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Abbot Point Growth Gateway Project - Technical Report for Wetland Hydrology, Water Quality and Aquatic Ecology Components (MNES)

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Abbot Point Growth Gateway Project - Technical Report for Wetland Hydrology, Water Quality and Aquatic Ecology Components (MNES)

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Synopsis: **A report to support the Environmental Impact Statement for the Abbot Point Gateway Project. The report considers wetland surface water hydrology, water quality and aquatic ecology components.**

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Executive Summary

The Abbot Point Growth Gateway Project (the Project) involves:

- Construction of onshore dredged material containment ponds (DMCPs) within the area previously allocated for the development of Terminal 2 (T2)
- Capital dredging of approximately 1.1 million m^3 *in situ* of previously undisturbed seabed for new berth pockets and ship apron areas required to support the development of Terminal 0 (T0)
- Relocation of the dredged material to the DMCPs and offshore discharge of return water
- Ongoing management of the dredged material including its removal, treatment and beneficial reuse within the port area and the State Development Area, where appropriate.

BMT WBM was engaged by Advisian to prepare technical assessments to inform an Environmental Impact Assessment report prepared under the *Environment Protection and Biodiversity Conservation Act 1999*. This report specifically assesses the potential impacts of the Project to the Caley (Kaili) Valley Wetlands, with respect to:

- Surface water hydrology and hydrodynamics
- Wetland surface water quality
- Wetland aquatic ecology (excluding birds).

Caley Valley Wetlands (the Wetlands) is listed under the Directory of Important Wetlands of Australia, and provides a range of biodiversity values for wetland flora and fauna. The Wetlands also provide ecosystem services at a local (wetland specific) scale, some of which are relevant to supporting the Outstanding Universal Value (OUV) of the Great Barrier Reef World Heritage Area and Great Barrier Reef Natural Heritage Place – most notably water quality regulation and fish habitat provisioning.

The development footprint of the DMCP does not contain wetland vegetation or habitats. All land within the DMCP and immediate surrounds has been previously cleared and currently supports pasture grassland. In the context of the wider catchment, the area directly impacted has limited contribution to the habitat values, but provides some values for regulating catchment runoff. The loss of habitat is predicted to have a Low impact level.

Highly localised, short-term impacts to wetland aquatic flora (within the vicinity of the construction footprints) are expected to occur as a result of the Project. In particular, the Project is predicted to result in:

- Potential short-term and localised water quality impacts during construction (sediments from footprint, spills), which can be mitigated through standard erosion and sediment control and house-keeping practices
- Potential spread of weeds during construction, which can be mitigated through standard controls including wash-downs, education weed control and monitoring
- Localised, short-term scour and salinity effects at stormwater discharge points and spillway of the DMCP. This can be partly mitigated by relocating the discharge points away from areas containing large areas of salt couch, post-operation rehabilitation of affected areas and possibly offsets if required.

The project and other concurrent proposals (proposed T0 and T3 terminals) are not individually or cumulatively expected to result in the loss or significant effects to any of the local expressions of the OUV of the Great Barrier Reef World Heritage Area at even highly localised spatial scales. In the context of EPBC Act Significant Impact Guidelines 1.1 (DoE 2013), it is not expected that the Project would result in significant cumulative impacts to the:

- Aquatic ecological values supported by the Wetlands that are relevant to the protection of World Heritage Area and Natural Heritage Place
- Threatened aquatic fauna.

A range of mitigation measures have been recommended to reduce the risk of impacts to aquatic habitats, flora and fauna within the Wetlands. Post-operation rehabilitation of affected areas and other management actions may be implemented if required.

Acronyms and Abbreviations

AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment Conservation Council
APCT	Abbot Point Coal Terminal
ARI	Average Recurrence Interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASS	Acid Sulfate Soils
CFL	Courant-Friedrichs-Lewy
CR	Community Respiration
DEHP	Queensland Department of Environment and Heritage Protection
DEM	Digital Elevation Modell
DIWA	Directory of Important Wetlands Australia
DMCP	Dredged Material Containment Ponds (includes Primary and Secondary DMCPs)
DO	Dissolved oxygen
DoE	Australian Department of Environment
EAM	Environmental Assessment and Management
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
FSL	Full Supply Level
GBRMP	Great Barrier Reef Marine Park
GBRNHP	Great Barrier Reef National Heritage Property
GBRWHA	Great Barrier Reef World Heritage Area

GDE	Groundwater-dependent ecosystems
GPP	Gross Primary Production
IUCN	International Union for the Conservation of Nature
Km	Kilometre
LAT	Lowest Astronomical Tide
LiDAR	Light Detection and Ranging
Mm^3	Million cubic metres
MNES	Matters of National Environmental Significance
MOL	Maximum Operating Level
NC Act	*Nature Conservation Act 1992* (Qld)
NCEP	National Centre for Environmental Prediction
NLSWE	Non-linear shallow water equations
NQBP	North Queensland Bulk Ports
OUV	Outstanding Universal Value
PASS	Potential Acid Sulfate Soils
PMST	Protected Matters Search Tool
ppt	Parts per thousand (equivalent to g/L or kg/m^3)
psu	Practical salinity units (approximately equal to ppt)
The Project	Abbot Point Growth Gateway Project
RE	Regional Ecosystems
RL	Reduced level
SRTM	Shuttle Rada Topography Mission
T0	Terminal 0 – coal terminal developed by Adani at Abbot Point
T1	Terminal 1

T2	Terminal 2 – coal terminal to be developed at Abbot Point
T3	Terminal 3 – coal terminal developed by Hancock Coal at Abbot Point
TN	Total nitrogen
TP	Total phosphorus
VMA	*Vegetation Management Act 1999* (Qld)
The Wetlands	Caley (Kaili) Valley Wetlands

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1 Introduction

1.1 Background

This report relates to the Abbot Point Growth Gateway Project ('the Project') and the associated Referral under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) dated 17 Apr 2015 (Reference Number: 2015/7467). On 14 May 2015, the Project was determined to be a controlled action, requiring assessment by Environmental Impact Assessment (EIA). The relevant controlling provisions were determined to be:

- World Heritage properties;
- National Heritage places;
- Listed threatened species and communities;
- Commonwealth marine areas; and
- Great Barrier Reef Marine Park.

BMT WBM was engaged by Advisian to undertake specialist technical studies as part of the EIA. Specifically, BMT WBM has been engaged to provide an assessment of the potential impacts to the Caley (Kaili) Valley Wetlands and provide inputs to an EMP for the following technical fields:

- Surface water hydrology and hydrodynamics;
- Wetland surface water quality; and
- Wetland ecology (excluding birds).

BMT WBM's flood impact assessment has been provided in a separate report (BMT WBM 2015).

1.2 Project Summary

The following provides a short description of the Project as provided in the Referral (2015/7467).

The proposed project is located at the Port of Abbot Point, approximately 25 km north of Bowen on the North Queensland Coast (Figure 1-1). The proposed action involves:

- Construction of an onshore dredged material containment pond (DMCP) within the area previously allocated for the development of Terminal 2 (T2);
- Capital dredging of approximately 1.1 million m^3 *in situ* (Mm^3) of previously undisturbed seabed for new berth pockets and ship apron areas required to support the development of Terminal 0 (T0);
- Relocation of the dredged material to the DMCP and offshore discharge of return water; and
- Ongoing management of the dredged material including its removal, treatment and beneficial reuse within the port area and the State Development Area, where appropriate.

1.3 Terminology and Nomenclature

The footprint of the DMCP is shown in Figure 1-2.

Caley (Kaili) Valley Wetlands are spatially defined by the Directory of Important Wetlands Australia (DIWA) (DEH 2006) for the area known as "Abbot Point - Caley Valley Wetland QLD 001" as shown in Figure 1-3. The area defined by these boundaries is hereafter referred to as the Wetlands. The Wetlands are subject to distinct “wetting” and “drying” periods, shown in Figure 1-4.

Several distinct functional habitat zones were defined by BMT WBM (2012) within the Wetlands on the basis of vegetation types, salinity and structural habitat conditions. These zones have been adopted in the present study as follows (Figure 1-3):

(1) Coastal water zone, which is located on the western side of the Wetlands and is comprised of marine habitat types;

(2) Western estuarine zone, which is located down-slope of the Western Bund[1] and is comprised of estuarine vegetation, tidal flats and creeks;

(3) Hypersaline zone, which is located between the Western and Causeway Bund, and contains a mosaic of natural saltpan and degraded wetland habitat;

(4) Wetland basin zone forms the majority of the Wetlands and is comprised of a shallow lagoon with fringing saltmarsh vegetation. The DMCP is located in this zone;

(5) Saltwater Creek zone, which contains permanent freshwaters and riparian vegetation (including some mangroves); and

(6) Terrestrial zone, which contains small ephemeral streams as well as terrestrial ecosystems (i.e. woodlands and grasslands).

1.4 Report Structure

The information presented within this report is provided in the following sections:

- Project description;
- Existing hydrological processes and surface water quality;
- Existing aquatic (wetland) ecology values;
- Assessment methodology, including the methodology for both the modelling and risk assessments; and
- Impacting processes and mitigation measures.

[1] [1] Refer to Section 3.1regarding the location and hydrological effects of the Western and Causeway bunds

Title:

Locality Plan – Abbot Point and Caley Valley Wetlands

Figure: 1-1

Rev: A

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Approx. Scale

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Title:

Proposed DMCP footprint and existing infrastructure

Figure: **1-2**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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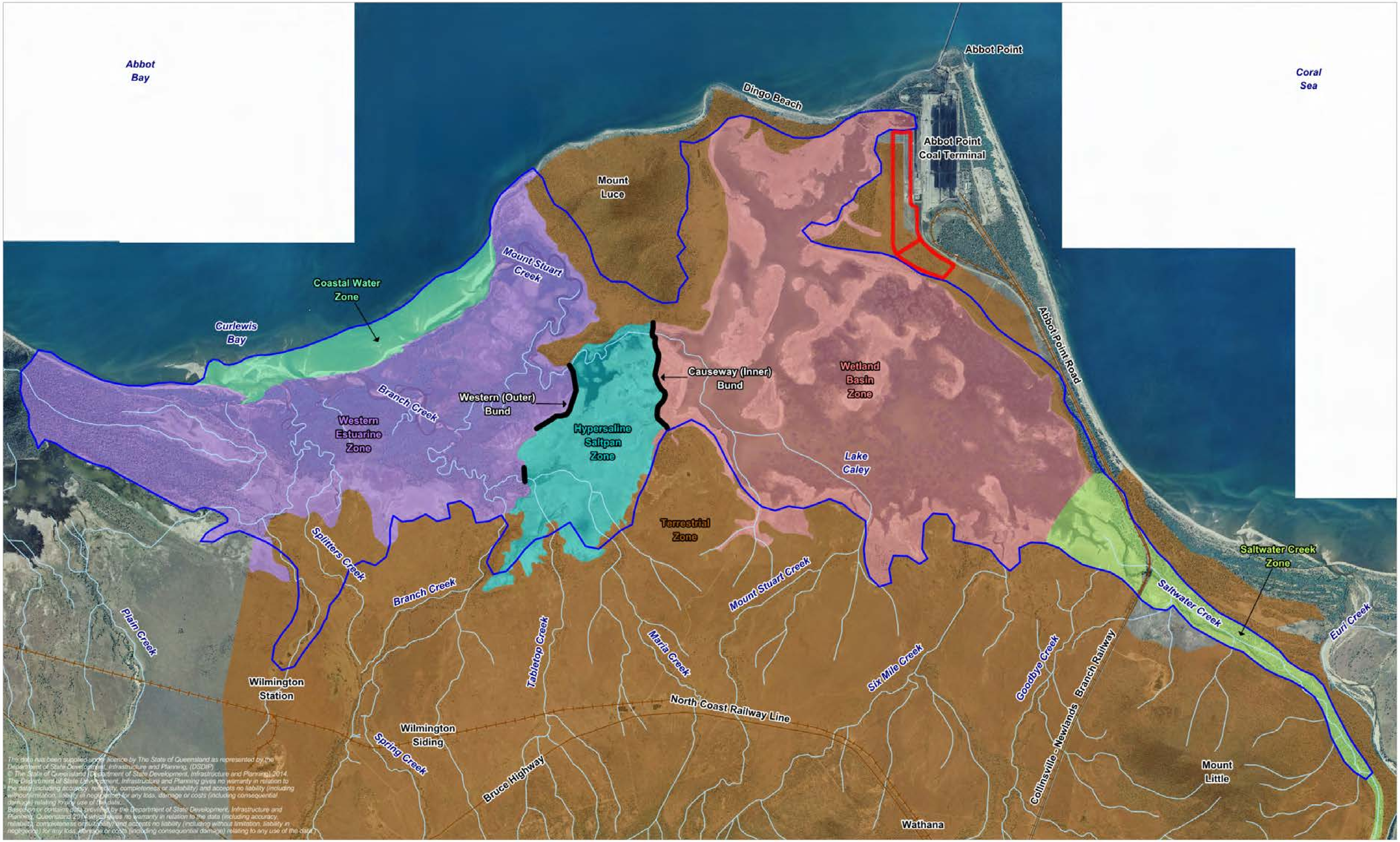

LEGEND

- Caley Valley Wetland Boundary as Defined through DIWA Listing
- Proposed Dredged Material Containment Ponds (DMCP)
- Road
- Railway
- Regrowth Watercourse (DERM)

Habitat Zone

- Saltwater Creek
- Coastal Water
- Hypersaline Saltpan
- Western Estuarine
- Wetland Basin
- Terrestrial

Title:

Caley Valley Wetlands and Functional Habitat Zones

Figure 1-3

Rev: A

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Title:

Examples of 'wetting' and 'drying' events for the Wetlands

Figure: 1-4

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2 Project Description

The following project description was provided to BMT WBM by Advisian on 13 July 2015, and provides a detailed explanation of the various project components. The description does not include detail regarding:

- Final DMCP land form;
- Reuse / treatment of dredged material;
- Potential Acid Sulfate Soils (PASS). It is assumed for the purposes of this report that PASS of dredge material is mitigated (noting that a conservative approach to Acid Sulphate Soils (ASS) management will be undertaken and addressed in an ASS Management Plan for the project, and there will be no ASS transport to the Wetlands); and
- Ancillary dredge activities (e.g. anchoring, booster pumps, refuelling).

2.1 Dredging

The dredging footprint is approximately 61 ha. The extent of dredging required for the T0 project includes the development of berth pocket and apron to design depths of -21.0 m Lowest Astronomical Tide (LAT) and -18.5m LAT, respectively.

It is estimated that approximately 1.1Mm^3 *in situ* volume of dredged material will be dredged during the program.

This volume has been calculated based on:

- The proposed T0 dredging extents;
- Abbot Point hydrographic survey carried out by Queensland Government Hydrographic Services on 27 October 2014;
- Dredged batter slopes of 1V:5H;
- An over-dredging allowance of 0.5m; and
- Allowance of an extra 50,000m^3 siltation from the date of the most recent survey noted above and the commencement of dredging.

A breakdown of the volume of material to be dredged for the berths and apron of T0 is provided in Table 2-1.

Table 2-1 Estimated volumes to be dredged for T0

Design Dredge Levels (m LAT)		Plan area to be dredged (to top of batter) (m^2)			*In situ* volume to be dredged (including 0.5m over-dredge) (m^3)		
Berth	Apron	Berths	Apron	Total	Berths	Apron	Total
-21	-18.5	105,535	501,127	606,662	376,832	674,986	1,051,818

The actual volume removed during the dredging program will be monitored by progress surveys, and confirmed at the completion of dredging by a post dredging survey.

During the dredging process the consolidated materials are loosened from the seabed by the dredge and mixed with water to form a slurry that is pumped to the DMCP. Air and water become entrained within the soil particles during this process, and the combined volume of water, air and dredged materials received in the DMCP, or the bulked dredging volume, can be much greater than the *in situ* volume depending on material type. A bed leveller may also be used during the dredging process to assist in flattening the seabed following dredging. This will ensure consistent levels are obtained, and target dredge depths are achieved throughout the dredge footprint.

The minimum design volume to be stored (based on an estimated bulking factor of 2.15 and the bulked material settling to an average RL of RL 7.0 m) is 2,370,000 m^3..

2.1.1 Material to be Dredged

Marine sediment studies at the Port of Abbot Point have essentially identified four (4) material types, based on material composition as follows:

- Silty Clayey Sand, Very Loose to Loose
- Silty Clayey Sand, Loose to Medium Dense
- Sandy Clayey Silt, Stiff
- Clayey Sand with Silt, Medium Dense.

The four material types identified each exist as a soil matrix of sand, silt, clay and some gravel.

The sand, silt, clay and gravel particles forming these soil matrices are not expected to separate significantly during the dredging process (i.e. the sands will not be separated from the cohesive silt and clay particles), but rather the dredged materials would retain much of their *in situ* matrix composition. No discrete layers of pure sand or other soil types have been identified. No rock material has been identified within the depth of the proposed dredging extents.

All sediments have been screened and tested in accordance with the National Assessment Guidelines for Dredging (2009) and found to be clear of contamination.

Tests of marine sediments within the dredge area indicate that whilst sediments are PASS, they have a neutralizing capacity greater than the acid generating capacity. This suggests that sediments are “self-neutralising”. A conservative approach to ASS management will be undertaken and addressed in an ASS Management Plan for the project.

2.1.2 Maintenance Dredging

Abbot Point is a naturally deep water port which, unlike most other Australian Ports, does not require regular maintenance dredging (NQBP 2010). The existing berth pockets at Terminal 1 have only required two minor periods of maintenance dredging since the port commenced operations in 1984 (in 1986 and 2008), albeit that the area has been subject to a number of extreme cyclonic events during that time. Little transport and deposition of fine grained material into dredged areas at the port has occurred since initial port construction. It is that maintenance dredging is not likely to be required (for the areas to be dredged as part of the Project) for up to 20 years.

2.1.3 Dredge Plant

Prior to the commencement of dredging, the dredging contractor will establish temporary onshore facilities including site offices and laydown areas in a suitable location within the Port.

It is proposed that a medium to large cutter suction dredge will be used to dredge all materials. A cutter suction type dredge is the most suited to the relocation of dredged materials onshore and will create considerably less turbidity at the dredging site than alternate options.

A cutter suction dredge is a stationary or self-propelled vessel that uses a rotating cutter head to loosen the seabed material. A suction inlet located beneath the cutter head is connected by a suction tube directly to one or more centrifugal pumps. The vacuum force at the suction inlet sucks up the loosened material. This material mixes with water and is then pumped onshore, as slurry, by a part floating and part submerged pipeline. A booster pump on a floating structure may be required offshore given the considerable pumping distance to the DMCP.

2.2 Onshore DMCPs

Dredged material will be pumped via temporary pipelines to the onshore DMCPs. There will be no dredged material placement in the Great Barrier Reef Marine Park (GBRMP) or in the Great Barrier Reef World Heritage Area (GBRWHA)/Great Barrier Reef National Heritage Property (GBRNHP).

The onshore area has been made available by NQBP for the development of common user DMCP infrastructure, and is located on the T2 site between the existing rail loop and the Caley Valley wetlands to the south (Figure 1-2). The area is adjacent to operating coal export terminal T1 and GVK Hancock's approved terminal site T3. The site has been previously cleared and used as agricultural land.

The DMCP area has been sited:

- In proximity to the existing port noting its ultimate use will be to provide suitable land and fill for port expansion once the dredged material has dried and settled
- In proximity of proposed dredging activities
- Outside of the Caley Valley Wetlands
- The final footprint of the DMCP has been located and designed to meet requirements for T0 dredging only.

It is noted that the DMCP area partly overlaps and/or is adjacent to existing and approved infrastructure.

Existing and approved infrastructure has been taken into account during the impact assessment process and will be considered in the detailed design. The intention is that existing infrastructure will be avoided.

In the circumstance that the proposed siting of the DMCPs overlaps with approved infrastructure, final siting will be subject to agreement with the relevant stakeholders.

2.2.1 DMCP Design

The overall DMCP area will be separated into a Primary DMCP, and a Secondary DMCP, via an internal bund. The separation into the Primary and Secondary DMCPs will facilitate accelerated management of material in the Secondary DMCP. This will enable the Secondary DMCP to be more rapidly returned to a landform suitable for the development of currently approved T3 infrastructure.

2.2.1.1 Embankments

It is proposed that earth embankments will be used to form the DMCP. These will be constructed for the outer perimeter of the Primary and Secondary DMCPs, as well as the internal bund separating these DMCPs. The embankment height, crest and batters will be optimised through detailed design to minimise earthworks volumes, maximise storage capacity, minimise leakage, prevent failure and allow required access for construction, operations and maintenance.

The earth embankments will be mainly constructed on top of the existing ground profile. The embankment crest will be capped with a 200mm thick gravel layer and external batters will be vegetated using topsoil won during construction to provide erosion protection. Proposed final embankment crest RL is 9.0m.

The current preliminary design has been developed considering internal borrow as source for embankment material construction. The design targets a final finish pond floor level of RL 2.84m. Therefore there will be areas where the final pond finish level is practically at existing ground level, and areas where over 2m of excavation is required to reach the final pond finish level.

Results of an ASS investigation undertaken for the Project do not indicate the presence of AASS and PASS within the upper 5m of soil across the proposed DMCP site. Excavation below this depth is not proposed.

All embankments will include an access road to allow access to any part of the DMCP. A permanent security fence, approximately 2.1m high and 4,800m long will be installed around the DMCP.

2.2.1.2 Liner Design

It is expected that a liner (e.g. Low Density Polyethylene liner or similar) will be installed on the inside face of the DMCP embankments (only) to prevent piping failure, to provide erosion control during dredging, and to minimise potential lateral seepage from the DMCP. The floors of the DMCP are to be unlined.

2.2.1.3 Stormwater Management

A stormwater management system has been designed for the Project, to manage local catchment drainage, regional flood levels, storm surge, and mean sea level rise associated with the DMCP. This is detailed in the stormwater management plan for the dredge material containment pond developed for the Project (Golder Associates 2015a). The intention of the external conceptual stormwater management strategy is to preserve as much as possible the existing hydrology associated with pre-development catchments, limit erosion impacts to the DMCP embankments, and at completion of dredging, return the pond area landform to mimic pre-development catchment areas.

The external stormwater management strategy:

- Maintains, as much as possible, the existing hydrology associated with pre-development catchments
- Limits erosion impacts to the DMCP embankments
- Returns (at completion of dredging) the pond area to a landform which mimic pre-development catchment areas.

The design also seeks to manage rainfall received (and supernatant fluid) within the DMCP's footprint, by providing sufficient freeboard to contain and manage design wind and storm events, during and post-dredging, providing means to reduce the permanent pool of water to facilitate drying and conditioning of dredged material for beneficial reuse. The general arrangement of the proposed DMCP prepared by Golder Associates (2015b) is reproduced below in Figure 2-1. The plan shows the boundary of the DMCP, embankment crest heights, access ramps, control gates and access roads, a topsoil stockpile area, an internal separation bund, the deposition pipe from dredge, tailwater pipes to discharge and a spillway fuse plug for emergency overflow.

2.3 DMCP Construction

The key construction activities are outlined below:

2.3.1 Pre-construction works:

Ahead of commencement of construction, the following activities are expected to be undertaken:

- Ordering Project equipment and materials
- Clear away existing infrastructure facilities, including:
  - Relocation of existing fence
  - Relocation of stockpiled material on north eastern portion of site to suitable location as directed by NQBP
  - Decommissioning, demolition and removal of waste water treatment plant.
- Pre-clearance surveys
- Establish monitoring programs
- Site surveying
- Supply and install barbwire perimeter fence
- Supply and install project signage.

2.3.2 Site Preparation

- Set out and installation of erosion and sediment control measures. The first site activities will be comprised of set out of the footprint and working areas and installation of the outer boundary erosion and sediment control measures.
- Site amenities and laydown area establishment. A suitable area will be identified for site amenities set up including site offices, crib rooms, toilet block, laboratory and workshop, including a laydown area for delivery of imported goods such as liner material and small stockpiles of materials.
- Construction of turkey nest ponds for water storage and implementation of storm water management plans.
- Clear away existing infrastructure facilities, including a material stockpile of un-characterised material along the northeast boundary, and an existing temporary wastewater treatment facility.
- Clearing, grubbing. The entire pond footprint, embankment footprint and the storm water diversion drain footprint areas will be cleared and grubbed of any vegetation. Grubbed vegetation is proposed to be mulched and stockpiled to be re-used during construction for storm water mitigation measures, side slope erosion protection and possibly final site rehabilitation.
- Topsoil stripping. The pond footprint, embankment footprint and the storm water diversion drain footprint areas will be stripped of topsoil to a minimum depth of 100mm. Topsoil will be stockpiled and potentially re-used for side slope erosion protection. It is proposed to use scrapers to undertake this task in conjunction with dozers and excavators for stockpile management and water carts for dust suppression.

2.3.3 Internal and External Embankment Construction

- Embankment subgrade preparation. Limited unsuitable material will be removed from the subgrade for embankment construction to form a suitable subgrade. Subgrade will be subsequently scarified and prepared for embankment construction. Material will be stockpiled on site within the pond footprint as required. It is proposed to use scrapers to undertake the bulk earthworks in conjunction with dozers and graders for ripping as required and general surface trimming.

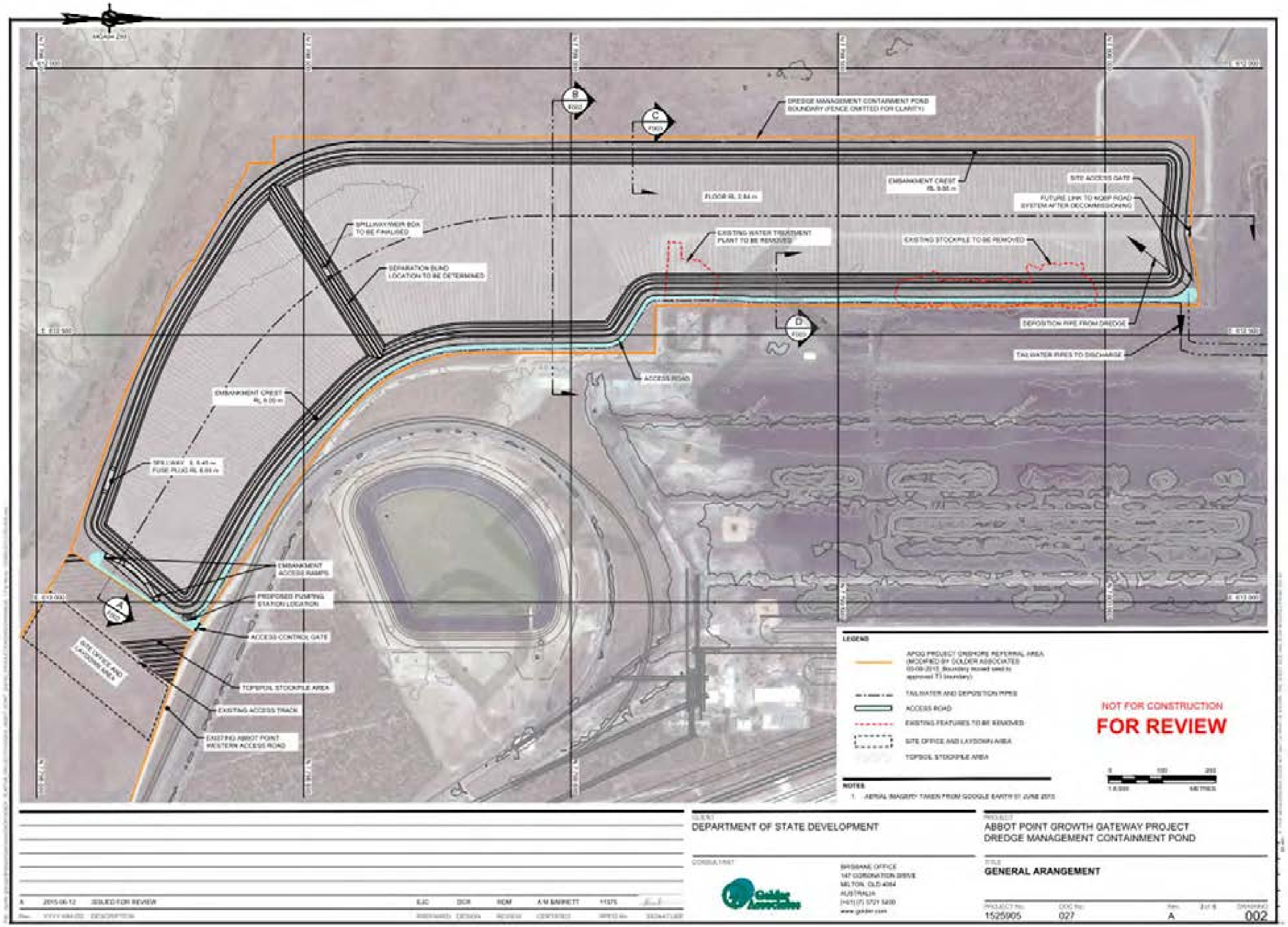

Figure 2-1 General arrangement of the dredge management containment pond (Golder Associates 2015b)

- Bulk earthworks for external and internal embankment. The construction of the embankments will be carried out sourcing the materials from the internal borrow. The material suitable for embankment construction has been identified to be below an approximately 1.0m thick layer of unsuitable material. The following is proposed:
  - Unsuitable will be cut and stockpiled within the pond footprint using scrapers.
  - Once the suitable layer is exposed it will be conditioned to required specifications using dozers, water carts and tractor ploughs.
  - External and internal embankment construction will be undertaken using scrapers that will win from conditioned material from the borrow area and place directly on embankment.
  - Unsuitable material may be required to be cut from stockpile using scrapers and placed over used borrow area either to allow access to additional suitable material or to form a suitable pond floor with limited steps and low areas.

2.3.4 Containment liner Installation

The DMCP will require a geomembrane liner to be installed on the external embankment internal walls, which will require the following activities:

- Pond footprint subgrade preparation. Internal embankment walls will need to be prepared to receive the containment liner. Once the detail trimming is completed using graders, final trimming will be undertaken with posi-tracks with grazer bar and finished with smooth drum rollers. In lots, and just prior to liner installation, the embankment subgrade will be wet down with water carts and prepared with smooth drum roller to receive the liner.
- Liner panels will be placed with a telehandler from crest to toe. Welding between panels will be undertaken using wedge welding machines and defect, tears, T-Seams and similar will be repaired using extrusion welding equipment.
- A crest anchor trench will be excavated, preferably with a trenching machine, to ensure adequate alignment and minimum disturbance to crest edge. Crest anchor trench shall be backfilled with compacted cement stabilised soil.
- Toe anchor trench will be excavated using a mid-size excavator and backfilled with compacted cement stabilised soil.

2.3.5 Access Roads, Spillway, Stormwater Diversion Drains and Fence Installation

- Access roads will be constructed on the crest of embankment and on the eastern perimeter of the DMCP. Suitable material to form a trafficable capping layer will need to be imported and placed with scrapers, and either compacted or rolled. Once the crest capping is complete, the wave, safety and liner protection bund will be placed and shaped.
- Additional works, such as internal and external spillways, weir gates, return water pumping facilities, and stringing the return water pipelines, will be actioned once all other embankment earthworks and lining activities have been completed and any necessary lining, armouring and fuseplug layerworks installed. Spillways will be armored using rip rap. Material will be sourced

from the nearby Deco quarry. Details of the final weir gates (in the internal bund wall), and return water facilities will be advised by the Contractor.

- Storm water outlets – the stormwater drains and outlets will be cut to design lines and levels using graders and excavators. The drains will be over excavated to allow for backfill with minimum 100 mm of ameliorated top soil. Top soil will be placed using a tractor and spreader.
- A 2.1 m high fence will be installed around the completed DMCP.

2.3.6 Construction water

It is expected that approximately between 60 ML and 100 ML of water will be required for the purpose of DMCP construction. Construction water sources are yet to be determined but are likely to be multiple and off site. The Deco/Fynbat quarry along Abbot Point Road operated by Hillery Quarries (approximately 10km from the Project site) is considered as a major source of construction water. The use of groundwater from existing borefields or new bores is considered unlikely. Construction water will be carted to and stored in site temporary ‘turkey nest’ ponds.

2.4 Pipelines

Pipelines to be installed as part of the project include:

- Temporary dredged material delivery pipelines from the dredging area to the DMCP (to be removed on completion of dredging)
- Temporary return water pipeline from the DMCP to a sub-tidal discharge location (to be removed on completion of dredging).

2.4.1 Pipeline Alignment

The proposed alignment has been routed to maximise the use of cleared corridors adjacent to existing port infrastructure, and to avoid sensitive environmental areas where possible. On land, where appropriate, the dredged material and return water pipelines will be co-located to minimise disturbance. The pipeline corridor width for the onshore section is expected to be approximately 12m.

The final routing of the pipelines will consider (amongst other things) avoidance or minimisation of impact to sensitive marine and terrestrial flora and fauna, as well as the needs of existing port users and construction limitations.

2.4.2 Dredged Material Pipeline

The dredged material (including seawater) will be pumped to the DMCP via a floating pipeline section connected to a submerged (sinker) pipeline, which in turn will join to the onshore section of the pipeline. It is anticipated that the majority of the onshore portion of the dredged material delivery pipeline will be installed above ground. Some sections may be required to be trenched, depending on T1 operator and dredge contractor requirements. The dredged material delivery pipeline will deliver material to the northern part of the Primary DMCP. The length of pipeline required to deliver dredged material from the dredging areas to the Primary DMCP will include approximately 1km of floating pipe, 3km of sinker / rising pipe and approximately 1.5km of onshore pipe.

2.4.3 Return Water Pipeline

Two pipelines are proposed for the return water pipelines. The return water pipelines will run from the southern end of the Secondary DMCP to a shallow sub-tidal area near the Abbot Point headland, where return water will be discharged subject to meeting licensed discharge criteria. Each return water pipeline will include approximately 300m of offshore, and 3.7km of onshore pipeline. The discharge depth is expected to be between -4 and -10m LAT.

2.5 Dredged Material Management

2.5.1 During the Dredging Campaign

The dredged material delivery pipeline will deliver the dredged material slurry into the Primary DMCP. It is expected that most coarse dredged material particles will drop out closer to the discharge location in the Primary DMCP, including sand, gravel and clay/silt balls. It is expected that less coarse dredged material particles, including fine sands and coarser silts, will then pass through a weir box located on the bund wall between the Primary and Secondary DMCP, and drop out within the Secondary DMCP. A floating booster station will be installed approximately 1km offshore, to maintain pressure within the pipeline.

During dredging operations, a pump will be used to return water from the Secondary DMCP back into the ocean. It is proposed that the return pipeline outlet would be positioned on the seabed in the inshore area. The pump for the return water pipeline will operate continuously, subject to the return water quality meeting discharge approval limits.

2.5.2 Post Dredging

At the completion of dredging, the dredging contractor will remain on site to pump out as much excess water from the DMCP as possible. Once this is complete, the dredging contractor will remove the return water pipeline and pumps from site.

The DMCP will be lined on the inner batters of the embankment walls. The floors will remain unlined. Post dredging, sea water remaining within the dredged material, along with any rainfall that falls within the DMCP, will progressively seep vertically through the unlined floor as the material consolidates. Initially the water retained within the DMCP will be a mix of fresh rain water and saline sea water, however the quantity of saline water in the system is finite and as such the salinity of the mixed fresh/saline seepage post dredging will decrease with time.

Lateral seepage that may exit the downstream side of the embankments is not expected to be significant due to the lining of the internal embankments. Seepage that may occur will be captured by the stormwater drainage system. It is assumed that vertical seepage from the DMCP into the subgrade does not enter into the surface water regime.

Once a point has been reached where water quality within the DMCP is compliant with discharge limits and approved to be released to the receiving surface water environment, outlets in the embankments will be constructed in strategic locations. Any surface runoff generated from the surface of the DMCPs will be directed to the natural or existing (T1) drainage network and as overland flow towards the T3 site. All runoff generated during this phase will be managed in accordance with the conceptual stormwater management plan.

2.5.3 Long Term Management

The operational life of the DMCP will be defined during the preliminary design phase. It is envisaged that the site will be returned to a final landform within 10 years' post dredging.

There is potential that the DMCP could be made available for future dredging campaigns (e.g. T3 and maintenance dredging) if this is able to be accommodated within the operational life of the DMCP. However, it is not part of the current project.

Separation of the coarser fractions (sands and gravels) from the finer materials (clays and silts) during the onshore placement process will provide a source of a range of materials that can be used for a number of purposes including use as a competent construction fill or for ground improvement activities of adjacent port sites or within the Abbot Point State Development Area.

Subject to appropriate regulatory approvals being in place, the dredged material may be mixed and improved (e.g. consolidated, mixed with aggregates or lime stabilised, etc.) within the DMCPs prior to its removal for beneficial reuse. In targeted areas, such as those areas associated with approved but not yet constructed infrastructure, this may be undertaken immediately post dredging.

The dredged material may potentially be beneficially reused as general fill in the construction of future port developments (e.g. T0 or T3) or remain on T2. Alternatively, the material may be moved elsewhere including the State Development Area to facilitate the development of the T2 site, subject to appropriate approvals being in place.

Alternatively, where required to allow for further industrial development, the dredged material could be removed, along with the DMCP embankments and the site restored.

If the DMCP was to remain and if no longer needed for management of dredged material, it will be returned to a suitable final landform, designed to shed surface water to natural drainage lines and mimic natural drainage patterns.

2.6 Project Schedule and Timeframes

Project stages include:

- DMCP construction, including construction contractor mobilisation and demobilisation
- Dredging operations, including pipeline installation and dredging contractor mobilisation and demobilisation
- Decommissioning and rehabilitation of the DMCP site.

DMCP construction is anticipated to occur over a three to six month timeframe. Mobilisation of the dredge, supply and installation of dredging pipelines will occur over a four to five month timeframe. DMCP construction, dredging pipe supply and transport to site, and dredge mobilisation may occur concurrently.

Capital dredging will commence as soon as practical post completion of the DMCP. Dredging and dredged material deposition will take place over a 5 to 13 week timeframe in a single dredging campaign, after which a period of stabilisation (dewatering and consolidation of dredged material) within the DMCPs will occur.

DMCP construction activity is planned to take place on a continuous basis during the dry season on a 12 hours per day, seven days per week cycle. However, if required to meet Project timeframes, working hours may need to increase to 24 hours per day, seven days per week.

Timing of the decommissioning and rehabilitation of the DMCP will be dependent on port beneficial reuse requirements, and is subject to discussions with other port users.

3 Hydrological Setting and Surface Water Quality

3.1 Hydrological Setting

3.1.1 Climate and Weather Patterns

The Wetlands are located in the Don River Basin, which extends from Bowen in the south to near the mouth of the Burdekin River within the North Queensland Dry Tropics climate zone. This zone experiences major seasonal variation in freshwater inputs from local runoff and rainfall. Important climatic patterns and processes in the broad region include:

- The region has a tropical monsoon climate with distinct wet and dry seasons as shown by mean monthly rainfall data (refer to Figure 3-1);
- The annual average rainfall at Bowen Post Office is 1013 millimetres (mm) (144 years of data, Bureau of Meteorology 2014);
- The months of December to March tend to be the warmest and wettest. Tropical cyclones occasionally traverse the coast during these summer months. Such events can cause substantial damage to coastal vegetation and flooding within the Wetlands; and
- The driest months occur in September to October.

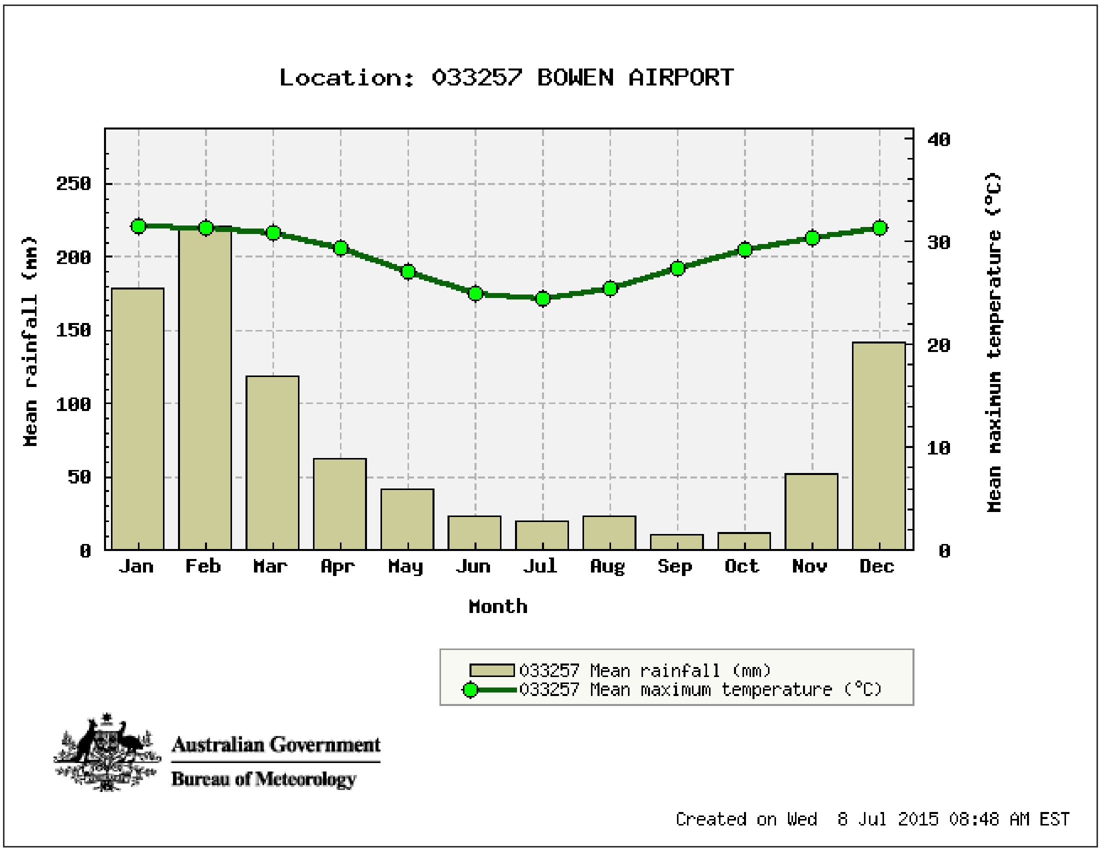

Figure 3-1 Mean monthly rainfall and maximum temperature for Bowen Airport – Station 033257 (BoM 2015)

During summer, winds are frequently from the east to northeast, but southeast trade winds can persist throughout the year. These southeast trade winds are stronger in the winter and create wind-driven currents of up to 0.1 metres per second which partially drive a net movement of offshore sands to the west–northwest along the coast of the Abbot Point region, including coastal sections of the Wetlands (WBM 2006).

The Abbot Point area and broader bioregion experienced one of the most severe droughts on record in 2001 to 2006, followed by four consecutive years of above average rainfall (Bureau of Meteorology, unpublished data). This high degree of inter-annual and seasonal variability in rainfall patterns results in significant changes to wetland habitats, communities and species, as discussed in the following sections of this report.

3.1.2 Catchment Hydrology

The fluvial hydrology of the Wetlands is dominated by local runoff from the Salisbury Plain and the slopes of Mount Roundback and Mount Little, located to the south and south east of the Wetlands respectively. The Wetlands are fed by numerous creek systems, which include: (from west to east) Plain, Splitters, Spring, Branch, Tabletop, Maria, Mount Stuart, Six Mile, Goodbye and Saltwater Creeks (BMT WBM 2012). Saltwater Creek also conveys breakout flow from the larger Don River catchment *via* the connecting Euri Creek (GHD 2013).

The catchment of the Wetlands is approximately 83,000 hectares. Saltwater Creek is the largest stream which flows into the Wetlands, and typically holds water throughout the year. Despite its name, Saltwater Creek is a freshwater system. All of the other streams that drain into the Wetlands are ephemeral but some such as Splitters, Branch and Mount Stuart Creeks can contain semi-permanent pools during the dry season. The lower reaches of these creeks are tidal, with mangroves fringing channels and inter-tidal overbank areas.

The hydrology of the Wetlands is controlled by three interactive processes:

- **Tidal processes** – tidal processes are a major control on water levels in the western sections of the Wetlands. The maximum tidal range for Abbot Point is 2.4 m (GHD 2009) however storm surges resulting from low atmospheric pressure and onshore winds can raise maximum tidal heights. Tidal regimes in the Great Barrier Reef lagoon and lower reaches of the Wetlands are semi-diurnal.

- **Catchment inflows** – Freshwater runoff from the local catchment generally occurs in a seasonal pattern with significant rainfall and catchment runoff during the summer months (December to March), and relatively little rainfall and runoff during the winter months (April to November). During the dry season tidal water movement dominates the western section of the Wetlands with saline waters entering from Curlewis Bay. During the wet season catchment runoff originates from the Salisbury Plain and the slopes of Mount Roundback and Mount Little. Spring, Table Top, Main and Mount Stuart Creeks drain into the western wetland at Curlewis Bay while Six Mile, Goodbye and Saltwater Creeks drain into the eastern wetland. During the wet season the Wetlands can fill with freshwater. The natural and artificial topography of the Wetlands means that some of this water will remain ponded in basins, which then evaporates during subsequent non-rain periods. A portion of the ponded water would also be transferred into groundwater reserves.

- **Groundwater processes** – groundwater levels below the Wetlands are largely unknown but expected to be shallow and generally within 5 m or less of the ground surface (GHD 2012). It is believed that groundwater flowing northward from the higher topographies to the east and west discharge into the Wetlands (GHD 2012). Groundwater forms an important source to the Wetlands during the dry season when freshwater inputs are minimal (GHD 2012). This is inferred due to the deep pools of water maintained in some areas during the dry season, for example a central pool in the wetland basin zone that experiences semi-permanent inundation and is referred to as Lake Caley (GHD 2012). Groundwater may also interact with Wetlands surface water within the hyporheic zone beneath ephemeral waterways, indicated by the shallow depth to groundwater suggested below Branch, Goodbye, Maria, Kangaroo, Saltwater, Plain, Split, Splitters, Tabletop and Mount Stuart Creeks.

The wetlands have features of an alluvial plain (east), lacustrine plain (centre) and tidal flat (west) with a distinct gradient in tidal influence (and salinity) from west to east. Several distinct functional habitat zones were defined by BMT WBM (2012) within the Wetlands on the basis of geology, hydrology, vegetation types, water quality and structural habitat conditions. These six zones previously identified can be further aggregated based on their hydrology. The three distinct hydrologic areas include the:

- Tidally-dominated western wetland areas (including the coastal water zone, western estuarine zone and the hypersaline zone);
- Wetland basin zone (a distinct hydrologic zone on its own and the focus of the current investigations); and
- Saltwater Creek and non-tidal drainages (including the Saltwater Creek zone and the terrestrial zone).

The dominant hydrological processes operating in these three distinct areas of the Wetlands are further described in the following sections.

3.1.2.1 Tidally-Dominated Western Wetland Areas

The hydrology of the coastal water zone, the western estuarine zone and hypersaline zone is regulated by tidal processes. Flooding can lead to a temporary increase in water levels in these areas.

The area is comprised of three functional habitat zones namely: open coast (beaches), mangrove/saltmarshes; and saltpan (high value) and impounded hypersaline waters (degraded). These presence/absence and health of these ecosystems are highly dependent on wetland hydrology and flushing. There are two bunds located in the western sections of the Wetlands which influence tidal hydraulics and therefore ecosystem functioning in wetland areas to the east of the bunds.

The Western Bund, located on Mount Stewart Creek, was constructed in the early 1980s. This bund restricts tidal movements into the Wetlands, particularly within the northern section of the

Wetlands between the Western Bund and the Causeway (the area which represents the hypersaline zone). Approximately 46 ha of mangroves (GHD 2010) have been replaced by saltpan and ponded hypersaline waters upslope of the Western Bund as a result of inadequate flushing. Furthermore, by limiting tidal exchange the Western Bund represents an aquatic fauna movement barrier, reducing fish habitat values of the Wetlands.

During large spring tides, the Western Bund can be overtopped with marine waters becoming impounded upslope of the bund, despite the apparent ‘leaky’ nature of this structure, and salinity increases as water evaporates. During spring tides, tidal waters also propagate along Branch Creek around the southern side of the Western Bund and onto the saltpan of the hypersaline zone.

The Causeway creates a further barrier to tidal interaction with the wetland basin zone and although this bund can also be overtopped, this only occurs during very large spring tides. During sustained rainfall periods, freshwater may flush the area upstream of the Western Bund although the bund remains a flow obstruction until upstream water levels are sufficiently high to overtop the crest of the bund.

Such overtopping is likely to occur only once or twice in a wet year depending on antecedent conditions so the area remains highly saline. During dry periods, marine waters become impounded upslope of the western estuarine zone outer bund, despite the apparent ‘leaky’ nature of this structure, and salinity increases as water levels decline in response to evaporation.

3.1.2.2 *Wetland Basin*

Water levels and depths within the wetland basin zone undergo dramatic seasonal and inter-annual variability (see Figure 1-4). In the wet season, the Wetlands can be 18 km long and 6 km wide, and cover an area of approximately 5,000 ha (GHD 2009). Under high flow conditions, water flows through the wetland basin zone in a predominantly east–west direction. During prolonged dry conditions, waters within the wetland basin contract into the area known as Lake Caley; a shallow (<0.25 m deep in November 2014) depression located in the centre of the basin. The wetland can at times be completely dried out.

The Causeway presents a major barrier to the hydrologic interactions between the tidally-dominated western wetland areas and the basin. The bund was originally constructed in the 1950s and refurbished in the early 1980s to provide access for construction equipment to the Abbot Point Coal Terminal (APCT) (GHD 2010). Tidal water movements cross under this structure *via* a small culvert (300 mm diameter pipe which is generally silted) located on the southern end of the Causeway during infrequent, high spring tides. It is also possible that tidal waters may very occasionally overtop the Causeway *via* a low-lying depression located on the northern end of the bund. The Causeway would be overtopped during high flood events combined with strong northerly winds.

While the wetland basin zone is partially tidal therefore, its hydrology is mostly regulated by runoff with likely, although unquantified, groundwater interactions. The groundwater interactions are considered likely given the reasons outlined in Section 3.1.1.

Dominated by ephemeral brackish marsh and samphire ecosystems (further described in Section 4.1.3), the wetland basin zone requires cyclic wetting and drying to maintain the dominant ecosystems and dependent species. As with the Western Bund, by limiting flows the Causeway represents an aquatic fauna movement barrier, reducing fish habitat value of the Wetlands.

3.1.2.3 Saltwater Creek and Non-Tidal Drainages

Saltwater Creek, located in the south-eastern corner of the Wetlands, is the largest creek system draining into the Wetlands. During flow events, Saltwater Creek connects to the Euri Creek and Don River to the east, and the wetland basin zone in the west. During non-flow periods Saltwater Creek forms a long continuous pool that is disconnected from the Wetlands and Euri Creek/Don River system. A small (<0.2 m high) bund is located across the creek at its confluence with the wetland basin zone which is likely to limit saltwater intrusion from wetland basin during non-flood periods; however, there are no measurement data to determine the role of this bund in regulating the hydrology of the Wetlands or creek.

There are no reports of Saltwater Creek completely drying; however, field surveys in November 2014 (drought conditions) found that water depths across the creek were <1 m, and typically <0.5 m. No studies have examined the role of groundwater in recharging Saltwater Creek.

A small channel connects Saltwater Creek to mangrove forests in the Euri Creek system. Marine waters could potentially intrude into Saltwater Creek from the east during large spring tide events or during storm surges. Notwithstanding this potential interaction, tidal processes do not appear to be a key control on the hydrology or water quality of Saltwater Creek, based on the following:

- Field measurements of water levels and electrical conductivity were undertaken at two sites in Saltwater Creek during a spring tide cycle (October to November 2010), and did not identify a strong tidal signal (BMT WBM 2012).
- The freshwater to slightly brackish water character Saltwater Creek do not suggest that tidal processes have a pronounced effect on water quality under typical conditions (see Section 3.2.1).
- A fluvial delta and small bund occurs at the mouth of Saltwater Creek, and appears to limit any tidal water movement into Saltwater Creek from the wetland basin zone.

The remaining creeks that flow into the Wetlands are ephemeral drainages, most of which dry or contain small pools during dry periods. Site inspections undertaken in November 2014 identified standing water in the lower reaches of one creek (Branch Creek), whereas all other streams were dry.

3.2 Water Quality Conditions

Surface water quality of the Wetlands is largely driven by the fluvial hydrology, groundwater and tidal influences described above. Other water sources which may influence the water quality of the Wetlands include treated surface water runoff from the Port of Abbot Point located to the north of the Wetlands, and runoff from the elevated dunes and ridges within the APCT which enter the Wetlands from the east (GHD 2009). Patterns in water quality within the Wetlands are summarised below based on the data sources shown in Table 3-1. Figure 3-2 shows the location of sampling sites referred to in the text (where available).

Table 3-1 Water quality data sources examined in the present study

Data source	Description	Spatial coverage	Temporal coverage	Parameters
Peter Hollingsworth and Associates (1979 and 1981)	Addendum to the Abbot Point Coal Terminal EIS, undertaken prior to APCT construction	Four sites within the Wetlands	One off - 1981	Salinity
APCT (unpublished data) in WBM (2006)	Routine monitoring data compiled by Ecowise Environmental on behalf of APCT.	Two sites – one site in the NE extremity of the Wetlands; one site downstream of the secondary settlement pond (refer Figure 3-2).	1997 to 2004	Salinity/EC, pH, occasional dissolved oxygen
Wetlands Database (DoE 2014)	Snap shot survey only.	Several sites around the lake	September 1999	Salinity
WBM (2006)	Data collected for APCT Stage 3 Expansion EIS. Data collected following catchment rainfall.	Six sites throughout the Wetlands (refer Figure 3-2).	Two sample events: April & June 2005.	In situ physio-chemical parameters, ions, trace metals, nutrients
GHD (2009)	Data collected for APCT X110 Expansion – Infrastructure Development Project Voluntary Environmental Assessment	Three sites within and adjacent to APCT.	Monthly sampling Jan 08 to Jan 09	Salinity/EC, nutrients, pH
GHD (2010)	Monitoring data collected on behalf of NQBP	14 sites throughout Wetlands	Monthly sampling, Feb to July 10	pH, temperature, turbidity, total suspended solids, dissolved oxygen, chlorophyll a, nutrients and metals
BMT WBM (2012)	Assessment of tidal influences on the Wetlands	Nine sites within the Wetlands	Oct to Nov 10 (EC, depth) Snap-shot for most other parameters	Continuous measurements of EC and depth over a one month period. Snap-shot survey of trace metals, nutrients and chlorophyll a.
GHD (2011)	Monitoring data collected on behalf of NQBP	14 sites throughout Wetlands	Monthly sampling, Feb to June 11	pH, temperature, turbidity, total suspended solids, dissolved oxygen, chlorophyll a, nutrients and metals
BMT WBM (2014)	Snap-shot survey of water quality at representative sites throughout the Wetlands	14 sites within the Wetlands and surrounding areas	Nov 14 - one week	Continuous measurements of EC and depth over a one week (spring tide) Continuous measurement of dissolved oxygen over 24 hours Snap-shot survey of *in situ* parameters

LEGEND

- Caley Valley Wetland Boundary as Defined through DIWA Listing
- Proposed Dredged Material Containment Ponds (DMCP)
- Road
- Railway
- Regrowth Watercourse (DERM)

Water Quality Sampling Sites

- Hollingsworth & Associates (1981)
- Ecowise (1997)
- WBM Oceanics (2005)
- GHD (2010)
- BMT WBM (2010)
- Continuous CTD/Diel DO (2014)
- In-Situ YSI (2014)

Title:
Water Quality Monitoring Stations

Figure: 3-2

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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3.2.1 Salinity

Monitoring by BMT WBM (2006, 2011 and 2012) indicates that the salinity of the Wetlands varies from freshwater to hypersaline) conditions. Freshwater inputs from Saltwater Creek and other runoff during the wetter months dilute saline influences from tidal intrusion downstream. During drier months when rainfall is reduced, the tidal inflow and greater effects of evaporation contributes to greater salinity particularly where the bunds limit tidal and freshwater flushing. Groundwater is also likely to be an important source of salt in the wetland particularly during the dry season.

The water quality monitoring program (GHD 2010) captured six months of physio-chemical *in-situ* and laboratory analyte parameters on a monthly basis (i.e. six events) at 14 sites across the wetland (Figure 3-4). Salinity data, together with patterns in vegetation community structure, reveal that a salinity gradient exists within the Wetlands, resulting in the creation of marine, hypersaline, brackish and freshwater waterbodies along this gradient which is also strongly related to cumulative rainfall conditions (refer Figure 3-5).

Box plots[2] of salinity based on a collation of historical water quality measurements are presented in Figure 3-3. Patterns of salinity within each functional zone are discussed further below.

Coastal Water Zone

The coastal water zone is dominated by marine waters, except during major floods which are expected to result in short term reductions in salinity. There are no salinity data currently available for the coastal water zone within the Wetlands, although some data are available for adjacent Port waters (refer WBM 2006).

Western Estuarine Zone

Monthly monitoring data collected by GHD (2010) shown in Figure 3-4 indicates that salinity at WQ01 was typically within the range of marine conditions during the monitoring period Measurements by BMT WBM in October to November 2010 also showed that the estuarine channels in the western sections of the Wetlands (the lower reaches of Branch Creek and Mount Stewart Creek) are typically marine to slightly hypersaline in character during dry periods (~35 ppt to 45 ppt). The slightly hypersaline conditions have been recorded in the upper reaches of Mount Stewart Creek immediately down slope of the Western Bund (WBM 2006; BMT WBM October 2010 – November 2010 study). Salinity measurements undertaken by BMT WBM indicate that highest salinities occur during low tides, suggesting some leakage of ponded hypersaline waters through the Western Bund wall.

Salinity can show marked declines following rain events. For example, a 100 mm rainfall event on the 18th November 2010 resulted in salinities declining from seawater salinity to 24,000 µS/cm (~15 ppt, or one third seawater) in the upper reaches of the Mount Stewart Creek, and 353 µS/cm (freshwater) in the upper estuary of Branch Creek.

[2] Box and whisker plots (box plots) show the non-parametric descriptors of the data in graphical form. In other words, they describe the median, the interquartile range and 1.5x the interquartile range. The median (or middle-ranked observation) is the middle line, the box is formed by the 25th and 75th ranked observations, which is the inter-quartile range. Fifty percent of the observations fall within the box formed by the inter-quartile range. The whiskers represent 1.5x the interquartile range, and are used to show outliers. On normally distributed data, the whiskers will encompass 99.3% of the observations in the data set, with only the most extremely small or extremely large observations shown.

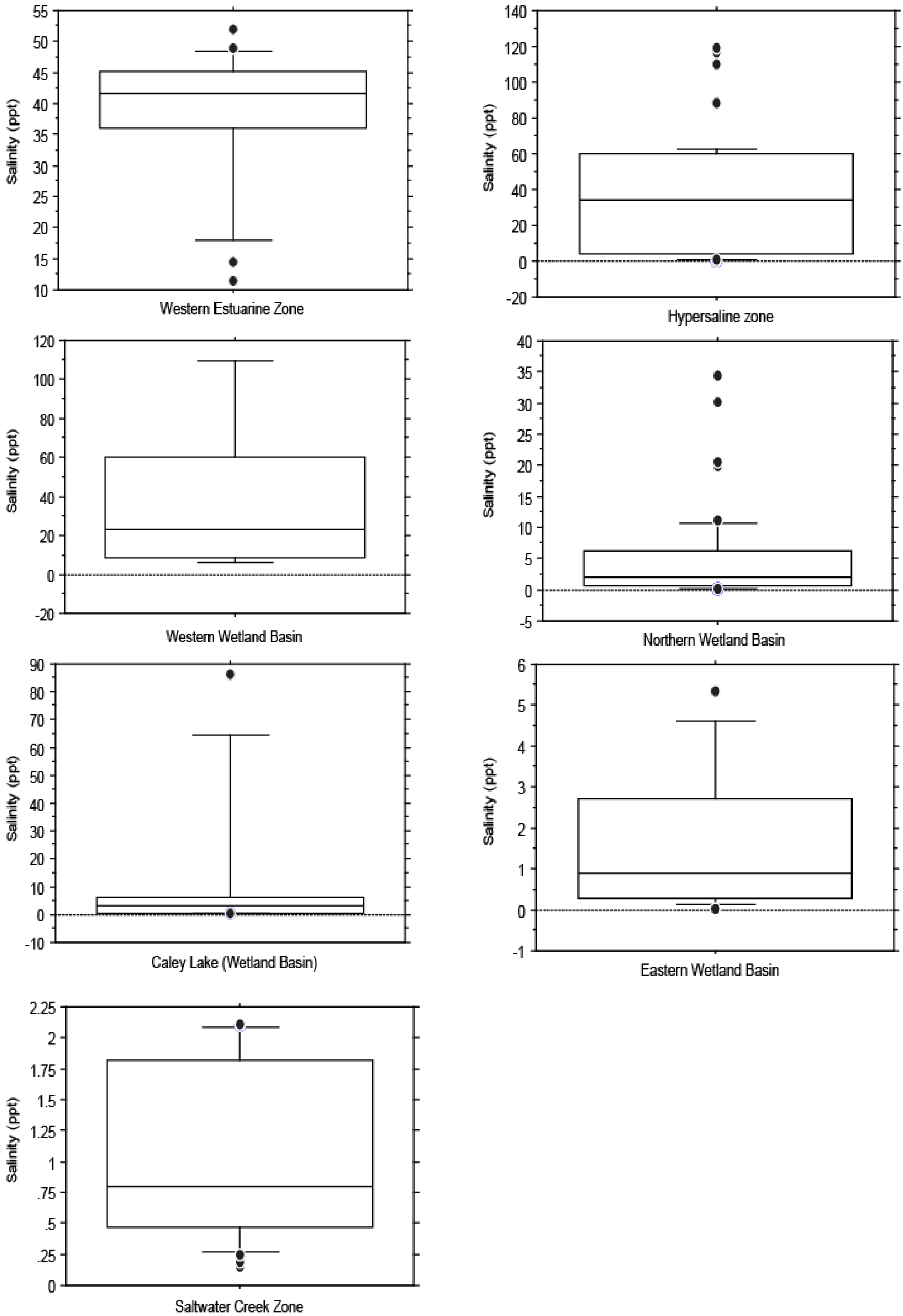

Figure 3-3 Box plots illustrating variability in salinity among wetland zones

Hypersaline Zone

This zone broadly occurs between the Causeway and Western Bunds. Figure 3-4 shows that salinity regimes in this zone vary over time in response to catchment rainfall patterns, varying from freshwater conditions during floods, to hypersaline during dry periods (GHD 2010).

During spring tides, tidal waters propagate along Branch Creek and onto the saltpan. It is also likely that tidal waters would intrude into this zone through the Western Bund. During dry periods, marine waters become impounded upslope of the Western Bund, despite the apparent 'leaky' nature of this structure, and salinity increases as water levels decline in response to evaporation. Waters within this zone can have very high salinities (>100 ppt; refer WBM 2006 and Figure 3-5), and a thick crust of salt and algae can form during dry condition.

As water depth increases in response to catchment runoff, salt concentrations are reduced through dilution, and can approach brackish water conditions (DEWHA 2010). Sampling undertaken in October and November 2010 indicate that salinity was generally >60 ppt (hypersaline), but declined to 21.6 ppt (approximately 60% seawater) following catchment rainfall in mid to late November. This can result in major shifts in vegetation community structure, with a range of brackish water macrophytes establishing in this zone in prolonged wet periods (DEWHA 2010).

Wetland Basin Zone

This zone occurs in wetland areas upslope of the Causeway and down-slope of Saltwater Creek. A weak east-west salinity gradient exists within this zone during non-flood periods, varying in response to rainfall conditions. During non-flow periods, large areas of the wetland basin zone experience salinities approaching marine conditions (GHD 2010 and BMT WBM 2010), which is reflected in the largely estuarine character of vegetation in this zone.

While estuarine conditions persist following rainfall events (GHD 2010), salinity can show rapid and marked declines following catchment rainfall (BMT WBM 2012). Logger measurements by BMT WBM indicated that during non-rainfall periods (27/10/10 to 1/11/10), salinity ranged from 27,979 µS/cm (~16 ppt salinity, or 46% seawater) in the eastern part of the wetland basin zone (site 3), to 48,804 µS/cm (~29 ppt, or 82% seawater) in the western part of the wetland basin zone and 70,153 µS/cm (42 ppt, hypersaline) immediately upslope of the Causeway. Salinity showed little variation over time for most of the subsequent measurement period at site 3 (eastern part of the wetland basin zone), but did decline to ~10,000 µS/cm (6 ppt, or 17% seawater) following >150 mm of rainfall between the 18th and 23rd November 2010. At the two sites located in the western sections of the wetland basin zone, salinity showed marked declines in response to rainfall events, most notably between 18th and 23rd November 2010 with salinities declining to ~10,000 to 13,000 µS/cm (6-8 ppt, or 17% to 22% seawater).

Monitoring in February – March 2010, February 2011 and May – June 2011, however, showed that the wetland basin zone tended towards freshwater conditions (recorded values all less than ~2,500 µS/cm) particularly with freshwater inputs from Saltwater Creek and other runoff during these periods diluting saline influences.

The variable salinity is a distinct feature of the wetland basin zone (GHD 2010). For example, APCT monitoring data for a site located in the north of the zone immediately downstream of the APCT settlements ponds shows that equivalent salinity ranged from approximately 1 ppt (freshwater) to 10 ppt (~28% seawater). Salinity regimes here are driven by rainfall, with cumulative three month rainfall explaining approximately 80% of the variation in electrical conductivity (Figure 3-5). Similar fluctuations in salinity were observed by GHD (2010) at sampling sites throughout the etland basin zone (see for example Figure 3-4).

Graphical information, sampling points, watercourses, and roads shown on this map created by GHD, 2010.

Title:

Electrical conductivity measured over six months in 2010

Figure 3-4

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Approx. Scale

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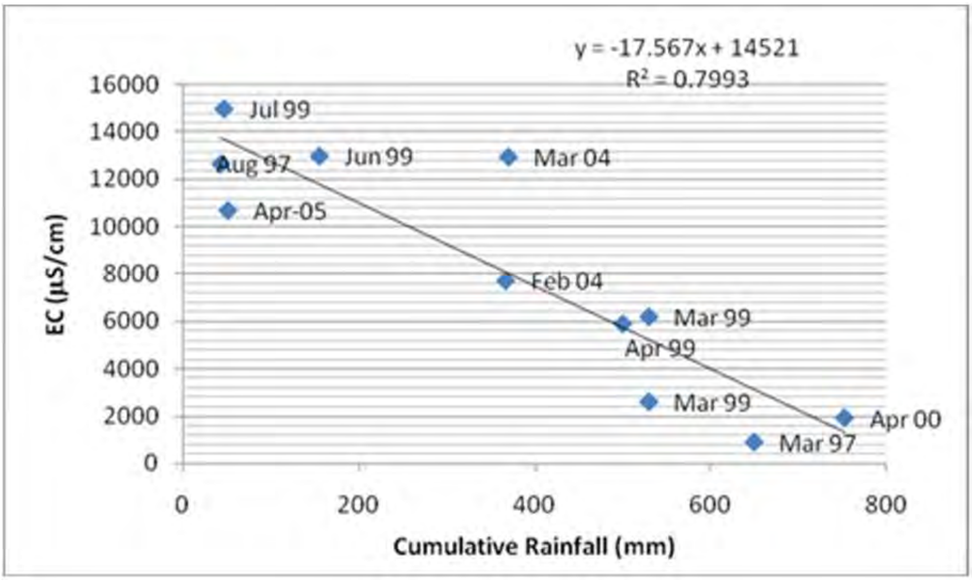


Figure 3-5 Electrical conductivity (µS/cm) and cumulative three month rainfall at the "Caley Valley Wetlands Site" (i.e. site 5 of WBM 2006) near APCT

Saltwater Creek Zone

Saltwater Creek has a freshwater to slightly brackish character (GHD 2010; BMT WBM 2012). Monthly monitoring undertaken by GHD (2010) at two sites in Saltwater Creek revealed a slight increase in salinity over time, approaching 2,000 µS/cm during dry periods. Similarly, measurements undertaken by BMT WBM during a dry period in October 2010 indicate that the downstream sections of the creek typically had salinities <1,600 µS/cm (freshwater), whereas further upstream slightly brackish conditions were recorded (3,800 µS/cm, 2.2 ppt or 6% of seawater).

Salinity can show marked short-term variability in response to rainfall in the catchment. The 2014 BMT WBM continuous measurements of electrical conductivity taken 30th of October 2014 and the 3rd November 2014 and associated *in situ* measurements of around 3,000 µS/cm. Similarly, logger data (BMT WBM 2012) shows that a rainfall event in late November 2010 resulted in an increase in salinity in the downstream sections of the creek (3,343 µS/cm), suggesting that the slightly brackish waters upstream were being pushed downstream by the stream flow. However, in upstream areas, there was little change in measured salinity during this rainfall event.

These complex salinity patterns appear to be partly a function of seawater intrusion into the creek from the east. A small channel, which connects Saltwater Creek to the sea, remained dry throughout the measurement period, suggesting that any connection occurs intermittently. No correlation between water levels at either sites in Saltwater Creek and tidal height were observed during the measurement period, again suggesting that any intrusion of seawater *via* tidal processes, if present, would only occur intermittently. It is notable that riparian vegetation along Saltwater Creek does include mangroves, suggesting that the creek maintains some connectivity to the sea.

3.2.2 Nutrients, Dissolved Oxygen and Algae Productivity

Benthic metabolism is an important indicator of the health of the wetland as it refers to the rates of gross primary production (GPP) and community respiration (CR) as they respond to environmental variables including light, temperature regimes, nutrient loads and rates of production. Production and biomass are often found to be positively correlated. Nutrients and dissolved oxygen therefore provide important indicators of productivity and its implications on ecosystem health.

Nutrient data are available from snapshot surveys undertaken by WBM (2006), BMT WBM (2010), GHD (2011) and WBM (2006) sampled a site within the hypersaline zone (site C) and two sites within the wetland basin zone. At the time of the survey, site C (hypersaline zone) had lower nitrogen but higher phosphorus concentrations than the two sites located in the wetland basin zone (sites 5 and E). Organic nitrogen was the dominant nitrogen species at all sites, and site C also had higher concentrations of nitrogen oxides (NOx) and ammonia than the other sites.

The BMT WBM October 2010 – November 2010 study assessed nutrient concentrations at nine sites throughout the Wetlands. Total nitrogen (TN) ranged from 0.9 (site 9, wetland basin zone) to 1.9 mg/L (site 2, Saltwater Creek zone), with exceedances of default regional guideline values outlined in DERM 2009 at most sites. The concentration of TN at sites in the hypersaline zone tended to increase from March to May 2010 and there was also an increase observed between February and May 2011, however this was not as great as in 2010. The TN concentration in the central wetland (WQ10) and eastern wetland (WQ13 and WQ14) also increased from April to July 2010 the same trend, however, was not seen in 2011. Organic nitrogen dominated, although concentrations of ammonia exceeded guideline values at most sites.

Total phosphorus (TP) concentrations also exceeded the regional guideline value at all sites in 2010, however filterable reactive phosphorus, which is bio-available and therefore able to exert a major influence on algae growth, was recorded in low concentrations. No other spatial or temporal patterns could be identified for TP.

Dissolved oxygen (DO) concentrations can show great spatial variability throughout the Wetlands. For example, the 2014 BMT WBM continuous measurements of DO show variations of DO between:

- ~50 and ~450% at site 1A (east of the western (outer bund) within the hypersaline zone
- ~5 and ~20% at site 3A (downstream of the Causeway within the hypersaline zone
- ~10 and ~160% at site 4 (within Saltwater Creek downstream of the rail bridge)
- ~25 and 325% at site 6 (Lake Caley).

Higher DO values recorded are correlated with daylight hours (and higher temperatures) and vice versa.

Similarly, sampling by DEWHA (2010) in 1999 recorded dissolved oxygen concentrations ranging from 50 percent saturation (4.5 mg/L) in the northern section of the wetland basin zone (taken at 9:30 am) to 267 percent (20.4 mg/L) south of Lake Caley (time of sampling not documented). Sampling by WBM (2005) suggested that most sites were well oxygenated, with slightly depressed concentrations recorded in the western estuarine zone immediately downstream of the Western Bund (Figure 3-6).

Dissolved oxygen concentrations tend to vary greatly in time in response to changes in algae and microbial production (which varies seasonally and in the case of algae between day and night) and wetland hydrology. DEWHA (2010b) suggests that the nutrient enriched sediments in these areas represent an important source of nutrients for the wetland ecosystem.

The high nutrient concentrations, coupled with shallow water (which allows light penetration to the base of the wetland) are driving primary productivity in the Wetlands. Large mats of benthic algae are common in the shallow waters of the hypersaline zone and wetland basin zone. During daylight hours when photosynthesis occurs, the algae and benthic microbes in these zones rapidly metabolise the readily available nutrients releasing super-saturated levels of oxygen into the water column. Increased algal biomass, however, drives increased plant respiration, drawing on DO, and when the algae die, bacterial decomposition spikes, using up most or all of the dissolved oxygen available. This creates an anoxic, or oxygen-depleted, environment where fish and other organisms cannot survive. Photosynthesis shuts down at night resulting in rapid and significant declines in dissolved oxygen levels (BMT WBM 2012).

3.2.3 Trace Metals

WBM (2006) found that concentrations of most trace metals were higher at the site in the hypersaline zone (site C) than the two sites in the wetland basin zone. By contrast, the BMT WBM October 2010 – November 2010 study found that sites in the hypersaline zone had lower trace metal concentrations than other parts of the Wetlands. In the BMT WBM October 2010 – November 2010 study, the Saltwater Creek zone and the western estuarine zone had the highest concentrations of most trace metals.

Trace metal concentrations were compared with ANZECC/ARMCANZ (2000) toxicant trigger values (95% species protection level). In summary:

- WBM (2006) found that trace metal concentrations were below marine trigger values at all sites (which are applicable given the saline nature of waters at the time of sampling).
- In the October-November 2010 study, the Saltwater Creek zone had concentrations of aluminium, chromium, copper and zinc which exceeded respective freshwater trigger levels (which are applicable given the conditions at the time of sampling).
- The October-November 2010 study also found that the following trace metals had concentrations above ANZECC/ARMCANZ (2000) trigger values for marine waters: copper (all sites except the hypersaline zone), chromium (western estuarine zone) and zinc (western estuarine zone, and one site in the wetland basin zone).

More recently, surface water quality monitoring results indicate that the concentration of total metals in the Wetland during February (2010), March, July and June (2011) exceeded the ANZECC guideline for aluminium, boron, chromium, cobalt, copper, iron, lead, nickel, vanadium and zinc at a number of sites (GHD 2010). Concentrations of metals were generally highest in February (2010), during the wet season.

There are many factors which influence spatial and temporal patterns in concentrations of trace metals and other pollutants. In particular, rainfall can exert a major influence on trace metals concentrations. It is noted that the November 2010 sampling was undertaken immediately following a rainfall event at the end of the dry season. Such 'first flush' events can flush large quantities of soil and other pollutants from the surrounding catchment into receiving waters, resulting in a temporary spike in pollutant concentrations. The WBM (2006) study may be more representative of background conditions.

Sampling across a range of sites across a range of time periods is required to adequately characterise background water quality conditions (DERM 2009), and the drivers leading to changes in water quality conditions. This is critical to establishing local water quality objectives for the Wetlands prior to industry and infrastructure development occurring in the Abbot Point State Development Area.

3.2.4 pH

The 1981 (Peter Hollingsworth and Associates 1981) sampling indicated that the two sites immediately upslope of the Causeway within the hypersaline zone were alkaline, pH ranging from 8.5 – 9.8. The northeast corner of the wetland basin zone (immediately downstream of the APCT) has a variable pH, with either mildly acidic or mildly alkaline conditions occurring. These variations would be associated with upstream inputs of low pH waters from APCT. Measurements of pH in 1999 (DEWHA 2010) ranged from 7.8 on the flat south east of Mount Luce to 8.9 on the eastern side of the northern end of the Causeway. Sampling from 2005 indicated that pH throughout other parts of the wetland basin zone ranged between 8.65 and 9.24 (Figure 3-6). During the period 2005-2008, the pH in Lake Caley proper was highly variable ranging from approximately 6 to 9.5 (GHD 2009).

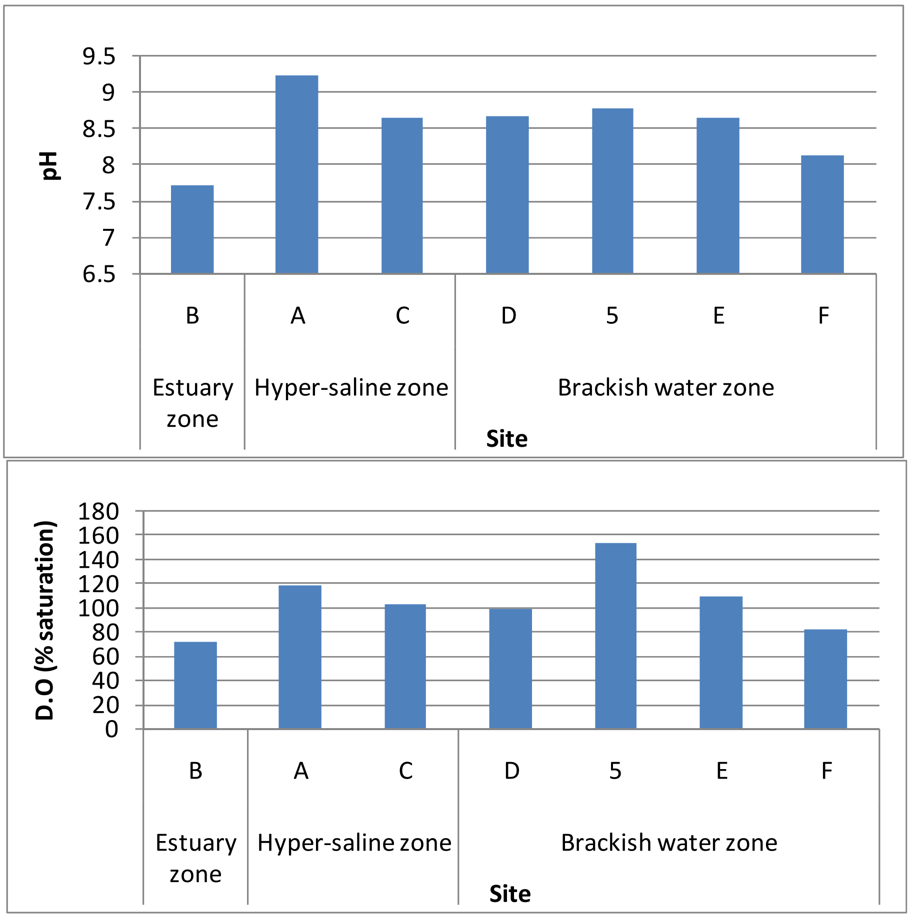


Figure 3-6 Measurements of pH and dissolved oxygen in the Wetlands 20th April 2005 (Source: WBM 2006)

4 Existing Aquatic (Wetland) Ecology Values

4.1 Wetland Vegetation

4.1.1 Methodology

Information Review

The ecological investigations of the proposed DMCP and surrounds builds on existing data collated for the Abbot Point Port and Wetland Project (BMT WBM 2014). A search using the Protected Matters Search Tool (PMST) was undertaken, and results are presented in Appendix A.

Field Surveys

Supplementary field surveys were undertaken to identify the ecological character and values of marine and wetland vegetation and Groundwater Dependent Ecosystems (GDEs) within and directly adjacent to the footprint of the DMCP (the study area).

Site data consistent with Neldner *et al*. (2012) was collected throughout the study area to describe vegetation composition and structure within remnant and non-remnant vegetation communities.

Secondary sites were used to classify and provide detailed descriptions of regional ecosystems and vegetation communities within the DMCP. Sites and traverses were distributed to sample as much as possible the environmental variability across the landscape, given the time constraints. Within each secondary site, 10m × 50 m plots were established along the observed contour. Data collected included location, environmental and overall structural information as well as a list of all species present and basal area (of woody stems using the Bitterlich stick method), percentage cover and stem density measures of abundance within 5 m of either side of the tape. As the footprint and adjacent land was extensively burned prior to the survey a comprehensive assessment of ground layer species was not possible.

Tertiary and quaternary sites were also collected throughout the study area. Data collected included location, environmental and overall structural information as well as a comprehensive list of woody species. An assessment of ground layer species was not possible at most sites due to extensive burning.

Throughout the survey informal notes were also made to ground-truth vegetation maps and to record new species or habitat condition.

4.1.2 Landforms

The Wetlands have complex geology and soil conditions with features of an alluvial plain, lacustrine plain and estuarine plain. Landform elements in and directly adjacent to the Wetlands include the lowest lying basin or lake, ephemeral drainage channels, tidal channels, alluvial plains, intertidal and supratidal flats, hills in the north and to the south, and sand plains, dunes and swales to the east adjacent to the coast.

The lake basin supports a mix of alluvial and estuarine deposits overlain with catchment-derived sediments. The upper plains surrounding the basin are comprised of estuarine deposits with alluvial influences in the south. Intertidal wetlands in the west are based on estuarine deposits.

Gently sloping sand dunes lie adjacent to the beach ridges along the coast comprised of Quaternary coastal sediments on sandy soils.

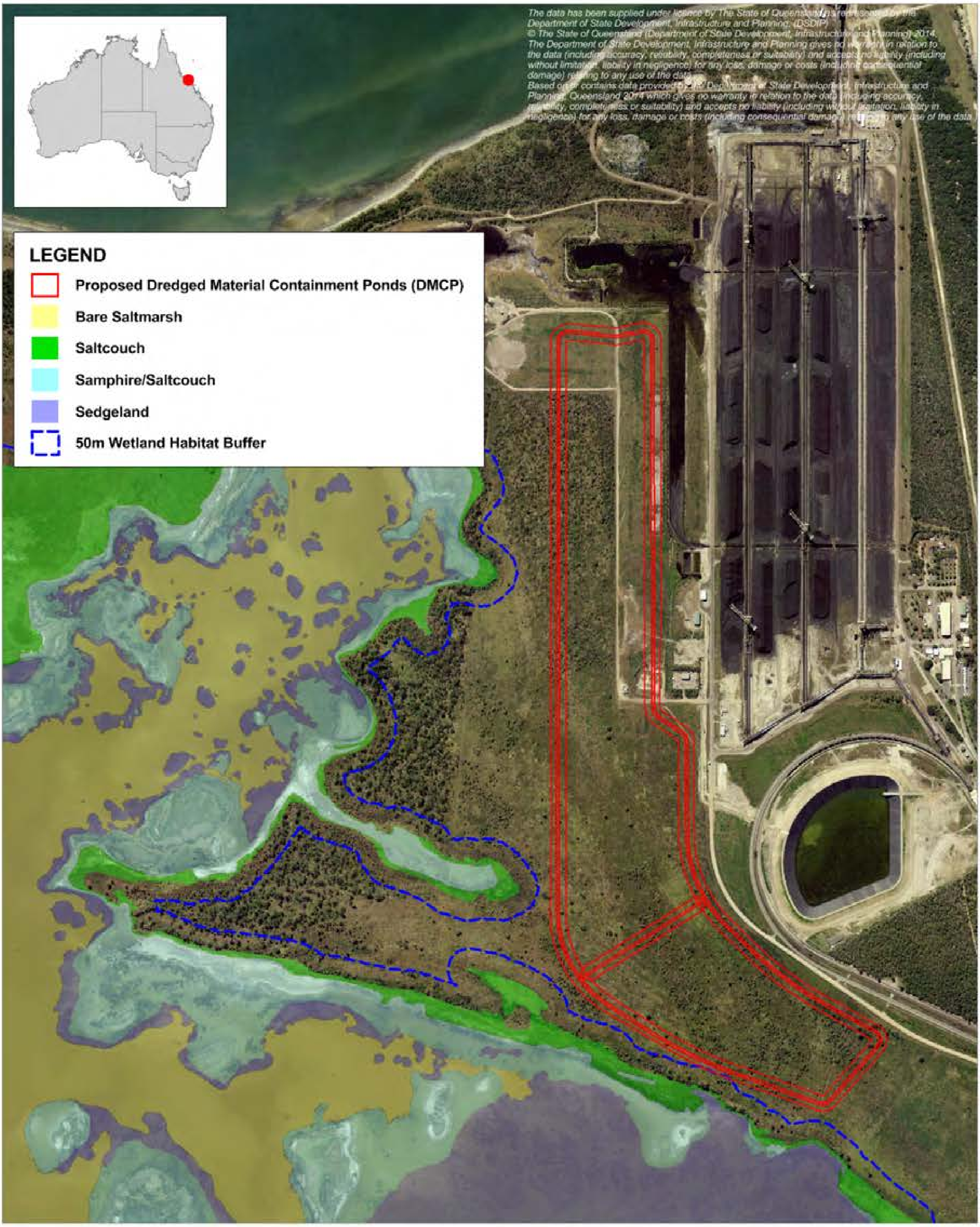
4.1.3 Vegetation Communities

The various wetland landforms described above support a mix of vegetation communities across a strong salinity gradient. The Wetlands support estuarine vegetation comprised of mangroves and saltmarsh. Mangroves are most well developed within tidal estuarine plains within the western estuarine zone and along Saltwater Creek. Saltmarsh wetlands dominate the western estuary occurring on the low gradient estuarine plains and the wetland basin which is subject to seasonal freshwater ponding.

Whilst current Regional Ecosystem (RE) mapping (V9.0) provides an accurate depiction of broad wetland type distribution, the high variability in saltmarsh composition over very small distances, particularly in the samphire and saltcouch communities is too small to map at the 1:100,000 RE mapping scale. For this reason, local scale mapping was prepared for the wetland habitats directly adjacent to the DMCP site to accurately quantify impacts to various wetland habitats. Figure 4-1 shows the mapped distribution of saline wetland habitats directly adjacent to the DMCP site based on 2009 wet season aerial photography (the highest resolution imagery available for this study) and groundtruthing surveys conducted by BMT WBM in October 2014 and June 2015.

It should be noted that intra-community variations, particularly differences in samphire community structure, are also too small to map at the local scale. In addition, saltmarsh boundaries are dynamic and may change within and between years as a result of seasonal wet periods and drought. More long term changes have/will also occur as a result of hydrological modifications within the wetland including the long term effects of sea level rise.

The landward limit of saltmarsh throughout the Wetlands is fairly well defined indicating a strong salinity and inundation gradient between the Wetlands and the surrounding dune plains which have been extensively cleared for grazing. Whilst the Wetlands are on a low gradient plain the micro-topography is highly variable with low rises, small channels and depressions which are subject to various levels of seasonal inundation and groundwater influence. The variable soil conditions, topography, groundwater and inundation levels promote high variability in saltmarsh composition and structure over very small distances (in the order of metres) with saltmarsh wetlands supporting both bare and vegetated habitats.



Title:

2009 Wet Season Wetland Habitats (BMT WBM, 2015)

Figure: 4-1

Rev: A

N

0m 300 600

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B21434_I_GML_Abbot_Point_Gateway_LBL\DRG\ECO_003_150629_BMTWBM 2009 Wet Season Wetland Habitats.wor

4.1.3.1 Bare Saltmarsh and Lake Pools, including Lake Caley

The lowest lying basin of the Wetlands supports highly variable and seasonal habitats in response to dry hypersaline conditions for most of the year alternating with wet hyposaline conditions during the wet season. The wetland basin, which is subject to seasonal freshwater pooling followed by prolonged drying, supports two main habitats: bare saltmarsh in the dry season and lake pools in the wet season. During the wet season the basin becomes inundated with shallow freshwater pools which convert to brackish and saline conditions as a result of evaporation and the saline soils and groundwater. These pools eventually dry up across most of the Wetlands, although some ponding can occur during dry periods at Lake Caley.

There are areas of the wetland basin that are lacustrine in nature, most notably Lake Caley, which encompasses approximately 79 ha. Based on 2009 wet season imagery a further 1,323 ha of the basin becomes seasonally inundated but dries out annually (BMT WBM, 2015). Lake Caley has variable depth (typically less than a metre, except during extreme flood events).

GHD (2009) recorded *Spirodela punctata, Nymphaea immutabilis* and *Monochoria cyanea* macrophytes within the lake pools following the wet season March (2009). The habitat values of these seasonal macrophyte beds to fish, macroinvertebrates and birds is not well understood, but generally aquatic fauna species diversity increases with habitat complexity including the presence of macrophytes.

During the BMT WBM October 2014 dry season survey, a thin layer of dried algal crust was observed in some areas of the bare saltmarsh (described below) indicating algal mats may form in the basin in shallow waters following floods. There is limited data available on the composition and extent of these algal mats or their potential contribution to the diets of estuarine fish and crustaceans, and in turn, migratory waders which are known to use the lake pools on a seasonal basis.

During the dry season the majority of the basin dries out and is comprised of exposed, dry, bare, cracking soils. The habitat values of these bare flats during the dry season are not well understood. *Tecticornia australasica* and *Cressa australis* form sparse monospecific samphire patches on the dry flats during the dry season and may remain in elevated sites during the wet season. *Tecticornia australasica* is an annual samphire species that is generally intolerant of highly saline areas and prefers seasonal freshwater inundation. *Cressa australis* prefers more saline and swamp habitats. Both species would dieback within inundated areas during flooding and would recolonise under drier conditions. The habitat values of these samphire communities are not well understood.

Under the RE framework the bare saltmarsh is analogous to RE11.1.2 (samphire) (VMA Class Least Concern / Biodiversity Status No Concern at present).

Bare saltmarsh/salt pan

Dried algal mats on sediment surface amongst sparse *Tecticornia*

Lake Caley (October 2014)

Figure 4-2 Bare saltmarsh

4.1.3.2 Vegetated Saltmarsh

Three vegetated saltmarshes occur in the Wetlands on the fringes of the inundation zone of the basin, throughout the upper estuarine plains landward the lake basin and landward the mangroves in the west. All the saltmarsh vegetation types tolerate salinity and periodic saline and freshwater inundation to various degrees. The vegetated saltmarsh types include:

- Monospecific sedgelands on raised catchment-derived sediment beds fringing the seasonally inundated areas of the basin.
- Samphire saltmarsh dominated by sparse to medium density dwarf shrubland of semi-woody plants. These communities are most extensive on the estuarine plains above the basin inundation zone.
- Sparse to dense, low tussock saltcouch grassland on the estuarine plains landward of the samphire and sedgelands. This saltmarsh community has the lowest inundation tolerance of all the vegetation types and does not occur in ponded or hypersaline areas.

Sedgelands

Patches of *Schoenoplectus subulatus* sedgelands (averaging 80-90% cover) with sparse *Sesuvium portulacastrum* groundcover are located on the fringes of the basin and on raised sediment beds within the basin. The sedgelands are periodically inundated with fresh water during the wet season (which becomes brackish to saline) but the raised sediment beds, comprised of catchment derived sediments, dry out faster than the surrounding lake pools. The residency time for freshwater and saline inundation within the basin, lake pools and sedgelands is not well understood, but the sedgelands, tolerant of periodic freshwater and brackish inundation, dry out completely each year. The habitat values of these sedgelands, including their importance for the threatened Australian painted snipe (*Rostratula australis*), are described in the Terrestrial Ecology report.

This vegetation is analogous to RE11.3.27x1c (VMA Class Least Concern / Biodiversity Status Of Concern at present).

Extensive sedgelands in the wetland basin

Sedgelands on fringe of bare saltmarsh

Isolated sedgeland on raised beds in basin

Figure 4-3 Sedgelands

Samphire

The most extensive samphire habitats of the Wetlands occur above the zone of seasonal pooling on estuarine flats with deep saline clay soils formed from estuarine sediments. They are dominated by a sparse (<10% cover) to medium (50-70% cover) shrub cover of *Tecticornia halocnemoides, Tecticornia indica, Tecticornia australasica, Tecticornia pergranulata* and/or *Sarcocornia quinqueflora*. Local species dominance depends on saline and inundation conditions with *T. halocnemoides* found on the most landward edge and *T. indica* occurring closer to the inundation zone.

The groundcover depends on saline and inundation conditions but common species include *Cressa australis, Sesuvium portulacastrum, Eleocharis plana, Schoenoplectus subulatus, Sporobolus virginicus* and sparse *Fimbristylis* sp.. Bare saltpans also occur in hypersaline areas and are most obvious directly east and west of the causeway.

As described above, *Tecticornia australasica* and *Cressa australis* also form monospecific samphire patches in the basin where dry hypersaline conditions alternate with wet hyposaline conditions during the wet season.

Sparse and stunted mangroves namely *Avicennia marina* and *Ceriops tagal* also occur along tidally influenced channels traversing samphire communities within the west of the Wetlands.

The habitat values of the samphire are described in the Terrestrial Ecology report.

The samphire communities are analogous to RE11.1.2 (VMA Class Least Concern / Biodiversity Status No Concern at present).

Saltcouch Grassland

Sporobolus virginicus grassland is the most landward saltmarsh type of the Wetlands occurring on estuarine sediments with saline cracking clays well above the zone of seasonal inundation and outside hypersaline areas. It typically forms pure stands averaging 80-90% cover but may comprise other salt tolerant species particularly *Sesuvium portulacastrum* and *Tecticornia* spp..

Eleocharis plana and/or *Fimbristylis* sp. may occur in seasonally waterlogged soils and depressions or channels that are dominated by freshwater influence. Isolated patches of *Typha* sp. also occur in close association with salt couch in freshwater channels in the north east of the

Wetlands. In the eastern basin the landward edge of saltcouch grassland grades into exotic pasture grasses on the fringes of the surrounding dune communities.

The habitat values of the samphire are described in the Terrestrial Ecology report.

These communities are analogous to RE11.1.1 (VMA Class Least Concern / Biodiversity Status No Concern at present).

Saltcouch (bottom) grading into pasture grasses (top)

Extensive saltcouch communities in north-east of Wetlands

Typha channels through saltcouch in north east of Wetlands

Figure 4-4 Saltcouch grasslands

4.1.3.3 Mangroves

Mangroves are most well developed west of the causeway on the well flushed estuarine creeks systems within the western estuarine zone (i.e. Splitters, Branch and Mount Stuart Creeks) and along Saltwater Creek. *Avicennia marina, Rhizophora stylosa* and *Ceriops tagal* co-dominate in the western estuarine zone. In contrast Saltwater Creek is fringed with *Excoecaria agallocha* and sparse *Lumnitzera racemosa* which have a preference for lower salinities.

Mangroves are classified as RE11.1.4 (VMA Class Least Concern / Biodiversity Status No Concern at present).

Saltwater Creek	Vicinity of Western Bund	Western Estuarine Basin
		

Figure 4-5 Mangroves

4.1.3.4 *Riparian Vegetation and Freshwater Aquatic Macrophytes*

The main freshwater/brackish stream in the Wetlands is Saltwater Creek. This creek forms a permanent aquatic refuge and has high habitat values for waterbirds and fish.

The riparian fringe of Saltwater Creek is dominated by a mix of *Melaleuca leucadendra* on the higher banks with the mangroves *Excoecaria agallocha* and *Lumnitzera racemosa* dominating the lower banks. The riparian groundcover is highly variable ranging from bare banks to dense fringing patches of commonly occurring wetland species including *Persicaria* spp., *Schoenoplectus subulatus, Eleocharis* spp., *Phragmites australis, Cyperus exaltatus* and *Marsilea mutica.*

The upper banks and alluvial plains have been predominantly cleared but support low lying patches of saltcouch grassland and samphire as described above. Weed diversity within and directly adjacent to the riparian fringe is high and dominated by *Acacia nilotica, Cryptostegia grandiflora* and *Parkinsonia aculeata*.

The submerged macrophyte, *Hydrilla verticillata*, forms dense masses throughout Saltwater Creek. Other widespread macrophytes include *Ottelia ovalifolia,* the floating *Nymphaea gigantea* and the introduced *Potamogeton crispus.*

Whilst the species composition of vegetation within Saltwater Creek is indicative of a freshwater to brackish system, the mangroves (dominated by more freshwater tolerant species) indicate some saline influence. In addition, the dominant aquatic macrophytes, though most widespread in freshwater systems, are tolerant of slightly brackish water conditions. For example, *Hydrilla verticillata* can tolerate salinity up to 2 ppt (7% salinity of seawater) (BMT WBM, 2012).

Numerous small freshwater streams drain into the Wetlands (e.g. Mount Stewart, Six Mile and Goodbye Creeks) with Maria, Tabletop, Branch and Splitters Creeks discharging into the hypersaline zone. These creeks are of an ephemeral nature and traverse a highly cleared landscape. As a result they support narrow and disjointed riparian fringes typically dominated by *Eucalyptus tereticornis, Melaleuca leucadendra, Pandanus spiralis* and *Melaleuca viminalis*. *Typha* sp. patches occur in waterlogged depressions.

4.1.3.5 Sand Plains

In comparison to the Wetlands, the slightly elevated sand plains to the east lie above the zone of seasonal inundation that occurs within the basin, and support vegetation communities influenced by freshwater overflow and groundwater. These undulating plains vary in topography, have been subject to various levels of disturbance and currently support a mosaic of remnant and regenerating *Melaleuca viridiflora* and *Corymbia tessellaris* woodland classified as RE11.2.5.

Remnant RE11.2.5 to the north-west of the DMCP site supported a canopy of *Corymbia tessellaris* and *Corymbia clarksoniana* ranging in height from 12 to 20m. The moderately dense understorey was comprised of *Alphitonia excelsa, Planchonia careya, Pandanus spiralis, Melaleuca viridiflora* and *Cupaniopsis anacardioides* over a shrub layer of *Acacia holosericea, Lantana camara* and *Cryptostegia grandiflora.*

In comparison, the DMCP site has been extensively cleared in the past for grazing and currently supports regrowth of varying maturity. The most well-established regrowth in the DMCP site occurred in the north-west, which supported an upper canopy of *Melaleuca viridiflora* with sparse *Planchonia careya* averaging 5-6m in height with a canopy cover averaging 20-30%. Sparse emergent *Corymbia tessellaris* and *Alstonia constricta* averaging 8m in height and 5% cover also occurred. The sub-canopy comprised *M. viridiflora*, averaging 3-4m in height and 10% cover. The upper shrub-layer ranged from 1.5-3m in height and 10% cover and was dominated by *Acacia holosericea, Ziziphus mauritiana* and *Alphitonia excelsa*. The lower shrub-layer averaged 0.5m in height and <5% cover and comprised *Stylosanthes scabra* and *Hyptis suaveolens*. A groundcover assessment was not possible at the time of survey as the area had been recently burned, however, based on general groundcover condition in disturbed habitats of the study area it would expected to be dominated by annual pasture grasses, particularly *Cenchrus ciliaris*. Based on BioCondition attributes, no coarse woody debris or large trees were recorded in this area.

The north east of the DMCP site supported low, dense woodland which supported an upper canopy of *M. viridiflora* with sparse *A. holosericea, M. leucadendra* and *Planchonia careya* averaging 2-3m in height and 30% canopy cover. Sparse (5% cover) emergent *Corymbia tessellaris* averaging 4m in height also occurred. The sub-canopy comprised *M. viridiflora* and sparse *A. holosericea* averaging 1.5-2m in height and 40% canopy cover. The highly variable shrub-layer ranged from 0.5-1.5m in height and 5-25% cover and was dominated by *M. viridiflora, Stachytarpheta cayennensis, H. suaveolens, S. scabra* and *Cryptostegia grandiflora*. The groundcover averaged 30% cover and comprised (in order of abundance) *Cenchrus ciliaris, Cynodon dactylon* and *Passiflora* sp.. Based on BioCondition attributes, no coarse woody debris or large trees were recorded in this area. The site was highly disturbed, particularly weed invasion in the shrub layer, and showed evidence of frequent and widespread pig disturbance.

The south of the DMCP site supported highly variable regrowth dominated by sparse (5-20% cover) *M. viridiflora, A. constricta, Pandanus spiralis* and *P. careya* ranging in height from 6-9m with sparse emergent *C. tessellaris* to 12m in height. Other canopy species included *Acacia* spp. and *Ficus*. sp.. The highly variable shrublayer comprised *A. holosericea, Z. mauritiana, A. excelsa, T. aspera* and *L. camara* averaging 2-4m in height and up to 20% cover in some sites. The lower shrublayer comprised *H. suaveolens, S. scabra* and *C. grandiflora*. A groundcover assessment was not possible at the time of survey as the area had been recently burned, however, based on general groundcover condition in disturbed habitats of the study area it would expected to be dominated by annual pasture grasses, particularly *Cenchrus ciliaris*.

Figure 4-6 Study Site Regrowth

Wetland Habitats

The Regional Ecosystem Description Database describes RE11.2.5 as containing palustrine wetlands in the swales. However, the vegetation across the DMCP site and immediate surrounds was relatively homogenous and no wetland vegetation, or species indicative of seasonal ponding such as sedges, were identified at the time of survey. Although it is recognised the survey was conducted during the dry season and was extensively burned, which would seriously limit identification of wetland species, the DMCP site and immediate surrounds supported a sand plain with limited relief and no obvious swale depressions.

In comparison, swales and wetland species were identified in the coastal fringe east of the DMCP site. The low-lying sand plains in the coastal fringe of the study area were dominated by remnant RE11.2.5 which supported an upper canopy of *M. viridiflora* averaging 9-11m in height and ranging from 40-70% canopy cover. Other canopy species included *C. tessellaris, M. leucadendra, P. careya, A. excelsa, Cupaniopsis anacardioides, Acacia* spp. and *Pandanus spiralis.* The sub-canopy comprised *M. viridiflora* averaging 7-8m in height and 30-50% canopy cover. Other species in this layer included *Alphitonia excelsa, Exocarpos latifolius, Planchonia careya, Acacia* spp. and *Petalostigma pubescens.* The highly variable shrub-layer ranged from 0.5-2.0m in height and 10-30% cover and was dominated by *C. grandiflora, L. camara, H. suaveolens* and *Carissa ovata*. The sparse groundcover (5-10% cover) was dominated by native grasses such as *Aristida* sp., *Heteropogon contorta* and *Themeda triandra*.

Throughout this coastal fringe, swales occurred as obvious depressions fringed by *M. viridiflora, M. leucadendra* and *P. tectorius* and with a very sparse groundcover of *Cyperus sp., Isolepis* sp. and *Fimbristylis polytrichoides*. These depressions are likely to become inundated with freshwater on a seasonal basis and may provide temporary habitat for aquatic species.

RE11.2.5 on Coastal Fringe

Wetland Swale in RE11.2.5 on Coastal Fringe

Figure 4-7 Sand Plains

4.1.3.6 Coastal Dunes

To the east of the *M. viridiflora* woodlands, beach scrub communities (RE11.2.3) occurred on the higher sand dunes on the leeward side of the foredune. These communities typically supported a dense canopy (60-90% cover) ranging from 6-10m height comprised of *Alectryon conatus*, *Cupaniopsis anacardioides, Pleiogynium timorensis* and *Niemeyera antiloga.* A lower shrub layer averaging 4-5m in height comprised *Diospyros geminata, Alphitonia excelsa, Elaeodendron australe, Psydrax odorata, Syzygium smithii, Sersalisia sericea, Drypetes deplanchei* and *Petalostigma pubescens.*

Figure 4-8 Beach Scrub

4.1.3.7 Groundwater Dependant Ecosystems

Vegetation communities occurring on beach ridges and swales composed of coastal sands (such as RE11.2.5 and RE11.2.3) typically occur on landforms with a single, unconsolidated sedimentary aquifer, where groundwater forms a freshwater lens in the intergranular voids of the coastal sand mass (DEHP, 2013). Terrestrial vegetation associated with these landforms can depend on the subsurface presence of aquifers where groundwater is typically accessed through the capillary zone above the water table (DEHP, 2013).

The AGE assessment indicates the groundwater of the alluvial terrace (sand plains) and coastal dunes of the study area is brackish to saline. All species associated with the *M. viridiflora* and beach scrub communities on these landforms are generally intolerant of saline conditions. During the field survey there was no indication that brackish to salt tolerant species or communities (such as saltcouch) occur on these landforms within the study area, with the exception of foredune species which are more influenced by exposure to ocean-derived salt-laden winds. These findings suggest the beach ridge and sand plain communities of the study area may be influenced, and depend on, freshwater overland flow rather than access to, and expression of, the brackish to saline groundwater table identified by AGE.

4.1.4 Threatened Species and Communities

No threatened flora species listed under the EPBC Act (or NC Act) have been recorded in the Wetlands. Based on the data review and searches of the current Wildnet and EPBC PMST, no threatened wetland-dependent flora species or communities were identified as likely to occur in the Abbot Point region.

4.1.5 Critical Processes

As discussed above, the landward limit of saltmarsh and mangroves throughout most of the Abbot Point area is fairly well defined indicating a strong salinity and inundation gradient between the Wetlands habitats and the surrounding dune plains in the north and east and alluvial plains to the south. Whilst the Wetlands are on a low gradient plain the micro-topography is highly variable with low rises, small channels and depressions which are subject to various levels of seasonal inundation. The variable soil conditions, groundwater influence, topography and inundation levels promote high variability in saltmarsh composition and structure over very small distances in the order of metres. There is also a strong east to west gradient in terms of tidal influence promoting extensive mangrove development in the west with mangroves limited to sparse stunted individuals east of the causeway.

4.1.5.1 Wetland Habitat Salinity and Inundation Tolerances

The most critical ecosystem processes in the Wetlands that underpin the distribution and condition of the component habitats and species are hydrology and salinity. The various habitats in the Wetlands and their constituent fauna are adapted to live in saline soils which are subject to seasonal waterlogging (particularly during summer) by fresh surface water runoff (which rapidly becomes saline), and brackish to hypersaline groundwater. The various habitats occupy different zones in the Wetlands along a decreasing inundation (and salinity) gradient as follows:

- Bare saltmarsh/pools: lowest lying habitat within basin subject to dry hypersaline conditions and wet hyposaline conditions supporting bare flats and sparse samphire
- Sedgelands: tolerate periodic inundation but dry out faster than the basin
- Samphire: occur above the zone of prolonged pooling, but is seasonally waterlogged
- Saltcouch grassland: most landward saltmarsh, occurs well above the zone of seasonal inundation and outside hypersaline areas.

Whilst the Wetland habitats may be tolerant of a range of salinities and inundation levels, extreme conditions (waterlogging with saline waters) only occurs over short periods during seasonal flooding. Any long term change in salinity may result in changes to habitat condition and structure. Growth of some saltmarsh species may be retarded at high (or low) salinities, primarily due to the high metabolic cost of osmotic adjustment causing a nutrient deficiency (Bradley and Morris 1991;

Messedi *et al*. 2004). Most of the recorded salinity tolerance thresholds for saltmarsh species are below that of typical seawater. For example, Naidoo and Naidoo (1998) found that biomass of *Sporobolus virginicus* was decreased at a salinity concentration of 28 ppt compared to low salinities, while Bell and O'Leary (2003) found that growth of this species was best between 6 and 9 ppt. Shoot biomass for *Tecticornia pergranulata* was greatest at salinities below 12 ppt, with growth completely inhibited at salinities exceeding 18 ppt (Short and Colmer 1999). Some saltmarsh species are more tolerant of higher salinities; for example *Sesuvium portulacastrum* has optimal growth at salinities between 24 and 35 ppt (Messedi *et al*. 2004).

In addition, salinity stress can also impact on germination rates and success. It has been shown that percentages and rates of *S. virginicus* germination are strongly affected by salinities of 9 ppt, while germination of *S. portulacastrum* is impaired at salinities of 18 ppt (Martínez *et al*. 1992). Consequently, should saltmarsh communities be exposed to elevated salinities over an extended period of time, it is likely that seedling recruitment and therefore community regeneration could be adversely impacted.

In the context of ecological thresholds, the case studies demonstrate that the habitats of the Wetlands are tolerant of a wide range of salinities, but with the exception of some species such as *Sesuvium portulacastrum*, generally prefer salinities <20 ppt. Overall, these data suggest that while the Wetland habitats may be tolerant of higher salinities this only occurs over short periods of exposure during seasonal flooding events and any long term change in salinity and inundation would be expected to result in changes to community structure and ecological character. Any long term increase in salinity would be expected to favour saltpan habitats in the basin, but would represent a stress to sedgelands, samphire and saltcouch.

4.1.5.2 Summary

The environmental tolerances and critical processes influencing current habitats in the study area can be summarised as follows:

Bare saltmarsh/lake pools:

- Alluvial and estuarine deposits
- Seasonally inundated with freshwater
- Prolonged freshwater pooling becoming brackish to saline
- Dries out annually for the majority of the year.

Sedgelands:

- Raised sediment beds above basin inundation
- Seasonally inundated with freshwater becoming brackish
- Dry out for most of the year.

Samphire saltmarsh:

- Estuarine sediments above the basin and intertidal lands
- Overland freshwater flows dominate in the east with tidal influence in the west

- Tolerate high salinities and infrequent waterlogging.

Saltcouch grassland:

- Most landward estuarine deposits
- Does not occur in ponded or hypersaline sites
- Tolerant of high salinities and infrequent inundation.

Mangroves:

- Tidally influenced estuarine deposits.

Riparian Vegetation and Freshwater Aquatic Macrophytes:

- Fluvial flows
- Rainfall patterns
- Groundwater influence
- Alluvial substrates.

Sand Plains:

- Coastal sand plains
- Rainfall patterns.

Coastal Dunes:

- Beach ridges and swales
- Rainfall patterns.

4.1.6 Functional Values of Surrounding Terrestrial Habitats to the Wetlands

Lands within the DMCP and immediate surrounds are comprised of regrowth and exotic pasture. The terrestrial areas surrounding the Wetlands provide a range of functional values to its aquatic ecosystems, including the following:

- Regulation of water flows (overland flow and groundwater)
- Trapping of sediment and stabilisation of soils
- Cycling and uptake of nutrients
- Carbon source to aquatic ecosystems
- Habitat linkage between for wetland and terrestrial habitats.

The DMCP and immediate surrounds do not contain defined waterways, and are therefore drained by overland and groundwater flow. The terrestrial vegetation surrounding the Wetlands regulates the flow of surface water runoff, and therefore stabilising sediment from erosion. The surrounding terrestrial vegetation also plays an additional water quality regulation role by trapping sediments and nutrients in runoff, and cycling and uptake of nutrients prior to discharge into the Wetlands.

Furthermore, terrestrial lands also represent a source of carbon to aquatic ecosystems, albeit in a highly modified form compared to the historical (pre-disturbance) baseline.

4.2 Aquatic Fauna

4.2.1 Methodology

The Wetlands support a range of fish and shellfish of direct economic importance. Three surveys of fish communities have previously been carried out in the Wetlands and form the basis for this assessment in Table 4-1. Figure 4-9 is a map of the sampling sites for each of these surveys, and Table 4-2 is a summary of sampling details. The wetland basin was dry in May 2015 so no surveys were carried out specifically for this assessment.

Fish species records for the wider Don River basin were compiled from a range of sources, and are referred to in this report:

- Pusey *et al*. (2004), which is based on a review of available information and sampling
- Sampling carried out in the Don River by Hogan and Vallance (1998)
- A search of the DEHP Wildlife Online database
- Search of the protected matters online search tool.

4.2.2 Species Composition and Community Structure

To date, 36 fish species from 25 families have been recorded in the Wetlands (Table 4-2). This is based on the following:

- Eight species recorded by GHD (2010) in a wet season survey in 2008. This survey used a small number of sampling methods and therefore results are not directly comparable to the BMT WBM surveys
- 23 species recorded by BMT WBM (2012) in a dry season survey in 2010
- 21 species recorded by BMT WBM in the present study (dry season - November 2014).

BMT WBM (2012) reviewed existing literature to identify other records of fish previously recorded in in waterways and wetlands within the wider Don River basin. An additional four fish species are known from the wider Don River basin (Pusey *et al.* 2004, Hogan and Vallance 1998), all of which BMT WBM (2012) concluded were likely to occur in the Wetlands. The Wetlands are also known to support several crustaceans of economic value, as discussed in Section 4.2.4.

Table 4-1 Fish surveys in Caley Valley Wetlands

Source	Timing	Sampling methods	Σ Sites	Saltwater Creek	Wetland basin	Hypersaline zone	Western estuary
GHD 2010	22 March to 4 April 2008 (wet season)	• baited box traps • opera house traps	17	0 sites	10 sites	4 sites	3 sites
BMT WBM 2012	25 to 29 October 2010 (dry/early wet season)	• Large beach seine net: 30 x 1.5 m, 12mm mesh (1-2 shots/site) • Small beach seine net: 3m long, 2m drop, 5mm stretched mesh (3 shots/site) • Gill nets: 30m long x 2.5 m drop, stretched mesh sizes of 25, 50, 75mm (3 hour soak time) • Fyke net: 5 m width (dual wings) with 12mm mesh, a 1 meter wide entrance and two non-return cones • Baited box traps x 10/site	8	2 sites	3 sites	1 site	2 sites
BMT WBM 2014	30 October to 3 November 2014 (dry/early wet season)	• Large beach seine net: 30 x 1.5 m, 12mm mesh (1-2 shots/site) • Small beach seine net: 3m long, 2m drop, 5mm stretched mesh (3 shots/site) • Gill nets: 30m long x 2.5 m drop, stretched mesh sizes of 25, 50, 75mm (3 hour soak time) • Fyke net: 5 m width (dual wings) with 12mm mesh, a 1 meter wide entrance and two non-return cones • Baited box traps x 10/site	7	2 sites	2 sites	1 site	2 sites

LEGEND

- Caley Valley Wetland Boundary as Defined through DIWA Listing
- Proposed Dredged Material Containment Ponds (DMCP)
- Road
- Railway
- Regrowth Watercourse (DERM)

Sampling Locations

- 2010
- 2014

Title:

Fish Sampling Sites

Figure 4-9

Rev: A

N

0km 1 2
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B21434_I_GML_Abbot_Point_Gateway_LBL\DRG\ECO_019_150709_Fish Sampling Sites.wor

Patterns in community structure vary spatially and over time. In terms of species richness (Figure 4-10), the Saltwater Creek zone supported the largest number of fish species, which in most cases, was comprised of euryhaline 'freshwater' species that utilise both freshwater and brackish water habitats. During non-flood periods when water levels are low, the wetland basin contains a small number of saline water tolerant, small-bodied fish species (BMT WBM 2012; present study). During flood events, euryhaline fish would likely move from Saltwater Creek (and possibly the western estuary) into the wetland basin zone, increasing species richness in this area. Patterns in fish movements during the wet season have not been investigated to date in detail.

The western estuary was comprised of wide a range of marine and estuarine species, dominated by small-bodied fish species and juvenile life-stages. The hypersaline pond located behind the Western Bund was found to contain a small number of fish species (but in high abundance) in 2010 (BMT WBM 2012), however no fish were recorded here in the present survey (Figure 4-10). Fish species recorded in this pond included several small baitfish species and juvenile oxeye herring.

4.2.3 Threatened Fish and Aquatic Macroinvertebrate Species

No fish or aquatic macroinvertebrate species recorded within the Wetlands or the wider Don River basin are listed as threatened under Commonwealth (EPBC Act) or State (NC Act) legislation. Furthermore, none of these fish species are considered to be threatened or near threatened at an international level, as defined under International Union for Conservation of Nature (IUCN) Red List.

A protected matters search indicates that marine/coastal areas adjacent to the Wetlands provide potential habitat for threatened and/or migratory shark species listed under the EPBC Act, namely porbeagle shark (*Lamna nasus*), green sawfish (*Pristis zijsron*) and whale shark (*Rhincodon typus*). Porbeagle and whale sharks are oceanic species (DoE 2013a and 2013b) and are highly unlikely to occur in the vicinity of the Wetlands.

Green sawfish is a coastal/estuarine species which has been recorded in inshore marine waters, estuaries, river mouths, embankments and along sandy and muddy beaches (Stevens *et al*. 2005). Sawfish have been recorded in very shallow water (<1 m) to offshore trawl grounds in over 70 m of water (Stevens *et al*. 2005). Potential habitats in the Wetlands include the western estuary and coastal zone, however the wetland basin is unlikely to provide suitable habitat due to its highly ephemeral nature and instream barriers (bunds). Green sawfish has not been recorded south of Cairns since the 1960s (DoE 2013c). Based on the analysis of Queensland Beach Control Program catch records for the Townsville region (Stevens *et al*. 2005), a major decline in sawfish catches was observed in the 1970's and 1980's, and no sawfish have been recorded by the netting program in the Townsville region since the early 1990's. On the basis of the range retraction and habitat requirements, it is considered unlikely that the wetland basin represents important habitat for green sawfish.

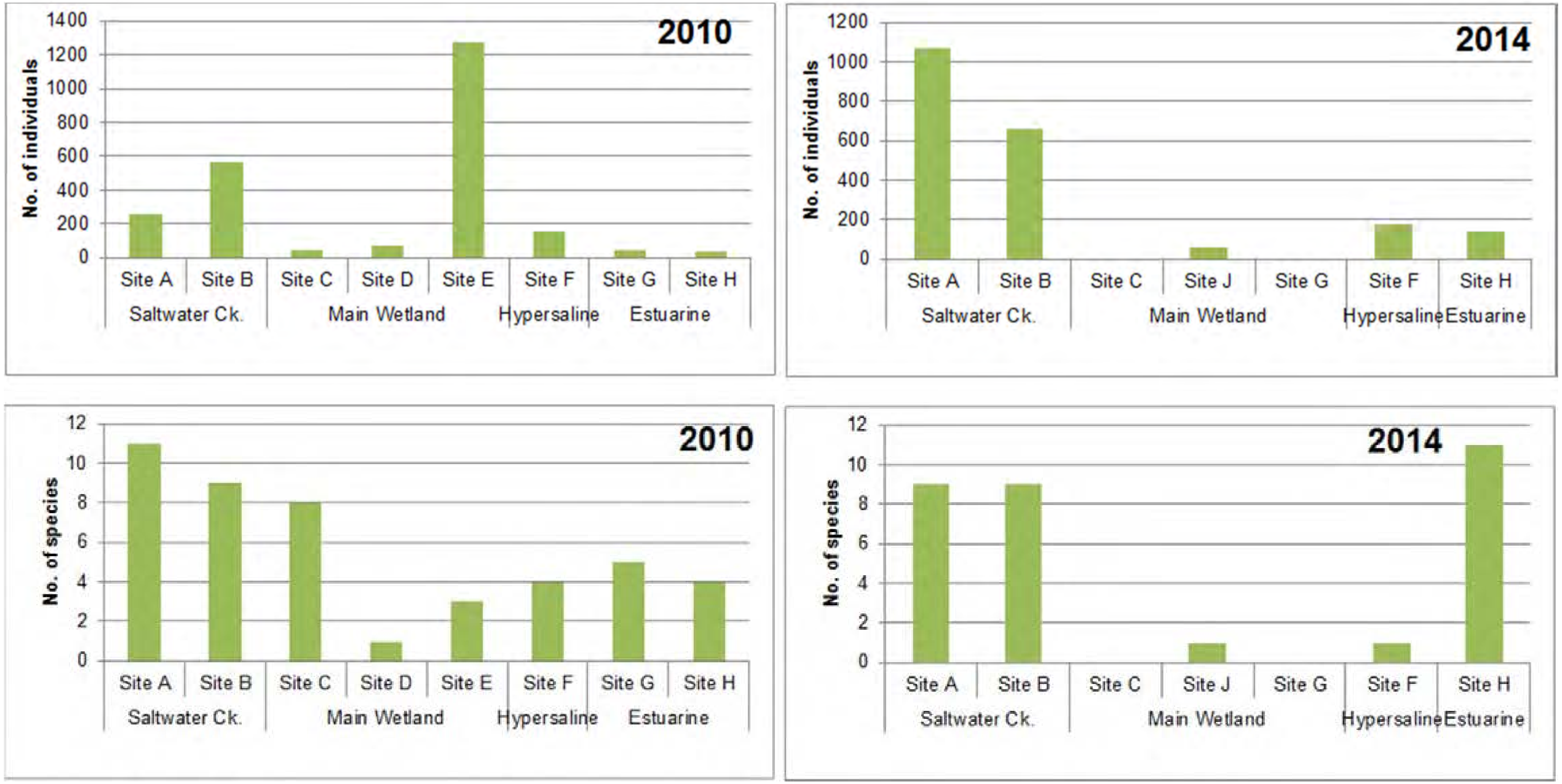


Figure 4-10 Total number of fish (individuals and species) recorded at each site in 2010 (BMT WBM 2012) and 2014 (BMT WBM 2014)

Table 4-2 List of fish species and their occurrence in different wetland zones

Scientific Name	Common Name	Primary Habitat (spawning)	Habitat Requirements	Zone recorded
Dasyatididae:				
Pastinachus sephen	Cowtail stingray	Marine	Found in coastal environments and reef habitat, also recorded in lagoons and river systems.	Western estuary[1]
Elopidae:				
Elops hawaiensis	Giant herring	Marine / Freshwater	A coastal fish, lagoon, bays, and estuaries, particularly around mangroves. Sometimes enters freshwater streams.	Wetland basin[1]
Megalopidae:				
Megalops cyprinoides	Oxeye herring	Marine/ Freshwater (Marine)	Habitat generalist, but typically more abundant in open waters, highly fecund with pelagic eggs.	Saltwater Ck[1,3] Hypersaline (pond)[1]
Anguillidae:				
*Anguilla reinhardtii**	Long fin eel	Freshwater (Marine)	Generalist, but usually more common in rivers than lakes.	Saltwater Ck[1,3]
Clupeidae:				
Nematalosa erebi	Bony bream	Freshwater	Open water generalist, common in rivers and lakes.	Saltwater Ck[1,3] Wetland basin[1] Western estuary[3]
Herklotsichthys castelnaui	Southern herring		A coastal fish, lagoon, bays, and estuaries, particularly around mangroves	Western estuary[3]
Gerreidae:				
Gerres filamentosus	Threadfinned silver biddy	Marine	A coastal fish, lagoon, bays, and estuaries, particularly around mangroves.	Western estuary[3]
Gerres subfasciatus	Silver belly	Marine	As for *G. filamentosus*	Western estuary[3]
Hemiramphidae:				
*Hyporhamphus sp.**	Garfish	Marine	Coastal areas / estuaries	Western estuary[1]

Scientific Name	Common Name	Primary Habitat (spawning)	Habitat Requirements	Zone recorded
Chanidae				
Chanos chanos	Milkfish	Marine (estuarine)	Mangrove lined estuaries, coastal creeks	Saltwater Ck[3]
Melanotaeniidae:				
Melanotaenia splendida	Eastern rainbowfish	Freshwater	Preference for small streams, but also found in wetland habitats and floodplains.	Saltwater Ck[1,3]
Atherinidae:				
Craterocephalus stercusmuscarum	Fly-specked hardyhead	Freshwater	Rivers, billabongs, streams and lakes, brackish estuaries	Saltwater Ck[3]
Poeciliidae:				
Gambusia holbrooki	Mosquito fish	Freshwater	Most common in slow-flowing waters near weed beds.	Saltwater Ck[3] Wetland basin[1]
Centropomidae:				
*Lates calcarifer**	Barramundi	Freshwater (Marine)	Coastal waters, estuaries, upper river reaches. Economically important.	Saltwater Creek[1, 2,3] Wetland basin[1]
Chandidae:				
Ambassis marianus	Estuary perchlet	Marine	Coastal rivers and embayments	Western estuary[3]
Ambassis agassizii	Agassiz's glassfish	Freshwater	More common in pools and reaches with high macrophyte growth. Some resilience to saline conditions.	Saltwater Creek[1, 2,3] Wetland basin[1]
Sparidae:				
*Acanthopagrus australis**	Yellow-finned bream	Marine	Intertidal creeks and embayments, coastal waters	Western estuary[3]
Terapontidae:				
Amniataba percoides	Barred grunter	Freshwater	Creeks, ponds, clear or turbid, from headwaters to estuaries.	Saltwater Creek[1]

Scientific Name	Common Name	Primary Habitat (spawning)	Habitat Requirements	Zone recorded
Amniataba caudavittata	Yellowtail trumpeter	Marine / Freshwater	Found in coastal marine waters, but also found in estuaries and freshwater sections of rivers	Wetland basin[1]
Leiopotherapon unicolor	Spangled perch	Freshwater	A tolerance for elevated salinity levels – though rarely found in estuaries. Prefers slow moving habitats and shallow pools. Frequently dominant species in intermittent rivers/creeks. Able to aestivate through droughts.	Saltwater Creek[1] Wetland basin[1, 2]
Terapon jarbua	Crescent perch	Marine / Freshwater	Common in sandy intertidal areas, occurs coastally in mangroves and freshwaters	Western estuary[2]
Sillaginidae				
*Sillago sihama**	Northern whiting	Marine	Intertidal creeks and embayments, coastal waters	Western estuary[3]
Lutjanidae:				
Lutjanus russelli *	Moses' perch	Marine / Freshwater	Marine fish. Juveniles often found in estuaries and lower reaches of streams.	Western estuary[2]
Gerreidae:				
Gerres filamentosus	Thread-finned silver biddy	Marine / Freshwater	Primarily marine species though will enter lakes and lower freshwater reaches of rivers.	Saltwater Creek[1] Wetland basin[1]
Gerres subfasciatus	Silver biddy	Marine	Occurs in coastal areas and marine dominated estuaries.	Hypersaline (pond) [1]
Haemulidae:				
Pomadasys argenteus	Spotted grunter	Marine / Freshwater	Occurs in coastal waters and is known to enter freshwater	Western estuary[1]
Scatophagidae:				
Scatophagus argus	Spotted scat	Marine / Freshwater	Found is lower reaches of freshwater streams and estuaries.	Saltwater Creek[1] Wetland basin[2]
Selenotoca multifasciata	Banded scat	Marine / Freshwater	Found in estuaries, mangrove creeks and lower reaches of freshwater streams.	Saltwater Creek[1] Wetland basin[2]
Mugilidae:				

Scientific Name	Common Name	Primary Habitat (spawning)	Habitat Requirements	Zone recorded
*Liza argentea**	Flat-tail mullet	Marine	Found in estuaries, mangrove creeks and lower reaches of freshwater streams.	Western wetland[3]
*Mugil cephalus**	Sea mullet	Freshwater (Marine)	Found from coastal areas to estuaries and freshwater reaches. Commercial species.	Saltwater Creek[1] Wetland basin[2] Bund[1] Western wetland[1,3]
Triacanthidae:				
Tripodichthys angustiformis	Tripodfish	Marine	Coastal creeks, embayments	Western wetland[1,3]
Eleotridae:				
Hypseleotris klunzingeri	Western carp gudgeon	Freshwater	Common around aquatic vegetation in lakes, dams & streams.	Saltwater Creek[1,3] Wetland basin[1]
Gobiidae:				
Periophthalmus argentilineatus	Common mudskipper	Marine	Intertidal flats, mangroves.	Western estuary[3]
Chlamydogobius ranunculus	Tadpole goby	Freshwater / Estuarine	Found in muddy creeks draining mangrove samphire plains or freshwater floodplains.	Wetland basin[1,3] Hypersaline pond[1]
Tetraodontidae:				
Arothron sp	Toadfish	Marine	Coastal areas / estuaries	Western estuary[1]
Tetractenos sp.	Toadfish	Marine	Coastal areas / estuaries	Western estuary[1]

(*) species of direct economic importance; Sources: 1 = BMT WBM (2012); 2 = GHD (2010); 3 = present study

4.2.4 Fisheries Values

Species of direct fisheries utility recorded in the Wetlands to date include:

- Long-finned eel (*Anguilla reinhardtii*) - Saltwater Creek
- Barramundi (*Lates calcarifer*) - recorded in all zones
- Sea mullet *(Mugil cephalus)* - recorded in all zones
- Flat-tail mullet (*Liza argentea*) - Western estuary
- Northern whiting (*Sillago sihama*) - Western estuary
- Yellow-finned bream (*Acanthopagrus australis*) - Western estuary
- Leatherjacket - Western estuary
- Moses perch (*Lutjanus russelli*) - Western estuary
- Mud crab (*Scylla serrata*) - Western estuary
- Penaeidae prawns (several species) - Western estuary.

These species have different life-history patterns and habitat preferences. The first four species (long finned eel, barramundi, sea mullet, flat-tail mullet) utilise both fresh and saltwater habitats to complete their life cycles (Allen 1989; Pusey *et al.* 2004). These species are catadromous, spawning in marine environments and spending the rest of their life-cycle in estuarine and freshwater environments (refer Table 4-2).

The remaining species do not typically occur in freshwater but spend part or all of their life cycle in estuaries. Species such as Moses perch (*Lutjanus russelli*) spends the majority of their adult life as a reef-associated species, whereas juveniles utilise coastal wetlands as nurseries. The remaining species listed above move offshore to spawn, and spend all or part of their life-cycle in estuaries.

The estuarine wetlands and coastal water zone downslope of the Western Bund provide high value habitats to commercially significant mud crab (*Scylla serrata*) and a variety of Penaeidae prawn species. In particular, the structurally complex mangrove-lined channels provide optimal habitat conditions for adult mud crab, as well a variety of prawns including the banana prawn (*Penaeus merguiensis*). These habitat values are discussed in Section 4.2.6.

4.2.5 Introduced Species

One introduced species has been recorded within the Wetlands, namely the eastern gambusia (*Gambusia holbrooki*). This species was recorded in low abundance by BMT WBM (2012) at one site within the wetland basin zone, and in high numbers within Saltwater Creek zone in the present study.

Eastern gambusia is declared a pest species under the *Fisheries Act 1994* and *Fisheries Regulation 1995*. This species aggressively competes with other fish species for habitat and food resources, and has been implicated in population declines of various small bodied fish species (Arthington 1996). While eastern gambusia can occur tolerate saline water, it generally prefers low salinity waterbodies that have low flows and high vegetation cover (Pusey *et al.* 2004), similar to habitat conditions within the Saltwater Creek zone.

It is likely that eastern gambusia represent a key pressure on native fish and frog assemblages within the Saltwater Creek zone. Eastern gambusia would disperse into the wetland basin zone during wet periods, and represent a pressure to native fish communities. The degree of persistence of eastern gambusia within the wetland basin zone will depend on rainfall patterns (i.e. non persistence during extended droughts, persist during wet periods). Saltwater Creek represents a dry season refugia for this species, although drying in the wetland basin zone will represent a key control on its abundance.

Several other introduced fish species occur in north Queensland coastal wetlands and represent a potential threat to the Wetlands. European carp and tilapia are declared pest species under the *Fisheries Act 1994* and *Fisheries Regulation 1995*, and are well established in numerous North Queensland waterways. Both species have similar habitat preferences and environmental tolerances as eastern gambusia, and both species can also have a significant adverse effect on native fish populations. The Saltwater Creek and wetland basin zones could provide favourable habitat for both species, particularly during extended wet periods.

4.2.6 Fish Biodiversity and Fisheries Habitat Values

When considering the fisheries and general biodiversity habitat value of an area, it is important to consider the spatial organisation of habitat patches and types (i.e. degree of fragmentation, connectivity), together with other attributes such structural complexity and size of habitat patches, and the degree of tidal inundation/flushing. Table 4-3 is a summary of the fisheries habitat and aquatic fauna biodiversity values of each zone within the Wetlands.

Coastal Water/Western Estuary ones

Extensive areas of high quality fisheries habitat occur in the western estuary and coastal water zones. This includes well-flushed mangals, tidal channels with undercut banks, and intertidal flats in the lower estuary and coastal water zone. The intertidal environments provide shelter and/or foraging areas for fish and shellfish during high tide. Subtidal habitats, which provide refugia during low tide, occur throughout this area. The habitats found here also represent potential breeding habitat for barramundi, bream and a range of other species, as well as nursery habitat for numerous estuarine and marine fish and shellfish (prawns, mud crabs) of economic significance.

Habitats in these sections of the Wetlands are in a largely undisturbed condition, and have a high degree of connectivity to wetlands and coastal areas outside the Wetlands. The Western Bund and Causeways would, however, limit connectivity to the Wetlands, which would impact on fisheries habitat values.

Hypersaline Zone

The hypersaline zone contains undisturbed saltpan habitat and impounded hypersaline waters within an area that once supported mangrove forest. Saltpan habitats are occasionally inundated during large spring tides and by floodwaters. Case-studies elsewhere demonstrate that saltpan and saltmarsh habitats provide important functional values from a fisheries perspective, particularly in its role as habitat for crustaceans that form the diet of economically significant species.

The impoundment behind the Western Bund is typically hypersaline (Section 3.2) with salinity well beyond the tolerance limits of most fish and commercially important shellfish species. A small number of species were recorded here in 2010, but in 2014 no fish or shellfish were recorded. The impoundment connects to the western wetland during large spring tides and floods, but is isolated from other areas for much of the year (due to the operation of the Western Bund and Causeway). This area is considered to have low fisheries habitat values in its current state.

Wetland Basin Zone

The wetland basin zone can provide habitat for small-bodied fish during dry periods when water levels are shallow. During 2014 when water levels were low (<0.3 m deep), only one species of goby was recorded in low abundance. During the 2010 survey when water levels were slightly higher (but still <0.4 m), and a larger number of species were recorded, all of which were small-bodied species. It would be expected that a greater number of species would occur here during floods due to: (i) higher water levels and larger waterbody size; and (ii) enhanced connectivity with other wetland areas.

The wetland areas within the area adjacent to the DMCP support fisheries habitat values that are representative of those in the wider wetland basin. The sedges, saltmarsh and areas of open water would provide habitat for fish during wet conditions, including potential feeding habitat for juvenile barramundi. However, it does not represent an especially important habitat from a fisheries perspective as a whole of wetland spatial scale.

Saltwater Creek Zone

Saltwater Creek provides high quality fisheries habitat, particularly for barramundi and eels. In this regard, Saltwater Creek represents a semi-permanent/permanent aquatic fauna refugia, forms part of a fish movement corridor, and contains a wide range of structurally complex micro-habitats that are in good condition. There are few current pressures on this creek, although it is possible at very low water levels during hot periods, dissolved oxygen concentrations could represent a stress to fish (Section 3.2.2).

Table 4-3 Fish biodiversity and fisheries habitat values

Attribute	Saltwater Creek	Wetland Basin	Hypersaline	Western Estuary	Coastal
Habitat diversity and condition	High micro-habitat complexity and diversity Good condition	Relatively simplified habitats, low diversity Good condition	Simplified degraded habitats, low diversity Poor condition (hypersaline, mangrove die-back)	High micro-habitat complexity and diversity Good condition	High micro-habitat complexity and diversity Good condition
High value fisheries habitat types	Creek channel and littoral margins, extensive macrophyte cover (year-round)	Sedges and saltmarsh provide habitat for small-bodied fish during wet and to a lesser extent dry periods	None - dead mangrove stumps	Creek channel and littoral margins, extensive mangrove and saltmarsh cover (year-round)	Creek mouth and sand bar and beach system provide high value fisheries habitats
Rare or unique natural/semi-natural aquatic habitat features	Large, permanent freshwater creeks are not well represented in bioregion	Lake Caley - semi-permanent saline lakes are not well represented in bioregion	None	None - broadly representative of estuarine wetland habitats found in surrounding region	None - broadly representative of estuarine wetland habitats found in surrounding region
Fish species of economic importance	Barramundi Long finned eel	Barramundi, long finned eels and possibly estuarine fish would be present during extended wet periods. Shallow water (or drying) limits values during dry periods, inc. Lake Caley	Flood periods - Possible temporary use by a range of species Non-flood periods - None known (some small fish present in 2010, but no fish in 2014)	Barramundi Numerous other species (mullet, whiting, bream etc.)	Numerous fish species (mullet, whiting, bream etc.)
Shellfish of economic importance	None	Limited values - low salinity during wet periods and lack of connectivity during dry periods significantly constrain values	Flood periods - Unlikely; prawns do typically move away from freshwaters Non-flood periods - Possible, but none known	Prawns (banana prawns) Mud crabs	Prawns (banana prawns) Mud crabs
Threatened fish or aquatic macroinvertebrate species	None known or likely	None known or likely	None known or likely	None known or likely	None known or likely
Water permanency and refugia value	Permanent/semi-permanent feature High refugia value	Lake Caley is a semi-permanent feature Shallow depth and high salinity during droughts limits its refugia value for fish	Ponded waters can provide refugia for small number of fish species that are tolerant of hypersaline conditions	Well flushed High refugia values (presence of subtidal channels)	Well flushed High refugia values (presence of subtidal channels and coastal waters)
Fish feeding habitat values	High values - abundant small-bodied fish (prey) year-round	Moderate values Abundant small-bodied fish (prey) likely to be present during wet periods Prey abundance low during dry season (1 species of goby recorded in Lake Caley in 2014 survey)	Low values - degraded condition, lack of connectivity limits values	High values - abundant small-bodied fish (prey) year-round	High values - abundant small-bodied fish (prey) year-round
Fish breeding or nursery habitat value	Important juvenile barramundi habitat Not an important breeding habitat for commercially significant species	Potential juvenile barramundi habitat during wet season Not an important breeding habitat for commercially significant species	None likely	Important nursery habitat for a wide range of estuarine and marine species, including barramundi	Important nursery habitat for a wide range of estuarine and marine species, including barramundi Likely breeding area for a range of species of fisheries value (bream)
Fish movement corridor	Connects Euri Creek/Don River to the Wetlands during flood periods Isolated from other areas during dry periods	Flood periods - movement corridor between Saltwater Creek and Western Estuary Low flow/zero flows - no connectivity due to shallow water depths and bunds	Forms an important corridor linking western estuary and wetland basin during floods Largely isolated from wetland basin during dry periods Partial connection to western estuary during high tides	Connects to wetland basin during floods Connects to coastal environments and wetland complex outside the Wetlands	Connects to coastal environments and wetland complex outside the Wetlands

4.3 Existing Condition and Resilience

4.3.1 Critical Controls on Wetland Condition

Hydrological processes fundamentally control aquatic flora fauna community structure within the Wetlands, most notably:

- Tidal flushing and inundation in the western estuary and coastal water zones - which maintain estuarine vegetation communities, water quality and connectivity
- Cyclic wetting and drying in the wetland basin - which controls salinity, maintains vegetation communities used by fish communities, and controls aquatic plant and animal populations. While wet periods provide favourable conditions for fish and aquatic macroinvertebrate communities, dry periods within the wetland basin result in:
  - A loss of fish and aquatic macroinvertebrate biomass
  - A reduction in area of available feeding, spawning and feeding habitat for native and introduced fish and many aquatic invertebrates
  - The control of populations of weeds and pest fish
  - The absence of connectivity between the wetland basin and other sections of the Wetlands.
- Semi-permanent freshwaters in the Saltwater Creek zone - which supports aquatic vegetation and fauna refugia values.

Key processes and their degree of modification are summarised in Table 4-4. The bunds represent the key pressure on existing fish communities within the Wetlands in the context of the following (BMT WBM 2012):

- Preventing movements of fish between the section of Mount Stuart Creek within the Western estuarine zone and the section of Mount Stuart Creek upstream of the Western Bund and the Causeway. Prior to installation of both bunds, Mount Stuart Creek would have represented the key fish movement corridor in the western half of the Wetlands. Branch Creek, the other main waterway in the western portion of the Wetlands, appears to only flow into the Wetlands during spring tides.
- The Causeway severely inhibits movements of fish between the western sections of the Wetlands and the wetland basin zone during now flood periods. A 300 mm diameter culvert may allow some fish movements, although its small size, together with the hypersaline character of waters running through this pipe, are likely to significantly restrict fish movements.
- Adversely impacting on water and sediment quality within the hypersaline zone and adjacent areas, and associated fish habitat values.

The conversion of the catchment to predominantly grazing land is also likely to have increased pollutant loads entering the Wetlands, and modified hydrology. Weeds and feral animals also represent key pressures on the Wetlands (BMT WBM 2012).

Table 4-4 Critical underlying processes affecting aquatic ecosystems in the Wetlands, and their condition

Process	Factor	Coastal zone	Western estuary	Hypersaline zone (unmod. saltpans)	Hypersaline zone (ponded waters)	Wetland basin	Saltwater Creek
Tidal flushing and inundation	Distribution/extent of wetland vegetation	Key control – good/mod condition	Key control – good/mod condition	Key control – good/mod condition	Key control – highly modified condition	Partial control – good/mod condition	Partial control – good/mod condition
	Salinity	Key control – good/mod condition	Key control – good/mod condition	Key control – good/mod condition	Key control – highly modified condition	Partial control – good/mod condition	Partial control – good/mod condition
	Other water quality conditions	Key control – good/mod condition	Key control – good/mod condition	Key control – good/mod condition	Key control – highly modified condition	Partial control – good/mod condition	Partial control – good/mod condition
	Aquatic habitat availability (water levels)	Key control – good/mod condition	Key control – good/mod condition	Key control – good/mod condition	Key control – highly modified condition	Partial control – good/mod condition	Partial control – good/mod condition
	Connectivity between habitats	Partial control – modified condition	Partial control – modified condition	Partial control – modified condition	Key control – highly modified condition	Partial control – modified condition	Partial control – modified condition
Catchment runoff and groundwater	Distribution/extent of wetland vegetation	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – modified condition	Key control – good/mod condition	Key control – good/mod condition
	Salinity	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – modified condition	Key control – good/mod condition	Key control – good/mod condition
	Other water quality conditions	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – modified condition	Key control – good/mod condition	Key control – good/mod condition
	Aquatic habitat availability (water levels)	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – good/mod condition	Key control – highly modified condition	Key control – good/mod condition	Key control – good/mod condition
	Connectivity between habitats	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – good/mod condition	Key control – highly modified condition	Partial control – modified condition	Partial control – modified condition
Catchment clearing and land uses	Pollutant inputs	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – modified condition	Key control – highly modified condition	Partial control – modified condition
	Altered hydrology	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – good/mod condition	Partial control – modified condition	Partial control – modified condition	Partial control – modified condition
	Weeds/feral animals	Partial control – modified condition	Partial control – good/mod condition	Partial control – modified condition	Partial control – modified condition	Partial control – modified condition	Partial control – modified condition

Key control – good/mod condition
Key control – highly modified condition
Partial control – good/mod condition
Partial control – modified condition

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4.3.2 Resilience and Resistance to Hydrological and Water Quality Changes

As described above, the aquatic vegetation and fauna communities in the Wetlands are under pressure from a range of stressors, most notably changes to hydrology, habitat connectivity and water quality due to bund operation. These changes to ecosystem processes affect the resistance and resilience of aquatic ecosystems to cope with additional changes.

Different wetland components differ in their sensitivity to disturbance (i.e. resistance) and capacity to recover following disturbance (i.e. resilience). The degree of resistance and resilience also differs depending on the disturbance type, and the spatial and temporal scales at which the process is operating. Key processes controlling resilience and resistance include the following:

- Tidal inundation in the western estuarine and hyper-saline zone – tidally influenced sections of the Wetlands experience highly variable water levels across a range of temporal scales. Aquatic vegetation and fauna therefore need to be tolerant of variable water levels, however long term changes outside natural variability will lead to changes in the structure, distribution and extent of aquatic communities. Therefore, communities here have low resistance and resilience to longer term changes.
- Changes to water levels in the wetland basin and Saltwater Creek – water levels in the wetland basin show great variability over multiple temporal scales (i.e. monthly, seasonal, inter-annual) in response to temporal patterns in rainfall. These patterns are not consistent within seasons, years or decadal time-scales. Aquatic vegetation and fauna species therefore must have adaptations to allow for this variability, including:
    - Resistance - adaptations to resist changes associated with wetting and drying cycles, as displayed by most wetland vegetation species. Aquatic fauna cannot cope with drying and therefore have low resistance.
    - Resilience - adaptations that allow rapid recovery, including high reproductive output (e.g. many zooplankton, benthic invertebrates and fish, as well as aquatic vegetation), rapid growth rates, the production of long lived seeds that can live in sediments for many years, and the ability to rapidly move to new habitats (i.e. most fish and many invertebrates).
- Changes to salinity – salinity within the wetland basin and to a lesser extent Saltwater Creek shows great variability, whereas other habitats show little variation except during flood events. Most vegetation species that are inundated for long periods of time (e.g. sedgeland species such as club rush) therefore have adaptations that allow high variability in salinity conditions, including the ability to persist in near marine salinity conditions. Salt couch by contrast is intolerant of high salinity conditions (or regular inundation), as described in Section 4.1.5.1. All fish species recorded in the Wetlands to date are euryhaline species that are tolerant of full marine salinities, and therefore have high resistance and resilience (see section 4.2.2).

Table 4-5 Resistance and resilience of key aquatic species groups

Component	Resistance				Resilience
	Desiccation and waterlogging	Variable salinity	Low salinity (freshwater/brackish)	High salinity (near seawater)	Re-colonisation
Aquatic vegetation (within regularly wetted areas of wetlands) – sedgelands and samphire	• High tolerance, but requires regular wetting and drying)	• High tolerance	• High tolerance	• Moderate tolerance	• High resilience – ability to rapidly colonise new areas through vegetated growth seeds banks etc.
Aquatic vegetation (within irregularly wetted areas of wetlands) – saltcouch and samphire	• Moderate tolerance – requires infrequent wetting and more frequent drying	• Low to moderate tolerance	• Moderate to high tolerance (optimal between 6-9 ppt)	• Low tolerance – can tolerate full marine salinity in short term, but prefers salinity <9 ppt	• High resilience – ability to rapidly colonise new areas through vegetated growth seeds banks etc.
Aquatic invertebrates (zooplankton)	• Low tolerance, except hyporheos (many worms, crustaceans, insect larvae) and burrowing species (e.g. crabs)	• Possible high tolerance for many , except perhaps assemblages at Saltwater Creek	• Low (marine species in western wetland, such as mud crabs) • High tolerance (estuarine and freshwater species found in wetland basin and Saltwater Creek)	• Low tolerance (freshwater spp found in Saltwater Creek) • High tolerance (estuarine/marine species found in all zones except Saltwater Creek)	• High – ability to rapidly colonise new areas through dispersal, migration from hyporheos, high growth rates, high reproductive rates etc.
Fish	• No tolerance to drying	• High tolerance, except at Saltwater Creek	• Low (marine species in western wetland, such as mud crabs) • High tolerance (estuarine and freshwater species found in wetland basin and Saltwater Creek)	• Low tolerance (freshwater spp found in Saltwater Creek) • High tolerance (estuarine/marine species found in all zones except Saltwater Creek)	• High – ability to rapidly colonise new areas through dispersal, migration from other areas during wet season, high growth rates, high reproductive rates etc.

- Modifications to habitat connectivity and fragmentation - fragmentation due to bund operation has substantially altered fish, aquatic invertebrates and aquatic vegetation communities within Wetlands. Further significant alterations to connectivity among habitat types is expected to result in further cascading effects to aquatic communities, depending on the magnitude, frequency and duration of disturbance. Aquatic fauna species have low resistance to change in the degree of habitat connectivity and fragmentation, but are expected to rapidly recover (i.e. high resilience) once connectivity is restored (i.e. as occurs every wet and dry season).

4.4 Matters of National Environmental Significance

4.4.1 General

A search for Matters of National Environmental Significance (MNES) using the Department of the Environment (DoE) protected matters search tool was conducted (Appendix A). Features of MNES identified by this search were the GBRWHA, GBRNHP, and GBRMP. The search also identified one threatened ecological community, 29 threatened species, and 30 migratory species.

As described in Section 4.2.3, no threatened fish or invertebrates are known or expected to occur in the Wetlands. Furthermore, no threatened aquatic vegetation or communities are known to occur in the Wetlands (see Sections 4.1.4 and 4.2.3). A number of marine mammals and reptiles are known or likely to occur in the western and/or the coastal sections of the Wetlands, but not within the wetland basin. These are described in the Marine Ecological Assessment.

4.4.2 Great Barrier Reef World Heritage Area, Natural Heritage Place and Marine Park

The GBRWHA, GBRNHP and GBRMP are all located in coastal waters immediately adjacent to Caley Valley Wetlands. Most streams in the Caley Valley Wetlands catchment ultimately discharge into Curlewis Bay. Curlewis Bay GBRWHA, GBRNHP and GBRMP (General Use Zone) occurs in waters directly below mean low water.

The GBRWHA extends from the low water mark on the Queensland coast to past the edge of the continental shelf, and from the tip of Cape York Peninsula to just north of Fraser Island. It includes mangroves, rocky reefs, sandflats, open ocean and the deep sea floor. GBRWHA, like other Australian World Heritage Properties, is listed as a MNES under sections 12 and 15A of the EPBC Act. The Great Barrier Reef is also listed as a Natural Heritage Place, which is listed as a MNES under sections 15B and 15C of the EPBC Act.

The GBRWHA was listed in 1981 on the basis of meeting a range of criteria, including all four natural criteria at the time of its listing:

- An outstanding example representing the major stages of the earth's evolutionary history.
- An outstanding example representing significant ongoing geological processes, biological evolution, and man's interaction with his natural environment.
- Contain unique, rare or superlative natural phenomena, formations, or features or areas of exceptional natural beauty, such as superlative examples of the most important ecosystems to man.

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- Provide habitats where populations of rare or endangered species of plants and animals still survive.

The GBRWHA extends to mean low water and is also listed on the Register of the National Estate. The GBRWHA in the Abbot Point area are mapped in Figure 4-11. Both of these MNES share the same boundaries and values. The GBRWHA occur along the Abbot Point coastline, and are represented in the far western section of the Wetlands, including within Mount Stuart Creek and Branch Creek.

The GBRWHA listing document identifies specific examples of values/attributes underpinning each criteria. With few exceptions, the examples of values/attributes identified in the GBRWHA listing document are not location specific, and therefore do not specifically define marine ecological values/assets supported at a local scale.

As part of the Abbot Point Cumulative Impact Assessment, an analysis was conducted to identify attributes of the GBRWHA expressed in the Abbot Point area (ELA & OpenLines 2012a). This analysis identified three natural heritage attributes represented at the Abbot Point area. These correspond to two of the four natural heritage criteria of the World Heritage Guidelines (UNESCO 2012) that the GBRWHA is listed against. Attributes as they relate to Abbot Point are presented in Table 4-6. All of aquatic ecological features are relevant to the coastal and possibly the western wetland zone, and are not relevant to the wetland basin or other zones. Other natural heritage attributes were also recognised at Abbot Point, though not present at a scale or value relevant to the GBRWHA as a whole. These include marine turtles and mangroves which would only be represented in the coastal section of the Wetlands.

Table 4-6 Natural heritage attributes of GBRWHA represented at Abbot Point. Underlined features are aquatic ecological features represented in the coastal sections of the Wetlands

Attribute	Description
Aesthetics	Aesthetic attributes relate to Criterion 7[3] of the Guidelines. Under this criterion, aesthetic attributes represented at Abbot Point include: • Roosting and feeding habitat for resident and migratory shorebirds. • Migrating whales, <u>dolphins</u>, dugong, <u>sea turtles</u> and seabirds. Neither of these attributes is outstanding *per se* or uniquely expressed in the Abbot Point area but both are represented in a way that contributes to overall GBRWHA scenic diversity.
Marine mammals	Two criteria (7 and 10) relate to the presence of marine mammals as a natural heritage attribute in the Abbot Point area. Attributes in the Abbot Point area reflecting these criteria are: • <u>Natural habitats for *in-situ* conservation of inshore dolphin species (i.e. snubfin and Indo-Pacific humpback dolphins) and dugongs (Criterion 10).</u> • <u>Transitory area for migrating humpback whales (Criterion 7).</u>

[3] Criterion 7: contain superlative natural phenomena or areas of exceptional beauty and aesthetic importance.

LEGEND

- Great Barrier Reef World Heritage Area
- Great Barrier Reef National Heritage Property
- Proposed Dredged Material Containment Ponds (DMCP)

Title:
GBRWHA and GBR National Heritage Property at Abbot Point Area

Figure: 4-11

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0km 0.75 1.5

Approx. Scale

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Filepath : I:\B21434_I_GML_Abbot_Point_Gateway_LBL\DRG\ECO_012_150707_GBRWHA.wor

In addition to individual biological components, the listing criteria also refer to the values provided by the GBRWHA in terms of interactions among habitats and species, and underpinning physical, chemical and biological processes. These processes include for example climatic, physical coastal processes, hydrology, water quality and energy and nutrient dynamics, and provide ecosystems services to the GBRWHA. Ecosystem services provided by the Wetlands that support the Outstanding Universal Value (OUV) of the GBRWHA are described in Section 4.4.3.

4.4.3 Ecosystem Services Provided by the Wetlands to MNES

Caley Valley Wetlands provides a range of ecosystems services at a local (wetland specific) scale, some of which are relevant to supporting the OUV of the GBRWHA. These are discussed below in the context of the following types of ecosystem services (Millennium Ecosystem Assessment 2005):

- Provisioning services – products obtained from ecosystems
- Regulating services – benefits obtained from regulation of ecosystem services
- Cultural services – nonmaterial benefits obtained from ecosystems
- Supporting services – services necessary for the production of all other ecosystem services.

The Reef 2050 Long-Term Sustainability Plan acknowledges the contribution of wetlands to maintaining the resilience and ecosystem health of the .The ecological importance of wetlands is acknowledged in the GBRWHA (Commonwealth of Australia, 2015).

4.4.3.1 Provisioning Services

Provisioning services are direct products provided by the ecosystem, such as fisheries resources. While the Wetlands is not an important area for fishing, it provides a range of fisheries habitat values that are discussed in Sections 4.2.4 and 4.2.6. In particular, the western section of wetlands provides good quality habitat for mud crabs, barramundi and a range of other fish species, and Saltwater Creek provides habitat for barramundi. While the wetland basin does not support high quality fish habitat, this zone would provide linkages (albeit adversely affected by bunds) between Saltwater Creek and the GBRWHA during floods. The Wetlands, like other coastal wetlands in the Great Barrier Reef region, therefore contributes to the fisheries productivity within the GBRWHA.

As the Wetlands and surrounds are relatively inaccessible to the public, the Wetlands provide a buffer for the Abbot Point Coal Terminal and port facilities. DEH (2006) suggests that the security of this international port facility is partly dependent on maintenance of uninhabited wetland areas around its perimeter.

The Wetlands are saline and therefore do not provide a source of freshwater for human uses.

4.4.3.2 Regulating Services

Wetlands can provide a range of regulating services, including climate regulation (i.e. precipitation, temperature etc.), hydrological regimes (groundwater and surface water), pollutant control, erosion control and protection against natural hazards. Table 4-7 is a list of ecosystem services supported by different ecosystem types within the Great Barrier Reef and its catchment, most of which can be broadly considered regulating services.

Coastal wetlands such as the Wetlands provide important roles in the context of trapping and processing of catchment pollutants, particularly sediments and nutrients, as well as floodwaters. The catchments draining into the Wetlands primarily consist of grazing lands, and therefore potentially represent a locally significant source of pollutants to the GBRWHA. Shallow sections of the wetland basin also contain extensive areas of microalgae mats, which would trap and process nutrients (BMT WBM 2011). These processes are especially important given the significant water quality stress on coastal ecosystems in the GBRWHA due to catchment derived inputs of pollutants.

The Wetlands natural detention of flood waters from its numerous small coastal streams. The role of the Wetlands in the protection of port facilities and infrastructure has not been examined to date.

4.4.3.3 Cultural Services

The Millennium Ecosystem Assessment (Sarukhán and Whyte 2005) defined cultural ecosystem services as “the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences”. This can include for example, recreational (non-financial), aesthetic, cognitive/scientific research, cultural heritage and iconic values of the Wetlands.

The Wetlands are mostly located within the Abbot Point State Development Area, and are therefore largely inaccessible to the public. The most accessible part of the Wetlands to the public is the bridge on the port access road which crosses Saltwater Creek. Firearm shells/pellets were observed during BMT WBM surveys in 2011 and 2014, which may be evidence of illegal hunting or feral control programs conducted in the Wetlands (BMT WBM 2012; pers. obs. 2015). The level of unauthorised usage of the Wetlands is not known, but is not expected to be particularly high. Traditional owners also use the Wetlands and surrounds, which is outside the scope of the present assessment but is considered in the cultural heritage report.

Recreation and tourism are not recognised as values supported by the Wetlands. The Wetlands are not promoted on the Tourism Bowen website as an area of interest for tourists. Although the Wetlands serve as important roosting and foraging ground for a wide range of bird species, it is not known to represent a key bird watching area. Similarly, while several charter fishing boats operate out of Bowen, the Wetlands are not known to represent an important fishing area for these operators (BMT WBM 2012).

Due to their inaccessibility, the Wetlands therefore have limited direct (non-traditional owner related) cultural and provisioning service values. The Wetlands do, however, provide existence values to the community. Existence value is the non-use value that people place on simply knowing that something exists, even if they will never see it or use it. While the Wetlands are largely inaccessible to the public, consultation undertaken by BMT WBM (2012) found that community members were aware of the Wetlands and their values, and were particularly concerned about the effects of future development on these values.

4.4.3.4 Supporting Services

Supporting services are those that underpin the other ecosystem services. Table 4-7 shows ecologically-based supporting services relevant to coastal ecosystem types in the Great Barrier Reef region (GBRMPA 2014). The table lists ecosystem services in coastal ecosystem types found within and adjacent to the Wetlands.

The supporting services[4] provided by the Wetlands that are considered particularly important in the context of linkages with the GBRWHA are:

- Detention of catchment flows prior to discharge into the GBRWHA – this underpins many critical functions, including retention of catchments sediment and nutrients, controlling salinity in the coastal zone, and provision of habitat for aquatic and wetland dependent terrestrial species (including waterbirds). The large volume provided by the wetland basin is considered especially important in this context.
- Nutrient cycling and ecosystem productivity – biogeochemical processes within the Wetlands regulates cycling of nutrients and the flow of nutrients into the GBRWHA. Nutrient trapping and cycling will vary spatially and temporally. Western estuary zone and the perennial Saltwater Creek supports ecosystem components that are important to regulating nutrient cycling processes (i.e. mangrove vegetation, micro and macroinvertebrates, aquatic macrophytes, extensive microbial communities). During periods of inundation, microbial, microalgae and benthic communities in the wetland basin will also be important regulators of nutrient cycling and conversion processes.
- Habitat provisioning – As discussed in previous sections, the Wetlands support a range of aquatic species that also inhabit the GBRWHA. In particular, catadromous species such as barramundi, mullet and Anguillidae eels reside in most zones of the Wetlands, whereas a range of marine/estuarine fish and shellfish species also use the mangrove forests in the western portions of the Wetlands (Section 4.2.4). The wetlands therefore provide a locally important fish habitat provisioning service to the GRBWHA.
- Connection of ecosystems and pathway for fish migration – refer to habitat provisioning above and Section 4.4.3.1.
- Ecosystem health and resilience. All of the above ecosystem services together contribute to the maintenance of ecosystem health and resilience of the GBRWHA.

[4] These supporting ecosystem services are also considered regulating and provisioning services.

Table 4-7 Ecological processes of natural and modified coastal ecosystems relevant to Caley Valley Wetlands and immediate surrounds that are linked to the health and resilience of the Great Barrier Reef (modified after GBRMPA 2012)

Process	Ecological Service	GBRMPA (2012) assessment of relative important to GBR (not location specific)				Caley Valley Wetlands
		Estuaries	Freshwater wetlands	Grass and sedgelands	Woodlands	
Physical processes - transport and mobilisation						
Recharge/discharge	Detains water	MH	H			✓
	Flood mitigation	M	✓	L		
	Connects ecosystems	✓	H			✓
	Regulates water flow (groundwater, overland flows)	MH	H	L	MH	✓
Sedimentation/ erosion	Traps sediment	H	H	L	MH	✓
	Stabilises sediment from erosion	✓	✓	L	MH	
	Assimilates sediment	✓	H		MH	✓
	Is a source of sediment		M		MH	
Deposition and mobilisation processes	Particulate deposition & transport (sed/nutr/chem. etc)		H			✓
	Material deposition & transport (debris, DOM, rock etc)		H			✓
	Transports material for coastal processes		H			✓
Biogeochemical Processes – energy and nutrient dynamics						
Production	Primary production	H	H		M	✓
	Secondary production	H	✓			✓
Nutrient cycling (N, P)	Detains water, regulates flow of nutrients		H			
	Source of (N,P)	H			M	✓
	Cycles and uptakes nutrients	H	MH	✓		✓
	Regulates nutrient supply to the reef	H	M		M	✓
Carbon cycling	Carbon source	H	H			✓
	Sequesters carbon	H	H			✓
	Cycles carbon	H			H	✓
Decomposition	Source of Dissolved Organic Matter	H	H			✓
Oxidation-reduction	Biochar source				H	
	Oxygenates water	✓				✓
	Oxygenates sediments	✓				✓
Regulation processes	pH regulation		H			✓
	PASS management	H	H			✓
	Salinity regulation					✓
	Hardness regulation		H			
	Regulates temperature	✓	✓			✓
Chemicals/heavy metal modification	Biogeochemically modifies chemicals/heavy metals	✓	H			✓
	Flocculates heavy metals	✓	H			✓
Biological processes (processes that maintain animal/plant populations)						
Survival/reproduction	Habitat/refugia for aquatic species with reef connections	H	H			✓
	Habitat for terrestrial spp with connections to the reef		H			✓
	Food source	✓	✓			✓
	Habitat for ecologically important animals	H		✓		✓
Dispersal/ migration/ regeneration	Replenishment of ecosystems – colonisation (source/sink)	H	H			✓
	Pathway for migratory fish		H			✓
Recruitment	Habitat contributes significantly to recruitment	H	H			✓

H = high, M = Medium, L = Low, tick = supported

5 Impact Assessment Approach

5.1 Modelling Methodology

5.1.1 Scope and Objectives

To inform the qualitative assessment of potential impacts, a two dimensional computer model was developed and configured to assess relative changes to wetland hydrodynamics (i.e. water level/depth, inundation extents and salinity) between existing site conditions and with the operation of the proposed DMCP as described in Section 2.5.

Model scenarios (refer to Section 5.1.4) were prepared to simulate the movement (hydrodynamics) and mixing (advection-dispersion) between tidal saltwater, freshwater catchment runoff and groundwater for a base case (existing wetland condition) and a realistic and worst case representation of DMCP operation during a dry year (2001), typical year (2012) and wet year (2011). The modelling assessment is focussed on the potential impact of recharge to the underlying aquifer as a consequence of the proposed dredge and DMCP operations.

The hydrodynamic computer model includes continuous coverage of the Wetlands. The spatial resolution of model geometry was adjusted to represent the important flow connections and expected inundation patterns (i.e. wetting and drying) as best as possible. The effects of hydraulic controls (e.g. causeway culvert) and ground controls (e.g. Western Bund and Causeway) were included as part of the definition of model geometry and hydraulic structure configuration.

Predicted tides were used to force hydrodynamic conditions (i.e. water level, discharge) and advection/dispersion processes (i.e. temperature and salinity) at the ocean boundary of the model. Freshwater inputs from contributing upstream subcatchments draining to the Wetlands are included using estimates obtained from the catchment model (Source for Catchments) and a daily rainfall runoff model (SIMHYD).

Further details of the computer model(s) used for the study are provided in the following sections.

5.1.2 Model Selection

5.1.2.1 Hydrodynamic Model (TUFLOW-FV)

The computer model of the Wetlands was prepared using the modelling software TUFLOW-FV (a flexible mesh finite volume numerical model capable of simulating hydrodynamic, sediment transport and water quality processes in oceans, coastal waters, estuaries and rivers).

The finite volume numerical scheme solves the conservative integral form of the non-linear shallow water equations (NLSWE). The scheme can also simulate advection and dispersion of multiple scalar constituents. The equations can be solved in 2D (vertically averaged) and 3D, and both 1st and 2nd order solution schemes are available. The solution scheme is explicit and uses a varying Courant dependent timestep. Bed friction is modelled using a Manning's roughness formulation.

The spatial domain (or study area extent) is discretised using contiguous, non-overlapping irregular triangular and quadrilateral "cells". The flexible mesh approach has significant benefits when applied to study areas involving complex coastlines and embayments, varying bathymetries and sharply varying flow and scalar concentration gradients.

TUFLOW-FV accommodates a wide variety of boundary conditions, including water level, flow and atmospheric boundaries which are necessary to represent key hydrologic and hydraulic processes in the wetland. The assumption of a well-mixed water body can be adequately represented by the two-dimensional hydrodynamic model. The three dimensional processes driven by salinity and / or thermal stratification are not significant issues for this study, even though they might occur from time to time.

Tidal flushing and water quality are influenced by currents generated from a combination of tides and fluvial processes and have been identified as the primary drivers influencing the issues of concern for the Wetlands. For the present study, salinity was used as an indicator of potential water quality impact within the wetland. A passive tracer was also used to simulate salinity above background for a highly unlikely 'worst case' scenario.

5.1.2.2 Catchment Model (Source for Catchments)

For this study, the eWater Source Modelling Framework (herein referred to as Source) (http://www.ewater.com.au/products/ewater-source/) was used to simulate the rainfall-runoff processes occurring in the Caley Valley Wetland catchment.

Source is an application that can be used for both catchment and river modelling. Source provides a flexible structure that allows selection of a level of model complexity appropriate to the problem at hand and within any constraints imposed by available data and knowledge. Users can construct models by selecting and linking component models from a range of available options (Delgado *et al.* 2012).

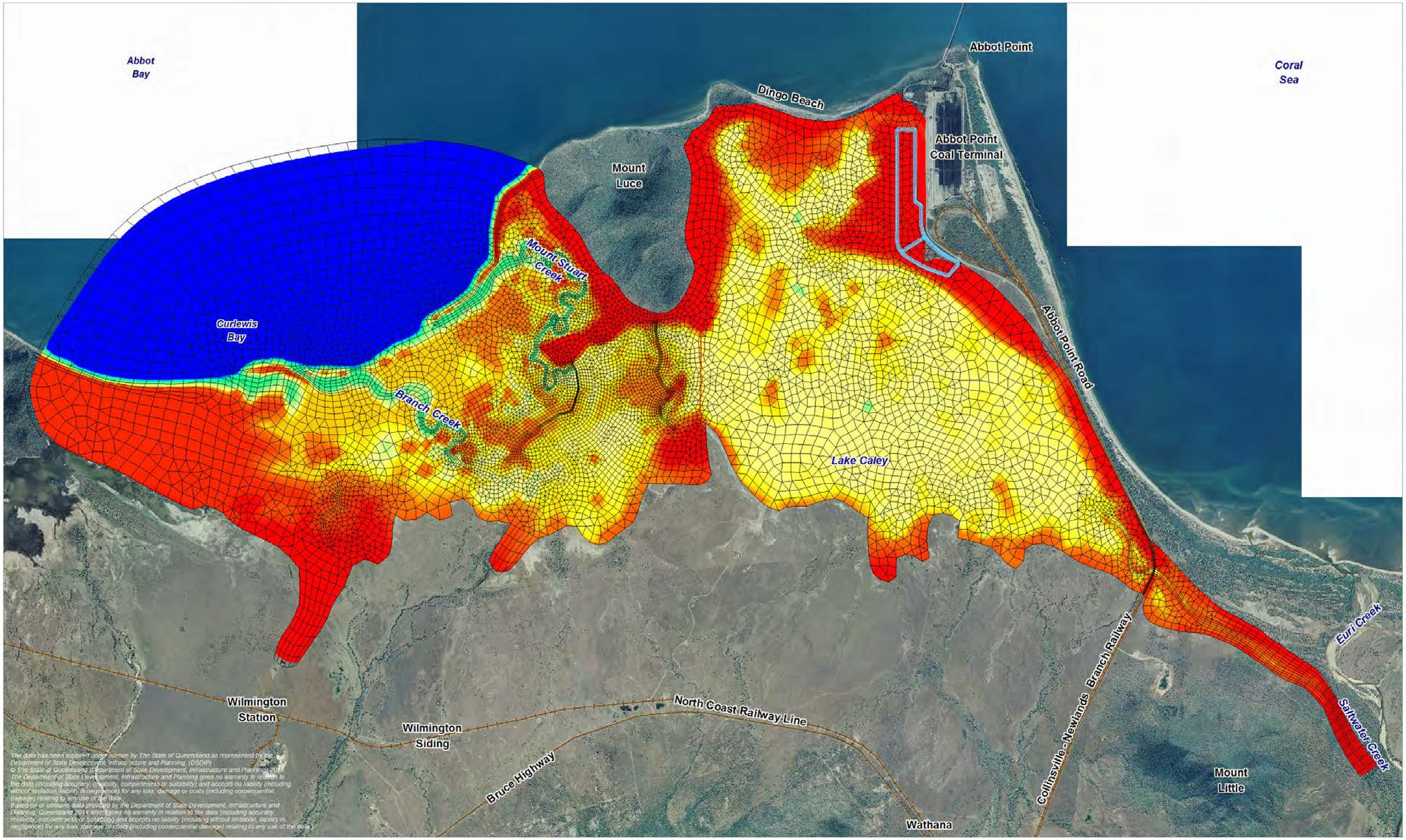
Source integrates an array of models, data and knowledge that can be used to simulate how climate and catchment variables (rainfall, evaporation, land use, vegetation) affect runoff, sediment and contaminants. The output can be used to offer scenarios and options for making improvements in a catchment. Source also features a wide range of data pre-processing and analysis functions that allows users to create and compare multiple scenarios, assess the consequences, and report on the findings.

5.1.3 Model Development

5.1.3.1 TUFLOW-FV

Model Extents

The computer model includes the tidal prism of the estuarine wetland downstream of the Western Bund, the palustrine wetland upstream of the Causeway, and the hypersaline/saltpan area between. The model extents are shown in Figure 5-1.



LEGEND

Model Mesh

Proposed Dredged Material Containment Ponds (DMCP)

<-1.50 | -1.00 | -0.50 | 0.00 | 0.50 | 1.00 | 1.50 | 2.00 | 2.50 | >3.00

Elevation (mAHD)

Road

Railway

Title:

TUFLOW-FV Model Extent and Geometry, and Digital Elevation Model

Figure **5-1**

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BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Bathymetry

Bathymetric data are required to describe the topography of the waterway over the domain of a numerical model. Substantial effort was made to develop a Digital Elevation Model (DEM) that includes the key topographical features and ground controls (e.g. open channels, levee banks, road embankments, culverts). The primary source of data used by the model was the 2009 LiDAR (raw dataset) provided by WorleyParsons. These data were processed by BMT WBM to provide a continuous high resolution DEM of the Wetlands and immediate surrounds.

An assumed bathymetry that extends offshore to a depth of -15 m AHD near the ocean boundary of the model was adopted. For areas in the north-western corner of the Wetlands, LiDAR coverage was not available. Consequently, inspection of another coarser ground elevation dataset (1 second or 30 metre) Australia wide SRTM 'bare-earth' hydrologically enforced DEM (Gallant *et al*., 2011) was undertaken to approximate wetland elevations for that area. Based on preliminary work, this portion of the Wetlands is elevated (typically 2.5 m AHD and above) compared to the intertidal areas within the GBRWHA which are the focus of the current assessment. Other bathymetric features including entrance shoals, channel entrances and major tidal creeks (i.e. Mount Stuart Creek and Branch Creek) were approximated based on available aerial photography and professional judgement. The above features were merged with available LiDAR data for the Abbot Point area. Some further improvements to the DEM were undertaken by BMT WBM using a multi-direction Lee filter to remove localised noise caused by dense vegetation present throughout the wetland.

The final composite DEM was used to assign bed elevations within the existing scenario model and is shown in Figure 5-1.

Model Geometry and Extent

The model geometry consists of nodes interconnected by a series of triangular and quadrilateral elements to form a two-dimensional mesh of the Abbot Point area. The model mesh focuses on providing a suitable representation of the primary wetland storage areas by using increased mesh resolution where abrupt changes to bathymetry occur, such as at channel edges and around significant ground controls such as the Western Bund and the Causeway. This resolution flexibility is a major advantage of using a flexible mesh model such as TUFLOW-FV.

The computer model includes the tidal prism of the estuarine wetland downstream of the Western Bund, the palustrine wetland upstream of the Causeway, and the hypersaline/saltpan area between. The geometry and extent of the model prepared for the current study is shown in Figure 5-1.

Model Configuration

The model accounts for dynamics in response to water level variations caused by ocean tides, meteorological conditions, local catchment runoff and groundwater. The model was used in 2D mode, i.e. model variables are depth averaged. The influence of the Coriolis force was calculated using a latitude of -19.9°S.

Water temperature and salinity were modelled as density coupled transport scalars. The scalar mixing model adopted was the Smagorinsky model which calculates the non-isotropic diffusivity using a global horizontal scalar diffusivity of 0.2m^2/s. The Smagorinsky momentum mixing model was adopted with a coefficient of 0.2 m^2/s. TUFLOW-FV has an adaptive time-step algorithm which automatically adjusts the model time-step to resolve hydrodynamic and advection dispersion processes based on Courant-Friedrichs-Lewy (CFL) values of 0.95 for both the internal and external stability constraints. This resulted in a typical time-step of between 1 and 2 seconds being applied during the model simulations.

TUFLOW-FV accounts for wetting and drying dynamically based of specified cell depths of 0.005 m and 0.05 m respectively. The drying value corresponds to a minimum depth below which the cell is dropped from computations (subject to the status of surrounding cells). The wet value corresponds to a minimum depth below which cell momentum is set to zero, in order to avoid unrealistic velocities at very low depths.

Bottom drag or bed roughness is specified as a Manning's n roughness, which is standard for many two-dimensional numerical models. The model was configured with two surface types, namely ocean/tidal channels and generic wetland adopting roughness values of 0.025 and 0.050 respectively. Model cells contained within the footprint of the proposed DMCP were inactivated (removed from the calculations) for simulation of the proposed site condition.

Boundary Conditions

The model adopts a water level boundary to simulate ocean tides based on tide predictions at Bowen. Salinity at the ocean boundary was assumed to be constant throughout the simulation adopting values of 35 ppt. Ocean water temperature variations were modelled by adopting long term average monthly sea surface water temperatures for Bowen which varies between 22.8°C and 28.8°C.

Catchment runoff was applied to the model (using the cell inflow option available to TUFLOW-FV) at major inflow locations corresponding to the outlet of local subcatchments. The salinity and water temperature of all catchment inflows was assumed to be 0.5 ppt and 20°C respectively.

An estimate of groundwater salinity ranging between 5 ppt and 20 ppt was assigned to the wetland model based on groundwater datasets provided by Australasian Groundwater & Environmental (AGE) Consultants. A notional water temperature of 18°C was adopted for all groundwater inflow. For relative assessment purposes, groundwater salinity and temperature was assumed to be unchanged between the existing (without the DMCP) and proposed development (with the DMCP) scenarios.

Atmospheric (surface) heat exchange calculations were included using standard meteorological parameter inputs (i.e. air temperature, windspeed, relative humidity, direct short wave radiation, direct long wave radiation and rainfall) available from the National Centre for Environmental Prediction (NCEP) database.

Model Calibration

A calibration of the TUFLOW-FV model was not possible, given the lack of data on existing hydrodynamic characteristics of the wetland system. The principal factor that typically controls hydrodynamics of shallow receiving water environments, like the Caley Valley Wetlands, is the adopted model bathymetry. Therefore, considerable effort has been made to use the LiDAR data that was available for this investigation, to ensure the bathymetry was as accurate as possible. Notwithstanding, the results of this modelling of the wetland still need to be considered with a degree of uncertainty, but for the purpose of impact assessment are considered suitable. Refer to Section 5.1.3.4 for a description of model assumptions and limitations.

5.1.3.2 Source for Catchments

The Source model is based on the following:

- Sub-catchments: The sub-catchment is the basic spatial unit, which is then divided into hydrological response units (or functional units) based on a common response or behaviour such as land use. Within each functional unit, three models can be assigned: a rainfall-runoff model, a constituent generation model and a filter model.
- Nodes: Nodes represent sub-catchment outlet, stream confluences or other places of interest such as stream gauges or dam walls. Nodes are connected by links, forming a representation of the stream network.
- Links: Links represent the river reaches. Within each link, a selection of models can be applied to route or delay the movement of water along the link; or modify the contaminant loads due to processes occurring within the links, such as decay of a particular constituent over time.

The Source (hydrological) model was configured to estimate the quantity of surface runoff generated by the major subcatchments draining to the Wetlands for current land use conditions.

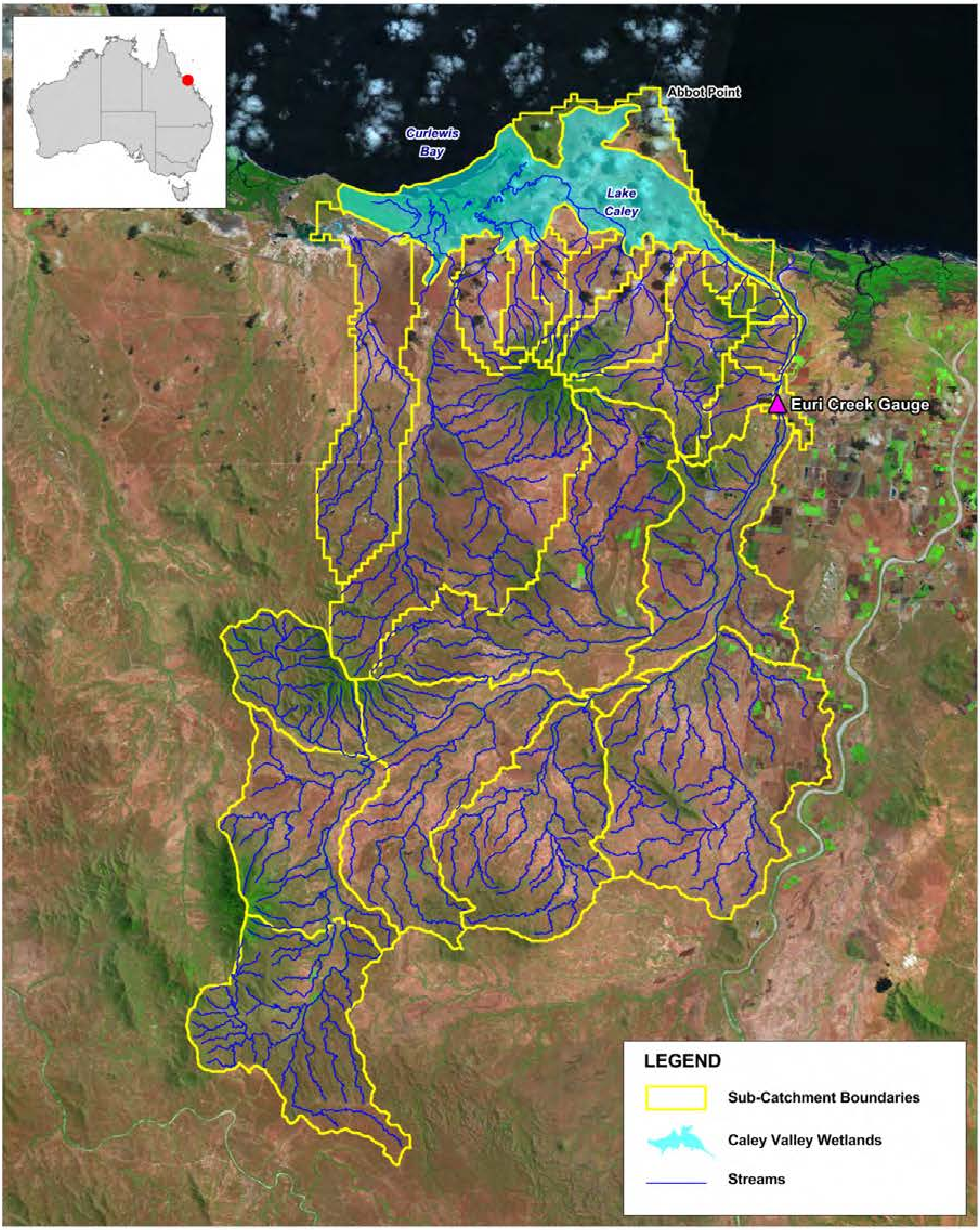
Catchment Delineation and Model Extents

Subcatchments and streams network sourced from DERM GeoScience database to represent the stormwater network of the region in the catchment model are presented in Figure 5-2. The total catchment area draining to the Wetlands (excluding Euri Creek and Plain Creek subcatchments) is approximately 200 km^2.

Rainfall-Runoff Model

The SIMHYD rainfall-runoff model was used to model runoff for all surface types defined in the model. SIMHYD is a conceptual rainfall-runoff model, which is itself a simplified version of the daily conceptual rainfall-runoff model, HYDROLOG that was developed in 1972. The model simplifies the rainfall-runoff processes and requires input of the following variables to perform the hydrological assessment:

- Rainfall;
- Potential evapotranspiration;
- Catchment parameters (area, % impervious and pervious areas); and
- Impervious and pervious area parameters (rainfall threshold, infiltration rates, field capacity, soil storage depths and groundwater parameters).



Title:
Sub-catchments and Stream Network Map

Figure: **5-2**

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Approx.Scale

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SIMHYD has been widely used in Australia and was applied for generating runoff for the Murray Darling Basin Sustainable Yields study in 2006-2008 (Delgado *et al*., 2012). SIMHYD model parameters are typically derived from calibration of the SIMHYD rainfall-runoff model to streamflow records if available for the Abbot Point area. Details of the approach to the preliminary model calibration are provided below.

Meteorological Data

The SIMHYD rainfall-runoff model estimates daily streamflow from daily rainfall and areal potential evapotranspiration data (APET). SILO is an enhanced climate database containing Australian climate data from 1889 (current to yesterday), in a number of ready-to-use formats (Qld Government, 2013). Source utilises SILO meteorological data from data drill locations to calculate spatially weighted (catchment averaged) rainfall timeseries for each subcatchment.

The meteorological data used by the catchment model on a sub-catchment closer to the wetland is provided in Figure 5-3.

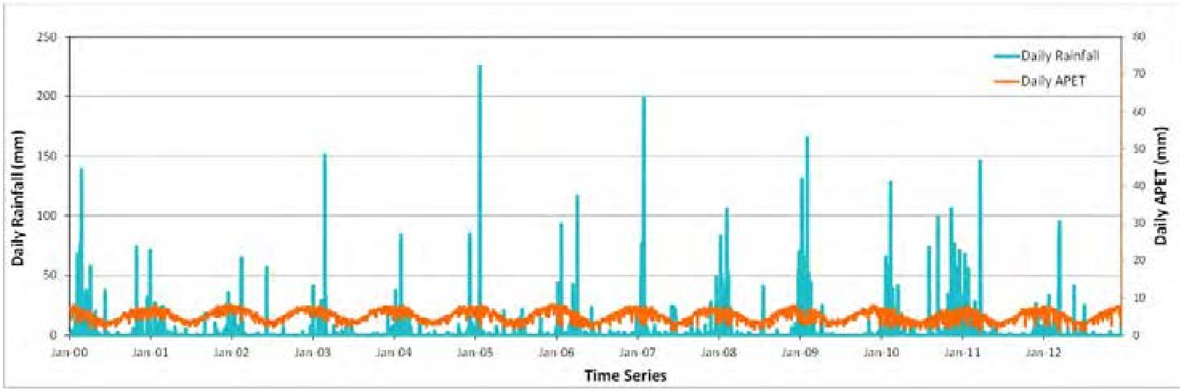


Figure 5-3 Meteorological data (rainfall and evaporation) from SILO (Qld Government 2013)

Catchment Parameters

Catchment parameters were assigned to the SIMHYD model by calibrating to observed streamflow data measured at Euri creek gauge at Koonandah between 2006 and 2012 (see Figure 5-4). When calibrating continuous rainfall-runoff models such as SIMHYD, it is important to adopt a calibration period that is representative of a 'wet period' where streamflows are typically higher. All available streamflow data were utilised for the model calibration, which included several large rainfall and streamflow events during 2005, 2007, 2009 and 2011. The calibration period included a period of high quality data (i.e. record was continuous with no data gaps) and the availability of a corresponding rainfall record for the same period.

Figure 5-4 through Figure 5-6 present the performance of the catchment model calibration qualitatively. Calibrated SIMHYD parameters (hydrologic) are presented in Table 5-1.

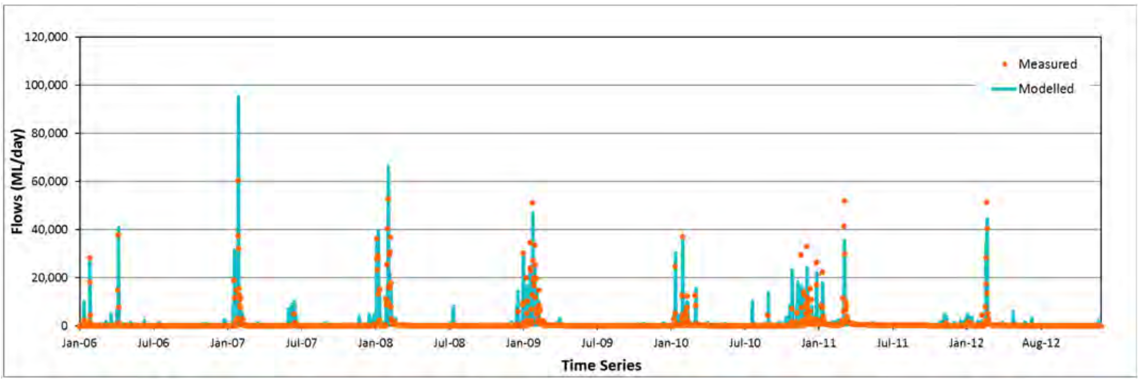


Figure 5-4 Time-series comparison of modelled and measured flow data (ML/day)

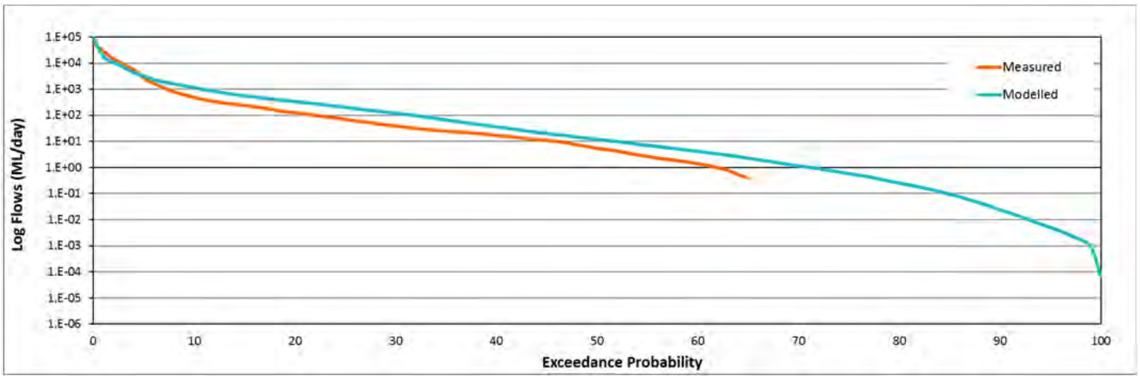


Figure 5-5 Log flow duration curve comparison (ML/day)

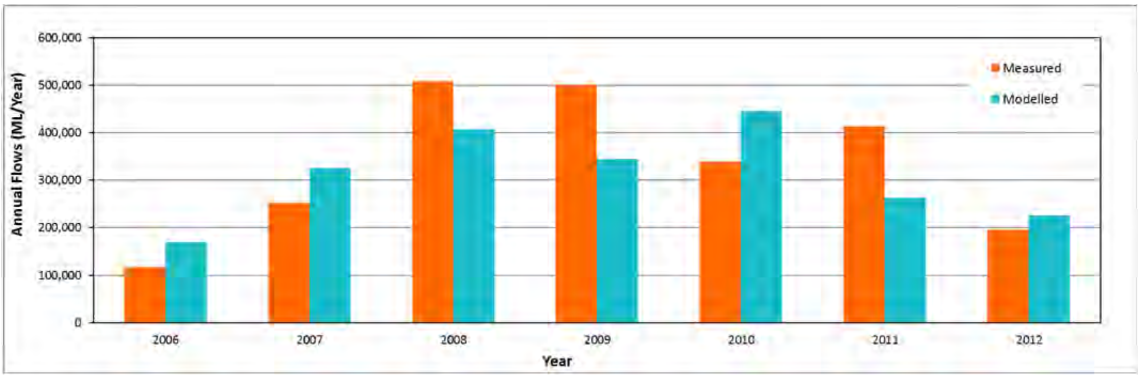


Figure 5-6 Annual flow comparison (ML/year)

Table 5-1 Adopted SIMHYD hydrologic parameters

SIMHYD hydrologic parameters	Calibrated values
Baseflow coefficient	0.17
Impervious threshold	0
Infiltration coefficient	400
Infiltration shape	10
Interflow coefficient	0
Pervious fraction	0.58
Rainfall interception store capacity	0
Recharge coefficient	1
Soil moisture store capacity	281

Estimation of Daily Runoff Volume

The calibrated catchment model was used to estimate the daily runoff volume from the study subcatchments for the period between 2001 and 2012. For the simulation of representative dry, average and wet years, daily flows were extracted from the model for the year 2001, 2012 and 2011 respectively, which were applied to the hydrodynamic model to define freshwater flows entering the Wetlands.

5.1.3.3 Groundwater Flow

Groundwater input to the wetland was accounted for using results of a groundwater model prepared by AGE Consultants. Weekly time series of groundwater flow were provided by AGE Consultants for the existing (without DMCP) and proposed (DMCP with lined embankments) site conditions during below average, average and above average climate years.

Groundwater fluxes (input/output) were assigned to the wetland model across five broad regions (or zones) of the wetland (refer to Figure 5-7), and represent the vertical groundwater flow interaction between the wetland and the underlying aquifer. An example of groundwater flow during an average climate condition is shown in Figure 5-8.

An approximation of a worst case overland surface expression of groundwater was provided by AGE Consultants which is shown in Figure 5-9. The estimate of the recharge volume flowing to the wetland was calculated as a pro rata to the total recharge volume from the DMCP based on the perimeter of the pond and the proportion of groundwater flowing toward the Wetland. Further detail of the worst case scenario is provided in Section 5.4.1.

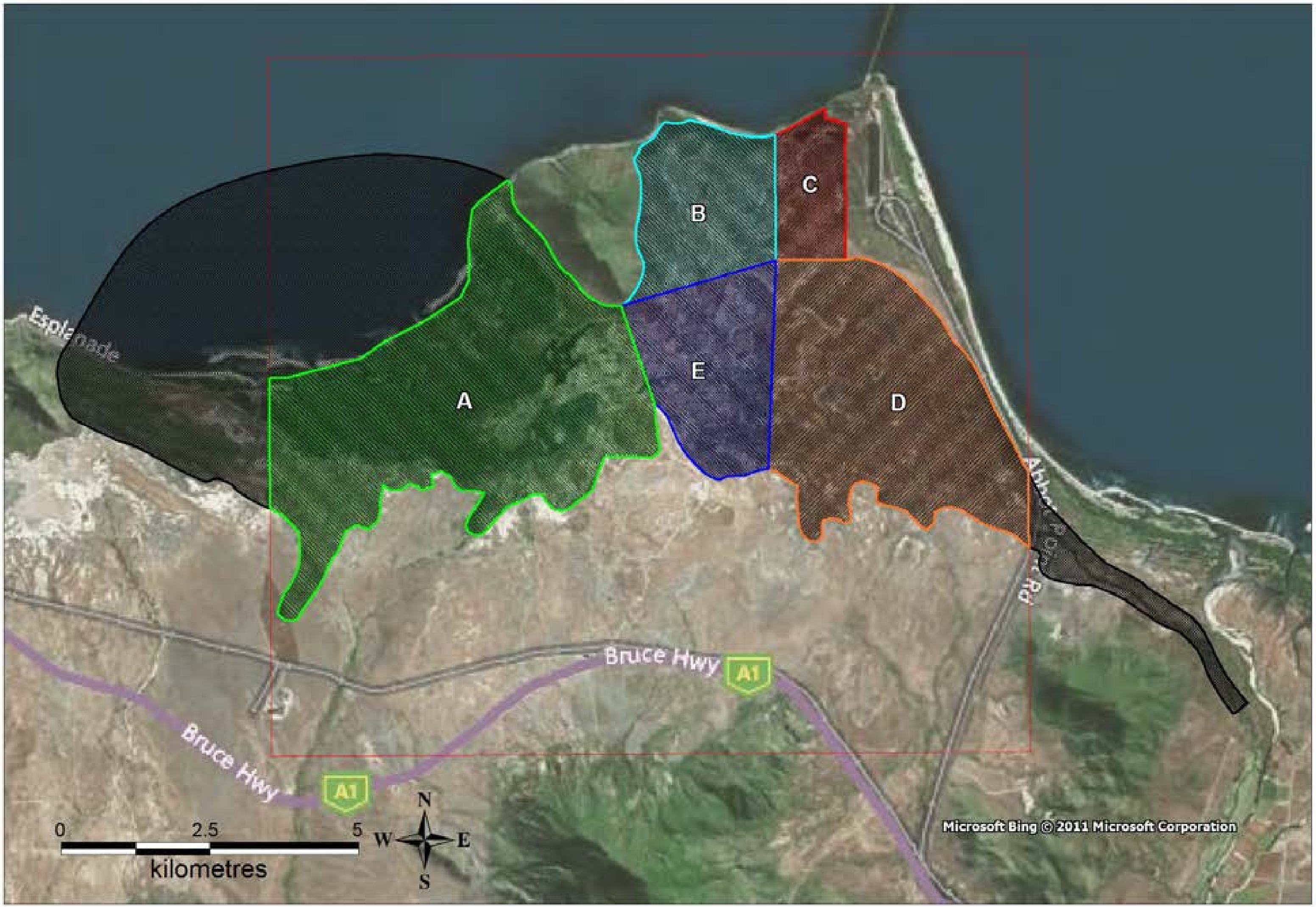
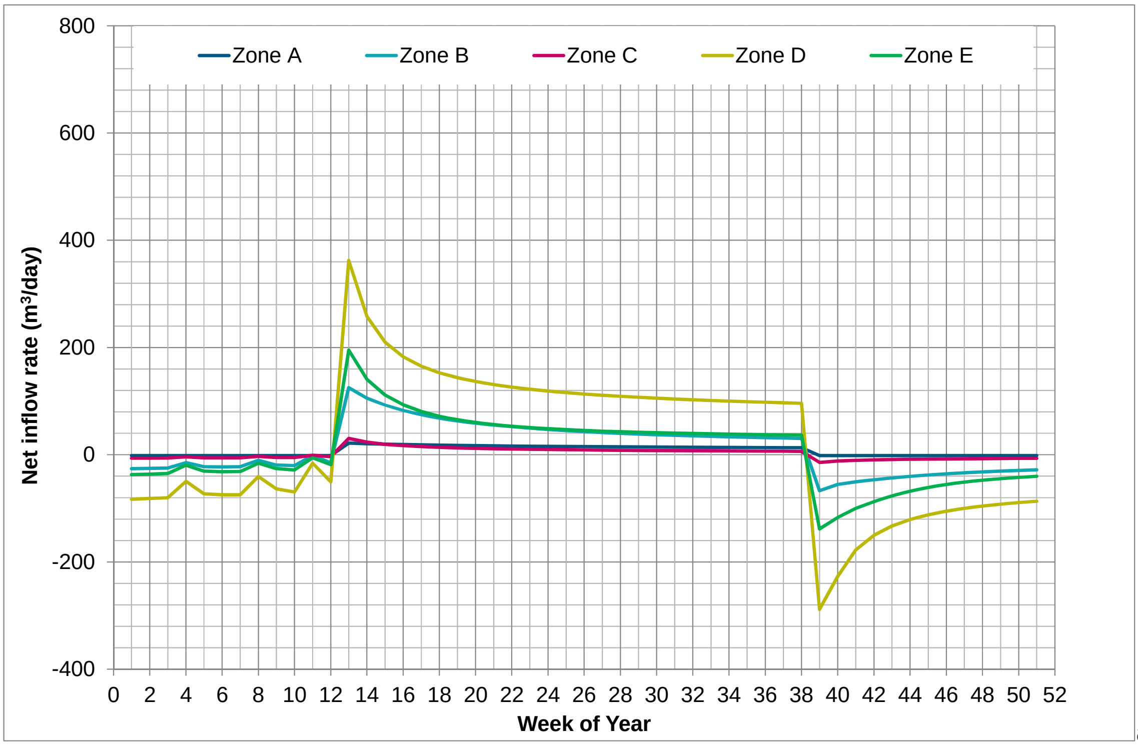
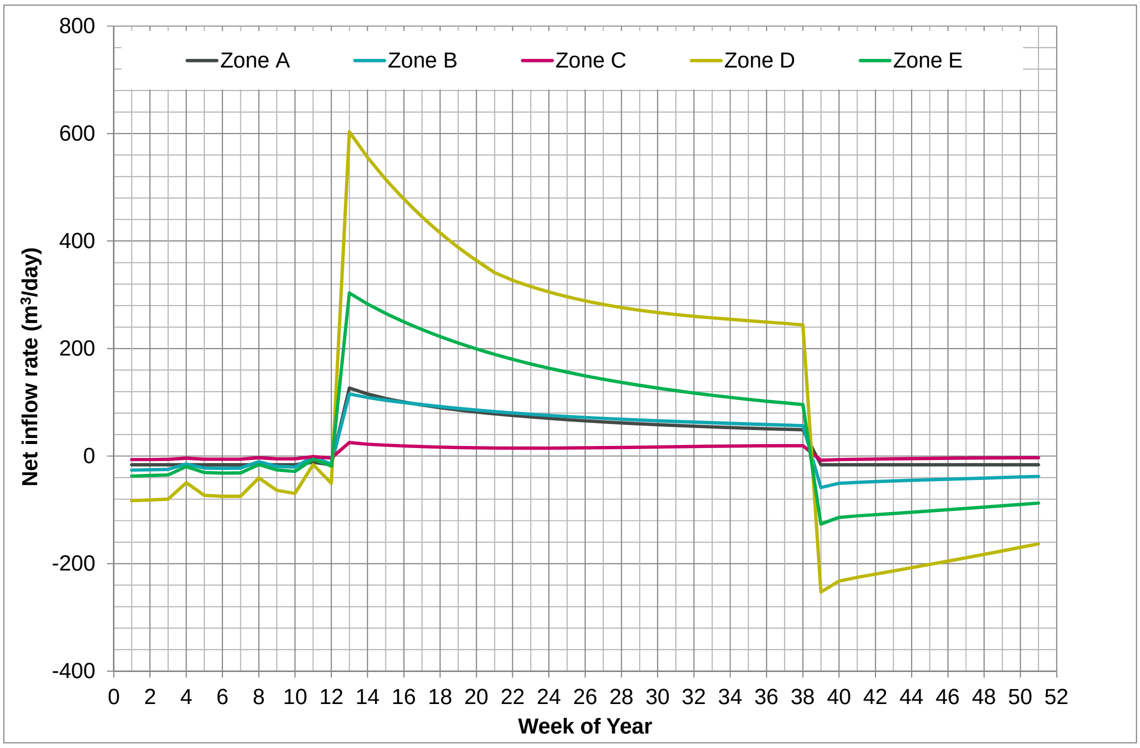


Figure 5-7 Wetland zones used for defining groundwater flow



a)



b)

Figure 5-8 Modelled groundwater flow during average climate conditions a) existing and b) with DMCP

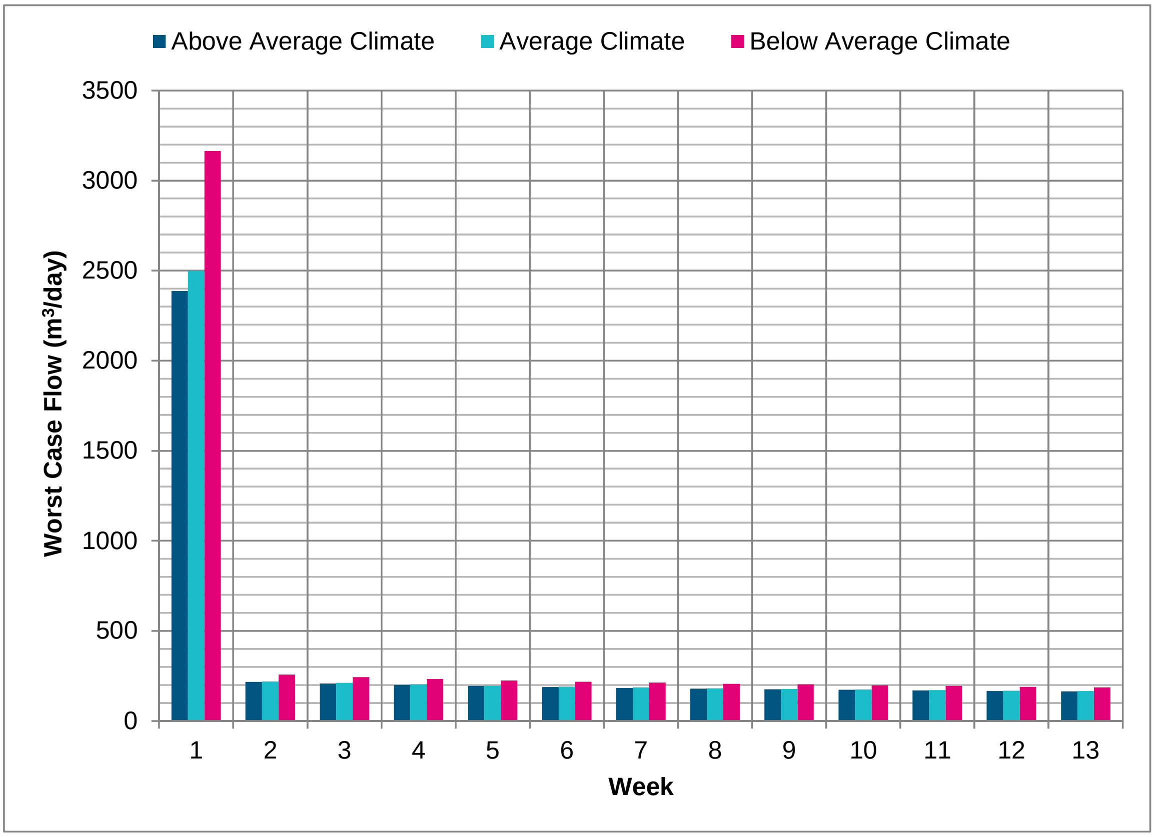


Figure 5-9 Estimate of groundwater flow emanating from the DMCP (worst case)

5.1.3.4 Assumptions and Limitations

The following assumptions and limitations of the models are noted:

- The Source catchment model is uncalibrated except for one flow gauging station. There was no information available that could be used to calibrate the catchment model for other subcatchments.
- The input of flows from Euri Creek to Saltwater Creek is largely unknown. Assumptions were made that some flow occurs, but the conditions in both Euri Creek and Saltwater Creek that lead to flow and salt load are not well known at this stage. Significant analysis and survey would be required to better simulate these conditions.
- The TUFLOW-FV model is uncalibrated for both hydrodynamics and salinity. This is because of a lack of available data for calibration purposes.
- The bathymetry used for the TUFLOW-FV model is based on available LiDAR, which has a degree of uncertainty. Considerable smoothing and manipulation of the LiDAR was required to enable the data to be used in the model.
- Assumed bathymetry was required for the ocean area of the model as well as many of the intertidal creeks (where mangroves prevented LiDAR data capture) and in the creek entrance deltas (where there is considerable shoaling and sediment movement).

- The size of the existing Causeway culvert was assumed, however, it is expected to be substantially blocked through siltation.
- There is no exchange of salt between the upper soil layers and the surface waters. The dynamics of this salt flux is unknown, and the mass of residual available salt in the soil is also unknown.

Notwithstanding these limitations, the available models provide a suitable tool for impact assessment of the current proposal particularly in light of the relative assessment approach adopted and the estimation of potential impacts above background conditions.

5.1.4 Wetland Hydrology Scenarios

To inform the assessment of potential impacting processes, the following nine (9) wetland hydrology scenarios were simulated based on a combination of:

- Three (3) site conditions:
  - Existing case (without DMCP) – used as a baseline for comparative purposes
  - Realistic case (with DMCP) – same as existing site condition but with revised groundwater inputs (based on groundwater flow modelling undertaken by AGE Consultants) accounting for recharge from the DMCP during dredging operation
  - Worst case (with DMCP) – assumes that recharge from the DMCP short-circuits the aquifer and enters as overland surface expression of groundwater along the margins of the wetland adjacent to the DMCP (refer to Figure 5-9). The salinity of water emanating from the DMCP is assumed to be 35 ppt.
- Three (3) climate conditions represented by the following year-long simulation periods:
  - Below average rainfall (2001)
  - Average rainfall (2012)
  - Above average rainfall (2011).

A relative assessment approach was adopted to estimate the potential impact of seepage from the DMCP. The difference between existing and realistic case scenario results was used as an approximation of possible impact on wetland hydrodynamics / water quality caused by additional recharge to the aquifer caused by operation of the DMCP. Time series of relative differences between scenario results is reported at a number of locations within the Wetland as shown in Figure 5-10.

For the worst case scenarios, the modelling utilised a conservative tracer to simulate the mixing and dilution of overland flow emanating from the DMCP. Tracer results were subsequently used to calculate salinity above background which is presented alongside statistics of salinity measured at locations within Lake Caley to provide context to the simulated 'above background' change. Again, time series results are reported at selected locations as well as snapshot results of additional salinity above background occurring 1 week, 1 month, 3 months, 6 months and 9 months after commencement of the dredge and DMCP operations (refer to Section 6.2.4.2).

LEGEND

- Proposed Dredged Material Containment Ponds (DMCP)
- Road
- Railway

Title:

Reporting Locations for the Wetland Hydrology Scenario Results

Figure **5-10**

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5.2 Risk Assessment

A risk assessment approach has been applied to assess potential environmental impacts associated with the Abbot Point Growth Gateway Project. The approach (Figure 5-11) is primarily based on the International Standard *ISO 31000:2009: Risk Management – Principles and Guidelines* and draws on a number of guidelines and standards to assist in conducting risk identification and assessment for the EIS:

- AS/NZS ISO 31000-2009 Risk management – Principles and guidelines
- Handbook 436-2004 – Risk management guidelines
- Handbook 89:2012 – Risk management guidelines on risk assessment techniques
- GBRMP Environmental Assessment and Management (EAM) Risk Management Framework
- Department of Environment Matters of National Environmental Significance – Significant Impact Guidelines 1.1 (2013).

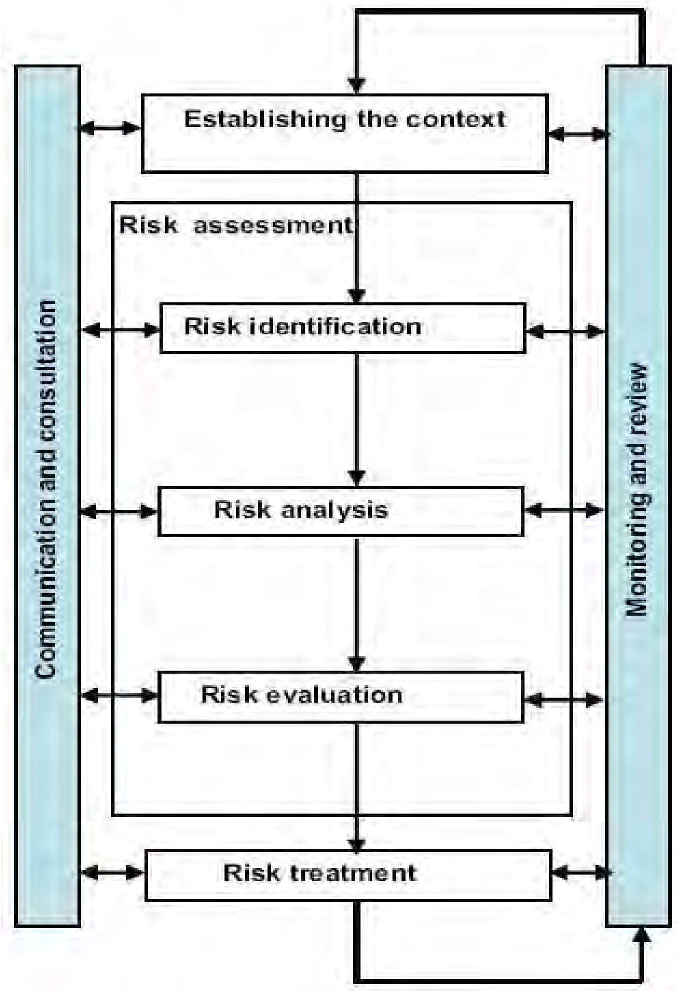


Figure 5-11 Risk management process (source: AS/NZS ISO 31000:2009)

The risk assessment process involved the following key steps:

(1) Context establishment – Confirm the project description, its environmental setting, policy and regulatory context, stakeholders that may be potentially affected by the project activities or interested in the environmental impacts of the proposal and stakeholder values associated with the environmental setting.

(2) Risk identification – Risks were systematically identified and classified by linking them to project phases, project activities, technical assessment areas and controlling provisions (MNES). This step informed the technical assessment in relation to the potential impacts and allowed incorporation of the evaluation of the impacts/risks and their mitigation measures in the respective assessments.

(3) Risk analysis and evaluation – Project specific risk matrix (Table 5-2), consequence and likelihood descriptors (Table 5-2 and Table 5-3) were utilised. The environmental consequence rating considers direct and indirect impacts, short and long term, temporary and irreversible impacts for the Project's lifecycle. The magnitude of potential environmental impacts was derived from the analysis of the amount and type of change and the sensitivity of the receiving environment. Risks were rated based on the consequence of the risk and the likelihood of the risk occurring (e.g. Extreme, High, Moderate, Low). This allowed prioritisation of risks and identification of those which required additional mitigation measures to reduce their risk ratings to acceptable levels.

(4) Risk treatment/mitigation – Mitigation measures were identified to reduce the potential for consequences to occur and/or to reduce their severity if they do occur. Risks were re-rated (residual risk) taking into consideration the adequacy and effectiveness of the mitigation measures.

A summary of the risk register is included in Table 6-2 at the end of Section 6.

Table 5-2 Consequence Definition

	Insignificant	Minor	Moderate	Major	Severe
Natural environment	Minor consequence, local response. No lasting effects. Low level impacts on biological and physical environment to an area of low significance	Event contained within site. Minor short-term and reversible damage to area of limited significance. Short-term effects but not affecting ecosystem functions.	Moderate effects on biological or physical environment and serious short-term effect to ecosystem functions (e.g. oil spill impacts on shoreline).	Major offsite release contained or immediately reportable event with very serious environmental effects, such as displacement of species and partial impairment of ecosystem. Widespread medium and some long-term impact.	Long term irreversible destruction of highly significant ecosystem or significant effects on endangered species or habitats.
Ecology (Aquatic, terrestrial, marine)	Minor, no or positive impacts to ecological structure and function. Minor degradation of habitat and/or increased disturbance leading to a small and/or short-term reduction in habitat use by fauna/flora, at a local scale. No disturbance of threatened ecological communities or species. Recovery expected to occur over a period of months.	Minor to moderate disturbance to ecological structure and function. Minor degradation of important habitat and/or increased disturbance leading to a small and/or short-term reduction in habitat use by fauna/flora at a local scale, including threatened or migratory species. Minimal disturbance of threatened ecological communities or species. Recovery expected to occur over a period of one year.	Moderate disturbance to ecological structure and function. Degradation of important habitat and/or increased disturbance leading to a reduction in habitat use by fauna/flora at a local or regional scale, including threatened and migratory species. Minor disturbance of threatened ecological communities or species. Recovery expected to occur over a period of one to three years.	Moderate to major change to ecological structure and function. Degradation of important habitat and/or increased disturbance leading to a temporary and substantial reduction in habitat use by fauna/flora at a regional scale, including threatened and migratory species. Moderate disturbance of threatened ecological communities or species. Recovery expected to occur over a period of five years.	Fundamental change to ecological structure and function. Degradation of important habitat and/or increased disturbance leading to a substantial reduction in habitat use by fauna/flora at a regional scale, including threatened and migratory species. Major disturbance of threatened ecological communities or species. Recovery unlikely to occur completely, or to occur over a period of 10+ years.
Hydrology and water quality	No detectable change to surface water quality, hydrology or flow regimes (including no loss or reduction of number and/or volume of dry	Local, short-term change in surface water quality, hydrology and flow regimes that can be readily remediated.	Widespread and short term, or local and long term significant change in surface water quality, hydrology and flow regimes.	Widespread and long term, or local and permanent significant change in surface water quality, hydrology and flow regimes.	Widespread and permanent significant change in surface water quality, hydrology and flow regimes.

	Insignificant	Minor	Moderate	Major	Severe
	season remnant pools.				

Table 5-3 Likelihood definition

Likelihood of Impact Occurring	Definition
Almost Certain	• It is known that the impact will occur, or • 95 – 100% chance of occurring
Likely	• Impact is likely to occur on this Project, or • 71 – 95% chance of occurring
Moderate	• Impact has occurred on a similar Project, or • 31 – 70% chance of occurring
Unlikely	• Given current practices and procedures, this impact is unlikely to occur on this Project, or • 5 – 30% chance of occurring
Rare	• Highly unlikely to occur on this Project, or • 0 – 5% chance of occurring

INCREASING LIKELIHOOD ↑ / INCREASING CONSEQUENCE →	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Severe
A Almost certain	Moderate	Moderate	High	Extreme	Extreme
B Likely	Moderate	Moderate	High	High	Extreme
C Moderate	Low	Moderate	High	High	Extreme
D Unlikely	Low	Low	Moderate	Moderate	High
E Rare	Low	Low	Moderate	Moderate	Moderate

Figure 5-12 Risk Matrix

6 Impacting Processes and Mitigation Measures

This section outlines the potential impacting processes that may occur during the construction and operation phases of the Project, and the recommended mitigation measures to address each of the impacting processes.

The summary risk register summarises these impacting processes and mitigation measures and is provided in Table 6-2 at the end of this chapter.

6.1 Direct Aquatic Habitat and Fauna Loss

6.1.1 Potential Impacts

The development footprint of the DMCP does not contain wetland vegetation or habitats. All land within the DMCP footprint and surrounds has been previously cleared and currently supports pasture grassland and, in the context of the wider catchment, has limited contribution to the habitat values and quality of the wetland and does not in itself support high ecological wetland values. On this basis no direct loss or fragmentation of aquatic habitat, vegetation and fauna will occur as a result of the Project.

As discussed in Section 4.1.3.5 and the terrestrial ecology report, the development footprint of the DMCP is comprised exclusively of terrestrial habitats (primarily pasture grasses and non-remnant Melaleuca woodland). As discussed in Section 4.1.6, terrestrial lands surrounding Caley Valley Wetlands provide a range of functional roles to aquatic ecosystems, particularly in the context of controlling sediment and other catchment pollutants inputs in runoff. The removal of terrestrial lands as a result of DMCP construction and operation therefore has the potential to indirectly affect wetland values, if inappropriately managed. However, no threatened, migratory or otherwise notable aquatic fauna or aquatic flora species are known or likely to occur in the Wetlands. Note that an assessment of potential impacts to wetland birds is provided in ELA (2015).

6.1.2 Mitigation Measures and Residual Impacts

A range of mitigation strategies could be undertaken to minimise potential impacts to wetland flora and fauna including:

- Removal of vegetation and bank/bed disturbance will be limited to within the approved development footprints, which are located outside the Wetlands
- The approved boundaries be established on the ground clearly delineated and readily identifiable by field staff, especially operators of heavy machinery.

Construction staff should be provided training to ensure compliance with the above measures, as outlined in the Construction EMP.

Through the implementation of these measures, the residual risk level for habitat loss impacts is rated as Low.

6.2 Hydrological and Water Quality Impacts

6.2.1 Contaminants Types and Sensitive Receptors

The key potential water quality parameters relevant to the Project are shown in Table 6-1. Water quality parameters relevant to the Project may be derived from a range of sources, including stormwater runoff (refer to the Stormwater Management Plan), DMCP waters (refer to the Stormwater Management Plan), dust (refer to the Air Quality report) and contaminated groundwater (refer to the Groundwater report). Potential impacts to aquatic ecological receptors and mitigation measures are described in the following sections.

Table 6-1 Potential water quality parameters relevant to the Project

Project water quality parameters	Key sensitive receptors	Project sources	Relevant project component
Sediments and nutrients	• Aquatic macrophytes • Aquatic invertebrates • Fish	• Stormwater runoff	• Construction phase – clearing and earthworks
		• Dredge pond waters	• Operation phase – overtopping of DMCP
		• Dust	• Construction phase – clearing and earthworks
Low pH waters and metals/metalloids	• Aquatic macrophytes • Aquatic invertebrates • Fish	• Stormwater runoff from any exposed acid sulfate soils	• Construction phase – clearing and earthworks
		• Acidic groundwater	• Construction and operation phase – modifications to groundwater hydrology
Saline waters	• Aquatic macrophytes (particularly salt couch)	• Stormwater runoff	• Operation phase – seepage through embankment intercepted by stormwater management system
		• Dredge pond waters	• Operation phase – seepage through base of DMCP
Hydrocarbons	• All aquatic components	• Construction machinery	• Construction phase– clearing and earthworks

6.2.2 Construction Phase Impacts

6.2.2.1 Stormwater Impacts

Topsoil and sediments will be disturbed during construction of the facility. Potential impacts to aquatic flora and fauna and their habitats exist if these sediments were to enter adjacent wetland areas *via* surface water runoff. Increased suspended solids can cause smothering of sessile macroinvertebrates, clogging of fish gills, and modifications to habitats. Submergent macrophytes, which are sensitive to light limitation, have been recorded in the wetland basin during wet periods (GHD 2009) and will be vulnerable to changes in water quality.

If the wetland is dry and there is no runoff during the construction phase, there is negligible risk of sediments being transported into adjacent wetland habitats. In flow periods there is a greater likelihood that sediment will be mobilised but it will then be mixed with the naturally turbid catchment runoff. Sediment and erosion control measures will therefore be developed and implemented to mitigate potential impacts of sediments entering the adjacent wetlands, as described in the Stormwater Management Plan (Golder Associates 2015a).

6.2.2.2 Accidental Release of Chemicals and Hydrocarbons

The accidental release of contaminants, such as fuels and chemicals associated with machinery operation, pose a risk to adjacent wetland ecosystems. Many of these chemicals are toxic to aquatic macroinvertebrates and fish. Although unlikely, severe spillages of hazardous substances have the potential to cause floral and faunal mortality and morbidity in affected areas. However, damaged communities are likely to fully recover over a period of months, assuming appropriate clean-up strategies were implemented. Mitigation measures will be required to ensure that water leaving the work sites will be of similar quality to that of receiving waters and that contaminants do not leave DMCP site.

6.2.2.3 Acid Sulfate Soils

Golder Associates (2015c) undertook an investigation into the occurrence of ASS in the DMCP. The field and laboratory results on soil samples did not indicate the presence of actual ASS and potential ASS within the upper 5m across the proposed DMCP site (Golder Associates 2015c). As all excavation is expected to occur in the upper 5m of the DMCP site (Golder Associates 2015c), direct disturbance of ASS is not expected.

Golder Associates (2015c) also undertook limited sampling of groundwater at and adjacent to the DMCP. Golder Associates (2015c) concluded that this sampling *"…generally indicates a relatively stable and neutral environment with a high buffering capacity. Test results do not indicate that groundwater has been affected by historical oxidation of sulfides although; relatively high levels of aluminium and iron have been detected in some groundwater samples. Groundwater dewatering will not be required to construct the DMCP and therefore monitoring and possible treatment of groundwater is not required."*

A final ASS Management Plan will be designed and implemented to ensure any PASS present in the dredged material is suitably managed within the DMCP. On this basis, it is considered that there is a low risk of ASS across the proposed DMCP site to cause impacts to aquatic ecosystems within the wetland basin or wider Wetlands.

6.2.2.4 Dust Deposition

Earthmoving and other construction activities will disturb soils and generate dust, which can disperse and settle in the adjacent Wetlands (Katestone 2015). The dust represents a potential source of sediment and other contaminants to the Wetlands. The air quality assessment undertaken by Katestone (2015) indicates that:

- Deposition of dust generated by construction would largely be limited to Wetland areas within close proximity to the construction areas. The predicted dust concentrations would be highly unlikely to result in high suspended sediment concentrations or sediment deposition within the Wetlands (relative to natural variability), if appropriately managed.

- Trace metal and metalloid concentrations in dust at sites within the Wetlands met relevant environmental protection guideline levels.

It would be expected that through the implementation of appropriate dust suppression measures, detectable impacts to aquatic flora and fauna due to dust emissions are unlikely to occur.

6.2.3 Construction Phase Mitigation and Residual Impacts

A range of mitigation strategies could be undertaken to minimise potential impacts to wetland flora and fauna including:

- Removal of vegetation and bank/bed disturbance will be limited to within the approved development footprints, which are located outside the Wetlands
- Appropriate sediment and erosion control measures will be developed and implemented for the construction site
- Construction and operation of roads and tracks within the DMCP footprint of the stormwater management system to minimise sediment generation, and subsequent rehabilitation at the completion of works
- Liming will be undertaken at appropriate dosages in areas containing potential ASS
- Where possible, replanting vegetation will be undertaken after construction completion, which would be particularly beneficial to the long term stability of wetland banks
- An environmental management objective during all construction will be to ensure that water leaving the work sites will be of similar quality to that of receiving waters and that contaminants do not leave DMCP site. Further detail on the management of waters within the construction area is provided within the Stormwater Management Plan (Golder Associates 2015a).

Through the implementation of these measures, the likelihood of any impact is rare, and the residual risk level for construction phase related water quality impacts is rated as Moderate.

6.2.4 Operation and Post-dredging Phase Impacts

The operation of the DMCP will involve the following three phases:

- Operation of the DMCP facility during dredging works (14 week duration)
- Post-dredging management of the DMCP, which will involve active management and monitoring of remaining water and solids in the DMCP over an approximately six month period
- DMCP final landform for reclamation, which will involve the reconfiguration of the DMCP to manage solids and the embankment to enable the reinstatement of the pre-DMCP landform stormwater hydrology.

The key potential impacting processes from a wetland ecology perspective are:

- Modifications of surface water and groundwater hydrology into the Wetlands due to operation of the DMCP
- Increased loads of sediment, salt and other contaminants due to operation of the DMCP.

Potential impacts to the Wetlands are considered below.

6.2.4.1 Local Stormwater Management

Stormwater from the DMCP will contain sediments, saline water and other contaminants that will require management to minimise the risk of water quality impacts to the Wetlands. Golder Associates (2015a) describe the stormwater management issues during the operational phases, as follows:

- Operation of the DMCP – erosion of the earth walls, stormwater runoff from the sub-catchments of the DMCP, over-topping of the DMCP, lateral seepage through the embankment
- Post-dredging management - stormwater runoff from the sub-catchments of the DMCP outer embankment wall
- DMCP final landform for reclamation - stormwater runoff from the DMCP footprint.

Golder Associates (2015a) provide a conceptual stormwater management plan for the proposed activities wherein runoff from local drainage catchments are to be diverted around the DMCP embankment via artificial drains before discharging into the wetland basin adjacent to the proposed works area. From a volumetric perspective, the quantity of surface runoff entering the wetland basin should not increase (in fact it should decrease given that any rain falling onto the DMCP will be captured within the embankment bunds and pumped externally along with dredge tailwater). Additionally, the quality of the runoff should not change significantly providing that there is not substantial change to use of the land within the subcatchment being diverted.

The main issue of consideration for the Wetlands is the concentration of flow associated with the diverted stormwater. The more concentrated rates of runoff may cause localised effects within the wetland basin, including scour and erosion of some sections at the end of the diversion channels, and associated impacts on benthic habitat, vegetation and species. The concentrated flows may also result in localised sedimentation, as sediment runoff from the diverted subcatchment would settle relatively quickly once discharged into the expansive wetland basin area. Given the sensitivities of salt couch grassland and to a lesser extent samphire saltmarsh to altered hydrology (and salinity), it is likely that there could be short-term localised impacts to these communities. As the management intent is to restore pre-disturbance stormwater hydrology, long term effects to salt couch and other wetland communities are not expected.

Possible impacts also could result from minor spills and contamination within the diverted subcatchments. As these areas are routed to the wetland basin, any potential contaminants within the local subcatchments would be directed to the Wetlands where, depending on the nature of the contaminant, may have potential impacts on water quality and ecology. It is expected that an appropriately developed and implemented stormwater management plan could mitigate most impacts from subcatchment contamination.

As described in Section 4.1 and Section 4.2, aquatic flora and fauna communities have a range of adaptations that allow them to persist during harsh environmental conditions, or to rapidly recolonise following disturbance. Long term impacts to aquatic flora and fauna communities are not expected in areas where habitat conditions (i.e. substrate types, water quality or sediment quality conditions) are not altered. Highly localised but long term changes to aquatic flora and fauna communities could occur in areas where stormwater management works cause scour and erosion. Mitigation strategies will be required in this regard, such as the erosion and sediment control measures outlined in Golder Associates (2015a). Refer to additional mitigation strategies in Section 6.2.5.

Stormwater will be managed to minimise the risks of impacts to wetland habitats (erosion and accretion), hydrology, water quality and aquatic ecology. Through the implementation of appropriate control measures, Low (water quality) to Medium (habitat changes due to erosion/accretion) localised (measured in 10s to 100s of metres) impacts on the wetland basin are expected. If the stormwater discharge points and flowpaths were directed away from sensitive marine vegetation, residual risk level could be Low.

6.2.4.2 Seepage of Pond Waters

Horizontal seepage into fringing vegetation

It is understood that the inside walls of the embankments of the proposed DMCP are to be lined with a low permeability liner. For this reason, seepage of dredge tailwater through the embankment wall will be negligible. Any horizontal seepage that occurs through the embankments would be intercepted by toe drains to be constructed around the perimeter of the DMCP. The volume of seepage water (expected to be small) would be directed to nominated discharge locations and interact with adjacent surface waters in the wetland basin.

It is possible that the saline waters at the discharge location could result in highly localised changes to fringing wetland vegetation in affected areas. In this regard, it is possible that salt tolerant samphire communities could replace salt sensitive saltcouch in affected areas (see Section 4.1.5.1). Any such change would be temporary (i.e. times scales measures in months to years), highly localised (i.e. immediately downstream of discharge point), and is unlikely to affect the functionality of aquatic habitats within the Wetlands. Despite the documented fisheries values typical of saltcouch grasslands, these habitats are well above the zone of seasonal inundation and are inaccessible to most species of fisheries significance. No plant or animal species are known to be endemic to saltcouch in Queensland (Jaensch, 2005) and no threatened aquatic species have been recorded in the saltcouch grasslands of the region. In addition, given their limited extent with the area and the wider region, it is not expected they provide significant buffers to local water quality entering the Wetlands.

Based on this assessment any potential salinity impacts to Wetland habitats will be localised, temporary and no threatened aquatic species will be affected. Despite this assessment, at least 20ha of degraded and highly disturbed estuarine habitat has been identified within the Wetlands which could be rehabilitated to promote saltcouch, samphire and/or sedgeland establishment should condition at the discharge location indicate that the habitat is adversely affected.

Vertical seepage into wetland basin

As the base of the DMCP is to be unlined, vertical seepage to the underlying aquifer is expected. The salinity of water seeping from the DMCP will be equivalent to seawater. The degree to which seepage from the DMCP could affect the hydrology and water quality of adjacent receiving environments will depend on the vertical exchange of groundwater between the wetland and the underlying aquifer as well as any change to regional groundwater flows that may occur as a consequence of additional recharge from the DMCP.

A groundwater assessment focussed on impacts from on shore disposal of dredge material within the T2 was undertaken by AGE Consultants. Wetland hydrology scenarios described in Section 5.1.4 were used to assess potential changes to wetland hydrology and water quality. Central to this was the incorporation of regional groundwater estimations based the groundwater flow modelling undertaken by AGE Consultants.

The key parameter of interest in terms of seepage of pond water is salinity. It is understood that no ASS is present in soils within the DMCP (refer Section 6.2.2), and a final ASS Management Plan will be designed and implemented to ensure any PASS present in the dredged material is suitably managed within the DMCP. Further, Section 6.2.2.3 notes that groundwater sampling "…generally indicates a relatively stable and neutral environment with a high buffering capacity" (Golder Associates, 2015c). For the purpose of the present report it has been assumed that there will be no acid seepage from the DMCP.

As discussed in Section 3 of the present report, the salinity of waters within the wetland basin (adjacent to the proposed DMCP) ranges from highly turbid freshwater (during floods) up to (and in places exceeding) seawater salinity during extended dry periods (typically with moderate turbidity). However depending on seasonal rainfall patterns, water quality conditions (e.g. salinity) of waters at the time of the works could vary considerably across the Wetlands.

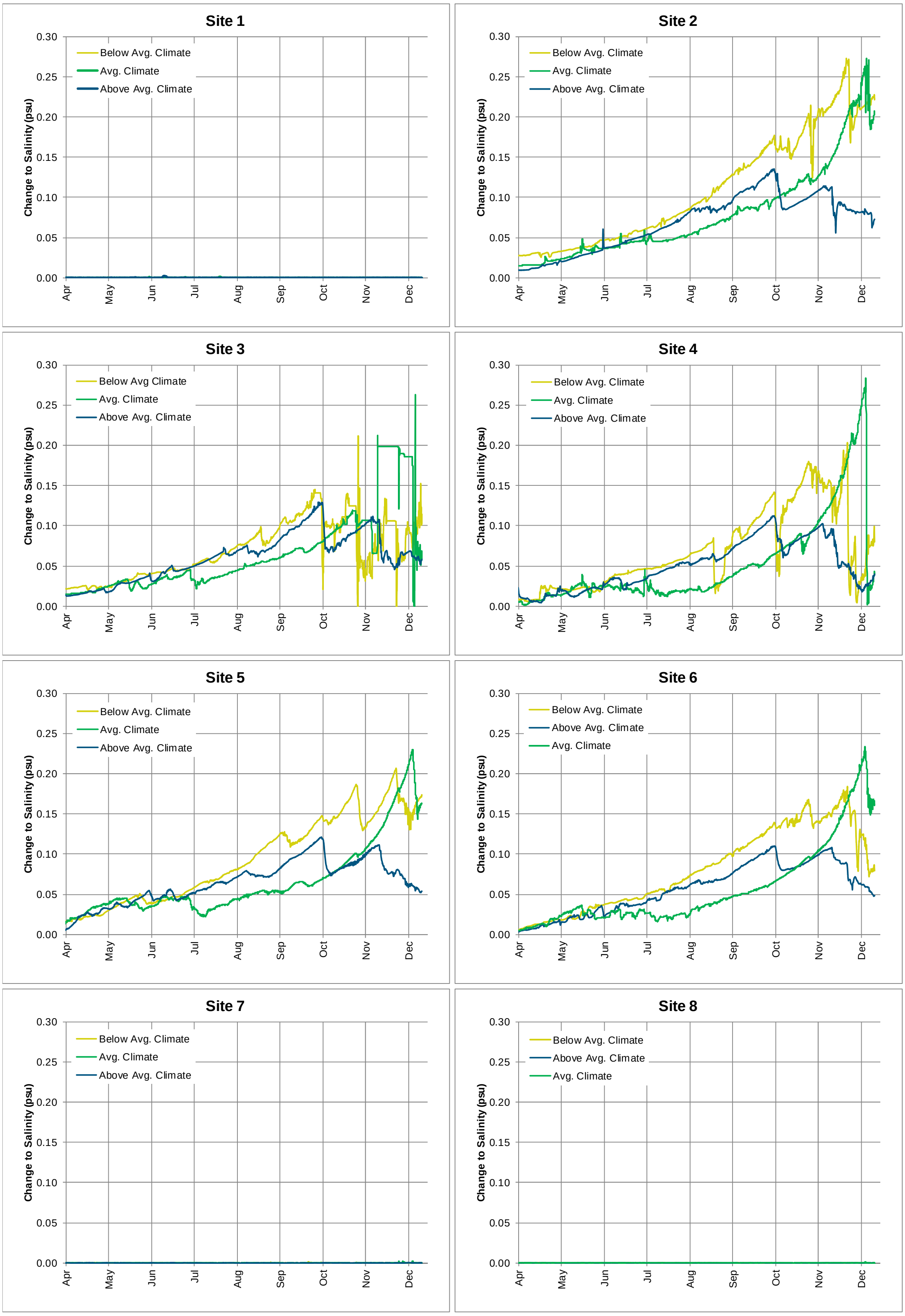
The results of the wetland hydrology scenarios for the realistic case Figure 6-1 reveals that there would be no discernible changes to water depth (magnitude of change is less than 5 mm) and within the range of variability experienced throughout the Wetlands. Likewise, the results show minor changes to salinity (refer to Section 5.1.4) for sites located upstream and downstream of Caley Wetland (i.e. Site 1, Site 7 and Site 8). Changes predicted for sites within Caley Wetland (Site 2, Site 3, Site 4, Site 5 and Site 6) are small (less than one ppt). With respect to climatic conditions, salinity change is greatest for the below average climate condition and least for the above average climate scenario. The results also highlight that the degree of impact on salinity is sensitive to catchment rainfall particularly during the wet season months and within the broad range of variability measured at the wetland (refer to Section 3.2.1).

To further investigate potential impacts on the Wetland, the worst case (hypothetical) scenario was simulated for the three climatic conditions. The results shown in Figure 6-2 are presented as the salinity above background which is comparable against historical measurements of salinity obtained at nearby locations. Again, the results show minor changes to salinity for sites located upstream and downstream of Caley Wetland (i.e. Site 1, Site 7 and Site 8). The greatest change to salinity would be experienced adjacent to the DMCP near Site 2. At that location, salinity is estimated to increase by 3 ppt above background conditions under below average climatic conditions. At Site 3 and Site 4, the salinity above background would be less than two ppt and at Site 5 and Site 6 less than 1 ppt for a majority of the time.

To provide context to the modelled salinity change, the salinity above background is presented 1 week, 1 month, 3 months 6 months and 9 months after commencement of the dredge and DMCP operations for below average rainfall (Figure 6-3), average rainfall (Figure 6-4) and above average rainfall (Figure 6-5) conditions. The results illustrate that under such a worst case scenario, salinity above background is small when compared to the range of natural (seasonal) variations of salinity experienced by the Wetland (shown in the box plots[5]). As an example, historical measurements of salinity at Caley Lake (near Site 6) reveal substantial variations with a median salinity of less than 5 ppt but infrequent hypersaline conditions of greater than 50 ppt occurring from time to time. The worst case scenario results show at that location an above background salinity (increase) of less than 0.1 ppt one week after and 1.7 ppt 9 months after commencement of the DMCP operation under below average rainfall conditions. Similarly at Site 2, the simulated salinity above background (during below average rainfall) after 1 week, 3 months and 9 months is 1.8 ppt, 1.6 ppt and 0.3 ppt, respectively. Salinity measurements available for the northern part of the Wetland also indicate variable conditions with a median of 2 ppt, 90%ile of about 12 ppt and higher (infrequent) measurements of between 20 and 35 ppt.

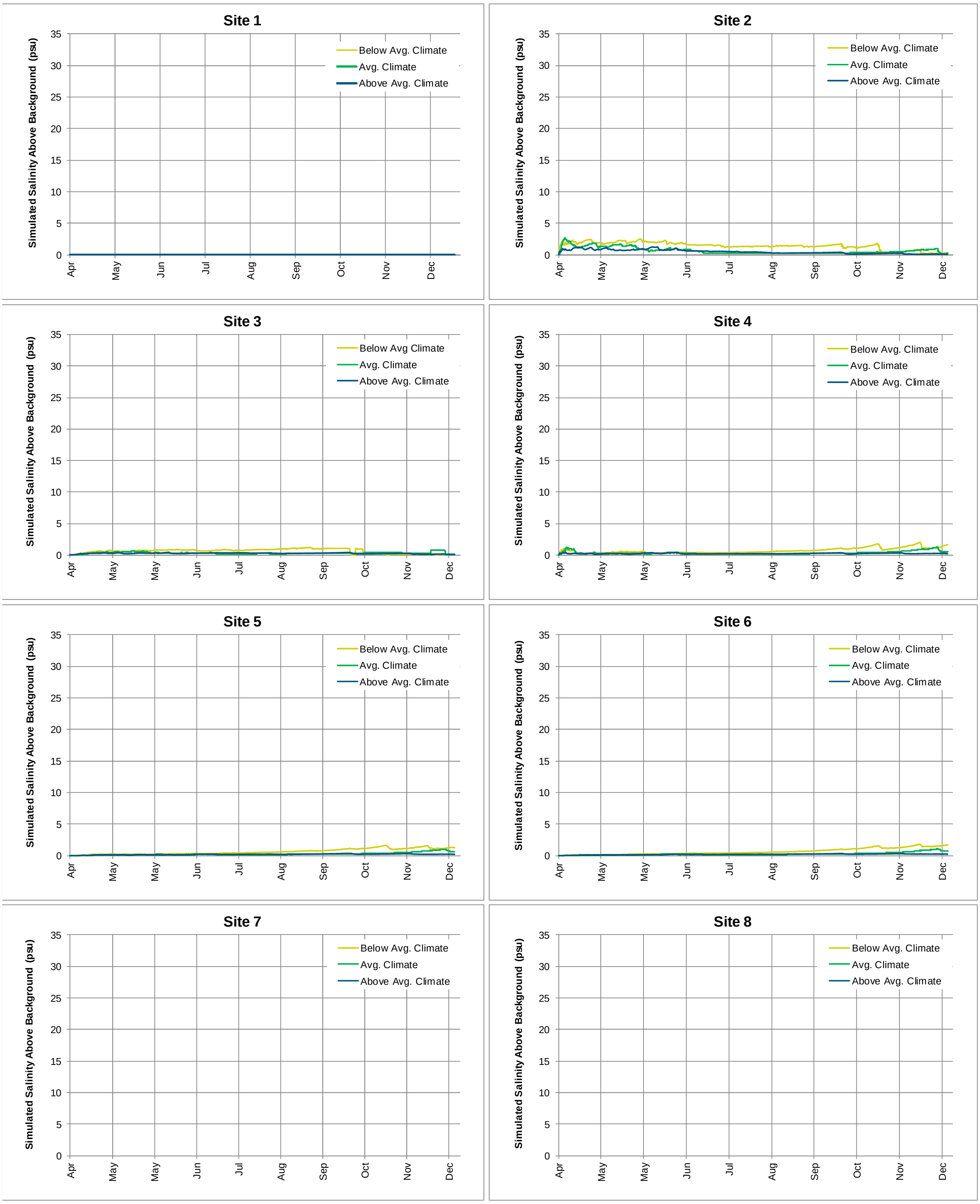
In light of measured salinity within the Wetlands, the results of the realistic and worst case wetland hydrology scenarios suggest that a persistent detrimental impact on aquatic flora and fauna within the ‘wetted’ sections is not expected to occur with operation of the DMCP.

[5] Box and whisker plots (or box plots) show the non-parametric descriptors of the data in graphical form. In other words, they describe the median, the interquartile range and 1.5x the interquartile range. The median (or middle-ranked observation) is the middle line, the box is formed by the 25th and 75th ranked observations, which is the inter-quartile range. Fifty percent of the observations fall within the box formed by the interquartile range. The whiskers represent 1.5x the interquartile range, and are used to show outliers. On normally distributed data, the whiskers will encompass 99.3% of the observations in the data set, with only the most extremely small or extremely large observations shown.



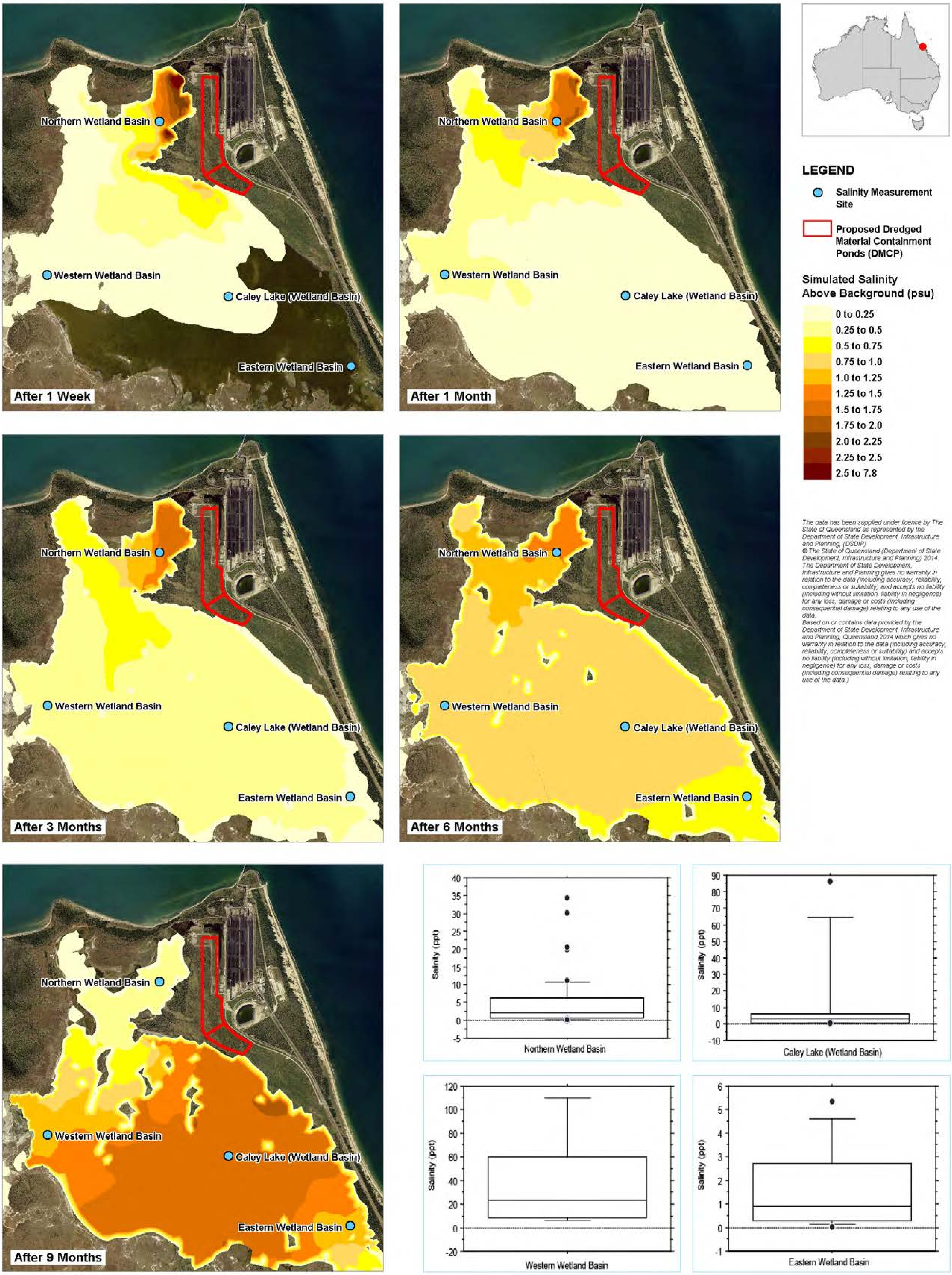
Charts show the relative change of salinity between the existing (base case) and proposed (with DCMP) site conditions during below average, average and above average climatic conditions

Figure 6-1 Simulated changes to salinity (realistic case) – psu = ppt



Charts show simulated salinity above background (psu) during below average, average and above average climatic conditions as a result of a surface expression (short-circuit) of groundwater adjacent to the DCMP

Figure 6-2 Simulated salinity above background (worst case) – psu = ppt



Title:
Worst Case Scenario:
Simulated Salinity Above Background for Below Average Rainfall (2001)

Figure: **6-3**

Rev: **A**

N

0km 2 4
Approx. Scale

BMT WBM
www.bmtwbm.com.au

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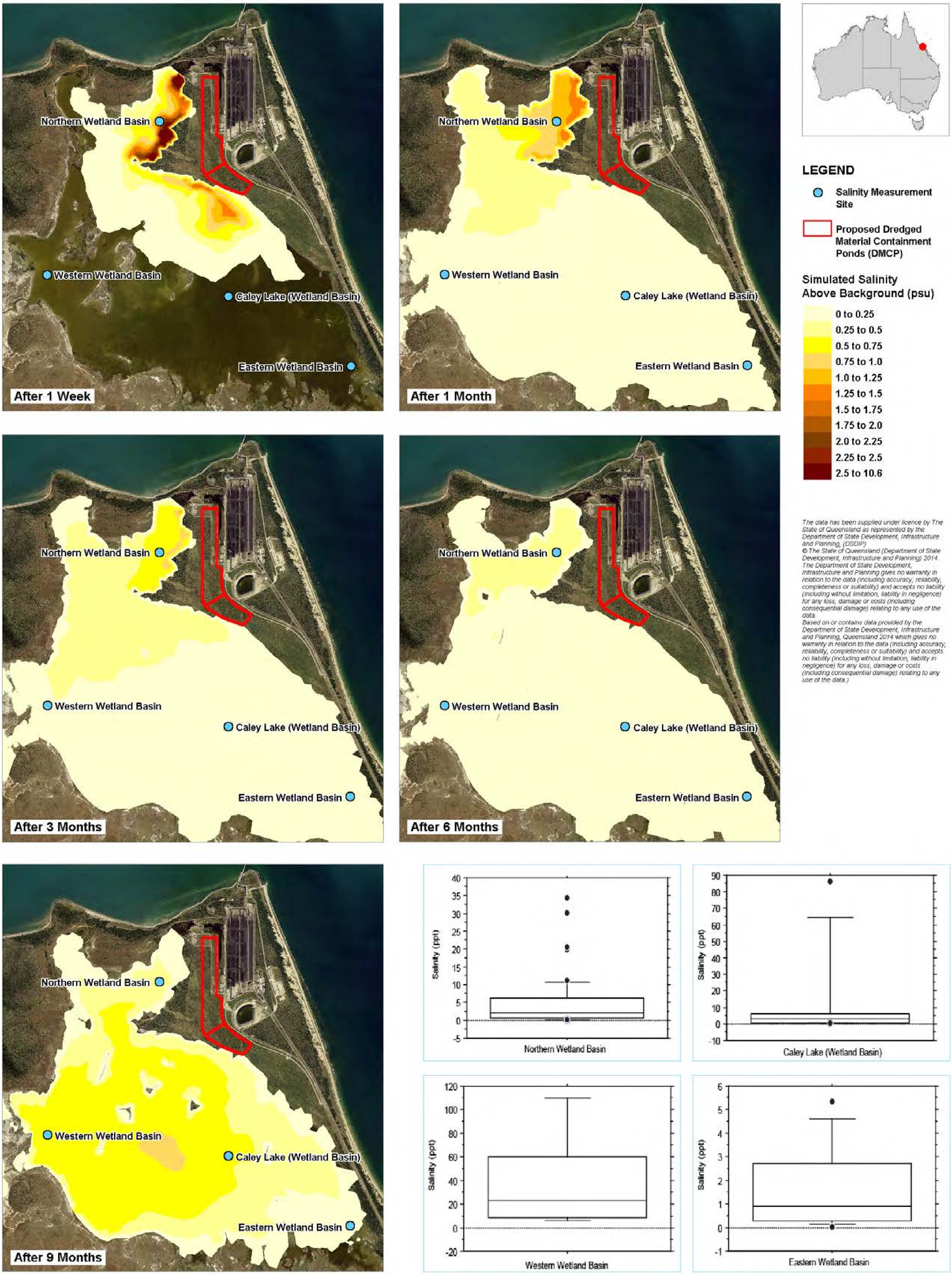


Title:
Worst Case Scenario: Simulated Salinity Above Background for Average Rainfall (2012)

Figure: 6-4

Rev: A

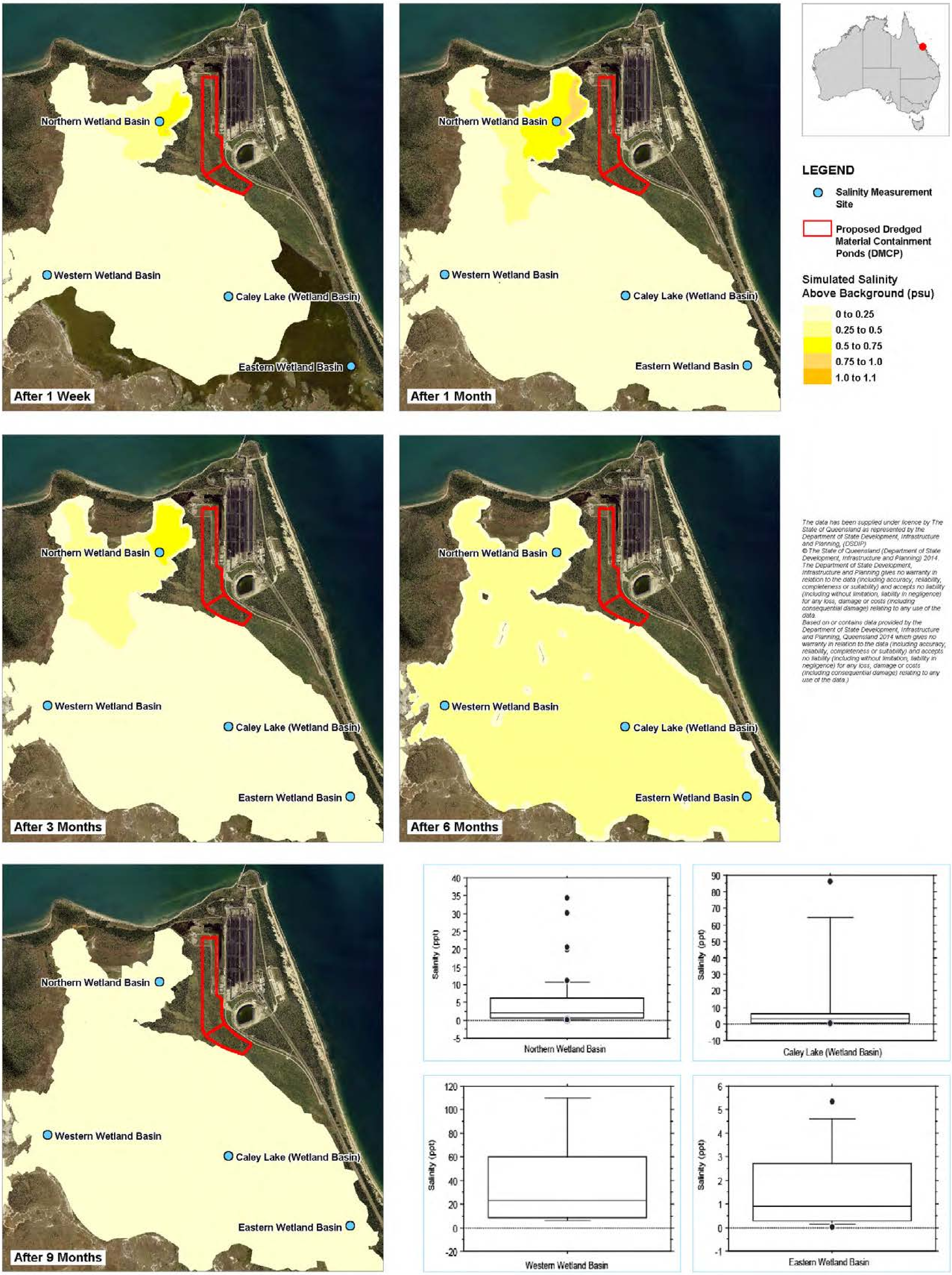
N

0km 2 4

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B21434_I_GML_Abbot_Point_Gateway_LBL\DRG\ECO_008_150707_SAB for Average Rainfall 2012.wor



Title:
Worst Case Scenario:
Simulated Salinity Above Background for Above Average Rainfall (2011)

Figure: **6-5**

Rev: **A**

N

0km 2 4
Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath : I:\B21434_I_GML_Abbot_Point_Gateway_LBL\DRG\ECO_009_150708_SAB for Above Average Rainfall 2011.wor

On the basis of the wetland hydrology scenarios investigated and knowledge of the existing wetland environment, changes to wetland hydrology and water quality as a consequence of DMCP operation are expected to have a relatively inconsequential impact on the local hydrology and water quality of this part of the Wetlands, even when considering seasonal influences on hydrology. In this regard:

- Should the wetland basin be in flood or partially full at the time of works, the salinity of the receiving environment will be freshwater or slightly brackish. Impacts to hydrology and water quality are unlikely to occur, except perhaps at highly localised spatial scales (i.e. in the immediate vicinity of the bund wall, measured in metres to 10's of metres).
- Should water levels within the wetland basin be very low at the time of works, the salinity of the receiving environment will be brackish to saline (at or above sea water salinity), similar to that of the DMCP. Impacts on hydrology, water quality and aquatic communities would therefore not be expected, except perhaps at highly localised spatial scales (i.e. in the immediate vicinity of the bund wall, measured in metres to 10's of metres).
- Should the wetland basin be dry or partially dry at the time of works, it is expected that seepage could result in localised recharge and ponding in the wetland basin adjacent to the DMCP. This could temporarily increase habitat availability for species tolerant of marine salinity (and moderate turbidity).

On this basis, major changes to water quality, hydrology and aquatic ecology are not expected as a result of DMCP operation. It is possible that highly localised minor to moderate level water quality and hydrological effects could occur directly adjacent to the bund wall of the DMCP, particularly if the wetland basin is dry or water levels are low at the time of works.

Any impacts to aquatic communities are expected to be short-term, with rapid recovery occurring in the next wet season following the completion of works. This is based on the following:

- The limited duration of the seepage (i.e. during and shortly after the Project) would limit any ongoing, chronic impacts to wetland hydrology, water quality and aquatic ecology in receiving environments.
- Long term impacts to wetland habitat and conditions are not expected as a result of the works (i.e. major changes to sediment types, sediment quality, benthic processing etc.).
- Aquatic vegetation and fauna species within the wetland basin experience great variation in hydrology and water quality conditions, and have adaptations that allow them to survive rapid changes in water levels, seawater salinity and moderately elevated turbidity (i.e. they are *resistant* to change).

Aquatic fauna species within the wetland basin display boom-and-bust cycles, with rapid recovery (e.g. wetland drying or flooding) following disturbance. In this regard, aquatic fauna species here are highly *resilient* to change, and have adaptations that allow them to rapidly recolonise the wetland when suitable conditions are present (e.g. migration from adjacent areas during the wet, rapid reproduction to exploit temporary habitats etc.). This is a fundamental requirement of living in wetlands within the dry tropics.

6.2.4.3 Storm Capacity and Overflows

Design criteria

The design process for the onshore DMCP is outlined by Golders (2015b). In determining important design levels of the DMCP such as the final embankment crest height and spillway invert, a range of short duration (6 to 72 hour) and long duration (1 to 3 months) design storm events were considered by Golders (2015b) for the 2, 5, 10, 20, 50 and 100-year Average Recurrence Interval (ARI).

Given the ‘low’ consequence category assigned by Golders for failure to contain (overtopping) event scenario no hydrological performance objectives are required for the DMCP. However, consistent with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures, the criteria for the short duration and long duration storm storage allowance was adopted by Golders (2015b) as the minimum of the 72 hour 20-year ARI storm event and the 3 month duration 20-year ARI wet season respectively. The corresponding depth (D) / volume (V) design parameters for those two design events are D=0.47 m | V=291 ML and D=1.42 m | V=913 ML respectively.

Golders (2015b) explain that a short duration event can occur at any time, and as such the DMCP should be designed to accept the full storm volume / depth assuming that the facility was operated at the Maximum Operating Level (MOL) at the start of the event. It is understood that the adopted spillway invert or Full Supply Level (FSL) is RL 8.45m or 0.45 metres above the MOL. A fuseplug level is proposed at RL 8.65 m, final embankment crest at RL 9.0 m and temporary wave bund crest at RL 9.4 m. The total storage allowance above the spillway is therefore 0.95 m providing a total storage depth of 1.4 m above the MOL.

Changes to DMCP salinity during storm events

The salinity of supernatant ponding within the DMCP will be equivalent to 35 ppt (or psu) which is the generally accepted average for seawater. During storm events up to and including the 20-year ARI 72 hour duration event, rainfall occurring over the surface of the pond will be contained by the additional storm capacity provided between the MOL and FSL. Assuming instantaneous and complete mixing between seawater and fresh (rain) water, the salinity of supernatant above dredge solids would decrease in response to rainfall as shown in Figure 6-6. For the 20-year ARI rainfall depth of 0.45 m, the pond salinity is estimated to be 24 ppt (a dilution of about 30%), and for the 100-year ARI about 21 ppt (a dilution of about 40%).

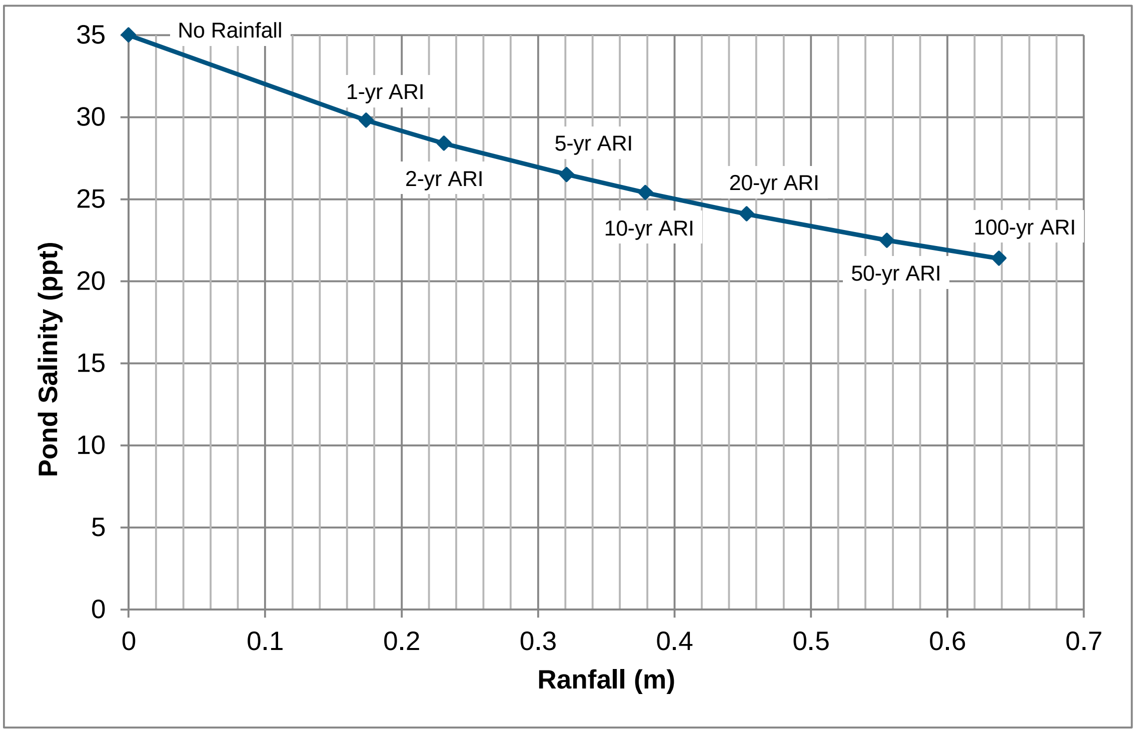


Figure 6-6 Dilution of pond salinity with rainfall

For rainfall events larger than the 20-year ARI, a portion of supernatant may be discharged to the receiving environment via the spillway. Again assuming idealised mixing conditions, the pond salinity could be reduced to about two-thirds that of seawater (between 20 ppt and 25 ppt) depending on the magnitude of the rainfall event and corresponding depth of rainfall.

For long duration storms occurring over a continuous 3 month period, a portion of the pond supernatant could exceed the available storm capacity. The rainfall depth over longer duration wet season rainfall conditions for a 20-year ARI is estimated to be 1.4 m which is significantly greater than the short duration rainfall depth. A rainfall depth of that magnitude could theoretically reduce pond salinity to 15 ppt if it was to fall over a short period. On the basis that dredge operations would maintain the MOL by balancing the tailwater and dredge water discharge streams, the pond salinity during a sustained high rainfall period would be closer to background seawater salinity. Any decrease to salinity below seawater background conditions over the wet season period would be influenced by the distribution of rainfall from day to day or one month to the next month.

Overflows from the DMCP

During dredging the water level within the DMCP will be maintained to a prescribed MOL to ensure there is appropriate freeboard for the tailwater and extreme rainfall events. Golders (2015b) notes that storage provided between the dredge solids and the spillway invert is to be provided to minimise the risk that suspended solids will be discharged through the spillway in to the wetland receiving environment. For rainfall events exceeding the storm capacity allocated within the DMCP, overflows released through a spillway could occur during the operational phase of the Project. The volume of water released would be dependent on the magnitude of the rainfall event and the attenuation provided by the DMCP storage itself and flows controlled by the operational spillway. Golder (2015b) explains that the width of the spillway will be varied to ensure that the active flow depth over the spillway is a small as possible (target of 0.13 m) and aid in reducing flow energy of the discharge to the wetland as much as possible.

In the event that spills from the DMCP occur, the impact on the Wetland would be highly localised (within 10s to 100's of metres of the proposed spillway location). To minimise potential impacts, mitigation measures relating to dredge and extraction flows rates as described by Golders (2015b) could be applied. For reference purposes, the time to empty the proposed short and long duration storm storage allowance is 32 hours and 101 hours respectively. The duration of spills from the DMCP could therefore be expected to range from a few hours during a short duration storm up to several days during long duration (wet season) periods.

Overall, the potential impact on the Wetland arising from DMCP overflows are expected to be minor on the basis that:

- Overflow is not expected for design rainfall events of up to the 20-year ARI for either short or long duration rainfall events. Rainfall captured by the DMCP would be stored by the additional storage allowance for extreme weather conditions;
- Although the rainfall depth for short duration rainfall events with an ARI of 50 or 100 years for example is greater, their likelihood of occurrence is much smaller than that allowed for by the DMCP design;
- Not all supernatant water captured by the DMCP would be discharged to the Wetland, only a portion of supernatant and rainwater above the spillway level may be discharged;
- Although the salinity of overflow water from the DMCP may vary between 20 ppt and 35 ppt as outlined above, the wetland basin would likely be in flood or partially full during overflow and the salinity of the receiving environment will be freshwater or slightly brackish; and
- Consequential impacts on hydrology and water quality are unlikely to occur, except perhaps at highly localised spatial scales (i.e. in the immediate vicinity of the spillway, measured in metres to 10's of metres). Overflows from the DMCP are expected to be readily diluted and dispersed under such weather conditions.

6.2.5 Operation and Post-dredging Phase Mitigation and Residual Impacts

Mitigation measures relevant to stormwater include (Golder Associates 2015a):

- Preserving as far as possible the existing hydrology of the DMCP area
- Interception and transport of stormwater from the DMCP embankment via drainage channels and swales, thereby limiting the occurrence of erosive flows on the embankment
- Revegetation of the DMCP outer embankment to minimise the potential sheet erosion and gullying
- At the completion of dredging, the DMCP area landform will be rehabilitated to mimic the pre-development catchment areas.

Golder Associates (2015a) also describe internal stormwater management issues and mitigation measures for the DMCP during the operational stage. Key measures that will be undertaken in this regard include:

- Minimise potential for erosion by implementing best practice erosion and sediment control measures and design principles. This may require the provision of suitable erosion protection (e.g. geotextile fabric overlain by rip rap) or energy dissipater immediately downstream of the spillway to minimise scour and disturbance to adjacent wetland flora and any well-established terrestrial vegetation.
- Designing the DMCP and managing dredge operations to minimise the potential for the pond to overtop due to the adopted design wind event ad design storm event.
- Liners installed on the internal embankment wall to minimise seepage from the downstream side of the embankment, and interception by the stormwater management system.
- Reducing the permanent pool of water in the pond post-dredging to allow drying and conditioning of soils.

It is also recommended that stormwater discharge points be located in areas not containing large areas of salt sensitive saltcouch.

With regard to pond overflows, potential mitigation strategies could include:

- Minimise potential for erosion by implementing best practice erosion and sediment control measures and design principles. This may require the provision of suitable erosion protection (e.g. geotextile fabric overlain by rip rap) or energy dissipater immediately downstream of the spillway to minimise scour and disturbance to adjacent wetland flora and any well-established terrestrial vegetation.
- In the event that the tailwater pond remains at MOL during the wet season, other mitigation means can be applied as outlined by Golders (2015b) which include:
    - Reduction in dredge inflow rates upon receipt of extreme weather forecasts;
    - Increase in extraction rates upon receipt of extreme weather forecasts; and
    - Increased extraction rates after the extreme events occur (during the duration of the three month allowance).

6.3 Weeds and Feral Animals

6.3.1 Weeds

As described in terrestrial ecology chapter, the Project footprint and immediate surrounds is heavily degraded by previous land uses. As a result, weeds are prevalent throughout the area. The highly dynamic hydrological regime of the basin and high salinities prevent the establishment of most weed species within the Wetlands. Weed invasion is currently restricted to terrestrial lands above the inundation zone of the basin and adjacent to the estuarine plains. In particular the noxious weeds Parkinsonia, prickly acacia and rubber vine are widespread throughout terrestrial lands within and surrounding the Wetlands (BMT WBM 2012).

The construction of the DMCP and the frequent vehicle movements associated with the Project may allow them to spread of existing weeds within the Project area. Furthermore, new weed species may be introduced into the Project area by construction machinery or topsoil/mulch sourced from elsewhere. Roads and other infrastructure corridors are common sites of weed introduction and spread, as the surrounding soils are disturbed and weed seeds or plant material can be transported on vehicles and machinery. These weeds could enter the areas surrounding the Wetlands via a number of vectors, including runoff, aerial dispersal or via vehicles.

Should salinity within the Wetland habitat directly adjacent to the DMCP be substantially reduced and/or the duration of inundation be substantially modified as a result of flow modifications, some weed species may benefit. In particular, *Phragmites australis*, a common invader in saltmarsh communities may benefit from localised hydrological and water quality modifications. However, given the highly saline conditions in the Wetland, it is highly unlikely that this species will establish to significant levels that could have a measurable impact on wetland habitat values or quality. Any localised freshwater pooling may benefit species such as *Typha* sp. and *Hymenachne amplexicaulis* but these species will not persist in water with moderate to high concentrations of salt and are not a significant threat to the quality and values of the Wetlands.

6.3.2 Feral and Domestic Animals

The Abbot Point area presently contains a number of feral animals including feral pigs, rabbits, red fox, black rat, house mouse, common starling, cane toad and eastern gambusia (BMT WBM 2012). BMT WBM (2012) considers that feral cats, common myna and Asian house geckoes are also likely to occur in the area.

The terrestrial fauna species would occur in suitable habitats in lands adjacent the Wetlands, and eastern gambusia would also utilise brackish waters in the Wetlands. These species are expected to be adversely affecting the biodiversity values of the Wetlands as a result of competition for habitat and food resources (e.g. eastern gambusia and cane toads) and predation (i.e. predatory mammals).

Construction activities will change the habitat values of the Project area for feral species, with potential flow-on effects to adjacent areas. In the short term, habitat loss within the Project area could lead to displacement of feral fauna, and an increase abundance of more mobile species in adjacent areas (possibly including areas adjacent to the Wetlands). Resource (food, habitat) limitation is likely to prevent a medium to long term increase in abundance of feral animal species in adjacent areas.

6.3.3 Mitigation and Residual Impact

Standard best practice weed control measures would need to be implemented to ensure construction activities do not spread or introduce new weeds to the Wetlands. Refer to the Terrestrial Ecology report for further details. Mitigation measures will include:

- Removal of vegetation and bank/bed disturbance will be limited to within the approved development footprints, which are located outside the Wetlands.

- Machinery used for earth-moving and vegetation-clearing will be cleaned and inspected prior to the commencement of work at the onshore development area to identify any attached material that needs to be removed for quarantine reasons.
- A temporary wash-down area for earth-moving and vegetation-clearing vehicles will be constructed for the construction phase.
- Monitoring and controlling of weeds will be undertaken in areas where vegetation has been removed.
- Lands within the DMCP will be landscaped and flow paths rehabilitated as part of the proposal. Unless appropriately managed, such works could provide suitable habitat for feral and pest animals, which could then disperse to the adjacent Wetlands (most notably the pest fish eastern gambusia).
- Infestations of declared weed species in the Project area will be controlled by spraying or removal by hand, in accordance with the requirements of the Queensland *Land Protection (Pest and Stock Route Management) Act 2002*. This will specifically target species that are known to be problematic in estuarine habitats, as well as class 1 and 2 plants.
- Construction crew will not be able to bring domestic animals to the site.
- Putrescible waste will be stored in covered containers on site to limit access by scavenger animals, and will be transported off site for disposal.

6.4 Project Impacts to MNES

6.4.1 World Heritage Area and Natural Heritage Place

Project Impacts

Parts of the western estuarine zone and the coastal section of the Wetlands are located within the Great Barrier Reef World Heritage Area and Natural Heritage Place (both hereafter referred to collectively as the GBRWHA). The proposed works are located outside the GBRWHA; therefore no direct impacts to the World Heritage Area property and Natural Heritage Place are expected to occur.

As described in Section 4.4.3, the Wetlands provide a range of ecosystem services that support the OUV of the GBRWHA. In particular, the Wetlands play a key role in regulating catchment flows and pollutants from its catchment before discharging into the GBRWHA, and also contribute to fish biodiversity and fisheries values of the GBRWHA at a local scale. These ecosystem services are supported by coastal wetlands throughout the GBRWHA region, and not unique to the Wetlands.

Highly localised, short-term impacts to wetland aquatic flora (measured in 10's to 100's of metres – within the vicinity of the construction footprints) are expected to occur as a result of the Project. In particular, the Project is predicted to result in:

- Potential short-term and localised water quality impacts during construction (sediments from footprint, spills), which can be readily mitigated through standard erosion and sediment control and house-keeping practices.

- Potential spread of weeds during construction, which can be readily mitigated through standard controls including wash-downs, education weed control and monitoring.
- Localised, short-term scour and salinity effects at stormwater discharge points around the DMCP. This can be partly mitigated by relocating the discharge points away from areas containing large areas of salt couch, post-operation rehabilitation of affected areas and possibly offsets if required.

Impacts are expected to be highly localised and short term at the local level, and as shown in Table 6-2, the risk rating is Moderate or below. While all risk types are potentially relevant to MNES (i.e. in the context of providing ecosystem services to the GBRWHA), as the risk levels are Low to Moderate, the project is not expected to result in significant impacts to GBRWHA.

Cumulative Impacts

The project will involve the removal of terrestrial vegetation that provides a buffer function to the Wetlands, however the area of vegetation loss will be highly localised. The T3 project will also result in the removal of terrestrial vegetation along the northern boundary of the Wetlands. In order to protect the biodiversity values of the Wetlands, it is important that appropriate water management practices are established that do not rely on the natural assimilative capacity of the Wetlands and buffers to manage water quality. The design of the existing project does not rely on fringing terrestrial lands and the Wetlands to provide this water quality regulation service (i.e. stormwater will be managed within the Project footprint).

The project is not expected to result in significant cumulative effects to any of the local expressions of the Outstanding Universal Value of the GBRWHA at even highly localised spatial scales. In the context of EPBC Act Significant Impact Guidelines 1.1 (DoE 2013), it is not expected that the Project would result in:

- One or more World Heritage values to be lost;
- One or more World Heritage values to be degraded or damaged; and
- One or more World Heritage values to be notably altered, modified, obscured or diminished.

Taking into account EPBC Act Significant Impact Guidelines 1.1 (DoE 2013), significant cumulative impacts to the World Heritage Area aquatic ecological values supported by the Wetlands are not expected.

6.4.2 Threatened Aquatic Communities and Species

Threatened and migratory aquatic species are mostly restricted to the coastal sections of the Wetlands, and these are described in the Marine Ecology report. The exceptions to this are:

- The green turtle (*Chelonia mydas*) and possibly nearshore dolphin species, which could enter the lower sections of the western estuary zone to feed. The middle and upper reaches of the creeks within the western estuary are narrow and shallow, and do not support suitable habitat for these species.
- Saltwater crocodile (*Crocodylus porosus*), which could feed in the western estuary. Saltwater crocodiles are known to occur in region, although there are few confirmed records for the Abbot

Point area. There are no nesting sites or preferred feeding habitats in the disturbance area (i.e. typically mangrove lined creeks), and it is not expected that the proposal would interfere with any movements through the site (should it occur). The project is therefore unlikely to impact on local populations of this species.

None of these species rely either directly or indirectly on potentially affected habitats in the wetland basin and surrounds (which includes the project area). Furthermore, the Abbot Point area is not known to support critical or otherwise important habitat for these or other marine megafauna species.

Impact significance has been assessed against Significant Impact Guidelines 1.1 (DoE 2013) for threatened species. Based on an assessment of criteria, and taking into account cumulative effects of this and proposed projects identified in Section 1.1, it is not expected that the Project would lead to any of the following impacts to threatened or migratory species:

- Lead to a long-term decrease in the size of an important population of a species
- Reduce the area of occupancy
- Fragment an existing important population into two or more populations
- Adversely affect habitat critical to the survival of a species
- Interfere substantially with the recovery of the species
- Disrupt the breeding cycle of an important population
- Modify, destroy, remove or isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to species becoming established in their habitat
- Introduce disease that may cause the species to decline.

Taking into account the matters set out in the Administrative Guidelines on Significance under the EPBC Act (DoE 2013), the habitat values of the Wetlands and the nature of the proposed development, the Project is not expected to result in significant cumulative impacts to populations of these EPBC listed threatened and migratory aquatic species.

Table 6-2 Risk Register Summary

Project Activity	Risk	Initial Risk	Mitigation Measure	Residual Risk	Risk type relevant to:				
					Threatened species/ communities	Migratory species	GBRWHA / GBRNHP	Great Barrier Reef Marine Park	Commonwealth marine areas
Footprint clearing and topsoil stripping	Direct loss of wetland vegetation leading to loss/impairment of functional values supported by the Wetlands	Moderate	Vegetated buffer, measures to ensure no unintended clearing outside approved footprint	Low			x	x	
Footprint clearing and topsoil stripping	Loss of vegetated buffer to the Wetlands, resulting in adverse effects to water quality ecosystem services	Moderate	Rehabilitation of disturbed areas	Moderate			x	x	
Footprint clearing and topsoil stripping	Direct loss of wetland vegetation leading to loss/impairment of functional values supported by the Wetlands	Moderate	Vegetated buffer, measures to ensure no unintended clearing outside approved footprint	Low			x	x	
Footprint clearing and topsoil stripping Earthworks including embankment preparation	Increased sediment and nutrient loading into the Wetlands due to construction activities leading to degradation/loss of aquatic habitats, flora and fauna	Moderate	Sediment erosion controls, maintenance of a buffer between the site works and the Wetlands	Moderate			x	x	

Project Activity	Risk	Initial Risk	Mitigation Measure	Residual Risk	Risk type relevant to:				
					Threatened species/ communities	Migratory species	GBRWHA / GBRNHP	Great Barrier Reef Marine Park	Commonwealth marine areas
Footprint clearing and topsoil stripping	Accidental contaminant spills (hydrocarbons) leading to leading to degradation/loss of aquatic flora and fauna	Moderate	Standard measures to minimise the likelihood of spillage, clean-up measures etc.	Moderate			x	x	
Footprint clearing and topsoil stripping Earthworks including embankment preparation	Introduction of new weeds during construction, or establishing habitats preferred by weed species, leading to modifications to aquatic vegetation	Moderate	Vegetated buffer, measures to ensure no unintended clearing outside approved footprint, weed monitoring, weed control	Low			x	x	
Footprint clearing and topsoil stripping Earthworks including embankment preparation	Creation of habitat conditions favouring feral and pest animals, resulting in impacts to wetland flora and fauna	Low	Rehabilitation of disturbed areas, standard house keeping	Low			x	x	
Footprint clearing and topsoil	Accidental contaminant spills (hydrocarbons) leading to leading to degradation/loss of aquatic flora and fauna	Moderate	Standard measures to minimise the likelihood of spillage, clean-up	Moderate			x	x	

BMT WBM

Project Activity	Risk	Initial Risk	Mitigation Measure	Residual Risk	Risk type relevant to:				
					Threatened species/ communities	Migratory species	GBRWHA / GBRNHP	Great Barrier Reef Marine Park	Commonwealth marine areas
stripping Earthworks including embankment preparation			measures etc.						
Earthworks including embankment preparation	Disturbance of acid sulfate soils leading to acid waters and increased metals in surface water runoff, leading to degradation/loss of aquatic flora and fauna	Low	Minimise disturbance to topsoils, liming where necessary	Low			x	x	
Pond operation	Seepage of saline dredge pond water to areas supporting salt couch (intolerant of prolonged waterlogging and high salinity), leading to loss of vegetation and impairment of functional values supported by the Wetlands	Moderate	Installation of stormwater discharge points remote from large salt couch meadows, rehabilitation of any affected areas post operation	Moderate			x	x	
Pond operation	Seepage of saline dredge pond water directly to the Wetlands but not into salt couch areas, leading to increased saline waters within the Wetlands	Low	None	Low			x	x	
Pond operation	Accidental contaminant spills (hydrocarbons) leading to degradation/loss of aquatic flora and fauna	Moderate	Standard measures to minimise the likelihood of spillage, clean-up	Moderate			x	x	

Project Activity	Risk	Initial Risk	Mitigation Measure	Residual Risk	Risk type relevant to: Threatened species/ communities	Migratory species	GBRWHA / GBRNHP	Great Barrier Reef Marine Park	Commonwealth marine areas
			measures etc.						
Pond operation	Overflow of pond resulting in waters discharging to the Wetlands, resulting in scour and possibly loss of vegetation	Moderate	Rehabilitation if required	Moderate			x	x	
Pond operation	Seepage of saline dredge pond water to areas supporting salt couch (intolerant of prolonged waterlogging and high salinity), leading to loss of vegetation and impairment of functional values supported by the Wetlands	Moderate	Installation of stormwater discharge points remote from large salt couch meadows, rehabilitation of any affected areas post operation	Moderate			x	x	
Pond operation	Seepage of saline dredge pond water directly to the Wetlands but not into salt couch areas, leading to increased saline waters within the Wetlands	Low	None	Low			x	x	
Pond operation	Accidental contaminant spills (hydrocarbons) leading to degradation/loss of aquatic flora and fauna	Moderate	Standard measures to minimise the likelihood of spillage, clean-up measures etc.	Moderate			x	x	

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Appendix A EPBC PMST

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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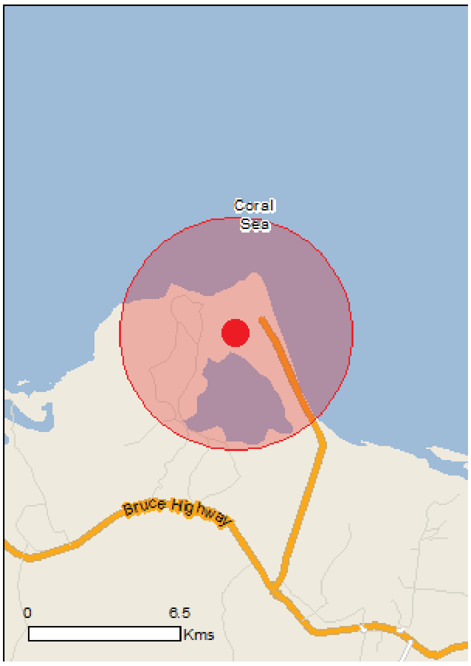

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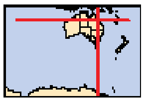

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	1
National Heritage Places:	1
Wetlands of International Importance:	None
Great Barrier Reef Marine Park:	1
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	24
Listed Migratory Species:	34

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	74
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Commonwealth Reserves Marine:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	18
Nationally Important Wetlands:	2
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

World Heritage Properties		[Resource Information]
Name	State	Status
Great Barrier Reef	QLD	Declared property

National Heritage Properties		[Resource Information]
Name	State	Status
Natural		
Great Barrier Reef	QLD	Listed place

Great Barrier Reef Marine Park		[Resource Information]
Type	Zone	IUCN
General Use	GU-16-6004	VI

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	Community likely to occur within area

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Fregetta grallaria grallaria White-bellied Storm-Petrel (Tasman Sea), White-bellied Storm-Petrel (Australasian) [64438]	Vulnerable	Species or species habitat likely to occur within area
Neochmia ruficauda ruficauda Star Finch (eastern), Star Finch (southern) [26027]	Endangered	Species or species habitat likely to occur within area
Poephila cincta cincta Black-throated Finch (southern) [64447]	Endangered	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Dasyurus hallucatus Northern Quoll [331]	Endangered	Species or species habitat likely to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or

Name	Status	Type of Presence
		aggregation known to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Species or species habitat may occur within area
Xeromys myoides		
Water Mouse, False Water Rat, Yirrkoo [66]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Omphalea celata		
[64586]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Denisonia maculata		
Ornamental Snake [1193]	Vulnerable	Species or species habitat may occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Egernia rugosa		
Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area
Lepidochelys olivacea		
Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharodon carcharias		
Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Sterna albifrons		
Little Tern [813]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Migratory Marine Species		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat may occur within area
Carcharodon carcharias Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area
Lamna nasus Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat likely to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Pandion cristatus Eastern Osprey [82411]		Breeding known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]		Species or species habitat likely to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat likely to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Species or species habitat may occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Species or species habitat likely to occur within area
Fish		
Acentronura tentaculata Shortpouch Pygmy Pipehorse [66187]		Species or species habitat may occur within area
Campichthys tryoni Tryon's Pipefish [66193]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys amplexus Fijian Banded Pipefish, Brown-banded Pipefish [66199]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Corythoichthys intestinalis Australian Messmate Pipefish, Banded Pipefish [66202]		Species or species habitat may occur within area
Corythoichthys ocellatus Orange-spotted Pipefish, Ocellated Pipefish [66203]		Species or species habitat may occur within area
Corythoichthys paxtoni Paxton's Pipefish [66204]		Species or species habitat may occur within area
Corythoichthys schultzi Schultz's Pipefish [66205]		Species or species habitat may occur within area
Cosmocampus darrosanus D'Arros Pipefish [66207]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Festucalex cinctus Girdled Pipefish [66214]		Species or species habitat may occur within area
Halicampus dunckeri Red-hair Pipefish, Duncker's Pipefish [66220]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Hippichthys cyanospilos Blue-speckled Pipefish, Blue-spotted Pipefish [66228]		Species or species habitat may occur within area
Hippichthys heptagonus Madura Pipefish, Reticulated Freshwater Pipefish [66229]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus bargibanti Pygmy Seahorse [66721]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus zebra Zebra Seahorse [66241]		Species or species habitat may occur within area
Micrognathus andersonii Anderson's Pipefish, Shortnose Pipefish [66253]		Species or species habitat may occur within area
Micrognathus brevirostris thorntail Pipefish, Thorn-tailed Pipefish [66254]		Species or species habitat may occur within area
Nannocampus pictus Painted Pipefish, Reef Pipefish [66263]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Solenostomus paegnius Rough-snout Ghost Pipefish [68425]		Species or species habitat may occur within area
Solenostomus paradoxus Ornate Ghostpipefish, Harlequin Ghost Pipefish, Ornate Ghost Pipefish [66184]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Species or species habitat known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Species or species habitat known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Enhydrina schistosa Beaked Seasnake [1126]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Laticauda colubrina a sea krait [1092]		Species or species habitat may occur within area
Laticauda laticaudata a sea krait [1093]		Species or species habitat may occur within area
Lepidochelys olivacea Olive Ridley Turtle, Pacific Ridley Turtle [1767]	Endangered	Breeding likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		

Name	Status	Type of Presence
Balaenoptera acutorostrata		
Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat may occur within area
Delphinus delphis		
Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus		
Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Congregation or aggregation known to occur within area
Orcaella brevirostris		
Irrawaddy Dolphin [45]		Species or species habitat likely to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata		
Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus		
Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops truncatus s. str.		
Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Anas platyrhynchos		
Mallard [974]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat likely to occur within area
Mammals		
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Acacia nilotica subsp. indica Prickly Acacia [6196]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Hymenachne amplexicaulis Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Vachellia nilotica Prickly Acacia, Blackthorn, Prickly Mimosa, Black Piquant, Babul [84351]		Species or species habitat likely to occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Abbot Point - Caley Valley	QLD
Great Barrier Reef Marine Park	QLD

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-19.90404 148.07198

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Geoscience Australia
-CSIRO
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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