season	Mean	Range (lowest – highest)
Nitrate/Nitrite (mg/L)	0.01	MD	**0.02**	0.01 – 0.03
		LD	**0.02**	0.01 – 0.03
TKN (mg/L)		MD	0.2	0.1 – 0.2
		LD	0.6	0.5 – 0.7
BOD (mg/L)		MD	1.3	1 – 2
		LD	1	1 - 1
Site I11				
Alkalinity – total (mg/L)		MD	-	-
		LD	3.3	3 – 4
Chloride (mg/L)		MD	-	-
		LD	9.3	5 – 15
Calcium (mg/L)		MD	-	-
		LD	0.5	0.5 – 0.5
Magnesium (mg/L)		MD	-	-
		LD	0.7	0.5 – 0.10
Sodium (mg/L)		MD	-	-
		LD	7.7	5 – 12
Potassium (mg/L)		MD	-	-
		LD	0.5	0.5 – 0.5
Sulfate (mg/L)		MD	-	-
		LD	2.5	2.5 – 2.5
Nitrogen – total (mg/L)	0.35 – 1.20	MD	-	-
		LD	**400**	200 – 800
Ammonia (µg/L)	10	MD	-	-
		LD	**46.7**	20 – 90
Nitrate/Nitrite (mg/L)	0.01	MD	-	-
		LD	**0.04**	0.01 – 0.05
TKN (mg/L)		MD	-	-
		LD	0.4	0.1 – 0.8
BOD (mg/L)		MD	-	-
		LD	1.3	1 - 2

Note: Values in bold are outside ANZECC trigger values for freshwater lake and wetland ecosystems. - = Sampling not undertaken.

7.3 Summary

Sampling was undertaken for physical and chemical properties from 18 marine/coastal wetland sites, including 14 sites during the mid dry season survey and 17 sites during the late dry season. At each site (except one), up to three samples were taken depending on the amount of water available.

Sampling was undertaken for physical and chemical properties from nine inland wetland sites, including six sites during the mid dry season survey and eight sites during the late dry season. Three of the 12 sites did not contain water during either survey. At each site, up to three samples were taken depending on the amount of water available.

Water temperature in wetland sites was generally lower in July than in October 2010, varying in relation to the type of system (e.g. low flowing water bodies such as lakes observed the highest increase in temperature, whereas the intermittent freshwater creek observed the smallest variation). Electrical conductivity was lower in July than in October 2010 in all saline wetland environments. Turbidity was usually lower in July than in October in all inland and marine/coastal sites, with the change most apparent in the freshwater habitats. Dissolved oxygen varied between surveys and sites. In general the open marine wetlands recorded adequate concentrations; however the closed systems often recorded very low concentrations. pH levels tended to vary depending upon the systems surveyed, for example the pH readings for the inland springs were acidic while the marine wetlands were slightly alkaline.

The concentrations of total nitrogen, nitrate/nitrite (NOx) and ammonia were usually higher than the ANZECC 2000 guidelines. However, in order to accurately assess nutrient concentrations a much larger data set is required. The data collected is still useful as it provides a snap shot of the conditions at the time of the surveys increasing the understanding of the ecology of the differing wetland types. In general the nutrient concentrations were higher in the late dry season than the mid dry season. This is often the situation as water bodies dry out, however rainfall was recorded between the two surveys which will also influence the results as water is transferred from one wetland to another.

Threats

A range of threats to wetland integrity were identified during the mid dry and late dry season surveys of marine/coastal and inland wetland sites, including feral animals, weeds, extreme weather, saltwater intrusion into freshwater areas, fire and anthropogenic disturbances. Based on field observations, the most evident threat across the wetlands of the Cobourg Peninsula Ramsar site was disturbance from feral animals.

8.0 Threats

8.1 Literature Review

Key threats to the ecological character of the Ramsar site, as identified through a review of the relevant literature, are described in the following sections.

8.1.1 Terrestrial Pest Fauna

Terrestrial pest species known to occur in the Ramsar site are as follows:

- Cane Toads (*Bufo marinus*)
- Feral Pigs (*Sus scrofa*)
- Water Buffaloes (*Bubalus bubalis*)
- Horses/Timor Ponies (*Equus caballus*)
- Banteng (*Bos javanicus*)
- Sambar Deer (*Cervus unicolor*).

With the exception of Cane Toads, these species generally graze on and trample native vegetation causing degradation in water quality, through resultant loss of vegetative cover and soil erosion.

Feral Pigs disturb soils, destroy forest regeneration, spread weeds and compete with native species for food such as plants, invertebrates and small vertebrates (Letts et al., 1979; Stone, 1985; Browman and McDonough, 1991; Alexiou, 1998). The impacts of root disturbance are more severe in the Ramsar site compared to adjacent regions because it is relatively isolated, therefore there is less human interaction and capability for control, and Feral Pigs are confined to particular areas, so disturbance is more intensive (Browman and Panton, 1991).

Water Buffalo cause turbidity resulting in decreased water quality (Jesser et al., 2008). They also consume substantial amounts of grasses and other plants, compete for food with native herbivores (Jesser et al., 2008), spread weed seeds and physically change wetland habitat by creating wallows and vegetation free channels along movement routes. Magpie Geese (*Anseranas semipalmata*) and Saltwater Crocodile (*Crocodylus porosus*) recruitment may consequently be affected (NTG, 2007) because of damage to habitat areas.

Timor Ponies were introduced to Port Essington between 1838 and 1884 (NRETAS, 2010). Timor Pony colonies established with great success, due to their hardiness, stamina and agility. They, like other large terrestrial herbivores, disturb soils, spread weeds, trample native vegetation, consume native seedlings and disturb waterways.

Populations of Banteng in the Ramsar site are the largest known wild populations in the world. They are nocturnal and live in monsoon forest. Banteng favour Common Sedge (*Fimbricystis cymosa*) as food (Calaby and Keith, 1974). Occasionally, they graze seaweed and are capable of drinking water of high salinity (Popenoe, 1983). Banteng have an impact on native vegetation and soil stability.

Sambar Deer is an Asian deer that was introduced into Australia in the 1800s. Potential impacts include degradation of native vegetation and erosion of waterways, resulting in decreased water quality. Sambar Deer feed on almost every plant species (NRETAS, 2008).

Cane Toads burrow under tree roots on wetland banks, are known to survive extended periods in saline waters and are toxic to carnivores (NRETAS, 2008).

8.1.2 Marine Pest Fauna

Cribb and Marshall (2003 to 2005) studied the natural marine fouling communities in Cobourg Peninsula's waters to provide for an early warning system for identifying the presence of marine pests. The monitoring program surveyed a number of sites including Gove Harbour, Milner Bay (Groote Eylandt), Raffles Bay (Cobourg Peninsula), Apsley Strait (Tiwi Islands) and Rankin Point (Bynoe Harbour). Within the two year period, the study did not determine the presence of any marine pest species.

8.1.3 Weeds

Several classified and unclassified weed species exist on the Cobourg Peninsula (**Appendix C**), though impacts are thought to be relatively minor (Sattler and Creighton, 2002). Recent small infestations may have major impacts on native species through competition and alteration of wetland dynamics (Sattler and Creighton, 2002).

8.1.4 Commercial Pearling

Pearling operations in the waters off Cobourg Peninsula probably commenced with diving from the early 1940s until the mid 1950s (NRETAS, 2009). Pearling leases for the cultured pearl industry in the waters surrounding the Cobourg Peninsula were first granted in 1979 although pearl farms were operating before this time (NRETAS, 2009). Pearling lease areas exist in Port Bremer, Raffles Bay, Berkley Bay as well as Knocker and Curlew Bays in Port Essington. The pearling lease site in Raffles Bay is directly adjacent to an outstation living area.

Commercial pearling has little impact on the environment. An independent report commissioned by the Pearl Producers Association in 1998 on the environmental impact of pearling in Western Australia found that the industry in general was environmentally benign (DoF, 2005). Pearl harvesting involves hand collection and as a result produces no bycatch and limits potential impacts on benthic marine flora and fauna (Young, 2004; DoF, 2005). However, no formal assessment on interactions with marine fauna has been conducted (Young, 2004). A quota system for pearl oyster stocks sets a maximum number of shells that can be caught by the industry in any year and ensures the stocks of oysters are sustained (DoF, 2005). Other potential impacts may be from boat strikes to marine flora or fauna.

8.1.5 Commercial Fishing

Commercial fishing operations within the Cobourg Marine Park include net, longline and drop line trapping, and troller fishing (NRETAS, 2007). Catch includes sharks, Barramundi, finfish, Mud Crabs, prawns, Mackerel and Trepang (Sea Cucumber). The NT Department of Resources (Fisheries) manages resources in the Marine Park under the NT *Fisheries Act*. Currently, little information exists on potential impacts of commercial fishery operations on native species (NRETAS, 2007).

8.1.6 Traditional Hunting

Traditional uses of Cobourg Peninsula include harvesting and hunting of plants and animals for food, medicine and art, and for cultural reasons. Marine resources are used for ceremony and ritual purposes. Potential impacts include uncontrolled use of resources within the Ramsar site, though there is no scientific research that has been carried out to assess this.

8.1.7 Fire

Fire regimes in the Ramsar site have changed from frequent fine scale mosaic burns throughout the year to infrequent and higher intensity burns in the late dry season (Williams et al., 2002; Woinarski and Baker, 2002). When people were more evenly distributed across the landscape, fires were widely distributed and patchy whereas when they aggregated to outstations, fire activities became more concentrated in these areas (Woinarski and Baker, 2002). As communities became less dependent on land, some traditional knowledge of burning regimes was lost, resulting in fewer (controlled) early dry season fires and therefore a greater risk of intense late dry season uncontrolled fires. Impacts on biodiversity may include the decline of fire-sensitive species, change of understorey structure and species diversity and increased susceptibility to weed invasion, a reduction in large old trees and changes in the abundance of fruits, seeds and flowers (Woinarski et al., 2001). In turn, these changes would have reduced habitat suitability for many mammals and some bird species (Woinarski et al., 2001).

8.1.8 Recreation and Tourism

The tourism and recreational opportunities in the Ramsar site are partly managed by a restriction in visitor numbers. Recreational activities include safaris, fishing tours, game hunting, boating, diving, sightseeing and wildlife viewing (DEWHA, 2009). Significant opportunities for commercial ecotourism activities with the Ramsar site have not been exploited to any great extent.

Commercial and recreational fishers target a number of different fish species in the Marine Park. Fishing is regulated by Marine Park zoning. Recreational fishing and tourism may have a large impact on bird breeding success (NRETA, 2007). Adult birds may abandon their nests leading to increased hatchling mortality (NRETA, 2007).

8.2 Threats Observed during Field Surveys

8.2.1 Marine/Coastal Wetlands

A range of disturbances were identified during the mid dry (July/August 2010) and late dry (October 2010) season surveys of marine/coastal wetland sites (**Table 64**). The most common disturbances were damage from extreme weather events (most likely including Cyclone Ingrid in 2005) and feral animals (primarily Banteng and Feral Pigs).

8.2.1.1 Feral Animals

Probably the most evident threat across the marine/coastal wetlands of the Cobourg Peninsula Ramsar site was disturbance from feral animals. Evidence of feral animals included tracks, diggings, droppings and wallows from Feral Pigs, Banteng and Buffaloes, especially in tidal channels, lagoons (sites M6 and M7), dune systems (site M9) and salt flats behind mangroves (e.g. site M5 and near to site M9).

Patterns of Feral Pig damage suggest they follow the receding water levels to excavate and eat the tubers of *Eleocharis* sedges. This is likely to have a large impact on species that specialise in the margins of these wetlands. Feral Pigs, Banteng and Buffaloes also cause soil disturbance, reduce water quality, damage and prevent vegetation recruitment, compete for food with native species (e.g. plants, invertebrates and small vertebrates) and have the potential to spread weeds.

The tracks of Rusa Deer (*Cervus timorensis*) were identified at site M20 and not commonly observed in the Ramsar site. It does not exhibit the same digging and rooting behaviour shown by Feral Pigs. The impacts of this species are poorly known, however, it may be considerably less than from Feral Pigs.

Cane Toads were also observed at or near most mainland wetland sites. They were observed burrowing under tree roots on wetland banks. They are toxic to carnivores.

8.2.1.2 Weeds

There was a general paucity of introduced flora in each marine/coastal wetland site. Two were observed (Caltrop (*Tribulus* sp.) and Wild Passionfruit (*Passiflora foeteda*). Caltrop was observed at the high water mark of site M11 (sand shore on Sandy Island No. 2).

8.2.1.3 Extreme Weather

Although a natural event, extreme weather (e.g. cyclones) has caused obvious direct impacts to particular wetlands (e.g. coastal saline lagoons and coastal freshwater lagoons). These impacts are likely to be periodic and many wetlands would be expected to return to similar states as prior to the event. Uprooted trees were regularly observed, though these were not extensive. The accumulation of dead trees against shore lines of these lagoons potentially indicates a storm tidal surge. Woody debris was also observed at the landward side of site M8 (rocky shore).

8.2.1.4 Saltwater Intrusion in Freshwater Areas

Indirect impacts from extreme weather events include saltwater intrusion into freshwater areas from tidal surges. Numerous coastal wetlands contained areas of dead freshwater-dependent flora (e.g. *Melaleuca* spp.) potentially from increased salinity. A number of small dead trees were observed in the centre of Sandy Island No. 2 (site M11).

If these impacts become more frequent through rising sea levels and global warming, then some coastal freshwater wetlands (e.g. coastal freshwater lagoons) may eventually become brackish or saline and subsequently lead to a change in flora and fauna assemblages.

8.2.1.5 Fire

Evidence of recent destructive fires across the Cobourg Peninsula Ramsar site was relatively uncommon. Trees in nearly all wetland sites exhibited limited scarring. Several freshwater wetland sites contained dense stands of *Melaleuca* seedlings indicating the recent absence of fire.

8.2.1.6 Anthropogenic

Historical anthropogenic impacts did not appear to affect wetland integrity and were limited to vehicle tracks and middens (site M5).

Table 64 Threats Identified in Marine/Coastal Wetland Sites

Wetland Type	Site	Feral Animals	Weeds	Extreme Weatherˇ	Fire	Anthropogenic
Coral Reef (C)	M3	×	×	×	×	×
	M14	×	×	×	×	×
	M10	×	×	×	×	×
Rocky Marine Shore (D)	M8	×	×	✓	×	×
	M12	×	×	×	×	✓
Sand Shore (E)	M9	✓	×	✓	×	×
	M11	×	✓	✓	×	×
	M13	×	×	×	×	×
Estuarine Waters (F)	M1	×	×	✓	×	×
	M15	×	×	✓	×	✓
	M17	✓	×	×	×	×
Intertidal Mud or Salt Flats (G)	M4	×	×	×	×	×
	M16	✓	×	×	×	×
Intertidal Forested Wetland (I)	M2	×	×	×	×	×
	M5	✓	×	×	×	✓
	M18	✓	×	×	×	✓
Coastal Saline/Brackish Lagoon (J)	M6	✓	×	×	×	×
	M7	✓	×	✓	×	✓
	M19	✓	×	×	×	×
Coastal Freshwater Lagoon (K)	M20	✓	×	✓	×	×

ˇ Extreme weather includes cyclones. Disturbances from extreme weather include uprooting and stripping of trees and saltwater intrusion.

8.2.2 Inland Wetlands

Threats to inland wetlands are described in the following sections and listed in **Table 65**.

8.2.2.1 Feral Animals

The most evident threat across the inland wetlands of the Cobourg Peninsula Ramsar site was disturbance from feral animals. All but one wetland site contained feral animal disturbance. Large numbers of Banteng were often seen around Smith Point and it is presumed they utilise wetlands in the area (e.g. site I2). Feral Pigs were observed predominantly around sites I1 (seasonal brackish/saline lake) and I4 (freshwater tree-dominated wetland) where there was considerable damage in the understorey of the *Melaleuca* forest. Their wallowing and defecation had significantly degraded the quality of the remaining water and their foraging had effectively removed nearly all non-woody plants from the understorey. Evidence of Feral Pigs, Buffalo and Banteng was observed at both freshwater, tree-dominated wetlands (i.e. sites I5 and I8). The intermittent presence of water (and therefore paucity of important food resources e.g. *Eleocharis* sp. at particular times of the year) would likely mean that these

animals are not abundant during the late dry season at these wetlands. Evidence of feral animals was obvious at freshwater springs, though was mostly restricted to the margins of the wet monsoon forests.

Evidence of feral animals included tracks, diggings, droppings and wallows from Buffaloes, Feral Pigs and Banteng especially in seasonal creeks (wetland type N), permanent saline lakes (wetland type Q) and freshwater springs (wetland type Y). These areas are likely to support the highest diversity of native species. Feral animal activity was spread along the length of the wetlands and not concentrated in any particular location, making it difficult to judge feral animal abundance. Their widespread distribution also makes feral animal control difficult.

Patterns of Feral Pig damage suggest they follow the receding water levels to excavate and eat the tubers of *Eleocharis* sedges (sites I1 and I2). This is likely to be significantly impacting on flora and fauna species that inhabit the wetland margins. Disturbances from feral animals include soil degradation and topsoil loss, reduced water quality, loss and damage to vegetation, competition for food with native species (e.g. plants, invertebrates and small vertebrates), loss of food resources for EPBC Act listed birds such as Brolgas and Magpie Geese, and the potential to spread weeds. Feral Pigs are likely to be an impediment towards post-cyclonic recovery of these wetland types.

Cane Toads were observed in many inland wetlands. Freshwater pools (along creeks and springs) provide ideal breeding habitat and allow them to persist in a landscape where freshwater is uncommon, especially during the dry season. During the wet season, they are able to disperse.

8.2.2.2 Introduced Flora

Weeds were generally uncommon. The only species noted was Wild Passionfruit (*Passiflora foetida*).

8.2.2.3 Extreme Weather

Widespread damage was observed as a result of severe weather, including tropical Cyclone Ingrid in 2005. Damage included uprooted and broken trees in several wetlands (e.g. seasonal freshwater pools, freshwater, tree-dominated wetlands). Dead patches of *Melaleuca* exist and in some areas the presence of juvenile mangrove species suggests increases in water salinity concentration due to storm surges (see **Section 8.2.2.4**). Salt crusts were observed in site I5.

Fallen trees in some freshwater wetlands were noted as harbouring small patches of *Eleocharis* sp. and ground dwelling fauna such as skinks and dragons, since these areas were effectively sheltered from Feral Pig impacts. If Feral Pigs were eliminated, these small remaining sheltered pockets would be of high value in recolonising the wetland and restoring its wetland values.

Some wetland types are far enough inland (e.g. freshwater springs) and generally located in sheltered valleys to be protected from destructive winds. Vegetation and water quality attributes are therefore more intact than in most other wetland types on Cobourg Peninsula.

8.2.2.4 Saltwater Intrusion in Freshwater Areas

The combination of numerous patches of dead melaleucas and brackish/saline water readings at several wetlands indicates that these systems may have only recently been exposed to water with higher than normal levels of salinity. Anecdotal records and physical evidence (an old pumping station) at site I1 (seasonal brackish/saline lake) suggest that the Black Point Ranger Station historically drew drinking water from this wetland. All inland wetlands have no connection to the sea and some are separated by only a relatively narrow beach dune. It is likely that a storm surge (possibly from tropical cyclone Ingrid in 2005) has resulted in a large influx of salt water. This event would have had a dramatic impact on the flora and fauna of the wetlands, particularly freshwater dependant species with low salt tolerance. No fish were present at such wetland sites. These events have almost certainly occurred before, and it is likely that successive high rainfall events may flush much of this salinity and restore some of the freshwater wetland values of the sites. This may be cyclic and these wetlands may be in a state of transition continually. Frequent increases in sea levels (whether from cyclonic events or climate change associated) could result in this wetland become a permanently saline or brackish wetland, with a resultant change in flora and fauna assemblages.

If these impacts become more frequent through rising sea levels and global warming, then this wetland type could be expected to eventually become a brackish or marine lake with a subsequent change in flora and fauna assemblages.

Wetlands (e.g. freshwater springs) located well inland are generally protected from storm surge and saltwater inundation. Springs are generally located in sheltered valleys where water percolates through surrounding ridges

and hills. Vegetation and water quality attributes are therefore more intact than in most other wetland types on the Cobourg Peninsula.

8.2.2.5 Fire

Disturbance from fires is not prevalent, especially within wetland and riparian areas. Fire scars were noted on woodland trees adjacent to wetlands. Seasonal creeks (wetland type N) are susceptible to high intensity wildfires due to their narrow riparian areas. Occasional braids in such creeks provide some fire protection and it is these areas that have the highest diversity of plant life. This in turn promotes a greater diversity of fauna species and trophic levels/ interactions. While these communities could probably cope with rare events, an increase in fire intensity and/or frequency may have negative impacts on associated flora and fauna values, so fire management should be sympathetic to these communities. Loss of fire sensitive species along creek banks can leave areas denuded and unprotected allowing increased erosion levels.

8.2.2.6 Anthropogenic

Historical anthropogenic disturbance includes the presence of tracks, abandoned buildings, water tanks, bottles, fuel drums, old creek crossing structures and associated bank cuttings, concrete pipes and disused Feral Pig traps. Several vehicle tracks traverse wetlands (e.g. creek at site I3) which may result in some increased turbidity, though it is unlikely that this would continue downstream too far (as the roads are infrequently used). Discarded rubbish or infrastructure does not appear to be having any significant ecological impact.

Wetlands that are more accessible to tourists (e.g. sites I1 and I2) may be exposed to higher levels of anthropogenic disturbances; however no damage or litter was observed.

Table 65 Threats Identified in Inland Wetland Sites

Wetland Type (Wetland Code)	Site	Feral Animals	Weeds	Extreme Weatherˇ	Fire	Anthropogenic
Seasonal Streams/Creeks (N)	I3	✓	×	×	×	✓
	I13	✓	×	×	×	×
Permanent Saline/Brackish Lakes (Q)	I2	✓	×	✓	×	×
Seasonal Saline/Brackish Lakes and Flats (R)	I1	✓	✓	✓	×	✓
Permanent Saline Pool (Sp)	I12	✓	×	✓	×	✓
Permanent Freshwater Pool (Tp)	I10	✓	×	✓	×	✓
Seasonal Freshwater Marshes Pools (Ts)	I5	✓	×	✓	×	×
Freshwater, Tree-dominated Wetlands (Xf)	I4	✓	×	✓	✓	×
	I8	✓	×	✓	✓	×
Freshwater Springs (Y)	I6	×	×	×	✓	✓
	I7	✓	×	✓	×	×
	I11	✓	×	×	✓	×

ˇ Extreme weather includes cyclones. Disturbances from extreme weather include uprooting and stripping of trees and salt water intrusion from storm surge.

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Appendix A

Fauna Recorded in the NT Fauna Atlas that are Not Considered to be Wetland Dependent

Conservation Status: LC (Least Concern); NE (Not Evaluated); LW (Lower Risk); DD (Data Deficient); NT (Near Threatened); VU (Vulnerable); EN (Endangered); CR (Critically Endangered); INT (Introduced); Mig (Migratory); Mar (Marine)

Species	Common Name	Conservation Status		
		TPWC Act	EPBC Act	IUCN
Reptiles				
Antaresia childreni	Children's Python	DD	-	-
Boiga irregularis	Brown Tree Snake	DD	-	-
Brachyurophis morrisi	Arnhem Shovel-nosed Snake	DD	-	-
Carlia amax	Two-Spined Rainbow Skink	LC	-	-
Carlia gracilis	Slender Rainbow Skink	LC	-	-
Carlia munda	Striped Rainbow Skink	LC	-	-
Carlia rufilatus	Red-Sided Rainbow Skink	LC	-	-
Carlia triacantha	Three-Spined Rainbow Skink	LC	-	-
Chlamydosaurus kingii	Frilled Lizard	LC	-	-
Cryptoblepharus cygnatus	Swanson's Snake-eyed Skink	NE	-	-
Cryptoblepharus metallicus	Metallic Snake-eyed Skink	NE	-	-
Cryptoblepharus plagiocephalus	Arboreal Snake-Eyed Skink	LC	-	-
Cryptophis pallidiceps	Northern Small-eyed Snake	DD	-	-
Ctenotus borealis	Northern Ctenotus	LC	-	-
Ctenotus essingtonii	Port Essington Ctenotus	LC	-	-
Ctenotus hilli	Hill's Ctenotus	LC	-	-
Delma borea	Rusty-topped Delma	LC	-	-
Delma tincta	Black-necked Snake-lizard	LC	-	-
Demansia olivacea	Olive Whip Snake	DD	-	-
Demansia papuensis	Papuan Whip Snake	DD	-	-
Demansia simplex	Grey Whip Snake	LC	-	-
Demansia vestigiata	Black Whip Snake	DD	-	-
Dendrelaphis punctulata	Green Tree Snake	DD	-	-
Diporiphora bilineata	Two-Lined Dragon	LC	-	-
Furina ornata	Orange-naped Snake	LC	-	-

Species	**Common Name**	**Conservation Status**		
		TPWC Act	**EPBC Act**	**IUCN**
Gehyra australis	Northern Dtella	LC	-	-
Glaphyromorphus darwiniensis	Darwin Skink	LC	-	-
Glaphyromorphus douglasi	Douglas' Skink	LC	-	-
Glaphyromorphus isolepis	Smooth-Tailed Skink	LC	-	-
Hemidactylus frenatus	Asian House Gecko	INT	-	-
Heteronotia binoei	Bynoe's Gecko	LC	-	-
Lialis burtonis	Burton's Legless Lizard	LC	-	-
Lophognathus gilberti	Gilbert's Dragon	LC	-	-
Morelia spilota	Carpet Python	LC	-	-
Morethia storri	Storr's Snake-Eyed Skink	LC	-	-
Oedura marmorata	Marbled Velvet Gecko	LC	-	-
Oedura rhombifer	Zig-zag Gecko	LC	-	-
Proablepharus tenuis	Slender Snake-Eyed Skink	LC	-	-
Pseudechis australis	King Brown Snake	LC	-	-
Pseudonaja nuchalis	Western Brown Snake	LC	-	-
Pygopus nigriceps	Western Hooded Scaly-foot	LC	-	-
Ramphotyphlops braminus	Flower-pot Blind Snake	INT	-	-
Ramphotyphlops tovelli	Darwin Blind Snake	LC	-	-
Ramphotyphlops unguirostris	Claw-snouted Blind Snake	LC	-	-
Stegonotus cucullatus	Slaty-grey Snake	LC	-	-
Strophurus ciliaris	Spiny-tailed Gecko	LC	-	-
Tiliqua scincoides	Common Blue-Tongued Lizard	DD	-	-
Varanus gouldii	Sand Goanna	LC	-	-
Varanus scalaris	Spotted Tree Monitor	DD	-	-
Varanus tristis	Black-tailed Monitor	LC	-	-
Vermicella intermedia	Wide-banded Northern Bandy-bandy	LC	-	-
Birds				
Accipiter cirrhocephalus	Collared Sparrowhawk	LC	-	LC

Species	Common Name	Conservation Status		
		TPWC Act	EPBC Act	IUCN
Accipiter novaehollandiae	Grey Goshawk	LC	-	LC
Aegotheles cristatus	Australian Owlet-nightjar	LC	-	LC
Aprosmictus erythropterus	Red-winged Parrot	LC	-	LC
Aquila audax	Wedge-tailed Eagle	LC	-	LC
Ardeotis australis	Australian Bustard	VU	-	NT
Artamus cinereus	Black-faced Woodswallow	LC	-	LC
Artamus leucorynchus	White-breasted Woodswallow	LC	-	LC
Artamus minor	Little Woodswallow	LC	-	LC
Artamus superciliosus	White-browed Woodswallow	LC	-	LC
Aviceda subcristata	Pacific Baza	LC	-	LC
Burhinus grallarius	Bush Stone-curlew	NT	-	NT
Cacatua galerita	Sulphur-crested Cockatoo	LC	-	LC
Cacatua sanguinea	Little Corella	LC	-	LC
Cacomantis variolosus	Brush Cuckoo	LC	-	LC
Calyptorhynchus banksii macrorhynchus	Red-tailed Black-cockatoo (Top End)	LC	-	-
Caprimulgus macrurus	Large-tailed Nightjar	LC	-	LC
Chalcophaps indica	Emerald Dove	LC	-	LC
Cissomela pectoralis	Banded Honeyeater	LC	-	LC
Cisticola exilis	Golden-headed Cisticola	LC	-	LC
Climacteris melanura	Black-tailed Treecreeper	LC	-	LC
Colluricincla harmonica	Grey Shrike-thrush	LC	-	LC
Colluricincla megarhyncha	Little Shrike-thrush	LC	-	LC
Colluricincla woodwardi	Sandstone Shrike-thrush	LC	-	LC
Corvus orru	Torresian Crow	LC	-	LC
Coturnix ypsilophora	Brown Quail	LC	-	LC
Cracticus nigrogularis	Pied Butcherbird	LC	-	LC
Cracticus torquatus	Grey Butcherbird	LC	-	LC
Dacelo leachii	Blue-winged Kookaburra	DD	-	LC

Species	Common Name	Conservation Status		
		TPWC Act	EPBC Act	IUCN
Daphoenositta chrysoptera	Varied Sittella	LC	-	LC
Dicaeum hirundinaceum	Mistletoebird	LC	-	LC
Dromaius novaehollandiae	Emu	VU	-	LC
Elanus axillaris	Black-shouldered Kite	LC	-	LC
Entomyzon cyanotis	Blue-faced Honeyeater	LC	-	LC
Erythrura gouldiae	Gouldian Finch	EN	EN	EN
Eulophus roseicapilla	Galah	LC	-	LC
Falco berigora	Brown Falcon	LC	-	LC
Falco longipennis	Australian Hobby	LC	-	LC
Falco peregrinus	Peregrine Falcon	LC	-	LC
Geopelia cuneata	Diamond Dove	LC	-	LC
Geopelia humeralis	Bar-shouldered Dove	LC	-	LC
Geopelia striata	Peaceful Dove	LC	-	LC
Gerygone albogularis	White-throated Gerygone	LC	-	LC
Hamirostra melanosternon	Black-breasted Buzzard	LC	-	LC
Hieraaetus morphnoides	Little Eagle	LC	-	LC
Lalage sueurii	White-winged Triller	LC	-	LC
Lichmera indistincta	Brown Honeyeater	LC	-	LC
Lonchura castaneothorax	Chestnut-breasted Mannikin	LC	-	LC
Lophoictinia isura	Square-tailed Kite	NT	-	LC
Malurus melanocephalus	Red-backed Fairy-wren	LC	-	LC
Manorina flavigula	Yellow-throated Miner	LC	-	LC
Melanodryas cucullata melvillensis	Hooded Robin (Tiwi Islands)	EN	EN	-
Melithreptus albogularis	White-throated Honeyeater	LC	-	LC
Melithreptus gularis	Black-chinned Honeyeater	LC	-	LC
Microeca fascinans	Jacky Winter	LC	-	LC
Milvus migrans	Black Kite	LC	-	LC
Mirafra javanica	Singing Bushlark	LC	-	LC

Species	Common Name	Conservation Status		
		TPWC Act	EPBC Act	IUCN
Myiagra rubecula	Leaden Flycatcher	LC	-	LC
Oriolus sagittatus	Olive-backed Oriole	LC	-	LC
Pachycephala rufiventris	Rufous Whistler	LC	-	LC
Pardalotus striatus	Striated Pardalote	LC	-	LC
Petrochelidon ariel	Fairy Martin	LC	-	LC
Phaps chalcoptera	Common Bronzewing	LC	-	LC
Philemon argenticeps	Silver-crowned Friarbird	LC	-	LC
Philemon buceroides	Helmeted Friarbird	LC	-	LC
Philemon citreogularis	Little Friarbird	LC	-	LC
Platycercus venustus	Northern Rosella	LC	-	LC
Poephila acuticauda	Long-tailed Finch	LC	-	LC
Poephila personata	Masked Finch	LC	-	LC
Pomatostomus temporalis	Grey-crowned Babbler	LC	-	LC
Psephotus dissimilis	Hooded Parrot	NT	-	LC
Psitteuteles versicolor	Varied Lorikeet	LC	-	LC
Ptilonorhynchus nuchalis	Great Bowerbird	LC	-	LC
Rhipidura albiscapa	Grey Fantail	LC	-	LC
Rhipidura leucophrys	Willie Wagtail	LC	-	LC
Rhipidura rufiventris	Northern Fantail	LC	-	LC
Smicrornis brevirostris	Weebill	LC	-	LC
Sphecotheres vieilloti	Australasian Figbird	LC	-	LC
Taeniopygia bichenovii	Double-barred Finch	LC		LC
Taeniopygia guttata	Zebra Finch	LC	-	LC
Trichoglossus haematodus	Rainbow Lorikeet	LC	-	LC
Turnix castanotus	Chestnut-backed Button-quail	DD	-	NT
Turnix maculosus	Red-backed Button-quail	LC	-	LC
Turnix maculosus	Red-chested Button-quail	LC	-	LC
Tyto javanica	Eastern Barn Owl	LC	-	LC

Species	Common Name	Conservation Status		
		TPWC Act	EPBC Act	IUCN
Tyto novaehollandiae kimberli	Masked Owl (mainland Top End)	VU	VU	-
Mammals				
Antechinus bellus	Fawn Antechinus	DD	-	LC
Canis lupus	Dingo	LC	-	LC
Cervus timorensis	Rusa Deer	INT	-	VU
Cervus unicolor	Sambar	INT	-	VU
Chalinolobus gouldii	Gould's Wattled Bat	LC	-	LC
Chalinolobus nigrogriseus	Hoary Wattled Bat	LC	-	LC
Conilurus penicillatus	Brush-tailed Rabbit-rat	VU	VU	NT
Dasyurus hallucatus	Northern Quoll	CR	EN	EN
Equus caballus	Horse	INT	-	LC
Felis catus	Cat	INT	-	-
Isoodon macrourus	Northern Brown Bandicoot	LC	-	LC
Macropus agilis	Agile Wallaby	LC	-	LC
Macropus antilopinus	Antilopine Wallaroo	LC	-	LC
Melomys burtoni	Grassland Melomys	LC	-	LC
Mesembriomys gouldii	Black-footed Tree-rat	DD	CR	NT
Miniopterus schreibersii	Large Bent-winged Bat	LC	-	LC
Mormopterus loriae	Little Free-tailed Bat	LC	-	LC
Nyctophilus arnhemensis	Northern Long-eared Bat	LC	-	LC
Nyctophilus bifax	Eastern Long-eared Bat	LC	-	LC
Nyctophilus geoffroyi	Lesser Long-eared Bat	LC	-	LC
Petaurus breviceps	Sugar Glider	LC	-	LC
Phascogale pirata	Northern Brush-tailed Phascogale	VU	-	VU
Pseudomys delicatulus	Delicate Mouse	LC	-	LC
Pseudomys nanus	Western Chestnut Mouse	NT	-	LC
Rattus tunneyi	Pale Field-rat	NT	-	LC
Rattus villosissimus	Long-haired Rat	NT	-	LC

Species	Common Name	Conservation Status		
		TPWC Act	EPBC Act	IUCN
Rhinonicteris aurantia	Orange Leaf-nosed bat	NT	-	LC
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat	LC	-	LC
Saccolaimus saccolaimus	Bare-rumped Sheath-tailed Bat	DD	CR	LC
Scotorepens balstoni	Inland Broad-nosed Bat	LC	-	LC
Scotorepens greyii	Little Broad-nosed Bat	LC	-	LC
Sminthopsis virginiae	Red-cheeked Dunnart	DD	-	LC
Tachyglossus aculeatus	Echidna	LC	-	LC
Trichosurus vulpecula arnhemensis	Common Brushtail Possum (Top End)	LC	-	LC
Vespadelus caurinus	Northern Cave Bat	LC	-	LC

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Appendix B

Literature Review: Wetland Dependent Fauna (Based on Habitat Preferences) Recorded in the Ramsar Site

Data Source: 1: NT Fauna Atlas; 2: NRETA and CPSMPB (2007); 3: Gomelyuk (2000); 4: PWCNT, 1995; 5: Cogger and Lindner (1974); 6: Chatto (2006); 7: NTG (2008); 8: Frith and Hitchcock (1974); 9: Calaby and Keith (1974)

TPWC Act: *Territory Parks and Wildlife Conservation Act*

EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999*

IUCN: International Union for Conservation of Nature

Conservation Status: LC (Least Concern); NE (Not Evaluated); LW (Lower Risk); DD (Data Deficient); NT (Near Threatened); VU (Vulnerable); EN (Endangered); CR (Critically Endangered); INT (Introduced); Mig (Migratory); Mar (Marine)

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Frogs													
Austrochaperina adelphe	Northern Territory Frog	LC	-	LC	✓								
Crinia bilingua	Bilingual Froglet	LC	-	LC	✓								
Crinia deserticola	Desert Froglet	LC	-	LC	✓								
Crinia remota	Remote Froglet	LC	-	LC	✓								
Crinia sp.	-	-	-	-					✓				
Limnodynastes convexiusculus	Marbled Frog	LC	-	LC	✓				✓				
Litoria australis	Giant Frog	DD	-	LC	✓				✓				
Litoria bicolor	Northern Dwarf Tree-frog	DD	-	LC	✓				✓				
Litoria caerulea	Green Tree-frog	LC	-	LC	✓				✓				
Litoria microbelos	Javelin Frog	LC	-	LC	✓				✓				
Litoria nasuta	Rocket Frog	LC	-	LC	✓				✓				
Litoria rothii	Roth's Tree-frog	LC	-	LC	✓				✓				

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Litoria rubella	Red Tree-frog	LC	-	LC	✓				✓				
Litoria tornieri	Tornier's Frog	LC	-	LC	✓				✓				
Litoria wotjulumensis	Wotjulum Frog	LC	-	LC	✓				✓				
Notaden melanoscaphus	Northern Spadefoot Toad	LC	-	LC	✓								
Opisthodon ornatus	Ornate Burrowing Frog	DD	-	LC	✓				✓				
Rhinella marina	Cane Toad	INT	-	LC	✓								
Uperoleia inundata	Floodplain Toadlet	LC	-	LC	✓								
Reptiles													
Acalyptophis peronii	Horned Sea Snake	LC	Mar	-	✓								
Aipysurus duboisii	Dubois' Sea Snake	LC	Mar	-	✓								
Aipysurus eydouxii	Spine-tailed Sea Snake	LC	Mar	-	✓								
Aipysurus laevis	Golden Sea Snake	LC	Mar	-	✓								
Astrotia stokesii	Stokes' Sea Snake	LC	Mar	-	✓								
Caretta caretta	Loggerhead Turtle	EN	EN, Mig, Mar	EN	✓								
Cerberus australis	Australian Bockadam	LC	-	-	✓				✓				
Chelonia mydas	Green Turtle	LC	VU, Mig, Mar	EN	✓								
Crocodylus porosus	Saltwater Crocodile	LC	Mig, Mar	LC	✓	✓			✓				

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Dermochelys coriacea	Leatherback Turtle	VU	VU, Mig, Mar	CR	✓								
Disteira major	Olive-headed Sea Snake	LC	Mar	-	✓								
Enhydrina schistosa	Beaked Sea Snake	DD	Mar	-	✓								
Eretmochelys imbricata	Hawksbill Turtle	DD	VU, Mig, Mar	CR	✓								
Fordonia leucobalia	White-bellied Mangrove Snake	LC	-	-	✓				✓				
Hydrelaps darwiniensis	Black-ringed Mud Snake	LC	Mar	-	✓								
Hydrophis elegans	Bar-bellied Sea Snake	LC	Mar	-	✓								
Lapemis curtus	Short Sea Snake	LC	-	-	✓								
Lepidochelys olivacea	Olive Ridley	DD	EN, Mig	VU	✓								
Liasis fuscus	Water Python	LC	-	-	✓				✓				
Liasis olivaceus	Olive Python	LC	-	-	✓				✓				
Lophognathus temporalis	Northern Water Dragon	LC	-	-	✓				✓				
Macrochelodina burrungandjii	Sandstone Long-necked Turtle	DD	-	-	✓								
Macrochelodina rugosa	Northern Long-necked Turtle	LC	-	-	✓				✓				
Myron richardsonii	Richardson's Mangrove Snake	LC	-	-	✓				✓				
Natator depressus	Flatback Turtle	DD	VU, Mig, Mar	DD	✓								
Tropidonophis mairii	Keelback	LC	-	-	✓				✓				

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Varanus indicus	Mangrove Monitor	NT	-	-	✓								
Varanus mertensi	Merten's Water Monitor	VU	-	-	✓				✓				
Varanus panoptes	Floodplain Monitor	VU	-	-	✓								
Birds													
Accipiter fasciatus	Brown Goshawk	LC	Mig, Mar	LC	✓							✓	
Acrocephalus australis	Australian Reed-Warbler	NT	Mig, Mar	LC	✓							✓	
Actitis hypoleucos	Common Sandpiper	LC	Mig, Mar	LC	✓							✓	
Amaurornis cinerea	White-browed Crake	LC	-	-	✓					✓			
Amaurornis moluccana	Pale-vented Bush-hen	NT	-	LC	✓								
Anas gracilis	Grey Teal	LC	Mig	LC	✓					✓		✓	
Anas superciliosa	Pacific Black Duck	LC	Mig	LC	✓					✓		✓	
Anhinga novaehollandiae	Australasian Darter	LC	-	LC	✓					✓		✓	
Anseranas semipalmata	Magpie Goose	LC	Mar	LC	✓					✓		✓	
Anthus novaeseelandiae	Australian Pipit	LC	Mar	LC	✓								
Apus pacificus	Fork-tailed Swift	LC	Mig, Mar	LC	✓								
Ardea alba	Great Egret	LC	Mig, Mar	-	✓					✓		✓	
Ardea ibis	Cattle Egret	LC	Mig, Mar	LC	✓					✓			

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Ardea intermedia	Intermediate Egret	LC	Mar	LC	✓					✓		✓	
Ardea pacifica	White-necked Heron	LC	-	LC	✓					✓			
Ardea sumatrana	Great-billed Heron	LC	-	LC	✓					✓		✓	
Arenaria interpres	Ruddy Turnstone	LC	Mig, Mar	LC	✓								
Artamus minor	Little Woodswallow	LC	-	LC	✓								
Aythya australs	Hardhead	LC	Mig	LC						✓			
Butorides striata	Striated Heron	LC	-	LC	✓							✓	
Cacomantis pallidus	Pallid Cuckoo	LC	Mar	LC	✓								
Calidris acuminata	Sharp-tailed Sandpiper	LC	Mig, Mar	LC	✓								
Calidris alba	Sanderling	LC	Mig, Mar	LC	✓								
Calidris canutus	Red Knot	LC	Mig, Mar	LC	✓								
Calidris ferruginea	Curlew Sandpiper	LC	Mig, Mar	LC	✓								
Calidris ruficollis	Red-necked Stint	LC	Mig, Mar	LC	✓							✓	
Calidris tenuirostris	Great Knot	LC	Mig, Mar	VU	✓								
Calonectris leucomelas	Streaked Shearwater	DD	Mig, Mar	LC	✓								
Centropus phasianinus	Pheasant Coucal	LC	-	LC	✓							✓	
Ceyx azureus	Azure Kingfisher	LC	-	LC	✓							✓	

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Ceyx pusilla	Little Kingfisher	LC	-	LC	✓							✓	
Chalcites basalis	Horsfield's Bronze-Cuckoo	LC	Mar	LC	✓								
Chalcites minutillus	Little Bronze-Cuckoo	LC	Mar	LC	✓							✓	
Charadrius leschenaultii	Greater Sand Plover	LC	Mig, Mar	LC	✓							✓	
Charadrius mongolus	Lesser Sand Plover	LC	Mig, Mar	LC	✓							✓	
Charadrius ruficapillus	Red-capped Plover	LC	Mig, Mar	LC	✓							✓	
Charadrius veredus	Oriental Plover	LC	Mig, Mar	LC	✓								
Chlidonias hybrida	Whiskered Tern	LC	Mar	LC	✓					✓			
Chlidonias leucopterus	White-winged Black Tern	LC	Mig, Mar	LC	✓					✓			
Chroicocephalus novaehollandiae	Silver Gull	LC	Mar	LC	✓	✓						✓	
Circus approximans	Swamp Harrier	LC	Mig	LC	✓					✓		✓	
Conopophila albogularis	Rufous-banded Honeyeater	LC	-	LC	✓							✓	
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC	Mar	LC	✓							✓	
Coracina papuensis	White-bellied Cuckoo-shrike	LC	Mar	LC	✓							✓	
Coracina tenuirostris	Cicadabird	LC	Mar	LC	✓							✓	
Cracticus quoyi	Black Butcherbird	LC	-	LC	✓							✓	
Cuculus optatus	Oriental Cuckoo	LC	Mig, Mar	LC	✓								

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Dendrocygna arcuata	Wandering Whistling-Duck	LC	Mig, Mar	LC	✓					✓		✓	
Dendrocygna eytoni	Plumed Whistling-Duck	LC	Mig	LC	✓					✓			
Dicrurus bracteatus	Spangled Drongo	LC	Mar	LC	✓							✓	
Dromaius novaehollandiae	Emu	VU	-	LC	✓								
Ducula bicolor	Pied Imperial Pigeon	LC	Mar	LC	✓							✓	
Egretta garzetta	Little Egret	LC	Mar	LC	✓					✓		✓	
Egretta novaehollandiae	White-faced Heron	LC	-	LC	✓					✓		✓	
Egretta picata	Pied Heron	LC	-	LC	✓					✓		✓	
Egretta sacra	Eastern Reef Egret	LC	Mig, Mar	LC	✓							✓	
Ephippiorhynchus asiaticus	Black-necked Stork	LC	-	NT	✓					✓		✓	
Erythrogonys cinctus	Red-kneed Dotterel	LC	Mig	LC	✓								
Erythrotriorchis radiatus	Red Goshawk	VU	VU	VU	✓								
Erythrura gouldiae	Gouldian Finch	EN	EN	EN	✓								
Esacus magnirostris	Beach Stone-curlew	LC	Mar	NT	✓							✓	
Eudnamys scolopacea	Common Koel	LC	Mar	LC	✓							✓	
Eulabeornis castaneoventris	Chestnut Rail	LC	-	LC	✓					✓		✓	
Eurostopodus argus	Spotted Nightjar	LC	Mar	LC	✓							✓	

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Eurystomus orientalis	Dollarbird	LC	Mar	LC	✓							✓	
Falco cenchroides	Nankeen Kestrel	LC	Mig, Mar	LC	✓							✓	
Fregata ariel	Lesser Frigatebird	LC	Mig, Mar	LC	✓							✓	
Fregata minor	Great Frigatebird	DD	Mig, Mar	LC	✓								
Fulica atra	Eurasian Coot	LC	-	LC						✓			
Gallinago hardwickii	Latham's Snipe	DD	Mig, Mar	LC	✓								
Gallinago megala	Swinhoe's Snipe	DD	Mig, Mar	LC	✓								
Gallinago stenura	Pin-tailed Snipe	DD	Mig, Mar	LC	✓							✓	
Gelochelidon nilotica	Gull-billed Tern	LC	Mar	LC	✓					✓		✓	
Geophaps smithii	Partridge Pigeon	NT	VU	NT	✓								
Gerygone chloronotus	Green-backed Gerygone	LC	-	LC	✓							✓	
Gerygone levigaster	Mangrove Gerygone	LC	-	LC	✓								
Gerygone magnrostris	Large-billed Gerygone	LC	-	LC	✓							✓	
Glareola maldivarum	Oriental Pratincole	LC	Mar	LC	✓							✓	
Grallina cyanoleuca	Magpie-lark	LC	Mar	LC	✓							✓	
Grus rubicunda	Brolga	LC	-	LC	✓					✓		✓	
Haematapus fuliginous	Pied Oystercatcher	LC	-	LC			✓					✓	

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Haematopus fuliginosus	Sooty Oystercatcher	LC	-	LC	✓							✓	
Haematopus longirostris	Pied Oystercatcher	LC	-	LC	✓								
Haliaeetus leucogaster	White-bellied Sea-eagle	LC	Mig, Mar	LC	✓					✓		✓	
Haliastur indus	Brahminy Kite	LC	Mig, Mar	LC	✓					✓		✓	
Haliastur sphenurus	Whistling Kite	LC	Mig, Mar	LC	✓							✓	
Himantopus himantopus	Black-winged Stilt	LC	Mig, Mar	LC	✓					✓		✓	
Hirundo nigricans	Tree Martin	LC	Mar	LC	✓							✓	
Hydroprogne caspia	Caspian Tern	LC	Mig, Mar	LC	✓								
Irediparra gallinacea	Comb-crested Jacana	LC	-	LC	✓					✓		✓	
Ixobrychus flavicollis	Black Bittern	DD	-	LC	✓								
Lagale leucomela	Varied Triller	LC	-	LC	✓							✓	
Lichenostomus unicolor	White-gaped Honeyeater	LC	-	LC	✓							✓	
Limosa lapponica	Bar-tailed Godwit	LC	Mig, Mar	LC	✓							✓	
Limosa limosa	Black-tailed Godwit	LC	Mig, Mar	NT	✓								
Malacorhynchus membranaceus	Pink-eared Duck	LC	Mig	LC						✓			
Megalurus timoriensis	Tawny Grassbird	LC	-	LC	✓							✓	
Megapodius reinwardt	Orange-footed Scrubfowl	LC	-	LC	✓							✓	

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Merops ornatus	Rainbow Bee-eater	LC	Mig, Mar	LC	✓							✓	
Microcarbo melanoleucos	Little Pied Cormorant	LC	-	LC	✓					✓		✓	
Microeca flavigaster	Lemon-bellied Flycatcher	LC	-	LC	✓							✓	
Myiagra alecto	Shining Flycatcher	LC	-	LC	✓							✓	
Myiagra inquieta	Restless Flycatcher	LC	-	LC	✓							✓	
Myiagra ruficollis	Broad-billed Flycatcher	LC	-	LC	✓								
Myzomela erythrocephala	Red-headed Honeyeater	LC	-	LC	✓							✓	
Myzomela obscura	Dusky Honeyeater	LC	-	LC	✓							✓	
Neochmia phaeton	Crimson Finch	LC	-	LC	✓							✓	
Nettapus pulchellus	Green Pygmy-Goose	LC	Mig, Mar	LC	✓					✓		✓	
Ninox connivens	Barking Owl	LC	-	LC	✓							✓	
Ninox novaeseelandiae	Southern Boobook	LC	Mar	LC	✓							✓	
Ninox rufa	Rufous Owl	LC	-	LC	✓							✓	
Numenius madagascariensis	Eastern Curlew	LC	Mig, Mar	VU	✓								
Numenius minutus	Little Curlew	LC	Mig, Mar	LC	✓								
Numenius phaeopus	Whimbrel	LC	Mig, Mar	LC	✓							✓	
Nycticorax caledonicus	Nankeen Night Heron	LC	Mar	LC	✓					✓		✓	

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Onychoprion anaethetus	Bridled Tern	LC	Mig, Mar	LC	✓	✓							
Onychoprion fuscata	Sooty Tern	NE	Mar	LC	✓								
Oriolus flavocinctus	Yellow Oriole	LC	-	LC	✓							✓	
Pachycephala lanioides	White-breasted Whistler	LC	-	LC	✓								
Pachycephala melanura	Mangrove Golden Whistler	LC	-	LC	✓								
Pachycephala simplex	Grey Whistler	LC	-	LC	✓							✓	
Pandion haliaetus	Osprey	LC	Mig, Mar	LC	✓					✓		✓	
Pelecanus conspicillatus	Australian Pelican	LC	Mar	LC	✓					✓		✓	
Peneoenanthe pulverulenta	Mangrove Robin	LC	-	LC	✓								
Phalacrocorax carbo	Great Cormorant	LC	-	LC	✓								
Phalacrocorax sulcirostris	Little Black Cormorant	LC	-	LC	✓					✓			
Phalacrocorax varius	Pied Cormorant	LC	-	LC	✓					✓			
Pitta iris	Rainbow Pitta	LC	-	LC	✓							✓	
Platalea regia	Royal Spoonbill	LC	-	LC	✓					✓			
Plegadis falcinellus	Glossy Ibis	LC	Mig, Mar	LC	✓					✓		✓	
Pluvialis fulva	Pacific Golden Plover	LC	Mig, Mar	LC	✓							✓	
Pluvialis squatarola	Grey Plover	LC	Mig, Mar	LC	✓							✓	

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Podargus strigoides	Tawny Frogmouth	LC	-	LC	✓							✓	
Porphyrio porphyrio	Purple Swamphen	LC	Mar	LC	✓					✓			
Porzana pusilla	Baillon's Crake	DD	Mar	LC	✓								
Ptilinopus regina	Rose-crowned Fruit-dove	LC	-	LC	✓							✓	
Ramsayornis fasciatus	Bar-breasted Honeyeater	LC	-	LC	✓							✓	
Rhipidura dryas	Arafura Fantail	LC	Mig, Mar	-	✓								
Scythrops novaehollandiae	Channel-billed Cuckoo	LC	Mar	LC	✓								
Sterna dougallii	Roseate Tern	LC	Mig, Mar	LC	✓	✓							
Sterna hirundo	Common Tern	LC	Mig, Mar	LC	✓					✓			
Sterna sumatrana	Black-naped Tern	LC	Mig, Mar	LC	✓	✓							
Sternula albifrons	Little Tern	LC	Mig, Mar	LC	✓							✓	
Stiltia isabella	Australian Pratincole	LC	Mar	LC	✓					✓		✓	
Sula dactylatra	Masked Booby	NE	Mig, Mar	-	✓								
Sula leucogaster	Brown Booby	LC	Mig, Mar	LC	✓							✓	
Tachybaptus novaehollandiae	Australasian Grebe	LC	-	LC	✓					✓		✓	
Tadorna radjah	Radjah Shelduck	LC	Mig, Mar	LC	✓					✓		✓	
Thalasseus bengalensis	Lesser Crested Tern	LC	Mig, Mar	LC	✓								

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Thalasseus bergii	Crested Tern	LC	Mar	LC	✓	✓						✓	
Threskiornis molucca	Australian White Ibis	LC	Mar	LC	✓					✓		✓	
Threskiornis spinicollis	Straw-necked Ibis	LC	Mar	LC	✓					✓		✓	
Todiramphus chloris	Collared Kingfisher	LC	-	LC	✓								
Todiramphus macleayii	Forest Kingfisher	LC	Mar	LC	✓							✓	
Todiramphus sanctus	Sacred Kingfisher	LC	Mar	LC	✓							✓	
Tringa brevipes	Grey-tailed Tattler	LC	Mig, Mar	LC	✓							✓	
Tringa glareola	Wood Sandpiper	NE	Mig, Mar	LC	✓								
Tringa nebularia	Common Greenshank	LC	Mig, Mar	LC	✓							✓	
Tringa stagnatilis	Marsh Sandpiper	LC	Mig, Mar	LC	✓								
Tyto novaehollandiae kimberli	Masked Owl (mainland Top End)	VU	VU	-	✓								
Vanellus miles	Masked Lapwing	LC	Mig	LC	✓					✓		✓	
Xenus cinereus	Terek Sandpiper	LC	Mig, Mar	LC	✓								
Zosterops luteus	Yellow White-eye	LC	-	LC	✓								
Mammals													
Bos javanicus	Banteng	INT	-	EN	✓								✓
Bubalus bubalis	Swamp Buffalo	INT	-	-	✓								✓

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Conilurus penicillatus	Brush-tailed rabbit-rat	VU	-	NT	✓								
Dugong dugon	Dugong	NT	Mig, Mar	VU	✓	✓							
Hydromys chrysogaster	Water-rat	LC	-	LC	✓								
Macroglossus minimus	Borthern Blossom Bat	LC	-	LC	✓								✓
Myotis macropus	Large-footed Myotis	LC	-	LC									✓
Nyctophilus arnhemensis	Arnhem Land Long-eared Bat	LC	-	LC									✓
Nyctophilus bifax	Eastern Long-eared Bat	LC	-	LC	✓								✓
Orcaella heinsohni	Australian Snubfin Dolphin	LC	-	NT	✓								
Pteropus alecto	Black Flying-fox	LC	-	LC	✓								✓
Pteropus scapulatus	Little Red Flying-fox	LC	-	LC	✓								✓
Sousa chinensis	Indo-Pacific Humpbacked Dolphin	LC	Mig	NT	✓								
Stenella attenuata	Pantropical Spotted Dolphin	DD	-	LC	✓								
Stenella longirostris	Long-snouted Spinner Dolphin	DD	-	DD	✓								
Sus scrofa	Feral Pig	INT	-	LC	✓								✓
Tursiops aduncus	Indo-Pacific Bottlenose Dolphin	NE	Mig	DD	✓								
Xeromys myoides	Water Mouse	DD	VU	VU	✓								
Invertebrates													

Species	Common Name	Conservation Status			Data Source Reference								
		TPWC Act	EPBC Act	IUCN	1	2	3	4	5	6*	7	8	9
Attacus wardi	Atlas Moth	EN	-	-							✓		
Clypeomorus admirabilis	A gastropod	-	-	-				✓					
Saccostrea echinata	Northern Black-lip Oyster	-	-	-			✓						
Sacrostrea cucculata amasa	Milky Oysters	-	-	-		✓	✓						
Scylla serrata	Mud Crab	-	-	-		✓	✓						
Tridacna squamosa	Scaley Giant Clam	-	-	LR				✓					

* fauna records are from the mouth of the East Alligator River, around the Cobourg Peninsula and along the northern coast to Junction Bay, just west of Maningrida, including the wetlands of Murganella and Salt Water Creeks.

Appendix C

Flora Listed in the NT Flora Atlas for the Cobourg Peninsula

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
MALVACEAE	*Abelmoschus moschatus* subsp. *tuberosus*			LC	-	✓
FABACEAE	*Abrus precatorius* subsp. *precatorius*			LC	-	×
MALVACEAE	*Abutilon indicum* subsp. *indeterminate*			-	-	×
MIMOSACEAE	*Acacia arafurica*		✓	LC	-	
MIMOSACEAE	*Acacia auriculiformis*			LC	-	✓
MIMOSACEAE	*Acacia convallium*		✓	LC	-	
MIMOSACEAE	*Acacia difficilis*			LC	-	×
MIMOSACEAE	*Acacia dimidiata*			LC	-	×
MIMOSACEAE	*Acacia hemignosta*			LC	-	×
MIMOSACEAE	*Acacia holosericea*			LC	-	×
MIMOSACEAE	*Acacia lamprocarpa*			LC	-	
MIMOSACEAE	*Acacia latescens*			LC	-	✓
MIMOSACEAE	*Acacia latifolia*			LC	-	×
MIMOSACEAE	*Acacia leptocarpa*			LC	-	×
MIMOSACEAE	*Acacia mimula*		✓	LC	-	
MIMOSACEAE	*Acacia multisiliqua*			LC	-	×
MIMOSACEAE	*Acacia oncinocarpa*		✓	LC	-	×
MIMOSACEAE	*Acacia pellita*			LC	-	×
MIMOSACEAE	*Acacia platycarpa*			LC	-	×
MIMOSACEAE	*Acacia praelongata*		✓	LC	-	×
MIMOSACEAE	*Acacia spondylophylla*			LC	-	
MIMOSACEAE	*Acacia torulosa*			LC	-	×
MIMOSACEAE	*Acacia yirrkallensis*		✓	LC	-	×
ACANTHACEAE	*Acanthus ilicifolius*			LC	-	✓
AMARANTHACEAE	*Achyranthes aspera*			LC	-	
PTERIDACEAE	*Acrostichum speciosum*			LC	-	✓
MIMOSACEAE	*Adenanthera pavonina*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
PASSIFLORACEAE	*Adenia heterophylla* subsp. *australis*			LC	-	×
PLUMBAGINACEAE	*Aegialitis annulata*			LC	-	✓
MYRSINACEAE	*Aegiceras corniculatum*			LC	-	✓
RUTACEAE	*Aegle marmelos*	✓		-	-	
AGAVACEAE	*Agave* sp.	✓		-	-	-
MELIACEAE	*Aglaia brownii*			LC	-	
RUBIACEAE	*Aidia racemosa*			LC	-	
MIMOSACEAE	*Albizia lebbeck*			--	-	
MIMOSACEAE	*Albizia procera*			LC	-	
SAPINDACEAE	*Allophylus cobbe*			LC	-	×
POACEAE	*Alloteropsis semialata*			LC	-	×
RHAMNACEAE	*Alphitonia excelsa*			LC	-	✓
RHAMNACEAE	*Alphitonia incana*			LC	-	
APOCYNACEAE	*Alstonia actinophylla*			LC	-	×
FABACEAE	*Alysicarpus ovalifolius*	✓		-	-	
FABACEAE	*Alysicarpus schomburgkii*			LC	-	
APOCYNACEAE	*Alyxia spicata*			LC	-	
APOCYNACEAE	*Alyxia tropica*			LC	-	
AMARANTHACEAE	*Amaranthus rhombeus*			LC	-	
AMARANTHACEAE	*Amaranthus* sp.			-	-	-
AMARANTHACEAE	*Amaranthus undulatus*			LC	-	
AMARANTHACEAE	*Amaranthus viridis*	✓		-	-	
ARACEAE	*Amorphophallus galbra*			LC	-	×
VITACEAE	*Ampelocissus acetosa*			LC	-	✓
VITACEAE	*Ampelocissus frutescens*		✓	LC	-	
LORANTHACEAE	*Amyema sanguinea* var. *sanguinea*			LC	-	×
LORANTHACEAE	*Amyema villiflora* subsp. *indeterminate*			-	-	×

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
LORANTHACEAE	*Amyema villiflora* subsp. *tomentilla*			NE	-	×
ACANTHACEAE	*Andrographis paniculata*	✓		-	-	
LAMIACEAE	*Anisomeles malabarica*			LC	-	
MORACEAE	*Antiaris toxicaria* var. *macrophylla*			LC	-	×
EUPHORBIACEAE	*Antidesma ghesaembilla*			LC	-	
FABACEAE	*Aphyllodium schindleri*			LC	-	
POACEAE	*Aristida holathera* var. *holathera*			LC	-	×
POACEAE	*Aristida schultzii*			LC	-	
POACEAE	*Aristida superpendens*			LC	-	
CYPERACEAE	*Arthrostylis aphylla*			LC	-	
MORACEAE	*Artocarpus glaucus*			LC	-	
POACEAE	*Arundo donax*	✓		-	-	
MYRTACEAE	*Asteromyrtus symphyocarpa*			LC	-	
AVICENNIACEAE	*Avicennia marina* var. *eucalyptifolia*			LC	-	✓
POACEAE	*Bambusa vulgaris*	✓		-	-	
PROTEACEAE	*Banksia dentata*			LC	-	×
CAESALPINIACEAE	*Bauhinia binata*			LC	-	
CYPERACEAE	*Baumea rubiginosa*			LC	-	
TILIACEAE	*Berrya javanica*			LC	-	
ASTERACEAE	*Bidens pilosa*	✓		-	-	
BLECHNACEAE	*Blechnum indicum*			LC	-	
BLECHNACEAE	*Blechnum orientale*			LC	-	✓
ASTERACEAE	*Blumea saxatilis*			LC	-	
ASTERACEAE	*Blumea* sp.			-	-	-
HYDROCHARITACEAE	*Blyxa aubertii* var. *aubertii*			LC	-	✓
NYCTAGINACEAE	*Boerhavia albiflora*			-	-	
NYCTAGINACEAE	*Boerhavia dominii*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
NYCTAGINACEAE	*Boerhavia schomburgkiana*			LC	-	
BOMBACACEAE	*Bombax ceiba*			LC	-	×
CONVOLVULACEAE	*Bonamia media* var. *media*			LC	-	
CONVOLVULACEAE	*Bonamia pannosa*			LC	-	
RUTACEAE	*Boronia lanceolata*			LC	-	
RUTACEAE	*Boronia* sp.			-	-	-
FABACEAE	*Bossiaea bossiaeoides*			LC	-	×
POACEAE	*Bothriochloa pertusa*	✓		-	-	
STERCULIACEAE	*Brachychiton diversifolius* subsp. *diversifolius*			LC	-	×
STERCULIACEAE	*Brachychiton megaphyllus*		✓	LC	-	×
STERCULIACEAE	*Brachychiton paradoxus*			LC	-	×
ASCLEPIADACEAE	*Brachystelma glabriflorum*			LC	-	
EUPHORBIACEAE	*Breynia cernua*			LC	-	×
EUPHORBIACEAE	*Bridelia tomentosa*			-	-	
SIMAROUBACEAE	*Brucea javanica*			LC	-	
RHIZOPHORACEAE	*Bruguiera exaristata*			LC	-	✓
RHIZOPHORACEAE	*Bruguiera gymnorhiza*			LC	-	✓
ACANTHACEAE	*Brunoniella acaulis* subsp. *acaulis*			LC	-	
ACANTHACEAE	*Brunoniella linearifolia*		✓	LC	-	
ANACARDIACEAE	*Buchanania arborescens*			LC	-	
ANACARDIACEAE	*Buchanania obovata*			LC	-	×
SCROPHULARIACEAE	*Buchnera linearis*			LC	-	×
SCROPHULARIACEAE	*Buchnera urticifolia*			LC	-	
CYPERACEAE	*Bulbostylis barbata*			LC	-	×
BURMANNIACEAE	*Burmannia coelestis*			LC	-	
CAESALPINIACEAE	*Caesalpinia bonduc*			LC	-	×
FABACEAE	*Cajanus geminatus*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
FABACEAE	*Cajanus marmoratus*			LC	-	
PORTULACACEAE	*Calandrinia gracilis*			LC	-	×
PORTULACACEAE	*Calandrinia* sp.			-	-	-
VERBENACEAE	*Callicarpa candicans*			LC	-	
CUPRESSACEAE	*Callitris intratropica*			LC	-	×
ORCHIDACEAE	*Calochilus holtzei*			DD	-	
CLUSIACEAE	*Calophyllum inophyllum*			LC	-	
CLUSIACEAE	*Calophyllum soulattri*			LC	-	✓
FABACEAE	*Calopogonium mucunoides*	✓		-	-	
MYRTACEAE	*Calytrix achaeta*			LC	-	×
MYRTACEAE	*Calytrix brownii*			LC	-	×
MYRTACEAE	*Calytrix exstipulata*			LC	-	×
BOMBACACEAE	*Camptostemon schultzii*			LC	-	✓
BURSERACEAE	*Canarium australianum*			LC	-	×
FABACEAE	*Canavalia cathartica*			NT	-	
FABACEAE	*Canavalia rosea*			LC	-	×
OPILIACEAE	*Cansjera leptostachya*			LC	-	
POACEAE	*Capillipedium parviflorum*			LC	-	
CAPPARACEAE	*Capparis jacobsii*			LC	-	
CAPPARACEAE	*Capparis sepiaria*			LC	-	
CAPPARACEAE	*Capparis umbonata*			LC	-	×
RHIZOPHORACEAE	*Carallia brachiata*			LC	-	✓
ARECACEAE	*Carpentaria acuminata*		✓	LC	-	✓
COMMELINACEAE	*Cartonema parviflorum*			LC	-	✓
COMMELINACEAE	*Cartonema spicatum*			LC	-	×
COMMELINACEAE	*Cartonema tenue*			LC	-	
LAURACEAE	*Cassytha filiformis*			LC	-	×

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
CASUARINACEAE	*Casuarina cunninghamiana* subsp. *miodon*			NE	-	✓
CASUARINACEAE	*Casuarina equisetifolia* subsp. *indeterminate*			-	-	✓
APOCYNACEAE	*Catharanthus roseus*	✓		-	-	
VITACEAE	*Cayratia maritima*			LC	-	✓
VITACEAE	*Cayratia trifolia*			LC	-	
ULMACEAE	*Celtis philippensis*			LC	-	×
POACEAE	*Cenchrus brownii*	✓		-	-	×
POACEAE	*Cenchrus echinatus*	✓		-	-	×
POACEAE	*Cenchrus elymoides* var. *elymoides*	✓		NE	-	
POACEAE	*Cenchrus elymoides* var. *indeterminate*			-	-	
PARKERIACEAE	*Ceratopteris thalictroides*			LC	-	✓
APOCYNACEAE	*Cerbera manghas*			NT	-	✓
RHIZOPHORACEAE	*Ceriops australis*			LC	-	✓
RHIZOPHORACEAE	*Ceriops tagal*			LC	-	✓
CAESALPINIACEAE	*Chamaecrista absus* var. *absus*			LC	-	
CAESALPINIACEAE	*Chamaecrista mimosoides*			LC	-	
CAESALPINIACEAE	*Chamaecrista nomame* var. *nomame*			LC	-	
ADIANTACEAE	*Cheilanthes fragillima*			LC	-	
ADIANTACEAE	*Cheilanthes* sp.			-	-	
ADIANTACEAE	*Cheilanthes tenuifolia*			LC	-	
POACEAE	*Chloris barbata*	✓		-	-	
LILIACEAE	*Chlorophytum laxum*			LC	-	
EUPHORBIACEAE	*Choriceras tricorne*			LC	-	×
POACEAE	*Chrysopogon elongatus*			LC	-	
POACEAE	*Chrysopogon fallax*			LC	-	✓
POACEAE	*Chrysopogon latifolius*			LC	-	
POACEAE	*Chrysopogon oliganthus*			LC	-	✓

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
POACEAE	*Chrysopogon pallidus*			LC	-	
VITACEAE	*Cissus adnata*			LC	-	×
VITACEAE	*Cissus reniformis*			LC	-	
CUCURBITACEAE	*Citrullus lanatus*	✓		-	-	
EUPHORBIACEAE	*Claoxylon tenerifolium*			LC	-	
RANUNCULACEAE	*Clematis pickeringii*			LC	-	
CAPPARACEAE	*Cleome viscosa*			LC	-	×
VERBENACEAE	*Clerodendrum costatum*			LC	-	
VERBENACEAE	*Clerodendrum floribundum* var. *indeterminate*			-	-	×
VERBENACEAE	*Clerodendrum inerme*			LC	-	✓
VERBENACEAE	*Clerodendrum* sp.			-	-	-
FABACEAE	*Clitoria australis*			LC	-	
FABACEAE	*Clitoria ternatea*	✓		-	-	
BIXACEAE	*Cochlospermum fraseri* subsp. *fraseri*			LC	-	×
BIXACEAE	*Cochlospermum fraseri* subsp. *indeterminate*			-	-	×
ARACEAE	*Colocasia esculenta*			LC	-	✓
POLYGALACEAE	*Comesperma secundum*			LC	-	
COMMELINACEAE	*Commelina ensifolia*			LC	-	✓
TILIACEAE	*Corchorus aestuans*			LC	-	✓
BORAGINACEAE	*Cordia subcordata*			LC	-	×
MYRTACEAE	*Corymbia bella*			LC	-	×
MYRTACEAE	*Corymbia bleeseri*			LC	-	×
MYRTACEAE	*Corymbia chartacea*		✓	LC	-	
MYRTACEAE	*Corymbia confertiflora*			LC	-	
MYRTACEAE	*Corymbia disjuncta*			LC	-	
MYRTACEAE	*Corymbia grandifolia* subsp. *longa*			LC	-	
MYRTACEAE	*Corymbia latifolia*			LC	-	×

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
MYRTACEAE	*Corymbia nesophila*			LC	-	
MYRTACEAE	*Corymbia polycarpa*			LC	-	×
MYRTACEAE	*Corymbia polysciada*		✓	LC	-	
MYRTACEAE	*Corymbia porrecta*		✓	LC	-	
MYRTACEAE	*Corymbia ptychocarpa* subsp. *aptycha*			LC	-	
MYRTACEAE	*Corymbia ptychocarpa* subsp. *indeterminate*			-	-	
MYRTACEAE	*Corymbia ptychocarpa* subsp. *ptychocarpa*			LC	-	
LILIACEAE	*Corynotheca lateriflora*			LC	-	
LILIACEAE	*Crinum angustifolium*			LC	-	✓
LILIACEAE	*Crinum uniflorum*			LC	-	✓
FABACEAE	*Crotalaria brevis*			LC	-	×
FABACEAE	*Crotalaria calycina*			LC	-	×
FABACEAE	*Crotalaria medicaginea* var. *indeterminate*			-	-	×
FABACEAE	*Crotalaria medicaginea* var. *medicaginea*			LC	-	×
FABACEAE	*Crotalaria medicaginea* var. *neglecta*			LC	-	×
FABACEAE	*Crotalaria montana* var. *angustifolia*			LC	-	×
FABACEAE	*Crotalaria pallida* var. *obovata*	✓		-	-	×
FABACEAE	*Crotalaria retusa*			LC	-	✓
EUPHORBIACEAE	*Croton armstrongii*		✓	NE	-	
EUPHORBIACEAE	*Croton arnhemicus*			LC	-	
EUPHORBIACEAE	*Croton habrophyllus*			LC	-	
EUPHORBIACEAE	*Croton* sp.			-	-	-
LAURACEAE	*Cryptocarya cunninghamii*			LC	-	
LAURACEAE	*Cryptocarya hypospodia*			EN	-	
ASCLEPIADACEAE	*Cryptostegia madagascariensis* var. *indeterminate*	✓		-	-	
CUCURBITACEAE	*Cucumis melo* subsp. *indeterminate*			-	-	✓

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
FABACEAE	*Cullen badocanum*			LC	-	
SAPINDACEAE	*Cupaniopsis anacardioides*			LC	-	×
LILIACEAE	*Curculigo ensifolia* var. *indeterminate*			-	-	
ASTERACEAE	*Cyanthillium cinereum*			LC	-	
ANNONACEAE	*Cyathostemma glabrum*			LC	-	
CYCADACEAE	*Cycas armstrongii*		✓	v	-	×
FABACEAE	*Cyclocarpa stellaris*			LC	-	
RUBIACEAE	*Cyclophyllum schultzii f.* indeterminate		✓	-	-	
RUBIACEAE	*Cyclophyllum schultzii f.* schultzii		✓	LC	-	
ORCHIDACEAE	*Cymbidium canaliculatum*			LC	-	
POACEAE	*Cymbopogon bombycinus*			LC	-	×
POACEAE	*Cymbopogon procerus*			LC	-	×
POACEAE	*Cymbopogon refractus*			LC	-	
CYMODOCEACEAE	*Cymodocea rotundata*			NE	-	
CYMODOCEACEAE	*Cymodocea serrulata*			NE	-	
ASCLEPIADACEAE	*Cynanchum carnosum*			LC	-	✓
POACEAE	*Cynodon dactylon* var. *dactylon*	✓		-	-	✓
POACEAE	*Cynodon radiatus*	✓		-	-	✓
CYPERACEAE	*Cyperus angustatus*			LC	-	
CYPERACEAE	*Cyperus aquatilis*			LC	-	✓
CYPERACEAE	*Cyperus bifax*			LC	-	
CYPERACEAE	*Cyperus bulbosus*			LC	-	
CYPERACEAE	*Cyperus conicus*			LC	-	
CYPERACEAE	*Cyperus haspan* subsp. *indeterminate*			-	-	✓
CYPERACEAE	*Cyperus javanicus* subsp. *armstrongii*			LC	-	✓
CYPERACEAE	*Cyperus pedunculatus*			LC	-	
CYPERACEAE	*Cyperus polystachyos*			LC	-	✓

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
CYPERACEAE	*Cyperus pulchellus*			LC	-	
CYPERACEAE	*Cyperus rotundus*	✓		-	-	
CYPERACEAE	*Cyperus scariosus*			LC	-	✓
CYPERACEAE	*Cyperus stoloniferus*			LC	-	
CYPERACEAE	*Cyperus zollingeri*			LC	-	
POACEAE	*Dactyloctenium aegyptium*	✓		-	-	
POACEAE	*Dactyloctenium radulans*			LC	-	×
FABACEAE	*Dalbergia candenatensis*			LC	-	✓
RESTIONACEAE	*Dapsilanthus elatior*			LC	-	
RESTIONACEAE	*Dapsilanthus* sp.			-	-	
RESTIONACEAE	*Dapsilanthus spathaceus*			LC	-	
LORANTHACEAE	*Decaisnina signata* subsp. *indeterminate*			-	-	×
LORANTHACEAE	*Decaisnina signata* subsp. *signata*			LC	-	×
LORANTHACEAE	*Decaisnina triflora*			LC	-	×
CAESALPINIACEAE	*Delonix regia*	✓		-	-	×
ORCHIDACEAE	*Dendrobium affine*			LC	-	✓
ORCHIDACEAE	*Dendrobium canaliculatum*			LC	-	✓
LORANTHACEAE	*Dendrophthoe odontocalyx*			LC	-	×
CELASTRACEAE	*Denhamia obscura*			LC	-	
FABACEAE	*Derris trifoliata*			LC	-	✓
FABACEAE	*Desmodium brownii*			LC	-	
FABACEAE	*Desmodium heterocarpon* var. *strigosum*			LC	-	✓
FABACEAE	*Desmodium pullenii*			LC	-	
FABACEAE	*Desmodium pycnotrichum*			LC	-	
FABACEAE	*Desmodium* sp.			-	-	-
FABACEAE	*Desmodium tortuosum*	✓		-	-	
FABACEAE	*Desmodium trichostachyum*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
LILIACEAE	*Dianella longifolia* var. *longifolia*			LC	-	
LILIACEAE	*Dianella odorata*			LC	-	
STERCULIACEAE	*Dicarpidium* sp.			-	-	
POACEAE	*Dichanthium fecundum*			LC	-	×
POACEAE	*Dichanthium sericeum* subsp. *indeterminate*			-	-	×
MIMOSACEAE	*Dichrostachys cinerea* subsp. *malesiana*	✓		-	-	
ACANTHACEAE	*Dicliptera ciliata*			LC	-	
GLEICHENIACEAE	*Dicranopteris linearis* var. *linearis*			LC	-	✓
POACEAE	*Digitaria bicornis*	✓		-	-	×
POACEAE	*Digitaria ctenantha*			LC	-	×
POACEAE	*Digitaria gibbosa*			LC	-	×
POACEAE	*Dimeria acinaciformis*			LC	-	
POACEAE	*Dimeria chloridiformis*			LC	-	
DIOSCOREACEAE	*Dioscorea bulbifera*			LC	-	✓
DIOSCOREACEAE	*Dioscorea* sp.			-	-	-
DIOSCOREACEAE	*Dioscorea transversa*			LC	-	×
EBENACEAE	*Diospyros calycantha*			LC	-	×
EBENACEAE	*Diospyros compacta*			LC	-	✓
EBENACEAE	*Diospyros cordifolia*			LC	-	
EBENACEAE	*Diospyros humilis*			LC	-	
EBENACEAE	*Diospyros littorea*			LC	-	✓
EBENACEAE	*Diospyros maritima*			LC	-	
EBENACEAE	*Diospyros* sp.			-	-	
CUCURBITACEAE	*Diplocyclos palmatus*			LC	-	
ORCHIDACEAE	*Dipodium stenocheilum*			LC	-	×
SAPINDACEAE	*Distichostemon hispidulus* var. *indeterminate*			-	-	×
BIGNONIACEAE	*Dolichandrone filiformis*			LC	-	×

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
DROSERACEAE	*Drosera burmanni*			LC	-	
DROSERACEAE	*Drosera dilatatopetiolaris*			LC	-	
DROSERACEAE	*Drosera falconeri*		✓	NE	-	
DROSERACEAE	*Drosera petiolaris*			LC	-	×
DROSERACEAE	*Drosera* sp.			-	-	-
EUPHORBIACEAE	*Drypetes deplanchei*			LC	-	
FABACEAE	*Dunbaria rotundifolia*			LC	-	
MELIACEAE	*Dysoxylum acutangulum* subsp. *foveolatum*			LC	-	
POACEAE	*Echinochloa colonum*	✓		-	-	✓
POACEAE	*Ectrosia agrostoides*			LC	-	
POACEAE	*Ectrosia leporina*			LC	-	
ELAEOCARPACEAE	*Elaeocarpus arnhemicus*			LC	-	
CYPERACEAE	*Eleocharis dulcis*			LC	-	✓
CYPERACEAE	*Eleocharis geniculata*			LC	-	✓
CYPERACEAE	*Eleocharis spiralis*			LC	-	✓
CYPERACEAE	*Eleocharis sundaica*			LC	-	✓
ASTERACEAE	*Elephantopus scaber*			LC	-	
POACEAE	*Eleusine indica*	✓		-	-	
MYRSINACEAE	*Embelia curvinervia*			LC	-	
ASTERACEAE	*Emilia sonchifolia* subsp. *indeterminate*	✓		-	-	
HYDROCHARITACEAE	*Enhalus acoroides*			NE	-	
POACEAE	*Enneapogon pallidus*			LC	-	×
MIMOSACEAE	*Entada rheedii*			NT	-	
ARACEAE	*Epipremnum amplissimum*			LC	-	
POACEAE	*Eragrostis cumingii*			LC	-	×
POACEAE	*Eragrostis pubescens*			LC	-	
POACEAE	*Eragrostis rigidiuscula*			LC	-	

Family	**Species**	**Introduced**	**Endemic**	**Conservation Status**		**Wetland Dependent**
				TPWC Act	**EPBC Act**	
POACEAE	*Eragrostis schultzii*			LC	-	
POACEAE	*Eragrostis* sp.			-	-	-
POACEAE	*Eriachne agrostidea*			LC	-	
POACEAE	*Eriachne armittii*			LC	-	
POACEAE	*Eriachne avenacea*			LC	-	
POACEAE	*Eriachne bleeseri*		✓	LC	-	
POACEAE	*Eriachne burkittii*			LC	-	
POACEAE	*Eriachne ciliata*			LC	-	×
POACEAE	*Eriachne pallescens* var. *pallescens*			LC	-	
POACEAE	*Eriachne schultziana*		✓	LC	-	
POACEAE	*Eriachne* sp.			-	-	
POACEAE	*Eriachne squarrosa*			LC	-	
POACEAE	*Eriachne stipacea*			LC	-	
POACEAE	*Eriachne sulcata*			LC	-	
POACEAE	*Eriachne triseta*			LC	-	
ERIOCAULACEAE	*Eriocaulon cinereum*			LC	-	✓
ERIOCAULACEAE	*Eriocaulon fistulosum*			LC	-	✓
ERIOCAULACEAE	*Eriocaulon pusillum*			LC	-	✓
ERIOCAULACEAE	*Eriocaulon setaceum*			LC	-	✓
ERIOCAULACEAE	*Eriocaulon* sp.			-	-	-
ERIOCAULACEAE	*Eriocaulon spectabile*			LC	-	✓
POACEAE	*Eriochloa procera*			LC	-	✓
FABACEAE	*Eriosema chinense*			LC	-	
CONVOLVULACEAE	*Erycibe coccinea*			LC	-	
FABACEAE	*Erythrina variegata* var. *orientalis*			LC	-	×
FABACEAE	*Erythrina vespertilio*			LC	-	×
CAESALPINIACEAE	*Erythrophleum chlorostachys*			LC	-	×

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
MYRTACEAE	*Eucalyptus alba* var. *australasica*			LC	-	×
MYRTACEAE	*Eucalyptus bigalerita*			LC	-	×
MYRTACEAE	*Eucalyptus jensenii*			LC	-	×
MYRTACEAE	*Eucalyptus miniata*			LC	-	×
MYRTACEAE	*Eucalyptus oligantha* subsp. *oligantha*			LC	-	×
MYRTACEAE	*Eucalyptus tetrodonta*			LC	-	×
POACEAE	*Eulalia mackinlayi*			LC	-	
EUPHORBIACEAE	*Euphorbia armstrongiana*		✓	LC	-	
EUPHORBIACEAE	*Euphorbia atoto*			LC	-	
EUPHORBIACEAE	*Euphorbia heterophylla*	✓		-	-	
EUPHORBIACEAE	*Euphorbia hirta*	✓		-	-	
EUPHORBIACEAE	*Euphorbia mitchelliana*			LC	-	
EUPHORBIACEAE	*Euphorbia* sp.			-	-	-
EUPHORBIACEAE	*Euphorbia tannensis* subsp. *eremophila*			LC	-	
EUPHORBIACEAE	*Euphorbia tannensis* subsp. *tannensis*			LC	-	
EUPHORBIACEAE	*Euphorbia vachellii*			LC	-	✓
CONVOLVULACEAE	*Evolvulus alsinoides* var. *decumbens*			LC	-	×
CONVOLVULACEAE	*Evolvulus alsinoides* var. *indeterminate*			-	-	×
CONVOLVULACEAE	*Evolvulus nummularis*	✓		-	-	
EUPHORBIACEAE	*Excoecaria agallocha*			LC	-	✓
EUPHORBIACEAE	*Excoecaria* sp.			-	-	-
SANTALACEAE	*Exocarpos latifolius*			LC	-	×
SANTALACEAE	*Exocarpos* sp.			-	-	-
LOGANIACEAE	*Fagraea racemosa*			LC	-	
MORACEAE	*Ficus aculeata* var. *aculeata*			LC	-	
MORACEAE	*Ficus aculeata* var. *indeterminate*			-	-	
MORACEAE	*Ficus aculeata* var. *orbicularis*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
MORACEAE	*Ficus hispida*			-	-	✓
MORACEAE	*Ficus hispida* var. *hispida*			LC	-	Tree
MORACEAE	*Ficus racemosa* var. *racemosa*			LC	-	✓
MORACEAE	*Ficus scobina*			LC	-	✓
MORACEAE	*Ficus virens* var. *indeterminate*			-	-	×
MORACEAE	*Ficus virens* var. *virens*			LC	-	×
CYPERACEAE	*Fimbristylis acicularis*			LC	-	✓
CYPERACEAE	*Fimbristylis acuminata*			LC	-	✓
CYPERACEAE	*Fimbristylis cymosa*			LC	-	✓
CYPERACEAE	*Fimbristylis densa*			LC	-	✓
CYPERACEAE	*Fimbristylis dichotoma*			LC	-	✓
CYPERACEAE	*Fimbristylis ferruginea*			LC	-	✓
CYPERACEAE	*Fimbristylis littoralis* var. *littoralis*			LC	-	✓
CYPERACEAE	*Fimbristylis nutans*			LC	-	✓
CYPERACEAE	*Fimbristylis ovata*			LC	-	✓
CYPERACEAE	*Fimbristylis oxystachya*			LC	-	✓
CYPERACEAE	*Fimbristylis pauciflora*			LC	-	✓
CYPERACEAE	*Fimbristylis polytrichoides*			LC	-	✓
CYPERACEAE	*Fimbristylis rara*			LC	-	✓
CYPERACEAE	*Fimbristylis sericea*			LC	-	✓
CYPERACEAE	*Fimbristylis* sp. *Darwin (*M.Lazarides 4251*)*		✓	LC	-	✓
CYPERACEAE	*Fimbristylis tetragona*			LC	-	✓
CYPERACEAE	*Fimbristylis xyridis*			LC	-	✓
FLACOURTIACEAE	*Flacourtia territorialis*		✓	LC	-	
FLAGELLARIACEAE	*Flagellaria indica*			LC	-	×
FABACEAE	*Flemingia lineata*			LC	-	
FABACEAE	*Flemingia parviflora*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
FABACEAE	*Flemingia* sp.			-	-	
EUPHORBIACEAE	*Flueggea virosa* subsp. *melanthesoides*			LC	-	✓
CYPERACEAE	*Fuirena ciliaris*			LC	-	✓
CYPERACEAE	*Fuirena umbellata*			LC	-	✓
FABACEAE	*Galactia* sp.			-	-	-
FABACEAE	*Galactia tenuiflora*			LC	-	
SAPINDACEAE	*Ganophyllum falcatum*			LC	-	
RUBIACEAE	*Gardenia megasperma*			LC	-	×
ORCHIDACEAE	*Geodorum neocaledonicum*			LC	-	
POACEAE	*Germainia grandiflora*			LC	-	
POACEAE	*Germainia* sp.			-	-	
POACEAE	*Germainia truncatiglumis*			LC	-	
MOLLUGINACEAE	*Glinus oppositifolius*			LC	-	✓
EUPHORBIACEAE	*Glochidion xerocarpum*			LC	-	×
ASTERACEAE	*Glossocardia bidens*			LC	-	
FABACEAE	*Glycine hirticaulis* subsp. *indeterminate*		✓	-	-	
RUTACEAE	*Glycosmis sapindoides*			LC	-	
RUTACEAE	*Glycosmis trifoliata*			LC	-	
VERBENACEAE	*Gmelina schlechteri*			LC	-	
ASTERACEAE	*Gnephosis* sp.			-	-	
FABACEAE	*Gompholobium subulatum*			LC	-	
AMARANTHACEAE	*Gomphrena canescens* subsp. *canescens*			LC	-	×
AMARANTHACEAE	*Gomphrena canescens* subsp. *indeterminate*			-	-	×
AMARANTHACEAE	*Gomphrena celosioides*	✓		-	-	×
AMARANTHACEAE	*Gomphrena flaccida*			LC	-	×
HALORAGACEAE	*Gonocarpus leptothecus*			LC	-	
GOODENIACEAE	*Goodenia armstrongiana*			LC	-	×

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
GOODENIACEAE	*Goodenia holtzeana*			LC	-	
GOODENIACEAE	*Goodenia leiosperma*		✓	LC	-	
GOODENIACEAE	*Goodenia* sp. Melville Island (N.B.Byrnes 666)			LC	-	
MALVACEAE	*Gossypium cunninghamii*		✓	NT	-	
MALVACEAE	*Gossypium hirsutum* var. *taitense*	✓		-	-	
PROTEACEAE	*Grevillea decurrens*			LC	-	×
PROTEACEAE	*Grevillea dryandri* subsp. *indeterminate*			-	-	×
PROTEACEAE	*Grevillea goodii*		✓	LC	-	×
PROTEACEAE	*Grevillea heliosperma*			LC	-	×
PROTEACEAE	*Grevillea pteridifolia*			LC	-	×
TILIACEAE	*Grewia breviflora*			LC	-	
TILIACEAE	*Grewia mesomischa*			LC	-	
TILIACEAE	*Grewia oxyphylla*			LC	-	
TILIACEAE	*Grewia retusifolia*			LC	-	×
RUBIACEAE	*Guettarda speciosa*			LC	-	
ASCLEPIADACEAE	*Gymnanthera oblonga*			LC	-	✓
RUBIACEAE	*Gynochthodes* sp. Docherty Hills (G.J.Leach 2186)			LC	-	
HERNANDIACEAE	*Gyrocarpus americanus*			NE	-	×
ORCHIDACEAE	*Habenaria hymenophylla*			DD	-	
ORCHIDACEAE	*Habenaria ochroleuca*			LC	-	
HAEMODORACEAE	*Haemodorum brevicaule*			LC	-	
HAEMODORACEAE	*Haemodorum coccineum*			LC	-	×
HAEMODORACEAE	*Haemodorum parviflorum*			LC	-	
PROTEACEAE	*Hakea arborescens*			LC	-	×
CYMODOCEACEAE	*Halodule uninervis*			DD	-	✓
HYDROCHARITACEAE	*Halophila ovalis*			NE	-	✓

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
HANGUANACEAE	*Hanguana malayana*			LC	-	✓
SAPINDACEAE	*Harpullia leichhardtii*		✓	LC	-	
PROTEACEAE	*Helicia australasica*			LC	-	
STERCULIACEAE	*Helicteres cana*			LC	-	
STERCULIACEAE	*Helicteres dentata* var. *flagellaris*			LC	-	
STERCULIACEAE	*Helicteres dentata* var. *indeterminate*			-	-	
BORAGINACEAE	*Heliotropium foertherianum*			LC	-	×
BORAGINACEAE	*Heliotropium ventricosum*			LC	-	×
POACEAE	*Heterachne gulliveri* var. *gulliveri*			LC	-	
POACEAE	*Heteropogon contortus*			LC	-	×
POACEAE	*Heteropogon triticeus*			LC	-	
DILLENIACEAE	*Hibbertia brownii*		✓	LC	-	×
DILLENIACEAE	*Hibbertia cistifolia*			LC	-	×
DILLENIACEAE	*Hibbertia* sp.			-	-	-
MALVACEAE	*Hibiscus meraukensis*			LC	-	✓
MALVACEAE	*Hibiscus tiliaceus*			LC	-	✓
MYRISTICACEAE	*Horsfieldia australiana*			LC	-	
FABACEAE	*Hovea arnhemica*		✓	LC	-	
VIOLACEAE	*Hybanthus enneaspermus* subsp. *enneaspermus*			LC	-	
ARECACEAE	*Hydriastele ramsayi*		✓	LC	-	
ARECACEAE	*Hydriastele* sp.			-	-	-
ARECACEAE	*Hydriastele wendlandiana*			LC	-	✓
ACANTHACEAE	*Hypoestes floribunda* var. *indeterminate*			-	-	×
ACANTHACEAE	*Hypoestes floribunda* var. *varia*			LC	-	×
LAMIACEAE	*Hyptis suaveolens*	✓			-	✓
APOCYNACEAE	*Ichnocarpus frutescens*			LC	-	×

Family	**Species**	**Introduced**	**Endemic**	**Conservation Status**		**Wetland Dependent**
				TPWC Act	**EPBC Act**	
AQUIFOLIACEAE	*Ilex arnhemensis* subsp. *arnhemensis*			LC	-	
POACEAE	*Imperata cylindrica*			LC	-	✓
FABACEAE	*Indigofera colutea*			LC	-	
FABACEAE	*Indigofera cordifolia*	✓		-	-	
FABACEAE	*Indigofera hirsuta*	✓		LC	-	×
FABACEAE	*Indigofera linifolia*			LC	-	
FABACEAE	*Indigofera linnaei*			LC	-	
FABACEAE	*Indigofera saxicola*			LC	-	
FABACEAE	*Indigofera tinctoria*	✓		-	-	
FABACEAE	*Indigofera trifoliata*			LC	-	
LILIACEAE	*Iphigenia indica*			LC	-	
CONVOLVULACEAE	*Ipomoea abrupta*			LC	-	×
CONVOLVULACEAE	*Ipomoea diversifolia*			LC	-	
CONVOLVULACEAE	*Ipomoea eriocarpa*			LC	-	
CONVOLVULACEAE	*Ipomoea graminea*			LC	-	
CONVOLVULACEAE	*Ipomoea macrantha*			LC	-	✓
CONVOLVULACEAE	*Ipomoea pes-caprae* subsp. *brasiliensis*			LC	-	×
CONVOLVULACEAE	*Ipomoea polymorpha*			LC	-	
CONVOLVULACEAE	*Ipomoea* sp. Cobourg (G.M.Wightman 380)		✓	LC	-	
CONVOLVULACEAE	*Ipomoea velutina*			LC	-	✓
POACEAE	*Isachne confusa*			LC	-	
POACEAE	*Isachne pulchella*	✓		LC	-	✓
POACEAE	*Isachne* sp.			-	-	-
POACEAE	*Ischaemum australe var. arundinaceum*			LC	-	✓
POACEAE	*Ischaemum decumbens*			LC	-	
POACEAE	*Ischaemum fragile*			LC	-	✓
POACEAE	*Ischaemum rugosum* var. *indeterminate*			-	-	✓

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
ISOETACEAE	*Isoetes coromandelina* subsp. *macrotuberculata*			LC	-	✓
RUBIACEAE	*Ixora / Pavetta* sp.			-	-	-
RUBIACEAE	*Ixora* sp.			-	-	-
RUBIACEAE	*Ixora timorensis*			LC	-	
FABACEAE	*Jacksonia dilatata*			LC	-	×
CONVOLVULACEAE	*Jacquemontia paniculata*			LC	-	×
OLEACEAE	*Jasminum aemulum*			LC	-	✓
OLEACEAE	*Jasminum didymum* subsp. *didymum*			LC	-	×
OLEACEAE	*Jasminum didymum* subsp. *indeterminate*			-	-	×
OLEACEAE	*Jasminum molle*			LC	-	
PEDALIACEAE	*Josephinia imperatricis*			NT	-	
RUBIACEAE	*Kailarsenia suffruticosa*		✓	LC	-	
RUBIACEAE	*Knoxia stricta*			LC	-	
LEEACEAE	*Leea indica*			LC	-	
LEEACEAE	*Leea rubra*			LC	-	×
CYPERACEAE	*Lepironia articulata*			LC	-	✓
POACEAE	*Leptochloa fusca* subsp. *fusca*			LC	-	×
POACEAE	*Leptochloa neesii*			LC	-	✓
EUPHORBIACEAE	*Leptopus decaisnei*			-	-	
EUPHORBIACEAE	*Leptopus* sp.			-	-	
MYRTACEAE	*Leptospermum madidum* subsp. *sativum*			LC	-	
POACEAE	*Lepturus repens*			LC	-	×
MIMOSACEAE	*Leucaena leucocephala* subsp. *indeterminate*	✓		-	-	
MIMOSACEAE	*Leucaena leucocephala* subsp. *leucocephala*	✓		-	-	
EPACRIDACEAE	*Leucopogon acuminatus*		✓	LC	-	
SCROPHULARIACEAE	*Limnophila chinensis*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
SCROPHULARIACEAE	*Limnophila fragrans*			LC	-	✓
SCROPHULARIACEAE	*Lindernia aplectra*			LC	-	
SCROPHULARIACEAE	*Lindernia ciliata*			LC	-	
SCROPHULARIACEAE	*Lindernia clausa*			LC	-	
SCROPHULARIACEAE	*Lindernia pubescens*		✓	LC	-	
LINDSAEACEAE	*Lindsaea ensifolia*			-	-	
LINDSAEACEAE	*Lindsaea walkerae*			NT	-	
MYRTACEAE	*Lithomyrtus retusa*			LC	-	
LAURACEAE	*Litsea glutinosa*			LC	-	✓
ARECACEAE	*Livistona humilis*		✓	LC	-	×
XANTHORRHOEACEAE	*Lomandra tropica* subsp. *indeterminate*			-	-	
MYRTACEAE	*Lophostemon lactifluus*			LC	-	
ONAGRACEAE	*Ludwigia adscendens*			LC	-	✓
ONAGRACEAE	*Ludwigia hyssopifolia*			LC	-	✓
ONAGRACEAE	*Ludwigia octovalvis*			LC	-	✓
ONAGRACEAE	*Ludwigia perennis*			LC	-	✓
COMBRETACEAE	*Lumnitzera littorea*			LC	-	✓
COMBRETACEAE	*Lumnitzera racemosa*			LC	-	✓
RUTACEAE	*Luvunga monophylla*			LC	-	
LYCOPODIACEAE	*Lycopodiella cernua*			LC	-	
LYGODIACEAE	*Lygodium flexuosum*			LC	-	✓
LYGODIACEAE	*Lygodium microphyllum*			LC	-	✓
EUPHORBIACEAE	*Macaranga* sp.			-	-	-
EUPHORBIACEAE	*Macaranga tanarius*			LC	-	
FABACEAE	*Macroptilium atropurpureum*	✓		-	-	
FABACEAE	*Macroptilium lathyroides* var. *semierectum*	✓		-	-	✓
EUPHORBIACEAE	*Mallotus nesophilus*			LC	-	×

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
EUPHORBIACEAE	*Mallotus philippensis*			LC	-	
EUPHORBIACEAE	*Mallotus* sp.			-	-	
CHRYSOBALANACEAE	*Maranthes corymbosa*			LC	-	✓
ASCLEPIADACEAE	*Marsdenia geminata*			LC	-	
ASCLEPIADACEAE	*Marsdenia glandulifera*			LC	-	
ASCLEPIADACEAE	*Marsdenia trinervis*			LC	-	
ASCLEPIADACEAE	*Marsdenia velutina*			LC	-	×
ASCLEPIADACEAE	*Marsdenia viridiflora* subsp. *tropica*			LC	-	
MYRTACEAE	*Melaleuca acacioides* subsp. *acacioides*			LC	-	✓
MYRTACEAE	*Melaleuca acacioides* subsp. *indeterminate*			-	-	✓
MYRTACEAE	*Melaleuca dealbata*			LC	-	✓
MYRTACEAE	*Melaleuca leucadendra*			LC	-	✓
MYRTACEAE	*Melaleuca nervosa* subsp. *indeterminate*			-	-	✓
MYRTACEAE	*Melaleuca viridiflora*			LC	-	✓
ASTERACEAE	*Melanthera biflora*			LC	-	✓
MELASTOMATACEAE	*Melastoma malabathricum* subsp. *malabathricum*			LC	-	
RUTACEAE	*Melicope elleryana*			LC	-	
POACEAE	*Melinis repens*	✓		-	-	
STERCULIACEAE	*Melochia corchorifolia*			LC	-	✓
MELASTOMATACEAE	*Memecylon pauciflorum*			LC	-	
CONVOLVULACEAE	*Merremia aegyptia*	✓		-	-	×
CONVOLVULACEAE	*Merremia dissecta*	✓		-	-	×
CONVOLVULACEAE	*Merremia quinata*			LC	-	×
RUTACEAE	*Micromelum minutum*			LC	-	✓
ANNONACEAE	*Miliusa brahei*			LC	-	✓
ANNONACEAE	*Miliusa traceyi*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
FABACEAE	*Millettia pinnata*			LC	-	
SAPOTACEAE	*Mimusops elengi*			LC	-	
ASTERACEAE	*Minuria macrorhiza*			LC	-	
RUBIACEAE	*Mitracarpus hirtus*	✓		-	-	
LOGANIACEAE	*Mitrasacme aggregata*		✓	LC	-	
LOGANIACEAE	*Mitrasacme connata*			LC	-	
LOGANIACEAE	*Mitrasacme elata*			LC	-	
LOGANIACEAE	*Mitrasacme laevis*		✓	LC	-	
LOGANIACEAE	*Mitrasacme multicaulis*			LC	-	
LOGANIACEAE	*Mitrasacme nudicaulis* var. *indeterminate*			-	-	
LOGANIACEAE	*Mitrasacme retroloba*			LC	-	
LOGANIACEAE	*Mitrasacme stellata*			DD	-	
LOGANIACEAE	*Mitrasacme subvolubilis*			LC	-	
POACEAE	*Mnesithea formosa*			LC	-	
POACEAE	*Mnesithea rottboellioides*			LC	-	
PONTEDERIACEAE	*Monochoria vaginalis*			LC	-	✓
RUBIACEAE	*Morinda bracteata* var. *celebica*			NE	-	
RUBIACEAE	*Morinda citrifolia*			LC	-	✓
RUBIACEAE	*Morinda jasminoides*			LC	-	
FABACEAE	*Mucuna gigantea* subsp. *gigantea*			LC	-	
CUCURBITACEAE	*Mukia maderaspatana*			LC	-	
COMMELINACEAE	*Murdannia cryptantha*			NE	-	
COMMELINACEAE	*Murdannia gigantea*			LC	-	
COMMELINACEAE	*Murdannia graminea*			LC	-	
COMMELINACEAE	*Murdannia vaginata*			LC	-	
RUTACEAE	*Murraya paniculata* var. *ovatifoliolata*			LC	-	×
MYOPORACEAE	*Myoporum montanum*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
MYRISTICACEAE	*Myristica insipida* var. *indeterminate*			-	-	✓
MYRSINACEAE	*Myrsine benthamiana*			LC	-	
MYRSINACEAE	*Myrsine pedicellata*			LC	-	
NAJADACEAE	*Najas malesiana*			LC	-	✓
DAVALLIACEAE	*Nephrolepis hirsutula*			LC	-	
ORCHIDACEAE	*Nervilia holochila*			LC	-	×
OLEACEAE	*Notelaea* sp. Elcho Island (C.R.Dunlop 7597)			LC	-	
NYMPHAEACEAE	*Nymphaea violacea*			LC	-	✓
MENYANTHACEAE	*Nymphoides parvifolia*			LC	-	✓
ARECACEAE	*Nypa fruticans*			NT	-	✓
OLACACEAE	*Olax imbricata*			LC	-	
RUBIACEAE	*Oldenlandia corymbosa* var. *corymbosa*	✓		-	-	
RUBIACEAE	*Oldenlandia galioides*			LC	-	✓
EUPHORBIACEAE	*Omalanthus novo-guineensis*			LC	-	
CONVOLVULACEAE	*Operculina brownii*			LC	-	
OPILIACEAE	*Opilia amentacea*			LC	-	×
CACTACEAE	*Opuntia inermis*	✓		-	-	
POACEAE	*Oryza rufipogon*			LC	-	✓
POACEAE	*Oryza* sp.			-	-	-
MELASTOMATACEAE	*Osbeckia australiana*			LC	-	✓
MYRTACEAE	*Osbornia octodonta*			LC	-	✓
MELIACEAE	*Owenia vernicosa*			LC	-	×
MENISPERMACEAE	*Pachygone ovata*			LC	-	
DILLENIACEAE	*Pachynema complanatum*			LC	-	×
DILLENIACEAE	*Pachynema junceum*		✓	LC	-	
ORCHIDACEAE	*Pachystoma pubescens*			DD	-	
PANDANACEAE	*Pandanus spiralis*			LC	-	✓

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
POACEAE	*Panicum decompositum* var. *indeterminate*			-	-	✓
POACEAE	*Panicum mindanaense*			LC	-	
POACEAE	*Panicum* sp.			-	-	-
POACEAE	*Panicum trichoides*			LC	-	
APOCYNACEAE	*Parsonsia velutina*			LC	-	×
POACEAE	*Paspalum longifolium*			LC	-	✓
POACEAE	*Paspalum scrobiculatum*			LC	-	
PASSIFLORACEAE	*Passiflora foetida*	✓		-	-	×
IRIDACEAE	*Patersonia macrantha*		✓	LC	-	×
CAESALPINIACEAE	*Peltophorum pterocarpum*			LC	-	✓
LYTHRACEAE	*Pemphis acidula*			LC	-	✓
POACEAE	*Pennisetum pedicellatum* subsp. *indeterminate*	✓		-	-	
POACEAE	*Pennisetum polystachion* subsp. *setosum*	✓		-	-	
POACEAE	*Perotis rara*			LC	-	×
PROTEACEAE	*Persoonia falcata*			LC	-	×
EUPHORBIACEAE	*Petalostigma pubescens*			LC	-	×
EUPHORBIACEAE	*Petalostigma quadriloculare*			LC	-	
EUPHORBIACEAE	*Petalostigma* sp.			-	-	
POACEAE	*Pheidochloa gracilis*			LC	-	
PHILYDRACEAE	*Philydrum lanuginosum*			LC	-	✓
VERBENACEAE	*Phyla nodiflora* var. *nodiflora*			LC	-	✓
EUPHORBIACEAE	*Phyllanthus amarus*	✓		-	-	
EUPHORBIACEAE	*Phyllanthus armstrongii*			DD	-	
EUPHORBIACEAE	*Phyllanthus exilis*			LC	-	
EUPHORBIACEAE	*Phyllanthus flagellaris*			LC	-	
EUPHORBIACEAE	*Phyllanthus* sp.			-	-	-
EUPHORBIACEAE	*Phyllanthus urinaria*			LC	-	✓

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
EUPHORBIACEAE	*Phyllanthus virgatus*			LC	-	
SOLANACEAE	*Physalis angulata*	✓		LC	-	
NYCTAGINACEAE	*Pisonia aculeata*			LC	-	
NYCTAGINACEAE	*Pisonia grandis*			NT	-	
LECYTHIDACEAE	*Planchonia careya*			LC	-	×
LAMIACEAE	*Plectranthus scutellarioides*			LC	-	
AGAVACEAE	*Pleomele angustifolia*			LC	-	✓
RUBIACEAE	*Pogonolobus reticulatus*			LC	-	
ANNONACEAE	*Polyalthia australis*			LC	-	✓
ANNONACEAE	*Polyalthia nitidissima*			LC	-	
CARYOPHYLLACEAE	*Polycarpaea breviflora*			-	-	×
CARYOPHYLLACEAE	*Polycarpaea corymbosa*			-	-	×
CARYOPHYLLACEAE	*Polycarpaea longiflora*			-	-	×
CARYOPHYLLACEAE	*Polycarpaea violacea*			LC	-	×
POLYGALACEAE	*Polygala eriocephala*			LC	-	
POLYGALACEAE	*Polygala exsquarrosa*			LC	-	
POLYGALACEAE	*Polygala longifolia*			LC	-	
POLYGALACEAE	*Polygala orbicularis* var. *orbicularis*			-	-	
POLYGALACEAE	*Polygala pycnophylla*			LC	-	
POLYGALACEAE	*Polygala* sp. Kakadu (R.Collins 205)			LC	-	
POLYGALACEAE	*Polygala* sp. Mudginberri (J.Russell-Smith 987)			LC	-	
POLYGALACEAE	*Polygala triflora*			LC	-	
CONVOLVULACEAE	*Polymeria ambigua*			LC	-	✓
EUPHORBIACEAE	*Poranthera coerulea*			LC	-	
PORTULACACEAE	*Portulaca australis*			LC	-	
PORTULACACEAE	*Portulaca bicolor*			-	-	
PORTULACACEAE	*Portulaca pilosa* subsp. *indeterminate*	✓		-	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
SAPOTACEAE	*Pouteria arnhemica*			LC	-	
SAPOTACEAE	*Pouteria richardii*			LC	-	
SAPOTACEAE	*Pouteria sericea*			LC	-	✗
VERBENACEAE	*Premna acuminata*			LC	-	
VERBENACEAE	*Premna odorata*			LC	-	
VERBENACEAE	*Premna serratifolia*			LC	-	
LILIACEAE	*Protasparagus racemosus*			LC	-	
POACEAE	*Pseudopogonatherum contortum*			LC	-	
POACEAE	*Pseudopogonatherum irritans*			LC	-	
POACEAE	*Pseudoraphis spinescens*			LC	-	✓
PSILOTACEAE	*Psilotum nudum*			LC	-	
RUBIACEAE	*Psychotria nesophila*			LC	-	
RUBIACEAE	*Psydrax odorata* subsp. *arnhemica*			LC	-	
ASTERACEAE	*Pterocaulon sphacelatum*			LC	-	
AMARANTHACEAE	*Ptilotus conicus*			LC	-	
AMARANTHACEAE	*Ptilotus distans*			-	-	
FABACEAE	*Pycnospora lutescens*			LC	-	
RAMALINACEAE	*Ramalina subfraxinea*			-	-	
RHIZOPHORACEAE	*Rhizophora apiculata*			LC	-	✓
RHIZOPHORACEAE	*Rhizophora lamarckii*			NT	-	✓
RHIZOPHORACEAE	*Rhizophora stylosa*			LC	-	✓
FABACEAE	*Rhynchosia australis*			LC	-	
FABACEAE	*Rhynchosia minima*			LC	-	
CYPERACEAE	*Rhynchospora brownii*			LC	-	
CYPERACEAE	*Rhynchospora heterochaeta*			LC	-	
CYPERACEAE	*Rhynchospora rubra*			LC	-	
POACEAE	*Sacciolepis indica*			LC	-	✓

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
POACEAE	*Sacciolepis myosuroides*			LC	-	✓
HIPPOCRATEACEAE	*Salacia chinensis*			LC	-	
CHENOPODIACEAE	*Salsola tragus* subsp. *indeterminate*	✓		-	-	×
CHENOPODIACEAE	*Salsola tragus* subsp. *pontica*			LC	-	×
SANTALACEAE	*Santalum album*			LC	-	×
POACEAE	*Sarga intrans*			LC	-	
POACEAE	*Sarga plumosum*			LC	-	
POACEAE	*Sarga* sp.			-	-	-
POACEAE	*Sarga timorense*			LC	-	
EUPHORBIACEAE	*Sauropus ditassoides*		✓	LC	-	
EUPHORBIACEAE	*Sauropus* sp. Port Essington (I.D.Cowie 3418)			NE	-	
EUPHORBIACEAE	*Sauropus stenocladus* subsp. *stenocladus*			LC	-	
GOODENIACEAE	*Scaevola taccada*			LC	-	×
POACEAE	*Schizachyrium fragile*			LC	-	×
POACEAE	*Schizachyrium pachyarthron*			LC	-	
POACEAE	*Schizachyrium* sp.			-	-	
SCHIZAEACEAE	*Schizaea dichotoma*			LC	-	✓
CYPERACEAE	*Schoenoplectus litoralis*			LC	-	
CYPERACEAE	*Schoenus calostachyus*			LC	-	
CYPERACEAE	*Schoenus falcatus*			LC	-	
CYPERACEAE	*Schoenus sparteus*			LC	-	
CYPERACEAE	*Scleria brownii*			LC	-	
CYPERACEAE	*Scleria ciliaris*			LC	-	
CYPERACEAE	*Scleria lingulata*			LC	-	
CYPERACEAE	*Scleria lithosperma* var. *lithosperma*			LC	-	
CYPERACEAE	*Scleria novae-hollandiae*			LC	-	✓
CYPERACEAE	*Scleria polycarpa*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
CYPERACEAE	*Scleria pygmaea*			LC	-	
CYPERACEAE	*Scleria* sp.			-	-	-
SCROPHULARIACEAE	*Scoparia dulcis*	✓		-	-	
RUBIACEAE	*Scyphiphora hydrophylacea*			LC	-	✓
ASCLEPIADACEAE	*Secamone elliptica*			LC	-	
POACEAE	*Sehima nervosum*			LC	-	×
SELAGINELLACEAE	*Selaginella pygmaea*			LC	-	
ANACARDIACEAE	*Semecarpus australiensis*			LC	-	
CAESALPINIACEAE	*Senna obtusifolia*	✓		-	-	✓
CAESALPINIACEAE	*Senna occidentalis*	✓		-	-	
CAESALPINIACEAE	*Senna surattensis* subsp. *indeterminate*			-	-	
FABACEAE	*Sesbania cannabina* var. *indeterminate*			-	-	×
AIZOACEAE	*Sesuvium portulacastrum*			LC	-	✓
POACEAE	*Setaria apiculata*			LC	-	×
MALVACEAE	*Sida acuta*	✓		-	-	
MALVACEAE	*Sida calyxhymenia*			NT	-	
MALVACEAE	*Sida cordifolia*	✓		-	-	
MALVACEAE	*Sida pusilla*			LC	-	×
MALVACEAE	*Sida rhombifolia*	✓		-	-	
SMILACACEAE	*Smilax australis*			LC	-	×
FABACEAE	*Smithia conferta*			LC	-	
SOLANACEAE	*Solanum tetrandrum*			LC	-	×
SONNERATIACEAE	*Sonneratia alba*			LC	-	✓
FABACEAE	*Sophora tomentosa* subsp. *australis*			NE	-	
LILIACEAE	*Sowerbaea alliacea*			LC	-	
RUBIACEAE	*Spermacoce brevicilia*		✓	LC	-	
RUBIACEAE	*Spermacoce calliantha*		✓	LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
RUBIACEAE	*Spermacoce leptoloba*			LC	-	
RUBIACEAE	*Spermacoce protrusa*		✓	LC	-	
RUBIACEAE	*Spermacoce* sp.			-	-	-
RUBIACEAE	*Spermacoce stenophylla*			LC	-	
ASTERACEAE	*Sphaeromorphaea australis*			LC	-	✓
POACEAE	*Spinifex longifolius*			LC	-	×
POACEAE	*Sporobolus virginicus*			LC	-	✓
VERBENACEAE	*Stachytarpheta cayennensis*	✓		-	-	
VERBENACEAE	*Stachytarpheta jamaicensis*	✓		-	-	
STACKHOUSIACEAE	*Stackhousia intermedia*			LC	-	
SCROPHULARIACEAE	*Stemodia lythrifolia*			LC	-	×
PROTEACEAE	*Stenocarpus acacioides*			LC	-	
PROTEACEAE	*Stenocarpus verticis*			LC	-	
BLECHNACEAE	*Stenochlaena palustris*			LC	-	✓
MENISPERMACEAE	*Stephania japonica* var. *indeterminate*			-	-	×
MENISPERMACEAE	*Stephania japonica* var. *timoriensis*			LC	-	×
STERCULIACEAE	*Sterculia quadrifida*			LC	-	✓
CONVOLVULACEAE	*Stictocardia tiliifolia*			LC	-	
SCROPHULARIACEAE	*Striga curviflora*			LC	-	
LOGANIACEAE	*Strychnos lucida*			LC	-	×
STYLIDIACEAE	*Stylidium candelabrum*		✓	LC	-	
STYLIDIACEAE	*Stylidium cordifolium*			LC	-	
STYLIDIACEAE	*Stylidium leptorrhizum*			LC	-	
STYLIDIACEAE	*Stylidium schizanthum*			LC	-	
STYLIDIACEAE	*Stylidium semipartitum*			LC	-	
FABACEAE	*Stylosanthes hamata*	✓		-	-	
FABACEAE	*Stylosanthes humilis*	✓		-	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
EUPHORBIACEAE	*Suregada glomerulata*			LC	-	
SURIANACEAE	*Suriana maritima*			LC	-	×
ARACEAE	*Syngonium* sp.	✓		-	-	-
MYRTACEAE	*Syzygium angophoroides*			LC	-	
MYRTACEAE	*Syzygium armstrongii*			LC	-	
MYRTACEAE	*Syzygium eucalyptoides* subsp. *bleeseri*			LC	-	×
MYRTACEAE	*Syzygium hemilamprum* subsp. *hemilamprum*			NT	-	
MYRTACEAE	*Syzygium minutuliflorum*		✓	LC	-	
MYRTACEAE	*Syzygium nervosum*			LC	-	✓
MYRTACEAE	*Syzygium suborbiculare*			LC	-	
APOCYNACEAE	*Tabernaemontana orientalis*			LC	-	
TACCACEAE	*Tacca leontopetaloides*			LC	-	×
CAESALPINIACEAE	*Tamarindus indica*	✓		-	-	
RUBIACEAE	*Tarenna dallachiana* subsp. *expandens*			LC	-	
RUBIACEAE	*Tarenna pentamera*			-	-	
CHENOPODIACEAE	*Tecticornia australasica*			LC	-	✓
FABACEAE	*Tephrosia arnhemica*		✓	LC	-	
FABACEAE	*Tephrosia brachyodon* var. *longifolia*			LC	-	
FABACEAE	*Tephrosia oblongata*			LC	-	
FABACEAE	*Tephrosia porrecta*		✓	LC	-	
FABACEAE	*Tephrosia remotiflora*			LC	-	
COMBRETACEAE	*Terminalia canescens*			LC	-	×
COMBRETACEAE	*Terminalia carpentariae*			LC	-	×
COMBRETACEAE	*Terminalia ferdinandiana*			LC	-	
COMBRETACEAE	*Terminalia grandiflora*			LC	-	
COMBRETACEAE	*Terminalia microcarpa*			LC	-	
COMBRETACEAE	*Terminalia* sp. Black Point (G.M.Wightman			NT	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
	120)					
HYDROCHARITACEAE	*Thalassia hemprichii*			NE	-	✓
POACEAE	*Thaumastochloa brassii*			LC	-	
POACEAE	*Thaumastochloa major*			LC	-	
THYMELAEACEAE	*Thecanthes punicea*			LC	-	
POACEAE	*Themeda arguens*			LC	-	
POACEAE	*Themeda triandra*			LC	-	×
MALVACEAE	*Thespesia populneoides*			LC	-	✓
MALVACEAE	*Thespesia thespesioides*			LC	-	×
ASTERACEAE	*Thespidium basiflorum*			LC	-	✓
LILIACEAE	*Thysanotus banksii*			LC	-	×
RUBIACEAE	*Timonius timon*			LC	-	✓
MENISPERMACEAE	*Tinospora smilacina*			LC	-	×
APIACEAE	*Trachymene didiscoides*			LC	-	
APIACEAE	*Trachymene rotundifolia*			LC	-	
ULMACEAE	*Trema tomentosa* var. *indeterminate*			-	-	×
ZYGOPHYLLACEAE	*Tribulus cistoides*	✓		LC	-	×
CUCURBITACEAE	*Trichosanthes holtzei*			LC	-	
CYPERACEAE	*Tricostularia undulata*			LC	-	
ASTERACEAE	*Tridax procumbens*	✓		-	-	
TILIACEAE	*Triumfetta pentandra*	✓		-	-	
TILIACEAE	*Triumfetta rhomboidea*	✓		-	-	
MORACEAE	*Trophis scandens* subsp. *scandens*			LC	-	
MELIACEAE	*Turraea pubescens*			NT	-	
ASCLEPIADACEAE	*Tylophora benthamii*			LC	-	
ASCLEPIADACEAE	*Tylophora cinerascens*			LC	-	
ASCLEPIADACEAE	*Tylophora flexuosa*			LC	-	

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
TYPHACEAE	*Typha domingensis*			LC	-	✓
ARACEAE	*Typhonium flagelliforme*			LC	-	
APOCYNACEAE	undetd sp.			-	-	-
FABACEAE	*Uraria lagopodioides*			LC	-	×
POACEAE	*Urochloa distachya*			LC	-	
POACEAE	*Urochloa holosericea* subsp. *holosericea*			LC	-	
POACEAE	*Urochloa holosericea* subsp. *indeterminate*			-	-	
POACEAE	*Urochloa mosambicensis*	✓		-	-	×
POACEAE	*Urochloa polyphylla*			LC	-	
POACEAE	*Urochloa pubigera*			LC	-	
POACEAE	*Urochloa subquadripara*			LC	-	
LENTIBULARIACEAE	*Utricularia aurea*			LC	-	✓
LENTIBULARIACEAE	*Utricularia caerulea*			LC	-	×
LENTIBULARIACEAE	*Utricularia chrysantha*			LC	-	✓
LENTIBULARIACEAE	*Utricularia leptoplectra*			LC	-	×
LENTIBULARIACEAE	*Utricularia limosa*			LC	-	×
LENTIBULARIACEAE	*Utricularia odorata*			LC	-	×
ANNONACEAE	*Uvaria holtzei*			LC	-	
MELIACEAE	*Vavaea australiana*		✓	LC	-	✓
ASTERACEAE	*Vernonia patula*			DD	-	
MYRTACEAE	*Verticordia cunninghamii*			LC	-	×
FABACEAE	*Vigna lanceolata* var. *filiformis*			LC	-	
FABACEAE	*Vigna lanceolata* var. *indeterminate*			-	-	
FABACEAE	*Vigna lanceolata* var. *lanceolata*			LC	-	
FABACEAE	*Vigna radiata* var. *sublobata*			LC	-	
FABACEAE	*Vigna vexillata* var. *angustifolia*			LC	-	×
FABACEAE	*Vigna vexillata* var. *indeterminate*			-	-	×

Family	Species	Introduced	Endemic	Conservation Status		Wetland Dependent
				TPWC Act	EPBC Act	
FABACEAE	*Vigna vexillata* var. *vexillata*			LC	-	×
VERBENACEAE	*Vitex acuminata*			LC	-	
VERBENACEAE	*Vitex glabrata*			LC	-	×
VERBENACEAE	*Vitex rotundifolia*			LC	-	×
VERBENACEAE	*Vitex* sp.			-	-	-
VERBENACEAE	*Vitex trifolia* var. *subtrisecta*			LC	-	×
STERCULIACEAE	*Waltheria indica*			LC	-	
ASTERACEAE	*Wedelia urticifolia*			LC	-	
POACEAE	*Whiteochloa airoides*			LC	-	
POACEAE	*Whiteochloa capillipes*			LC	-	
APOCYNACEAE	*Wrightia pubescens* subsp. *pubescens*			LC	-	×
APOCYNACEAE	*Wrightia saligna*			LC	-	
MYRTACEAE	*Xanthostemon eucalyptoides*			LC	-	
MYRTACEAE	*Xanthostemon paradoxus*			LC	-	×
MYRTACEAE	*Xanthostemon psidioides*			LC	-	
CONVOLVULACEAE	*Xenostegia tridentata*			LC	-	
POACEAE	*Xerochloa imberbis*			LC	-	✓
POACEAE	*Xerochloa* sp.			-	-	-
OLACACEAE	*Ximenia americana*			NT	-	
MELIACEAE	*Xylocarpus granatum*			NT	-	✓
MELIACEAE	*Xylocarpus moluccensis*			LC	-	✓
XYRIDACEAE	*Xyris cheumatophila*			LC	-	
XYRIDACEAE	*Xyris complanata*			LC	-	
POACEAE	*Yakirra pauciflora*			LC	-	×
RUTACEAE	*Zanthoxylum parviflorum*			LC	-	
FABACEAE	*Zornia muelleriana* subsp. *congesta*			NE	-	
FABACEAE	*Zornia oligantha*		✓	DD	-	

Family	**Species**	**Introduced**	**Endemic**	**Conservation Status**		**Wetland Dependent**
				TPWC Act	**EPBC Act**	
FABACEAE	*Zornia prostrata* var. *indeterminate*			-	-	

Appendix D

Likelihood of Occurrence of Wetland Dependent Conservation Signficant Flora Not Previously Recorded in the Ramsar Site

Species	Common Name	Conservation Status			Description, Habitat and Distribution	Likelihood of Occurrence
		TPWC Act	EPBC Act	IUCN		
Arenga australasica	Australian Arenga Palm	DD	VU		This species is a large and robust clumping palm, with fronds up to five meters long (Woinarski et al., 2007). It is normally associated with monsoon forests in coastal dunes or sandstone gorges (Woinarski et al., 2007). Although occurring in scattered populations in coastal and near coastal areas of Arnhem Land, no records exist for the Cobourg Peninsula, with the nearest locality being Murgenella at the base of the Peninsula (Woinarski et al., 2007). The Queensland Herbarium in Brisbane also has a specimen collected from the Mary River (DEWHA 2010). This is a very prominent and distinctive species which has eluded detection, despite significant amounts of botanical surveys on the Cobourg peninsula.	**Unlikely**. There is limited potential habitat.
Cryptocarya hypospodia	Northern Laurel	EN	-	-	This is a relatively nondescript rainforest tree to 30 m. It has been recorded on Croker Island but not on Cobourg Peninsula (Woinarski et al., 2007). It is widespread in Queensland, particularly the wet tropics region. Substantial searches have been undertaken on the Cobourg Peninsula (Woinarski et al., 2007), and there are few areas that would provide suitable habitat. It may occur in the wet monsoon forests associated with freshwater springs (wetland type Y).	**Possible**.
Utricularia dunstaniae	Bladderwort	VU	-		This species is a small annual leafless herb with an unusual flesh-coloured flower containing two thin erect lobes to 4 cm long (Woinarski et al., 2007). It generally grows in wet sand or shallow water in *Melaleuca nervosa* woodland or *Verticordia* spp. shrubland (Woinarski et al., 2007). It has been recorded from Cobourg Peninsula (Woinarski et al., 2007).	**Possible**.

Appendix E

Likelihood of Occurrence of Wetland Dependent Conservation Significant Fauna (Based on Habitat Preferences) Not Previously Recorded in Inland or Estuarine Systems in the Ramsar Site

Species	Common Name	Conservation Status			Habitat	Likelihood of Occurrence
		TPWC Act	EPBC Act	IUCN		
Fish						
Glyphis garricki	Northern River Shark	EN	EN	EN	Thought to be restricted to shallow, brackish reaches of large rivers from the Adelaide and East and South Alligator Rivers (NRETA, 2006e).	**Unlikely**. No records exist and site does not contain large rivers.
Glyphis glyphis	Speartooth Shark	VU	CR	CR	Thought to occur in turbid waters in the Alligator and Adelaide River systems (Fowler, 1997 in NRETA, 2006f).	**Possible**. No records exist though potentially suitable habitat exists.
Pristis clavata	Dwarf Sawfish	VU	VU	CR	Estuarine or fresher waters during the wet season and marine areas after the wet season (Peverall, 2005) in the Keep River, Victoria River, Buffalo Creek, Rapid Creek and the South Alligator River catchments (NRETA, 2006a).	**Possible**. No records exist though potentially suitable habitat exists.
Pristis microdon	Freshwater Sawfish	VU	VU	CR	Reported to be a marine or estuarine species that spends its first three to four years in freshwater. Recorded in the Keep, Victoria, Darwin, Adelaide, East Alligator, South Alligator, Daly, Goomadeer, Wearyan, McArthur and Robinson Rivers (NRETA, 2006b).	**Possible**. No records exist though potentially suitable habitat exists.
Pristis zijsron	Green Sawfish	VU	VU	CR	Reported to inhabit marine inshore waters, estuaries, lagoons and freshwater (NRETA, 2006c). Recorded in Buffalo Creek though anecdotal records exist for Garig Gunak Barlu National Park (NRETA, 2006c).	**Possible**. Anecdotal records exist for the Cobourg Peninsula and suitable habitat exists.
Carcharias taurus	Grey Nurse Shark	DD	VU	-	Rocky inshore reefs and waters around 200 m deep (NRETA, 2006d). Recorded in Lynedoch Bank in the Arafura Sea.	**Possible**. No records exist though potentially suitable habitat exists.

Appendix F

Flora Recorded During the Mid Dry Season Survey

Key to Abundance Status: U (Uncommon), A (Abundant), C (Common), R (Rare)

Family	Genus	Species	Conservation Status		NT Flora Atlas	Endemic	Marine/Coastal Wetland Sites												Inland Wetland Sites								
			TPWC Act	EPBC Act			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	I1	I2	I3	I4	I5	I6	I7	I8	M20
ACROPORIDAE	*Acropora*	sp.	-	-	N/A											U											
APOCYNACEAE	*Gymnanthera*	*oblonga*	LC	-	✓														C				C				C
ARECACEAE	*Carpentaria*	*acuminata*	LC	-	✓	✓																		C	C		R
ARECACEAE	*Hydriastele*	*ramsayi*	LC	-	✓	✓																			C		
ARECACEAE	*Hydriastele*	*wendlandiana*	LC	-	✓																			C	A		
ASCLEPIADACEAE	*Tylophora*	*erecta*	LC	-	×														R								
BLECHNACEAE	*Blechnum*	*orientale*	LC	-	✓																			U			
BLECHNACEAE	*Stenochlaena*	*palustris*	LC	-	✓																			C	C		
BURMANNIACEAE	*Burmannia*	*coelestis*	LC	-	✓														R	C							
CAMPANULACEAE	*Lobelia*	*dioica*	LC	-	×																					R	
CAMPANULACEAE	*Lobelia*	*douglasiana*	-	-	×																U					R	
CASUARINACEAE	*Casuarina*	*equisetifolia*	-	-	✓										A												
CAULERPACEAE	*Caulerpa*	sp.	-	-	-				C																		
CERATOPTERIDACEAE	*Acrostichum*	*speciosum*	LC	-	×							C															R
CHARACEAE	*Chara*	sp.	-	-	-															C							
CODIACEAE	*Halimeda*	sp.	-	-	-				C																		
COMBRETACEAE	*Lumnitzera*	*littorea*	LC	-	✓								A							C							C
COMBRETACEAE	*Lumnitzera*	sp.	-	-	-						C	A															
CONVOLVULACEAE	*Ipomoea*	*pes-caprae*	LC	-	×										C				C								
CYPERACEAE	*Cyperus*	*javanicus*	LC	-	×																		R				
CYPERACEAE	*Cyperus*	sp (small)	-	-	-																		R				
CYPERACEAE	*Cyperus*	*aquatilis*	LC	-	✓																					A	
CYPERACEAE	*Eleocharis*	*dulcis*	LC	-	✓														A	A		R					A
CYPERACEAE	*Eleocharis*	*geniculata*	LC	-	✓														C			R	C				
CYPERACEAE	*Eleocharis*	*spiralis*	LC	-	✓															A							C
CYPERACEAE	*Fimbristylis*	*ferruginea*	LC	-	✓								C										U				C
CYPERACEAE	*Fimbristylis*	*pauciflora*	LC	-	✓																C						
CYPERACEAE	*Rhynchospora*	*corymbosa*	LC	-	×																				A		

Family	Genus	Species	Conservation Status		NT Flora Atlas	Endemic	Marine/Coastal Wetland Sites												Inland Wetland Sites								
			TPWC Act	EPBC Act			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	I1	I2	I3	I4	I5	I6	I7	I8	M20
CYPERACEAE	*Schoenoplectus*	*litoralis*	LC	-	✓							A								C							
CYPERACEAE	*Scleria*	*lingulata*	LC	-	✓																			A	C		C
DICTYOTACEAE	*Padina*	sp.	-	-	-				A								C										
DROSERACEAE	*Drosera*	*burmanni*	LC	-	✓																U			R	R		
EBENACEAE	*Diospyros*	*maritima*	LC	-	✓																			C			
ELAEOCARPACEAE	*Elaeocarpus*	*arnhemicus*	LC	-	✓																C				U		
ERIOCAULACEAE	*Eriocaulon*	*cinereum*	LC	-	✓																					C	
ERIOCAULACEAE	*Eriocaulon*	*setaceum*	LC	-	✓																A				R		
ERIOCAULACEAE	*Eriocaulon*	*spectabile*	LC	-	✓																					R	
ERIOCAULACEAE	*Eriocaulon*	*willdenovium*	LC	-	×																			U	C		
EUPHORBIACEAE	*Excoecaria*	*agallocha*	LC	-	✓															C							
FABACEAE	*Jacksonia*	*dilatata*	LC	-	✓																R						
FLAGELLARIACEAE	*Flagellaria*	*indica*	LC	-	✓														U		U			C			
GLEICHENIACEAE	*Dicranopteris*	*linearis var. linearis*	LC	-	✓																			C	A		
GOODENIACEAE	*Goodenia*	*pumilio*	LC	-	×								U														
HYDROCHARITACEAE	*Blyxa*	*aubertii*	LC	-	✓														U								
LAURACEAE	*Cassytha*	*filiformis*	LC	-	✓														C								
LECYTHIDACEAE	*Barringtonia*	*acutangula*	LC	-	×																				R		
LECYTHIDACEAE	*Planchonia*	*careya*	LC	-	✓																						R
LENTIBULARIACEAE	*Utricularia*	*caerulea*	LC	-	✓																				R		
LENTIBULARIACEAE	*Utricularia*	*chrysantha*	LC	-	✓								C														
LENTIBULARIACEAE	*Utricularia*	*leptoplectra*	LC	-	✓																				R		
LILIACEAE	*Dianella*	*odorata*	LC	-	✓																C						
LINDERNIACEAE	*Lindernia*	sp.	-	-	-																R						
LOGANIACEAE	*Fagraea*	*racemosa*	LC	-	✓																				U		
LOGANIACEAE	*Stylidium*	*multiscapum*	LC	-	×																C				R		
LYCOPODIACEAE	*Lycopodiella*	*cernua*	LC	-	✓																				C		
LYGODIACEAE	*Lygodium*	*flexuosum*	LC	-	✓																			U			

Family	Genus	Species	Conservation Status		NT Flora Atlas	Endemic	Marine/Coastal Wetland Sites												Inland Wetland Sites								
			TPWC Act	EPBC Act			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	I1	I2	I3	I4	I5	I6	I7	I8	M20
LYTHRACEAE	*Ammannia*	*multiflora*	LC	-	×																	C	C				
LYTHRACEAE	*Sonneratia*	*alba*	LC	-	×			C																			
LYTHRACEAE	*Sonneratia*	**ulma*	-	-	×						C																
MALVACEAE	*Thespesia*	*populneoides*	LC	-	✓						C	C															
MELASTOMATACEAE	*Melastoma*	*malabathricum*	LC	-	✓																			A	A		U
MELASTOMATACEAE	*Osbeckia*	*australiana*	LC	-	✓																U						
MELIACEAE	*Xylocarpus*	*granatum*	NT	-	✓						U																
MENYANTHACEAE	*Nymphoides*	*exiliflora*	DD	-	×																U						
MIMOSACEAE	*Acacia*	*auriculiformis*	LC	-	✓														C								U
MYRTACEAE	*Corymbia*	*porrecta*	LC	-	✓	✓															C						
MYRTACEAE	*Corymbia*	*ptychocarpa*	LC	-	✓																			C	C		
MYRTACEAE	*Leptospermum*	*madidum*	LC	-	✓																A						
MYRTACEAE	*Lophostemon*	*lactifluus*	LC	-	✓																C			C			
MYRTACEAE	*Melaleuca*	*acacioides* subsp. *acaciodes*	LC	-	✓							C	A														
MYRTACEAE	*Melaleuca*	*leucadendra*	LC	-	✓														A	A	C	A	A				A
MYRTACEAE	*Melaleuca*	*nervosa*	-	-	✓																			A			
MYRTACEAE	*Melaleuca*	sp	-	-	-							C															A
MYRTACEAE	*Melaleuca*	*viridiflora*	LC	-	✓								U												C	A	
MYRTACEAE	*Osbornia*	*octodonta*	LC	-	✓						U																
MYRTACEAE	*Syzygium*	*angophoroies*	LC	-	✓																			U	C		
MYRTACEAE	*Syzygium*	*forte*	LC	-	×																			U	C		
MYRTACEAE	*Xanthostemon*	*paradoxus*	LC	-	✓																				U		
NAJADACEAE	*Najas*	sp	-	-	-														U								
NYMPHAEACEAE	*Nymphaea*	*violacea*	LC	-	✓														U		A	R		C	U		
ORCHIDACEAE	*Dendrobium*	*affine*	LC	-	✓														R								R
OROBANCHACEAE	*Buchnera*	*gracilis*	LC	-	×																R						
PANDANACEAE	*Pandanus*	*spiralis*	LC	-	✓														C		C		U	U	U		U
PARKERIACEAE	*Ceratopteris*	*thalictroides*	LC	-	✓														U			R					

Family	Genus	Species	Conservation Status		NT Flora Atlas	Endemic	Marine/Coastal Wetland Sites												Inland Wetland Sites								
			TPWC Act	EPBC Act			M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	I1	I2	I3	I4	I5	I6	I7	I8	M20
PASSIFLORACEAE	*Passiflora*	*foetida*	INT	-	✓														C								
PHILYDRACEAE	*Philydrum*	*lanuginosum*	LC	-	✓																C						U
PLUMBAGINACEAE	*Aegialitis*	*annulata*	LC	-	✓						C																
POACEAE	*Isachne*	*confusa*	LC	-	✓																			C	C		
POACEAE	*Pseudoraphis*	*spinescens*	LC	-	✓																					A	
PROTEACEAE	*Banksia*	*dentata*	LC	-	✓																			R			
PROTEACEAE	*Grevillea*	*pteridifolia*	LC	-	✓																C						
PROTEACEAE	*Helicia*	*australasica*	LC	-	✓																			R	C		
RESTIONACEAE	*Dapsilanthes*	*elatior*	LC	-	✓								U														
RHAMNACEAE	*Alphitonia*	*excelsa*	LC	-	✓																				C		
RHIZOPHORACEAE	*Bruguiera*	*exaristata*	LC	-	✓						A	C															
RHIZOPHORACEAE	*Carallia*	*brachiata*	LC	-	✓																C				C		R
RHIZOPHORACEAE	*Ceriops*	sp	-	-	-			U																			
RHIZOPHORACEAE	*Ceriops*	*tagal*	LC	-	✓						A																
RHIZOPHORACEAE	*Rhizophora*	*stylosa*	LC	-	✓			A			A		U														
RUBIACEAE	*Cyclophyllum*	*schultzii*	LC	-	✓																			U	C		R
RUBIACEAE	*Dentella*	*dioeca*	LC	-	×																					A	
RUTACEAE	*Melicope*	*elleryana*	LC	-	✓																			C			
SANTALACEAE	*Exocarpos*	*latifolius*	LC	-	✓																U						
SCROPHULARIACEAE	*Limnophila*	*chinensis*	LC	-	✓																A				U		
SELAGINELLACEAE	*Selaginella*	*pygmaea*	LC	-	✓																C			U			
SMILACACEAE	*Smilax*	*australis*	LC	-	✓																			C			
STYLIDIACEAE	*Stylidium*	*schizanthum*	LC	-	✓																				R		
TYPHACEAE	*Typha*	*domingensis*	LC	-	✓																		R				
VERBENACEAE	*Avicennia*	*marina*	LC	-	×			U			C	C	U														R
	Gmelina	*schlechteri*	LC	-	✓																				U		
VITACEAE	*Cayratia*	*maritima*	LC	-	✓																		R				
XYRIDACEAE	*Xyris*	*complanata*	LC	-	✓																				C	U	

Family	**Genus**	**Species**	**Conservation Status**		**NT Flora Atlas**	**Endemic**	**Marine/Coastal Wetland Sites**												**Inland Wetland Sites**								
			TPWC Act	**EPBC Act**			**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**M20**
	Xyris	*indica*	LC	-	×																C						
	Xyris	*oligantha*	LC	-	×								U														
TOTAL		**114**					**0**	**4**	**3**	**0**	**10**	**8**	**10**	**0**	**2**	**1**	**1**	**0**	**17**	**8**	**26**	**8**	**10**	**22**	**29**	**6**	**19**

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Appendix G

Abundance of Fauna (Excluding Macroinvertebrates) Recorded During Mid Dry and Late Dry Season Surveys of Marine/Coastal Wetland Sites

		Conservation Status			Mid Dry Season															Late Dry Season																		
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN Red List**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M20**	**Total**	**Wurgulu Bay**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**Total**
Reptiles																																						
Caretta caretta	Loggerhead Turtle	EN	EN, Mar	EN														0											1									1
Carlia munda	Striped Rainbow Skink	LC	-	-													1	1																				0
Chelonia mydas	Green Turtle	LC	VU, Mar	EN										1	1			2																				0
Crocodylus porosus	Saltwater Crocodile	LC	Mig, Mar		3	2		2			1			1	1	1		11											1									1
Diporiphora bilineata	Two-lined Dragon	LC	-	-							1							1																				0
Eretmochelys imbricata	Hawksbill Turtle	DD	VU, Mar	CR										1	1			2																				0
Natator depressus	Flatback Turtle	DD	VU, Mar	DD										1	1			2																				0
Abundance					**3**	**2**	**0**	**2**	**0**	**0**	**2**	**0**	**0**	**4**	**4**	**1**	**1**	**19**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
No. Species					**1**	**1**	**0**	**1**	**0**	**0**	**2**	**0**	**0**	**4**	**4**	**1**	**1**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
Birds																																						
Actitis hypoleucos	Common Sandpiper	LC	Mig, Mar	LC														0														10						10
Anhinga melanogaster	Darter	LC	-	NT	1			2	2	1							1	7															1					1
Anseranas semipalmata	Magpie Goose	LC	Mar	LC														0															2				500	502
Aprosmictus erythropterus	Red-winged Parrot	LC	-	LC													3	3																				0
Ardea alba	Great Egret	LC	Mar	LC				5									20	25															2				2	4
Arenaria interpres	Ruddy Turnstone	LC	Mig, Mar	LC														0																	1	1		2
Artamus leucorynchus	White-breasted Woodswallow	LC	-	LC				1		2					8	3		14																	2	1		3
Butorides striatus	Striated Heron	LC	-	LC		1												1																				0
Cacomantis variolosus	Brush Cuckoo	LC	-	LC														0																	1		1	2
Calidris tenuirostris	Great Knot	LC	Mig, Mar	VU														0				7				4												11
Calyptorhynchus banksii	Red-tailed Black Cockatoo	LC	-	LC	1				2	1							1	5																			20	20
Centropus phasianinus	Pheasant Coucal	LC	-	LC	1				1		1							3																				0
Charadrius leschenaultii	Greater Sand Plover	LC	Mig, Mar	LC							1							1				15																15
Charadrius mongolus	Lesser Sand Plover	LC	Mig, Mar	LC														0																20		4		24

		Conservation Status			Mid Dry Season															Late Dry Season																		
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN Red List**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M20**	**Total**	**Wurgulu Bay**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**Total**
Charadrius ruficapillus	Red-capped Plover	LC	Mar	LC							1							1																				0
Chlamydera nuchalis	Great Bowerbird	LC	-	LC														0				1																1
Colluricincla harmonica	Grey Shrike-thrush	LC	-	LC													1	1	1																			0
Coracina papuensis	White-bellied Cuckoo-shrike	LC	Mar	LC				1										1	1																			0
Corvus orru	Torresian Crow	LC	-	LC							1		1				2	4															1				1	2
Dendrocygna arcuata	Wandering Whistling Duck	LC	Mar	LC													32	32															1					1
Dicrurus bracteatus	Spangled Drongo	LC	Mar	LC														0															1					1
Ducula bicolor	Pied Imperial Pigeon	LC	Mar	LC														0															1					1
Egretta garzetta	Little Egret	LC	Mar	LC		30		20										50																				0
Egretta intermedia	Intermediate Egret	LC	Mar	LC	15		4	30			1						30	80															8					8
Egretta novaehollandiae	White-faced Heron	LC	-	LC														0																		1		1
Egretta sacra	Eastern Reef Egret	LC	Mig, Mar	LC				30							10	2		42				1				1			1	3	3							9
Ephippiorhynchus asiaticus	Black-necked Stork	LC	-	NT				2			1	1						4								1								1	1		1	4
Esacus neglectus	Beach Stone-curlew	LC	Mar	NT			1					1						2																	2			2
Eudynamys scolopacea	Common Koel	LC	Mar	LC														0																	1			1
Falco berigora	Brown Falcon	LC	-	LC												1		1																				0
Fregata ariel	Lesser Frigatebird	LC	Mig, Mar	LC										1	1	1		3												1	1							2
Geopelia humeralis	Bar-shouldered Dove	LC	-	LC	2	4				3	5						1	15	1															1				1
Geopelia striata	Peaceful Dove	LC	-	LC														0																		1		1
Gerygone levigaster	Mangrove Gerygone	LC	-	LC		1				1								2																				0
Grallina cyanoleuca	Magpie Lark	LC	Mar	LC													1	1																				0
Grus rubicunda	Brolga	LC	-	LC						2							1	3																				0

		Conservation Status			Mid Dry Season															Late Dry Season																		
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN Red List**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M20**	**Total**	**Wurgulu Bay**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**Total**
Haematopus fuliginosus	Sooty Oystercatcher	LC	-	LC			1								2			3																				0
Haematopus longirostris	Pied Oystercatcher	LC	-	LC			1											1												2	2			1				5
Haliaeetus leucogaster	White-bellied Sea-eagle	LC	Mig, Mar	LC	1	1		2			2		1			1		8					1			1											1	3
Haliastur indus	Brahminy Kite	LC	Mar	LC	2			3	1			1				2	1	10														1		1				2
Haliastur sphenurus	Whistling Kite	LC	Mar	LC	2		1	2	1	2	1	2					2	13														1	1					2
Hydroprogne caspia	Caspian Tern	LC	Mar	LC							1							1																				0
Irediparra gallinacea	Comb-crested Jacana	LC	-	LC													5	5															3					3
Ixobrychus flavicollis	Black Bittern	DD	-	LC														0															1					1
Lalage leucomela	Varied Triller	LC	-	LC														0	1			1													1			2
Larus novaehollandiae	Silver Gull	LC	Mar	LC	5						1				100			106												2	2							4
Lichenostomus unicolor	White-gaped Honeyeater	LC	-	LC														0								1											2	3
Melithreptus albogularis	White-throated Honeyeater	LC	-	LC							1							1	1																		1	1
Merops ornatus	Rainbow Bee-eater	LC	Mig	LC							1						5	6	7										1			1		1				3
Microeca flavigaster	Lemon-bellied Flycatcher	LC	-	LC													5	5																			1	1
Myiagra alecto	Shining Flycatcher	LC	-	LC							1							1	1																			0
Myiagra inquieta	Restless Flycatcher	LC	-	LC														0																			1	1
Myzomela erythrocephala	Red-headed Honeyeater	LC	-	LC					3									3	1																			0
Numenius madagascariensis	Eastern Curlew	LC	Mig, Mar	VU														0																2	3			5
Numenius phaeopus	Whimbrel	LC	Mig, Mar	LC		1												1																				0
Nycticorax caledonicus	Nankeen Night-heron	LC	Mar	LC				1										1																				0
Onychoprion anaethetus	Bridled Tern	LC	Mar	LC											500			500																				0

		Conservation Status			Mid Dry Season															Late Dry Season																		
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN Red List**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M20**	**Total**	**Wurgulu Bay**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**Total**
Oriolus flavocinctus	Yellow Oriole	LC	-	LC					2	1								3																				0
Pachycephala rufiventris	Rufous Whistler	LC	-	LC														0	1																1			1
Pandion haliaetus	Osprey	LC	Mig, Mar	LC			1	2				2	1	1	3	2		12				1							1	2	2							6
Pelecanus conspicillatus	Australian Pelican	LC	Mar	LC	1										7			8																				0
Phalacrocorax varius	Pied Cormorant	LC	-	LC													1	1																				0
Philemon argenticeps	Silver-crowned Friarbird	LC	-	LC					1								1	2																3	1			4
Plegadis falcinellus	Glossy Ibis	LC	Mig, Mar	LC													1	1																				0
Pluvialis fulva	Pacific Golden Plover	LC	Mig, Mar	LC														0				2														1		3
Pluvialis squatarola	Grey Plover	LC	Mig, Mar	LC											1			1																				0
Psitteuteles versicolor	Varied Lorikeet	LC	-	LC							10						1	11																				0
Ptilinopus regina	Rose-crowned Fruit-dove	LC	-	LC					2									2																				0
Sterna albifrons	Little Tern	LC	Mig, Mar	LC														0								4												4
Sterna bergii	Crested Tern	LC	Mar	LC				30							1000	2		1032												10	10							20
Sterna nilotica	Gull-billed Tern	LC	Mar	LC							5							5								19												19
Sula leucogaster	Brown Booby	LC	Mig, Mar	LC											50			50												5	5							10
Threskiornis molucca	Australian White Ibis	LC	Mar	LC	3			15		1			7				2	28														3						3
Todiramphus macleayii	Forest Kingfisher	LC	Mar	LC													5	5														2	1				1	4
Todiramphus sanctus	Sacred Kingfisher	LC	Mar	LC							1				2			3																				0
Trichoglossus rubritorquis	Red-collared Lorikeet	LC	-	LC					5								1	6	1																			0
Vanellus miles	Masked Lapwing	LC	-	LC														0																			3	3
Xenus cinereus	Terek Sandpiper	LC	Mig, Mar	LC														0								1												1
Abundance					**34**	**38**	**9**	**14 6**	**20**	**14**	**35**	**7**	**10**	**2**	**1684**	**14**	**123**	**2136**	**16**	**0**	**0**	**28**	**1**	**0**	**0**	**32**	**0**	**0**	**3**	**25**	**25**	**18**	**23**	**30**	**14**	**9**	**535**	**743**
No. Species					**11**	**6**	**6**	**15**	**10**	**9**	**17**	**5**	**4**	**2**	**12**	**8**	**23**	**56**	**10**	**0**	**0**	**7**	**1**	**0**	**0**	**8**	**0**	**0**	**3**	**7**	**7**	**6**	**12**	**8**	**10**	**6**	**13**	**51**
Mammals																																						
Bos javanicus	Banteng	Feral	-	EN							1							1	1																	1		1

		Conservation Status			Mid Dry Season															Late Dry Season																		
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN Red List**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M20**	**Total**	**Wurgulu Bay**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**Total**
Cervus timorensis	Rusa Deer	Feral		VU													1	1																				0
Macropus agilis	Agile Wallaby	LC		LC													5	5																				0
Sousa chinensis	Indo-pacific Humpback Dolphin	LC		NT									2					2																				0
Sus scrofa	Feral Pig	Feral	-	LC							1						1	2	1																			0
Abundance					**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**2**	**0**	**0**	**0**	**7**	**11**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
No. Species					**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**0**	**0**	**3**	**5**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**
Invertebrates																																						
Acanthopleura gemmata	Chitons	NE	-	-			1					1						2																				0
Clypeaster sp.	Sand Dollar	-	-	-									1					1																				0
Holothuria sp	-	-	-	-			1						1		1			3																				0
Mictyris longicarpus	Light-blue Soldier Crab	NE	-	-									1					1																				0
Panulirus ornatus	Tropical Rock Lobster	NE	-	-										3				3																				0
Portunus pelagicus	Blue-swimmer Crab	NE	-	-				2										2																				0
Scylla serrata	Mud Crab	NE	-	-				1					1					2																1	1			2
Telescopium telescopium	-	NE	-	-					1									1																				0
Terebralia palustris	-	NE	-	-					1									1																				0
Stomatopoda sp.	Mantis shrimp	-	-	-			1											1																				0
Abundance					**0**	**0**	**3**	**3**	**2**	**0**	**0**	**1**	**4**	**3**	**1**	**0**	**0**	**17**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**2**
No. Species					**0**	**0**	**3**	**2**	**2**	**0**	**0**	**1**	**4**	**1**	**1**	**0**	**0**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**
Fish																																						
Acanthopagrus palmaris	North-west Black Bream	LC	-	-	4													4																				0
Aetobatus narinari^*	White-spotted Eagle Ray	LC	-	NT		3												3																				0
Apogon sp.	Cardinalfish (unidentified)	-	-	-									4					4																				0
Arius	Sand	LC	-	-	3													3		1	1													1				3

		Conservation Status			Mid Dry Season															Late Dry Season																		
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN Red List**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M20**	**Total**	**Wurgulu Bay**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**Total**
argyroleuron	Catfish																																					
*Arius thalassinus**	Giant Sea Catfish	LC	-	-	2	1		5										8																				0
Arramphus sclerolepis	Snub-nosed Garfish	LC	-	-								2						2																				0
Caranx papuensis	Brassy Trevally	NE	-	-		1												1																				0
Caranx sp.	Trevally (unidentified)	-	-	-										3	1			4																				0
*Carcharhinus melanopterus**	Blacktip Reef Shark	LC	-	NT	5				1						1			7		1			1									1						3
Carcharhinus sorrah	Spot-tail Shark	LC	-	NT	1	2		3	5									11																				0
*Dasyatis kuhlii^*	Blue-spotted Maskray	LC	-	DD											2			2																				0
Drepane punctata	Sicklefish	LC	-	-					2									2																				0
Dussumieria elopsoides	Slender Sardine	LC	-	-								3						3																				0
*Echenius naucrates**	Sharksucker	LC	-	-											1			1																				0
Eleutheronema tetradactylum	Blue Threadfin Salmon	LC	-	-					1									1																				0
*Elops hawaiensis**	Giant Herring	LC	-	-	4													4																				0
*Epinephelus lanceolatus^*	Giant Groper	DD	-	VU	2													2																				0
Glossogobius biocellatus	Estuary Goby	NE	-	LR / NT				1										1																				0
Lates calcarifer	Barramundi	LC	-	-	5													5			1		1									1		1				4
Liza vaigiensis	Diamond-scale Mullet	LC	-	-	3	2												5		1			1															2
Lotella rhacina	Rock Cod	NE	-	-														0																1				1
Lutjanus argentomaculatus^*	Mangrove Jack	LC	-	-				1					1					2																				0
Mugil cephalus	Sea Mullet	LC	-	LC				9										9																				0
*Negaprion acutidens**	Lemon Shark	LC	-	VU		1												1																				0
Periophthalmus argentilineatus	Silver-lined Mudskipper	LC	-	-							7							7																				0
Periophthalmus sp.	Mudskipper (unidentified)	-	-	-	11													11																				0
Pranesus endrachtensis	Endracht Hardyhead	LC	-	-								4						4																				0

		Conservation Status			Mid Dry Season															Late Dry Season																		
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN Red List**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M20**	**Total**	**Wurgulu Bay**	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M12**	**M13**	**M14**	**M15**	**M16**	**M17**	**M18**	**M19**	**M20**	**Total**
Scatophagus argus	Spotted Scat	LC	-	LC											1			1																				0
*Scomberoides commersonnianus**	Talang Queenfish	LC	-	-	12	1		10	6			1						30																				0
Toxotes chatareus	Seven-spot Archerfish	LC	-	-												1		1		1														1				2
Tylosurus gavialoides	Stout Longtom	LC	-	-		3		7				5						15																				0
Valamugil buchanani	Bluetail Mullet	LC	-	-	20										5			25																				0
-	Garfish (unidentified)	-	-	-					1									1		1			1											1				3
-	Shovelnose Ray (unidentified)	-	-	-											1			1																				0
-	Mullet (unidentified)	-	-	-		8									8			16														1		1				2
-	Shark (unidentified)	-	-	-								1			1			2																				0
-	Bream (unidentified)	-	-	-														0					1									1						2
Abundance					**72**	**22**	**0**	**36**	**16**	**0**	**7**	**16**	**5**	**3**	**21**	**1**	**0**	**199**	**0**	**5**	**2**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**6**	**0**	**0**	**0**	**22**
No. Species					**12**	**9**	**0**	**7**	**6**	**0**	**1**	**6**	**2**	**1**	**9**	**1**	**0**	**35**	**0**	**5**	**2**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**0**	**6**	**0**	**0**	**0**	**9**
TOTAL ABUNDANCE					**109**	**62**	**12**	**187**	**38**	**14**	**46**	**24**	**21**	**12**	**1710**	**16**	**131**	**2382**	**18**	**5**	**2**	**28**	**6**	**0**	**0**	**32**	**0**	**0**	**5**	**25**	**25**	**22**	**23**	**37**	**15**	**10**	**535**	**770**
GRAND TOTAL NO. SPECIES					**24**	**16**	**9**	**25**	**18**	**9**	**22**	**12**	**11**	**8**	**26**	**10**	**27**	**112**	**12**	**5**	**2**	**7**	**6**	**0**	**0**	**8**	**0**	**0**	**5**	**7**	**7**	**10**	**12**	**15**	**11**	**7**	**13**	**64**

^ recorded previously in at Black Point area and adjacent water of Garig Gunak Barlu National Park in Gomelyuk (2003).

* recorded previously in Port Essington in sandy bank, rock reef or coral reef by Gomelyuk (2008).

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Appendix H

Abundance of Fauna (Excluding Macroinvertebrates) Recorded During Mid Dry and Late Dry Season Surveys of Inland Wetland Sites

		Conservation Status			Mid Dry Season									Late Dry Season								
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**
Frogs																						
Litoria bicolor	Northern Dwarf Tree-frog	DD	-	LC	1					1			2									0
Litoria microbelos	Javelin Frog	LC	-	LC			1						1									0
Litoria rothii	Roth's Tree-frog	LC	-	LC	1								1									0
Litoria tornieri	Tornier's Frog	LC	-	LC								1	1									0
Litoria wotjulumensis	Wotjulum Frog	LC	-	-						1			1									0
Litoria sp.	-	-	-	-			1						1									0
Rhinella marina	Cane Toad	INT	INT	LC	1		1						2									0
Abundance					**3**	**0**	**3**	**0**	**0**	**2**	**0**	**1**	**9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
No. Species					**3**	**0**	**3**	**0**	**0**	**2**	**0**	**1**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Reptiles																						
Carlia mundia	Striped Rainbow Skink	LC	-	-	1		1					1	3									0
Chelodina rugosa	Northern Long-necked Turtle	LC	-	-								1	1									0
Crocodylus porosus	Saltwater Crocodile	LC	Mig, Mar	LR/LC		1							1									0
Cryptoblepharus cygnatus	Swanson's Snake-eyed Skink	-	-	-	1			1	1			1	4									0
Dendrelaphis punctulatus	Common Tree Snake	DD	-	LC								1	1								1	1
Diporiphora bilineata	Two-lined Dragon	LC	-	-			1	1	1				3									0
Hemidactylus frenatus	Asian House Gecko	INT	-	LC	1								1	1								1
Lophognathus temporalis	Northern Water Dragon	LC	-	-	1								1									0
Varanus sp.	goanna (unidentified)	-	-	-							1		1								1	1
Abundance					**4**	**1**	**2**	**2**	**2**	**0**	**1**	**4**	**16**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**
No. Species					**4**	**1**	**2**	**2**	**2**	**0**	**1**	**4**	**9**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**
Birds													**0**									**0**
Accipiter cirrhocephalus	Collared Sparrowhawk	LC	Mig	LC			1						1									0
Alcedo azurea	Azure Kingfisher	LC	-	LC							1		1									0
Anas superciliosa	Pacific Black Duck	LC	Mig	LC		3							3									0
Aprosmictus erythropterus	Red-winged Parrot	LC	-	LC							1		1									0
Ardea alba	Great Egret	LC	Mar	LC									0		1							1

		Conservation Status			Mid Dry Season									Late Dry Season								
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**
Ardea picata	Pied Heron	LC	-	LC									0		10							10
Aviceda subcristata	Pacific Baza	LC	-	LC						1			1									0
Cacatua galerita	Sulphur-crested Cockatoo	LC	-	LC	1		1			1	1	1	5								1	1
Cacomantis variolosus	Brush Cuckoo	LC	-	LC						1			1									0
Calyptorhynchus banksii	Red-tailed Black Cockatoo	LC	-	LC	1		1				1		3	2							2	4
Centropus phasianinus	Pheasant Coucal	LC	-	LC	1	1		1	1	1			5	1	2							3
Chlamydera nuchalis	Great Bowerbird	LC	-	LC									0							1		1
Colluricincla harmonica	Grey Shrike-thrush	LC	-	LC				1	1				2									0
Conopophila albogularis	Rufous-banded Honeyeater	LC	-	LC					1				1	1								1
Conopophila rufogularis	Rufous-throated Honeyeater	LC	-	LC					1				1									0
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC	Mar	LC									0		1							1
Coracina papuensis	White-bellied Cuckoo-shrike	LC	Mar	LC	1				1				2		1							1
Corvus orru	Torresian Crow	LC	-	LC	1		1			1			3	4							1	5
Daphoenositta chrysoptera	Varied Sittella	LC	-	LC			1	1					2									0
Dicaeum hirundinaceum	Mistletoebird	LC	-	LC					1				1	1						2		3
Dendrocygna arcuata	Wandering Whistling Duck	LC	Mar	LC	1	1							2									0
Dicrurus bracteatus	Spangled Drongo	LC	Mar	LC							1		1						1	1		2
Ducula bicolor	Pied Imperial Pigeon	LC	Mar	LC	1								1									0
Egretta intermedia	Intermediate Egret	LC	Mar	LC	4	15							19	1	10							11
Entomyzon cyanotis	Blue-faced Honeyeater	LC	-	LC								1	1									0
Falco berigora	Brown Falcon	LC	-	LC		1							1									0
Fregata ariel	Lesser Frigatebird	LC	Mig, Mar	LC		2							2									0
Geopelia humeralis	Bar-shouldered Dove	LC	-	LC	1	1	1	1	1		1		6	3						1		4
Geopelia striata	Peaceful Dove	LC	-	LC	1	1		1	1	1	1	1	7	1	4						1	6
Geophaps smithii	Partridge Pigeon	VU	VU	NT			1						1									0
Gerygone magnirostris	Large-billed Gerygone	LC	-	LC									0	1								1
Grallina cyanoleuca	Magpie Lark	LC	Mar	LC								1	1	1								1
Grus rubicunda	Brolga	LC	-	LC		1							1	2								2

		Conservation Status			Mid Dry Season									Late Dry Season								
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**
Haliaeetus leucogaster	White-bellied Sea-eagle	LC	Mig, Mar	LC									0	1	1							2
Haliastur indus	Brahminy Kite	LC	Mar	LC			1						1									0
Haliastur sphenurus	Whistling Kite	LC	Mar	LC	1	2		1	1	1		1	7						1			1
Himantopus himantopus	Black-winged Stilt	LC	Mig, Mar	LC									0		4							4
Hirundo ariel	Fairy Martin	LC	-	LC									0								1	1
Irediparra gallinacea	Comb-crested Jacana	LC	-	LC		1							1									0
Ixobrychus flavicollis	Black Bittern	DD	-	LC									0									0
Lalage leucomela	Varied Triller	LC	-	LC				1	1				2	3								3
Lichenostomus unicolor	White-gaped Honeyeater	LC	-	LC			1						1	3						2	1	6
Malurus melanocephalus	Red-backed Fairy-wren	LC	-	LC						1			1									0
Megapodius reinwardt	Orange-footed Scrubfowl	LC	-	LC	1								1									0
Melithreptus albogularis	White-throated Honeyeater	LC	-	LC					1	1			2	1						2	2	5
Merops ornatus	Rainbow Bee-eater	LC	Mig	LC	3	2						2	7									0
Microeca flavigaster	Lemon-bellied Flycatcher	LC	-	LC	1			1	1				3						1	1		2
Myiagra inquieta	Restless Flycatcher	LC	-	LC	1								1	1								1
Myiagra rubecula	Leaden Flycatcher	LC	-	LC	1		1		1		1		4							1		1
Myzomela obscura	Dusky Honeyeater	LC	-	LC	1						1		2									0
Ninox connivens	Barking Owl	LC	-	LC		1				1			2									0
Ninox novaeseelandiae	Southern Boobook	LC	Mar	LC	1								1									0
Oriolus flavocinctus	Yellow Oriole	LC	-	LC						1			1	2					1			3
Oriolus sagittatus	Olive-backed Oriole	LC	-	LC								1	1									0
Pachycephala rufiventris	Rufous Whistler	LC	-	LC				1				1	2						2	1	3	6
Petrochelidon nigricans	Tree Martin	LC	-	LC				1				1	2									0
Phalacrocorax sulcirostris	Little Black Cormorant	LC	-	LC	1								1		1							1
Phalacrocorax varius	Pied Cormorant	LC	-	LC	10								10									0
Philemon argenticeps	Silver-crowned Friarbird	LC	-	LC							1	1	2							1		1
Philemon citreogularis	Little Friarbird	LC	-	LC							1	1	2									0
Platalea regia	Royal Spoonbill	LC	-	LC									0	4								4

		Conservation Status			Mid Dry Season									Late Dry Season								
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**
Plegadis falcinellus	Glossy Ibis	LC	Mig, Mar	LC									0		2							2
Psitteuteles versicolor	Varied Lorikeet	LC	-	LC		1			1	1		1	4									0
Ptilinopus regina	Rose-crowned Fruit-dove	LC	-	LC	1								1									0
Ramsayornis fasciatus	Bar-breasted Honeyeater	LC	-	LC	1								1									0
Rhipidura leucophrys	Willie Wagtail	LC	-	LC	1								1									0
Rhipidura rufiventris	Northern Fantail	LC	-	LC				1					1	1								1
Sphecotheres viridis	Figbird	LC	-	LC							1		1									0
Sterna nilotica	Gull-billed Tern	LC	Mar	LC									0		2							2
Tadorna radjah	Radjah Shelduck	LC	Mig, Mar	LC	1	3							4	2								2
Threskiornis spinicollis	Straw-necked Ibis	LC	Mar	LC									0	1	8							9
Todiramphus macleayii	Forest Kingfisher	LC	Mar	LC				1	1			1	3	2						1		3
Todiramphus sanctus	Sacred Kingfisher	LC	Mar	LC	1						1		2									0
Trichoglossus rubritorquis	Red-collared Lorikeet	LC	-	LC	1	1	1		1	1	1		6									0
Vanellus miles	Masked Lapwing	LC	-	LC	2	1							3	2								2
Abundance					**42**	**38**	**11**	**12**	**16**	**13**	**14**	**14**	**160**	**41**	**47**	**0**	**0**	**0**	**6**	**14**	**12**	**120**
No. Species					**27**	**17**	**11**	**12**	**16**	**13**	**14**	**13**	**62**	**23**	**13**	**0**	**0**	**0**	**5**	**11**	**8**	**40**
Mammals													**0**									**0**
Bos javanicus	Banteng	INT	-	EN	1	1		1		1	1	1	6									0
Bubalus bubalis	Water Buffalo	INT	-	-			1				1	1	3							1		1
Canis lupus	Dingo	LC	-	LC									0	1								1
Equus caballus	Horse (Timor Pony)	INT	-	-					1				1									0
Macropus agilis	Agile Wallaby	LC	-	LC	1	1							2									0
Sus scrofa	Feral Pig	INT	-	LC	1	1	1	1	1	1	1	1	8	1	1					1	1	4
Abundance					**3**	**3**	**2**	**2**	**2**	**2**	**3**	**3**	**20**	**2**	**1**	**0**	**0**	**0**	**0**	**2**	**1**	**6**
No. Species					**3**	**3**	**2**	**2**	**2**	**2**	**3**	**3**	**5**	**2**	**1**	**0**	**0**	**0**	**0**	**2**	**1**	**3**
Fish																						
Hypseleotris compressa	Carp Gudgeon	LC	-	-			1						1									0
Melanotaenia nigrans	Black-banded Rainbowfish	LC	-	-							1		1									0

		Conservation Status			Mid Dry Season									Late Dry Season								
Species Name	**Common Name**	**TPWC Act**	**EPBC Act**	**IUCN**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**	**I1**	**I2**	**I3**	**I4**	**I5**	**I6**	**I7**	**I8**	**Total**
Ophisternon gutturale	Australian Swamp Eel	LC	-	-						1			1									0
Oxyeleotris nullipore	Poreless Gudgeon	LC	-	-						1	1		2									0
Pseudomugil gertrudae	Spotted Blue-eye	LC	-	-							1		1									0
Abundance					**0**	**0**	**1**	**0**	**0**	**2**	**3**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
No. Species					**0**	**0**	**1**	**0**	**0**	**2**	**3**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
TOTAL ABUNDANCE					**52**	**42**	**19**	**16**	**20**	**19**	**21**	**22**	**211**	**44**	**48**	**0**	**0**	**0**	**6**	**16**	**15**	**129**
GRAND TOTAL NO. SPECIES					**37**	**21**	**19**	**16**	**20**	**19**	**21**	**21**	**88**	**26**	**14**	**0**	**0**	**0**	**5**	**13**	**11**	**46**

Appendix I

Abundance of Benthic Macroinvertebrates Recorded During Mid Dry Season Surveys of Marine/Coastal Wetland Sites

Taxa*	**Family**	**Site**												**Total**
		M1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	
POLYCHAETA (Class)	Amphinomidae	8	1		33	5					96	2		145
	Cirratulidae	10			1	3					8	4		26
	Dorvilliidae	2												2
	Eunicidae							2	4					6
	Glyceridae		9		3	4			2		8	1		27
	Lumbrineridae		10		7	8			1		6			32
	Nephtyidae		8		5	7					6			26
	Nereididae			11		6		3	12	1	2	5	3	43
	Onuphidae				1									1
	Phylodocidae	2				2				1				5
	Pisionidae											1		1
	Polynoidae								1					1
	Sigalionidae	2	1		1						2			6
	Syllidae	8		1	1	1			1	3	2	5	4	26
	Sacrocirridae											1		1
	Ampharetidae								1		4			5
	Chaecopteridae										2			2

Taxa*	Family	Site												Total
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	
	Megalonidae		12			42					2	1		57
	Oweniidae				5	1						1		7
	Sabellidae	14	1			1					2			18
	Spionidae	4	10			12			4	7	2			39
	Sternaspidae					13								13
	Trichobranchidae				7	1					12			20
	Capitellidae	2	3		1	2		1			6			15
	Maldanidae				21				4		38			63
	Opheliidae								7	31				38
	Orbiniidae	2							7	14				23
	Paraonidae		1		1									2
NEMATODA (Phylum)	Nematode								1			1		2
ARACHNIDA (Class)	Tetragnathidae						1							1
AMPHIPODA (Order)	Caprellidae								1					1
	Gammaridea	6	1	13					14	4		6	3	47
CUMACEA (order)	Cumacea sp. a		1							1				2
ISOPODA (Order)	Anthuridae								1					1

Taxa*	**Family**	**Site**												**Total**
		M1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	
	Spheridae									1			2	3
TANAIDACEA (Order)	Apseudidae									1				1
	Leptochaeliidae								4	3				7
STOMATOPODA (Order)	Squillidae				1									1
DECAPODA (Order)	Ocypodidae		2			1						1		4
	Palaemonidae								2					2
	Caridea	2												2
	Brachyura												1	1
	Diogenidae	2	3			1				2		1		9
	Grapsidae						1					1		2
	Luciferidae									1				1
	Mictyridae									1				1
	undifferentiated									1				1
PEDUNCULATA (Order)	undifferentiated												13	13
SESSILIA (Order)	Balanidae												4	4
OSTRACODA (Class)	Ostracoda sp. a								1					1
ODONATA (Order)	Libellulidae						1							1

Taxa*	**Family**	**Site**												**Total**
		M1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	
BRYAZOA (Phylum)	undifferentiated								1					1
CNIDARIA (Phylum)	undifferentiated												2	2
	Cnidaria sp.												2	2
ECHINODERM (Phylum)	Clypeasteridae									1				1
	Holothuroidea sp.a		3	1										4
	Ophurida spp.	2	2		1				1					6
BIVALVIA (Class)	Lanternulidae		3			2								5
	Cardiidae								1					1
	Lucinidae		1		1						4			6
	Mactridae				1									1
	Veneridae											1		1
	Tellinoidea spp.		8		9	12			4	1	28			62
	Psammobiidae										2			2
	Bivalve sp.a	2	1											3
	Mytillidae												170	170
	Ostreidae												17	17
	Pteriidae												8	8

Taxa*	**Family**	**Site**												**Total**
		M1	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	
GASTROPODA (Class)	Muricidae												4	4
	Nacticidae					8					2			10
	Batillariidae					3		20						23
	Nissaridae												1	1
	Haminoeidae					2								2
	Pleurobranchidae												2	2
	Siphonariidae												5	5
	Naritidae												15	15
	Trochidae			1										1
POLYPLACOPHORA (Class)	Chitonidae			1										1
NEMERTIA (Phylum)	Hoplonemertea spp.					1			1	4		1	1	8
PLATYHELMINTHES (Phylum)	Polycladida sp.								1					1
PORIFERA (Phylum)	undifferentiated			1										1
SIPINCULA (Phylum)	Sipuncula sp.a				1									1
TOTAL		**68**	**81**	**29**	**101**	**138**	**3**	**26**	**77**	**78**	**234**	**33**	**257**	**1125**

* Taxonomic level in this column represents that term which is more commonly used to identify the group of species

Appendix J

Abundance of Benthic Macroinvertebrates Recorded During Mid Dry Season Surveys of Inland Wetland Sites

PHYLUM / CLASS ORDER	FAMILY	SPECIES	Occ	I1 Dup1	I1 Dup2	I2 Dup1	I2 Dup2	I3 Dup1	I3 Dup2	I4 Dup1	I4 Dup2	I6 Dup1	I6 Dup2	I7 Dup1	I7 Dup2	M20 Dup1	M20 Dup2
PLATYHELMINTHES	**Turbellaria**	*Turbellaria* spp.	I	0	0	0	0	0	0	0	9	0	0	0	0	0	0
	Temnocephalidae	*Temnocephala* spp.	I	0	0	0	0	0	0	0	0	0	0	0	150	0	0
NEMATODA		*Nematoda* spp.	I	0	1700	0	0	20	14	0	9	11	50	2833	2300	0	0
MOLLUSCA																	
GASTROPODA	**Bithyniidae**	*Gabbia* sp.	I	0	0	333	733	0	0	0	0	0	0	0	0	0	0
	Lymnaeidae	*Austropeplea lessoni*	A	100	600	0	0	0	0	0	3	0	0	0	0	0	0
	Planorbidae	*Amerianna cumingi*	A	300	800	0	0	0	0	0	0	0	0	0	0	0	0
		Gyraulus sp.	A	200	1500	0	0	0	0	0	0	0	0	0	0	0	0
	Thiaridae	*Thiara australis*	I	1	1	0	0	0	0	0	0	0	0	0	0	0	0
ANNELIDA																	
OLIGOCHAETA		*Oligochaeta* spp.	I	100	2400	0	0	60	0	30	18	29	900	33	650	50	0
ARTHROPODA																	
CRUSTACEA																	
AMPHIPODA		*Amphipoda* spp.**	I	0	0	167	367	0	0	0	0	0	0	0	0	0	0
CLADOCERA		*Cladocera* spp.	I	NP	600	NP	NP	NP	NP	NP	NP	16	350	1867	2650	200	NP
COPEPODA		*Cyclopoida* spp.	I	NP	4100	NP	NP	NP	NP	NP	NP	11	750	1000	3600	0	NP
OSTRACODA		*Ostracoda* spp.	I	NP	8300	NP	NP	NP	NP	NP	NP	12	0	33	0	50	NP
DECAPODA	**Palaemonidae**	*Macrobrachium bullatum*	N	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Macrobrachium sp. (imm./damaged)	I	0	0	0	0	0	0	0	0	0	0	1	1	0	0
	Parastacidae	*Cherax* spp.**	I	0	0	0	0	0	0	0	0	1	1	1	5	0	0
ARACHNIDA																	
ACARIFORMES																	
ACARINA		*Acarina* spp.	I	0	0	0	0	20	186	40	55	80	400	0	300	400	500
ORIBATIDA		*Oribatida* spp.	I	15400	34300	67	33	400	414	0	0	5	600	233	2550	4200	13900
COLLEMBOLA		*Sminthuridae* spp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	200
INSECTA																	
EPHEMEROPTERA	**Baetidae**	*Cloeon* sp.	I	100	0	0	0	0	0	0	0	0	0	33	1	0	100
		Baetidae spp. (imm./damaged)	I*	800	700	0	0	0	29	40	45	3	0	200	500	1500	1800
	Caenidae	*Tasmanocoenis* arcuata	A	0	0	0	0	0	0	0	0	6	0	33	0	0	0
		Tasmanocoenis sp H	N	0	0	0	0	0	0	0	0	6	0	0	0	0	0

PHYLUM / CLASS ORDER	FAMILY	SPECIES	Occ	I1 Dup1	I1 Dup2	I2 Dup1	I2 Dup2	I3 Dup1	I3 Dup2	I4 Dup1	I4 Dup2	I6 Dup1	I6 Dup2	I7 Dup1	I7 Dup2	M20 Dup1	M20 Dup2
		Tasmanocoenis spp. (imm./damaged)	I*	0	0	0	0	180	29	0	0	6	50	0	50	0	0
ODONATA																	
Zygoptera		Zygoptera spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	12	0	67	100	0	500
	Coenagrionidae	*Aciagrion* fragilis	C	0	0	0	0	0	0	0	0	0	0	0	1	50	2
		Agriocnemis sp. (imm./damaged)	C	0	2	0	0	0	0	1	1	4	0	0	0	50	200
		Austroagrion watsoni	C	3	5	0	1	0	0	0	0	0	0	0	0	100	8
		Ceriagrion aeruginosum	C	0	0	0	0	1	0	0	0	8	0	3	2	50	100
		Ischnura ? heterosticta**	C	0	2	0	0	0	0	0	0	0	0	0	0	1	1
		Ischnura sp. (imm./damaged)	C	100	0	0	100	0	0	5	9	0	0	0	0	3	3
		Pseudagrion aureofrons	A	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		Coenagrionidae spp. (imm./damaged)	I	0	200	0	0	40	14	0	9	0	0	0	0	200	0
	Isostictidae	*Eurysticta* coomalie**	N	0	0	0	0	0	0	0	0	0	0	1	1	0	0
	Lestidae	*Indolestes* sp.	I	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Anisoptera		Anisoptera spp. (imm./damaged)	I	200	100	0	0	40	0	0	0	15	250	0	0	50	100
	Corduliidae	*Pentathemis membranulata*	N	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		?*Hemicordulia* spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Libellulidae	*Libellulidae* spp. (imm./damaged)	I	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Camacinia othello	C	0	0	0	0	0	0	2	0	0	0	0	0	0	0
		Diplacodes nebulosa/Nannodiplax rubra	I	0	0	0	0	0	0	0	0	1	1	0	2	0	0
		Orthetrum migratum/villosovittatum	I	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		Orthetrum spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		Rhyothemis phyllis	C	0	0	0	0	0	0	0	9	0	0	0	0	0	0
		Tramea sp.	C	5	2	0	2	0	0	0	0	0	0	1	0	1	6
		Zyxomma petiolatum	C	0	0	0	0	0	0	0	0	0	0	0	2	0	0
HEMIPTERA	**Belostomatidae**	*Diplonychus rusticus*	C	0	1	0	0	0	0	1	0	0	0	0	0	1	0
		Diplonychus sp. (imm./damaged)	I	4	0	0	0	0	0	2	2	0	0	0	0	1	1
	Corixidae	*Micronecta* sp.	I*	0	0	33	0	0	0	0	0	0	0	0	0	0	500
	Gerridae	*Gerrinae* sp.	I*	0	0	0	0	0	0	0	0	5	0	1	150	0	0
		Limnogonus hungerfordi	C	0	1	0	0	0	0	0	0	1	1	0	0	0	0
		Limnogonus luctuosus	C	0	0	0	0	0	0	0	0	2	3	0	0	0	0

PHYLUM / CLASS ORDER	FAMILY	SPECIES	Occ	I1 Dup1	I1 Dup2	I2 Dup1	I2 Dup2	I3 Dup1	I3 Dup2	I4 Dup1	I4 Dup2	I6 Dup1	I6 Dup2	I7 Dup1	I7 Dup2	M20 Dup1	M20 Dup2
		Limnogonus spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Hebridae	*Merragata hackeri*	A	200	300	0	0	0	0	0	0	0	0	0	0	0	0
		Hebridae spp. (imm./damaged)	I	100	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydrometridae	*Hydrametra* spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	Mesoveliidae	*Mesovelia ebbenielseni*	N	0	0	0	0	0	0	0	0	4	0	0	0	0	0
		Mesovelia horvathi	C	0	0	0	0	0	0	0	0	4	0	1	0	0	0
		Mesovelia vittigera	C	0	0	0	0	0	0	0	0	14	0	0	0	0	0
		Mesovelia sp. (imm./damaged)	I	0	0	0	0	0	0	0	9	41	1	0	0	50	0
		Mesoveliidae spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	0	0	0	0	0	200
	Naucoridae	*Naucoris subopacus*	N	0	8	0	0	0	0	0	9	0	0	0	0	0	0
		Naucoris sp. (imm./damaged)	I	5	100	0	0	0	0	0	0	0	0	0	0	3	0
	Nepidae	*Cercotmetus brevipes australis*	N	0	0	0	0	0	0	0	0	0	0	0	4	0	0
		Laccotrephes tristis	C	0	0	0	0	1	0	0	0	0	0	0	2	0	0
		*Goondnomdanepa weiri***	N	0	0	0	0	0	14	0	0	0	0	0	0	0	0
		*Goondnomdanepa brittoni***	LE	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		Ranatra diminuta	A	0	1	0	0	0	0	0	0	1	50	0	0	0	0
		Ranatra dispar	C	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Notonectidae	*Anisops ? deanei***	A	0	0	0	0	0	0	0	9	0	1	0	0	0	0
		Anisops elstoni	C	0	1	0	0	0	0	30	0	0	0	0	0	0	0
		Anisops nasutus	C	0	0	1	0	0	0	30	9	0	0	0	0	0	0
		Anisops nodulatus	C	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		Anisops paracrinitus	C	0	0	0	0	0	0	0	9	0	0	0	0	0	0
		*Anisops ? philippinensis***	C	0	0	0	0	0	0	0	0	0	1	0	1	0	0
		Anisops sp. CBG01 (nr. A. elstoni)**	I	0	0	0	0	0	0	0	9	0	0	0	0	0	0
		Enithares sp. CBG01**	I	0	0	0	0	0	0	10	18	0	0	0	0	1	0
		Nychia sappho	C	0	0	0	0	0	0	0	0	4	0	5	1	0	0
		Anisops sp. (imm./female)	I	0	0	0	0	0	0	30	109	2	50	0	6	0	0
		Anisopinae spp. (imm./damaged)	I	0	0	33	0	0	0	0	0	0	0	0	0	0	0
		Notonectidae spp. (imm./damaged)	I	0	300	0	0	0	0	60	100	28	50	0	1	100	0
	Pleidae	*Paraplea brunni*	C	0	1	0	0	0	0	0	0	50	2	33	150	0	0

PHYLUM / CLASS ORDER	FAMILY	SPECIES	Occ	I1 Dup1	I1 Dup2	I2 Dup1	I2 Dup2	I3 Dup1	I3 Dup2	I4 Dup1	I4 Dup2	I6 Dup1	I6 Dup2	I7 Dup1	I7 Dup2	M20 Dup1	M20 Dup2
		Paraplea spp. (imm./damaged)	I	0	0	0	0	0	1	0	0	0	0	0	0	50	0
	Veliidae	Microveliinae sp.	I	0	0	0	0	0	0	0	0	0	0	67	0	50	0
		Microvelia (*Pacifiovelia*) ? *lilliput***	N	0	0	0	0	0	0	0	0	4	0	0	0	0	0
		Microvelia (*Austromicrovelia*) *pennicilla*	N	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		Microvelia (*Austromicrovelia*) *torresiana*	N	0	0	0	0	0	14	0	0	3	0	0	0	0	0
		Microvelia (*Picaultia*) sp. CBG01**	I*	0	0	0	0	0	14	0	0	3	0	0	50	0	0
		Microvelia sp. (imm./damaged)	I	0	0	0	0	0	0	0	0	0	0	0	150	0	0
		Veliidae spp. (imm./damaged)	I	0	0	0	0	0	14	0	0	87	0	0	150	150	200
COLEOPTERA	**Dytiscidae**	*Austrodytes insularis*	N	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		Clypeodytes feryi	N	0	0	0	0	0	0	0	0	3	0	0	0	0	0
		Clypeodytes migrator	N	0	0	0	0	0	0	0	0	5	0	0	0	0	0
		Cybister godeffroyi	C	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Cybister sp. (L)	I	0	1	0	0	0	0	2	9	0	0	0	0	0	0
		Hydaticus vittatus	C	0	0	0	0	0	0	0	0	0	0	0	1	0	1
		Hydaticus sp. CBG01**	I	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Hydaticus sp. CBG02**	I	0	0	0	0	2	0	0	0	0	0	0	1	0	0
		Hydroglyphus sp. CBG01**	I*	0	0	0	0	0	0	0	9	0	0	0	0	0	0
		Hydroglyphus sp. CBG02**	I*	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		Hydrovatus fasciatus	C	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Hydrovatus sp. (L)	I	0	0	0	0	0	0	0	0	1	0	0	0	0	100
		Hyphydrus lyratus	A	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Laccophilus cingulatus	C	0	0	0	0	0	0	0	0	6	2	33	50	0	0
		Laccophilus quadrimaculatus	C	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		Laccophilus seminiger	C	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		Neobidessodes thoracicus	N	0	0	0	0	0	29	0	0	56	0	3	0	0	0
		Neobidessodes mjobergi	N	0	0	0	0	0	0	0	0	32	0	33	0	0	0
		Onychohydrus sp. (L)	I	0	0	0	0	0	0	0	0	0	0	0	0	1	107
		Platynectes sp. CBG01**	I	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Sternopriscus alligatorensis	N	0	0	0	0	0	0	0	0	1	0	33	0	0	0
		Sternopriscus sp. (L)	I*	0	0	0	0	0	0	0	0	0	0	1	0	0	0

PHYLUM / CLASS ORDER	FAMILY	SPECIES	Occ	I1 Dup1	I1 Dup2	I2 Dup1	I2 Dup2	I3 Dup1	I3 Dup2	I4 Dup1	I4 Dup2	I6 Dup1	I6 Dup2	I7 Dup1	I7 Dup2	M20 Dup1	M20 Dup2
		Tiporus collaris	N	0	0	0	0	0	1	0	0	6	0	5	2	0	0
		Tiporus josepheni	A	0	0	0	0	0	14	0	0	0	0	0	0	0	0
		Tribe Bidessini sp. (L)	I	0	0	0	0	0	0	0	0	1	50	0	0	100	100
	Elmidae	Elmidae spp. (L)	I	0	0	0	0	0	14	0	0	0	0	0	0	0	0
		Austrolimnius spp. (L)	I	0	0	0	0	0	129	0	0	0	0	0	0	0	0
	Gyrinidae	*Dineutus neohollandicus*	C	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Macrogyrus (*Tribolominus*) *gouldi*	N	0	0	0	0	0	1	0	0	0	0	1	0	0	0
	Haliplidae	*Haliplus* sp. (L)	I	0	101	4	0	0	0	0	0	0	0	0	0	0	0
	Hydrophilidae	*Amphiops duplopunctatus*	C	0	0	0	0	1	0	0	9	56	4	0	1	0	0
		Amphiops sp. CBG01**	I	0	0	0	0	0	0	0	9	0	0	0	0	0	0
		Amphiops sp.	I	0	0	0	0	20	0	0	0	0	0	0	0	0	0
		Amphiops sp. (L)	I	0	0	0	0	40	29	0	9	22	50	0	0	0	200
		Anacaena horni	A	0	0	0	0	0	0	0	0	1	0	1	50	0	0
		Berosus sp. (L)	I	0	0	0	0	0	14	0	0	0	0	0	0	0	0
		Enochrus deserticola	A	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		*Enochrus ? isabellae***	I*	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		Enochrus malabarensis	A	0	0	8	7	0	0	0	0	1	0	0	0	0	0
		Enochrus sp. (L)	I	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		Helochares sp.** (females)	I*	0	0	0	0	0	0	0	0	5	0	1	0	0	0
		Helochares sp. (L)	I*	0	0	0	0	0	0	0	0	1	50	0	0	0	0
		Paracymus pygmaeus	C	100	0	0	0	0	0	0	0	3	0	1	0	0	0
		?*Paracymus* sp. (L)**	I	0	0	33	0	0	0	0	0	0	0	0	0	0	0
		Sternolophus marginicollis	C	0	0	0	0	3	0	0	0	0	0	0	6	0	0
		Sternolophus sp. (L)	I	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Hydrochidae	*Hydrochus* sp.**	I	0	0	0	0	120	214	0	0	90	100	0	1	0	0
		Hydrochus imamkhani	C	0	0	0	0	0	0	0	0	0	0	0	50	0	0
		Hydrochus obscuroaeneus	A	0	0	0	0	40	29	0	0	7	50	1	0	0	0
		Hydrochus radjiei	A	0	0	0	0	80	57	0	0	65	150	33	50	0	0
	Hydraenidae	*Hydraena* sp.	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Noteridae	*Canthydrus bovillae*	N	0	0	0	0	0	0	0	0	1	0	0	0	0	0

PHYLUM / CLASS ORDER	FAMILY	SPECIES	Occ	I1 Dup1	I1 Dup2	I2 Dup1	I2 Dup2	I3 Dup1	I3 Dup2	I4 Dup1	I4 Dup2	I6 Dup1	I6 Dup2	I7 Dup1	I7 Dup2	M20 Dup1	M20 Dup2
		Canthydrus ephemeralis	N	0	0	0	0	0	0	0	0	0	0	26	200	0	0
		Hydrocanthus waterhousei	N	0	0	0	0	0	0	0	0	0	0	0	0	1	0
DIPTERA	**Culicidae**	*Aedes* sp. (L)	I	0	0	133	433	0	0	0	0	0	0	0	0	0	0
		Anopheles sp. (L)	I	0	0	0	0	0	0	0	0	0	0	0	0	150	100
		Coquillettidia/*Mansonia* spp. (L)	I	0	2	0	0	0	0	0	0	0	0	0	0	0	0
		Culex spp. (L)	I	0	0	0	0	0	0	0	0	9	150	0	0	100	100
		Culicidae spp. (L) imm./damaged	I	0	0	33	67	0	0	0	0	0	0	0	0	0	0
		Culicidae spp. (P) imm./damaged	I	0	0	0	67	0	0	0	0	0	0	0	0	0	0
	Chironomidae																
	Tanypodinae	*Ablabesmyia notabilis* (L)	C	100	100	0	0	140	29	0	0	1	0	0	0	0	0
		Djalmabatista sp. (L)	A	0	0	0	0	140	0	0	0	0	0	0	0	0	0
		Fittkauimyia disparipes (L)	C	0	0	0	0	0	0	0	0	3	0	133	2	0	0
		Larsia albiceps (L)	C	700	800	0	0	100	29	0	0	12	100	0	0	1000	1200
		Larsia albiceps (P)	C	0	1	0	0	0	0	0	0	15	0	0	0	150	100
		?*Larsia* nr. *albiceps*** (L)	I	0	0	0	0	0	0	0	0	4	400	0	0	0	0
		Paramerina spp.** (L)	I	0	200	0	0	60	14	0	0	3	150	233	450	50	0
		Paramerina spp.** (P)	I	0	0	0	0	0	0	0	0	0	0	0	0	50	0
		Procladius paludicola (L)	A	0	200	33	67	40	43	0	0	20	400	33	100	0	0
		Tanypus sp. (L)	I	0	0	0	0	0	0	30	0	0	0	0	0	0	0
		Zavrelimyia/*Paramerina* sp. (L)	I	0	1	0	0	0	0	0	0	0	200	0	0	0	0
		Tanypodinae spp.(L)	I	200	100	0	0	20	0	0	0	3	0	0	0	100	0
	Orthocladiinae	*Corynoneura* sp. (L)	I	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		Nanocladius sp. 1 (L)	I	0	0	0	0	0	14	0	0	0	0	0	0	0	0
	Chironominae	*Chironomus februarius* group (L)	I	100	100	0	0	0	0	70	45	2	50	33	0	50	0
		Cladopelma nr. *curtivalva** (L)	I	0	0	0	0	0	0	0	0	2	50	133	1	0	0
		Cladopelma nr. *curtivalva** (P)	I	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Cladotanytarsus sp. (L)	I	0	0	0	0	20	57	0	0	1	100	33	0	0	0
		Harrisius sp. (L)	I	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Kiefferulus barbatitarsis (L)	C	0	5	0	0	0	0	40	27	3	50	33	2	0	0
		Kiefferulus spp. (P)	I	0	0	0	0	0	0	20	0	0	0	0	0	0	0

PHYLUM / CLASS ORDER	FAMILY	SPECIES	Occ	I1 Dup1	I1 Dup2	I2 Dup1	I2 Dup2	I3 Dup1	I3 Dup2	I4 Dup1	I4 Dup2	I6 Dup1	I6 Dup2	I7 Dup1	I7 Dup2	M20 Dup1	M20 Dup2
		Conochironomus ? australiensis (L)	N	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		Dicrotendipes lindae (L)	N	0	0	0	0	40	43	0	0	0	0	33	100	0	0
		Dicrotendipes spp. (L)	I	0	0	0	0	0	57	0	0	0	0	0	0	0	0
		Parachironomus K1 (L)	A	0	0	0	0	0	0	0	0	0	0	67	0	0	0
		Parachironomus sp. (L) imm./damaged	I	0	200	0	0	0	0	0	0	0	0	0	0	0	0
		Polypedilum convexum (L)	C	0	0	0	0	60	100	0	0	27	750	33	0	0	0
		Polypedilum leei (L)	A	100	200	0	0	0	0	0	0	0	0	0	0	0	1
		Polypedilum nubifer (L)	C	0	200	0	0	0	0	0	0	0	0	0	0	0	0
		Polypedilum nr. *seorsus*** (L)	I	0	0	0	0	0	0	0	0	33	750	0	0	650	300
		Polypedilum nr. *seorsus*** (P)	I	0	0	0	0	0	0	0	0	6	50	0	0	0	0
		Polypedilum watsoni (L)	A	0	0	0	0	40	14	0	0	0	100	0	0	0	0
		Polypedilum K3** (L)	I	0	0	0	0	440	57	0	0	0	150	3	150	0	0
		Polypedilum nr. K13** (P)	I	0	0	0	0	0	0	0	0	5	0	0	0	0	0
		Polypedilum spp. (L) imm./damaged	I	0	0	0	0	20	29	0	0	10	100	33	0	100	0
		Stempellina ? australiensis (P)	A	0	0	0	0	0	0	0	0	0	0	0	50	0	0
		Stempellina sp. (L)	I	0	0	0	0	0	0	0	0	0	0	33	50	0	0
		Tanytarsus nr. *bispinosus*** (L)	I	100	2	0	0	0	0	0	0	16	800	0	0	100	0
		Tanytarsus formosanus (L)	C	300	400	0	0	0	0	0	0	0	0	0	0	0	0
		Tanytarsus hardwicki (L)	N	0	0	0	0	20	14	0	0	0	750	0	50	0	0
		Tanytarsus micksmithi (L)	N	0	0	0	0	40	0	0	0	0	0	1	0	0	0
		Tanytarsus richardsi (L)	N	0	0	0	0	60	29	0	0	0	0	33	0	0	0
		Tanytarsus K10 (L)	N	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Paratanytarsus/*Rheotanytarsus* (L)	I	0	0	0	0	0	14	0	0	0	0	0	0	0	0
		Zavrelliella marmorata (L)	C	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		Chironominae spp. (L)	I	0	1	0	0	20	43	0	27	2	200	0	50	0	0
		Chironominae spp. (P)	I	0	0	0	0	0	0	0	0	2	0	0	0	0	0
	Ceratopogonidae	Ceratopogoninae sp. (L)	I	600	1400	533	567	480	114	20	82	173	900	33	50	200	0
		Ceratopogoninae sp. (P)	I	0	0	67	33	0	0	0	0	2	0	0	0	150	200
		Forcipomyiinae sp. (L)	I	0	0	0	0	0	0	0	0	0	0	0	0	50	0
	Sciomyzidae	Sciomyzidae spp. (L)	I	0	0	0	0	0	0	0	0	58	0	0	0	0	0

PHYLUM / CLASS ORDER	FAMILY	SPECIES	Occ	I1 Dup1	I1 Dup2	I2 Dup1	I2 Dup2	I3 Dup1	I3 Dup2	I4 Dup1	I4 Dup2	I6 Dup1	I6 Dup2	I7 Dup1	I7 Dup2	M20 Dup1	M20 Dup2
	Stratiomyidae	*Odontomyia* sp. (L)	I	300	400	0	0	0	0	0	0	0	0	0	0	150	1
	Tabanidae	Tabanidae spp. (L)	I	0	0	0	1	0	2	0	9	0	1	0	0	1	0
	Tipulidae	Tipulidae spp. (L)	I	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TRICHOPTERA	**Ecnomidae**	*Ecnomina* sp. (imm./damaged)	I	0	0	0	0	0	0	0	0	0	50	0	0	0	0
		Ecnomus sp. CBG01	I	0	0	0	0	40	0	0	0	0	0	0	0	0	0
		Ecnomidae spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Hydroptilidae	*Hellyethira* nr. *cornuta*	N	0	0	0	0	80	14	0	0	4	0	0	0	0	0
		Hellyethira sp. (imm./damaged)	I*	100	0	0	0	0	0	0	0	0	0	0	0	0	0
		Orthotrichia spp. (imm./damaged)	I*	0	0	0	0	0	29	0	0	0	0	0	0	0	0
		Hydroptilidae spp. (imm./damaged)	I	0	0	0	0	20	0	0	0	0	0	0	0	0	0
	Leptoceridae	*Oecetis* sp.	I*	0	0	0	0	40	43	0	0	0	0	0	1	0	0
		Oecetis sp. (P)	I*	0	0	0	0	0	14	0	0	0	0	0	0	0	0
		Triaenodes sp.	I	0	0	0	0	20	0	0	0	0	0	0	0	0	0
		Triplectides ciuskus seductus	A	0	0	0	0	0	0	0	0	24	50	1	1	0	0
		Triplectides helvolus	N	0	8	0	0	0	0	0	0	0	0	0	0	0	0
	Philopotamidae	*Chimarra* nr. *monticola*	I*	0	0	0	0	0	0	0	0	6	0	0	0	0	0
LEPIDOPTERA		Lepidoptera spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	6	0	0	0	0	0
	Pyralidae	Nymphulinae sp. 45	N	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		Nymphulinae CBG01	I	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Nymphulinae spp. (imm./damaged)	I	0	0	0	0	0	0	0	0	3	0	0	0	0	0
		Pyralidae spp. (imm./damaged)	I	0	0	0	0	0	14	0	0	0	0	0	0	0	0

Occurrence (Occ) or Distribution:
I = indeterminate
I* = indeterminate but probably northern Australian endemic
N = Endemic to northern Australia
A = Australia (not necessarily Australia wide, but more than a northern distribution)
C = Cosmopolitan (Australia and beyond - however not necessarily worldwide)
LE = local endemic

Other annotations and abbreviations
** Awaiting expert taxonomic verification
NP = Taxon not picked from (i.e. left remaining in) sample
L = larva
P = Pupa
imm. = immature

Appendix K

Water Quality Results for Marine/Coastal Wetland Sites

Marine Sites July/August																									
				Field_ID	DUP 3	DUP-01	DUP-02	M1-A	M1-B	M1-C	M2-A	M2-B	M2-C	M3-A	M3-B	M3-C	M4-A	M4-B	M4-C	M5-A	M5-B	M5-C	M6-A	M6-B	M6-C
				Sampled_Date-Time	2/08/2010	31/07/2010	1/08/2010	31/07/2010	31/07/2010	31/07/2010	1/08/2010	1/08/2010	1/08/2010	2/08/2010	2/08/2010	2/08/2010	29/07/2010	29/07/2010	29/07/2010	29/07/2010	29/07/2010	29/07/2010	1/08/2010	1/08/2010	1/08/2010
Chem Group	**Chem Name**	**Units**	**EQL**	ANZECC 2000 (Aquatic Ecosystems- Marine 99% Protection)																					
Alkalinity	Alkalinity (Hydroxide) as CaCO3	µg/L	1000		<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
	Alkalinity (total) as CaCO3	mg/L	1		153	114	1	160	159	143	129	109	120	111	114	116	127	130	127	129	126	127	<1	<1	<1
	Bicarbonate																								
	Total																								
Anions Total		meq/L	0.01		974	625	322	769	769	830	668	680	616	604	599	603	628	630	627	627	624	632	311	309	311
Cations Total		meq/L	0.01		948	614	312	747	727	761	644	668	621	629	628	638	640	655	644	668	659	634	297	299	299
Ionic Balance		%	0.01		1.38	0.92	1.53	1.48	2.82	4.32	1.81	0.94	0.42	2.05	2.31	2.83	0.91	1.88	1.35	3.18	2.65	0.09	2.18	1.6	1.97
Chloride		mg/L	1		31500	19900	10100	24800	24800	27000	21300	21700	19600	19300	19200	19300	20100	20200	20100	20000	19900	20200	9810	9720	9810
Major Ions	Sodium (Filtered)	mg/L	1	300**	17800	10800	5430	13900	13400	14200	11300	11700	10900	11600	11600	11900	11800	12200	11900	12400	12200	11600	5200	5230	5230
	Calcium (Filtered)	mg/L	1		609	432	239	514	505	507	460	468	428	432	424	425	447	441	446	447	452	446	241	241	242
	Magnesium (Filtered)	mg/L	1		1590	1360	709	1300	1310	1290	1450	1490	1390	1130	1120	1120	1180	1150	1170	1180	1200	1180	665	672	673
	Potassium (Filtered)	mg/L	1		493	428	215	399	393	391	455	460	421	343	333	339	349	343	351	358	359	356	174	172	176
	Sulphate (Filtered)	mg/L	1	400**	3980	2940	1790	3140	3130	3140	3110	3180	2900	2740	2640	2700	2810	2790	2770	2890	2910	2880	1630	1660	1660
Nitrogen	Ammonia as N	µg/L	10	500	190	130	600	80	60	450	30	110	40	80	40	100	50	60	130	50	30	90	320	260	280
	Nitrate (as N)	mg/L	0.01	10*	0.04	0.03	0.03	0.04	0.06	0.1	0.04	0.05	0.06	0.03	0.04	0.05	0.03	0.02	0.04	0.04	<0.01	0.05	0.02	0.05	0.04
	Nitrite (as N)	mg/L	0.01	1*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nitrogen (Total Oxidised)	mg/L	0.01	0.002	0.04	0.03	0.03	0.04	0.06	0.1	0.04	0.05	0.06	0.03	0.04	0.05	0.03	0.02	0.04	0.04	<0.01	0.05	0.02	0.05	0.04
	TKN (as N)	mg/L	0.1		0.8	<0.5	0.8	<0.5	0.5	0.6	<0.5	0.9	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5
	Nitrogen (Total)	µg/L	100	100	800	<500	800	<500	600	700	<500	1000	800	<500	<500	<500	<500	<500	<500	600	<500	<500	<500	<500	<500
BOD		mg/L	2		<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	2	<2	<2	3	<2

ANZECC 2000 (Aquatic Ecosystems- Marine 99% Protection) — Trigger values for toxicants at 99% protection level. Highlighted cells show exceedences

*ANZECC 2000 (Aquatic Ecosystems) — Default trigger values for physical and chemical stressors for Tropical Australia for slightly disturbed ecosystems- marine

**ANZECC 2000 (Primary Contact Recreation) — Water quality guidelines for recreational purposes

Marine Sites July/August																					
				Field_ID	M7-B	M7-C	M8-A	M8-B	M8-C	M9-A	M9-B	M9-C	M10-A	M10-B	M10-C	M12-A	M12-B	M12-C	M20-A	M20-B	M20-C
				Sampled_Date-Time	2/08/2010	2/08/2010	28/07/2010	28/07/2010	28/07/2010	28/07/2010	28/07/2010	28/07/2010	30/07/2010	30/07/2010	30/07/2010	31/07/2010	31/07/2010	31/07/2010	3/08/2010	3/08/2010	3/08/2010
Chem Group	**Chem Name**	**Units**	**EQL**	ANZECC 2000 (Aquatic Ecosystems- Marine 99% Protection)																	
Alkalinity	Alkalinity (Hydroxide) as CaCO3	µg/L	1000		<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
	Alkalinity (total) as CaCO3	mg/L	1		152	153	119	121	120	118	119	122	114 - 116	115	113 - 115	115	116	115	2	51	51
	Bicarbonate																				
	Total																				
Anions Total		meq/L	0.01		996	1010	610	630	614	645	639	636	584 - 625	594 - 622	591 - 627	652	595	593	0.47	26.6	26.3
Cations Total		meq/L	0.01		907	919	641	643	671	612	623	636	606 - 631	607 - 618	605 - 626	662	617	620	0.36	25.6	24.9
Ionic Balance		%	0.01		4.65	4.83	2.44	1.04	4.41	2.6	1.32	<0.01	1.5 - 3.84	0.32 - 1.1	1.84 - 2.83	0.78	1.76	2.25	-	1.87	2.72
Chloride		mg/L	1		32200	32800	19400	20100	19500	20600	20400	20300	18700 - 19900	19000 - 19800	18900 - 20000	21000	19000	18900	14	866	857
Major Ions	Calcium (Filtered)	mg/L	1		603	599	438	440	448	435	438	434	416 - 431	423 - 430	424 - 427	426	427	427	<1	15	15
	Magnesium (Filtered)	mg/L	1		1920	1960	1170	1180	1190	1370	1360	1440	1090 - 1350	1100 - 1350	1110 - 1340	1130	1140	1120	<1	46	45
	Potassium (Filtered)	mg/L	1		602	600	361	355	364	434	431	429	327 - 429	334 - 423	329 - 424	343	341	340	<1	19	18
	Sodium (Filtered)	mg/L	1	300**	16200	16400	11800	11800	12400	10700	11000	11100	10600 - 11800	10900 - 11200	10600 - 11600	12400	11300	11400	8	474	460
	Sulphate (Filtered)	mg/L	1	400**	4050	4040	2900	2890	2960	2950	2950	2940	2620 - 2940	2680 - 2920	2680 - 2910	2740	2740	2750	1	55	54
Nitrogen	Ammonia as N	µg/L	10	500	390	1230	120	50	30	80	20	30	20 - 80	40 - 160	30 - 50	50	60	30	10	140	120
	Nitrate (as N)	mg/L	0.01	10*	0.03	0.03	0.04	0.04	<0.01	0.05	0.03	0.04	0.03 - 0.04	0.02 - 0.07	0.02 - 0.05	0.04	0.1	0.05	0.06	0.08	0.05
	Nitrite (as N)	mg/L	0.01	1*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nitrogen (Total Oxidised)	mg/L	0.01	0.002	0.03	0.03	0.04	0.04	<0.01	0.05	0.03	0.04	0.03 - 0.04	0.02 - 0.07	0.02 - 0.05	0.04	0.1	0.05	0.06	0.08	0.05
	TKN (as N)	mg/L	0.1		0.6	<0.5	0.6	<0.5	0.5	<0.5	<0.5	<0.5	<0.5 - 0.6	0.9	<0.5	<0.5	<0.5	1.1	0.3	0.5	0.6
	Nitrogen (Total)	µg/L	100	100	600	<500	600	<500	500	<500	<500	<500	<500 - 600	900 - 1000	<500	<500	<500	1200	400	600	600
	BOD	mg/L	2		3	5	<2	<2	<2	<2	<2	<2	<2	<2 - 2	<2 - 2	<2	<2	<2	<2	2	<2

ANZECC 2000 (Aquatic Ecosystems- Marine 99% Protection) — Trigger values for toxicants at 99% protection level
Highlighted cells show exceedences

*ANZECC 2000 (Aquatic Ecosystems) — Default trigger values for physical and chemical stressors for Tropical Australia for slightly disturbed ecosystems- marine

**ANZECC 2000 (Primary Contact Recreation) — Water quality guidelines for recreational purposes

Marine Sites October																										
				Field_ID	M1-A	M1-B	M1-C	M2-A	M2-B	M2-C	M3 dup	M3-A	M3-B	M3-C	M4-A	M4-B	M4-C	M5-A	M5-B	M5-C	M6-A	M6-B	M6-C	M7-A	M7-B	M7-C
				Sampled_Date-Time	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	4/10/2010	4/10/2010	4/10/2010	4/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	4/10/2010	4/10/2010	4/10/2010
Chem Group	**Chem Name**	**Units**	**EQL**	ANZECC 2000 (Aquatic Ecosystems-Marine 99% Protection)																						
Inorganics	Alkalinity (Hydroxide) as CaCO3	µg/L	1000		<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
	Alkalinity (total) as CaCO3	mg/L	1		67	155	129	123	123	127	117	119	116	113	123	122	122	122	121	121	109	101	111	132	134	133
	Bicarbonate																									
	Total																									
	Ammonia as N	µg/L	10	500	40	60	70	30	30	120	20	30	10	10	80	950	40	100	30	60	430	740	270	660	560	650
Anions Total		meq/L	0.01		684	644	595	591	585	817	596	594	596	598	672	663	572	570	572	565	1000	1030	1020	1160	1300	1330
Cations Total		meq/L	0.01		733	689	650	635	645	747	648	614	622	630	680	665	623	622	628	623	953	940	927	1120	1190	1220
BOD		mg/L	2		<2	<2	<2	<2	<2	<2	<2	18	17	14	<2	<2	<2	<2	<2	<2	4	4	4	<2	<2	<2
Chloride		mg/L	1		21000	20000	18400	18400	18100	26200	18700	18600	18700	18700	21300	21000	17800	17700	17700	17500	32000	33000	32700	37200	41900	43000
Ionic Balance		%	0.01		3.47	3.39	4.44	3.61	4.92	4.5	4.19	1.68	2.06	2.56	0.62	0.13	4.3	4.4	4.65	4.9	2.43	4.65	4.89	1.99	4.23	4.28
	Nitrate (as N)	mg/L	0.01	10*	0.04	0.02	<0.01	<0.01	0.02	0.03	0.02	0.01	<0.01	0.03	0.04	0.05	0.02	0.03	0.08	<0.01	0.08	0.02	0.02	0.02	0.03	0.02
	Nitrite (as N)	mg/L	0.01	1*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nitrogen (Total Oxidised)	mg/L	0.01	0.002	0.04	0.02	<0.01	<0.01	0.02	0.03	0.02	0.01	<0.01	0.03	0.04	0.05	0.02	0.03	0.08	<0.01	0.08	0.02	0.02	0.02	0.03	0.02
	Nitrogen (Total)	µg/L	100	100	400	200	200	800	700	2600	1000	1200	1100	1100	700	2200	600	700	600	900	1300	1200	1200	1800	1300	1100
	TKN (as N)	mg/L	0.1		0.4	0.2	0.2	0.8	0.7	2.6	1	1.2	1.1	1.1	0.7	2.1	0.6	0.7	0.5	0.9	1.2	1.2	1.2	1.8	1.3	1.1
Metals	Calcium (Filtered)	mg/L	1		548	514	471	465	473	471	429	434	432	444	456	448	446	446	456	452	637	643	645	686	696	706
	Magnesium (Filtered)	mg/L	1		1690	1580	1470	1440	1460	1610	1330	1350	1340	1370	1440	1400	1410	1390	1410	1400	2090	2070	2030	2380	2510	2530
	Potassium (Filtered)	mg/L	1		561	507	489	478	482	499	443	448	449	467	420	423	450	462	463	460	592	594	590	868	844	858
	Sodium (Filtered)	mg/L	1	300**	12700	12000	11300	11100	11200	13300	11600	10800	11000	11100	12100	11900	10900	10900	11000	10900	16900	16600	16400	19900	21400	22000
	Sulphate (Filtered)	mg/L	1	400**	4320	3680	3510	3340	3440	3610	3180	3220	3200	3280	3290	3260	3230	3270	3390	3320	4600	4740	4680	5380	5440	5580

ANZECC 2000 (Aquatic Ecosystems- Marine 99% Protection) — Trigger values for toxicants at 99% protection level

Highlighted cells show exceedences

*ANZECC 2000 (Aquatic Ecosystems) — Default trigger values for physical and chemical stressors for Tropical Australia for slightly disturbed ecosystems- marine

**ANZECC 2000 (Primary Contact Recreation) — Water quality guidelines for recreational purposes

Marine Sites October																													
				Field_ID	M8-A dup	M9-A	M9-B	M9-C	M9-C Dup	M12-A	M12-B	M12-C	M13-A	M13-B	M13-C	M14-A	M14-B	M14-C	M15-A	M15-B	M15-C	M17-A	M17-B	M17-C	M18-A	M18-B	M20-A	M20-B	M20-C
				Sampled_Date-Time	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	4/10/2010	4/10/2010	4/10/2010	4/10/2010	4/10/2010	4/10/2010	4/10/2010	4/10/2010	5/10/2010	4/10/2010	4/10/2010	4/10/2010	5/10/2010	5/10/2010	5/10/2010	5/10/2010	5/10/2010	3/10/2010	3/10/2010	3/10/2010
Chem Group	**Chem Name**	**Units**	**EQL**	ANZECC 2000 (Aquatic Ecosystems- Marine 99% Protection)																									
Alkalinity	Alkalinity (Hydroxide) as CaCO3	µg/L	1000		<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
	Alkalinity (total) as CaCO3	mg/L	1		117	118	117	120	114	116	113	115	115	117	115	116	116	120	126	122 - 124	122	148	147	150	121	119	250	222	251
	Bicarbonates																												
	Total																												
Anions Total		meq/L	0.01		750	661	550	690	553	542	542	539	646	577	531	665	580	548	719	566 - 789	711	685	580	682	596	592	177	191	185
Cations Total		meq/L	0.01		696	648	602	648	598	586	591	578	618	601	582	639	592	597	653	610 - 719	659	684	626	693	608	620	190	177	200
Ionic Balance		%	0.01		3.72	1.01	4.5	3.16	3.92	3.83	4.29	3.49	2.24	2.03	4.59	2	1.01	4.23	4.81	3.73 - 4.7	3.79	0.11	3.72	0.78	0.98	2.33	3.3	3.84	3.93
Chloride		mg/L	1		24100	20900	17100	21900	17200	16900	16900	16800	20500	18000	16500	21200	18200	17000	23000	17600 - 25300	22700	21700	18000	21600	18600	18500	5780	6270	6050
Major Ions	Calcium (Filtered)	mg/L	1		432	437	438	434	431	419	424	420	421	430	418	415	427	433	446	442 - 463	444	478	470	478	443	445	131	120	133
	Magnesium (Filtered)	mg/L	1		1500	1420	1350	1410	1360	1310	1320	1310	1350	1340	1320	1390	1320	1340	1430	1390 - 1540	1450	1450	1420	1470	1370	1360	401	359	414
	Potassium (Filtered)	mg/L	1		451	457	444	454	428	420	421	418	437	444	411	447	440	441	478	448 - 489	480	438	455	440	449	477	111	123	119
	Sodium (Filtered)	mg/L	1	300**	12400	11400	10500	11500	10400	10300	10400	10100	10900	10500	10200	11300	10400	10400	11500	10600 - 12800	11600	12200	10900	12400	10600	10900	3380	3180	3600
	Sulphate (Filtered)	mg/L	1	400**	3270	3330	3160	3340	3140	3040	3050	3020	3170	3160	3030	3120	3150	3190	3300	3200 - 3520	3320	3370	3360	3370	3330	3270	450	469	453
Nitrogen	Ammonia as N	µg/L	10	500	120	120	50	90	30	70	40	110	100	90	60	<10	80	10	<10	70 - 100	70	1560	40	1050	<10	20	40	70	<10
	Nitrate (as N)	mg/L	0.01	10*	0.04	0.03	<0.01	0.03	0.04	0.03	0.08	0.05	0.04	0.06	0.05	0.02	0.08	0.01	<0.01	0.02 - 0.04	<0.01	0.05	0.07	0.05	<0.01	<0.01	0.04	0.05	0.06
	Nitrite (as N)	mg/L	0.01	1*	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nitrogen (Total Oxidised)	mg/L	0.01	0.002	0.04	0.03	<0.01	0.03	0.04	0.03	0.08	0.05	0.04	0.06	0.05	0.02	0.08	0.01	<0.01	0.02 - 0.04	<0.01	0.05	0.07	0.05	<0.01	<0.01	0.04	0.05	0.06
	TKN (as N)	mg/L	0.1		0.6	0.6	0.2	1.5	0.1	0.1	0.2	0.2	0.6	0.2	0.1	1.1	0.1	0.4	1.3	0.2 - 0.5	1	1.8	0.2	4.8	0.4	0.2	1.4	1.5	1.7
	Nitrogen (Total)	µg/L	100	100	600	600	200	1500	100	100	300	200	600	300	200	1100	200	400	1300	200 - 500	1000	1800	300	4800	400	200	1400	1600	1800
BOD		mg/L	2		<2	<2	<2	<2	<2	<2	<2	<2	<2	14	<2	<2	13	10	6	<2 - 25	4	<2	<2	<2	11	17	<2	<2	13

ANZECC 2000 (Aquatic Ecosystems- Marine 99% Protection) — Trigger values for toxicants at 99% protection level
Highlighted cells show exceedences
*ANZECC 2000 (Aquatic Ecosystems) — Default trigger values for physical and chemical stressors for Tropical Australia for slightly disturbed ecosystems-marine
**ANZECC 2000 (Primary Contact Recreation) — Water quality guidelines for recreational purposes

Appendix L

Water Quality Results for Inland Wetlands

				Field_ID	DUP-A	DUP-B	DUP-C	I1-A	I1-B	I1-C	I2-A	I2-B	I2-C	I3-A	I3-B	I4-A	I4-B	I4-C	I6-A	I6-B	I6-C	I7-A	I7-B	I7-C
				Sampled_Date-Time	3/08/2010	3/08/2010	4/08/2010	29/07/2010	4/08/2010	4/08/2010	29/07/2010	29/07/2010	29/07/2010	30/07/2010	30/07/2010	31/07/2010	31/07/2010	31/07/2010	1/08/2010	1/08/2010	1/08/2010	1/08/2010	1/08/2010	1/08/2010
Chem_Group	**ChemName**	**Units**	**EQL**	ANZECC 2000 (Aquatic Ecosystems- Freshwater 99% Protection)																				
Inorganics	Alkalinity (Hydroxide) as CaCO3	µg/L	1000		<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
	Alkalinity (total) as CaCO3	mg/L	1		3	49	212	120	214	215	100	81	84	4	4	58	72	68	3	4	3	3	3	3
	Ammonia as N	µg/L	10	320	110	<10	<10	250	<10	170	400	1800	30	230	<10	700	1480	520	20	250	180	<10	<10	<10
	Anions Total	meq/L	0.01		0.49	26.7	92.6	90.2	93.2	92.5	242	256	258	0.41	0.27	23.2	22.9	23	0.28	0.29	0.2	0.26	0.26	0.25
	BOD	mg/L	2		<2	3	2	2	3	4	67	3	2	2	<2	10	6	3	<2	11	<2	<2	<2	2
	Cations Total	meq/L	0.01		0.39	27.1	87.3	85.5	84.6	86.1	221	233	235	0.38	0.2	22.9	22.3	22.6	0.18	0.17	0.13	0.18	0.19	0.15
	Chloride	mg/L	1		14	868	3000	2920	3020	2990	7430	7820	7860	12	7	770	751	755	7	7	5	7	7	6
	Ionic Balance	%	0.01		-	0.74	2.98	2.68	4.87	3.58	4.57	4.8	4.71	-	-	0.82	1.4	1.03	-	-	-	-	-	-
	Nitrate (as N)	mg/L	0.01	0.017	0.04	0.04	0.01	0.04	0.03	0.03	0.05	0.03	0.02	0.01	0.02	0.03	<0.01	0.03	0.05	0.06	0.05	<0.01	0.03	0.02
	Nitrite (as N)	mg/L	0.01	1**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nitrogen (Total Oxidised)	mg/L	0.01	0.01	0.04	0.04	0.01	0.04	0.03	0.03	0.05	0.03	0.02	0.01	0.02	0.03	<0.01	0.03	0.05	0.06	0.05	<0.01	0.03	0.02
	Nitrogen (Total)	µg/L	100	350-1200*	300	500	1200	1400	1300	1500	800	1900	800	200	300	2900	2900	1600	200	300	200	200	200	100
	Sodium (Filtered)	mg/L	1	300**	9	503	1430	1410	1380	1410	3720	3930	3960	9	4	403	388	394	4	4	3	4	4	3
	Sulphate (Filtered)	mg/L	1	400**	1	58	180	262	182	184	1470	1640	1650	<1	<1	17	14	17	1	1	<1	<1	<1	1
	TKN (as N)	mg/L	0.1		0.3	0.5	1.2	1.4	1.3	1.5	0.8	1.9	0.8	0.2	0.3	2.9	2.9	1.6	0.1	0.2	0.2	0.2	0.2	0.1
Metals	Calcium (Filtered)	mg/L	1		<1	16	243	230	239	239	366	390	393	<1	<1	39	40	39	<1	<1	<1	<1	<1	<1
	Magnesium (Filtered)	mg/L	1		<1	48	142	142	140	142	461	471	472	<1	<1	34	35	35	<1	<1	<1	<1	<1	<1
	Potassium (Filtered)	mg/L	1		<1	20	47	41	45	47	128	142	143	<1	<1	22	21	22	<1	<1	<1	<1	<1	<1

ANZECC 2000 (Aquatic Ecosystems- Freshwater 99% Protection) — Trigger values for toxicants at 99% protection level
Highlighted cells show exceedences
*ANZECC 2000 (Aquatic Ecosystems) — Default trigger values for physical and chemical stressors for Tropical Australia for slightly disturbed ecosystems- wetlands
**ANZECC 2000 (Primary Contact Recreation) — Water quality guidelines for recreational purposes

				Field_ID	I1-A	I1-B	I1-C	I2-A	I2-B	I2-C	I3-B	I3-C	I6-A	I6-B	I6-C	I7-A	I7-B	I7-C	I7-C dup	I10-A	I10-B	I10-C	I11-A	I11-B	I11-C	I12-A	I12-B	I12-C
				Sampled Date-Time	3/10/2010	8/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	6/10/2010	6/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	3/10/2010	4/10/2010	4/10/2010	4/10/2010	5/10/2010	5/10/2010	5/10/2010	5/10/2010	5/10/2010	5/10/2010
Chem Group	**ChemName**	**Units**	**EQL**	ANZECC 2000 (Aquatic Ecosystems- Freshwater 99% Protection)																								
Inorganics	Alkalinity (Hydroxide) as CaCO3	µg/L	1000		<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000	<1000
	Alkalinity (total) as CaCO3	mg/L	1		435	375	188	102	133	95	5	3 - 27	2	4	3	6	4	5	4	3	3	2	3	3	4	575	566	578
	Ammonia as N	µg/L	10	320	140	1680	180	160	220	100	40	50 - 60	50	30	40	220	280	520	270	60	30	40	20	90	30	<10	20	<10
	Anions Total	meq/L	0.01		303	247	262	641	682	622	0.85	0.91 - 1.4	0.21	0.25	0.23	0.51	0.3	0.34	0.39	1.04	0.87	0.73	0.2	0.48	0.3	122	120	119
	BOD	mg/L	2		<2	<2	25	<2	5	<2	<2	<2	9	10	8	<2	<2	<2	<2	<2	3	7	<2	2	<2	<2	12	21
	Cations Total	meq/L	0.01		283	233	246	620	656	581	0.99	0.95 - 1.21	0.25	0.44	0.24	0.39	0.2	0.2	0.21	1.2	1.05	0.86	0.2	0.64	0.26	111	126	130
	Chloride	mg/L	1		10400	8450	8860	19100	20500	18600	22	26	6	6	6	14	8	7	10	30	29	24	5	15	8	3640	3590	3560
	Ionic Balance	%	0.01		3.37	3	3.16	1.65	1.95	3.43	-	2.16	-	-	-	-	-	-	-	-	-	-	-	-	-	4.77	2.5	4.55
	Nitrate (as N)	mg/L	0.01	0.017	0.02	0.01	<0.01	0.04	0.03	0.03	<0.01	0.06 - 0.07	0.04	0.08	0.09	<0.01	0.03	0.01	0.04	<0.01	0.04	0.05	0.05	0.01	0.05	0.02	<0.01	<0.01
	Nitrite (as N)	mg/L	0.01	1**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Nitrogen (Total Oxidised)	mg/L	0.01	0.01	0.02	0.01	<0.01	0.04	0.03	0.03	<0.01	0.06 - 0.07	0.04	0.08	0.09	<0.01	0.03	0.01	0.04	<0.01	0.04	0.05	0.05	0.01	0.05	0.02	<0.01	<0.01
	Nitrogen (Total)	µg/L	100	350-1200*	5500	5500	21800	1600	3400	1900	700	400 - 1400	1400	600	600	700	500	500	500	600	7400	2600	200	800	200	4200	4000	3900
	Sodium (Filtered)	mg/L	1	300**	4420	3530	3840	10400	11000	9710	19	17 - 20	6	8	6	9	5	4	5	25	22	20	5	12	6	1990	2300	2410
	Sulphate (Filtered)	mg/L	1	400**	32	57	374	4790	4870	4600	6	5 - 6	<5	<5	<5	<1	<1	2	2	6	<5	<5	<5	<5	<5	384	362	343
	TKN (as N)	mg/L	0.1		5.5	5.5	21.8	1.6	3.4	1.9	0.7	0.3 - 1.3	1.4	0.5	0.5	0.7	0.5	0.5	0.5	0.6	7.4	2.6	0.2	0.8	0.1	4.2	4	3.9
Metals	Calcium (Filtered)	mg/L	1		772	771	631	934	977	909	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	28	28	28
	Magnesium (Filtered)	mg/L	1		588	456	530	1360	1460	1280	2	2 - 3	<1	1	<1	<1	<1	<1	<1	1	1	<1	<1	1	<1	255	269	265
	Potassium (Filtered)	mg/L	1		145	122	125	357	369	331	<1	<1 - 1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	87	100	92

ANZECC 2000 (Aquatic Ecosystems- Freshwater 99% Protection) — Trigger values for toxicants at 99% protection level

Highlighted cells show exceedences

*ANZECC 2000 (Aquatic Ecosystems) — Default trigger values for physical and chemical stressors for Tropical Australia for slightly disturbed ecosystems- wetlands

**ANZECC 2000 (Primary Contact Recreation) — Water quality guidelines for recreational purposes