Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Southern Gulf Catchments

Flora, Fauna and Ecology Expert Panel Report

Version 1.1

Queensland Government

Prepared by: Biodiversity Assessment, Queensland Herbarium, Department of Environment and Science

Disclaimer

This document has been prepared with all due diligence and care, based on the best available information at the time of publication. The department holds no responsibility for any errors or omissions within this document. Any decisions made by other parties based on this document are solely the responsibility of those parties. Information contained in this document is from a number of sources and, as such, does not necessarily represent government or departmental policy.

If you need to access this document in a language other than English, please call the Translating and Interpreting Service (TIS National) on 131 450 and ask them to telephone Library Services on +61 7 3170 5470.

This publication can be made available in an alternative format (e.g. large print or audiotape) on request for people with vision impairment; phone +61 7 3170 5470 or email <library@des.qld.gov.au>.

Citation

DES 2020. Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Southern Gulf Catchments: Flora, Fauna and Ecology Expert Panel Report, Version 1.1. Department of Environment and Science, Queensland Government.

Acknowledgements

This report was prepared by Mark Kelton, Linda Lawrence, Chris Sanderson, Shane Chemello, Steven Howell, Stephen Trent, Harriet Preece, Courtney Duncan and Ofalia Ho. Special area decisions were refined by Jim Tait. The authors wish to thank all the experts who gave their time and knowledge at the expert panel workshops.

July 2020

Contents

Tables

Figures

Nb. This report should be read in conjunction with the accompanying summary report - Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Southern Gulf Catchments: Summary Report, Version 1.1. Department of Environment and Science, Queensland Government.

Acronyms and abbreviations

ACA	Aquatic Conservation Assessment
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Methodology
ASL	Above Sea Level
BAMM	Biodiversity Assessment and Mapping Methodology
BPA	Biodiversity Planning Assessment
CAMBA	China–Australia Migratory Bird Agreement
CE	Critically endangered
CIM	Criteria, indicators and measures (used in AquaBAMM)
DIWA	Directory of Important Wetlands in Australia
DERM	Department of Environment and Heritage Protection
DES	Department of Environment and Science
E	Endangered
EIU	Einasleigh Uplands bioregion
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
GUP	Gulf Plains bioregion
IBA	Important Bird Area
IBRA	Interim Biogeographic Regionalisation for Australia
JAMBA	Japan–Australia Migratory Bird Agreement
MGD	Mitchell Grass Downs
NCA	*Nature Conservation Act 1992*
NP	National Park
NT	Near threatened
QWS	Queensland Wetland System
Ramsar	Ramsar Convention on Wetlands
RE	Regional Ecosystem
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SOR	State of the Rivers
V	Vulnerable

1 Introduction

The Department of Environment and Science (DES) has undertaken freshwater Aquatic Conservation Assessments (ACA) for the Settlement Creek, Nicholson River, Leichhardt River, Morning Inlet and Mornington Island hydrological basins. Aquatic conservation assessments involve a non-social, non-economic and tenure blind assessment of wetland ecological values at the individual wetland scale. They are based on the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM; Clayton et al. 2006) and incorporate a comprehensive set of criteria, indicators and measures founded upon a large body of national and international literature.

The AquaBAMM uses expert knowledge to acquire data for a number of criterion measures (Clayton et al. 2006). This data is elicited during expert panel workshops comprised of individuals with knowledge and expertise in local aquatic dependent species, wetland ecology, water quality, hydrology, geomorphology and vegetation. AquaBAMM expert panel processes aim to add flexibility and a reality check to AquaBAMM assessment process. They are based on the premise of scientific reasoning, multiple lines of evidence and consensus building allowing the incorporation of unpublished or anecdotal data.

This report describes results and recommendations stemming from expert panel workshops held for the Southern Gulf Catchments Aquatic Conservation Assessment. Three workshops (flora, fauna, and ecology) were held in Brisbane from 29 April to 3 May 2019. Terms of Reference for these workshops can be found in Appendix I - Expert Panel Terms of Reference.

The report should be read in conjunction with the accompanying summary report – Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Southern Gulf Catchments Summary Report Version 1.1 (DES 2020).

2 Method

2.1 Study Area

The Southern Gulf Catchments study area covers an area of 85,468 km^2 and includes the Settlement Creek, Nicholson River, Leichhardt River, Morning Inlet and Mornington Island hydrological basins. Each basin constitutes a unique study area, and separate, stand-alone assessments have been completed for each study area.

Summary descriptions of the geographic, geomorphic and ecologic characteristics of the study areas can be found in the accompanying summary report (i.e. Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Southern Gulf Catchments Summary Report Version 1.1 (DES 2020)).

2.2 Panel composition

The expert panels for the Southern Gulf Catchments ACA was comprised of the persons listed in Table 1. They included individuals with local knowledge and expertise in aquatic dependent flora and fauna, and non-riverine and riverine wetland ecology including fish, macro invertebrates, water quality, hydrology, geomorphology and vegetation. Members who were unavailable to attend the workshop were consulted prior to, or after, the workshop.

Prior to attending the workshops all participants were provided with background material including a Terms of Reference (Appendix I - Expert Panel Terms of Reference), relevant definitions (Appendix II - Expert Panel Definitions), and taxon lists for flora and fauna recorded within each study area.

Organisation and technical support for the panels was provided by Mark Kelton, Shane Chemello, Courtney Duncan, Ofalia Ho, Harriet Preece and Steven Howell.

2.3 Workshop format

Three expert panel workshops were held in Brisbane 29 April to 3 May, 2019. The flora panel was held 29 to 30 April, the fauna panel 30 April to 1 May, and the ecology panel 2 May to 3 May. The workshops used ArcGIS Desktop software to display datasets, such as species sightings records and background topographic data, to help identify wetland components and processes of interest. Where possible, region specific data were sourced from technical reports and scientific publications.

Table 1. Composition and details of the expert panel

Name	Organisation	Expertise	Flora panel	Fauna panel	Ecology panel
Alastair Freeman	Senior Technical Officer, Department of Environment and Science	Zoologist		Attended	Attended
Andrew MacLean	CEO - Southern Gulf NRM	NRM		Attended	Attended
Charles Curry	Project Coordinator - Southern Gulf NRM	Flora, weeds	Attended		
Chris Appelman	Principal Botanist, Department of Environment and Science	Vegetation communities, aquatic flora, aquatic ecology	Attended		Attended
Dr Colton Perna	Aquatic ecologist - Department of Environment and Science	Freshwater ecology		Attended	Attended
Gethin Morgan	Ecologist, Magnetic Island Nature Association	Landscape ecology	Attended	Attended	Attended
Hans Dillewaard	Principal Botanist, Department of Environment and Science	Vegetation communities, aquatic flora, aquatic ecology	Attended		Attended
Jim Tait	Consultant, EConcern Environmental Consulting	Aquatic ecology			Attended
Katharine Glanville	Project Manager, Department of Environment and Science	Ground water dependent ecosystems, aquatic ecology	Attended		
Nick Cuff	Senior Botanist, Northern Territory Herbarium	Aquatic flora, aquatic ecology	Attended		
Dr Peter Driscoll	Queensland Wader Study Group	Birds		Attended	
Peter Negus	Senior Scientist - Department of Environment and Science	Aquatic fauna, aquatic ecology		Attended	Attended
Terry Vallance	Consultant - Tropical River Consulting	Aquatic ecology		Attended	Attended

3 Flora

The role of the flora expert panel is to provide expert advice on the aquatic flora values of the waterways and wetlands within each study area.

Flora records were compiled from corporate databases including Herbrecs (19/07/2019), Corveg (18/06/2019) and WildNet (25/07/2019). Records were filtered by precision (<=2,000m) and included all records irrespective of the year of collection as per panel suggestion. Duplicate records, defined as same species collected in same location in same year, were removed.

3.1 Exotic flora

Exotic flora are plants that cause, or have the potential to cause, significant detrimental impact on natural systems within a non-riverine, riverine landscape. The panel recommended we only include exotic plants known to cause significant detrimental impacts on natural wetland systems within the Southern Gulf Catchments study areas.

No aquatic or semi-aquatic exotic plants causing significant detrimental impacts on natural wetland systems within the Southern Gulf Catchments study areas were identified by the experts.

The panel identified eleven exotic non-aquatic flora taxa impacting riverine or non-riverine wetlands within the study areas (Table 2). Pest distribution (species occurrence) maps produced by Biosecurity Queensland (Department of Agriculture and Fisheries) and point records for the listed species were used to pinpoint spatial units containing exotic flora species for AquaBAMM measure 2.1.1 (Presence of exotic terrestrial (i.e. non-aquatic) plants in the assessment unit).

The panel also highlighted abundance and degree of infestation as important factors in determining the overall impact of exotic species on wetland ecosystems. The project team will attempt to incorporate information on abundance and degree of infestation information in future assessments, but we are limited by the accuracy and currency of data published by the Department of Department of Agriculture and Fisheries.

Table 2. Exotic flora taxa impacting study area wetland values

Scientific Name	Common Name	Riverine	Non-riverine
Achyranthes aspera		Y	Y
Azadirachta indica		Y	Y
Calotropis gigantea		Y	
Calotropis procera		Y	
Cenchrus ciliaris		Y	Y
Cenchrus pennisetiformis		Y	
Cryptostegia grandiflora	Rubber vine	Y	Y
Jatropha gossypiifolia	Bellyache bush	Y	Y
Leonotis nepetifolia		Y	Y
Mesosphaerum suaveolens		Y	
Xanthium occidentale		Y	Y

3.2 Flora species richness

Flora species richness (total number of species) was calculated using wetland indicator species nominated by the expert panel. The panel defined flora wetland indicator species to mean:

Species that are adapted to and dependent on living in wet conditions for at least part of their life and are found either within or immediately adjoining a riverine, non-riverine or estuarine wetland.

When applied to flora species this definition extends beyond the more traditional definition of submerged and floating aquatic plants as it includes plants inhabiting the littoral zone (water's edge) and plants that usually have 'wet feet' on the toe of the bank. This meaning was chosen because it was considered to best capture the intent of the AquaBAMM measure of species richness (M3.1.5). The Criterion 3.1 Indicator is a measure of the floristic richness of a particular spatial unit's aquatic environment, and hence, a broader definition of aquatic species better depicts the flora richness values at a given location.

The panel identified 194 flora wetland indicator species relevant to the riverine and non-riverine wetlands of the study areas (Table 3). Taxa were accessed from the corporate databases of WildNet and Herbrecs and from panel member records.

Point records for the listed species were used to a calculate wetland flora indicator species richness scores for AquaBAMM measure 3.1.5 (Richness of native aquatic plants).

Table 3. Aquatic dependent native flora taxa

Scientific Name	Common Name	Riverine	Non-riverine
Acacia stenophylla	Belalie	Y	Y
Aeschynomene indica	Budda pea		Y
Ammannia multiflora	Jerry-jerry		Y
Aponogeton queenslandicus		Y	Y
Bacopa floribunda		Y	Y
Bergia ammannioides		Y	Y
Bergia pedicellaris			Y
Bolboschoenus caldwellii		Y	Y
Byblis liniflora			Y
Caldesia oligococca			Y
Casuarina cunninghamiana		Y	
Casuarina cunninghamiana subsp. cunninghamiana		Y	
Casuarina cunninghamiana subsp. miodon		Y	
Cathormion umbellatum subsp. moniliforme		Y	Y
Ceratopteris thalictroides		Y	Y
Chara vulgaris		Y	Y
Chenopodium auricomum			Y
Commelina agrostophylla		Y	Y
Crinum flaccidum	Murray lily	Y	Y
Cyanotis axillaris		Y	Y
Cyclosorus interruptus		Y	Y
Cyperus angustatus		Y	
Cyperus aquatilis		Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Cyperus betchei		Y	Y
Cyperus betchei subsp. betchei		Y	Y
Cyperus dactylotes		Y	Y
Cyperus decompositus		Y	Y
Cyperus difformis	Rice sedge	Y	Y
Cyperus exaltatus	Tall flatsedge	Y	Y
Cyperus flaccidus		Y	Y
Cyperus fucosus		Y	
Cyperus haspan		Y	Y
Cyperus haspan subsp. haspan		Y	Y
Cyperus haspan subsp. juncoides		Y	Y
Cyperus holoschoenus		Y	Y
Cyperus iria		Y	Y
Cyperus javanicus		Y	Y
Cyperus macrostachyos		Y	Y
Cyperus nutans var. eleusinoides	Flatsedge	Y	Y
Cyperus oxycarpus		Y	Y
Cyperus polystachyos		Y	Y
Cyperus procerus		Y	Y
Cyperus pygmaeus	Dwarf sedge	Y	Y
Cyperus scariosus		Y	Y
Cyperus squarrosus	Bearded flatsedge	Y	Y
Cyperus vaginatus		Y	Y
Dichanthium setosum		Y	
Dinebra neesii			Y
Diplachne fusca		Y	Y
Diplachne fusca var. fusca			Y
Diplachne fusca var. muelleri			Y
Drosera burmanni			Y
Drosera finlaysoniana		Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Drosera lanata		Y	Y
Duma florulenta			Y
Echinochloa turneriana	Channel millet	Y	Y
Eleocharis atropurpurea		Y	Y
Eleocharis brassii			Y
Eleocharis dulcis		Y	Y
Eleocharis geniculata			Y
Eleocharis pallens	Pale spikerush	Y	Y
Eleocharis philippinensis		Y	Y
Eleocharis rivalis			Y
Eleocharis sanguinolenta			Y
Eleocharis spiralis		Y	Y
Elytrophorus spicatus		Y	Y
Eremophila bignoniiflora	Eurah	Y	Y
Eriocaulon cinereum		Y	Y
Eriocaulon depressum			Y
Eriocaulon fistulosum			Y
Eriocaulon pygmaeum		Y	Y
Eriocaulon setaceum		Y	Y
Eriocaulon tortuosum			Y
Eriocaulon truncatum			Y
Eucalyptus camaldulensis		Y	Y
Eucalyptus camaldulensis subsp. obtusa		Y	Y
Eucalyptus microtheca	Coolibah	Y	Y
Excoecaria parvifolia		Y	Y
Ficus racemosa		Y	
Ficus racemosa var. racemosa		Y	
Fimbristylis blakei		Y	Y
Fimbristylis complanata		Y	
Fimbristylis littoralis		Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Fimbristylis microcarya		Y	Y
Fimbristylis nuda		Y	Y
Fimbristylis nutans		Y	Y
Fimbristylis pauciflora		Y	Y
Fimbristylis polytrichoides			Y
Fimbristylis quinquangularis		Y	
Fimbristylis sieberiana			Y
Fuirena ciliaris		Y	Y
Fuirena incrassata		Y	Y
Glinus lotoides	Hairy carpet weed	Y	Y
Glossostigma diandrum		Y	Y
Hydrilla verticillata	Hydrilla	Y	Y
Hydrocotyle grammatocarpa		Y	Y
Hydrolea zeylanica			Y
Hygrophila angustifolia		Y	Y
Ischaemum australe var. australe		Y	Y
Ischaemum fragile			Y
Juncus aridicolaT	Tussock rush	Y	Y
Juncus continuus		Y	Y
Lemna aequinoctialis	Common duckweed	Y	Y
Leptochloa digitata		Y	Y
Limnophila fragrans		Y	Y
Lindernia stantonii			Y
Lipocarpha microcephala		Y	Y
Livistona rigida		Y	
Lobelia membranacea		Y	Y
Lophostemon grandiflorus		Y	
Lophostemon grandiflorus subsp. riparius		Y	
Ludwigia octovalvis	Willow primrose	Y	Y
Ludwigia peploides subsp. montevidensis		Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Ludwigia perennis		Y	
Lygodium microphyllum	Snake fern	Y	Y
Marsilea costulifera	Narrow-leaved nardoo	Y	Y
Marsilea drummondii	Common nardoo	Y	Y
Marsilea hirsuta	Hairy nardoo	Y	Y
Marsilea mutica	Shiny nardoo	Y	Y
Melaleuca argentea	Silver tea-tree	Y	
Melaleuca bracteata		Y	Y
Melaleuca dealbata	Swamp tea-tree		Y
Melaleuca fluviatilis		Y	
Melaleuca leucadendra	Broad-leaved tea-tree	Y	
Melaleuca trichostachya		Y	
Melaleuca viminalis		Y	
Melastoma malabathricum subsp. malabathricum		Y	Y
Monochoria cyanea		Y	Y
Myriophyllum dicoccum		Y	Y
Myriophyllum filiforme		Y	Y
Myriophyllum implicatum		Y	Y
Myriophyllum verrucosum	Water milfoil	Y	Y
Najas graminea var. graminea			
Najas marina			Y
Najas tenuifolia	Water nymph	Y	Y
Nauclea orientalis	Leichhardt tree	Y	
Nitella hyalina		Y	
Nymphaea carpentariae		Y	Y
Nymphaea elleniae		Y	Y
Nymphaea gigantea		Y	Y
Nymphaea immutabilis		Y	Y
Nymphaea violacea		Y	Y
Nymphoides crenata	Wavy marshwort	Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Nymphoides exiliflora		Y	Y
Nymphoides indica	Water snowflake	Y	Y
Oldenlandia spathulata		Y	
Oryza australiensis		Y	Y
Ottelia alismoides		Y	Y
Pandanus aquaticus		Y	
Panicum trachyrhachis			Y
Paspalum distichum	Water couch	Y	Y
Paspalum scrobiculatum	Ditch millet	Y	
Peplidium maritimum			Y
Persicaria attenuata		Y	Y
Persicaria barbata		Y	Y
Persicaria lapathifolia	Pale knotweed	Y	Y
Philydrum lanuginosum	Frogs mouth	Y	Y
Phragmites australis	Common reed	Y	Y
Phragmites karka		Y	Y
Polygonum plebeium	Small knotweed	Y	Y
Potamogeton crispus	Curly pondweed	Y	Y
Potamogeton tepperi		Y	Y
Potamogeton tricarinatus	Floating pondweed	Y	Y
Pseudoraphis spinescens	Spiny mudgrass	Y	Y
Rhamphicarpa australiensis			Y
Rhynchospora rubra		Y	Y
Rotala diandra		Y	Y
Rotala mexicana		Y	Y
Rotala occultiflora		Y	Y
Rotala tripartita			Y
Schoenoplectiella dissachantha			Y
Schoenoplectiella laevis		Y	Y
Schoenoplectiella lateriflora var. lateriflora			Y

Scientific Name	Common Name	Riverine	Non-riverine
Schoenoplectiella mucronata		Y	Y
Schoenoplectus subulatus		Y	Y
Schoenus falcatus		Y	Y
Scleria pygmaea		Y	
Sphenoclea zeylanica		Y	Y
Spirodela oligorrhiza		Y	Y
Sporobolus virginicus	Sand couch		Y
Syzygium angophoroides		Y	Y
Tecticornia indica			Y
Tecticornia indica subsp. leiostachya			Y
Terminalia bursarina		Y	
Typha domingensis		Y	Y
Utricularia aurea	Golden bladderwort	Y	Y
Utricularia gibba	Floating bladderwort	Y	Y
Utricularia limosa			Y
Vallisneria australis		Y	Y
Vallisneria caulescens			Y
Vallisneria nana		Y	Y
Xyris complanata	Yellow-eye	Y	Y
Xyris oligantha			Y
Xyris pauciflora		Y	y

3.3 Near threatened and threatened flora

The panel identified three near-threatened or threatened flora taxa relevant to the riverine and non-riverine wetlands of study areas (Table 4). Only species judged to be aquatic, semi-aquatic or riparian dependent and scheduled as near threatened (NT), vulnerable (V), endangered (E), or critically endangered (CE) under the Queensland *Nature Conservation Act 1992* (NCA) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) were considered.

Point records for the listed species were used to pinpoint spatial units containing near-threatened or threatened flora taxa to calculate scores for AquaBAMM measure 4.1.2 (Presence of near threatened or threatened aquatic ecosystem dependent flora species — NCA, EPBC Act).

Table 4. Aquatic dependent near threatened and threatened flora taxa

Scientific Name	Common Name	Riverine	Non-riverine
Dichanthium setosum		Y	
Lobelia membranacea		Y	Y
Oldenlandia spathulata		Y	

3.4 Priority flora

Priority taxa are defined as those not listed as NT, V, E, or CE in Queensland or Commonwealth legislation but are considered important by the expert panel for the integrity of local aquatic ecosystems as they exhibit one or more of the following priority attributes:

1. It forms significant macrophyte beds (in shallow or deep water)
2. It is an important/critical food source
3. It is important/critical habitat
4. It is implicated in spawning or reproduction for other fauna and/or flora species.
5. It is at its distributional limit or is a disjunct population
6. It provides stream bank or bed stabilisation or has soil-binding properties
7. It is a small population and subject to threatening processes
8. Taxa vulnerable to impacts of climate change - Species that are considered to be adversely affected by the predicted changes in climate, e.g. increasing temperatures, sea level rise and increasing frequency of extreme weather events (drought, flood & cyclones).

The panel identified 55 priority flora taxa relevant to the riverine and non-riverine wetlands of the study areas (Table 5). Only species judged to be aquatic, semi-aquatic or riparian dependent were considered. Point records for the listed species were used to pinpoint spatial units containing priority flora taxa to calculate scores for AquaBAMM measure 5.1.2 (Presence of aquatic ecosystem dependent 'priority' flora species).

Table 5. Aquatic dependent priority flora taxa

Scientific Name	Common Name	Riverine	Non-riverine	Priority Attributes
Casuarina cunninghamiana		Y		2, 3, 6
Casuarina cunninghamiana subsp. cunninghamiana		Y		2, 3, 6
Cathormion umbellatum subsp. moniliforme		Y	Y	2
Cyperus exaltatus	Tall flatsedge	Y	Y	6
Duma florulenta			Y	3, 5
Eleocharis atropurpurea		Y	Y	2, 3, 4, 6
Eleocharis brassii			Y	2, 3, 4, 6
Eleocharis dulcis		Y	Y	1, 2, 3
Eleocharis geniculata			Y	2, 3, 4, 6
Eleocharis pallens	Pale spikerush	Y	Y	1
Eleocharis philippinensis		Y	Y	2, 3, 4, 6
Eleocharis spiralis		Y	Y	2, 3, 4, 6
Eucalyptus camaldulensis		Y	Y	2, 3, 6

Scientific Name	Common Name	Riverine	Non-riverine	Priority Attributes
Ficus racemosa		Y		2, 3, 6
Ficus racemosa var. racemosa		Y		2, 3, 6
Hydrilla verticillata	Hydrilla	Y	Y	1, 2, 3, 4
Livistona rigida		Y		2, 3, 4, 6
Ludwigia peploides subsp. montevidensis		Y	Y	1, 2, 3, 4, 6
Marsilea costulifera	Narrow-leaved nardoo	Y	Y	1, 2
Marsilea drummondii	Common nardoo	Y	Y	1, 2
Marsilea mutica	Shiny nardoo	Y	Y	1, 2
Melaleuca bracteata		Y	Y	3, 6
Melaleuca fluviatilis		Y		2, 3, 6
Melaleuca leucadendra	Broad-leaved tea-tree	Y		2, 3, 6
Melaleuca viminalis		Y		2, 3, 5, 6
Monochoria cyanea		Y	Y	1, 2, 3, 4
Myriophyllum dicoccum		Y	Y	1, 3
Myriophyllum filiforme		Y	Y	1, 3
Myriophyllum implicatum		Y	Y	1, 3
Myriophyllum verrucosum	Water milfoil	Y	Y	1, 2, 3, 4, 6
Najas graminea var. graminea				1, 3
Najas marina			Y	1, 3
Najas tenuifolia	Water nymph	Y	Y	1, 2, 3, 4
Nauclea orientalis	Leichhardt tree	Y		2, 6
Nymphaea carpentariae		Y	Y	1, 3
Nymphaea elleniae		Y	Y	1, 3
Nymphaea gigantea		Y	Y	1, 2, 3
Nymphaea immutabilis		Y	Y	1, 3
Nymphaea violacea		Y	Y	1, 2, 3
Nymphoides crenata	Wavy marshwort	Y	Y	1, 2, 3, 4
Nymphoides exiliflora		Y	Y	1, 3
Nymphoides indica	Water snowflake	Y	Y	1, 2, 3, 4
Oryza australiensis		Y	Y	1, 2, 3, 4, 6, 8

Scientific Name	Common Name	Riverine	Non-riverine	Priority Attributes
Ottelia alismoides		Y	Y	2
Pandanus aquaticus		Y		2, 3, 4, 6
Panicum trachyrhachis			Y	2, 3, 6
Persicaria barbata		Y	Y	2, 3, 6
Phragmites karka		Y	Y	2, 3, 6, 7, 8
Pseudoraphis spinescens	Spiny mudgrass	Y	Y	2, 3, 4, 6
Schoenoplectiella mucronata		Y	Y	2, 3, 4, 6
Sphenoclea zeylanica		Y	Y	1, 2, 5, 8
Typha domingensis		Y	Y	2, 3, 5, 6, 8
Vallisneria australis		Y	Y	1
Vallisneria caulescens			Y	1
Vallisneria nana		Y	Y	1, 2, 3, 4

4 Fauna

4.1 Exotic fauna

Exotic fauna species found in or likely to invade study area wetlands were evaluated by the panel. Only species known or suspected to cause significant detrimental impact to wetland habitat and/or native species were considered.

The panel identified seven exotic vertebrate fauna taxa impacting riverine or non-riverine wetlands within the study areas (Table 6). Pest distribution (species occurrence) maps produced by Biosecurity Queensland (Department of Agriculture and Fisheries) and point records for the listed species were used to pinpoint spatial units containing exotic vertebrate fauna taxa to calculate scores for the AquaBAMM measure 1.1.4 (Presence of feral/exotic vertebrate fauna (other than fish) within the wetland).

No 'alien' fish (AquaBAMM measure 1.1.1 (Presence of 'alien' fish species within the wetland)) or exotic invertebrate fauna (AquaBAMM measure 1.1.3 (Presence of exotic invertebrate fauna within the wetland)) species were nominated by the expert panel.

The panel also highlighted abundance and degree of infestation as important factors in determining the overall impact of exotic species on wetland ecosystems. The project team will attempt to incorporate information on abundance and degree of infestation information in future assessments, but we are limited by the reliability and currency of data published by the Department of Agriculture and Fisheries.

Table 6. Exotic fauna taxa impacting study area wetland values

Scientific Name	Common Name	Riverine	Non-riverine	M1.1.4
Bos indicus	Zebu	Y	Y	Y
Bos taurus	European cattle	Y	Y	Y
Canis familiaris	Dog	Y	Y	Y
Equus caballus	Horse	Y	Y	Y
Felis catus	Cat	Y	Y	Y
Rhinella marina	Cane toad	Y	Y	Y
Sus scrofa	Pig	Y	Y	Y

4.2 Fauna species richness

Fauna species richness (total number of species) was calculated using wetland dependent species. Wetland dependent fauna species were defined as:

Species that are adapted to and dependent on living in wet conditions for at least part of their life and are found either within or immediately adjoining a riverine, non-riverine or estuarine wetland.

4.2.1 Amphibian richness

The panel identified 29 native amphibian wetland indicator species relevant to the riverine and non-riverine wetlands of the study areas (Table 7). Point records for the listed species were used to pinpoint spatial units containing native amphibian taxa to calculate species richness scores for AquaBAMM measures 3.1.1 (Richness of native amphibians (riverine wetland breeders)) and 3.1.6 (Richness of native amphibians (non-riverine wetland breeders)).

Table 7. Aquatic dependent native amphibian taxa

Scientific Name	Common Name	M3.1.1 (Riverine)	M3.1.6 (Non-riverine)
Crinia bilingua	Bilingual froglet		Y
Crinia deserticola	Chirping froglet	Y	Y
Crinia remota	Northern froglet		Y
Cyclorana alboguttata	Greenstripe frog		Y
Cyclorana australis	Northern snapping frog		Y
Cyclorana brevipes	Superb collared frog		Y
Cyclorana cryptotis	Earless frog		Y
Cyclorana cultripes	Grassland collared frog		Y
Cyclorana maculosa	Spotted collared frog		Y
Cyclorana maini	Western collared frog	Y	Y
Cyclorana manya	Little collared frog		Y
Cyclorana novaehollandiae	Eastern snapping frog		Y
Limnodynastes tasmaniensis	Spotted grassfrog	Y	Y
Litoria bicolor	Northern dwarf treefrog	Y	
Litoria caerulea	Common green treefrog	Y	Y
Litoria coplandi	Sandstone frog	Y	Y
Litoria dahli	Dahl's aquatic frog	Y	
Litoria electrica	Buzzing treefrog	Y	Y
Litoria inermis	Bumpy rocketfrog	Y	Y
Litoria nasuta	Broad-palmed rocketfrog	Y	
Litoria pallida	Pallid rocketfrog	Y	Y
Litoria rothii	Northern laughing treefrog	Y	Y
Litoria rubella	Ruddy treefrog	Y	Y
Litoria watjulumensis	Giant rocketfrog	Y	Y
Notaden melanoscaphus	Brown shovelfoot		Y
Notaden nichollsi	Desert shovelfoot		Y
Platyplectrum ornatum	Ornate burrowing frog	Y	Y
Uperoleia inundata	Floodplain gungan		Y
Uperoleia lithomoda	Stomemason gungan		Y

Scientific Name	Common Name	M3.1.1 (Riverine)	M3.1.6 (Non-riverine)
Uperoleia trachyderma	Orange-shouldered gungan		Y

4.2.2 Fish richness

The panel identified 67 native fish taxa relevant to the riverine and non-riverine wetlands of the study areas (Table 8). Point records for the listed species were used to pinpoint spatial units containing native fish taxa to calculate species richness scores for AquaBAMM measure 3.1.2 (Richness of native fish).

Table 8. Aquatic dependent native fish taxa

Scientific Name	Common Name	Riverine	Non-riverine
Acanthopagrus berda/pacificus	Pikey bream	Y	
Ambassis agrammus	Sailfin glassfish	Y	Y
Ambassis elongatus	Elongate glassfish	Y	Y
Ambassis macleayi	Macleay's glassfish	Y	Y
Ambassis sp. 'Northwest' (mulleri)	Northwest glassfish	Y	Y
Amniataba caudavittata	Yellowtail grunter	Y	Y
Amniataba percoides	barred grunter	Y	Y
Anodontiglanis dahli	Toothless catfish	Y	Y
Arrhamphus sclerolepis	Snubnose garfish	Y	Y
Bostrychus zonatus	Sunset gudgeon	Y	
Brachirus salinarum	Saltpan sole	Y	Y
Brachirus selheimi	freshwater sole	Y	Y
Butis butis	Duckbill/upside down sleeper	Y	Y
Carcharhinus leucas	Bull shark	Y	
Chanos chanos	Milk fish	Y	
Chlamydogobius ranunculus	Tadpole goby		Y
Clupeoides cf paupuenus	Sprat	Y	Y
Craterocephalus munroi		Y	
Craterocephalus stercusmuscarum	Flyspecked hardyhead	Y	Y
Craterocephalus stramineus	Blackmast	Y	Y
Eleotris melanosoma	Black spine-cheek gudgeon	Y	
Elops hawaiensis/australis	Hawaiiang giant herring	Y	
Gerres filamentosus	Threadfin silverbiddy	Y	
Glossamia aprion	Mouth almighty	Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Glossogobius aureus	Golden flathead goby	Y	Y
Glossogobius giurus	Tank goby	Y	Y
Glossogobius munroi	Square-blotch/Munro's goby	Y	Y
Glossogobius sp. 2	Goby sp.	Y	Y
Hephaestus carbo	Coal grunter	Y	Y
Hephaestus fuliginosus	Sooty grunter	Y	Y
Kurtus gulliveri	Nurseryfish	Y	Y
Lates calcarifer	Barramundi	Y	Y
Leiognathus equulus	Common ponyfish	Y	
Leiopotherapon unicolor	Spangled perch	Y	Y
Liza alata	Diamond mullet	Y	
Megalops cyprinoides	Oxeye Herring/Tarpon	Y	Y
Melanotaenia splendida inornata	Checkered rainbowfish	Y	Y
Mogurnda mogurnda	Northern purple spotted gudgeon	Y	Y
Mugil cephalus	Flathead grey mullet	Y	
Nematalosa erebi	Bony bream	Y	Y
Neoarius berneyi	Highfin catfish	Y	
Neoarius graeffei	Blue catfish	Y	Y
Neoarius leptaspis	boofhead catfish	Y	Y
Neosilurus ater	Black catfish	Y	Y
Neosilurus hyrtlii	Hyrtl's catfish	Y	Y
Ophisternon gutturale	Swamp eel	Y	Y
Oxyeleotris lineolata	Sleepy cod	Y	Y
Oxyeleotris selheimi	Blackbanded gudgeon	Y	Y
Parambassis gulliveri	Giant glassfish	Y	Y
Porochilus rendahli	Rendahl's catfish	Y	Y
Prionobutis microps	Smalleye gudgeon	Y	Y
Pristis clavata		Y	
Pristis pristis	Freshwater sawfish	Y	Y
Pristis zijsron		Y	

Scientific Name	Common Name	Riverine	Non-riverine
Scatophagus argus	Spotted scat	Y	
Sciades leptaspis	Boofhead catfish	Y	Y
Sciades paucus	Shovelnose catfish	Y	Y
Scleropages jardinii	Northern saratoga		Y
Scortum ogilbyi	Gulf grunter	Y	Y
Selenotoca multifasciata	Striped scat	Y	
Strongylura krefftii	Freshwater longtom	Y	Y
Terapon jarbua	Crescent grunter	Y	
Thryssa scratchleyi	Freshwater thryssa	Y	Y
Toxotes chatareus	Sevenspot archerfish	Y	Y
Toxotes jaculatrix	Banded archerfish	Y	
Urogymnus dalyensis	Freshwater whipray	Y	
Zenarchopterus buffonis	Buffon's river garfish	Y	

4.2.3 Reptile richness

The panel identified 13 native reptile wetland dependent species relevant to the riverine and non-riverine wetlands of the study areas (Table 9). Point records for the listed species were used to pinpoint spatial units containing native reptile taxa to calculate scores for AquaBAMM measure 3.1.3 (Richness of native aquatic dependent reptiles).

Table 9. Aquatic dependent native reptile taxa

Scientific Name	Common Name	Riverine	Non-riverine
Acrochordus arafurae	Arafura file snake	Y	Y
Chelodina canni	Cann's longneck turtle		Y
Chelodina rugosa	Northern snake-necked turtle	Y	Y
Crocodylus johnstoni	Australian freshwater crocodile	Y	Y
Crocodylus porosus	Estuarine crocodile	Y	Y
Elseya lavarackorum	Gulf snapping turtle	Y	
Emydura subglobosa worrelli	Diamond head turtle	Y	Y
Liasis fuscus	Water python	Y	Y
Pseudoferania polylepis	Macleay's water snake	Y	Y
Tropidonophis mairii	Freshwater snake	Y	Y
Varanus mertensi	Mertens' water monitor	Y	Y
Varanus mitchelli	Mitchell's water monitor	Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Wollumbinia latisternum	Saw-shelled turtle	Y	

4.2.4 Waterbird richness

The panel identified 100 native bird wetland indicator species relevant to the riverine and non-riverine wetlands of the study areas (Table 10). Only bird species inhabiting freshwater wetland environments for all or part of their natural life functions were considered.

Point records for the listed species were used to pinpoint spatial units containing native bird taxa to calculate species richness scores for AquaBAMM measure 3.1.4 (Richness of native waterbirds).

Table 10. Aquatic dependent native bird taxa

Scientific Name	Common Name	Riverine	Non-riverine
Acrocephalus australis	Australian reed-warbler	Y	Y
Actitis hypoleucos	Common sandpiper	Y	Y
Amaurornis cinerea	White-browed crake	Y	Y
Anas castanea	Chestnut teal	Y	Y
Anas gracilis	Grey teal	Y	Y
Anas superciliosa	Pacific black duck	Y	Y
Anhinga novaehollandiae	Australasian darter	Y	Y
Anseranas semipalmata	Magpie goose	Y	Y
Ardea alba modesta	Eastern great egret	Y	Y
Ardea intermedia	Intermediate egret	Y	Y
Ardea pacifica	White-necked heron	Y	Y
Ardea sumatrana	Great-billed heron	Y	Y
Aythya australis	Hardhead	Y	Y
Biziura lobata	Musk duck	Y	Y
Bubulcus ibis	Cattle egret	Y	Y
Butorides striata	Striated heron	Y	Y
Calidris acuminata	Sharp-tailed sandpiper		Y
Calidris ferruginea	Curlew sandpiper	Y	Y
Calidris melanotos	Pectoral sandpiper		Y
Calidris ruficollis	Red-necked stint		Y
Calidris subminuta	Long-toed stint		Y
Ceyx azureus	Azure kingfisher	Y	Y
Ceyx pusillus	Little kingfisher	Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Charadrius ruficapillus	Red-capped plover	Y	Y
Chenonetta jubata	Australian wood duck	Y	Y
Chlidonias hybrida	Whiskered tern	Y	Y
Chlidonias leucopterus	White-winged black tern	Y	Y
Chroicocephalus novaehollandiae	Silver gull	Y	Y
Circus approximans	Swamp harrier	Y	Y
Cladorhynchus leucocephalus	Banded stilt		Y
Cygnus atratus	Black swan	Y	Y
Dendrocygna arcuata	Wandering whistling-duck	Y	Y
Dendrocygna eytoni	Plumed whistling-duck	Y	Y
Egretta garzetta	Little egret	Y	Y
Egretta novaehollandiae	White-faced heron	Y	Y
Egretta picata	Pied heron	Y	Y
Elseyornis melanops	Black-fronted dotterel	Y	Y
Ephippiorhynchus asiaticus	Black-necked stork	Y	Y
Epthianura crocea	Yellow chat		Y
Erythrogonys cinctus	Red-kneed dotterel	Y	Y
Erythrotriorchis radiatus	Red goshawk	Y	Y
Fulica atra	Eurasian coot	Y	Y
Gallinago hardwickii	Latham's snipe	Y	Y
Gallinago megala	Swinhoe's snipe	Y	Y
Gallinula tenebrosa	Dusky moorhen	Y	Y
Gallirallus philippensis	Buff-banded rail	Y	Y
Gelochelidon nilotica	Gull-billed tern	Y	Y
Grus antigone	Sarus crane	Y	Y
Grus rubicunda	Brolga	Y	Y
Haematopus longirostris	Australian pied oystercatcher	Y	Y
Haliaeetus leucogaster	White-bellied sea-eagle	Y	Y
Haliastur indus	Brahminy kite	Y	Y
Himantopus himantopus	Black-winged stilt	Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Hydroprogne caspia	Caspian tern	Y	Y
Irediparra gallinacea	Comb-crested jacana	Y	Y
Ixobrychus flavicollis	Black bittern	Y	Y
Limosa limosa	Black-tailed godwit	Y	Y
Malacorhynchus membranaceus	Pink-eared duck	Y	Y
Malurus coronatus	Purple-crowned fairy-wren	Y	
Microcarbo melanoleucos	Little pied cormorant	Y	Y
Myiagra alecto	Shining flycatcher	Y	
Neochmia phaeton phaeton	Crimson finch	Y	Y
Neochmia ruficauda	Star finch	Y	Y
Nettapus coromandelianus	Cotton pygmy-goose	Y	Y
Nettapus pulchellus	Green pygmy-goose	Y	Y
Nycticorax caledonicus	Nankeen night-heron	Y	Y
Oxyura australis	Blue-billed duck		Y
Pandion cristatus	Eastern osprey	Y	Y
Pelecanus conspicillatus	Australian pelican	Y	Y
Phalacrocorax carbo	Great cormorant	Y	Y
Phalacrocorax sulcirostris	Little Black cormorant	Y	Y
Phalacrocorax varius	Pied cormorant	Y	Y
Platalea flavipes	Yellow-billed spoonbill	Y	Y
Platalea regia	Royal spoonbill	Y	Y
Plegadis falcinellus	Glossy ibis	Y	Y
Pluvialis fulva	Pacific golden plover	Y	Y
Podiceps cristatus	Great crested grebe	Y	Y
Poliocephalus poliocephalus	Hoary-headed grebe	Y	Y
Porphyrio melanotus	Australasian swamphen	Y	Y
Porzana fluminea	Australian spotted crake	Y	Y
Porzana pusilla	Baillon's crake	Y	Y
Porzana tabuensis	Spotless crake	Y	Y
Ramsayornis fasciatus	Bar-breasted honeyeater	Y	Y

Scientific Name	Common Name	Riverine	Non-riverine
Recurvirostra novaehollandiae	Red-necked avocet	Y	Y
Rostratula australis	Australian painted snipe	Y	Y
Spatula querquedula	Garganey	Y	Y
Spatula rhynchotis	Australasian shoveler	Y	Y
Stictonetta naevosa	Freckled duck	Y	Y
Tachybaptus novaehollandiae	Australasian grebe	Y	Y
Tadorna radjah	Radjah shelduck	Y	Y
Tadorna tadornoides	Australian shelduck	Y	Y
Thalasseus bergii	Crested tern	Y	Y
Threskiornis molucca	Australian white ibis	Y	Y
Threskiornis spinicollis	Straw-necked ibis	Y	Y
Todiramphus sordidus	Torresian kingfisher	Y	Y
Tribonyx ventralis	Black-tailed native-hen	Y	Y
Tringa glareola	Wood sandpiper		Y
Tringa nebularia	Common greenshank	Y	Y
Tringa stagnatilis	Marsh sandpiper	Y	Y
Vanellus miles	Masked lapwing	Y	Y

4.2.5 Mammal richness

Only two mammal taxa were considered by the panel to be aquatic dependent and relevant to the riverine and non-riverine wetlands of the study areas (Table 11). Point records for the listed species were used to pinpoint spatial units containing mammal taxa to calculate species richness scores for AquaBAMM measure 3.1.7 (Richness of native aquatic dependent mammals).

Table 11. Aquatic dependent native mammal taxa

Scientific Name	Common Name	Riverine	Non-riverine
Hydromys chrysogaster	Water rat	Y	Y
Myotis macropus	Large-footed myotis	Y	Y

4.2.6 Macroinvertebrate richness

The panel advised against using wetland-dependent macroinvertebrate taxa lists to calculate macroinvertebrate diversity for the study areas. They based this recommendation on the lack of detailed macroinvertebrate surveys across the region. Past ACAs have used maximum richness scores derived from higher-level macroinvertebrates studies undertaken using recognised survey and analysis methods (e.g. such as those used by Conrick & Cockayne 2000, Chessman 2003, and Healthy Waterways 2012). Such methods estimate macroinvertebrate diversity at the broad taxonomic group level (e.g. sub-family, family, order or class), and the panel felt such an approach would provide the best available representation of macroinvertebrate richness for the study areas. This type of data was not available for the Southern Gulf Catchments assessments.

While specific taxa were not listed for AquaBAMM measure 3.2.1, experts were still invited to nominate individual Priority macroinvertebrate species for measure 5.1.1 (See section 3.4.1).

Maximum macroinvertebrate richness values were used to estimate macroinvertebrate richness for AquaBAMM measure 3.2.1 (Richness of macroinvertebrate taxa).

4.3 Near threatened and threatened fauna

The panel identified 11 near threatened or threatened fauna taxa relevant to the riverine and non-riverine wetlands of the study areas (Table 12). Only species judged to be aquatic, semi-aquatic or riparian dependent and scheduled as NT, V, E, or CE under the NCA or the EPBC Act were considered.

Point records for the listed species were used to pinpoint spatial units containing near threatened or threatened fauna taxa to calculate scores for AquaBAMM measure 4.1.1 (Presence of rare or threatened aquatic ecosystem dependent fauna species — NCA, EPBC Act).

Table 12. Aquatic dependent near threatened and threatened fauna taxa

Scientific Name	Common Name	Riverine	Non-riverine	NCA	EPBC Act
Calidris ferruginea	Curlew sandpiper	Y	Y	E	CE
Crocodylus porosus	Estuarine crocodile	Y	Y	V	
Elseya lavarackorum	Gulf snapping turtle	Y		V	E
Emydura subglobosa worrelli	Diamond head turtle	Y	Y	NT	
Epthianura crocea	Yellow chat		Y	V	
Erythrotriorchis radiatus	Red goshawk	Y	Y	E	V
Malurus coronatus	Purple-crowned fairy-wren	Y		V	
Pristis clavata		Y			V
Pristis pristis	Freshwater sawfish	Y	Y		V
Pristis zijsron		Y			V
Rostratula australis	Australian painted snipe	Y	Y	E	E

4.4 Priority fauna

The panel deliberated on all aquatic-dependent fauna species within the study areas to identify priority fauna. Priority taxa are defined as those not listed as NT, V, E, or CE in Queensland or Commonwealth legislation but are considered significant within the study region as they exhibit one or more of the following attributes:

1. It is endemic to the study area (>75% of its distribution is in the study area/catchment)
2. It has experienced, or is suspected of experiencing, a serious population decline
3. It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment
4. It is currently a small population and threatened by loss of habitat
5. It is a significant disjunct population
6. It is a migratory species (other than birds)
7. A significant proportion of the breeding population (>1% for waterbirds, >75% other species) occurs in the waterbody (see Ramsar Criterion 6 for waterbirds)
8. Taxa vulnerable to impacts of climate change - Species that are considered to be adversely affected by the predicted changes in climate, e.g. increasing temperatures, sea level rise and increasing frequency of extreme weather events (drought, flood & cyclones). Species can only be listed under this reason if there is sufficient knowledge of species' biology and its interaction with climate that would support an assessed impact under climate change scenarios.

4.4.1 Priority species

The panel identified twenty-two priority fauna taxa relevant to the riverine and non-riverine wetlands of study areas (Table 13). Point records for the listed species were used to pinpoint spatial units containing priority fauna taxa to calculate scores for AquaBAMM measure 5.1.1 (Presence of aquatic ecosystem dependent 'priority' fauna species).

Table 13. Aquatic dependent priority fauna taxa

Scientific Name	Common Name	Riverine	Non-riverine	Priority Attributes	Panel Comments
Acrochordus arafurae	Arafura file snake	Y	Y	2	Declines due to feral pig (*Sus scrofa*) predation (Fordham et al. 2006).
Ambassis elongatus	Elongate glassfish	Y	Y	1	The species is restricted to Gulf catchments.
Calidris acuminata	Sharp-tailed sandpiper		Y	7	Large population at Morning Inlet catchment.
Calidris ruficollis	Red-necked stint		Y	7	Seasonal concentrations of species e.g. Buffalo Lake in Morning Inlet catchment. Population can be very high at times.
Carcharhinus leucas	Bull shark	Y		2,6	This species is an apex predator. Juveniles remain in freshwater for first 4 or 5 years and as adult, then move into estuaries. Migratory species in this context.
Chelodina rugosa	Northern snake-necked turtle	Y	Y	2,4	Impacted by feral pigs (*Sus scrofa*) (population declines as in the Cape York Peninsula) according to traditional owners.
Crinia bilingua	Bilingual froglet		Y	1	Occurs widely in northern Australia, but within Queensland the species is endemic to the Southern Gulf Catchments.
Hephaestus fuliginosus	Sooty grunter	Y	Y	6	Migratory within main channel. Uses riffles and runs as spawning grounds.
Lates calcarifer	Barramundi	Y	Y	6	This species is massively abundant and is the best example of a migratory fish species in northern Australia.
Leiopotherapon unicolor	Spangled perch	Y	Y	6	This species colonises during flooding and persists where other species can't.
Litoria coplandi	Sandstone frog	Y	Y	1	Occurs widely in northern Australia, but within Queensland the species is endemic to the Southern Gulf Catchments.
Litoria electrica	Buzzing treefrog	Y	Y	1	Near endemic (also occurs in catchments to the south) but more than 75% of distribution

Scientific Name	Common Name	Riverine	Non-riverine	Priority Attributes	Panel Comments
					likely to be in study area (HH).
Litoria watjulumensis	Giant rocketfrog	Y	Y	1	Occurs widely in northern Australia, but within Queensland the species is endemic to the Southern Gulf Catchments.
Neosilurus ater	Black catfish	Y	Y	6,8	Moves into ephemeral creeks to breed.
Neosilurus hyrtlii	Hyrtl's catfish	Y	Y	6,8	Moves into ephemeral creeks to breed.
Notaden nichollsi	Desert shovelfoot		Y	5	A small, disjunct population.
Scortum ogilbyi	Gulf grunter	Y	Y	1	Largely endemic to the Southern Gulf Catchments.
Strongylura krefftii	Freshwater longtom	Y	Y	6	This species can access a range of habitats, and spawns under low or no flow. This species is very unlike other fish species in the region.
Tringa stagnatilis	Marsh sandpiper	Y	Y	7	Seasonal concentration of species e.g. Buffalo Lake in Morning Inlet. Population can be very high at times (PD, GM)
Urogymnus dalyensis	Freshwater whipray	Y		4	This species is poorly known. It is one of only 3-4 obligate freshwater *Elasmobrachii*, and the only freshwater stingray in Australia. Species has a stronghold in the Gulf catchments.
Varanus mertensi	Mertens' water monitor	Y	Y	2	Impacted by Cane Toads (*Rhinella marina*). May be making a recovery in the Cape York Peninsula.
Varanus mitchelli	Mitchell's water monitor	Y	Y	2	Impacted by Cane Toads (*Rhinella marina*). Particularly threatened, low numbers of records (AF).

4.4.2 Migratory species

In addition to the priority species identified above, the panel nominated migratory species for inclusion in AquaBAMM measure 5.1.3. Only species listed under the Convention on Migratory Species (Bonn), Japan Australia Migratory Bird Agreement (JAMBA), the China Australia Migratory Bird Agreement (CAMBA), or Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) as significant fauna taxa were considered.

The panel identified twenty-six seven migratory species relevant to the riverine and non-riverine wetlands of the study areas (Table 14). Point records for the listed species were used to pinpoint spatial units containing migratory taxa to calculate the scores for AquaBAMM measure 5.1.3 (Habitat for, or presence of, migratory species).

Table 14. Migratory taxa listed on international agreements

Scientific Name	Common Name	Riverine	Non-riverine	Convention
Actitis hypoleucos	Common sandpiper	Y	Y	M-C/J/R/B/E
Calidris acuminata	Sharp-tailed sandpiper		Y	M-C/J/R/B/E
Calidris ferruginea	Curlew sandpiper	Y	Y	M-C/J/R/B/E
Calidris melanotos	Pectoral sandpiper		Y	M-J/R/B/E
Calidris ruficollis	Red-necked stint		Y	M-C/J/R/B/E
Calidris subminuta	Long-toed stint		Y	M-C/J/R/B/E
Carcharhinus leucas	Bull shark	Y		Panel
Chlidonias leucopterus	White-winged black tern	Y	Y	M-C/J/R/E
Crocodylus porosus	Estuarine crocodile	Y	Y	M-B/E
Gallinago hardwickii	Latham's snipe	Y	Y	M-J/R/B/E
Gallinago megala	Swinhoe's snipe	Y	Y	M-C/J/R/B/E
Gelochelidon nilotica	Gull-billed tern	Y	Y	M-C/E
Hydroprogne caspia	Caspian tern	Y	Y	M-J/E
Lates calcarifer	Barramundi	Y	Y	Panel
Limosa limosa	Black-tailed godwit	Y	Y	M-C/J/R/B/E
Pandion cristatus	Eastern osprey	Y	Y	M-B/E
Plegadis falcinellus	Glossy ibis	Y	Y	M-B/E
Pluvialis fulva	Pacific golden plover	Y	Y	M-C/J/R/B/E
Pristis clavata	Dwarf sawfish	Y		M-B/E
Pristis pristis	Freshwater sawfish	Y	Y	M-B/E
Pristis zijsron	Green sawfish	Y		M-B/E
Spatula querquedula	Garganey	Y	Y	M-C/J/R/B/E
Thalasseus bergii	Crested tern	Y	Y	M-J/E
Tringa glareola	Wood sandpiper		Y	M-C/J/R/B/E
Tringa nebularia	Common greenshank	Y	Y	M-C/J/R/B/E
Tringa stagnatilis	Marsh sandpiper	Y	Y	M-C/J/R/B/E

5 Springs

A distinct hydrological component of the study areas are the deep artesian groundwater systems operating almost entirely independent of shallower surface water alluvial aquifers. Artesian water emanating from these result in numerous spring systems displaying unique geomorphic appearances and specialised habitats of high intrinsic conservation value (Fensham 2006).

Spring wetlands were not assessed as part of the Southern Gulf Catchments assessments. In the absence of an Aquatic Conservation Assessment for spring wetlands, the reader is referred to the Queensland spring database published by the Queensland Herbarium (Queensland Herbarium 2020). This database provides comprehensive data on the condition, threats and biodiversity values associated with springs within the database. The database also includes a conservation priority rating for springs within the Great Artesian Basin. These ratings were developed by Fensham and Fairfax (2005) and are based on the following criteria:

- Category 1a: These spring wetlands provide habitat for biota endemic to one spring complex.
- Category 1b: These spring wetlands provide habitat for biota endemic to more than one spring complex.
- Category 1c: These spring wetlands provide habitat for species listed under State or Commonwealth legislation (except *Callistemon* sp. Boulia (L. Pedley 5297) which is listed as vulnerable under the EPBC and has since been identified as the common species *C. viminalis*).
- Category 2: These spring wetlands provide habitat for some isolated populations of plant species, or are outstanding examples of their type.
- Category 3: Any spring of lower value than above that is relatively intact.
- Category 4: Severely degraded by any threatening processes.

The Southern Gulf Catchments assessments assigned value to non-riverine spatial units containing springs under Criterion 6 (Special and Unique Values). Conservation value ratings were assigned to measures 6.3.1, 6.3.4 and 7.2.1 based on the conservation rating developed by Fensham and Fairfax (2005) and Fensham (2006). For example, non-riverine spatial units intersection springs with a conservation rating of 1a, 1b, 1c or 2 were given a conservation value rating of 4 for measures 6.3.1, 6.3.4 and 7.2.1. Non-riverine spatial units intersection springs with a conservation rating of 1a, 1b, 1c or 2 were given a conservation value rating of 4 for measures 6.3.1, 6.3.4 and 7.2.1.

6 Special Features

6.1 Special Features

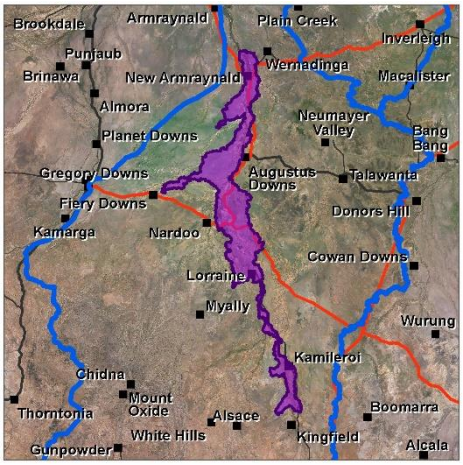
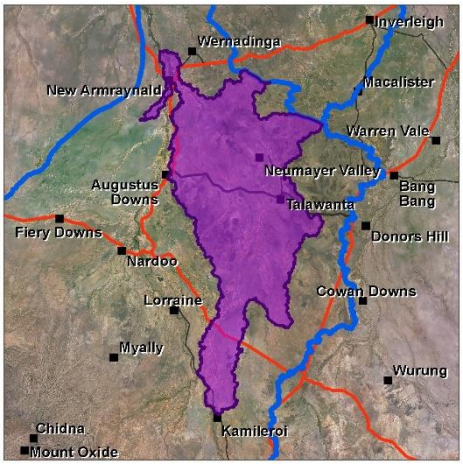
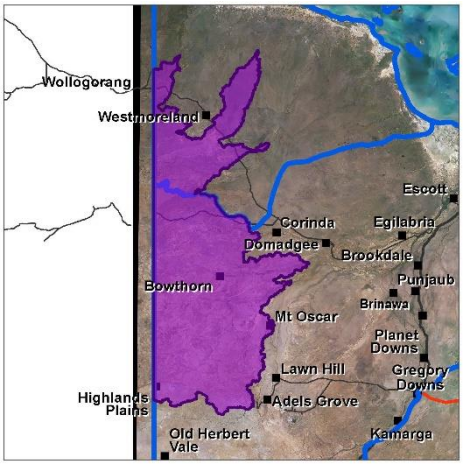
The flora, fauna and ecology expert panels were asked to identify special and unique features relevant to the riverine and non-riverine wetlands within each study area. Expert panel derived special features are used to calculate scores for the following AquaBAMM measures:

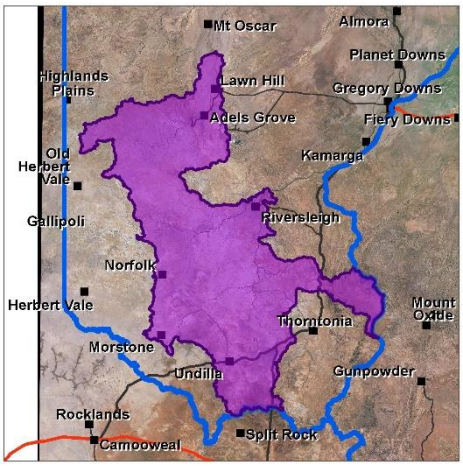
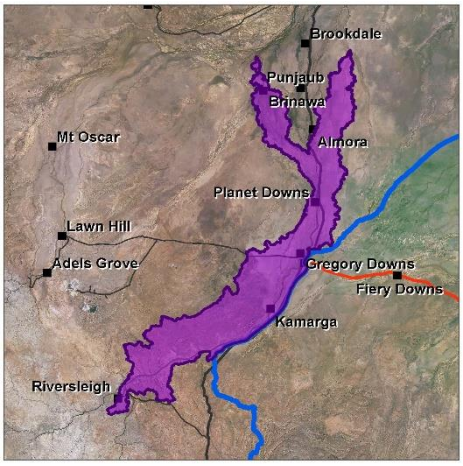
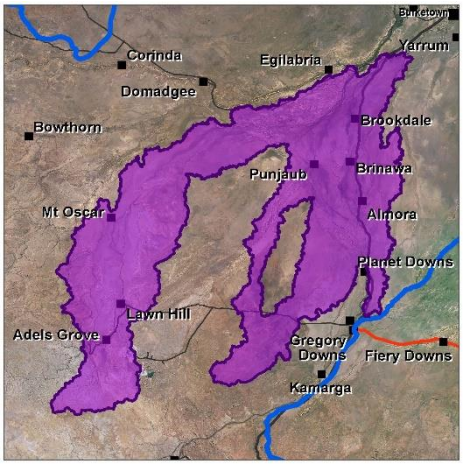
- 5.1.4 (Habitat for significant numbers of waterbirds)
- 5.2.1 (Presence of 'priority' aquatic ecosystem)
- 6.1.1 (Presence of distinct, unique or special geomorphic features)
- 6.2.1 (Presence of or requirement for distinct, unique or special ecological processes)
- 6.2.2 (Proportion of the wetland subject to community shifts from natural e.g. mangrove encroachment)
- 6.3.1 (Presence of distinct, unique or special habitat, including habitat that functions as refugia or other critical purpose)
- 6.3.3 (Ecologically significant wetlands identified through expert opinion and/or documented study)
- 6.3.4 (Areas important as refugia from the predicted effects of climate change (e.g. source of species re-population)
- 6.4.1 (Presence of distinct, unique or special hydrological regimes, e.g. spring fed stream, ephemeral stream or boggomoss)
- 8.2.5 (Wetland type representative of the study area).

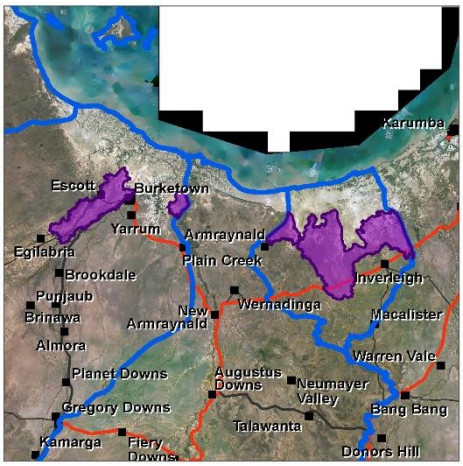
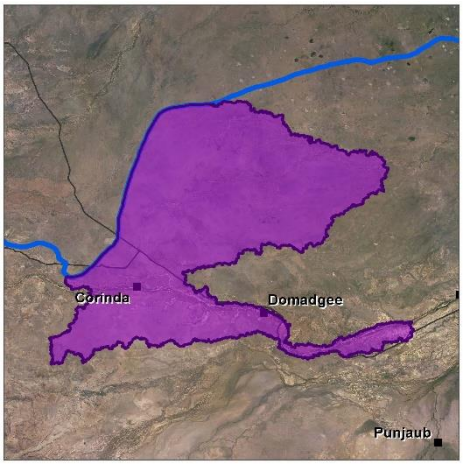
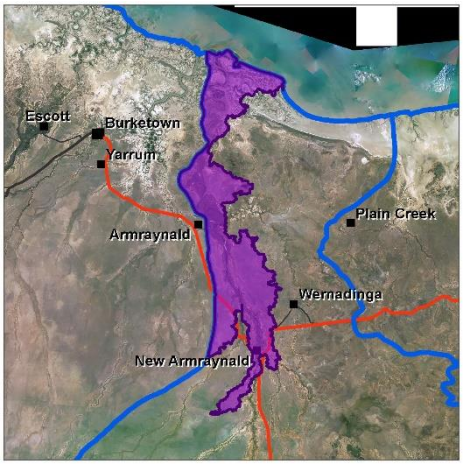
Where a single special feature decision crossed more than one study area, the special feature was implemented separately in each study area. Special features were assigned a conservation rating between 3 (i.e. High) and 4 (i.e. Very High). Areas having multiple values (e.g. flora and fauna values) were consolidated and implemented as ecology special feature decisions. Decisions that were not able to be implemented due to uncertainty or a lack of available data are indicated as "Not Implemented" in the special feature tables.

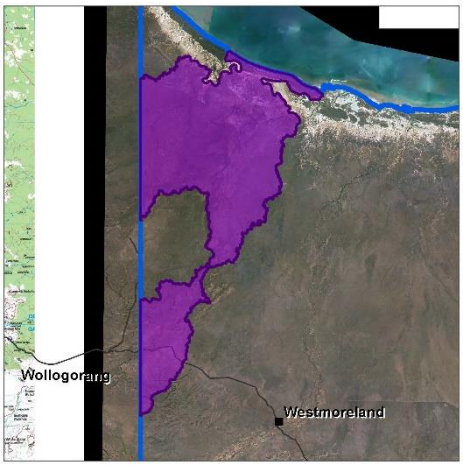
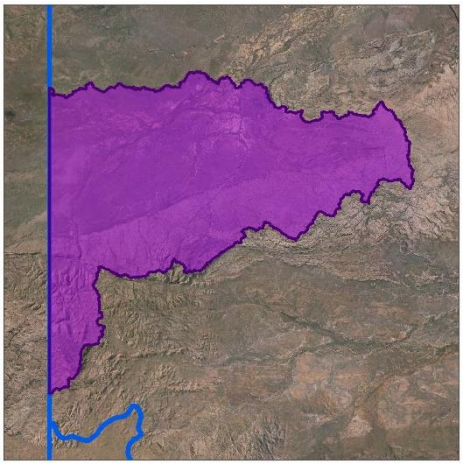
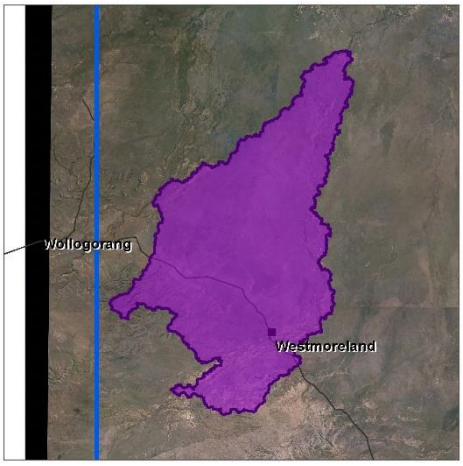
The riverine and non-riverine special features identified by the Southern Gulf Catchments expert panels are listed in Table 15 and Table 16 respectively. Each feature may have fauna, flora and/or ecology values, either singularly or in combination. For detailed descriptions of decision values refer to Appendix III - Detailed Special Features Descriptions.

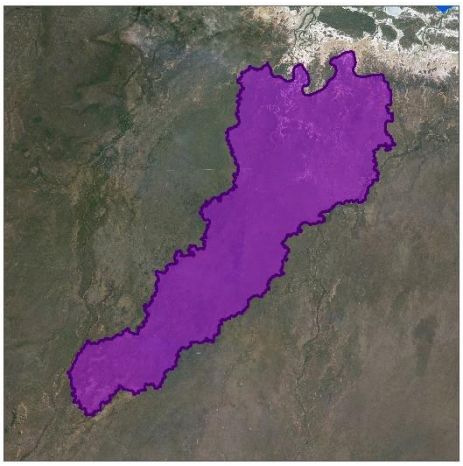
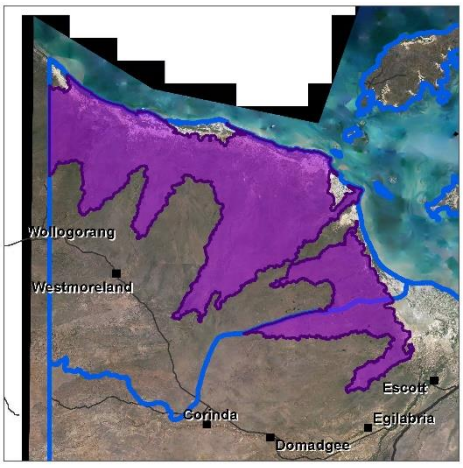
Table 15. Riverine special features and their values

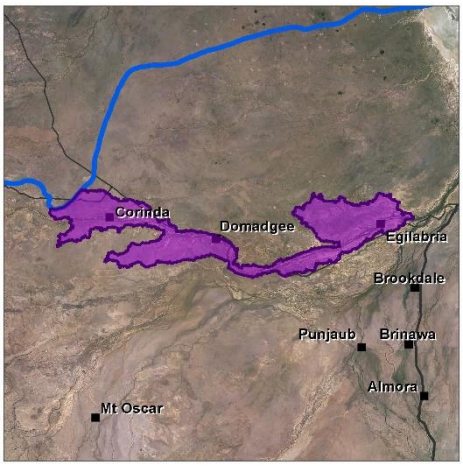
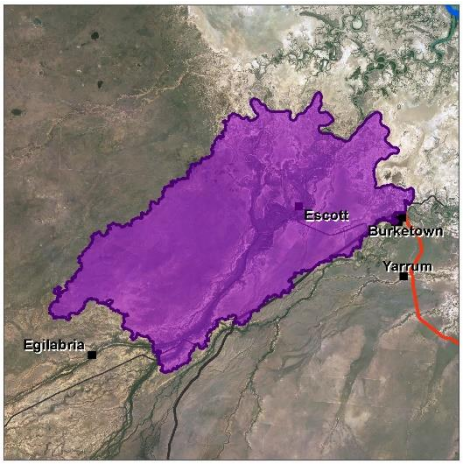
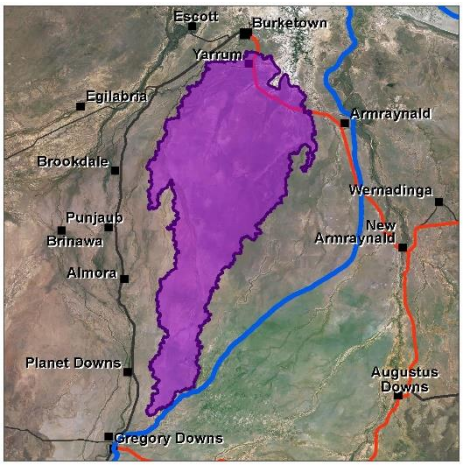
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Leichhardt lowland riverine system		Leichhardt			Y	lr_r_ec_03	5.1.4 6.2.1 6.3.1 6.3.4 7.1.1 7.1.2 7.2.1 7.3.1 7.3.2 7.4.1	4 4 4 4 4 4 4 4 4 4
Alexandra lowland riverine system		Leichhardt			Y	lr_r_ec_04	5.1.4 6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.2.1 7.3.1 7.3.2 7.4.1	4 4 4 4 4 4 4 4 4 4 4 4 4
Perennial aquatic habitats within the sedimentary hills and plateaus of the McArthur subregion		Nicholson Settlement			Y	nr_r_ec_06	5.2.1 6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.2 7.4.1 8.2.5	4 4 4 3 4 4 4 4 4 4 4 4 4 4

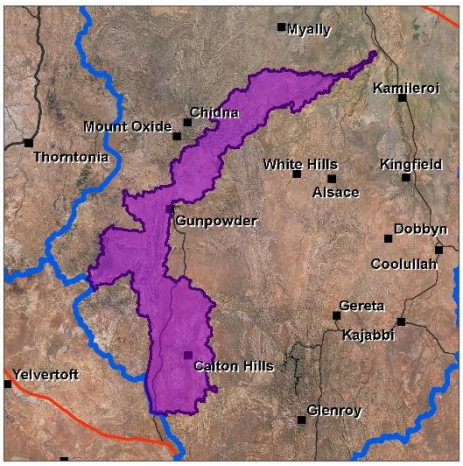
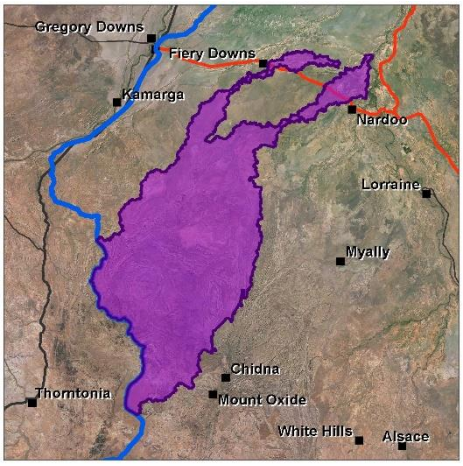
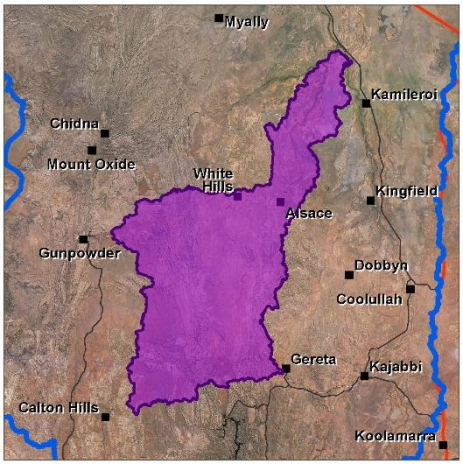
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Perennial instream habitats associated with limestone springs of the Thorntonia subregion		Nicholson			Y	nr_r_ec_07	6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.1 7.3.2 7.4.1 7.5.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
Alluvial levee riparian forests of the lower Gregory River system		Nicholson			Y	nr_r_ec_08	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4
Limestone spring supplied perennial channels and waterholes on the Armraynald Plains subregion within the lower Lawn Hill creek and Gregory River subcatchments		Nicholson			Y	nr_r_ec_09	5.1.4 6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4

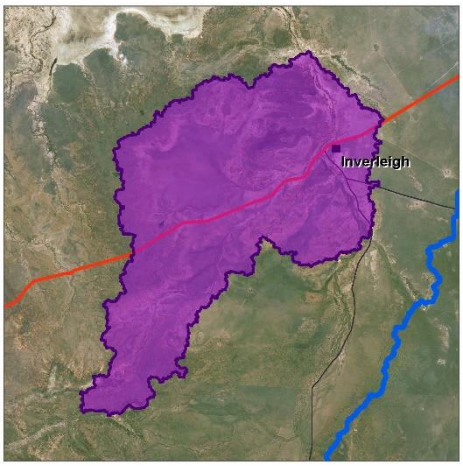
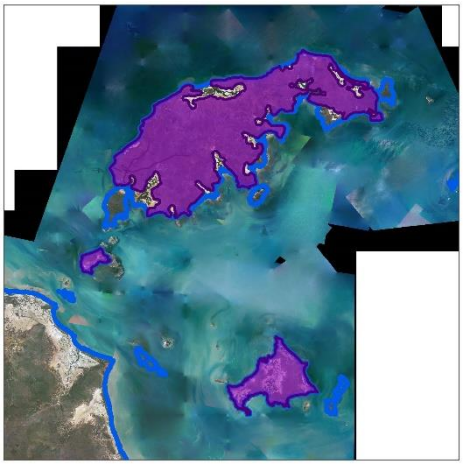
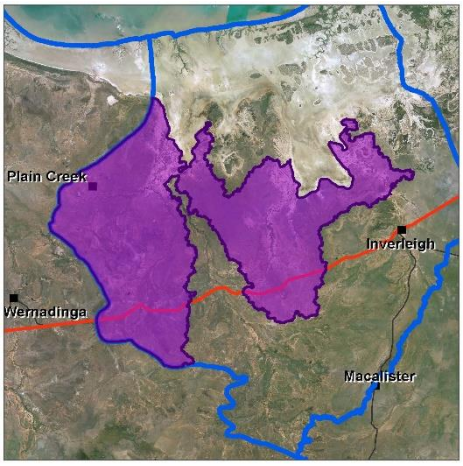
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Transitional areas adjacent to estuarine zone		Leichhardt Morning Inlet Nicholson Settlement Wellesley Islands			Y	md_r_ec_11 nr_r_ec_11	5.2.1 6.3.4 7.1.1 7.3.1 7.5.1	3 3 3 3 3
Creek headwater cut Tertiary surface steeps of the Doomadgee Plains subregion		Nicholson			Y	nr_r_ec_12	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.2.1 7.3.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4
Wetlands on Leichhardt River scroll belt		Leichhardt			Y	lr_r_ec_13	5.1.4 6.1.1 6.2.1 6.3.1 7.1.1 7.1.2 7.1.3 7.3.2 7.4.1 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4

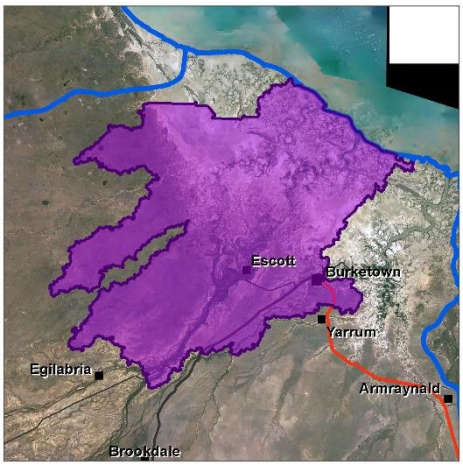
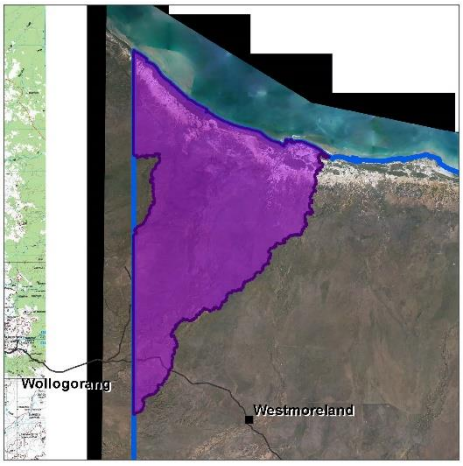
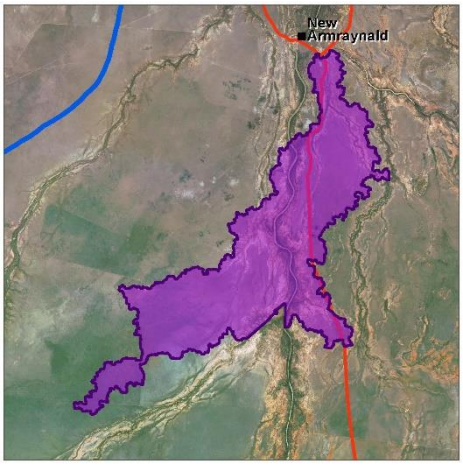
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Perennial channel hosted waterholes of the western Settlement Creek Basin		Settlement			Y	sc_r_ec_15	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.2.1 7.3.2	4 4 4 4 4 4 4 4 4
Westmoreland Gorges complex		Settlement			Y	sc_r_ec_16	5.2.1 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 3 4 4 4 4
Perennial instream waterholes of lower Lagoon creek		Settlement			Y	sc_r_ec_17	5.1.4 5.2.1 6.1.1 6.2.1 6.3.1 6.4.1 7.1.1 7.1.2 7.1.3 7.3.1 7.3.2 7.4.1	4 4 4 4 4 4 4 3 4 4 4 4

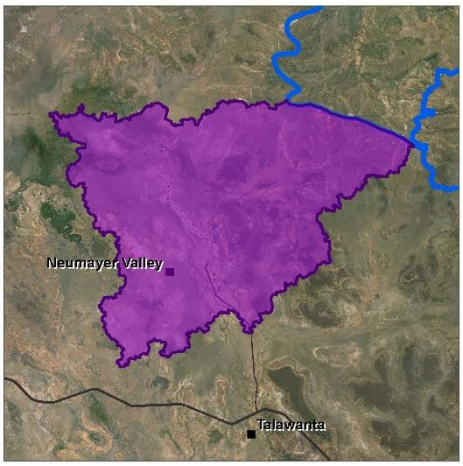
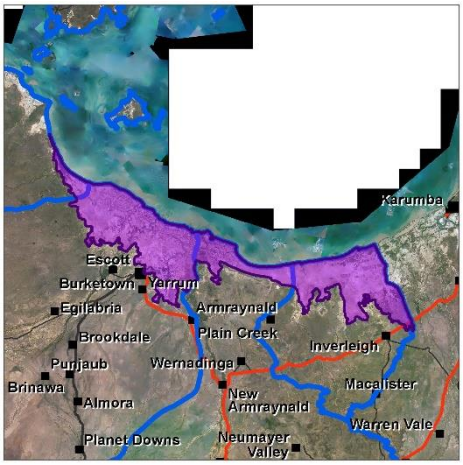
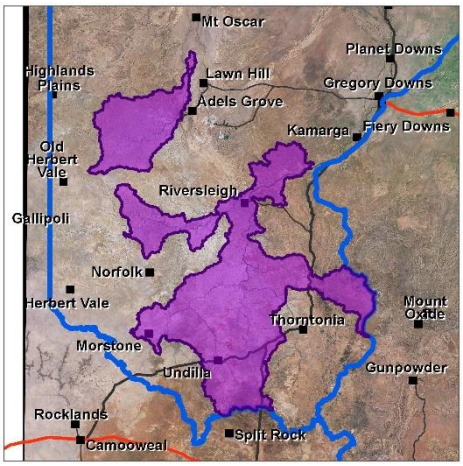
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Troutbeck Lagoon wetland complex		Settlement			Y	sc_r_ec_18	5.1.4 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.2 7.4.1	4 4 4 4 4 4 4 4
Permanent instream waterholes of Cliffdale creek system		Settlement			Y	sc_r_ec_21	5.1.4 6.1.1 6.2.1 6.3.1 6.4.1 7.1.1 7.1.2 7.1.3 7.3.1 7.3.2 7.4.1	4 4 4 4 4 4 4 3 4 4 4
Lateritic barrier pools		Nicholson Settlement			Y	nr_r_ec_24 sc_r_ec_24	5.1.4 6.1.1 6.2.1 6.3.1 6.4.1 7.1.1 7.1.2 7.1.3 7.5.1 7.5.2	4 4 4 4 4 4 4 4 4 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Permanent Nicholson River waterholes hosted within the Gulf Plains Bioregion		Nicholson			Y	nr_r_ec_25	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 3 4 4 4 4 4 4
Nicholson River channel habitats below Gregory River confluence		Nicholson			Y	nr_r_ec_26	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.3.1 7.3.2 7.4.1 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 3 4 4 3 4 4 4 4
Ephemeral creeks with Tertiary clay plain catchments		Nicholson			Y	nr_r_ec_27	6.1.1 6.2.1 6.3.1 6.4.1 7.4.1 8.2.5	4 3 3 4 3 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Perennial instream waterholes in Gunpowder creek		Leichhardt			Y	lr_r_ec_29	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.2.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4
Perennial waterholes in north west headwaters of the Leichhardt Basin		Leichhardt			Y	lr_r_ec_30	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.2.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4
Perennial waterholes in central southern headwaters of the Leichhardt Basin		Leichhardt			Y	lr_r_ec_31	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.2.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Inverleigh Dam aggregation		Morning Inlet			Y	mi_r_ec_34	5.1.4 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.3 8.2.5	4 4 4 4 4 3 4 4
Perennial to semi-perennial riverine waterholes hosted in ferricrete channel reaches		Wellesley Islands			Y	md_r_ec_39	6.1.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.2.1 7.3.1 7.3.2 7.4.1 7.5.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4
Fluctuating freshwater to hypersaline instream waterbodies in Morning Inlet Basin		Morning Inlet			Y	mi_r_ec_52	5.1.4 6.1.1 6.2.1 6.3.1 6.3.3 6.4.1 7.1.1 7.1.2 7.1.3 7.3.2 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 3 3 4 4 4 3 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Nicholson Delta Wetland Aggregation		Nicholson			Y	nr_r_ec_53	5.1.4 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.1 7.3.2 7.4.1 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
Wentworth Aggregation		Settlement			Y	sc_r_ec_57	5.1.4 6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.3.1 7.3.2 7.4.1 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
Washpool Waterhole		Leichhardt		Y		lr_r_fa_18	5.1.4 6.3.1	3 3

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Significant bird and turtle rookeries on the Alexandra River		Leichhardt		Y		lr_r_fa_19	5.1.4 6.3.1	4 4
Important Bird Areas (IBA) - Migratory wader and waterbird roosting, feeding and breeding sites		Leichhardt Mornington Inlet Nicholson Settlement		Y		lr_r_fa_20 mi_r_fa_20 nr_r_fa_20 sc_r_fa_20	5.1.4 6.2.1 6.3.1 6.3.4	4 4 4 4
Riparian vegetation fringing perennial deep spring-fed waterholes in lime stone gorges		Nicholson	Y			nr_r_fl_01	6.1.1 6.2.1 6.3.1 6.3.4 6.4.1	4 4 4 4 4

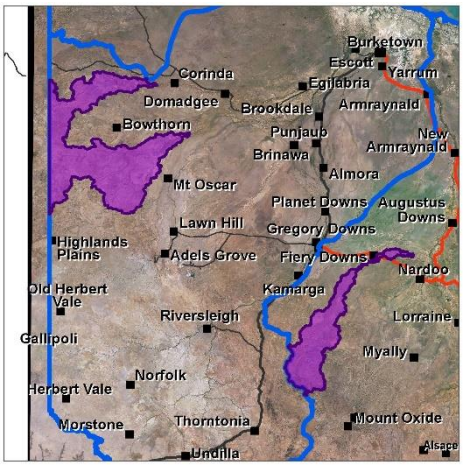
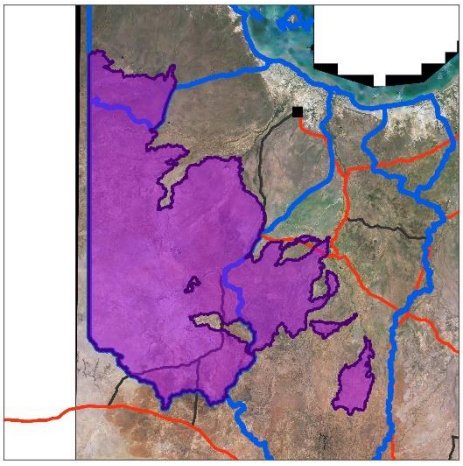
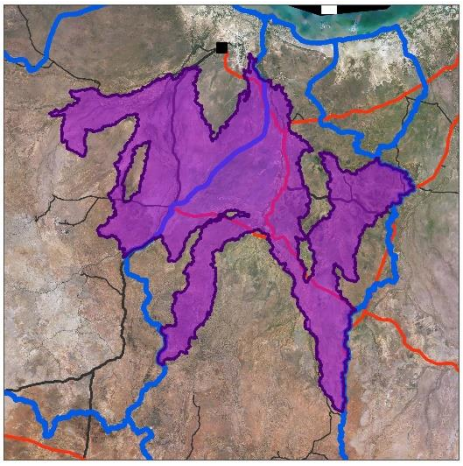
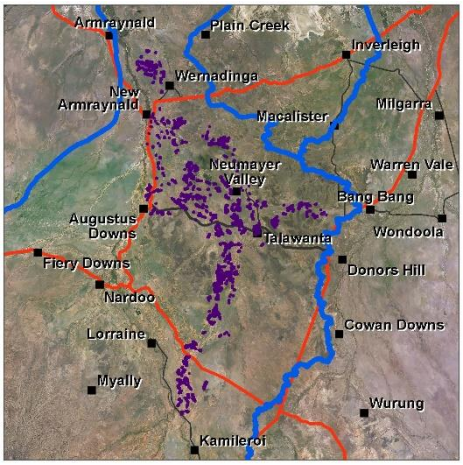
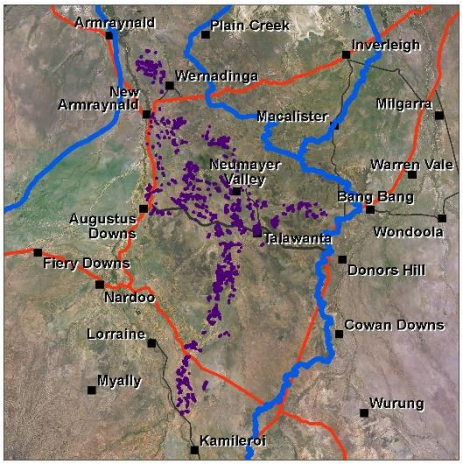
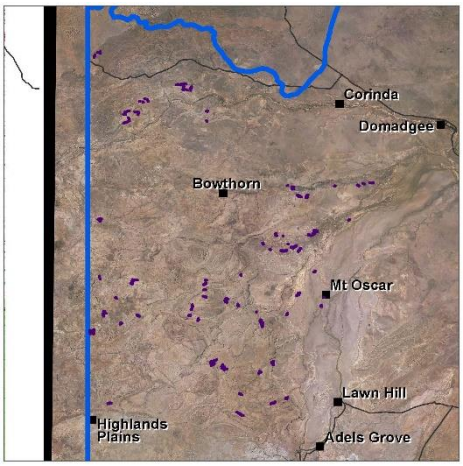
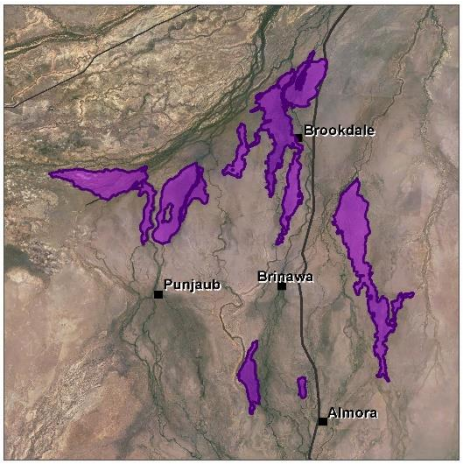
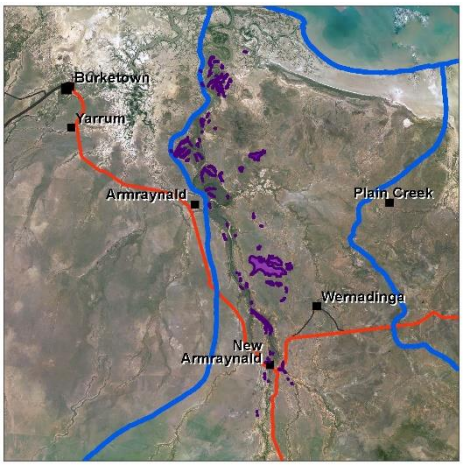
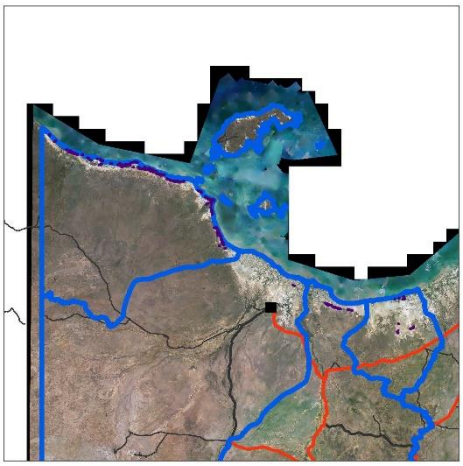
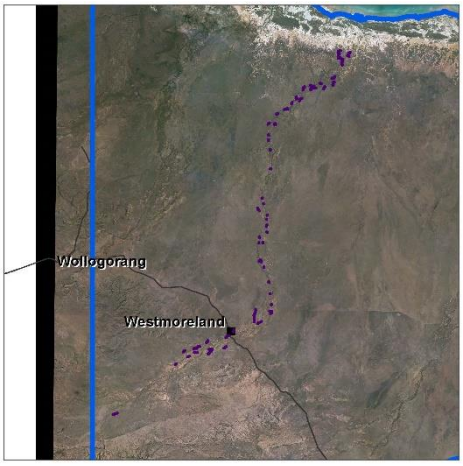
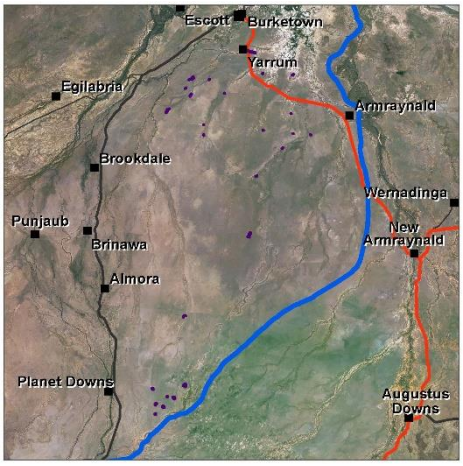
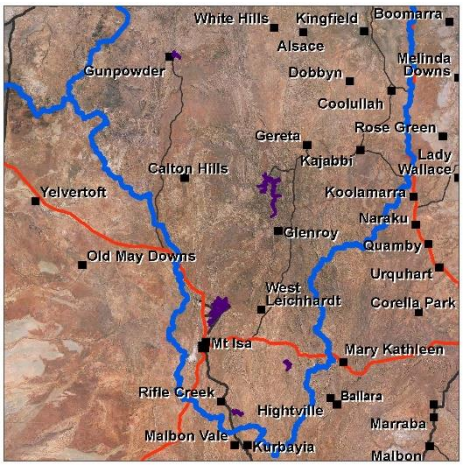
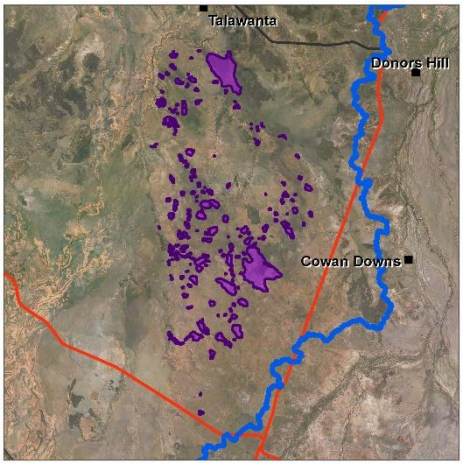
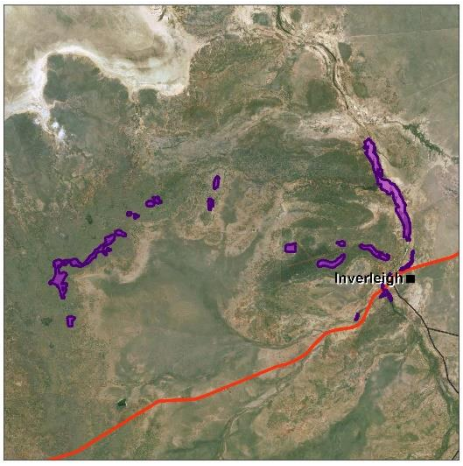
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Riparian vegetation fringing permanent spring-fed waterholes in sandstone gorges		Leichhardt Nicholson	Y			lr_r_fl_02 nr_r_fl_02	5.2.1 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1	4 4 4 4 4 4
Riverine systems containing *Terminalia bursarina*		Leichhardt Nicholson Settlement	Y			lr_r_fl_16 nr_r_fl_16 sc_r_fl_16	5.2.1 6.3.1	4 3
Low woodlands fringing major or minor watercourses		Leichhardt Mornington Inlet Nicholson Settlement Wellesley Islands	Y			lr_r_fl_17 nr_r_fl_17	5.2.1	4

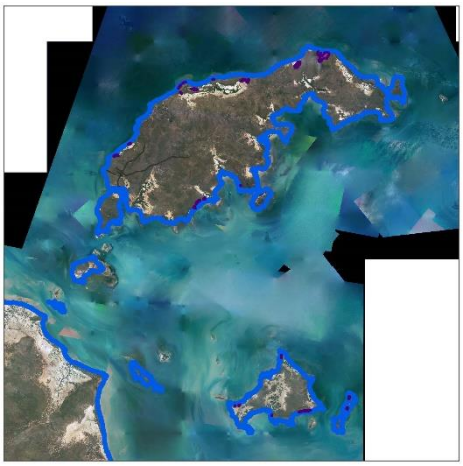
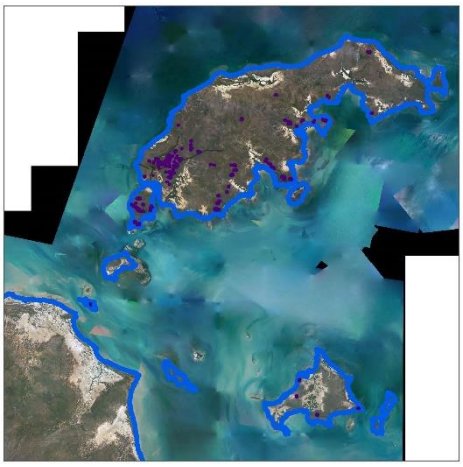
Table 16. Non-riverine expert panel decisions and their values

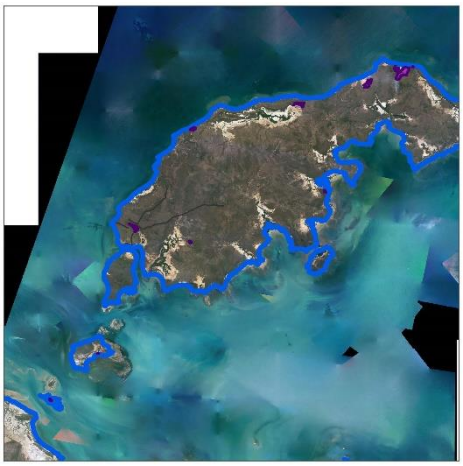
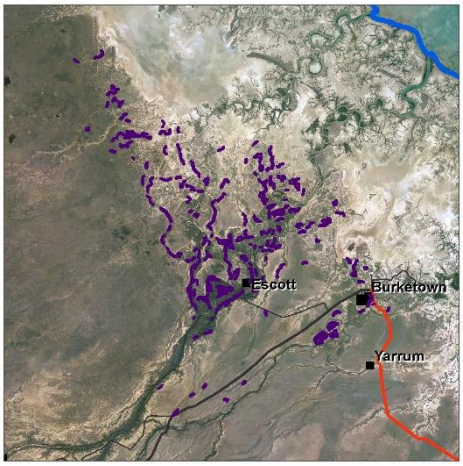
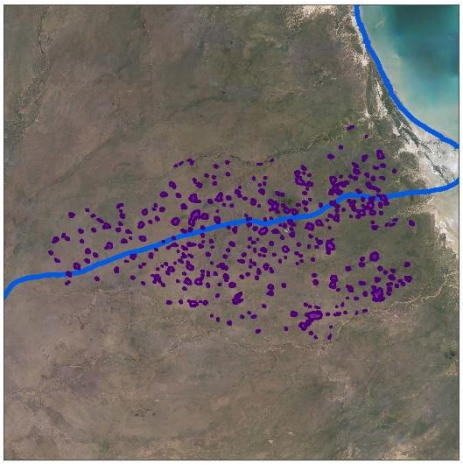
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Leichhardt River floodplain aggregation (non-riverine component)		Leichhardt			Y	lr_nr_ec_01	6.2.1 6.3.1 6.3.3 6.3.4 7.1.1 7.1.2 7.1.3 7.3.1 7.3.2 7.4.1 8.2.5	4 4 4 3 4 4 4 4 4 4 4
Alexandra River floodplain aggregation (non-riverine component)		Leichhardt			Y	lr_nr_ec_02	6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.3.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4
Donors Plateau spring fields		Leichhardt Morning Inlet			Y	lr_nr_ec_05 mi_nr_ec_05	6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.4.1 8.2.5	4 4 4 4 4 4 4 4

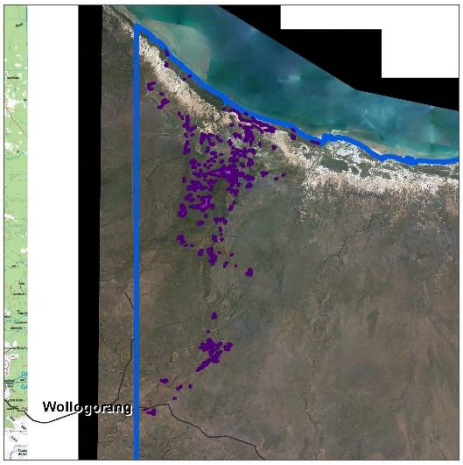
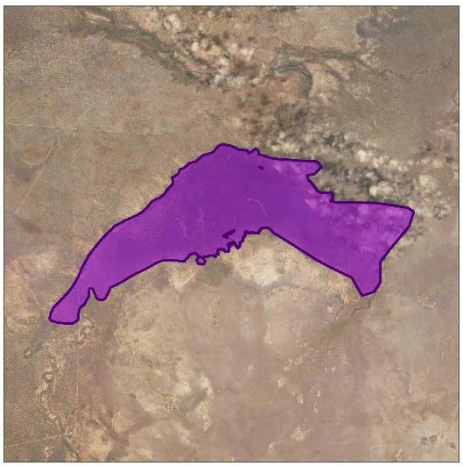
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Perennial aquatic habitats within the sedimentary hills and plateaus of the McArthur subregion		Nicholson Settlement			Y	nr_nr_ec_06	5.2.1 6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.2 7.4.1 8.2.5	4 4 4 3 4 4 4 4 4 4 4 4 4 4
Semi-perennial channel supplied palustrine wetland complexes on the Gulf Plains in the lower Gregory River subcatchment		Nicholson			Y	nr_nr_ec_10	5.1.4 6.1.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4
Wetlands on Leichhardt River scroll belt		Leichhardt			Y	lr_nr_ec_13	5.1.4 6.1.1 6.2.1 6.3.1 7.1.1 7.1.2 7.1.3 7.3.2 7.4.1 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4

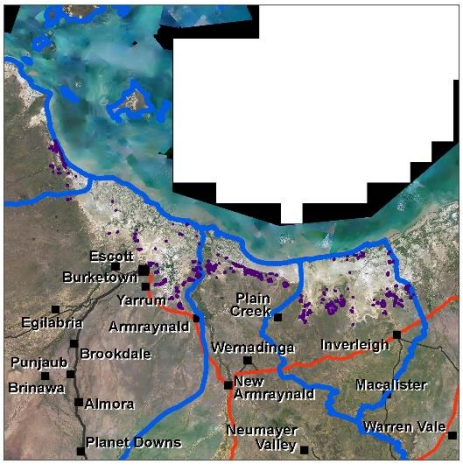
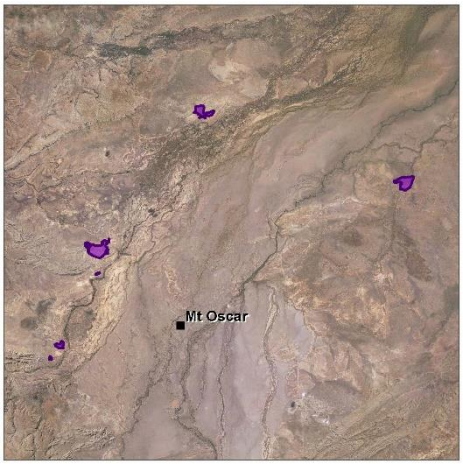
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Coastal swale complexes		Leichardt Morning Inlet Nicholson Settlement			Y	lr_nr_ec_14 mi_nr_ec_14 nr_nr_ec_14 sc_nr_ec_14	5.1.4 5.2.1 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.4.1 7.5.1 7.5.2	4 4 4 4 4 4 4 3 3 4 4 4
Lagoon creek floodplain swamp complex		Settlement			Y	sc_nr_ec_19	5.1.4 6.1.1 6.2.1 6.3.1 7.1.1 7.1.2 7.1.3 7.3.1 7.3.2 7.4.1 8.2.5	4 3 4 4 4 4 4 4 4 4 4
Ephemeral creeks with Tertiary clay plain catchments		Nicholson			Y	nr_nr_ec_27	6.1.1 6.2.1 6.3.1 6.4.1 7.4.1 8.2.5	4 3 3 4 3 4

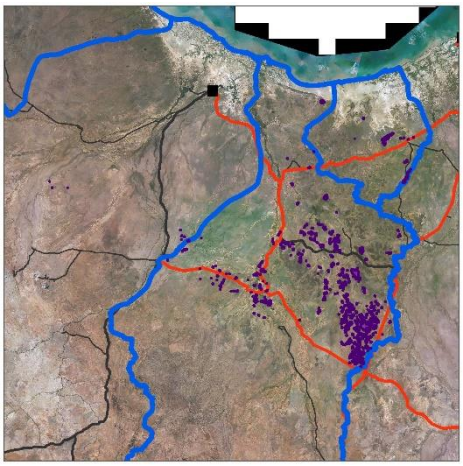
Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Large artificial impoundments in upper Leichhardt Basin		Leichhardt			Y	lr_nr_ec_28	5.1.4 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.3 7.4.1	4 4 4 4 4 3 4 4
Murgulla sand sheet aggregation		Leichhardt			Y	lr_nr_ec_32	5.1.4 6.1.1 6.2.1 6.3.1 6.3.3 6.4.1 8.2.5	4 4 4 4 4 4 4
Inverleigh Dam aggregation		Morning Inlet			Y	mi_nr_ec_34	5.1.4 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.3 8.2.5	4 4 4 4 4 3 4 4
Unwooded swamps on Ferricrete (Mornington Is.)	Due to the lack of available springs mapping, this special feature decision could not be implemented at this time.	Wellesley Islands			Y	md_nr_ec_35	6.1.1 6.3.1 6.3.3 6.4.1 7.1.2 7.2.1 7.3.2 7.5.1 8.2.5	4 3 3 4 3 4 4 3 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Swale swamps of the Wellesley Islands		Wellesley Islands			Y	md_nr_ec_36	5.1.4 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.4.1 7.5.1 7.5.2	3 4 3 4 4 4 4 4 4
Gunna Impoundment (Mornington Island)		Wellesley Islands			Y	md_nr_ec_37	5.1.4 6.3.1 6.3.4 6.4.1	4 4 4 4
Tree swamps on Tertiary surface depressions		Wellesley Islands			Y	md_nr_ec_38	5.1.4 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.2.1 7.3.1 7.3.2 7.4.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Transitional fresh to brackish palustrine swamps including Eleocharis sedge swamps		Wellesley Islands			Y	md_nr_ec_50	5.1.4 6.1.1 6.2.1 6.3.1 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.1 7.3.2 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 4 4 3 4 4 4 4 4
Springs and soaks of the Wellesley Islands	Due to the lack of available springs mapping, this special feature decision could not be implemented at this time.	Wellesley Islands			Y		6.1.1 6.3.1 6.3.4 6.4.1 7.1.1 7.2.1 7.3.1 7.3.2 7.4.1 7.5.1 8.2.5	4 4 4 4 4 4 4 4 4 4 4
Nicholson Delta Wetland Aggregation		Nicholson			Y	nr_nr_ec_53	5.1.4 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.2.1 7.3.1 7.3.2 7.4.1 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
Marless Lagoon Wetland Aggregation		Nicholson Settlement			Y	nr_nr_ec_54 sc_nr_ec_54	6.1.1 6.3.1 6.3.3 6.4.1 8.2.5	4 4 4 4 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Wetlands fed by Great Artesian Basin springs (Queensland Herbarium 2020 - Class 1 & 2)	Due to the lack of available springs mapping, this special feature decision could not be implemented at this time.	Leichhardt Mornington Inlet Nicholson Settlement Wellesley Islands			Y		6.3.1 6.3.4 7.2.1	4 4 4
Wetlands fed by Great Artesian Basin springs (Queensland Herbarium 2020 - Class 1 & 2)	Due to the lack of available springs mapping, this special feature decision could not be implemented at this time.	Leichhardt Mornington Inlet Nicholson Settlement Wellesley Islands			Y		6.3.1 6.3.4 7.2.1	3 3 3
Wentworth Aggregation		Settlement			Y	sc_nr_ec_57	5.1.4 6.1.1 6.2.1 6.3.1 6.3.3 6.3.4 6.4.1 7.1.1 7.1.2 7.1.3 7.3.1 7.3.2 7.4.1 7.5.1 7.5.2 8.2.5	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
Bluebush Swamp		Nicholson			Y	nr_nr_ec_58	6.3.1 6.3.3 6.4.1 8.2.5	4 4 4 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Important Bird Areas (IBA) - Migratory wader and waterbird roosting, feeding and breeding sites		Leichhardt Mornington Inlet Nicholson Settlement		Y		lr_nr_fa_20 mi_nr_fa_20 nr_nr_fa_20 sc_nr_fa_20	5.1.4 6.2.1 6.3.1 6.3.4	4 4 4 4
Acacia stenophylla swamps		Nicholson	Y			nr_nr_fl_09	5.2.1 6.1.1 6.2.1 6.3.1 6.3.4 6.4.1 8.2.5	4 4 4 4 4 3 4
Swamps on the Armraynald Plain sub-region		Leichhardt Nicholson Settlement	Y			lr_nr_fl_10 nr_nr_fl_10	6.1.1 6.3.1 6.3.4	4 4 4

Expert Panel Decision Name		Study Area	fl	fa	ec	Special Feature ID	CIM	Rating
Seasonal wooded swamps dominated by *Eucalyptus microtheca*		Leichhardt Mornington Inlet Nicholson Settlement Wellesley Islands	Y			lr_nr_fl_15 mi_nr_fl_15 nr_nr_fl_15	5.2.1	4

7 Connectivity

Aquatic ecosystem connectivity refers to the connections between and within aquatic ecosystems. An appreciation of the connections between wetlands and broader catchment processes and functioning is important for effective management decisions (DEHP 2017).

The ecology expert panel was asked to develop and/or identify principles that could be applied to determine relative connectivity scores for riverine and non-riverine wetlands within the Southern Gulf Catchments.

7.1.1 Importance of connectivity

There was agreement by the panel that the concept of connectivity is important in the Southern Gulf Catchments due to its direct or indirect link to most facets of aquatic ecology, geomorphology and water quality. The scientific literature reviewed for the AquaBAMM program reflects this view. The ecological value of a particular river reach is directly linked, in quantity and quality, to the movement both up and downstream (and between adjoining terrestrial lands) of resources such as water, sediment and debris and recruitment and distribution of species (Cullen 2003).

An inherent connectivity (or lack of connectivity in drier periods) is a significant feature of riverine and non-riverine wetlands. For example, in arid-zone systems and floodplains, the irregular flow regime and sporadic connectivity underpins the conservation of the instream and floodplain wetland biota such as the invertebrate assemblages (Sheldon et al. 2002). Similarly, this relationship is evident for maintaining the health and productivity of end-of-river estuarine systems (Cullen 2003). A largely unknown and unseen linkage also occurs within the hyporheic zone between surface waters and groundwater ecosystems sustaining many endemic or relictual invertebrate fauna (Boulton et al. 2003).

7.1.2 Applying principles for measuring connectivity

The practicalities of measuring connectivity for aquatic environments are complex making general principles and spatially explicit models difficult to develop and implement. Connectivity in its broadest meaning incorporates hydrological processes (quantity and quality, temporal and spatial variability), organism dispersal (barriers) and disturbances from natural conditions. Connectivity can be bi-directional movements within a stream (e.g., fish passage), uni-directional contributions to downstream areas, or lateral connectivity between instream areas and non-riverine floodplain wetlands or groundwater ecosystems. These aspects of connectivity combine to provide a matrix of competing and differing values from an ecological conservation viewpoint.

The Southern Gulf Catchments ecology expert panel made the following comments regarding wetland connectivity across the study areas:

1. In general, appropriate/pre-European connectivity remains high across all study areas.
2. Wetlands on the coastal plains are highly connected during the wet season.
3. The nature of overland flow is important (i.e. instream channel flow (in-channel longitudinal; in-channel lateral (overbank flow)).
4. Known barriers to fish movement include the natural Leichhardt Falls, a weir at Doomadgee, and road crossings on the Nicholson River at Escot, on the Gregory River at Doomadgee, and on Lagoon creek.
5. Connectivity can occur at different temporal and spatial scales.
6. To assess connectivity appropriately, the components of an ecosystem, and the processes affecting them, must be considered.

The principles for measuring connectivity developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton et al. 2006) were tabled at the Southern Gulf Catchments wetland ecology expert panel workshop. After consideration of these methods the ecology expert panel determined that this was not suitable for the Southern Gulf Catchments. The ecology expert panel discussed alternative methods for determining Criterion 7 connectivity values. A summary of the panel's discussions and recommendations for each of the Criterion 7 measures is described below.

The panel recommended that all special features identified by the panel that contribute (upstream or downstream) to the maintenance of significant species or populations, be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for Measure 7.1.1.

The principles for the fish passage connectivity rating (AquaBAMM Measure 7.1.2) developed by the riverine ecology expert panel from the Burnett River Aquatic Conservation Assessment (Clayton et al. 2006) were discussed by the ecology expert panel. Under this methodology, the assumption is that barriers lower in the catchment have more impact on fish passage then those in upper reaches of the catchment. There is also recognition that each barrier can be rated according to its relative level of fish passage. After consideration of the aforementioned methodology, the ecology expert panel determined that this method was not suitable for the Southern Gulf Catchments. The panel discussed alternative methods for determining riverine connectivity (and

hence fish passage). The panel recommended that all special features identified by the panel as supporting fish passage be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for AquaBAMM Measure 7.1.2.

The panel recommended that all special features identified by the panel, that are part of an aerial or terrestrial migratory route for biological connectivity, be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for Measure 7.1.3.

Connectivity between freshwater wetlands and groundwater (AquaBAMM Measure 7.2.1) was recognised by the panel as being important in the Southern Gulf Catchments with much of the region being under the influence of groundwater. The panel members discussed several methods for assessing the connectivity of freshwater and groundwater systems and agreed that anything that is connected hydrologically and/or biologically to groundwater areas should be given a higher connectivity rating. The panel recommended that all special features identified by the panel as being connected to groundwater (e.g. discharge areas and spring fed systems), be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for Measure 7.2.1.

The panel recommended that all special features identified by the panel that help maintain floodplain and wetland ecosystems with significant biodiversity values, be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for Measure 7.3.1.

The panel recommended that all special features identified by the panel that retains critical ecological and hydrological connectivity, where it should exist, with floodplains, rivers, groundwater, etc., be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for Measure 7.3.2.

The panel recommended that all special features identified by the panel as contributing to the maintenance of terrestrial ecosystems with significant biodiversity values, be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for Measure 7.4.1.

Connectivity between freshwater wetlands (riverine and non-riverine) and estuarine ecosystems was also recognised by the panel as being important (AquaBAMM Measures 7.5.1 and Measure 7.5.2) in the Southern Gulf Catchments. The panel members discussed several methods for assessing the lateral connectivity of freshwater and estuarine wetlands and agreed that anything that is connected hydrologically and/or biologically to estuarine areas could be given a high connectivity rating. To implement this the panel recommended that all special features identified by the panel as contributing to the maintenance of estuarine and marine ecosystems with significant biodiversity values being connected to groundwater (e.g. discharge areas and spring fed systems), be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for Measure 7.5.1. The panel also recommended that all special features identified by the panel as contributing to the retention of critical ecological and hydrological connectivity in marine or estuarine areas, be assigned a score of 3 (i.e. High) or 4 (i.e. Very High) for Measure 7.5.2.

8 Stratification

AquaBAMM stratification attempts to mitigate the effect of data averaging across large study areas. Stratification is particularly useful when ecological diversity is high. For example, in the Wet Tropics bioregion stratification would be appropriate because higher numbers of native amphibian species (i.e. AquaBAMM measure 3.1.1 (Richness of native amphibians (riverine wetland breeders)) are known to inhabit upland areas compared to adjacent lowland floodplains. Stratification is unwarranted for measures where there is an equal probability of species throughout the study area.

Study area stratification is a user decision and is not mandatory for a successful assessment. In fact, the AquaBAMM makes provision for one or more measures to be stratified in any manner determined to be ecologically appropriate. Decisions concerning how to stratify are typically considered by the ecology expert panel. To date, assessments have been stratified based on elevation (e.g. 150m ASL for coastal catchments and 400 m ASL for catchments west of the Great Dividing Range in the Murray-Darling Basin) or bioregional boundaries.

For the Southern Gulf Catchments, the ecology expert panel noted that fish and some turtle assemblages are likely affected by elevation. A caveat to this is known barriers to fish movement, such as the natural fish barrier caused by the Leichhardt Falls, and road crossings on the Nicholson River at Escot, at Doomadgee, and on Lagoon creek. The experts also noted that differences in flow regimes and water chemistry can exist between creeks in the Southern Gulf Catchments which may affect fish and turtle diversity, particularly on the coastal alluvial plains. For example, seasonal creeks of the lower Nicholson generally have different species assemblages to adjacent perennial creeks fed by the limestone springs of the Thorntonia sub region.

On the panel's advice we stratified the study areas for the purpose of assessing like systems for AquaBAMM Measures 3.1.2 (Richness of native fish, 3.1.3 (Richness of native aquatic dependent reptiles). The Wellesley Islands (Mornington Island study area) was one stratum. The Nicholson River, Leichhardt River, Settlement Creek and Morning Inlet study areas were each stratified into three strata including uplands, coastal alluvial lowlands, and the coastal zone. The boundary used for the uplands stratum was based on the North West Highlands and Mitchell Grass Downs Bioregional boundaries. For the coastal zone we used a generalised boundary derived from the maximum extent of estuarine wetlands in the Queensland Wetland Mappings (v5.0). Subsections between the upland and coastal zone strata constituted the coastal alluvial lowlands stratum.

Subsections and non-riverine wetlands were assigned to each stratum based on a 'majority' rule (i.e. >= 50%). For example, riverine subsections were assigned the stratum containing the majority of the subsection; non-riverine spatialunits were assigned the stratum of the subsection containing the majority of the non-riverine spatialunit.

The Southern Gulf Catchments coastal zone included systems dominated by estuarine processes. Estuarine wetlands were not assessed as part of this project, so the results are only relevant to the freshwater riverine and non-riverine wetlands within these areas. Finer scale hydrological (subsection) modelling is needed to undertake estuarine assessments and this is hindered by the availability of high-resolution digital evaluation models suitable for detecting the small gradients in elevation typical of coastal zone.

Stratification was used for AquaBAMM Measures 3.1.2 (Richness of native fish) and 3.1.3 (Richness of native aquatic dependent reptiles).

9 Discussion

AquaBAMM expert panel processes draw on the knowledge and experience of experts and are based on the premise of scientific reasoning, multiply lines of evidence, and consensus building allowing unpublished or anecdotal data to be incorporated into the assessment process.

Expert panels workshops were held for the Southern Gulf Catchments Aquatic Conservation Assessments in May 2019. At these workshops experts helped to identify exotic and aquatic dependent species used to calculate measures within AquaBAMM Criteria 1, 2, 3, 4 and 5. Experts also helped to identify significant bird habitat areas and priority ecosystems used for measures within AquaBAMM Criterion 5, representative wetland types for a Criterion 8 measure, and special features for measures within Criterion 6. In the absence of comprehensive connectivity models, recent Aquatic Conservation Assessments, including the Southern Gulf Catchments, have also relied on experts to identify wetlands with significant connectivity values for measure within AquaBAMM Criterion 7.

This report lists the aquatic dependent species compiled for the Southern Gulf Catchments. In total, the Southern Gulf Catchments expert panels identified 30 amphibians, 69 fish, 16 reptiles, 104 freshwater waterbirds, 194 aquatic or semi-aquatic plants, two mammals, 27 macroinvertebrates, 55 priority flora species, 22 priority fauna species, three rare or threatened flora species, 11 rare or threatened fauna species and 26 migratory birds relevant to the freshwater wetlands of the Southern Gulf Catchments. Among other things, these lists can be used to inform species inventories, to plan survey work, and for natural resource management and development assessment processes.

Eight exotic vertebrates and 11 exotic terrestrial plants (i.e. non-aquatic dependent species impacting wetlands) were identified by the experts as impacting riverine or non-riverine wetlands within the Southern Gulf Catchments. No exotic fish, aquatic or semi-aquatic plants, or aquatic invertebrates were nominated by the expert panel indicating the low degree in which exotic species are impacting on wetlands in the region.

The Southern Gulf Catchments expert panels also nominated 54 special feature decisions relevant to the wetlands of the Southern Gulf Catchments. In total, 224 (69.6%) of the 322 riverine spatial units were identified as having one or more special features. A further 2,793 (63.1%) of the 4,425 non-riverine spatial units were identified as having one or more special features. Detailed special feature value descriptions are provided for each special feature decision (i.e. Appendix III - Detailed Special Features Descriptions). Where possible, species names, regional ecosystem codes and the AquaBAMM measures (i.e. values) nominated by the panel have been included providing transparency and allowing for independent verification. In some cases, threats contributing to known degradation have also been listed but were not systematically addressed for all special features. The end user is encouraged to corroborate or ground truth any listed threats or degradation processes prior to use.

Comprehensive modelling of ecological connectivity of aquatic ecosystems was not undertaken as part of the assessments. Instead, spatial units providing connectivity supporting key aquatic components or processes were flagged by experts as part of the special feature delineation process. The AquaBAMM provides the scope and flexibility for inclusion of comprehensive connectivity models and this modelling should be undertaken as part of a separate process prior to revisions of the Southern Gulf Catchments ACA. The 'Walking the landscape' (DEHP, 2012) – a whole-of-system framework for understanding and mapping environmental processes and functioning – provides a potential framework for assessing aquatic connectivity. For example, the method employs a workshop format for examining environmental function in terms of components and processes at multiple levels of scale. 'Walking the landscape' workshops focussed on the integration of existing data with expert knowledge could be used to develop robust conceptual models of connectivity which could be spatially linked to real world components.

Experts at the expert panel workshops highlighted a general lack of knowledge and survey data for many of the Southern Gulf Catchment study areas, particularly Wellesley Island group (i.e. Mornington Islands study area) and parts of Settlement Creek. Significant knowledge gaps noted by the experts included knowledge concerning aquatic invertebrate fauna, especially those associated with springs and sub-surface environments, the interaction of groundwater with above surface wetlands, and the ecology of groundwater-dependent ecosystems in region. Barriers to survey work in the region include remoteness and prolonged seasonal wet seasons, resulting in access difficulties, as well as high resourcing needs relative to other areas of the state including some experiencing higher threats. The experts also noted a major knowledge gap concerning the wetlands of the Wellesley Islands group which are likely to have high scientific value due to isolation for the past 12,000 years. For example, freshwater obligate biota of the Wellesley Islands are likely to provide examples of how mainland species compositions and genetics would be in the absence of disturbance (J Tait pers. comm.).

AquaBAMM expert panel workshops held to date have focussed on identifying special features (Criterion 6) and connectivity values (Criterion 7) with High (i.e. 3) or Very High (i.e. 4) conservation significance. In contrast, other AquaBAMM measures result in standardised scores from 1 to 4, where 1 = Low (i.e. conservation value), 2 = Medium, 3 = High, and 4 = Very High. Assigning lower conservation scores to spatial units for Criterion 6 and 7 measures should be done as part of future revisions of the Southern Gulf Catchments ACAs as this will help to

improve the relativity of the results.

Wetland systems below the scale or minimum threshold size of the Queensland Wetlands Mapping have not been assessed as part of the Southern Gulf Catchments assessments and will not be present in any special feature implementations. Special feature decisions which could not be implemented because of this reason included "unwooded swamps on ferricrete located on Mornington Island", "springs and soaks of the Wellesley Islands", "Donors Plateau spring fields in the Leichhardt River and Morning Inlet study areas" and "Springs of the Great Artesian Basin" which are one of the few EPBC listed communities in the region. Finer scale mapping of non-riverine wetlands would allow more precise delineation of non-riverine special features and connectivity values.

Aquatic Conservation Assessments, such as the Southern Gulf Catchments assessments, use riverine spatial units based on fine-scale riverine catchments to represent specific stream reaches or groups of reaches. As such, riverine special features may only apply to specific reaches, sections of reaches or discrete locations (e.g. instream waterholes) within a riverine spatial unit. Where possible, descriptions of the precise location and extent of riverine special features have been included with the riverine special feature value descriptions and this information can be used to facilitate interpretation. Finer scale riverine wetland area mapping similar to the non-riverine wetlands would allow more precise delineation of riverine special features and connectivity values.

References

Bayliss, P., Kennard, M., Bartolo, R., Close, P. 2011. An assessment of risks to aquatic ecosystems in northern Australia from development and sea level rise threats. Final report for NAWFA - Chapter 4. Dutton Park, Qld: CSIRO. https://doi.org/10.4225/08/586e8d1c38e3b

Blackman, J.G., Perry, T.W., Ford, G.I., Craven, S.A., Gardiner, S.J. and De Lai, R.J. 1999. Characteristics of Important Wetlands in Queensland. Environmental Protection Agency, Queensland.

Boulton, A.J, Humphreys, W.F, Eberhard, S.M 2003, Imperilled subsurface waters in Australia: Biodiversity, threatening processes and conservation. *Aquatic Ecosystem Health and Management* 6: 41-54.

Chessman, B 2003, Signal 2iv: A Scoring System for Macro-Invertebrates ('water bugs') in Australian Rivers - User Manual, Department of Environment Heritage, Canberra.

Clayton, P.D, Fielder, D.F, Howell, S, Hill, CJ 2006, *Aquatic biodiversity assessment and mapping method (AquaBAMM): a conservation values assessment tool for wetlands with trial application in the Burnett River catchment*, Environmental Protection Agency, Brisbane.

Conrick, D, Cockayne, B 2000, Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual, Queensland Department of Natural Resources, Freshwater Biological Monitoring Unit, Rocklea.

Cullen, P 2003, The Heritage River Proposal – Conserving Australia's undamaged rivers. In: Aquatic Protected Areas. What works best and how do we know? *Proceedings of the World Congress on Aquatic Protected Areas, Cairns, Australia – August 2002*. (eds. J.P. Beumer, A. Grant and D.C. Smith) University of Queensland Printery, St Lucia: Queensland, Australia. pp. 513-520.

DEHP 2012, Walking the landscape—A whole-of-system framework for understanding and mapping environmental processes and values, 6pp, Queensland Wetlands Program, Queensland Government, Brisbane.

DEHP 2017, *Connectivity and the landscape*, Wetland*Info*, Department of Environment and Heritage Protection, Queensland, viewed 6 December 2017, <https://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/landscape/>

DES 2020. Aquatic Conservation Assessment using AquaBAMM for the riverine and non-riverine wetlands of the Southern Gulf Catchments - Summary Report, Version 1.1. Department of Environment and Science, Queensland Government.

Driscoll, P.V. (2001), Gulf of Carpentaria wader surveys 1998–9. Report by Queensland Wader Study Group and Australasian Wader Studies Group to Queensland Environmental Protection Agency, p 84 and appendices.

Fensham, R, Fairfax, R 2005, *Great Artesian Basin Water Resource Plan. Ecological Assessment of GAB springs in Queensland*, Report for the Department of Natural Resources and Mines, Queensland Environmental Protection Agency, Brisbane.

Fensham, R.J 2006, Spring wetlands of the Great Artesian Basin, paper for the 2006 Australian State of the Environment Committee, Department of Environment and Heritage, Canberra.

Garnett, S.T. 1989. Wading Bird Abundance and Distribution - South-eastern Coast of the Gulf of Carpentaria. RAOU Report Series. 58:1-39.

Healthy Waterways 2012, Report Card Methods - How are the grades calculated? Healthy Waterways, Brisbane.

Lovelock C.E. et al. 2014. Contemporary Rates of Carbon Sequestration Through Vertical Accretion of Sediments in Mangrove Forests and Saltmarshes of South East Queensland, Australia. Estuaries and Coasts. 37. 763-771. 10.1007/s12237-013-9702-4.

Sheldon, F, Boulton, AJ, Puckridge, JT 2002, Conservation value of variable connectivity: aquatic invertebrate assemblages of channel and floodplain habitats of a central Australian arid-zone river, Cooper Creek. Biological Conservation 103: 13-21.

Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts (2020) QLD Springs Dataset 2019. <https://www.data.qld.gov.au/dataset/springs/resource/4cdc89ef-b583-446e-a5c7-0836a91a3767>

Watkins, D. (1993). A national plan for shorebird conservation in Australia. RAOU Report Series. 90.

Appendix I - Expert Panel Terms of Reference

Flora Expert Panel Terms of Reference

The role of the Flora Expert Panel is to provide expert advice on aquatic floristic values for the waterways and wetlands of the study area. This advice is a critical component of the Aquatic Conservation Assessment (ACA).

The panel membership will consist of experts in the field of aquatic flora values including species, communities and processes.

The advice provided by the expert panel at the workshop will be incorporated into the ACA results where appropriate.

The tasks to be undertaken by the panel include, but without limitation, the following:

- Review relevant existing spatial data (species point records) and available information (reports etc.).
- Provide advice on aquatic dependent rare or threatened flora species habitat and localities.
- Provide advice on aquatic dependent priority flora species habitat and localities.
- Identify priority ecosystems or areas important for significant floral communities or species.
- Provide advice on aquatic dependent exotic flora species localities and abundance.
- Weight Measures relative to their importance for an Indicator.
- Rank Indicators relative to their importance for a Criterion.

Fauna Expert Panel Terms of Reference

The role of the Fauna Expert Panel is to provide expert advice on aquatic fauna values for the waterways and wetlands of the study area. This advice is a critical component of the Aquatic Conservation Assessment (ACA).

The panel membership will consist of experts in the field of aquatic fauna values including species, communities and processes.

The advice provided by the expert panel at the workshop will be incorporated into the ACA results where appropriate.

The tasks to be undertaken by the panel include the following:

- Review relevant existing spatial data (species point records) and available information (reports etc.).
- Provide advice on aquatic dependent rare or threatened fauna species habitat and localities.
- Provide advice on aquatic dependent priority fauna species habitat and localities.
- Identify priority ecosystems or areas important for significant faunal communities or species.
- Provide advice on aquatic dependent exotic fauna species localities and abundance.
- Weight Measures relative to their importance for an Indicator.
- Rank Indicators relative to their importance for a Criterion.

Ecology Expert Panel Terms of Reference

The role of the Ecology Expert Panel is to provide expert advice on aquatic values for the freshwater wetlands and waterways of the study area. This advice is a critical component of the Aquatic Conservation Assessment (ACA) and is based on experience and demonstrated scientific theory on natural geological, geomorphological and hydrological processes as well as identifying connectivity within and between aquatic systems.

The panel membership consists of experts in the fields of ecological and hydrological processes, geomorphology, connectivity, water quality and river health assessment.

The advice provided by the expert panel at the workshop will be incorporated into the ACA results where appropriate.

The tasks to be undertaken by the panel include the following:-

- Identify areas of significant geomorphological, ecological or hydrological values (Special Features).
- Provide advice on biodiversity areas of particular significance for species or communities.
- Provide advice on identifying and applying the Connectivity Criterion for the study area.
- Provide advice on whether to stratify the study area.
- Weight Measures relative to their importance for an Indicator.
- Rank Indicators relative to their importance for a Criterion.

Appendix II - Expert Panel Definitions

Flora Expert Panel

Wetland indicator Species (WIS)

Flora wetland indicator species are those species that are adapted to and dependent on living in wet conditions for at least part of their life and are found either within or immediately adjoining a riverine, non-riverine or estuarine wetland.

This definition of a flora wetland indicator species extends beyond the more traditional definition of submerged and floating aquatic plants to include plants inhabiting the littoral zone (water's edge) and plants that usually have 'wet feet' on the toe of the bank. This meaning was chosen because it was considered to best capture the intent of the AquaBAMM indicator and measure of Species Richness: "Richness of wetland dependent plants" (3.1.5). The indicator is a measure of floristic richness of a particular spatial unit's aquatic environment, and hence, a broad definition will better depict the flora richness value at a given location.

For additional information on Fauna Wetland Indicator Species, go to:

http://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/flora/flora-indicator-species-list.html

Aquatic Species (QLD Herbarium definition)

Species adapted to growing in or on permanent water (obligate)

Semi-aquatic Species (QLD Herbarium definition)

Species that can withstand near-permanent shallow water and require only periodic temporary inundation - bordering permanent water, in bogs and shallow swamps.

Priority Species (Flora)

A priority species is NOT listed as Endangered, Vulnerable or Near-threatened and exhibits one or more of the following significant values:

1. It forms significant macrophyte beds (in shallow or deep water)
2. It is an important/critical food source
3. It is important/critical habitat
4. It is implicated in spawning or reproduction for other fauna and/or flora species
5. It is at its distributional limit or is a disjunct population
6. It provides stream bank or bed stabilisation or has soil-binding properties
7. It is a small population and subject to threatening processes
8. Taxa vulnerable to impacts of climate change - Species that are considered to be adversely affected by the predicted changes in climate, e.g. increasing temperatures, sea level rise and increasing frequency of extreme weather events (drought, flood & cyclones). Species can only be listed under this reason if there is sufficient knowledge of species' biology and its interaction with climate that would support an assessed impact under climate change scenarios.

Exotic Flora

Plants that cause, or have the potential to cause, significant detrimental impact on natural systems within a riverine or non-riverine landscape be included.

Aquatic Conservation Assessment – Flora species measures

Measure 1.1.2 - Presence of exotic aquatic and semi-aquatic plants within the wetland.

Measure 2.1.1 - Presence of exotic terrestrial plants in the assessment unit.

Measure 3.1.5 - Richness of native aquatic plants.

Measure 4.1.2 - Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act, EPBC Act.

Measure 5.1.2 - Presence of aquatic ecosystem dependent 'priority' flora species

Aquatic Conservation Assessment – Flora Special feature measures

Measure 6.1.1 – Presence of distinct, unique or special geomorphic features

Measure 6.2.1 – Presence of (or requirement for) distinct, unique or special ecological processes

Measure 6.3.1 – Presence of distinct, unique or special habitat

Measure 6.3.4 – Areas important as refugia from the predicted effects of climate change (e.g. source of species re-population

Measure 6.4.1 – Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)

Fauna Expert Panel

Wetland indicator species (WIS)

Fauna wetland indicator species are species that are adapted to and dependent on living in wetland conditions for all, or at least part of, their life. WIS have adapted to living in wetlands and are dependent on them for:

- all of their life; or
- a major part of their life; or
- for critical stages of their lifecycle, such as breeding and larval development.

Wetland ecosystems tend to include species evolved for wet conditions. Some of these species are dependent on the presence of water for every stage of their life cycle, and need to be immersed in water, or floating upon water, for their total life cycle, while others require water for most of their life cycle stages or for a critical stage in their development. These species are considered as WIS unlike those that may only access a wetland to drink.

The WISL includes the more common fauna species. Most rare species and all vagrant fauna species have not been included as they are considered too poorly known or erratic. Species, other than those listed, may be accepted as a wetland indicator for a certain locality given expert recommendation and reliable site-specific data.

Most marine species are also not included in the WISL as the wetland definition excludes marine water more than 6m below low tide.

Priority Species (Fauna)

A priority species must exhibit one or more of the following significant values:

1. It is endemic to the study area (>75% of its distribution is in the study area/catchment)
2. It has experienced, or is suspected of experiencing, a serious population decline
3. It has experienced a significant reduction in its distribution and has a naturally restricted distribution in the study area/catchment
4. It is currently a small population and threatened by loss of habitat
5. It is a significant disjunct population
6. Migratory species (other than birds)
7. A significant proportion of the breeding population (>1% for waterbirds, >75% other species) occurs in the waterbody. (see Ramsar Criterion 6 for waterbirds)
8. Taxa vulnerable to impacts of climate change - Species that are considered to be adversely affected by the predicted changes in climate, e.g. increasing temperatures, sea level rise and increasing frequency of extreme weather events (drought, flood & cyclones). Species can only be listed under this reason if there is sufficient knowledge of species' biology and its interaction with climate that would support an assessed impact under climate change scenarios.

Waterbird

Bird species that are dependent on wetland environments.

Migratory Species

Bird species that are dependent on wetland environments whose entire population or any geographically separate part of the population cyclically and predictably cross one or more national jurisdictional boundaries. This definition excludes those species listed as "nomadising" or "range extensions" and those travelling less than 100 km.

(Based on Convention on Migratory Species; use JAMBA, CAMBA and ROKAMBA lists as a starting list)

Aquatic Conservation Assessment – Fauna species measures

Measure 1.1.1 – Presence of 'alien' fish species within the wetland.

Measure 1.1.3 - Presence of exotic invertebrate fauna within the wetland.

Measure 1.1.4 - Presence of feral/exotic vertebrate fauna (other than fish) within the wetland.

Measure 3.1.1 - Richness of native amphibians (riverine wetland breeders).

Measure 3.1.2 - Richness of native fish.

Measure 3.1.3 - Richness of native aquatic dependent reptiles.

Measure 3.1.4 - Richness of native waterbirds.

Measure 3.1.6 - Richness of native amphibians (non-riverine wetland breeders).

Measure 3.1.7 - Richness of native aquatic dependent mammals.

Measure 3.2.1 - Richness of macroinvertebrate taxa

Measure 4.1.1 - Presence of rare or threatened aquatic ecosystem dependent fauna species – NC Act, EPBC Act.

Measure 5.1.1 - Presence of aquatic ecosystem dependent 'priority' fauna species (expert panel list/discussion or other lists such as ASFB, WWF, etc).

Measure 5.1.3 - Habitat for, or presence of, migratory species (Expert Panel list/discussion and/or JAMBA / CAMBA agreement lists and/or Bonn Convention).

Aquatic Conservation Assessment – Fauna Special feature measures

Measure 5.1.4. Habitat for significant numbers of waterbirds

Measure 6.1.1. Presence of distinct, unique or special geomorphic features

Measure 6.2.1. Presence of (or requirement for) distinct, unique or special ecological processes

Measure 6.3.1. Presence of distinct, unique or special habitat.

Measure 6.3.4. Areas important as refugia from the predicted effects of climate change (e.g. source of species re-population

Ecology Expert Panel

Aquatic Conservation Assessment – Ecology Special feature measures

Measure 5.2.1 – Presence of 'priority' aquatic ecosystems (Ecosystems at risk)

Measure 6.1.1 – Presence of distinct, unique or special geomorphic features

Measure 6.2.1 - Presence of (or requirement for) distinct, unique or special ecological processes.

Measure 6.3.1 – Presence of distinct, unique or special habitat.

Measure 6.3.3 – Ecologically significant wetlands identified through expert opinion and/or documented study.

Measure 6.3.4 – Areas important as refugia from the predicted effects of climate change (e.g. source of species re-population

Measure 6.4.1 – Presence of distinct, unique or special hydrological regimes (e.g. spring fed stream, ephemeral stream, boggomoss)

Measure 8.2.5 – Wetland type representative of the study area non-riverine only)

Appendix III - Detailed Special Features Descriptions

Overview

The determination of what constitutes a special feature within a catchment is a highly technical process requiring a great deal of expert judgement. This appendix augments the special feature decision summary values descriptions presented in the Southern Gulf Catchments Aquatic Conservation Assessments expert panel report and contains a much greater level of detail that may be useful for stakeholders in making decisions affecting these special areas. Numbers in brackets represent the special feature measures (e.g. 6.3.3), a regional ecosystem code (e.g. regional ecosystem (e.g. RE2.3.9)), or a cross-reference to another special feature (e.g. lr_nr_ec_01).

Glossary:

ACA = Aquatic Conservation Assessment

ec = Ecology

GAB = Great Artesian Basin

GDE = Groundwater Dependent Ecosystem

lr = Leichhardt River

md = Wellesley Islands

mi = Morning Inlet

NCA = Nature Conservation Act 1992 (Qld)

nr = Nicholson River (beginning 2 letter section of special feature code name)

nr = Non-riverine (second 2 letter section of special feature code name)

r = Riverine

REDD = Regional Ecosystem Description Database

sc = Settlement Creek

Leichhardt River floodplain aggregation (non-riverine component)

lr_nr_ec_01

The Leichhardt River floodplain aggregation is a complex, continuous aggregation of floodplain palustrine, lacustrine and riverine wetlands formed on active alluvial landforms of Quaternary alluvial plains associated with overbank flows from the Leichhardt River. It is contiguous with the Alexandra River floodplain aggregation (lr_nr_ec_02) which is also supplied by Leichhardt River overbank flows. Collectively they form the largest aggregation of floodplain wetlands associated with a major river in the Southern Gulf region (6.3.3). The formation and size of this floodplain aggregation is a consequence of overbank flows generated by the proximal confluence of several major subcatchments (Gunpowder, Mistake and Myally) that drain the hard rock dominated south west uplands of the Leichhardt River basin. When synchronised flood peaks from these systems meet the Leichhardt River it breaks out into a floodplain wide distributary flows (7.3.2), a major portion of which drains to the Alexandra River before it reunites with the Leichhardt. Wetlands on the margin of the floodplain also receive run in from local catchments. Impermeable clay and underlying shale substrates, distributary channels blocked by river levees, groundwater seeps from sandy alluvial areas and run in from local catchments on the margin of the floodplain prolong the seasonal duration of wetlands beyond the wet season particularly in deeper waterholes in backplain swamps. These have value as refugia for aquatic biota (6.3.1) which is likely to increase with emerging climate change weather extremes (6.3.4). Permanent waterholes also host floodplain dependent aquatic biota including macrophyte spawning fish species which recruit to and from riverine habitats during times of flood generated connectivity (7.1.1, 7.3.2). Given the natural fish passage barrier created by the Leichhardt Falls in the lower catchment floodplain fish communities of the upper Leichhardt do not include catadromous species.

This system is data poor but it is recognised that at least five palustrine wetland associated regional ecosystems (regional ecosystems 2.3.49, 2.3.33, 2.3.34e, 2.3.12, and 2.3.16) comprise the non-riverine component of the aggregation, the majority of which have an 'of concern' biodiversity status. These include both wooded and unwooded swamps in closed depressions on active seasonally flooded alluvial plains with numerous distributary channels. They have a rich aquatic macrophyte communities and varying levels of seasonality. One of the

dominant regional ecosystems (regional ecosystem 2.3.49) is considered the key unwooded back plain swamp in the Southern Gulf (8.2.5) and supports flora species not found in unwooded swamps in the Eastern Gulf. The most common fringing or overstore tree across all regional ecosystems is Coolabah (*Eucalyptus microtheca*) though more permanent swamps associated with the most active channels (regional ecosystem 2.3.16) include tree species also found on the main river channel fringing community e.g. Red Gum (*Eucalyptus camaldulensis*) and/Paperbarks (*Melaleuca spp*.). Other common tree species include Guttapercha (*Excoecaria parvifolia*), Whitewood (*Atalaya hemiglauca*) and Beefwood (*Grevillea striata*). The density and structural complexity of fringing riparian forest communities associated with some of these swamps contrast with the open woodlands and grasslands of the surrounding landscape and they provide refugial and seasonal nesting and food resources such as nectar for birds and other terrestrial fauna (7.4.1).

The ground layer of these swamps is comprised of mixed sedgelands, grasslands and forblands with community composition determined by substrate type and wetland hydrology. Substrates vary from coarse grained alluvium to gleyed podsolics, solodised solonetz and cracking clays. Communities include combinations of the species *Eleocharis spp., Ludwigia peploides, Pseudoraphis spinescens, Marsilea spp*. and *Oryza spp*., *Nymphaea spp*., and *Nymphoides indica* may occur in deeper less seasonal water and *Astrebla spp.* and *Aristida spp*. grasses in more ephemeral wetland basins.

Many of these plant species represent important feeding and nesting resources for waterbirds including threatened species. The seasonal 'boom and bust' ecology of these wetlands creates a regional primary (and secondary) productivity hot spots utilised by wetland associated birds (including threatened species e.g. finches, honey eaters, chats and wrens and significant number of water birds as feeding, breeding and moulting sites (6.2.1). Migratory shore birds also utilise these wetlands as stop over and feeding areas during their migrations to and from Australia along the East Asian – Australasian flyway (7.1.3).

Swamps exposed to more active channel flow (regional ecosystem 2.3.16) are commonly deeper, have more open water and provide important breeding and feeding sites for freshwater crocodiles (*Crocodylus johnstoni*) in addition to waterbirds. Numerous other vertebrates including a diverse frog community and long-neck turtles which reach their highest densities in seasonal swamps occur within the system. The near threatened diamond-headed turtle (*Emydura subglobosa worrelli*) could also be expected to be reliant on permanent waterholes.

There are a number of potential threats to the values of this special feature decision. Sedge lands within these swamps including *Eleocharis spp*. host edible corms and are commonly excavated by feral pigs (*Sus scrofa*). They are also subject to degradation from grazing pressure during dry season and where elevated swamp basin margins are comprised of dispersive soils significant erosion and sedimentation of swamp basins can occur. Basins in close proximity to active riverine channels are at risk of breaching by widespread severe gully erosion radiating from stream banks toward the floodplain. The floodplain of the Leichhardt River is also impacted by bunding and diversion of flows, construction of water storages and cultivation on palustrine wetlands regional ecosystems (e.g. regional ecosystems 2.3.15 and 2.3.11b), which can modify the hydrology, condition and extent of floodplain wetlands.

Alexandra River floodplain aggregation (non-riverine component)

lr_nr_ec_02

The Alexandra River floodplain aggregation is a continuous complex floodplain of palustrine, lacustrine and riverine wetlands formed on active alluvial landforms on Quaternary alluvial plains associated with overbank flows from the Leichhardt River. It is contiguous with the Leichhardt River floodplain aggregation (lr_nr_ec_01) with both mutually supplied by Leichhardt River overbank distributary flows. Collectively they form the largest aggregation of floodplain wetlands associated with a major river in the Southern Gulf region (6.3.3).

The formation and size of the Alexandra River floodplain aggregation is a consequence of overbank flows generated by the proximal and perpendicular confluence of the Leichhardt River main channel and two major confluent subcatchments (Gunpowder and Mistake) that drain the hard rock dominated south west uplands of the Leichhardt River basin. When synchronised flood peaks from these systems meet the Leichhardt River, they break out across the main channel into floodplain wide distributary flows (7.3.2), with two major preferential flow paths of which (Middle and Lygeri Creeks) drain to the Alexandra River. Hydrological connectivity from these distributaries to and along the Alexandra River is convoluted by changes in the host landscape geomorphology between residual sand sheets of the elevated Donors Plateau and the clayey Armraynald Plains subregions. Intersection of drainage lines with these changing geomorphologies creates main channel bifurcations, terminal drainage floodouts and radiating and recoalescing braided channels (6.1.1). This underpins the distinct hydrological regimes (6.4.1) and distribution of wetlands observed within the aggregation.

Palustrine wetland basins are formed where drainage depressions and tributary valleys are blocked by riverine levees and within levee back swamps. A unique wetland basin setting within the aggregation occurs where drainage lines have cuts through elevated sand sheets creating a venturi scour in the process (6.1.1). Examples

such as ‘the Lakes’ and ‘Boogan Lagoon’ are perennial lacustrine wetlands with palustrine margins.

Impermeable clay, underlying shale or lateritised surface substrates, groundwater seeps from overlying sand sheets and sandy alluvial areas running in from local catchments on the margin of the floodplain, prolong the seasonal duration of many wetlands (6.4.1) beyond the wet season. This is particularly evident in deeper waterholes associated with concentrated flow scours. These have value as refugia for aquatic biota (6.3.1) which is likely to increase with emerging climate change driven weather extremes (6.3.4). Permanent waterholes also host floodplain dependent aquatic biota including macrophyte spawning fish species which recruit to and from riverine habitats during times of flood generated connectivity (7.1.1, 7.3.2). Given that the confluence of the Alexandra River with the Leichhardt River occurs below the natural fish passage barrier presented by the Leichhardt Falls, accessible floodplain habitats of the Alexandra River host catadromous species potentially including species of fishery importance such as barramundi (*Lates calcarifer*) and threatened species such as sawfish (*Pristis spp.*).

This system is data poor, but seven mapped palustrine wetland associated regional ecosystems including two subdominant riverine regional ecosystems (regional ecosystems 2.3.49, 2.3.33, 2.3.33b, 2.3.13b, 2.3.20d, 2.3.26a, 2.3.34e, 2.3.12 and 2.3.16) comprise the non-riverine component of the aggregation, the majority of which have an 'of concern' biodiversity status. These include both wooded and unwooded swamps in closed depressions on active seasonally flooded alluvial plains with numerous distributary channels. They have a rich aquatic macrophyte communities and varying levels of seasonality. One of the dominant regional ecosystems (regional ecosystem 2.3.49) is considered the key unwooded back plain swamp in the Southern Gulf (8.2.5) and supports flora species not found in unwooded swamps in the Eastern Gulf. The most common fringing or overstory tree across all regional ecosystems is Coolabah (*Eucalyptus microtheca*). The more permanent swamps associated with the most active channels (regional ecosystem 2.3.16) and subdominant riverine regional ecosystems (e.g. regional ecosystem 2.3.36), include tree species also found on the main river channel fringing community. For example River Red Gum (*Eucalyptus camaldulensis*), Paperbarks (*Melaleuca spp*.) and swamp box (*Lophostemon grandifloras*). Other common tree species include Guttapercha (*Excoecaria parvifolia*), Whitewood (*Atalaya hemiglauca*), Bohemia (*Lysiphyllum cunninghamii*) and Beefwood (*Grevillea striata*). The density and structural complexity of fringing riparian forest communities associated with some of these swamps, contrast with the open woodlands and grasslands of the surrounding landscape and provide refugial and seasonal nesting and food resources such as nectar for birds and other terrestrial fauna (7.4.1).

The ground layer of these swamps is comprised of mixed sedgelands, grasslands and forblands with community composition determined by substrate type and wetland hydrology. Substrates vary from coarse grained alluvium to gleyed podsolics, solodised solonetz and cracking clays. Communities include combinations of the species *Eleocharis spp*., *Ludwigia peploides*, *Pseudoraphis spinescens*, *Marsilea spp*. and *Oryza spp*. *Nymphaea spp*. and *Nymphoides indica* may occur in deeper less seasonal water, where *Astrebla spp*. and *Aristida spp*. grasses may occur in more ephemeral wetland basins.

Many of these plant species represent important feeding and nesting resources for waterbirds. The seasonal ‘boom and bust’ ecology (6.2.1) of these wetlands creates regional primary (and secondary) productivity hot spots utilised by wetland-associated birds (including threatened species like finches, honey eaters, chats and wrens and a significant number of water birds) as feeding, breeding and moulting sites (6.2.1). Migratory shore birds including threatened species, also utilise these wetlands as stop over and feeding areas during their migrations to and from Australia along the East Asian – Australasian flyway (7.1.3).

Swamps exposed to more active channel flow (regional ecosystem 2.3.16) are commonly deeper, have more open water and provide important breeding and feeding sites for freshwater crocodiles, in addition to waterbirds. Numerous other vertebrates including a diverse frog community and long-neck turtles (*Chelodina spp*.) which reach their highest densities in seasonal swamps, occur within the system. The near threatened diamond-headed turtle (*Emydura subglobosa worrelli*) could also be expected to be reliant on permanent waterholes.

There are a number of potential threats to the values of this special feature decision. Sedge lands within these swamps including *Eleocharis spp*. host edible corms and are commonly excavated by feral pigs (*Sus scrofa*). They are also subject to degradation from grazing pressure during the dry season and where elevated swamp basin margins are comprised of dispersive soils, significant erosion and sedimentation of swamp basins can occur. Floodplains are subject to the diversion of flows from permanent waterholes, which if implemented across the floodplain distributary networks, could impact the aquatic conservation values of the broader floodplain wetland aggregation.

Leichhardt lowland riverine system

lr_r_ec_03

The Leichhardt River becomes a lowland system at the break in slope between the rocky, hilly North West Highland bioregion which characterise its uplands, and the clayey, alluvial Gulf Plains Bioregion which forms its lowlands. Numerous confluences of major subcatchments also occur along the river reach in this transitional

boundary area. This forms a large main river channel hosting near contiguous perennial waterholes and numerous overbank flow distributary channels, that supply a rich aggregation of floodplain wetlands (7.3.1). They are predominantly located on the eastern side of the river channel due to the dominance of the Gunpowder Creek subcatchment generating a cross main channel outflow (see lr_nr_ec_01). These two features collectively underpin the high aquatic conservation values of the Leichhardt River lowland riverine system. For the purposes of this description the downstream margin used is the natural fish passage barrier presented by the Leichhardt Falls, which is located just upstream of tidal influence. It represents the boundary of several biophysical and fish biota associated values. Although the falls are known to be inundated infrequently by very large flood events, for most years they present a barrier to upstream movement for catadromous fish from lower estuarine reaches, including species of fishery and conservation importance such as barramundi (*Lates calcarifer*) and sawfish (*Pristis spp*.) respectively. Within the Southern Gulf this presents a unique fish community for a large near coastal lowland river system (6.3.3). However, the size and permanence of waterholes within the Leichhardt River lowlands are productive habitats that support top order predators including bull sharks (*Carcharhinus leucas*), estuarine crocodile (*Crocodylus porosus*) and freshwater crocodiles (*Crocodylus johnsoni*).

The permanence of main channel aquatic habitats provides a major, regionally significant refugia for both aquatic and terrestrial fauna which will gain increasing importance under emerging climate change weather extremes (6.3.4). They support breeding fish and reptile populations and act as recruitment source areas for the more extensive seasonal aquatic habitats occurring on the floodplain and upper catchment tributaries. They also provide a dry season refuge for waterbird populations associated with seasonal floodplain habitats (5.1.4). They include threatened species such as the diamond-headed turtle (*Emydura subglobosa worrelli*). Fringing riparian vegetation communities associated with these seasonal and permanent sources or water also host numerous conservation values.

The lowland riverine network is comprised of up to seven riverine associated regional ecosystems the majority of which have an 'of concern' biodiversity status. These include regional ecosystems (regional ecosystem 2.3.17) *Eucalyptus microtheca +/- Excoecaria parvifolia*, *Lysiphyllum cunninghamii*, *Atalaya hemiglauca* woodland fringing channels in fine-textured alluvial systems; (regional ecosystem 2.3.17g) *Eucalyptus microtheca* low woodland commonly with *Lysiphyllum cunninghamii* and *Excoecaria parvifolia* occurring on narrow channels on silty Quaternary alluvial plains derived from coarse-grained parent material; (regional ecosystem 2.3.20) *Corymbia bella*, *Eucalyptus pruinosa*, *C. terminalis*, *Lysiphyllum cunninghamii* in mixed woodlands on active levees and alluvial plains; (regional ecosystem 2.3.24) *Melaleuca spp*. woodland-open forest on sands in channels and on levees; (regional ecosystem 2.3.26) *Eucalyptus camaldulensis +/- Melaleuca spp*. woodland fringing sandy, seasonal channels; (regional ecosystem 2.3.50b) waterholes in active stream channels, occasionally with scattered aquatic vegetation with a variable wooded fringe including *Eucalyptus camaldulensis*, *Melaleuca spp*., *E. microtheca* and *Barringtonia acutangula subsp. acutangular* and (regional ecosystem 2.3.50a) bare sand with scattered low shrubs and patches of grasses, forbs and sedges occurring in larger river channels.

Relative to the seasonally arid open woodlands and grasslands that characterise landscapes surrounding the riverine system, the density, structural complexity and floristic diversity of these fringing communities provide movement corridors, bioregional and provincial refugial habitats, nesting and breeding sites (including for migratory passerines, turtles and freshwater crocodiles). They also provide seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (6.2.1, 6.3.1, 7.4.1). They also support locally uncommon plant species and threatened wetland associated bird species including finches, honey eaters, chats and wrens.

One of the key functional values of the riverine system is the hydrological connectivity (7.3.2) it provides for seasonal aquatic habitat including palustrine and lacustrine wetlands that form the Leichhardt River floodplain aggregation (lr_nr_ec_01). During flows, including overbank flood events, this connectivity supplies water to floodplain wetlands, supports the replenishment of shallow seasonal aquifers (7.2.1) and allows for longitudinal and lateral movement of main channel and floodplain dependent fish (7.1.2, 7.1.1) and other vertebrate species between habitat types. It also performs a host of geomorphological roles scouring and resetting channel and pool basins and transporting sediment and organic loads through the system. A significant proportion of the overbank distributary flows from the lower Leichhardt River heads east beyond the immediate levee and floodplain system and supplys water to the Alexandra River Floodplain Aggregation (lr_nr_ec_02).

The riverine system of the lower Leichhardt River is subject to a range of ecological pressures including disturbance by feral pigs (*Sus scrofa*), rubber vine (*Cryptostegia grandiflora)* infestation and grazing pressure. Riverine channel margins are commonly comprised of dispersive soils making them prone to erosion. Across the lower Leichhardt River system widespread severe gully erosion can be observed to be radiating from stream banks toward the floodplain.

The values of this special feature decision are potentially impacted by the development of off-stream water storages through the bunding and diversion of flows from riverine distributaries. Expansion of such development across distributary networks would impact the function of the riverine system and the aquatic conservation values

of the broader floodplain wetland aggregation.

Alexandra lowland riverine system

lr_r_ec_04

Topographically, almost all the Alexandra River other than the uppermost 6km (which extends into the North West Highlands Bioregion), can be considered a ‘lowland’ system given that it drains the flat low-lying Gulf Plains Bioregion. For most of its upper length there is insufficient contributory catchment area or rainfall to support the formation of a contiguous defined channel or off river wetlands. However, once the system receives tributary inflows from floodplain distributary channels of the Leichhardt River (e.g. Lygeri and Middle Creeks) it develops a defined channel, hosts semi-perennial to perennial waterholes and breaks out into a network of distributary networks. These networks supply and/or connect with high value wetlands (7.3.1) of the Alexandra River Floodplain aggregation (lr_nr_ec_02). Floodplain wetland connectivity and perennial waterholes underpin the high aquatic conservation values of the lower Alexandra river system and it is the section of the river bearing these values downstream to its confluence with the Leichhardt River that is the focus of this description. Unlike the adjoining Leichhardt River system, falls in the lower most reach are smaller and do not present a barrier to upstream movement of catadromous fish from estuarine reaches. species of fishery and conservation importance such as barramundi (*Lates calcarifer*) and Freshwater Sawfish (*Pristis pristis*) respectively, are recorded from its perennial waterholes. It also hosts other top order predators including both estuarine crocodile (*Crocodylus porosus*) and freshwater crocodile (*Crocodylus johnsoni*).

Hydrological connectivity along the lower Alexandra River and its distributary channels, is convoluted by a range of distinct landscape settings including residual sand sheets of the elevated Donors Plateau and the clayey Armraynald Plains subregion. Intersection of drainage lines with these geomorphic settings, tributary confluences and levees creates main channel bifurcations, near- terminal drainage floodouts and radiating and recoalescing braided channels. This underpins the distinct hydrological regimes (6.4.1) and diverse riverine channel and wetland basin forms within the system and is itself a significant conservation value (6.3.3). While most of the lower Alexandra Riverine channel network is seasonal, perennial waterholes occur in several distinct geomorphic (6.1.1) and associated hydrologic settings. These include those hosted within the main river channel with a range of sediment textures and underlying impermeable clays and/or lateritised surfaces, and those hosted within distributary channels of the floodplain. Most perennial floodplain waterholes are underlain by lateritised surfaces which act as a conduit for lateral inflows of groundwater seeps emanating from overlying sand sheets, a feature representative of the subregion (8.2.5). Such basins have a unique geomorphology having been formed by distributary flows cutting through the overlying sand sheet and creating ‘venturi scours’ in the underlying surfaces (6.1.1). The most well-developed of these systems include named waterholes including Boogan Lagoon and ‘The Lakes’ and smaller waterholes distributed along the ‘The Lakes Creek’ distributary. Nearly all perennial distributary and main channel waterholes are clustered in two adjoining discrete areas where the river channel network intersects residual sand sheets associated with The Donors Plateau subregion. Two outlying perennial distributary waterholes are located at the bottom of the system on a ferricrete surface that also forms the foundation for the nearby Alexandra River and Leichhardt River Falls. While most main river channel waterholes are relatively narrow (~20m) with lengths of up to hundreds of metres, two much larger reach long systems located in the lower and mid floodplain are kilometres in length. The lowermost hosted in a ferricrete channel just upstream of the falls is approximately five kilometres long and up to 100m wide. The other on Newmayer Station is formed upstream of a blocked valley floodout created by confluent tributary sediment deposition. It is approximately 25 kilometres long and up to 100m wide and also has a ferricrete substrate. Water quality varies significantly between waterholes. Floodplain distributary waterholes hosted in sand sheets and supplemented with groundwater seeps often have clearer water conditions and support a diverse aquatic macrophyte community including submerged and emergent species which provide waterfowl food and nesting resources. Main channel waterholes primarily supplied by wet season runoff are generally turbid and have less developed macrophyte communities.

These perennial waterholes provide regionally significant refugia (6.3.1) for both aquatic and terrestrial fauna and will gain increasing importance under emerging climate change weather extremes (6.3.4). They support breeding fish and reptile populations (6.2.1) and provide nursery habitat for catadromous fish species from the estuary (including barramundi) and biota recruitment source areas for the more extensive seasonal aquatic habitats occurring on the floodplain and within tributary systems. They also provide a dry season refuge for waterbird populations associated with more extensive seasonal floodplain habitats (5.1.4) and host threatened species such as the Freshwater Sawfish (*Pristis pristis*) and diamond-headed turtle (*Emydura subglobosa worrelli*).

Fringing riparian vegetation communities associated with permanent sources of water also host numerous conservation values. The lowland riverine system of the Alexandra River is comprised of a diverse suite of up to eleven riverine associated regional ecosystems the majority of which have an 'of concern' and one 'endangered' biodiversity status. These include regional ecosystems 1.3.7 (from the adjoining bioregion), 2.3.6b, 2.3.16, 2.3.17. 2.3.17g, 2.3.20, 2.3.24, 2.3.26, 2.3.26f, 2.3.50a and 2.3.50b. This ecosystem diversity is driven by variable textured soils, size and extent of channel development, level of channel activity and levee development and seasonality of

site hydrology. Dominant overstory eucalypts include river red gum (*Eucalyptus camaldulensis*) on coarser grained material and coolabah (*Eucalyptus microtheca*) on finer, heavier soils with *Eucalyptus pruinosa* present on some alluvial levees along with bloodwoods (*Corymbia bella* and *C. confertiflora*). Melaleucas are a dominant to co-dominant riparian species on channel margins with species again determined by soil texture and hydrology but including *Melaleuca bracteata* on levees of smaller channels and *M. fluviatilis* or *M. leucadendra* on those of larger ones and *Asteromyrtus symphyocarpa* in areas of impeded drainage. Other common species comprising riparian woodlands include *Excoecaria parvifolia*, *Lysiphyllum cunninghamii*, *Atalaya hemiglauca*, *Lysiphyllum cunninghamii*, *Barringtonia acutangular*, *Terminalia platyphylla* and *Cochlospermum gregorii*.

Relative to the seasonally arid open woodlands and grasslands that characterise the broader landscapes surrounding the riverine system, the density, structural complexity and floristic diversity of these fringing communities provide many ecological benefits. These include movement corridors, bioregional and provincial refugial habitats, nesting and breeding sites (including for migratory passerines, turtles and freshwater crocs) and seasonally important food resources like nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (6.2.1, 6.3.1, 7.4.1). They also support locally uncommon plant species and threatened wetland associated bird species including finches, honey eaters, chats and wrens.

One of the key functional values of the riverine system is the hydrological connectivity (7.3.2) it provides for seasonal aquatic habitat, including palustrine and lacustrine wetlands that form the Alexandra floodplain aggregation (lr_nr_ec_02). During flows, including overbank flood events, this connectivity supplies water to floodplain wetlands, supports the replenishment of shallow seasonal aquifers (7.2.1) and allows for longitudinal and lateral movement of main channel, floodplain and estuarine dependent (catadromous) fish (7.1.2, 7.1.1) and other vertebrate species between habitat types. It also performs a host of geomorphological roles scouring and resetting channel and pool basins and transporting sediment and organic loads through the system. A significant proportion of the distributary flows supplying water to the Alexandra River Floodplain Aggregation are sourced from overbank flows from the lower Leichhardt River.

The riverine system of the lower Alexandra River is subject to a range of ecological pressures including disturbance by feral pigs (*Sus scrofa*), rubber vine (*Cryptostegia grandiflora)* infestation and grazing pressure.

Potential threats to the system are developments like the diversion of flows from permanent waterholes via drains. If expanded, these developments could potentially impact the aquatic conservation values of the lower Alexandra River system particularly if it involves alteration to the floodplain distributary networks.

Donors Plateau spring fields

lr_nr_ec_05, mi_nr_ec_05

The Donors Plateau subregion of the Gulf Plains Bioregion occurs in the Leichhardt River and Morning Inlet river basins within the Southern Gulf study area. It is an undulating complex of shales lateritised Tertiary plateaus and sandy outwash. Within the study area, outcropping fine labile sandstones are overlain by a dissected lateritised Tertiary plateau which includes Tertiary sand sheet. Where the subregion abuts the North West Highlands Bioregion in the mid Leichhardt River basin the underling sedimentary rocks are also overlain by sandy outwash from the uplands of this bioregion. The combination of flat to gently undulating topography, free draining sand sheet surfaces and underlying impermeable layers created by lateritised surfaces or sedimentary bedrock, creates a geological structure suited to hosting shallow predominantly seasonal groundwater aquifers (6.1.1). Given that the Donors Plateau is an erosion resistant, elevated, residual landscape, relative to adjoining Gulf Plains subregions, groundwater from these aquifers discharges to surface drainage networks via springs, soaks and associated palustrine wetland features representative of the Donors Plateau subregion (6.4.1, 8.2.5). Most of these features are too small in scale to be captured by existing wetland mapping and the seasonality of most springs means that associated wetland features may not be interpreted as groundwater dependent ecosystems.

This collective ‘groundwater dependent ecosystem’ (GDE) associated with the spring field is considered ecologically significant to the hosting basins and region (6.3.3) and is the broad feature addressed by this description of aquatic conservation values. These systems are poorly surveyed or documented and so features and their values described here have largely been interpreted from aerial imagery and informed by better documented examples of the same system types in the adjoining Flinders River basin. Receiving riverine and associated channel hosted palustrine wetlands downstream of spring field areas, receive some level of groundwater supplementation in addition to surface run off, due to receiving environments downstream of interpreted spring points. However, they are predominantly riverine and their occurrence is in downstream channels that may receive groundwater seeps and hyporheic flows rather than being adjacent to spring discharge points. Where occurrences of the Donors Plateau spring field adjoin the high value Leichhardt River and Alexandra River floodplain wetland aggregations, discharges from springs contribute to the water supplied to palustrine wetlands on the margins of the floodplain. Spring supplied wetlands and soaks that are elevated relative to the floodplain and not supplied by floodplain distributary flows, still comprise part of the aggregation by their proximity. They contribute to wetland

diversity and support unique habitat settings like swamps free of fish predators advantageous to breeding amphibians (6.2.1) and invertebrate populations (6.3.1). Within the Morning Inlet basin spring field discharges and soaks provide equivalent values in the uppermost margins of the basin in an otherwise seasonally arid landscape. They also present unique habitats (6.3.1) in terms of seasonal sources of open water in upper catchment areas. Spring discharges in these upper catchment areas of the Morning Inlet basin also extends the duration (beyond surface flow periods) of water supplied (likely via hyporheic flows) to receiving riverine systems including fringing vegetation communities. The seasonality of spring heads identified by aerial photo interpretation could not be determined, but the association of mesic vegetation patches with some and not others, would suggest a range of flow regimes. Less seasonal and perennial springs will have value as climate change refugia for dependent biotic communities (6.3.4), while potential reductions in reliable rainfall associated with climate change is likely to drive reduction in the occurrence and duration of functioning spring heads and associated community shifts (6.2.2).

Seasonal surface freshwater sources and more mesic vegetation communities supported by springs and soaks and groundwater supplied fringing riparian systems, form an important habitat component of surrounding terrestrial ecosystems and dependent fauna (7.4.1). Unique floristics are often associated with spring hosting regional ecosystems (e.g. regional ecosystem 2.7.3x6) which are recognised to act as regional refuges for both fauna and flora. While the spring systems within the study area have not been subject to survey, experience from adjoining basins and regions would suggest they have the potential to host rare and threatened aquatic ecosystem dependent fauna and flora species, including endemic frogs and aquatic macrophytes.

Several of the regional ecosystems hosting springheads or associated soaks and palustrine wetlands, have an 'of concern' or 'endangered' (e.g. regional ecosystems 2.3.38) biodiversity status. This special feature is likely to be impacted by grazing pressure and damage from feral pig (*Sus scrofa*) diggings. Many identified springs are associated with stock watering point development via bunding, excavation and/or ring tank development. This generally results in modification of the original habitat and exacerbates stock pressure on surrounding groundwater dependent habitat features. Spring features that retain natural habitat integrity therefore represent a priority aquatic ecosystem (5.2.1).

Perennial aquatic habitats within the sedimentary hills and plateaus of the McArthur subregion

nr_nr_ec_06, nr_r_ec_06

The McArthur subregion is comprised almost entirely of outcropping sedimentary rock occurring as low hills and plateaus formed from folded pre-Cambrian sediments overlaid in places by Mesozoic sediments of the Carpentaria basin. These sedimentary rock sequences host groundwater aquifers and provide impermeable water shedding and holding surfaces. Derived sandy alluvium is common along larger watercourses and functions as both a conduit for groundwater contributions from upper catchment areas and a host for seasonal shallow aquifers (7.2.1, 7.3.2). Collectively this distinct geomorphic setting (6.1.1) contributes to an abundance of perennial aquatic habitat features representative of the subregion (8.2.5) including rocky gorge and sandy channel hosted waterholes, instream macrophyte communities, diverse fringing forests and associated springs within what is essentially a seasonally arid landscape (6.4.1). Unique geomorphic features within the subregion also include subterranean streams e.g. within the sandstone gorge tributaries of Lagoon Creek (6.1.1). Unlike the limestone catchments of the Thorntonia subregion to the south, most streams within the McArthur subregion do not convey perennial flows although waterhole permanence is often supplemented by groundwater inputs and hyporheic flows within bed sands which extend downstream beyond the subregion to other high value wetland systems (7.1.1, 7.2.1). The McArthur subregion is remote occurring in the north west margin of Queensland and extends across the Queensland – Northern Territory border. Queensland components drain into the lower reaches of the Settlement Creek and Nicholson River basins.

Within the Settlement Creek basin, subcatchments hosting perennial waterholes drain to four independent mouths to the Gulf via Settlement Creek (with confluent tributary Branch Creek), Lagoon Creek (with confluent tributaries Stoney and Snake Creeks), Eight Mile Creek and Cliffdale Creek (with confluent tributary Scrutton Creek). Within the Nicholson River basin, at least five named subcatchments and the main river channel host perennial waterholes within the McArthur subregion, all ultimately drain to the main Nicolson channel, three via the Lawn Hill Creek subcatchment (Musselbrook, Elizabeth and Accident Creeks) and several more as direct tributaries of the Nicholson River (including Border, Gorge and Hedley's Creeks). Within the Nicholson River basin the McArthur subregion includes the national directory listed Musselbrook Wetland Aggregation which includes some minor components associated with this description (6.3.2).

Across the McArthur subregion at least 11 riverine, three palustrine and six floodplain regional ecosystems are associated with its perennial aquatic habitat features including some that extend into the region from the adjoining Gulf Plains bioregion. Riverine regional ecosystems are predominantly comprised of communities dominated by paperbark (*Melaleuca spp*.), river red gum (*Eucalyptus camaldulensis*), coolabah (*Eucalyptus microtheca*), bloodwood (*Corymbia spp.*), and swamp box (*Lophostemon grandifloras*) (e.g. regional ecosystems 1.3.5, 1.3.7a, 1.3.7f, 1.3.7g, 1.3.9a, 1.3.9b, 1.3.12, 2.3.17d, 2.3.26f, 2.3.26e, 2.3.50b, 2.3.52). However, these include examples

with a high proportion of typically rainforest floristics (e.g. regional ecosystems 1.3.9b, 2.3.52) that persist due to the availability of perennial moist habitats. This is also observed in the subregion's described spring wetland regional ecosystem (regional ecosystem 1.10.6) which is associated with quartzose sandstone and often occurs as channel hosted palustrine wetlands with typically rainforest genera in its fringing communities. For example, *Syzygium, Alphitonia* and a host of other rare and remote plant communities for which it functions as a regionally significant refugia (5.2.1, 6.3.1). Other palustrine wetland regional ecosystems with perennial habitats or association by proximity include billabongs (regional ecosystem 2.3.16) and seasonal swamps (regional ecosystem 2.3.15). Floodplain regional ecosystems that occur in proximity to perennial habitats within the subregion (e.g. regional ecosystem 1.3.11, 2.3.20b, 2.3.20e, 2.3.30e, 2.3.42c) also contribute additional ecological values including important feeding sites for waterbirds and provincial refuges for woodland fauna and flora (6.3.1).

Relative to the surrounding arid landscapes the floristic richness and structural complexity of these regional ecosystems provide a host of nesting and feeding resources for fauna including birds, bats and macropods and function as bioregional refuges and movement corridors (6.2.1, 7.4.1, 7.1.3). Terrestrial species known to be supported by perennial aquatic habitats of the region include the threatened purple-crowned fairy wren (*Malurus coronatus*). Several of the listed regional ecosystems are recognised to have an 'endangered' or 'of concern' status or to represent a rare vegetation community (e.g. regional ecosystem 2.3.17d).

The aquatic refugia value of the subregion's waterholes also extends to providing a source of recruits to replenish obligate freshwater biota populations in more seasonal lowland or upland aquatic habitats (7.1.1). Fish species recorded within perennial pools include catadromous species such as barramundi (*Lates calcarifer*), tarpon (*Megalops cyprinoides*) *and* sawfish (*Pristis spp*.), indicating biological connectivity with distal marine ecosystems (7.1.2).

While the McArthur subregion is a poorly surveyed area and its biology poorly known, the combination of geologically old perennial aquatic habitat features hosted within subcatchments isolated by rugged topography and poorly connected highly seasonal lowlands is recognised by experts to present the potential for high conservation values associated with disjunct populations, potentially endemic species and spatial and temporal aquatic refugia included on evolutionary time scales (6.3.1, 6.3.3). The importance of these refugia within the context of unfolding climate change is likely to increase (6.3.4). Surveys of subterranean streams in the upper catchment of sandstone gorges within the Lagoon Creek catchment have recorded an isolated Purple spotted gudgeon (*Mogurnda mogurnda*) population with genetic affinities to populations from the Flinders Ranges in inland South Australia (J. Tait pers comms). Larger perennial waterholes within the region including Kingfisher waterhole on the Nicholson River main channel also provide habitat for threatened freshwater sawfish (*Pristis pristis*) and the Gulf snapping turtle (*Elseya lavarackorum*), the latter recognised as a 'living fossil'.

Perennial aquatic habitats not only provide resources for native biodiversity but also opportunities for invasive and exotic species. Rubber vine (*Cryptostegia grandiflora*) and other weed species are a key threat to fringing communities. Most are subject to grazing pressure due to the availability of watering points, although it should be recognised that the rockiness and inaccessibility of some stream reaches presents the prospect of stock free refuges being present within the subregion. Feral pig (*Sus scrofa*) disturbance is also a prevalent threat to riparian communities and present a predation thereat to nesting reptiles including threatened turtle species. The entire subregion is highly mineralised and contains known reserves of uranium, iron ore, copper, lead and zinc. Intensive mining development in the future could present a risk to these conservation values. Changing rainfall and temperature regimes associated with climate change are likely to lead to community shifts toward more xeric and less mesic habitat types including changes in fringing communities and reductions in the extent of perennial aquatic habitat (6.2.2).

Perennial instream habitats associated with limestone springs of the Thorntonia subregion

nr_r_ec_07

The Thorntonia sub region is comprised almost entirely of hills on limestones. It is drained by the Gregory River and it's eastern (Lawn Hill Creek) and southern tributaries (O'Shannassy and Thorton Rivers). Springs draining from the limestone make the lower reaches of these tributaries and the Gregory itself perennial, supporting a diverse suite of aquatic habitats including flowing streams on the larger systems. These systems are uniquely recognised as the only perennial streams in arid Queensland (6.4.1). Perennial habitats are characterised by aesthetic clear to blue hued 'limestone' water and often deep channel hosted waterholes with interconnecting flowing channel systems including riffle and race reaches. The perennial moisture also supports dense and diverse fringing riparian communities with rainforest structural and floristic affinities. Perennial limestone spring supplied aquatic habitats are very representative of the Nicholson River basin (8.2.5).

Water draining from limestone springs is saturated in calcium carbonate and where it flows to surface water systems it forms unique tufa features on precipitation surfaces including bound roots and rim pools (6.1.1). The karst landscape supplying these limestone springs also represents a unique geomorphic feature as do perennial riffle habitats in this arid landscape.

The significance of the wetlands within the site are widely recognised by experts as unique hydrologically and for being evolutionary refugia (6.3.3). Three (3) wetlands listed in the national Directory of Important Wetlands in Australia occur within this area including the Thorntonia Aggregation, Lawn Hill Gorge and Gregory River. The site also hosts the Boodjamulla (Lawn Hill) National Park which includes the internationally significant Riversleigh World Heritage Area fossil field.

Catadromous estuarine dependent fish species including the endangered freshwater sawfish (*Pristis pristis*) have been recorded from larger waterholes through the described area (7.1.2). The persistence of perennial habitat within the area through geological time has provided aquatic refugia (6.3.1) that have retained a host of species with disjunct populations across northern Australia including the threatened 'living fossil' Gulf snapping turtle (*Elseya lavarackorum*). Other examples include a host of fish species including northern saratoga (*Scleropages jardini*), coal grunter (*Hephaestus carbo*) and blackmast (*Craterocephalus stramineus*). Considering the site's past functioning as a refugia through geological time, the more perennial aquatic habitats within it can be expected to continue to perform such roles under the predicted effects of climate change (6.3.4).

The described area includes spring discharges and associated flows which support a diversity of downstream aquatic and fringing riparian habitats beyond the site that have high biodiversity values and are in effect groundwater dependent ecosystems (7.1.1, 7.2.1).

The site includes diverse aquatic macrophyte communities. Aquatic beds are often dominated by *Nymphaea violacea*, and include *Ludwigia octovalvis*, *Ludwigia perennis*, *Nymphoides spp*., *Ottelia alismoides*, *Utricularia sp.*, and water ferns (*Ceratopteris cornuta* and *C. thalictroides*) occur in the riverine wetland. Emergent palustrine wetland on the levees include *Typha spp., Phragmites australis, Imperata cylindrica, Vetiveria elongata, Cyperus spp., Eleocharis spp., Fimbristylis spp., Polygonum spp.* with the fern *Lygodium microphyllum* on moist ground. Forested and shrub-scrub palustrine wetlands are well developed on levees and, in the shallower seasonal channels. These fringing communities host a range of Regional Ecosystems including small often unmappable occurrences of springs (regional ecosystem 1.9.8) and spring fed watercourses (regional ecosystem 2.3.52 and regional ecosystems 1.3.9a and 1.3.7f). Floodplain regional ecosystems (regional ecosystems 1.3.5 and 2.3.20b) also occur in close association with these perennial habitats. Dominant species include *Livistona rigida, Melaleuca spp., Nauclea orientalis, Eucalyptus camaldulensis, Corymbia spp., Terminalia bursarina, Lysiphyllum cunninghamii and Lophostemon grandiflorus,* with numerous shrubs dominating the seasonally flooded areas. *Pandanus aquaticus* and *Ficus racemosa* occur with the above species on levees of the main channels and semi permanently flooded channels. A notable aspect of the flora is the rainforest influence and marked differences between the fringing communities of the gorges and channels and surrounding semi-arid country.

Relative to the seasonally arid open woodlands and grasslands that characterise landscapes surrounding the riverine system, the density, structural complexity and floristic diversity of the fringing riparian communities provide movement corridors (7.1.3), bioregional and provincial refugial habitats (6.3.1), nesting and breeding sites (6.2.1) including for migratory passerines (7.1.3), turtles and freshwater crocs. They also provide seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (7.4.1). The area is also a known hot spot for the threatened purple crowned fairy wren (*Malurus coronatus*).

Although far removed, groundwater contributions from the site contribute to perennial flows in the lower river system which support a host of floodplain and wetland ecosystems within the mid catchment (7.3.1) and extend all the way to its mouth(s) generating a relatively greater mix (than non-perennial systems) of estuarine salinities and associated biodiversity and productivity values (7.5.1).

Although mining development and associated groundwater dewatering within the described area has been implicated in alteration to stream baseflows, the majority of the catchment areas lacks intensive development and critical hydrological connectivity between groundwater, stream flow and floodplains has been retained (7.3.2)

In recent decades anecdotal observations suggest that the permanence of some aquatic habitats and the permanence of flows in some reaches within the described area has reduced relative to long term local experience. The emerging impact of climate change on rainfall and groundwater recharge - discharge processes is likely to drive community shifts throughout the site toward more xeric habitats and a reduction in the extent of perennial refugia (6.2.2).

The fringing regional ecosystems associated with these perennial habitats are subject to degradation due to grazing pressure, weed invasion, feral pig disturbance and human recreational use and include two with an 'endangered' and 'of concern' biodiversity status. The catchment area for these systems is highly mineralised and mining development both past and potential presents an ongoing risk to system hydrology and water quality.

Alluvial levee riparian forests of the lower Gregory River system

nr_r_ec_08

The best developed alluvial levee systems of the Gregory River covered by this description occur downstream of the constrained upper catchment valleys associated with the Thorntonia subregion's limestone hills (nr_r_ec_07), and upstream of the low gradient small channel network that characterises the Gregory's lower catchment within the clay plains of the Armraynald Plains subregion (nr_r_ec_09).

Approximately 80% of the description area overlaps with the national Directory of Important Wetlands in Australia listing (6.3.2) for the blue hued, limestone spring fed, perennial flowing Gregory River. The river is hydrologically unique (6.4.1) within arid Queensland, but representative of the Nicholson River basin (8.2.5) and to which the same prescribed values can be attributed. However, this description area extends further downstream beyond the settlement of Gregory to include the main river channel within the Armraynald Plains subregion. This is where alluvial levees comprised of coarser material i.e. sand and loams occur rather than finer grained clays that characterise the lower channel network.

Given the unconstrained flat topography of the adjoining Gulf Plains and the geomorphic impact of wet season flood peaks descending from the north west highlands, alluvial levees adjoining this reach of the Gregory River are up to more than 250m wide. The combination of a broad band of alluvial soils and perennial moisture lead this reach of the Gregory to have structurally complex and floristically rich riparian forests. Along the most active channel front these rich riverine wetland regional ecosystems are mapped as regional ecosystem 1.3.9a or 2.3.52 which includes paperbarks (*Melaleuca spp.*), River Red Gum (*Eucalyptus camaldulensis*), Leichhardt Tree (*Nauclea orientalis*), Cluster Fig (*Ficus racemosa*), Swamp box (*Lophostemon grandiflorus*) and Cabbage Palm (*Livistona rigida*) in mixed woodlands fringing major spring-fed watercourses. On active levees off the main channel front more sclerophyllous communities occur including mixed woodland of eucalypts, bloodwoods, and bauhinia (*Lysiphyllum cunninghamii*) (regional ecosystem 2.3.20a). Further downstream where the alluvial levees are comprised of finer soils, represented regional ecosystems include those with Coolabah as a dominant canopy species (i.e. regional ecosystems 2.3.17a and 2.3.17d).

Relative to the seasonally arid open woodlands and grasslands that characterise landscapes surrounding the riverine system, the density, structural complexity and floristic diversity of the fringing riparian communities provide movement corridors (7.1.3), bioregional and provincial refugial faunal habitats (6.3.1), nesting and breeding sites (6.2.1) including for migratory passerines (7.1.3), turtles, and freshwater crocodile (*Crocodylus johnsoni*). They also provide seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (7.4.1). The area is also a known hot spot for the threatened purple crowned fairy wren *(Malurus coronatus*).

Catadromous estuarine dependent fish species including the endangered freshwater sawfish (*Pristis pristis*) have been recorded from larger waterholes through the described area (7.1.2). The persistence of perennial habitat within the area through geological time has provided aquatic refugia (6.3.1) that have retained a host of species with disjunct populations across northern Australia. This includes the threatened 'living fossil' Gulf snapping turtle (*Elseya lavarackorum*) which occurs in lower densities within this site than at Lawn Hill Gorge. Other examples include a host of fish species including northern saratoga (*Scleropages jardini*), coal grunter (*Hephaestus carbo*) and blackmast (*Craterocephalus stramineus*). Considering the site's past functioning as a refugia through geological time, the more perennial aquatic habitats within it can be expected to continue to perform such roles under the predicted effects of climate change (6.3.4). In recent decades anecdotal observations suggest that the permanence of some aquatic habitats and the perenniality of flows in some reaches within the described area has reduced relative to long term local experience. The emerging impact of climate change on rainfall and groundwater recharge - discharge processes is likely to drive community shifts throughout the site toward more xeric habitats and a possible reduction in the extent of perennial refugia (6.2.2).

The presence of permanent riffle -race channel systems is also unique both hydrologically and geomorphologically within the study area (6.1.1, 6.4.1). The described area includes flows which support a diversity of downstream aquatic, fringing riparian and floodplain habitats beyond the site that have high biodiversity values and are in effect groundwater dependent ecosystems (7.1.1, 7.2.1, 7.3.1).

Mining development and associated groundwater drawdown has been implicated in alteration to stream baseflows. However, most of the catchment areas lack intensive development and critical hydrological connectivity between groundwater, stream flow and floodplains have been retained (7.3.2)

The fringing regional ecosystems associated with these perennial habitats are subject to degradation due to grazing pressure, weed invasion, feral pig disturbance and high levels of human recreational use. Several of these regional ecosystems have an 'of concern' biodiversity status. The catchment area for this site is highly mineralised and mining development could present a risk to system hydrology and water quality. Large scale development of irrigation in this area could present a significant risk to the values associated with this reach of the Gregory River.

Limestone spring supplied perennial channels and waterholes on the Armraynald Plains subregion within the lower Lawn Hill creek and Gregory River subcatchments

nr_r_ec_09

Within the upper Lawn Hill Creek and Gregory River subcatchments of the Nicholson River basin, perennial flows are maintained by groundwater contributions from limestone springs of the Thorntonia sub region (nr_r_ec_08). These flows extend downstream beyond the hilly landscape of the Thorntonia subregion and onto the flat Armraynald Plains, one of several Gulf Plains Bioregion subregions characterised by clay plains. Most clay plains subregions of the Gulf Plains are seasonally arid environments that apart from major river channels only support seasonal wetland habitats. In contrast, the distribution of perennial flows through the lower Lawn Hill Creek and Gregory River catchments create a hydrologically unique complex (6.4.1) of perennial aquatic habitats that present a starkly contrasting environment to the surrounding seasonally dry grasslands and open woodlands.

Blue hued limestone spring derived water and associated perennial aquatic habitats is representative of the Nicholson River basin (8.2.5). Given the extremely flat topography of the Armraynald Plains and the geomorphic influence of annual wet season flood flows, stream channels associated with the lower Lawn Hill and Gregory systems are comprised of a braided and anastomosing distributary and confluent network that create channel fringed ‘islands’ of land that can be greater than 30 kilometres in length (6.1.1). Where channels break into anastomosing floodouts, large treed or open palustrine wetlands can be formed (nr_nr_ec_10). The permanence of channel habitats is determined by the volume and seasonal duration of flow that enters them, which is often related to the depth of distributary channel networks that feed into them. Permanence can vary between years in response to the magnitude of the wet season, with wet season flood events also capable of resetting the connective network via erosion and deposition. Larger, deeper channels are generally the most perennial. Where channels converge and/or flood flow patterns create channel scour, large channel hosted waterholes occur including named sites such as ‘Bella’ (-18.24602, 138.63629) and ‘Bluehole’ (-18.07189, 138.92981) on the Lawn Hill Creek system and Lake Corinda (-18.10334, 139.08192) at its confluence with Gregory River channel systems. Contiguous reaches of deeper albeit narrower perennial channel waterholes are also well developed along the major channel of the Gregory River system downstream of Gregory. Some perennial channels particularly in the eastern margin of the Gregory system end in terminal floodouts. Ultimately most channels including those of the Lawn Hill system converge back into the Gregory River upstream of its confluence with the Nicholson River. An exception is the Beamesbrook channel which diverges ahead of the Nicolson confluence and heads east merging with other smaller eastern distributaries to ultimately form a major tributary of the Albert River east of the Nicholson River. The described area overlaps with the margins of three wetlands listed in the Directory of important Wetlands in Australia (6.3.2) and includes a fourth within its catchment proximally to the listed riverine spatial units. These are Lawn Hill Gorge in the upper Lawn Hill Creek system, the Musselbrook Creek Aggregation adjoining the Lawn Hill Creek channel and the Gregory River listing in the upper channel system of the Gregory. Bluebush Swamp (at or about -18.5365080, 138.7790938) occurs adjacent to the middle reaches of the Lawn Hill Creek channel system and is hydrologically connected to it.

Riparian vegetation development adjoining these perennial habitats is largely determined by soil type and channel morphology. Where small channels are smaller and/or hosted in heavy clays, overstory vegetation development is limited despite perennial moisture. Riparian vegetation is often reflective of adjoining floodplains and include a predominance of coolabah (*Eucalyptus microtheca*) open woodlands often with a mid-storey of *Terminalia platyphylla*, *Excoecaria parvifolia* and *Lysophyllum cunninghamii*. Where soil texture is most limiting to overstorey development, riparian communities can be dominated by thickets of white berry (*Flueggea virosa*). There are a number of associated riverine (regional ecosystems 2.3.17a and 2.3.17d) and floodplain (regional ecosystems 2.3.11, 2.3.42c, 2.3.7, and 2.3.63) regional ecosystems. Several of these floodplain regional ecosystems form extensive seasonal wetlands (7.3.1) hosting significant populations of breeding waterfowl post wet season (5.1.4). The most significant occur where channels feed into broad depressions sustaining wetland habitat beyond the wet season period. These include wooded (regional ecosystems 2.3.12 and 2.3.61b) and grassland (regional ecosystems 2.3.69a and 2.3.4) regional ecosystems.

Where sandier alluvium is present adjoining larger higher energy channels or in proximity to reworked sand sheets dense, diverse fringing communities such as regional ecosystem 2.3.52 which includes paperbarks (*Melaleuca spp.*), red gum (*Eucalyptus camaldulensis)*, swamp box (*Lopostemon grandiflorus)* and cabbage palm (*Livistona rigida)* fringing major spring fed watercourses. Relative to the seasonally arid open woodlands and grasslands that characterise landscapes surrounding the riverine system, the density, structural complexity and floristic diversity of these fringing riparian communities provide movement corridors (7.1.3), bioregional and provincial refugial habitats (6.3.1), nesting and breeding sites (6.2.1) including for migratory passerines (7.1.3), turtles and freshwater crocodiles. They also provide seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (7.4.1). The area is also a known hot spot for the threatened purple crowned fairy wren *Malurus coronatus*.

Catadromous estuarine dependent fish species including the endangered freshwater sawfish (*Pristis pris*tis) have

been recorded from larger waterholes through the described area (7.1.2). The persistence of perennial habitat within the area through geological time has provided aquatic refugia (6.3.1) that have retained a host of species with disjunct populations across northern Australia including the threatened 'living fossil' Gulf snapping turtle (*Elseya lavarackorum*). Other examples include a host of fish species including northern saratoga (*Scleropages jardini*), coal grunter (*Hephaestus carbo*) and blackmast (*Craterocephalus stramineus*). Considering the site's past functioning as a refugia through geological time, the more perennial aquatic habitats within it can be expected to continue to perform such roles under the predicted effects of climate change (6.3.4).

The described areas perennial flows support a diversity of downstream aquatic and fringing riparian habitats beyond the site that have high biodiversity values and are in effect groundwater dependent ecosystems (7.1.1, 7.2.1).

Mining development and associated groundwater dewatering upstream of the described area has been implicated in some alteration to stream baseflows. However, the majority of the described areas lack intensive development and critical hydrological connectivity between groundwater, stream flow and floodplains have been retained (7.3.2). Large scale development of irrigation including altering hydrological flows through levee or weir construction would present a risk to the maintenance of the ecology associated with these perennial habitats.

In recent decades anecdotal observations suggest that the permanence of some aquatic habitats and the perenniality of flows in some reaches within the described area has reduced relative to long term local experience. The emerging impact of climate change on rainfall and groundwater recharge - discharge processes is likely to drive community shifts throughout the site toward more xeric habitats and a reduction in the extent of perennial refugia (6.2.2).

The fringing regional ecosystems associated with these perennial habitats are subject to degradation due to grazing pressure, weed invasion particularly rubber vine (*Cryptostegia grandiflora*), feral pig (*Sus scrofa*) disturbance and human recreational use. These perennial habitats include a rare ecosystem type and numerous have an 'of concern' biodiversity status. The catchment area for these systems is highly mineralised and mining development both past and potential presents an ongoing risk to system hydrology and water quality.

Semi-perennial channel supplied palustrine wetland complexes on the Gulf Plains in the lower Gregory River subcatchment

nr_nr_ec_10

The Gulf plains have a very flat, low-lying topography. In this landscape wet season overbank distributary flows from rivers form extensive channel networks that supply seasonal wooded and open palustrine wetlands. Within the study area the lower Gregory River catchment is unique geomorphologically and hydrologically (6.1.1, 6.4.1) in having perennial flows and not one main channel but a complex of anastomosing codominant channels formed in response to the low energy environment created by the extremely flat topography of the Armraynald Plains subregion that comprise its lower catchment. Unlike other southern Gulf river systems that supply seasonal flows to clay Gulf plains channel networks the Gregory River's distributaries exhibit a range of perennial to semi-perennial flows that extend beyond the typical wet season period. The permanence of the channel supplied aquatic habitats is determined by the volume and seasonal duration of flow which is related to the depth and size of the distributary channel network that feeds into them or seepage pathways provided by alluvium associated with prior channels. Permanence of channel flows and supported habitats can vary between years in response to the magnitude of the wet season with wet season flood events also capable of resetting the connective network via erosion and deposition.

Where these channels break into anastomosing floodouts or flow into broad depressional areas, large treed or open palustrine wetlands can be formed. The consequence of extended inflows or seepage to these palustrine systems is that wetland habitat is sustained beyond the wet season period. In the case of perennial inflows, a diversity of zoned vegetation communities may be supported subject to their proximity to inflows but can include fringing regional ecosystems associated with spring fed watercourses (e.g. regional ecosystem 2.3.52) which includes paperbarks (*Melaleuca spp.*), river red gum (*Eucalyptus camaldulensis*), swamp box (*Lophostemon grandiflorus*) and cabbage palm (*Livistona rigida*), and/or coolabah (*Eucalyptus microtheca*) woodland to open forest, commonly with *Terminalia platyphylla* and a shrub layer of white berry (*Flueggea virosa*) (regional ecosystem 2.3.17d). Where supplied by channel inflows these regional ecosystems can occur in broad palustrine wetland settings rather than as narrow riverine wetlands adjoining a defined main channel. Where heavier soil or more seasonal hydrology occurs in zones away from the main inflow channel or in more seasonally supplied systems, other treed palustrine wetlands occur including coolabah (*Eucalyptus microtheca*) and/or Gutta Percha (*Excoecaria parvifolia*) open woodland, occasionally with Whitewood (*Atalaya hemiglauca)* and a ground layer commonly including native rice (*Oryza spp.)* and spike rushes (*Eleocharis spp.)* (regional ecosystem 2.3.12) or coolabah woodland occasionally with *Terminalia platyphylla*, *Lysiphyllum cunninghamii*, *Vitex trifolia*, and *Flueggea virosa* (regional ecosystem 2.3.61b). The latter often contains small areas of *Chenopodium auricomum* dwarf shrubland with a seasonally variable ground layer of sedges, forbs and grasses.

Within the described area these wetlands can occur as large, seasonally flooded plains/depressions with numerous distributary channels and cracking clay soils. An endangered regional ecosystem associated with these systems is lignum (*Duma florulenta*) open shrubland to shrubland (regional ecosystem 2.3.14), which occurs on channelled and flooded backplains. The best example of this regional ecosystem occurs as part of a diverse ecosystem mosaic within a large palustrine wetland within the Beames Brook channel sub-catchment of the lower Gregory (-18.044288, 139.235726). Some semi-perennial channels particularly in the eastern margin of the Gregory system end in terminal floodouts. Wetlands created in these setting are essentially irrigated floodplain communities including mixed tussock grasslands such as regional ecosystem 2.3.4 comprised of *Eulalia aurea*, *Panicum decompositum*, *Astrebla pectinata* and *Dichanthium spp.*

The wetlands included within the described area are representative of four Gulf Plains palustrine regional ecosystems (8.2.5). The unique mix of hydrological processes that supplies them includes surface water runoff, seepage, and spring discharge (6.3.4, 7.3.2). The seasonally extended duration or permanence of aquatic habitats within them creates a productivity dividend for dependent species. They contain high value feeding, nesting and moulting habitats for waterbirds and seasonally host significant populations (5.1.4). They are also a focal area for reproduction (6.2.1). The more diverse and structurally complex vegetation communities also provide bioregional and provincial refugial faunal habitats (6.3.1) and seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (7.4.1). The perennial nature of some of these wetlands and connectivity with perennial channels results in them being habitat for migratory fish (7.1.2) and a refugial source of recruits for re-establishing populations in more seasonal habitats (7.1.1).

The regional ecosystems associated with these palustrine habitats are subject to degradation due to grazing pressure, weed invasion particularly rubber vine (*Cryptostegia grandiflora*) and feral pig (*Sus scrofa*) disturbance. These habitats also include an endangered regional ecosystem type, but most have an ‘of concern’ biodiversity status. Given the dependence of receiving environments on the flow regime experienced through the channel network changes to the flow regime via water extraction, bunding or diversion, could impact significantly on the described values within receiving systems. Anecdotal reports of reductions in the seasonal duration of some channel flows could, if realised via climate change impacts result in community shifts toward more xeric vegetation communities (6.2.2). Sites better supplied by channel inflows represent potential climate refugia particularly in the scenario where wet season rain events become less reliable for inundating seasonal wetlands (6.3.4).

Transitional areas adjacent to estuarine zone

md_r_ec_11, nr_r_ec_11

Coastal wetlands of the Gulf of Carpentaria are recognised to be vulnerable (5.2.1) to impacts associated with predicted sea level rise (Bayliss et al. 2011). Freshwater wetlands that occur at the tidal interface are particularly vulnerable. Unhindered landward migration of coastal wetland complexes in response to sea level rise presents some opportunity for the maintenance of habitat values and ecological processes (6.3.4) (Lovelock et al. 2014). Coastal floodplains that can accommodate the landward migration of these wetlands are the focus of this expert panel decision (7.1.1, 7.3.1, 7.5.1). These will be areas where seasonal freshwater-brackish swamps (important to waterbirds and migratory waders (6.3.1) can still form under conditions of higher sea level and where mangroves and other marine vegetation can establish landward of the current tidal influence boundary (6.2.2). Two coastal floodplain regional ecosystems have been identified as defining these areas: Mixed tussock grasslands occurring on raised sandy or silty areas adjacent to the tidal zone with many depressions or distributary channels (regional ecosystem 2.3.1b) and Mixed tall open shrubland occurring on coastal alluvial surfaces adjacent to the tidal zone (regional ecosystem 2.3.59a).

Creek headwater cut Tertiary surface steeps of the Doomadgee Plains subregion

nr_r_ec_12

The Doomadgee Plains subregion is characterised by lateritised Tertiary surfaces that have been partially overlain with sandy outwash from the adjacent uplands. On the southern margin of the main occurrence of this subregion north of the Nicholson River, there is an altitudinal grade from the elevated lateritised Tertiary surface of the Doomadgee Plains to the adjoining clay plains of the Armraynald subregion. Several creeks draining this area (Seven Mile, Tarpot, Lilly, Buffalo and Percy Creeks) have develop headwater cuts into the lateritised surface and these points provide an outlet for groundwater seeps emanating from the overlying sand sheet and conveyed by ferricrete surfaces. While this unique geomorphological (6.1.1) and hydrological (6.4.1) setting occur at the tops of drainage lines the hydrology is related to groundwater flow.

These seeps collectively form soaks some of which are up toward a 100ha in area that remain wet for most of the year, supporting plant growth well into the dry season (6.2.1) and providing a provincial refuge for fauna and flora (6.3.1). Under the spectre of increased rainfall variability associated with climate change these features are likely to increase in importance for their refugial values (6.3.4). These soaks are vegetated by a rare riverine wetland

ecosystem with limited extent that is representative of the Nicholson River basin (8.2.5). This is river red gum (*Eucalyptus camaldulensis*) woodland, commonly with Bloodwood (*Corymbia polycarpa*) and/or Broad leaf tea tree (*Melaleuca viridiflora*) in the canopy or as a secondary tree layer (regional ecosystem 2.3.62b).

Other regional ecosystems associated with these soaks that occur in drainage lines immediately downstream of them (7.2.1, 7.3.1, 7.3.2) include *Eriachne glauca var. glauca*, *Oryza australiensis* and *Eulalia aurea* tussock grassland in shallow alluvial depressions (regional ecosystem 2.3.58), coolabah (*Eucalyptus microtheca*) low open woodland to woodland on floodplain, commonly with *Excoecaria parvifolia*, *Grevillea striata*, *Lysiphyllum cunninghamii* and *Atalaya hemiglauca* (regional ecosystem 2.3.42c), waterholes, bare sand and rock in the channels of major watercourses (regional ecosystem 2.3.50b) and seasonal to permanent wooded palustrine swamps of coolabah (*Eucalyptus microtheca*) and/or *Melaleuca viridiflora* low open woodland in closed depressions (regional ecosystem 2.3.66).

This collection of regional ecosystems collectively forms a wetland mosaic with high habitat values for a range of wetland fauna including the provision of important breeding and feeding sites for waterbirds. Vegetation communities here are more diverse and structurally complex relative to surrounding Gulf Plains environments also seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (7.4.1). Although poorly surveyed the permanence of the aquatic habitats associated with these systems would infer their role as habitat and potential endemism hotspots for biota such as freshwater crabs and amphibians.

The majority of the regional ecosystems comprising these wetland mosaics have an ‘of concern’ biodiversity status and are subject to degradation from grazing pressure.

Wetlands on Leichhardt River scroll belt

lr_nr_ec_13, lr_r_ec_13

A scroll belt is an alluvial landform that results from the continuous lateral migration of a river meander loop creating an asymmetrical ridge and swale floodplain topography. The Leichhardt River scroll belt initiates below the Leichhardt Falls which act as a control on lateral channel migration. It becomes progressively wider downstream through the flat tidally influenced riverine reach below the falls and extends for several river bends into the estuarine zone where it ends due to the dominance of tidal processes. This distinctive geomorphic feature (6.1.1) is considered the most well-developed scroll belt in Queensland and is representative of large rivers draining to the Gulf of Carpentaria (8.2.5). It’s abandoned channels, associated billabongs, closed depressions, elevated levees, main channel and fringing vegetation create a complex floodplain environment hosting a rich assemblage of riverine and palustrine wetland and floodplain regional ecosystems, most of which have an ‘of concern’ biodiversity status.

These regional ecosystem assemblages vary along the river length of the scroll belt as it becomes broader, lower and subject to greater overbank distributary flows, flood inundation and tidal influence. Riverine wetland regional ecosystems are dominated by paperbark (*Melaleuca spp.*) and river red gum (*Eucalyptus camaldulensis*) woodlands (regional ecosystems 2.3.24, 2.3.26d) along with bare sand and scattered shrubs (regional ecosystem 2.3.50a) on the main channel and coolabah (*Eucalyptus microtheca*), bauhinia (*Lysiphyllum cunninghami*) and whitewood (*Atalaya hemiglauca*) woodlands on minor channels (regional ecosystems 2.3.17b, 2.3.17a). Palustrine wetland regional ecosystems include both seasonal and permanent swamp basins with diverse macrophyte communities made up of aquatic species, mixed sedgelands, grasslands and forblands usually with woody fringes comprised of overstory trees represented in riverine and floodplain communities. They also include seasonally flooded shallow lagoons, closed depressions on low coastal alluvial plans (regional ecosystem 2.3.34) and seasonal to permanent billabongs (regional ecosystems 2.3.2a, 2.3.16). The dominant floodplain regional ecosystems are coolabah (*Eucalyptus microtheca*), gutta percha (*Excoecaria parvifolia*) and whitewood (*Atalaya hemiglauca*) woodland with similar floristics (regional ecosystems 2.3.63, 2.3.11). Others include different floristic woodlands e.g. gutta percha (*Excoecaria parvifolia*) and paperbark (*Melaleuca spp.*) woodland (regional ecosystem 2.3.59) and bloodwood (*Corymbia spp.*) and bauhinia *Lysiphyllum cunninghami* (regional ecosystem 2.3.20b), and tussock grasslands (regional ecosystems 2.3.1a, 2.3.4).

All represented palustrine wetland and most floodplain and riverine regional ecosystems support macrophyte and grass species that provide important waterbird feeding and nesting resources and the site is an important feeding and moulting site for significant numbers of waterbirds particularly in the late dry season when the permanent swamps provide a freshwater refuge in the near coastal zone (6.2.1, 6.3.1, 5.1.4). These habitats are also demonstrated to be important to migratory shorebirds (Driscoll 2001) and passerines (7.1.3). In a regional context the diverse floristics and relative structural complexity of the vegetation assemblages within the site provide additional feeding, roosting and shelter resources relative to the broader Gulf Plans bioregion and many component regional ecosystems are recognised as a provincial refuge for woodland flora and fauna (7.4.1). Limited channel migration in the Leichhardt River above the falls means that cut off meander billabongs within the site represent relatively restricted, special habitats for the lower basin (6.3.1). Both permanent and seasonal freshwater

swamps hosted in landforms of the downstream extent of the scroll bar, create hydrological diversity within the adjacent estuarine areas. In this area permanent swamps provide refugia for obligate freshwater biota in the lower tidally influence reaches of the river system and seasonally connected fish nursery habitat for the important fishery species barramundi (6.2.1).

Barramundi (*Lates calcarif*er) and other fish species including freshwater sawfish (*Pristis pristis*) utilise these billabong and main channel habitats as nurseries, including perennial waterholes above the Alexandra River falls and estuarine and marine areas beyond the river mouth (7.1.1). Some main channel freshwater species including macrophyte spawners e.g. glassfishes (*Ambassis spp.*) also make lateral movements to these floodplain wetlands to access breeding and nursery habitat (7.1.2). The presence of flow regimes that provide for longitudinal and lateral hydrological connectivity within and beyond the site is an aquatic conservation value (7.3.2). The lowermost extent of the scroll bar extends into and forms a component of the nationally listed Directory of Important Wetlands in Australia Southern Gulf Wetland Aggregation (6.3.2). Critical biotic connectivity via fish recruitment and shorebird movement and hydrological connectivity via river and tidal flows between the site and downstream reaches, help to maintain the receiving estuarine system (7.5.2, 7.5.1). On the downstream margin of the site wetland community composition is influenced by tidal processes. Here rising sea levels are likely to drive community shift in coming decades (6.2.2).

There are a range of ecological pressures operating upon the site. Sedgelands particularly *Eleocharis spp.* are subject to significant disturbance by feral pigs (*Sus scrofa*). Riverine channel margins, palustrine wetland edges and basin and floodplain groundcovers are subject to grazing pressure particularly during the dry season. Some old fine-grained alluvial soils are dispersive and subject to erosion and significant river bank margins have been lost to advancing gully erosion. Rubber vine (*Cryptostegia grandiflora*) infestations are extensive in northern parts of the site and fringing communities of the main river channel. Several wetland basins including billabongs on the margin of the site have been bunded to create longer lasting cattle waterpoints which also creates localised trampling and pugging impacts. In the absence of grazing many of the more permanent wetlands of the site would be vulnerable to infestation by exotic ponded pasture species used in local catchments. Coolabah woodlands on cracking clays included within the site are also vulnerable to high biomass (and hot fire regime generating) of exotic buffelgrass (*Cenchrus ciliaris*) establishment and are also the focus of intensive agricultural development in adjoining basins.

Coastal swale complexes

lr_nr_ec_14, mi_nr_ec_14, nr_nr_ec_14, sc_nr_ec_14

Beach ridge systems and associated wetland swale landforms are not evenly distributed across all Southern Gulf river basins and therefore represent a limited habitat type. The best examples occur along the coastal margin of the Settlement Creek basin where specific geomorphic features occur (6.1.1) including a steeper gradient beach strand shoreline to the Gulf of Carpentaria. Where the Gulf shoreline is comprised of extensive intertidal mud flats and mangrove stands i.e. fronting the Nicholson River, Leichhardt River and Morning Inlet River basins there is limited to no occurrence (in the case of Morning Inlet basin) of beach strand and associated ridge and swale system development.

Freshwater wetlands associated with coastal swale complexes are mapped as two palustrine regional ecosystems both of which have an ‘of concern’ biodiversity status (5.2.1). These are paperbark (*Melaleuca dealbata*) low woodland to open forest in swales associated with coastal dunes (regional ecosystem 2.2.5), and seasonal swamps of mixed sedgelands or tussock grasslands in closed depressions in the swales of coastal dunes (regional ecosystem 2.2.6). These swamps are seasonally important habitat for waterbird feeding and breeding.

Given the functional capacity of beach ridges to act as seasonal groundwater aquifers, associated swale swamps can represent one of the more common and most reliable sources of freshwater in the near coastal zone of the Gulf particularly where drainage systems are highly seasonal and perennial sources of water associated with groundwater discharge tend to be up catchment. In some coastal zones they often represent the only refugial dry season source of surface freshwater (6.3.1), and the refugial value of the more perennial systems is likely to increase under more extreme climate scenarios (6.3.4). Groundwater soaks and springs commonly associated with the occurrence of swale swamps (6.4.1) can act as sources and/or conduits for groundwater discharges to adjoining estuarine systems (7.5.2) where they may support seasonally productive, transitional fresh to brackish palustrine wetlands (7.5.1).

Swale swamps provide potential habitat for NCA listed threatened species e.g. *Paspalum multinodum*. The extended moisture regime they provide can also support locally uncommon plant species associated with vine thickets and allow for the development of taller, denser Melaleuca forest communities both of which provide refugia and feeding habitats for dependent fauna species (6.3.1, 7.4.1). Supported macrophyte communities include waterfowl food plants such as *Eleocharis spp.* sedges and native rice *Oryza sp.* and larger systems provide seasonally important feeding and breeding habitat for significant numbers of water birds (5.1.4). Swamps with good connectivity to estuarine areas can also function as nursery areas for catadromous fish species (6.2.1, 7.1.1, 7.1.2). Seepage from swale systems has also been identified as an important sand temperature regulator affecting

sea turtle nesting success (6.2.1).

Evidence of vegetation die back is observed in swale systems of the north western coastline and along the Leichhardt River basin Gulf frontage including adjacent the most seaward swales or lower elevation swamps. This is interpreted as evidence of these swale systems being vulnerable (5.2.1) to climate change impacts associated with storm surges, elevated seas levels and other weather extremes (temperatures, low rainfall) or combinations of that could lead to community shifts within these landform settings (6.2.2). The broader swale ecosystems set is also subject to other threatening processes including grazing pressure (particularly during the wet season when they provide flood refuges for stock) leading to wind erosion, invasion by rubber vine (*Cryptostegia grandiflora*) and other weed species such as Calotrope (*Calotropis procera*), and feral animal disturbance particularly feral pig (*Sus scrofa*) rooting in *Eleocharis spp.* sedgelands.

Perennial channel hosted waterholes of the western Settlement Creek Basin

sc_r_ec_15

The Settlement Creek basin is comprised of several subcatchments that have independent mouths to the Gulf of Carpentaria. Catchments in the west of the basin have less seasonal flows and retain greater extents of perennial aquatic habitat than those in the east as a consequence of higher rainfall, a greater proportion of hard rock upper catchment area including groundwater aquifer bearing sandstone and impermeable lateritic pans underlying lowland stream reaches (6.1.1, 7.3.2).

In contrast to eastern subcatchments, most in the west including Settlement Creek drain to a common estuary, the Tully Inlet. Drainages to the Tully inlet include Settlement Creek with upper tributaries Branch and Redbank creeks and Camel Creek with upper tributary Gold Creek. In lower reaches channel lateritic ridge and sediment barriers between pool reaches impact the ingress of tides contributing to hydrological diversity.

These creek systems have habitats and associated aquatic conservation values not prevalent elsewhere in the Settlement Creek basin. In contrast to the soft, clayey substrates of lowland drainages elsewhere within the Settlement Creek basin the western drainages exhibit a diverse suit of substrates including cobble, sand, ferricrete and clay. All have reaches hosting deep clear permanent pools with good hydrological connectivity to lower estuarine reaches (7.1.1, 7.1.2) providing good refugial habitat (6.3.1) for a diverse suite of catadromous fish species including the threatened freshwater sawfish (*Pristis pristis*) and fishery species such as barramundi (*Lates calcarifer*). All host breeding populations of freshwater crocodile (*Crocodylus johnsoni*) (6.2.1) and larger pools have estuarine crocodiles (*Crocodylus porosus*). The deeper more permanent of these pools are likely to function as increasingly important aquatic refugia under the influence of climate change (6.3.4).

The extended flow duration creating riffle and race habitats and rich fringing vegetation communities of some upper catchment systems particularly the spring fed upper Branch Creek system (6.4.1, 7.2.1) also make it potentially suitable habitat for the threatened ‘living fossil’ Gulf snapping turtle (*Elseya lavarackorum*). Regional ecosystems mapped in association with these waterholes also include those recognised as habitat for the purple-crowned fairy wren (*Malurus coronatus*).

Some of the diversity observed across the range of perennial waterholes and associated fringing habitat is not captured by the scale of exiting regional ecosystem mapping. Most waterholes are mapped as waterholes, bare sand and rock in the channels of major watercourses in active stream channels, occasionally with scattered aquatic vegetation (regional ecosystem 2.3.50b). A variable wooded fringe commonly occurs, including river red gum (*Eucalyptus camaldulensis*), paperbark (*Melaleuca spp.*), *Eucalyptus microtheca* and *Barringtonia acutangula*. Site observations would also suggest some occurrences of, particularly in the upper Branch Creek system, the riverine regional ecosystem *Melaleuca spp.*, *Eucalyptus camaldulensis*, *Lophostemon grandiflorus* and *Livistona rigida* in mixed woodlands fringing major spring-fed watercourses, including combinations of the species *Melaleuca leucadendra*, *Melaleuca fluviatilis*, *Eucalyptus camaldulensis*, *Lophostemon grandiflorus*, *Livistona rigida* and *Nauclea orientalis* (regional ecosystem 2.3.52). Occasional canopy species include *Ficus racemosa*, *Pandanus sp.*, *Eucalyptus microtheca* and *Melaleuca argentea*, with associated floodplain regional ecosystems (regional ecosystems 2.3.26e and 2.3.42c). Collectively these regional ecosystems are recognised to provide provincial refuges for fauna and important movement and feeding sites for birds, fish and reptiles (7.4.1). All are recognised to have an ‘of concern’ biodiversity status.

Given the availability of permanent water most are subject to degradation from grazing pressure. There are also consequently susceptible to weed invasion including herbaceous species and canopy vines such as rubber vine (*Cryptostegia grandiflora*). The immediate catchment is also recognised to contain highly mineralised areas and mining development could present a risk to the future conservation of these systems. Redbank, an existing abandoned copper mine, occurs on a tributary of Settlement Creek on the Northern Territory side of the border and is known to be contributing acid drainage and mobilised heavy metals to the drainage system with undocumented consequences for the receiving environment.

Westmoreland Gorges complex

sc_r_ec_16

The Westmoreland Gorge complex includes several proximal and hydrologically linked perennial waterholes hosted within Precambrian sandstone gorges and narrow valleys representative of the McArthur subregion (8.2.5). These waterholes collectively provide important aquatic refugia (6.3.1) and repopulation source areas (7.1.1) for the obligate freshwater biota of the upper catchment of the seasonally arid Lagoon Creek catchment, the freshwater aquatic habitats of which reduce to a limited number of perennial pools through the late dry season. The main Westmoreland Gorge is formed where the upper reaches of Lagoon Creek (a major catchment within the Settlement Creek basin) cuts 1.7 km through a residual plateau of quartz rich Precambrian sandstones. Upstream of this primary and largest gorge, main and tributary channels of Lagoon Creek drain several different sedimentary rock units creating smaller gorges, seasonal races and falls and bedrock hosted waterholes with rocky scarps and narrow sandy alluvium hosting valleys.

While the main channel of Lagoon Creek extends beyond the Queensland border into the Northern Territory, several key tributaries emanate directly from a spring field (6.4.1, 7.2.1) located in the immediate vicinity of the State border, forming perennial ‘oasis pools’ with carbonate tufa formations in receiving channels (6.1.1) at the base of an overlying limestone aquifer hosting sedimentary unit. Extending east perpendicularly from the main Westmoreland Gorge the plateau through which it has formed is traversed by a series of much smaller, narrower gorges which have formed along the bed lines of more erosion prone components of the sedimentary strata (6.1.1) that have been tipped to a near vertical strike orientation. While some smaller gorges are only fissures in the rocky surface at least five have developed sufficient depth and water holding capacity to retain perennial waterholes through the dry season. The upper reaches of one of these gorge systems includes a subterranean channel system (6.1.1) hosting perennial aquatic habitats and seasonal falls and races. A refugial, endemic population of purple-spotted gudgeon (*Mogurnda mogurnda*) with genetic affinities to populations from the Flinders Ranges in inland South Australia has been recorded from this site (6.3.1) but not lower in the catchment where large predatory fish species occur (J. Tait pers comms). The uppermost reaches of most of these smaller gorge systems are above fish passage barriers and lack fish.

In the north east of the hosting riverine spatial unit a broad east-west valley has been cut into the sandstone plateau and conveys collected runoff from the hard surface catchment west. The head of this collector valley host a perennial (named Junnagunna, -17.479094, 138.185396) channel hosted lagoon. Underlain by bedrock and supplemented by groundwater inputs it also forms part of Lagoon Creek’s upper catchment aquatic refugia network. Runoff and seepage from the hard pan sandstone plateaus drain to the adjoining Lagoon Creek lowlands (7.2.1, 7.3.2) which in proximal areas are underlain by sandstone, features which collectively enhance the seasonal duration of channel hosted waterholes (6.4.1) and support more mesic vegetation communities and seasonal wetlands.

The site hosts a large population or breeding freshwater crocodiles (*Crocodylus johnsoni*) (6.2.1) and a high diversity (~18 species) of freshwater fish including five species of eel-tailed catfish and at least one catadromous fish species (7.1.2). Merten’s water monitors (*Varanus mertensi*) also occur at most sites. All permanent freshwater habitats also support a diverse suite of aquatic macrophytes dominated by seasonally emergent species and diverse fringing vegetation communities.

Across the complex at least 3 riverine, 1 palustrine and 3 floodplain regional ecosystems are associated with its perennial aquatic habitat features including some representative of the adjoining Gulf Plains bioregion. Riverine regional ecosystems include communities dominated by paperbark (*Melaleuca spp*.), river red gum (*Eucalyptus camaldulensis*), coolabah (*Eucalyptus microtheca*), bloodwood (*Corymbia spp.*), swamp box (*Lophostemon grandifloras*) and cabbage palm (*Livistona rigida*) (e.g. regional ecosystems 1.3.7f, 1.3.9b, 2.3.26f). Although not mapped aerial photo interpretation suggest small scale occurrences of a spring wetland regional ecosystem (regional ecosystem 1.10.6) also occurs within the site and hosts rare and remote plant communities for which it functions as a regionally significant refugia (5.2.1, 6.3.1). Relative to the surrounding arid landscapes the floristic richness and structural complexity of the regional ecosystems associated with perennial aquatic habitats provide a host of nesting and feeding resources for fauna including birds, bats and macropods and function as bioregional refuges and movement corridors (6.2.1, 7.4.1, 7.1.3). Terrestrial species known to be supported by perennial aquatic habitats of the complex include the threatened purple-crowned fairy wren (*Malurus coronatus*). Several of the listed regional ecosystems are recognised to have an 'endangered' or 'of concern' status.

Most regional ecosystems associated with perennial aquatic habitats are subject to grazing pressure due to the provision of cattle watering points, however in the case of this site complex the rockiness and inaccessibility of most sites limits opportunities for stock access and impacts. Livestock and feral pig (*Sus scrofa*) disturbance is a threat to riparian communities at the more accessible large gorge and lagoon sites and pigs present a predation threat to nesting reptiles including turtles and crocodiles. The site contains significant reserves of uranium. Intensive mining development would present a risk to the future conservation of the area as does climate change.

Changing rainfall and temperature regimes associated with climate change are likely to lead to community shifts across the site toward more xeric and less mesic habitat types including changes in fringing communities and reductions in the extent and/or number of perennial aquatic refugia (6.2.2). Under such a scenario a subset of the existing perennial sites is likely to gain increased importance as refugia and repopulation source areas (6.3.4).

Perennial instream waterholes of lower Lagoon creek

sc_nr_ec_17

The Lagoon Creek catchment drains the central Settlement Creek basin to an independent mouth to the Gulf. While the whole basin is seasonally arid, Lagoon Creek experiences lower rainfall than western catchments like Settlement Creek and lacks its extensive hard rock upper catchment and lateritised surfaces within lower reach channels. Consequently, its aquatic habitats experience a high level of seasonality. Immediately post wet season Lagoon Creek supports extensive areas of seasonal palustrine, lacustrine and riverine wetlands (7.3.1, 7.3.2). However, by the late dry season freshwater habitat within the entire catchment is represented by approximately ten perennial refugial waterholes (6.3.1). Several of these occur in upper reaches within the Westmoreland Gorge complex and are supplemented by sandstone groundwater aquifers (sc_r_ec_16). The remainder occur in lowland reaches as isolated channel hosted lagoons with variable hydrology, water quality, substrate/channel geomorphology and associated fringing and instream habitat. All that remain perennial during extreme dry seasons have unique and/or specific geomorphologies and hydrologies (6.1.1, 6.4.1). This includes deeper channel section created by flow scour, underlying lateritised hard pan surfaces and groundwater seepage contributions from adjoining sand sheets and/or prior channels (7.3.2).

Distinctions in fish community suites recorded from different lagoons (Jim Tait, pers. obs.) suggest each may be responsible for maintaining different components of Lagoon Creek's obligate freshwater biota through the dry season. Recorded species include catadromous species from the lower estuary (7.1.2) and the threatened freshwater sawfish (*Pristis pristis*). Freshwater crocodiles (*Crocodylus johnsoni*) and water monitors (*Varanus spp.*) are also present at most sites and estuarine crocodiles (*Crocodylus porosus*) have been recorded at some of the larger lagoons. All perennial lagoons are collectively assessed to be critical refugia for sustaining fish and other aquatic biota within the upper and lower reaches of the Lagoon Creek system (6.3.1, 7.1.1). Extreme climate events associated with climate change particularly extended drought periods, is likely to lead to reductions in the number functional refugia and consequent changes to the creeks system's aquatic biodiversity (6.2.2, 6.3.4).

Recognised refugia lagoons include: DuckHole (-17.370914, 138.210289), Westmoreland Station Lagoon (-17.338569, 138.253034), Big Lagoon (-17.308431, 138.289475), Pioneer Waterhole (-17.272131, 138.322171), Thalkamurra Lagoon (-17.179977, 138.306417).

These waterholes support several mapped regional ecosystems (regional ecosystems 2.3.50b, 2.3.15. 2.3.26e, 2.3.42c and 2.3.20e) all of which have an 'of concern' biodiversity status (5.2.1). Relative to the arid surrounding Gulf plains these site and associated floodplain ecosystems also act as regional refuges for fauna and provide feeding and nesting resources that support a host of terrestrial vertebrate fauna including birds, bats and reptiles (7.4.1). During the wet season and late dry season significant number of waterbirds are observed to utilise these sites for both reproduction and feeding (5.1.4, 6,.2.1) including migratory wader birds (7.1.3).

These lagoons and associated floodplain ecosystems are subject to grazing pressure and extensive feral pig (*Sus scrofa*) and horse (*Equus caballus*) disturbance. They are also a receiving environment for a mineralised catchment which has been the focus for proposed mining development.

Troutbeck Lagoon wetland complex

sc_nr_ec_18

Troutbeck Lagoon (-16.856028, 138.356286) is approximately 2.5 km long and is the main perennial waterhole located in the lowland reaches of a riverine – palustrine wetland complex formed by an overbank distributary system of Lagoon Creek. Its geomorphology and permanence is influenced by lateritic surfaces (6.1.1, 6.4.1) and outcrops which distinguishes it from the clayey substrate hosted waterholes of the connected Lagoon Creek system and gives it greater affinity with pool geomorphology of the Settlement Creek system to the west. The site is well connected (7.3.2) to lower estuarine reaches and it hosts a full complement of catadromous fish species including barramundi (*Lates calcarifer*) for which it provides valuable nursery habitat (7.1.2, 6.2.1). It also provides suitable habitat for the threatened freshwater sawfish (*Pristis pristis*) and has a resident estuarine crocodile (*Crocodylus porosus*) population. It is one of the largest but isolated perennial freshwater bodies within a large estuarine dominated coastal wetland complex and provides important nesting and feeding habitat for freshwater dependent waterbirds. Significantly large numbers of waterfowl (5.1.4) including ducks and geese and waterbirds including pelicans have been observed at the site in the late dry season. The site is likely to gain increasing importance as an aquatic refugia under increased climate stress due to its greater persistence of holding water relative to other lower reach waterholes of the lower Lagoon Creek system (6.3.4).

The waterhole is mapped as riverine wetland (regional ecosystem 2.3.50b) which has an 'Of concern' biodiversity status. This regional ecosystem is described as waterholes, bare sand and rock in the channels of major watercourses in active stream channels, occasionally with scattered aquatic vegetation. A variable wooded fringe commonly occurs, including *Eucalyptus camaldulensis*, *Melaleuca spp.*, *E. microtheca* and *Barringtonia acutangula*. Site observations indicate that there is a rich instream macrophyte community including extensive beds of water lily *Nymphaea spp.* and water snowflake *Nymphoides spp.* Well-developed palustrine wetlands associated with the waterhole include *Melaleuca spp.* tree swamps and treeless sedge swamps of *Eleocharis spp.* spike rush. Adjacent floodplain regional ecosystems include *Melaleuca spp.* low woodland in seasonally flooded depressions (2.3.30a), *Eucalyptus camaldulensis* low woodland to woodland, occasionally with *Melaleuca fluviatilis*, *E. microtheca*, *Cochlospermum gregorii*, *Terminalia platyphylla*, *M. nervosa* and *Corymbia bella* (2.3.26e) and floodplain mixed low open woodland to woodland, including combinations of the species *Corymbia bella*, *Eucalyptus chlorophylla*, *E. tectifica*, *Erythrophleum chlorostachys*, *C. curtipes* and *C. confertiflora* (2.3.20e).

The site acts as both an aquatic refugia (6.3.1) for freshwater biota of the lower Lagoon Creek system and a regional refugia for terrestrial fauna including bats, reptiles and birds (7.4.1). Historically the site was used for a cattle station settlement and it has been exposed to significant total grazing pressure in the past but is now relatively conservatively used by traditional owners. Feral pig disturbance is still prevalent. If the upper Lagoon Creek catchment is subject to intensive mining development and associated receiving environment impact risks, the Troutbeck Lagoon system has been recognised as a potential impact refuge.

Lagoon creek floodplain swamp complex

sc_nr_ec_19

The Lagoon Creek catchment has a relatively large area of hard rock upper catchment comprised of several tributaries that converge within a reach that transitions to flat lowlands below the Westmoreland Gorge. These lowlands drain 100km to the coast along a very low gradient of approximately 1 meter per kilometre (1:1,000). Consequently, the river channel has a small cross-sectional area and a low sediment transport capacity and overbank flows (7.3.2) and channel avulsion occur frequently in association with flood spates. Over time alternating active channels have created (7.3.1) an up to several kilometre-wide broad corridor of alluvium which supports a forested floodplain assemblage and hosts a dense complex of seasonal palustrine and riverine wetlands and isolated perennial riverine channel hosted waterholes (see sc_r_ec_17). This floodplain complex is the best representative example of equivalent systems associated with lowland dominated catchments of the Settlement Creek basin (8.2.5). Floodplain vegetation assemblages are comprised predominantly of two regional ecosystems including mixed low open woodland to woodland, including combinations of bloodwoods (*Corymbia bella*, *C. curtipes* and *C. confertiflora*), eucalypts (*Eucalyptus chlorophylla*, *E. tectifica*, *E. pruinosa*), ironwood (*Erythrophleum chlorostachys*), and bauhinia (*Lysiphyllum cunninghamii*) (regional ecosystem 2.3.20e) and coolabah (*Eucalyptus microtheca*) low open woodland to woodland, commonly with guttapercha (*Excoecaria parvifolia*), beefwood (*Grevillea striata*), bauhinia (*Lysiphyllum cunninghamii*) and whitewood (*Atalaya hemiglauca*) (regional ecosystem 2.3.42c).

Up to six seasonal palustrine wetland regional ecosystems are mapped within the complex including coolabah woodland in seasonally flooded depressions (regional ecosystem 2.3.15), mixed sedgelands, grasslands and forblands in rounded shallow lagoons (regional ecosystem 2.3.34), broadleaf tea tree woodlands on gently undulating sand sheets (regional ecosystem 2.3.55a), paperbark woodlands in seasonally flooded depressions on podzolic soils (regional ecosystem 2.3.30a), seasonal wooded (coolabah, paperbark) swamps in closed depressions on broad Tertiary lateritic surfaces (regional ecosystem 2.3.66) and in the near coastal zone, sedges, grasses and aquatic species in closed depressions with a wooded coolabah, paperbark fringe on low elevated coastal alluvial plains commonly adjacent to the tidal zone (regional ecosystem 2.3.2a).

Three riverine regional ecosystems form an integral component of the floodplain wetland complex consisting primarily of woodlands to open forests of river red gum, coolabah, paperbarks, bloodwood and swamp box and bare rock, sand and waterholes in active stream channels (regional ecosystems 2.3.26e, 2.3.24, 2.3.50b).

Most of the mapped regional ecosystems within the floodplain complex have an 'of concern' biodiversity status. Relative to the arid surrounding Gulf plains the habitat structure and resources provided by this floodplain wetland complex act as a regional refuge for fauna and provide feeding and nesting resources that support a host of terrestrial vertebrate fauna including birds, bats and reptiles potentially including the purple crowned fairy wren (*Malurus coronatus*) (7.4.1). Given their seasonality the life history of much of the biota within the wetlands including macroinvertebrates, macrophytes and fish is geared to a 'boom and bust' cycle which results in the wetlands being seasonal productivity hotspots utilised by both terrestrial and aquatic fauna including migratory species. Most of the palustrine wetlands and floodplain vegetation assemblages include groundcovers and macrophyte communities that are important waterbird feeding, nesting and moulting resources. During the wet season significant numbers of waterbirds are observed to utilise these sites for both reproduction and feeding (5.1.4, 6.2.1) including migratory wader birds particularly in the near coastal section (7.1.3). Although seasonal

these wetlands host a diverse suite of fish species and provide breeding and feeding habitats for riverine channel dwelling but floodplain habitat dependent (6.3.1) fish during the wet season. When inundated they also provide movement pathways for migratory species (7.1.1, 7.1.2) potentially including the threatened freshwater sawfish (*Pristis pristis*) known to inhabit perennial waterholes within the system.

These palustrine wetlands and associated floodplain ecosystems are subject to grazing leading to habitat loss and erosion. Feral pig (*Sus scrofa*) and horse (*Equus caballus*) disturbance are also extensive the former particularly of *Eleocharis spp.* sedgelands and the latter of drying swamps. Cattle will also access swamps to browse on macrophytes such as water lily. Some wetland basins formed on permeable sandy substrates retain water due to an organic seal created by organic material growth and deposition within the wetland (6.1.1). Stock and feral animal disturbance can impinge upon the water holding capacity of such systems.

Permanent instream waterholes of Cliffdale creek system

sc_r_ec_21

The Cliffdale Creek catchment drains the eastern central Settlement Creek basin to an independent mouth to the Gulf. Cliffdale Creek experiences some of the lowest rainfall and shortest flow durations within Settlement Creek basin catchments. Its aquatic habitats experience extreme seasonality although a corridor of seasonal palustrine, lacustrine and riverine wetlands is commonly associated with the creek system immediately post wet season (7.3.1, 7.3.2). By the late dry season freshwater habitat within the entire catchment is represented by a small number (<10) of perennial refugial waterholes (6.3.1). Several of these occur in upper reaches within the Scrutton Creek subcatchment. The remainder occur in lowland reaches as isolated channel hosted lagoons with variable hydrology, water quality, substrate /channel geomorphology and associated fringing and instream habitat variability. All that remain perennial during extreme dry seasons have unique and/or specific geomorphologies and hydrologies (6.1.1, 6.4.1). This includes deeper channel section created by flow scour, underlying lateritised hard pan surfaces and groundwater seepage contributions from adjoining sand sheets and/or prior channels (7.3.2).

Distinctions in fish community suites recorded from different lagoons (J. Tait pers. obs.) suggest each may be responsible for maintaining different components of Cliffdale Creek's obligate freshwater biota through the dry season. Recorded species include catadromous species such as barramundi (*Lates calcarifer*) from the lower estuary (7.1.2) and the threatened freshwater sawfish (*Pristis pristis*). Water monitors (*Varanus spp.*) are present at most sites and estuarine crocodiles (*Crocodylus porosus*) have been recorded at some of the larger lagoons.

All perennial lagoons in this area are likely to act collectively as assessed to be critical refugia for sustaining fish and other aquatic biota within the upper and lower reaches of the Cliffdale Creek system (6.3.1, 7.1.1). Extreme climate events associated with climate change particularly extended drought periods, is likely to lead to reductions in the number functional refugia and consequent changes to the creeks system's aquatic biodiversity (6.2.2, 6.3.4).

Recognised refugia lagoons include: Knobs Lagoon (-17.500099, 138.510931), Cliffdale Station Lagoon - 17.410139, 138.582666), Lagoon#1 (-17.371536, 138.629004), Lagoon#2 (-17.324521, 138.633113), Ballys Lagoon (-17.329075, 138.648506), Lagoon#3 (-17.251527, 138.672020).

There are a number of regional ecosystems mapped in relation to these waterholes all of which have an 'of concern' biodiversity status (regional ecosystems 2.3.50b, 2.3.15. 2.3.26e, 2.3.42c and 2.3.20e). Relative to the arid surrounding Gulf plains these site and associated floodplain ecosystems also act as regional refuges for fauna and provide feeding and nesting resources that support a host of terrestrial vertebrate fauna including birds, bats and reptiles (7.4.1). During the wet and late dry seasons significant number of waterbirds are observed to utilise these sites for both reproduction and feeding (5.1.4, 6.2.1) including migratory wader birds (7.1.3).

These lagoons and associated floodplain ecosystems are subject to high total grazing pressure and extensive feral pig (*Sus scrofa*) and horse (*Equus caballus*) disturbance.

Lateritic barrier pools

nr_r_ec_24, sc_r_ec_24

The lowlands of the Settlement Creek and north western Nicholson River basins are dominated by the Doomadgee Plains subregion which is characterised by lateritised Tertiary surfaces overlain by sandy outwash from the uplands. In coastal areas where these plains extend into the tidal zone, drainage channel hosted pools reflect unique hydrological and water quality conditions created by the distinct geomorphic setting (6.1.1) associated with residual lateritised surfaces representative of the sub region. Within channels, these surfaces function as impermeable substrates extending the fresh water holding capacity of pools post-wet season particularly where groundwater seeps from overlying sand sheets also supplement pool water supply (6.4.1). Where residual surfaces form rock bars within channels barriers to tidal movement occur with the elevation of the barriers interacting with tidal range to determine the frequency and volume of tidal ingress (7.5.2).

Lateritic barrier pools are the outcome of these described conditions. They create hydrological diversity within the

adjacent estuarine environment. Pool water quality can vary spatially and temporally from pure fresh through a range of brackish salinities to hypersaline. They can provide a source of freshwater and associated refugial habitats for dependent species (6.3.1) including waterbirds that utilise the extensive estuarine habitats of the Gulf's near coastal environment. They also function as nursery (and adult) habitats for a host of catadromous and marine vagrant fish species (7.1.1, 7.1.2, 7.5.1) including barramundi (*Lates carcarifer*) and the threatened freshwater sawfish (*Pristis pristis*) that utilise brackish habitats. Seasonal variability in water quality and hydrology can generate primary and secondary productivity booms (6.2.1) that are utilised by consumer species including migratory wader birds in the case of more open pool habitats (5.1.3, 7.1.3). These barriers pools are part of a wetland mosaic recognised as feeding and breeding areas of national significance for water birds (5.1.4).

Regional ecosystems associated with these pools vary in relation to their location within tidally influenced areas. The predominant generic regional ecosystem is fringing riverine wetland waterholes in stream channels on low elevated coastal alluvial plains adjacent to the tidal zone (regional ecosystem 2.3.2b). Subject to seasonal fresh water flows and prone to back fill with saline water at high tides. A wooded fringe may occur, including *Eucalyptus microtheca*, *Excoecaria parvifolia* and *Melaleuca spp.* Areas of open water and bare ground. Occurs in stream channels on low elevated coastal alluvial plains, commonly adjacent to the tidal zone.

The best examples of these barrier pool systems are developed on smaller more seasonal local coastal creek catchments rather than major basin drainages although they can be associated with tributary systems of the latter. Extending from west of the Nicholson River mouth west to the Northern Territory border a non-exhaustive list of Named creek systems include: Lily, Marless, Moonlight, Syrell, Arthurs, James, Passmore, Elizabeth.

These pool habitats are vulnerable to community shifts in extent and characteristics from rising sea levels under potential climate change scenarios (6.2.2).

Permanent Nicholson River waterholes hosted within the Gulf Plains Bioregion

nr_r_ec_25

The reach of the Nicholson River hosting these permanent waterholes associated with this expert panel decision has only seasonal surface flows. It occurs downstream of the sandstone hills and plateaus and associated springs that characterise upper catchment areas within the McArthur subregion (nr_nr_ec_06, nr_r_ec_06) and upstream of the perennial surface flows associated with the Gregory River confluence (nr_r_ec_26). This reach lies entirely within the Doomadgee Plains subregion of the Gulf Plains Bioregion. This subregion is characterised by lateritised Tertiary surfaces that have been partially overlain with sandy outwash from the adjacent uplands.

The occurrence of permanent waterholes within this reach can be attributed to a combination of factors including groundwater contributions from sandstone springs upstream of the site which supply the reach via river bed sand hyporheic flows (7.2.1), groundwater seeps from adjoining sand sheets on the Gulf plains and underlying lateritised surfaces that provide an impermeable substrate to bring hyporheic flows to the surface and to pool seasonal surface flows (7.3.2). The permanence of these pools and the hydrological conditions that support them provide both contemporary aquatic refugia (6.3.1) that act as sources of recruits for the repopulation of the extensive seasonal habitats that form during the wet season (7.1.1). Such refugia are also likely to increase in importance with climate change (6.3.4).

The size of these permanent waterholes varies but average approximately 1.7km length, up to 80m in width and several metres (e.g. 3m) deep. Some are only several hundred meters long and the largest at Doomadgee is 4.5 kilometres long. Most of the waterholes are hosted within bed sands although lateritic rock outcrops are apparent at some sites including the large waterhole that supports the settlement of Doomadgee which is retained behind a bedrock barrier that also host the Nicholson River Falls. These falls and a weir crest constructed across the top of the barrier rock bar present a partial barrier (7.5.2) to upstream fish movement which is only not present during large falls inundating flood flow events.

Waterholes downstream of the falls (and the entire site following falls inundating flow events) host a full complement of migratory catadromous estuarine dependent fish species (7.1.2) including recorded populations of the threatened freshwater sawfish (*Pristis pristis*). Lower waterholes also host good populations of barramundi (Lates calcarifer) including fist year individuals underpinning its function as a nursery area. This lower reach is also known to host very large individuals of barramundi (>1.5m), and a diverse assemblage of other species including several species of fork tailed catfish (*Ariidae*), the freshwater anchovy (*Thryssa scratchleyi*), sooty grunter (*Hephaestus carbo*), gulf grunter (*Scortum ogilbyi*), giant glassfish (*Parambassis gulliveri*), bull sharks (*Carcharhinus leucas*) and archer fish (*Toxotes spp.*). The site is also known to be inhabited by large estuarine crocodiles (*Crocodylus porosus*) with some recorded individuals up to greater than 4m in length.

The Nicholson River's channel morphology has been formed by large flood events which have created a broad (greater than 1km wide in some reaches) corridor of alluvial landforms (7.3.1) including parallel and braided high and low flow channels systems, extensive sand beds, within channel benches and adjoining levee systems. These landforms support relatively dense and diverse fringing riparian communities dominated by a several paperbark

species (*Melaleuca spp.*) and river red gum (*Eucalyptus camaldulensis*). One of the river red gum dominated regional ecosystems recorded for this reach is a rare vegetation community within the broader study area but representative (8.2.5) of the Nicholson River. This is river red gum and bloodwood with broad leaf tea tree (*Melaleuca viridiflora*) woodland on abandoned stream channels and upper drainage areas in lateritic landscapes (regional ecosystem 2.3.62). This rare community sustains vegetative growth into the dry season due to the moisture provided by groundwater seeps emanating from sand sheets overlying lateritised surfaces (6.1.1, 6.4.1). More diverse fringing communities also present include spring fed aquatic ecosystems of the Nicholson River basin, paperbarks (*Melaleuca spp.*), river red gum (*Eucalyptus camaldulensis*), swamp box (*Lophostemon grandifloras*), cabbage palm (*Livistona rigida*), cluster fig (*Ficus racemosa*) and Leichhardt tree (*Nauclea orientalis*) (regional ecosystem 2.3.52).

On active levees adjoining the main channel frontage more sclerophyll dominated communities occur including mixed woodland of eucalypts, bloodwoods, and bauhinia (*Lysiphyllum cunninghamii*) with occasional ironwood (*Erythrophleum chlorostachys*) (regional ecosystem 2.3.20f). Other prominent drier levee communities are coolabah (*Eucalyptus microtheca*) dominated (e.g. regional ecosystem 2.3.42c). Other represented regional ecosystems include bare sand and rock with scattered shrubs and patches of grasses, forbs and sedges which occurs in the channels of major watercourses (regional ecosystem 2.3.50a) and waterholes in active stream channels, occasionally with scattered aquatic vegetation and a variable wooded fringe including river red gum, paperbarks, coolabah and freshwater mangrove (*Barringtonia acutangula*) (regional ecosystem 2.3.50b).

Relative to the seasonally arid open woodlands and grasslands that characterise landscapes surrounding the riverine system, the density, structural complexity and floristic diversity of the fringing riparian communities provide movement corridors (7.1.3), bioregional and provincial refugial faunal habitats (6.3.1), nesting and breeding sites (6.2.1) including for migratory passerines (7.1.3), turtles and freshwater crocodiles (*Crocodylus johnsoni*). They also provide seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (7.4.1).

The fringing regional ecosystems associated with these permanent waterholes are subject to degradation due to grazing pressure, weed invasion particularly rubber vine, feral pig (*Sus scrofa*) disturbance and human recreational use. These habitats include regional ecosystem types with an ‘of concern’ biodiversity status. The catchment area for these systems is highly mineralised and future mining development could present a risk to system hydrology and water quality.

Nicholson River channel habitats below Gregory River confluence

nr_r_ec_26

This site is a subset of the National Directory of Important Wetlands in Australia listed Nicholson Delta Aggregation (6.3.2). Its high values are derived from the combination of perennial flow inputs from the Gregory River and the geomorphic setting provided by the much larger Nicholson River main channel. Amongst southern Gulf River basins, the Nicholson is unique in receiving perennial flows to its lowermost reaches (6.4.1), which also contributes to greater diversity in estuarine salinity regimes and associated productivity values (7.5.1). From the Gregory River confluence downstream, the site is comprised of an alluvial corridor up to a kilometre broad hosting multiple braided and parallel sandy channels with intervening alluvial levees. These channels host dense, diverse fringing vegetation communities which is representative (8.2.5) of limestone spring fed aquatic ecosystems of the Nicholson River basin and includes paperbarks (*Melaleuca spp.*), river red gum (*Eucalyptus camaldulensis*), swamp box (*Lophostemon grandiflorus*) and cabbage palm (*Livistona rigida*) fringing major spring fed watercourses (e.g. regional ecosystem 2.3.52). Relative to the seasonally arid open woodlands and grasslands that characterise landscapes surrounding the riverine system, the density, structural complexity and floristic diversity of these fringing riparian communities provide movement corridors (7.1.3), bioregional and provincial refugial faunal habitats (6.3.1), nesting and breeding sites (6.2.1) including for migratory passerines (7.1.3), turtles, fresh and saltwater crocodiles (*Crocodylus porosus*).They also provide seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (7.4.1). The area is also suitable habitat for the threatened purple crowned fairy wren (*Malurus coronatus*).

Downstream the multi-channel reach converges into a single channel hosted waterhole known as the ‘Five Mile’ (-17.803217, 139.358034) which is approximately 10 km long, up to 150m wide and reputed to be up to 20m deep. This deep large waterhole has formed where the Nicholson River has incised deeply into a Tertiary clayplain (6.1.1) and contrasts with the shallower sandy channel hosted waterholes upstream where the river is hosted in a lateritic surface. Below the Five Mile the river channel bifurcates into a western ‘Gin Arm’ branch and an eastern Nicholson River mouth branch. Alluvial landforms adjoining and formed by overbank flows from the main channel (7.3.1) are broad (~1.5 km) and diverse and support fringing forest and floodplain communities as well as oxbow lagoons, scroll belts and back levee swamps as described in the Nicholson Delta national directory listing. This complex of freshwater habitats is near downstream estuaries and hosts a full complement of migratory catadromous estuarine

dependent fish species (7.1.2) including good populations of the endangered freshwater sawfish (*Pristis pristis*). Road crossings on both the lower Gin Arm and Nicholson River branches have presented partial fish passage barriers (7.5.2) to the site in past decades but these have largely been rectified by fish passage works. The site hosts large populations of barramundi (*Lates calcarifer*) including fist year individuals underpinning its function as a nursery area. It is also known to host very large individuals of barramundi (>1.5m), and a diverse assemblage of other species including several species of fork tailed catfish (*Ariidae*), the freshwater anchovy (*Thryssa scratchleyi*), sooty grunter (*Hephaestus carbo*), gulf grunter (*Scortum ogilbyi*), giant glassfish (*Parambassis gulliveri*), bull sharks (*Carcharhinus leucas*) and archer fish (*Toxotes spp.*). The site is also known to be inhabited by a breeding population of very large estuarine crocodiles (*Crocodylus porosus*) with some recorded individuals up to greater than 5m in length. The depth and permanence of the site make it a major aquatic refugia (6.3.1) for the entire Nicholson River basin and this function could be expected to increase in importance under the spectre of climate change (6.3.4).

Given the site is close to sea level, future sea level rise could impact salinity regimes and supported habitats (6.2.2). The fringing regional ecosystems associated with these perennial habitats are subject to degradation due to grazing pressure, weed invasion particularly by rubber vine, feral pig (*Sus scrofa*) disturbance and human recreational use and include several with an 'of concern' biodiversity status. The catchment area for these systems is highly mineralised and mining development both past and potential presents an ongoing risk to system hydrology and water quality, and anecdotal reports note a significant change in flow regimes feeding the site. Water extraction from the Five Mile is used to irrigate fodder crops on adjoining alluvial plains. Water is also extracted from above the Nicholson Road crossing which functions as a saltwater exclusion weir, to supply water to the nearby township of Burketown. Significant increases in water extractions to support agricultural development would present risks to the area's values.

Ephemeral creeks with Tertiary clay plain catchments

nr_nr_ec_27, nr_r_ec_27

This wetland feature has been nominated primarily on geomorphic and hydrological uniqueness (6.1.1, 6.4.1). This series of adjoining creeks (Twelve Mile, Harris, Woody and Crooky Creeks) have their catchments contained entirely within the clay plains of the Armraynald subregion of the Gulf plains bioregion and are representative of Gulf Plains catchments (8.2.5). Consequently, water supply to these creeks comes entirely from local catchment run off and does not involve overbank flows from river systems.

Wetlands associated with these creeks are seasonal and include broad braided channel riverine systems with channel hosted seasonal waterholes on a Tertiary floodplain and backplain swamps. Regional ecosystems associated with these system predominantly include riverine coolabah (*Eucalyptus microtheca*), guttapercha (*Excoecaria parvifolia*), bauhinia (*Lysiphyllum cunninghamii*), and whitewood (*Atalaya hemiglauca*) woodland fringing channels in fine-textured alluvial systems (regional ecosystem 2.3.17) and coolabah (*Eucalyptus microtheca*), guttapercha (*Excoecaria parvifolia*), whitewood (*Atalaya hemiglauca*), and beefwood (*Grevillea striata*) low woodland on active Quaternary alluvial floodplains with cracking clay soils (regional ecosystem 2.3.11). Occurrences of spring associated riverine mixed woodland, including combinations of the paperbarks (*Melaleuca leucadendra*, *Melaleuca fluviatilis)*, river red gum (*Eucalyptus camaldulensis*), swamp box (*Lophostemon grandiflorus*), cabbage palm (*Livistona rigida*), Leichhardt tree (*Nauclea orientalis*), cluster fig (*Ficus racemose*) and *Pandanus spp.* (regional ecosystem 2.3.52) is also mapped for the site though the extent of this regional ecosystems in this seasonal system would be questionable. Palustrine back swamps present include seasonal swamps of mixed sedgelands, grasslands and forblands in circular depressions on podsolic soils (regional ecosystem 2.3.34).

During the wet season these regional ecosystems provide high value waterbird habitat including important feeding and moulting resources (6.2.1). Relative to the surrounding arid grasslands that characterise landscapes surrounding these wetlands, the density, structural complexity and floristic diversity of these communities provide movement corridors (7.1.3) and refugial faunal habitats (6.3.1). They also provide seasonally important food resources including nectar, fruits and insects for a host of terrestrial vertebrate fauna including mammals (e.g. macropods), birds, bats, reptiles and amphibians (7.4.1).

Most of these regional ecosystems are subject to high grazing pressure, particularly in the dry season, and widespread erosion and habitat loss has been observed across frontage areas. Most have an 'of concern' biodiversity status. Several of the seasonal drainage lines within these creek systems have been converted to dams for livestock water. Sedges *Eleocharis spp.* within the back swamps are commonly excavated and disturbed by feral pigs (*Sus scrofa*).

Large artificial impoundments in upper Leichhardt Basin

lr_nr_ec_28

Five relatively large artificial impoundments constructed to support mining development and settlement occur in the upper catchment of the Leichhardt River basin. They range from 116 to 1,900 ha in size and include Lake Julius (1,054 ha) on the main stem of the Leichhardt River, Lake Moondarra (1,884 ha) on the West Leichhardt River, Lake Mary Kathleen (152 ha) on the East Leichhardt River, Waggaboonya Lake (116 ha) on Greenstone Creek, a side tributary of Gunpowder Creek, and Rifle Creek Dam (161 ha) on a tributary of the upper West Leichhardt River. In the arid environment of the upper Leichhardt River basin all have value as aquatic refugia for both obligate freshwater biota and dependent terrestrial fauna (6.3.1). Natural lacustrine and fringing palustrine aquatic macrophyte and forested wetland communities have developed in association with these permanent waterbodies which now support a range of wetland conservation values. The conservation value of the two largest impoundments Lake Moondarra and Lake Julius have been recognised by their listing on the national Directory of Important Wetlands in Australia (6.3.2). Most values associated with these two impoundments would also apply to the smaller systems although variation in impoundment basin bathymetry influences the extent of palustrine margins and associated values. Impoundments formed in narrower river valleys e.g. Lake Julius, Rifle Creek Dam have created gorge hosted lakes, while shallower systems like Lake Moondarra and Waggaboonya Lake are more like natural lagoons in terms of habitat features.

Ninety-four species of bird have been recorded from Lake Julius and eight-four species of bird have been recorded from Lake Moondarra and its environs including up to nine species of vulnerable or endangered wetland dependent species. Up to fourteen species of shorebird including migratory species are also recorded from both these impoundments (7.1.3). Lake Moondarra is much shallower than other impoundments and supports extensive areas of submerged and emergent aquatic macrophytes many of which are important waterfowl feeding and nesting resources. Waterbird diversity is high for all these systems and during the dry season significant numbers find refuge at the perennial habitats provided by these impoundments (5.1.4, 6.3.1). They are also used as nesting and moulting sites by some waterbird species (6.2.1).

Riparian forest communities present within the riverine systems prior to impoundment construction have been inundated in the deeper, steeper margins of impoundment basins but have developed denser canopies and broader extents in association with the broader wetted margins of shallow gradient banks on the upstream ends of inundation zones. Relative to the surrounding arid landscape these vegetation communities provide a refuge and a host of feeding and nesting resources (6.2.1) including fruits, nectar and insects for many terrestrial vertebrate species including bats, birds, reptiles and arboreal mammals (7.4.1).

All impoundments support relatively high fish diversity with up to 15 resident species in Lake Moondarra and Lake Julius with additional recreationally important species including barramundi (*Lates calcarifer*) and sooty grunter (*Hephaestus carbo*) being regularly stocked. Seasonal drawdown and inundation of impoundment margins generates primary productivity booms which supports predatory fish and other piscivores including breeding populations of freshwater crocodiles (*Crocodylus johnsoni*) and seasonally abundant pelican (*Pelecanus conspicillatus*) and cormorant populations. Fish populations within these impoundments also provide a source of recruits for the extensive area of seasonal riverine habitats that occur in the upper catchments draining to them (7.1.1). Impoundment walls present impassable upstream fish passage barriers for species restricted to lower reaches of the system.

Land use pressures at most of these impoundments are relatively well managed though some are subject to grazing.

Perennial instream waterholes in Gunpowder creek

lr_r_ec_29

The uplands of the Leichhardt River basin are an arid environment that experience low and erratic rainfall. Most wetlands including riverine systems are seasonal or ephemeral. Within this context the maintenance of obligate freshwater in seasonal wetland communities is dependent upon the persistence of perennial waterholes that act as aquatic refugia and connectivity between such refugia and seasonal wetland habitats. The presence of perennial waterholes in the arid upper catchment depends upon one or more factors including: sufficient contributory catchment area to ensure run in reliability, and or a waterhole basin with an impermeable substrate and sufficient depth to retain water through the dry season, and or groundwater supplementation from rock, sand sheet or alluvial aquifers.

The Gunpowder Creek subcatchment is one of the largest in the Leichhardt River basin. Despite its extensive size, natural perennial aquatic habitat is restricted to a series of channel hosted waterholes distributed along its main channel and predominantly from its mid to lower catchment. Several small, groundwater supplied perennial waterholes also occur in the uppermost catchment of Gunpowder Creek on Calton Hills Station in the reach adjoining the Station Homestead and in an adjoining tributary Gidya Creek.

Relative to the broader catchment all perennial waterholes have a distinct geomorphology (6.1.1) and special hydrological regime (6.4.1), though these can vary between individual waterholes. The majority are hosted within sandy alluvium in narrow valleys cut through the heavily folded sedimentary rocks that form the stony hills and ranges of the Northwest Highlands Bioregion and this waterhole setting is very representative of the Leichhardt River basin (8.2.5). These sedimentary rocks also provide an impermeable base to the alluvium and a source of limited groundwater seeps that convey along with surface run off through the alluvium as hyporheic flows (7.2.1, 7.3.2). Where these basement rocks outcrop to the surface, permanent pools occur as rocky waterholes, some within spectacular gorges with impressive scarps. Towards the bottom of the catchment the valley broadens as the topography flattens and the size and number of waterholes decreases. In the mid reaches, waterholes are large up to almost 2km in length and up to 180m wide and deep (e.g. >5m). The most upstream small perennial waterholes on Calton Hills Station have a different geomorphology being only several hundred metres long, up to 20 m wide, relatively shallow and hosted within a broad flat valley floor. These are suspected to be supplemented by groundwater seeps possibly from limestone aquifers associated with an outlier of the Thorntonia subregion.

The large waterholes of the mid Gunpowder Creek reaches have been recorded to contain more than 17 freshwater fish species (T. Vallance pers. comm.), and to host large breeding populations of freshwater crocodiles (*Crocodylus johnsoni*) and turtles. Fish populations within these refugial waterholes provide recruits that migrate throughout the catchment during the wet season (7.1.1, 7.1.2). These Important seasonal refugia (6.3.1) will also gain increasing importance as climate change refuges (6.3.4) under emerging extremes of lower rainfall.

Where permanent waterholes are hosted within alluvium they support well developed riparian forest and woodland communities. A range of fringing riverine regional ecosystems are mapped in association with these waterholes (regional ecosystems 1.3.7a, 1.3.7d, 2.3.26d and 2.3.50b) with the former having an 'endangered' biodiversity status and the latter an ‘of concern’ status. These waterholes associated with fringing forests and woodlands include eucalypts e.g. river red gum (*Eucalyptus camaldulensis*) and coolabah (*Eucalyptus microtheca*), paperbarks (*Melaleuca leucadendra* and *Melaleuca argentea*), swamp box (*Lophostemon grandifloras*), cabbage palm (*Livistona rigida*), bush plums (*Terminalia platyphylla*), figs (*Ficus opposita*) and a shrub layer dominated by *Vitex trifolia* and *Flueggea leucopyrus*. The ground layer is usually sparse, with tussock grasses, forbs and sedges and waterholes commonly contain aquatic plants.

Relative to the surrounding arid landscape these vegetation communities represent a refuge for many terrestrial vertebrate species (7.4.1). They also provide a provincial refuge for some plant species and provide fauna movement corridors and a host of feeding and nesting resources (6.2.1) including fruits, nectar and insects which support bats, birds, reptiles and arboreal mammals.

These habitats are subject to invasion by rubber vine (*Cryptostegia grandiflora*) and grazing pressure that can lead to habitat loss and erosion. A historical copper mining operation (Mt Oxide) in the mid reaches of Gunpowder Creek has left a legacy of acid mine drainage which enters the system via overflow from a waste retention facility. This provides an ongoing source of potential heavy metal and acid drainage contaminants to receiving reaches including perennial waterholes downstream from its confluence.

Perennial waterholes in north west headwaters of the Leichhardt Basin

lr_r_ec_30

The uplands of the Leichhardt River basin are an arid environment that experience low and erratic rainfall. Most wetlands including riverine systems are seasonal or ephemeral. Within this context the maintenance of obligate freshwater in seasonal wetland communities is dependent upon the persistence of perennial waterholes that act as aquatic refugia and connectivity between such refugia and seasonal wetland habitats. The presence of perennial waterholes in the arid upper catchment depends upon one or more factors including: sufficient contributory catchment area to ensure run in reliability, and/or a waterhole basin with an impermeable substrate and sufficient depth to retain water through the dry season, and/or groundwater supplementation from rock, sand sheet or alluvial aquifers.

The north west headwaters of the Leichhardt River basin are comprised of three subcatchments Cartridge, Fiery, and Sandy Creeks. This part of the basin is extremely arid and only the latter two subcatchments contain natural perennial waterholes. All drain to the main Leichhardt channel. Cartridge and Fiery Creek subcatchments join the Leichhardt River just upstream of the Leichhardt Falls via a long network of seasonal channels crossing the Gulf Plain. Sandy Creek has a much shorter reach length through the Gulf Plains and joins the Leichhardt River in its mid floodplain reach. Given the seasonal and spatial isolation of perennial pools in the upper catchment of Fiery and Sandy Creeks, and the dependence of infrequent sustained wet season flows to establish connectivity with lower catchment refugia, they have an important function as refugia for obligate freshwater biota within these systems. Values and geomorphic setting are similar to those described for upper Gunpowder Creek though the waterholes are smaller, not as deep, more widely separated, have less developed riparian vegetation communities and occur in a less hilly landscape within a broader valley without the gorges and scarps encountered in the Gunpowder system.

Relative to the broader catchment all perennial waterholes have a distinct geomorphology (6.1.1) and special hydrological regime (6.4.1), though these can vary between individual waterholes. The majority are hosted in perennial waterhole settings very representative of the upper Leichhardt River basin (8.2.5). Sedimentary rocks provide an impermeable base to valley accumulated alluvium and a source of limited groundwater seeps that convey along with surface run off through the alluvium as hyporheic flows (7.2.1, 7.3.2). Where these basement rocks outcrop to or near the surface, permanent pools occur as rocky waterholes or as river sand bed hosted pools with fringing riparian vegetation. Toward the bottom of the catchment the size and number of waterholes decreases as the valley broadens as the topography flattens and waterholes are all hosted within riverbed sands. During the dry season perennial waterholes recede to only several hundred metres long, up to 30 metres wide and less than a couple of metres deep. The uppermost catchment pools are much smaller and predominantly rock holes.

These waterholes have not been surveyed but could be expected to host a subset of the 17 freshwater fish species recorded for the larger Gunpowder Creek system and to also host breeding populations of freshwater crocodiles and turtles. Fish populations within these refugial waterholes provide recruits that migrate both upstream and downstream through the catchment during the wet season (7.1.1, 7.1.2). The more permanent of these seasonal refugia (6.3.1) will gain increasing importance as climate change refuges (6.3.4) under emerging extremes of lower rainfall.

Where permanent waterholes are hosted within alluvium they support riparian woodland communities. Up to seven riverine regional ecosystems are mapped in association with these waterholes (e.g. regional ecosystems 1.3.7a, 1.3.7d, 1.3.9a, 2.3.26f, 2.3.62a, 2.3.50a and 2.3.50b) with the former having an 'endangered' biodiversity status and the majority of the latter an ‘of concern’ status. These waterholes associated with fringing forests and woodlands include eucalypts e.g. river red gum (*Eucalyptus camaldulensis*) and coolabah (*Eucalyptus microtheca*), paperbarks (*Melaleuca leucadendra* and *Melaleuca argentea*), *Asteromyrtus symphyocarpa*, swamp box (*Lophostemon grandifloras*), cabbage palm (*Livistona rigida*), bush plums (*Terminalia platyphylla*), Leichhardt trees (*Nauclea orientalis*), figs (*Ficus racemose* and *Ficus opposita*), and a shrub layer dominated by *Vitex trifolia* and *Flueggea leucopyrus*. The ground layer is usually sparse, with tussock grasses, forbs and sedges.

Relative to the surrounding arid landscape these vegetation communities represent a refuge for many terrestrial vertebrate species (7.4.1). They also provide a provincial refuge for some plant species and provide fauna movement corridors and a host of feeding and nesting resources (6.2.1) including fruits, nectar and insects which support bats, birds, reptiles and arboreal mammals. They are subject to invasion by rubber vine (*Cryptostegia grandiflora*) and to grazing pressure that can lead to habitat loss and erosion.

Perennial waterholes in central southern headwaters of the Leichhardt Basin

lr_r_ec_31

The uplands of the Leichhardt River basin are an arid environment that experience low and erratic rainfall. Most wetlands including riverine systems are seasonal or ephemeral. Within this context the maintenance of obligate freshwater in seasonal wetland communities is dependent upon the persistence of perennial waterholes that act as aquatic refugia and connectivity between such refugia and seasonal wetland habitats. The presence of perennial waterholes in the arid upper catchment depends upon one or more factors including: sufficient contributory catchment area to ensure run in reliability, and/or a waterhole basin with an impermeable substrate and sufficient depth to retain water through the dry season, and/or groundwater supplementation from rock, sand sheet or alluvial aquifers.

Two main subcatchments of the central southern headwaters of the Leichhardt River basin contain significant numbers of perennial waterholes, Mistake and Surprise Creeks. This part of the basin is extremely arid and few of the surrounding subcatchments contain few natural perennial waterholes. Both drain to the main Leichhardt River channel, Mistake Creek via a confluence with the Gunpowder Creek main channel immediately upstream of its confluence with the Leichhardt River and Surprise Creek via a confluence with Ewen Creek to the reach below Lake Julius.

Pools within these subcatchments have an important function as refugia for obligate freshwater biota that seasonally occupy the more extensive seasonal riverine habitats within these systems and for other dependent terrestrial fauna described below. Values and geomorphic setting are very similar to those described for upper Gunpowder Creek. Mistake Creek has significantly more exposed bedrock and this creates greater lengths of rocky waterhole reaches with associated gorges, scarps and seasonal races. Major waterholes within Surprise Creek are sand bed channel hosted and restricted to its lowermost reach above the Leichhardt River main channel confluence with which it shares analogous habitat types but retains a hydrological regime unmodified by upstream impoundments.

Relative to the broader catchment perennial waterholes have a distinct geomorphology (6.1.1) and special hydrological regime (6.4.1), though these can vary between individual waterholes. The majority are hosted in perennial waterhole settings representative of the upper Leichhardt River basin (8.2.5). Sedimentary rocks provide

an impermeable base to valley accumulated alluvium and a source of limited groundwater seeps that convey along with surface run off through the alluvium as hyporheic flows (7.2.1, 7.3.2). Where these basement rocks outcrop to or near the surface, permanent pools occur as rocky waterholes or as river sand bed hosted pools with fringing riparian vegetation. Toward the bottom of the catchment the size number of waterholes decreases as the valley broadens as the topography flattens and waterholes are all hosted within riverbed sands. Larger waterholes within both systems are up to a kilometre long, up to 30 metres wide and potentially several metres deep. The uppermost catchment pools are much smaller and within Surprise Creek are predominantly rock holes but in Mistake Creek lower gradient uppermost catchment reaches support alluvium filled valleys and hosted pools.

These waterholes have not been surveyed but could be expected to host the same suite of 17 freshwater fish species recorded for the Gunpowder Creek system and to also host breeding populations of freshwater crocodiles and turtles. Fish populations within these refugial waterholes provide recruits that migrate both upstream and downstream through the catchment during the wet season (7.1.1, 7.1.2). The more permanent of these seasonal refugia (6.3.1) will gain increasing importance as climate change refuges (6.3.4) under emerging extremes of lower rainfall.

Where permanent waterholes are hosted within alluvium they support riparian woodland communities. Up to five riverine regional ecosystems are mapped in association with these waterholes (e.g. regional ecosystems 1.3.7, 1.3.7d, 1.3.7e, 2.3.26d and 2.3.50b) with the former having an 'endangered' biodiversity status and the majority of the latter an ‘of concern’ status. These waterholes associated with fringing forests and woodlands include river red gum (*Eucalyptus camaldulensis*), paperbarks (*Melaleuca leucadendra* and *Melaleuca fluviatilis*), swamp box (*Lophostemon grandifloras*), cabbage palm (*Livistona rigida*), bush plums (*Terminalia platyphylla*), figs (*Ficus opposita*) and a shrub layer dominated by *Vitex trifolia* and *Flueggea leucopyrus*. The ground layer is usually sparse, with tussock grasses, forbs and sedges and waterholes commonly host aquatic plants.

Relative to the surrounding arid landscape these vegetation communities represent a refuge for many terrestrial vertebrate species (7.4.1). They also provide a provincial refuge for some plant species and provide fauna movement corridors and a host of feeding and nesting resources (6.2.1) including fruits, nectar and insects which support bats, birds, reptiles and arboreal mammals. They are subject to invasion by rubber vine (*Cryptostegia grandiflora*) and to grazing pressure that can lead to habitat loss and erosion.

Murgulla sand sheet aggregation

lr_nr_ec_32

This feature is considered the key, largest aggregation of palustrine wetlands (6.3.3) in the Donors Plateau subregion of the Gulf Plains Bioregion. This subregion is comprised of lateritised Tertiary plateaus with overlying sand sheets which form relatively elevated residual landscapes within the Gulf Plains. The Murgulla Sand Sheet that host this aggregation is representative of the subregion (8.2.5). It is flat lying and relatively undissected by coordinated drainage development. Consequently, most rain falling on the landscape accedes to seasonal groundwater aquifers within the sand sheet bound by the lateritic base. Low lying depressions within the sand sheet including collapsed areas within the underlying lateritic surface create often large seasonal wetland basins up to hundreds of hectares in surface area. Seepage from the overlying sand sheet provides groundwater supplementation to the wetlands and extends their seasonal duration into the dry season (6.4.1). This supports the development of rich aquatic macrophyte communities. Up to four palustrine wetland associated regional ecosystems are mapped within the aggregation (regional ecosystems 2.3.33, 2.3.33b, 2.3.34e and 2.3.12). These are predominantly seasonal wooded swamps with coolabah (*Eucalyptus microtheca*) open woodland and sedges in circular depressions in sand plains, on cracking clays the most dominant in terms of areal occurrence (regional ecosystem 2.3.33). The majority have an ‘of concern’ biodiversity status. While some swamps have an open woodland physiognomy, others have less overstorey and have only a wooded fringe. Other tree species forming woodland fringes include bloodwoods (*Corymbia polycarpa* and *C. bella*), guttapercha (*Excoecaria parvifolia*), whitewood (*Atalaya hemiglauca*), and bauhinia (*Lysiphyllum cunninghamii*). The ground layer of these swamps is comprised of mixed sedgelands, grasslands and forblands with community composition determined by substrate type and wetland hydrology. Communities include combinations of the species *Aeschynomene indica*, *Eleocharis spp.*, *Ludwigia peploides*, *Pseudoraphis spinescens*, *Marsilea spp.*, *Persicaria spp.* and *Oryza spp. Nymphaea spp.* and *Nymphoides indica* may occur in deeper longer sustained water and *Astrebla spp.* and *Aristida spp.* grasses in more ephemeral wetland basins.

Many of these plant species represent important feeding and nesting resources for waterbirds and the ‘boom and bust’ ecology of these seasonal wetlands creates a regional primary (and secondary) productivity hot spots utilised by wetland associated birds (potentially including threatened species e.g. finches, honey eaters, chats and fairywrens and significant number of water birds (5.1.4) as feeding, breeding and moulting sites (6.2.1).

Despite the areal extent of wetland, elevated free draining sandy areas of the sand sheet are seasonally very dry and support vegetation typically associated with arid areas including gidgee (*Acacia cambagei*) and spinifex (*Triodia spp.*) which creates a unique juxtaposition of habitat types (6.3.1) where they occur near wetlands.

These wetlands are a poorly surveyed vegetation community. Limited hydrological connectivity with downstream population source areas is likely to limit fish community establishment within the aggregation beyond the more defined drainage lines. Swamp habitats present are likely to be exploited by more vagile aquatic vertebrates such as frogs and long-necked turtles. These wetlands are recognised to be subject to degradation from grazing pressure and damage from feral pigs (*Sus scrofa*).

Inverleigh Dam aggregation

mi_nr_ec_34, mi_r_ec_34

Inverleigh Dam is a private onstream water storage formed behind a 210 meter wide and several meter high cement wall on L Creek several kilometres downstream of the East Inverleigh Station homestead. It was constructed initially in the 1940s and raised in the 1980s. Although artificially created it is the largest perennial freshwater body within the entire Moring Inlet basin (6.4.1). It has a range of wetland habitats and functional values associated with it and adjoining riverine, palustrine and floodplain regional ecosystems that are hydrologically influenced by the impoundment of water within the dam or are so proximately located as to form an ecologically connected aggregation of wetland habitat of which the dam forms a central perennial component.

Regional ecosystems represented at the dam waterbody include waterholes in active stream channels with aquatic and emergent beds of aquatic vegetation and a variable wooded fringe including river red gum (*Eucalyptus camaldulensis*), coolabah (*Eucalyptus microtheca*), and paperbarks (*Melaleuca spp.*) (regional ecosystem 2.3.50b); seasonal floodplain wetland comprised of an overstorey of coolabah (*Eucalyptus microtheca*), guttapercha (*Excoecaria parvifolia*), whitewood (*Atalaya hemiglauca*) and beefwood (*Grevillea striata*) with an understorey of tussock grasses including native rice (*Oryza australiensis*) (regional ecosystem 2.3.11); and several mixed tussock grasslands (e.g. regional ecosystems 2.3.4, 2.9.1 and 2.5.31). Adjoining palustrine wetlands include billabongs (regional ecosystem 2.3.16), coolabah open woodland and sedges in circular depressions in sand plains, on cracking clays (regional ecosystem 2.3.33) and coolabah and guttapercha open woodland with a ground layer of native rice and sedges *Eleocharis spp.* occurring in large, seasonally flooded depressions (regional ecosystem 2.3.12). Contiguous floodplain habitat includes paperbark (*Melaleuca viridiflora*) low open woodland, occasionally with *Asteromyrtus symphyocarpa* and other *Melaleuca spp.* and emergent bloodwood (*Corymbia polycarpa*) and a tussock grass ground layer occurring in drainage depressions in dissected Tertiary lateritic landscapes (regional ecosystem 2.3.30c).

The dam is located on the inland margins of the Southern Gulf wetland aggregation which is predominantly an estuarine wetland complex and a major stop over and feeding area for migratory shorebirds during their migrations to and from Australia along the East Asian – Australasian Flyway. Dam margins and adjoining seasonal wetland habitats provide suitable feeding habitat for shorebirds and represents a proximal freshwater habitat within a near coastal estuarine dominated environment (7.1.3).

Adjoining floodplain and fringing vegetation and aquatic habitats including macrophyte beds at the dam provide a range of feeding, nesting and moulting (6.2.1) resources for waterbirds which can occur in significant numbers at the site (5.1.4), particularly in the dry season when it functions as a refugia (6.3.1) not only for waterbirds but for all obligate aquatic biota including freshwater fish that recruit from the site to colonise the extensive network of seasonal stream habitat and rarer perennial pools that occurs upstream of it (7.1.1). Most catadromous fish species would not be included in this community due to the effective fish passage barrier the dam wall creates with lower estuarine reaches in all but the largest flood events. With increasing rainfall variability associated with climate change it is highly likely that in some years the dam will represent the primary aquatic refugia (6.3.4) within the L Creek subcatchment of the basin if natural shallower stream hosted pools do not persist through extended dry seasons.

While the dam is primarily supplied by surface catchment run in via the L Creek main channel, it also has lateral tributaries e.g. Redbank Creek that contribute groundwater seepage from adjoining sand sheet plateaus overlying the lateritised surface that forms the lateral margins and substrate of the dam basin. This seepage extends beyond surface flow inputs and this hydrological feature and geomorphic setting are especially associated and representative of the Donors Plateau subregion in which the dam is located (6.4.1, 8.2.5). This contributes to it appearing and functioning much like a larger version of the natural perennial to semi perennial ferricrete channel hosted waterholes that occur proximally (<5km) upstream within the L Creek riverine system.

The majority of regional ecosystems comprising the Inverleigh Dam aggregation are subject to grazing. Which may have contributed to gully and slope erosion and stripping of dispersive and skeletal soils (back to hard underlying surfaces) surrounding the dam and along some reaches of the tributaries leading to it. This contributes to seasonally turbid water conditions and run in events. Overstorey vegetation in some fringing vegetation communities including tributary systems has also been infested by rubber vine (*Cryptostegia grandiflora*). Exotic ponded pasture species have also been introduced to the site, but substantial grazing pressure limits their infestation and impact potential. Despite these pressures wetland biota and conservation values continue to be supported at the site.

Unwooded swamps on Ferricrete (Mornington Is.)

md_nr_ec_35

These shallow wetland basins and drainage depressions are widespread on the larger of the Wellesley Islands and are characteristic of the Wellesley Island subregion (8.2.5). They have distinct geomorphic features (6.1.1) forming in areas where the dominant lateritised Tertiary plateaus have been subject to fluvial erosion that has stripped soil profiles back to underlying ferricrete surfaces. Their treeless nature is a distinct habitat type (6.3.1) and is a consequence of both their hard, impermeable substrate and sustained waterlogging during wet season months. While their hard substrate can limit aquatic macrophyte establishment they often host aquatic grasses and sedges e.g. *Pseudoraphis spinescens* and *Eleocharis spp.* that provide waterbird food resources. They have a distinct hydrological regime (6.4.1) being more ephemeral wetlands than deeper floodplain and channel hosted systems but while inundated provide less predator rich habitats for invertebrates and frogs. These treeless wetlands are characteristically shallow as areas that are deeper due to scouring of the lateritised surface in the same landscape become depositional environments supporting treed wetlands. They are found throughout the catchment where overland flow fluvial processes operate including floodplain back levees and provide biotic connectivity between less ephemeral floodplain habitats (7.1.2, 7.3.2). They are less common on flat lying plateaus except for areas where they form drainage depressions that convey wet season groundwater discharge in some instances to downstream dependent communities (7.2.1). In near coastal areas they convey and hold water in areas subject to tidal mixing creating dynamic and productive brackish habitats (7.5.1) that are part of the habitat matrix used by migratory wader birds.

Due to the lack of available springs mapping, this special feature decision can’t be implemented at this time.

Swale swamps of the Wellesley Islands

md_nr_ec_36

Beach ridge systems and associated swale landforms occur on all but a few of the smaller Wellesley Islands with the largest extents and best developed swamps occurring on Mornington, Bentick, Lingnoonganee, Denham and Sweers Islands respectively. Given the functional capacity of beach ridges to act as seasonal groundwater aquifers, associated swale swamps (regional ecosystem 2.2.6) can represent the most common and reliable sources of freshwater in the near coastal zone of the islands and for smaller islands potentially the only seasonal or refugial source of surface freshwater (6.3.1).

The refugial value of the more perennial systems is likely to increase under more extreme climate scenarios (6.3.4). Groundwater soaks and springs including in adjacent Tertiary surface landscapes are commonly associated with the occurrence of swale swamps (6.4.1) which can act as sources and conduits for groundwater discharges to adjoining estuarine systems (7.5.2) where they may support seasonally productive, transitional fresh to brackish palustrine wetlands (7.5.1). The geomorphic setting of swale swamps within the Wellesley Islands is often distinctly (6.1.1) influenced by the interaction of beach ridge formation with hard pan lateritised Tertiary surfaces with the latter providing a substrate for lateral groundwater inflows and swamp basins which may not represent actual swales but stripped surfaces between residual sand sheets.

Swale swamps provide potential habitat for threatened species e.g. *Paspalum multinodum*. The extended moisture regime they provide can also support locally uncommon plant species associated with vine thickets and allow for the development of taller, denser Melaleuca forest communities both of which provide refugia and feeding habitats for dependent fauna species (6.3.1, 7.4.1). Supported macrophyte communities include waterfowl food plants such as Eleocharis sedges and rice grass (*Oryza sp.)* and larger systems provide seasonally important feeding and breeding habitat for significant numbers of water birds (5.1.4). Swamps with good connectivity to estuarine areas can also function as nursery areas for catadromous fish species (6.2.1).

Evidence of vegetation die back is observed across most swale systems of the islands including adjacent to the most seaward swales or lower elevation swamps. This is interpreted as evidence of climate change impacts associated with storm surges, elevated sea levels and other weather extremes (temperatures, low rainfall) or combinations of these (6.2.2).

Gunna Impoundment (Mornington Island)

md_nr_ec_37

The water supply impoundment for the Mornington Island settlement of Gunna has been constructed on the tidal reaches of a local catchment formed by a linear depression that diagonally transects the lateritised Tertiary plateau on the western end of the main island. At full supply level the impoundment has a surface area of approximately 70 hectares and can spill out of the unimpounded north western end of the linear depression into a separate small estuary. This impoundment provides a relatively unique lacustrine habitat (6.4.1) and represents the largest perennial freshwater body on the Wellesley Islands. Having been constructed on what was originally a natural

wetland drainage depression it has developed rich fringing riparian and instream macrophyte vegetation communities and now functions as productive wetland habitat for a range of dependent biota including waterbirds, amphibians and fish, although estuarine connectivity is impaired for the latter. Given its size and permanence it has important aquatic refugia values (6.3.1) and this role is likely to increase under the scenario of increased climate variability with climate change (6.3.4). The impoundment acts as a beacon for island waterbird populations and can seasonally host significant numbers (5.1.4). During periods of lower water levels its exposed margins also provide suitable habitat resources for migratory wader birds.

Tree swamps on Tertiary surface depressions

md_nr_ec_38

The Wellesley Islands are predominantly comprised of residual erosion resistant landforms of elevated, lateritised Tertiary plateaus. A distinct geomorphic setting (6.1.1) comprised of circular depressions and impeded drainage lines on flat undissected areas of the lateritised surface host seasonal to permanent palustrine wetlands including melaleuca tree swamps, unwooded sedge and aquatic grasslands, other macrophyte communities and areas of open water. These wetlands are representative of the Wellesley Island subregion (8.2.5) and have affinities with mainland wetland systems formed in a similar geomorphic setting within the Doomadgee Plains subregion including the national directory listed Marless wetland aggregation. There has been little or no documented survey of these or other Wellesley Island wetlands.

These wetlands are captured by Queensland wetland mapping though smaller and more seasonal examples are not. Most are mapped as seasonal swamps (wooded) of *Eucalyptus microtheca* and or *Melaleuca viridiflora* low open woodland with a lower tree or shrub layer of *M. viridiflora* (regional ecosystem 2.3.66). Others as *Melaleuca viridiflora* (predominantly) and or *Melaleuca clarksonii* low woodland, occasionally with *Asteromyrtus symphyocarpa* (regional ecosystem 2.3.55a). The ground layer in both these wetland regional ecosystems includes a range of waterbird feeding and nesting resources including *Pseudoraphis spinescens*, *Eleocharis sp.*, tussock grasses and rice grass (*Oryza sp.*). They are seasonally important feeding, breeding and moulting sites (6.2.1) for significant numbers of water birds (5.1.4). During low water periods their exposed banks also provide suitable habitat for migratory wader birds.

Most of these wetlands are seasonal though some function as or are supplied by springs and groundwater seeps from overlying sand sheets via ferricrete surfaces and these persist longer seasonally and can have aquatic refugia values (6.3.1). Such sites are likely to become more valuable under climate change extreme weather scenarios (6.3.4). In some cases, these circular depression wetlands provide a conduit through ferricrete layers for the seasonal outwelling of groundwater which can support dependent vegetation communities on the margins of the wetlands (7.4.1) or downstream in areas supplied by discharge drainages (7.2.1), including floodplain ecosystems and receiving stream systems (7.3.1, 7.3.2).

Perennial to semi-perennial riverine waterholes hosted in ferricrete channel reaches

md_r_ec_39

From a freshwater ecosystem perspective, the Wellesley Islands represent an in-situ trial of biogeographic isolation instituted within the last 10 000 years as rising sea levels separated island land masses from the mainland. For aquatic ecosystem dependent species their persistence on the island has depended on the maintenance of refugial population through the vagaries of a variable climate over the intervening period. For obligate freshwater biota their persistence has specifically depended on the continuous maintenance of perennial aquatic habitats. On the seasonally dry Wellesley Islands the most significant occurrence of such refugial habitat (6.3.1, 6.3.3) occurs as waterholes hosted in distinct geomorphic settings representative of the study area (6.1.1, 8.2.5) associated with ferricrete stream reaches maintained by special hydrological regimes (6.4.1).

Under future climate change variable weather projections, the most perennial of these waterholes will have increasingly critical values (6.3.4). The ferricrete surfaces associated with these wetlands provide an impermeable substrate that maintains waterholes and a conduit for groundwater seepage (7.2.1) emanating from overlying sand sheets or outwelling from upper catchment springs. Subject to the extent of connectivity (7.3.2) between these wetlands, groundwater source areas and downstream receiving environments they can contribute to the maintenance of biodiversity values within floodplain and other wetland systems (7.3.1) and estuaries (7.5.1).

In lower catchment tidally influenced areas waterholes formed in these settings are often brackish and treeless but provide productive habitat for a range of species including migratory wader birds (5.1.3) and catadromous fish for which they can provide nursery habitat (6.3.1). They also add to the hydrological diversity within the adjacent estuarine ecosystem. With the spectre of rising sea levels and declining rainfall such waterholes at the tidal margin will be subject to community shifts toward more saline regimes (6.2.2). Distributed along a stream channel network these waterholes act as temporal stepping stones for fish and other aquatic biota passage through the system (7.1.2) and as recruitment source areas to maintain populations elsewhere within the system (7.1.1).

Transitional fresh to brackish palustrine swamps including Eleocharis sedge swamps

md_nr_ec_50

These wetland features occur across a range of distinct geomorphic settings (6.1.1) that present a specific hydrological regime (6.4.1) involving both the spatial and temporal transition from freshwater supplied systems to tidally influence systems. Equivalent system types occur on adjoining mainland Interim Biogeographic Regionalisation for Australia subregions (e.g. those associated with md_r_ec_11, nr_r_ec_11, md_nr_ec_35) though island examples are of a smaller scale given smaller contributory catchments and higher gradient fresh to tidal transition zones. Due to their small scale and complexity most are not captured by current wetland mapping which generally includes them within the estuarine class though many are supra-tidal and maintain fresh to brackish water quality regime for extended periods post-wet season due to sustained fresh inflows including from beach dune or adjoining Tertiary plateau sand sheet aquifers. They include all mapped examples of freshwater and brackish wetlands in old river channels on low plains adjacent to estuarine zone (regional ecosystem 2.3.2), and some are currently mapped as mixed sedgelands (predominantly) or tussock grassland, commonly *Cyperaceae species* occurring in closed depressions in the swales of Quaternary coastal beach ridges and dunes (regional ecosystem 2.2.6). Both these regional ecosystem descriptions are not fully applicable to the geomorphology of the systems concerned as the depressions hosting these wetlands appear to be more associated with drainage depressions (cf. river channels) in lateritised old Tertiary surfaces and ferricrete basements (characteristic of the study area 8.2.5) intersecting marine plains. Although some wetland basins are bound by beach ridges or residual beach dune sands.

These systems are productivity hot spots. When inundated with freshwater they often host extensive sedgelands of *Eleocharis spp.* which provides productive feeding and nesting areas for significant numbers of waterbirds (5.1.4) and can also function as fishery nursery swamps (6.3.1) for catadromous fish species such as barramundi (*Lates calcarifer*). Catadromous fish move and recruit from these systems to both upstream and downstream habitats (7.2.1, 7.1.2). During the post wet season these wetlands transition toward brackish conditions (6.2.1). Invertebrate productivity and exposed bank margins create valuable migratory shorebird habitat utilised as stop over points on major migratory fly ways (7.1.3).

The conveyance of freshwater inflows through these systems, including from groundwater sources (7.3.2, 7.2.1) to receiving estuarine ecosystems, contributes to the hydrological diversity and connectivity within estuarine areas (7.5.2) and supports significant biodiversity values associated with the estuarine ecosystem (7.5.1) including mangrove and other marine plant communities that depend on freshwater inputs. Given their occurrence at the fresh - marine interface these wetland systems will be subject to community shifts toward greater marine influence under the spectre of sea level rise (6.2.2).

Springs and soaks of the Wellesley Islands

Can’t be implemented

Springs and associated soaks are representative (8.2.5) and a distinct hydrological regime (6.4.1) associated with the lateritised Tertiary plateaus, ferricrete surfaces and overlying sand sheets that characterise the Wellesley Islands subregion. Beach ridge dune systems are another source of groundwater aquifer across the Wellesley Islands but spring expressions from these sources are also often associated with the distinct geomorphic setting (6.1.1) provided by impermeable underlying ferricrete surfaces, sandstones or shales. Swale swamps supported by springs may provide potential habitat for threatened species e.g. *Paspalum multinodum*.

In the context of a seasonally dry island environment springs and soaks are critical aquatic refugia (6.3.1) that may seasonally provide the only available source of surface freshwater supporting downstream groundwater dependent biodiversity values within floodplain and wetland ecosystems including upper estuaries (7.1.1, 7.2.1, 7.3.1, 7.3.2, 7.5.1), where such groundwater inputs contribute to hydrological diversity within the adjacent estuarine area. Springhead and other supported riparian vegetation communities also provide important food and habitat resources to support terrestrial fauna and ecosystems (7.4.1).

Under future climate change, reliable springs will have increasingly critical value in supporting aquatic refugia (6.3.4). Site level spring data is not available for the Wellesley Islands, so springs and soaks were observed for this assessment using aerial imagery. The majority of the springs and soaks identified are likely to be seasonal only functioning during the wet season when the landscape is saturated. Those in close proximity to perennial waterholes and stream reaches (md_r_ec_39) are likely to be more perennial and of greater ecological value.

Due to the lack of available springs mapping, this special feature decision can’t be implemented at this time.

Fluctuating freshwater to hypersaline instream waterbodies in Morning Inlet Basin

mi_r_ec_52

Fluctuating freshwater to hypersaline waterbodies that occur within the lower catchment channels of major

drainages (i.e. L and M Creeks) within the Morning Inlet basin are mapped as waterholes in stream channels on low elevated coastal alluvial plains adjacent to the tidal zone (regional ecosystem 2.3.2b). They are subject to seasonal freshwater flows and prone to backfill with saline water at high tides. They have a scattered wooded fringe including coolabah (*Eucalyptus microtheca*), guttapercha (*Excoecaria parvifolia*) and paperbarks (*Melaleuca spp.*) and include areas of open water and bare ground. Within the Morning Inlet basin these waterbodies are formed as a consequence of specific geomorphic features (6.1.1) representative of the Donors Plateau subregion (8.2.5) that dominates all but the marine/tidal margin of the basin. This subregion is comprised of lateritised Tertiary plateaus which include sand sheets overlying lateritised surfaces and shale and sandstone bedrock. The erosion resistant nature of this geology limits the depth of fluvial channel incision and creates impermeable ferricrete or sedimentary bedrock basements within channels which consequently host perennial and semi perennial waterbodies. In the tidally influenced near coastal zone, tidal exchange is limited along the length of riverine channels due to depositional sediment bars created by sediment laden side tributary inflows draining bank, slope and gully erosion dominated floodplain catchments. These bars separate reaches into lengths that are hydrologically isolated except during high spring tides or periods of wet season run off. Near where these channels have mouths to the shallow mud flats of the Gulf their depth is increased by 'venturi scour' where contributory catchment run off generates concentrated flow through narrow channel outlets cut into sand sheets and underlying lateritic surfaces. Once the energy of these flows is dissipated by confluence with the Gulf, carried sediment loads are deposited and create delta like sand bars that also restrict tidal exchange with tributary channels. The outcome of this geomorphology and hydrology is a series of semi-perennial to perennial waterbodies that fluctuate temporally and spatially from freshwater in the wet season and upper reaches to hypersaline in the late dry season. The lateral contribution of groundwater seeps along reaches that have overlying sand sheets in their tributary catchments also contributes to the unique hydrological complexity (6.4.1, 6.3.3) and water quality diversity of the site which extends into the estuarine system, part of the nationally listed Directory of Important Wetlands in Australia Southern Gulf Wetland Aggregation (6.3.2).

Water quality can vary from turbid fresh to ultra-clear hypersaline along the length of the channel system and seasonally from the wet to dry season. This variability creates 'boom and bust' primary and secondary productivity hot spots (6.2.1) particularly in the more seasonal waterholes which host algae, plankton, micro-crustacea and fish production. This production is targeted by consumers including migratory shorebirds that utilise the Southern Gulf Wetland Aggregation as a major stop over and feeding area during their migrations to and from Australia along the East Asian – Australasian Flyway (7.1.3). Significant numbers of waterbirds also seasonally utilise the site (5.1.4) including piscivores such as cormorants and pelicans. Raptors such as white-bellied sea-eagles (*Haliaeetus leucogaster*) also exploit the fish abundance available within these channels particularly as water levels recede. Some perennial reaches provide good fish nursery and adult habitat (6.3.1) including for fishery species such as barramundi (*Lates calcarifer*). Channel habitat and baitfish abundance is also highly suited to endangered sawfish (*Pristis spp*.) including juveniles. Fish species utilising these waterbodies as nursery areas ultimately recruit to downstream estuarine and marine systems (7.1.1, 7.1.2, 7.5.1).

The described punctuated hydrological connectivity of these systems with upper catchment, lower catchment and floodplain areas represents the retention of the natural hydrological system (7.3.2, 7.5.2). However, there is some indication that the channel network may be subject to community shifts (6.2.2) associated with accelerated rates of erosion, bar deposition and channel infilling due to catchment stock impacts. The spectre of sea level rise will also ultimately change the longitudinal distribution of water quality and hydrological regimes.

Nicholson Delta Wetland Aggregation

nr_nr_ec_53, nr_r_ec_53

The aggregation comprises a complex disjunct wetland aggregation of closed depressions in impeded drainage lines, floodouts, backplains and riverine channels merging with an extensive estuarine system of saline clay pans and tidal channels. The major catchment is that of the Nicholson River, Gregory and Albert rivers which flow from the northwest highlands to the southwest. On the western side Lily, Wattle and several small unnamed streams drain northeast off the elevated Tertiary surface of the Doomadgee Plain.

Riverine systems with emergent, aquatic beds, open water and associated deep water habitats, together with associated seasonally rich lacustrine and palustrine wetlands with open water, aquatic beds, emergent and forested wetlands characterise the alluvial systems of the area. These merge across a freshwater to saltwater gradient forming a rich complex of wetland habitats. Water levels decline seasonally.

The Nicholson River Delta is also the best example of a deltaic, alluvial system in the southwestern portion of the Southern Gulf. The rich array of permanent, semi-permanent and seasonal wetlands provides drought refuge for waterbirds as well as breeding, roosting, feeding and moulting habitat.

The aggregation also includes the Nicholson River scroll belt. Refer to the Nicholson Delta Aggregation - QLD111 Directory of Important Wetlands in Australia Information sheet for more information.

Marless Lagoon Wetland Aggregation

nr_nr_ec_54, sc_nr_ec_54

The Marless Lagoon Aggregation (DIWA - 6.3.3) is a unique wetland complex on elevated tertiary lateritic surface characterised by a complex of discrete seasonal and semi-permanent forested and emergent freshwater wetlands within the Doomadgee Plain subregion of the Gulf Plains Bioregion. Extensive seasonally rich lacustrine and palustrine wetlands occur as isolated characteristically circular to semicircular wetlands (6.1.1), which together with numerous smaller palustrine wetlands dominate the aggregation. Water supply is entirely from runoff from the internal catchment of the Tertiary surface. Water samples from three separate wetlands on 20/5/92 had a pH of 6.70, 7.50 and 9.17 and a specific conductance of 0.02, 0.24 and 0.11 mScm-1 (6.4.1). The wetlands are mostly seasonal to semi-permanent with depths to c. 3 m. Water levels decline seasonally and only a few depressions hold water throughout the year. Riverine wetlands are less extensive with some permanent pools.

The Marless Lagoon Aggregation is a characteristic example (8.2.5) of a complex of discrete seasonal and semi-permanent forested and emergent freshwater wetlands within the Doomadgee Plain subregion of the Gulf Plains Bioregion. It has a seasonally abundant waterbird fauna and provides rich aquatic habitat for moulting Pacific black duck (*Anas superciliosa*), grey teal (*Anas gracilis*) and hardhead (*Aythya austr*alis) (6.3.1).

Refer to the Marless Lagoon Aggregation - QLD108 Directory of Important Wetlands in Australia - Information sheet for more information.

Wentworth Aggregation

sc_nr_ec_57, sc_r_ec_57

The site is a hydrologically related section of the Doomadgee and Karumba Plains subregions in the far north-western extent of the Gulf Plains Bioregion. It extends from the junction of the Settlement Creek and Branch creeks in the south, widens out to be bounded by Redbank Creek in the west and at its coastal extent stretches from Massacre Inlet on the east to an unnamed coastal stream some 3 km east of the Queensland-Northern Territory border. The alluvial areas comprise a complex disjunct aggregation which borders a complex continuous aggregation of saline wetlands at the coastal extent. The site comprises portions of the Westmoreland, Keighran and Littoral land systems. In the southern sections it includes deeply incised and shallow stream lines with permanent waterholes, levees and seasonally flooded backplains. An elevated Tertiary surface within the site has shallow depressions; it also serves to dam up waters in the depressions of alluvial backplains associated with Redbank and Settlement creeks. Coastwards, Gold and Settlement creeks empty into alluvial floodplains which drain into saline clay plains fronted by heavily vegetated beach ridges and well-developed beaches intersected by tidal streams. The major catchment is that of Settlement and Gold Creeks which rise in the adjacent highlands of the Mt. Isa Inlier bioregion and drain northwards into the Gulf of Carpentaria. The elevated Tertiary surface forms a minor internally draining catchment for the seasonally inundated depressions within it.

Riverine systems, some with permanent pools, extend throughout the site. Seasonally rich palustrine and lacustrine wetlands dominate the alluvial plain sections of the aggregation. The estuarine sections are dominated by mangrove forest and scrub-shrub wetlands some extensive unvegetated salt pans and some emergent wetlands. Tidal channels intersect the coastal sections.

The Wentworth Aggregation (DIWA - 6.3.3) is one of the best examples of the full range of wetland types characteristic of hydrologically related alluvial and estuarine systems, occurring in the Doomadgee and Karumba Plains subregions of the Gulf Plains Bioregion in the far northwest of Queensland. It provides seasonally rich waterfowl habitat and extensive shorebird habitat.

Refer to the Wentworth Aggregation - QLD116 Directory of Important Wetlands in Australia - Information sheet for more information.

Washpool Waterhole

lr_r_fa_18

Washpool waterhole is a large instream waterhole associated with the Alexandra River floodplain aggregation (lr_nr_ec_02), a continuous complex of floodplain palustrine, lacustrine and riverine wetlands formed on active alluvial landforms on Quaternary alluvial plains associated with overbank flows from the Leichhardt River. Washpool Waterhole is known to contain large concentration of estuarine crocodiles (*Crocodylus porosus*) (Hogan and Vallance 2005), as well as historical records of black-necked stork (*Ephippiorhynchus asiaticus*), red goshawk (*Erythrotriorchis radiatus*), Gouldian finch (*Erythrura gouldiae*) and pictorella mannikin (*Heteromunia pectoralis*) (Birdlife Australia Atlas data). This decision was sourced from the Gulf Plains Biodiversity Planning Assessment (gup_fa_14) and is applicable to the instream waterhole located at or about 139.7675258, 19.3453431.

Significant bird and turtle rookeries on the Alexandra River

lr_r_fa_19

Significant bird and turtle rookeries on the Alexandra River. This waterhole is known to contain large numbers of egrets (*Ardea spp*., *Egretta sp*.), ibis (*Threskiornis spp*.), spoonbills (*Platalea spp*.), and cormorants (*Phalacrocorax spp*.) recorded in major rookeries. Significant sites of colonially nesting waterbirds (up to 10,000 pairs), all of which are considered of international importance (Criterion 4 under Ramsar, with two sites also meeting Criterion 6) (Jaensch and Richardson 2013). Generally little turtle nesting on mainland in southern part of Gulf of Carpentaria (Living Planet Analysis 1993) with significant rookeries of green turtle (*Chelodina mydas*) and flatback turtle (*Natator depressus*) confined to islands in the Wellesley Group (Limpus 2007a, b). This decision was sourced from the Gulf Plains Biodiversity Planning Assessment (gup_fa_11) and is applicable to the instream waterhole located at or about at or about 140.2074504, 18.4317506.

Bluebush Swamp

nr_nr_ec_58

Bluebush Swamp is a large, partially infilled drainage depression with some areas of shallow open water. The catchment for the swamp is principally that of Lawn Hill Creek via Bull Creek to the southeast, as well as Mackenzie and Surprise creeks form a local catchment to the southeast of the swamp. Most of the area is seasonally saturated, with small areas of free water present as semi-permanent pools less than 1.0 m deep (6.4.1). Notable flora include aquatic bed dominated by *Nymphoides crenata* and *Ipomoea aquatica*, and emergent wetland dominated by the grasses *Pseudoraphis spinescens* and *Sporobolus mitchellii*, and the woody herb *Aeschynomene indica*. Scrub-shrub wetland dominated by *Acacia stenophylla* with *Eucalyptus microtheca* on slightly higher areas and *Excoecaria parviflora* on outer margins. Notable fauna include Pacific black duck (*Anas superciliosa*), white-necked heron (*Ardea pacifica*), pink-eared duck (*Malacorhynchus membranaceus*), coots (*Fulica atra*), Australasian grebe (*Tachybaptus novaehollandiae*), brolga (*Grus rubicundus*), straw-necked ibis (*Threskiornis spinicollis*), royal spoonbill (*Platalea regia*), egrets (*Ardea spp*.), and Australian white ibis (*Threskiornis molucca*).

Bluebush Swamp is a good example (8.2.5) of a palustrine scrub-shrub wetland in an alluvial plain of the Armraynald Plain subregion of the Gulf Plains Bioregion. Feeding, nesting and breeding habitat for waterfowl and waterbirds in late wet season, autumn and spring (6.3.1). One of a number of scrub- shrub wetlands dominated by *Acacia stenophylla* (6.3.1).

Refer to the Bluebush Swamp - QLD102 Directory of Important Wetlands in Australia - Information sheet for more information.

Important Bird Areas (IBA) - Migratory wader and waterbird roosting, feeding and breeding sites

lr_nr_fa_20, mi_nr_fa_20, nr_nr_fa_20, sc_nr_fa_20, lr_r_fa_20, mi_r_fa_20, nr_r_fa_20, sc_r_fa_20

The Gulf Plains Important Bird Area (IBA) encompasses an extensive mosaic of saline mudflats, coastal grasslands, wetlands and woodlands in an area stretching from west of Burketown to north of the mouth of the Mitchell River, in the south-eastern Gulf of Carpentaria. The whole length of the coast is included within a single IBA as the whole area is used by significant numbers of birds, although the distribution of some species varies between years depending on the extent of flooding. This low-lying area is at the interface of the shallow Gulf of Carpentaria and the outflow of numerous river systems including the Mitchell, Gilbert, Norman, Flinders, Leichhardt River and Nicholson Rivers. In the summer (December to March) wet season much of the area can be inundated as rivers overflow their banks, occasionally submerging all but the highest sand ridges. Rivers are fringed with woodlands dominated by *Melaleuca spp.*, frequently with some rainforest elements including *Nauclea orientalis*, *Ficus spp.* and *Cathormium umbellatum*. Many of these riparian areas are dominated by the invasive, introduced species rubber vine (*Cryptostegia grandiflora*) that is altering the structure of the woody strata. Levees are generally dominated by bloodwood (*Corymbia spp.*) woodlands. Extensive floodplain vegetation includes grassy eucalypt woodlands and open-woodlands, generally dominated by *Eucalyptus microtheca*, and freshwater *Dichanthium spp.* grasslands. Depressions on the floodplains contain wild rice (*Oryza spp.*) grasslands that are of great importance to birds. These floodplains and levees are also an important resource for grazing cattle, the dominant industry in the region. In some parts, overgrazing has seen a change in the ground layer from being dominated by perennial grasses to annuals which has implications for granivorous bird species. Numerous freshwater wetlands are present, both permanent and ephemeral, and these have great importance for waterbird populations as breeding areas and feeding grounds. Marine wetlands are both subtidal and intertidal, comprising open water over unconsolidated muddy to sandy bottoms (Blackman et al. 1999). Along coastal margins, tidal inlets are fringed with mangrove low open-forests, while extensive salt flats support samphire (*Halosarcia spp.*) low shrublands and patchy grasslands of *Sporobolus virginicus* and *Xerochloa imberbis*. The Gulf of Carpentaria region is an important fishery, with permanent fishing camps situated on each major estuary. In general terms, apart from

shorebirds, the fauna of the IBA is poorly documented, and the IBA may be globally important for other waterbirds. Threatening processes include weed infestation and degradation associated with feral pigs (*Sus scrofa*) and cattle grazing.

Key biodiversity: Individual locations are important breeding sites for waterbirds. A 1992 survey at Macaroni Swamp included magpie goose (*Anseranas semipalmata*) - c. 3500, Pacific black duck (*Anas superciliosa*) and grey teal (*Anas gracilis*) - c. 2000, sarus crane (*Grus antigone*) - c. 100 and Australian pelican (*Pelecanus conspicillatus*) - c. 500. The great concentration of wetlands in the Smithburne-Gilbert Fan Aggregation north of Karumba is important for many species. In 1992 a breeding colony of herons and cormorants estimated at 10-12,000 birds was noted along the Smithburne River and included egrets and Little Black Cormorant (*Phalacrocorax sulcirostris*) (Blackman et al. 1999). In 1982, heronries of several thousand great egret (*Ardea alba modesta*), intermediate egret (*Ardea intermedia*) and little egrets (*Egretta garzetta*), pied heron (*Egretta picata*), nankeen night-heron (*Nycticorax caledonicus*), royal spoonbill (*Platalea regia*), Australian white ibis (*Threskiornis molucca*), Australasian darter (*Anhinga melanogaster*), little black cormorant (*Phalacrocorax sulcirostris*), and little pied cormorant (*Microcarbo melanoleucos*) (Garnett 1989). Smaller colonies at the mouth of the Bynoe and Flinders Rivers in 1983 contained, in addition, a nest of great-billed heron (*Ardea sumatrana*). Mangrove grey fantail (*Rhipidura phasiana*), white-breasted whistler (*Pachycephala lanioides*), nationally significant numbers of many other non-breeding shorebirds, some of which show declines perhaps related to seasonal fluctuation or count timing, including bar-tailed godwit (*Limosa lapponica*) – c. 1443-2087; greater sand plover (*Charadrius leschenaultii*) – c. 1732-2504; red-capped plover (*Charadrius rufeicapillus*) - c. 324-679 from 5000 in 1993; pacific golden plover (*Pluvialis fulva*) – c. 48-70 from 2000; common greenshank (*Tringa nebularia*) – c. 2751-6331, marsh sandpiper (*Tringa stagnatilis*), c. 2943-4661, terek sandpiper (*Xenus cinereus*) – c. 289-4315, curlew sandpiper (*Calidris ferruginea*) – c. 8500 recorded 1993 and 371-537 recorded 1999; whimbrel (*Numenius phaeopus*) – c. 1031-3441, masked lapwing (*Vanellus miles*) – c. 1514-2520, and grey plover (*Pluvialis squatarola*) – c. 577-1279 (Garnett 1989, Watkins, 1993; Driscoll 2001). Little tern (*Sternula albifrons*) is recorded breeding in the area, and sightings of grey falcon (*Falco hypoleucos*), bush stone-curlew (*Burhinus grallarius*), white-browed robin (*Poecilodryas superciliosa*) and masked finch (*Poephila personata*) are recorded in the Atlas of Australian Birds database.

Non-bird biodiversity: The Southeast Gulf of Carpentaria contains important populations of estuarine crocodile (*Crocodylus porosus*) and the more common freshwater crocodile (*Crocodylus johnsoni*). Loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), Olive Ridley turtle (*Lepidochelys olivacea*) and flatback turtle (*Natator depressus*) have been recorded from the adjacent ocean and are likely to utilise the beaches of the IBA. Rare plants include *Aponogeton queenslandicus* and *Sesbania erubescens*, both found in wetlands of the area. In general, the flora and fauna of the area is poorly documented.

Riparian vegetation fringing perennial deep spring-fed waterholes in lime stone gorges

nr_r_fl_01

This special feature includes riparian vegetation communities fringing large, long, deep and almost continuously permanent instream waterholes located primarily along sections of the Gregory River (including Lawn Hill Gorge) and O'Shannassy Rivers. With hard rock or organic matter substrates, the adjacent waterholes are limestone fed systems resulting in unique water chemistry including very clear low turbidity water (no sand and silt from upland) leading to remarkably stable systems, and includes two regional ecosystems distinct to the local region (regional ecosystems 1.3.9a and 1.3.9b). Regional ecosystem 1.3.9a is unique in the North West Highlands as it is the only regional ecosystem containing *Nauclea orientalis*, *Ficus racemosa*, *Livistona rigida*. Similarly, regional ecosystems 1.3.9 a and 1.3.9b are the only regional ecosystems in the North West Highlands bioregion containing *Melaleuca leucadendra*. Regional ecosystem 1.3.9 is described in the Regional Ecosystem Description Database (REDD) as a poorly known aquatic ecosystems threatened by increasing human use and urgently requiring survey to verify condition. Other threatening processes include weed infestation and disturbance by feral pigs (*Sus scrofa*).

Riparian vegetation fringing permanent spring-fed waterholes in sandstone gorges

lr_r_fl_02, nr_r_fl_02

This special feature is similar to nr_r_fl_01 (Riparian vegetation fringing perennial deep spring-fed waterholes in lime stone gorges), and includes riparian vegetation communities fringing small (shallow and short) permanent instream waterholes in sandstone areas, and includes two regional ecosystems distinct to the local region (regional ecosystems 1.3.9a and 1.3.9b). Regional ecosystem 1.3.9a a is unique in the North West Highlands bioregion as it is the only regional ecosystem containing *Nauclea orientalis*, *Ficus racemosa*, *Livistona rigida*. Similarly, regional ecosystems 1.3.9 a and 1.3.9b are also the only regional ecosystems in the North West Highlands bioregion containing *Melaleuca leucadendra*. While the features captured by nr_r_fl_01 are similar, the features in this decision are functionally different due to their adjacent waterholes containing higher fertility, mostly loose, sandy (mostly) or muddy substrates resulting in variable and seasonally turbid water quality. Ground cover is more

exposed and erosion-prone than the limestone gorges. Regional ecosystem 1.3.9 is described in the Regional Ecosystem Description Database (REDD) as a poorly known aquatic ecosystems threatened by increasing human use and urgently requiring survey to verify condition. Other threatening processes include weed infestation and disturbance by feral pigs (*Sus scrofa*).

Riverine systems containing *Terminalia bursarina*

lr_r_fl_16, nr_r_fl_16, sc_r_fl_16

Terminalia bursarina is a rare tree species occurring within-channel deposits and levees of major watercourses or on the fringes of minor watercourses. Vegetation communities in the Gulf which contain *Terminalia bursarina* are important because this is the only area in Queensland where it is found. This includes woodland including river red gum (*Eucalyptus camaldulensis*), swamp box (*Lophostemon grandiflorus*), *Melaleuca argentea*, *Terminalia bursarina*, *Lysiphyllum cunninghamii* and *Acacia holosericea* (regional ecosystem 1.3.7f), and river red gum (*Eucalyptus camaldulensis*) woodland commonly with *Terminalia bursarina*, swamp box (*Lophostemon grandiflorus*) and paperbarks (*Melaleuca spp*.) in the canopy (regional ecosystem 2.3.26f).

Low woodlands fringing major or minor watercourses

lr_r_fl_17, nr_r_fl_17

This special feature consists of low open woodland to woodland coolabah (*Eucalyptus microtheca*) communities occurring along major watercourses or minor channels in landscapes (i.e. Wondoola and Armraynald Plains subregions) where they represent the only or most significant riparian communities. For example, they form the key riparian corridors across the large clay plains of the western Gulf Plains, whilst in the Armraynald Plain subregion they form the main (or only) source of water and shade. This decision includes vegetation communities dominated by coolabah (*Eucalyptus microtheca*) low open woodland to woodland, commonly with *Excoecaria parvifolia*, *Lysiphyllum cunninghamii* and *Atalaya hemiglauca* (regional ecosystem 2.3.17), coolabah low open woodland to woodland, commonly with *Excoecaria parvifolia* and *Lysiphyllum cunninghamii* (regional ecosystem 2.3.17a), coolabah woodland (regional ecosystem 2.3.17b), and coolabah woodland to open forest, commonly with *Terminalia platyphylla* (regional ecosystem 2.3.17d). These communities are diverse and ecologically complex especially in areas with braided watercourses. They are known to provide refuge for fauna, including macropods, and are the only permanent coolabah regional ecosystems in the Gulf Plains. All are generally subject to grazing pressure, widespread erosion and habitat loss. Regional ecosystems 2.3.17 and 2.3.17a are also known to be subject to extensive invasion by buffel grass (*Cenchrus ciliaris*) on sandier soils, whilst regional ecosystem 2.3.17d is commonly heavily invaded by *Cryptostegia grandiflora* (rubber vine).

Wetlands fed by Great Artesian Basin springs (Queensland Herbarium 2020 - Class 1 & 2)

Springs feed permanent wetlands that provide oases for unique aquatic life forms in otherwise dry landscapes. For example, an abundance of specialised invertebrates including ostracods, snails, spiders, flatworms and dragonflies are known to occur only in wetlands associated with Great Artesian Basin springs. Likewise, certain grass, herb and sedge species are often restricted to wetlands associated with Great Artesian Basin springs (Fensham 2006).

This expert panel decision applies to all catchments. In arid environments, a spring with a permanent saturation regime and fixed spatial location may only support surface expression groundwater dependent ecosystems extending less than one hectare from the spring vent.

Due to the lack of available springs mapping, this special feature decision can’t be implemented at this time.

***Acacia stenophylla* swamps**

nr_nr_fl_09

This special feature includes backplain swamps associated with limestone capture due to the presence of sandstone levies. These systems include seasonal swamps (wooded) of *Acacia stenophylla* tall shrubland to low open woodland, commonly with *Excoecaria parvifolia* and *Eucalyptus microtheca*. A narrow fringe of *E. microtheca* may occur (regional ecosystem 2.3.13). The ground layer is a seasonally variable combination of sedges, forbs and grasses. Occurs in closed depressions on active Quaternary alluvial backplains. These are the only communities of *Acacia stenophylla* in the Gulf region. These are very mature woodlands that are known to also have cultural significance. The best example is Widdallon swamp. These areas are subject to grazing pressure leading to habitat loss, and disturbance by feral pigs (*Sus scrofa*).

Swamps on the Armraynald Plain sub-region

lr_nr_fl_10, nr_nr_fl_10

This special feature includes all occurrences of mixed tussock grassland, including combinations of the species

Dinebra neesii, *Panicum trachyrhachis*, *Dichanthium sericeum subsp. polystachyum, Oryza spp*., *Cyperus sp*. and *Astrebla spp*. (regional ecosystem 2.3.67). This may also include small areas of *Chenopodium auricomum* dwarf shrubland. The habitat occurs in shallow depressions on broad, Tertiary clay plains. This regional ecosystem is a restricted and rare vegetation community with unique or unusual flora species, such as *Dinebra neesii*, *Panicum trachyrhachis, Dichanthium sericeum subsp. polystachyum, Oryza spp*., *Cyperus sp*. and *Astrebla spp*.. Threatening processes include grazing pressure and invasion by mimosa bush (*Vachellia farnesiana*).

Seasonal wooded swamps dominated by *Eucalyptus microtheca*

lr_nr_fl_15, mi_nr_fl_15, nr_nr_fl_15

This special feature encompasses coolabah (*Eucalyptus microtheca*) open woodland and sedges in circular depressions in sand plains on cracking clays. This expert panel decision includes wooded seasonal swamps dominated by *Eucalyptus microtheca* open woodland over *Aeschynomene indica*, *Eleocharis spp*., *Marsilea spp*. and *Pseudoraphis spinescens* on margins of larger depressions and in centres of smaller depressions, and *Astrebla spp*. or *Aristida spp*. in centres of larger depressions (regional ecosystem 2.3.33). The habitat occurs in closed depressions on sandy Tertiary plains and cracking clays with solodised solonetz in centres of larger depressions. These are seasonal wetlands known to be important feeding sites for water birds.