FOI 180804
Document 2

From: Barker, James
To: s22
Cc: de Brouwer, Gordon; Knudson, Dean; Cahill, Matt; Papps, David; Taylor, Mark; s22 Codina, Martin; Richardson, Geoff; Oxley, Stephen
Subject: Toondah harbour, further brief [DLM=Sensitive:Legal]
Date: Wednesday, 5 April 2017 5:31:18 PM
Attachments: s47C

Hi s22

As flagged earlier, enclosed is briefing on the Toondah Harbour proposal, as well as associated TPs which are also enclosed. This has also been put through pdms (including an attachment of an earlier brief on this proposal, which isn't enclosed with this email because of size).

Happy to discuss further.

Regards
James

FOI 180804
Document 6

THE HON STEVEN CIOBO MP

Minister for Trade, Tourism and Investment

Link: 3/5
Date: 4/5

The Hon Josh Frydenberg MP
Minister for the Environment and Energy
Parliament House
CANBERRA ACT 2600

Dear ~~Minister~~ Josh

I recently received a letter from Cr Karen Williams, Mayor Redland City Council, regarding the Australian Government's environmental assessment process for the Toondah Harbour development in Cleveland, Queensland. As you are aware, the project has been referred to you for consideration under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*.

Cr Williams wrote to me as I granted Tourism Major Project Facilitation (TMPF) service status to the Toondah Harbour project in late 2016 following an assessment against certain selection criteria. The TMPF service provides approved significant tourism infrastructure projects with a case manager in Austrade to help guide project proponents through the Australian Government's approval processes.

Please find enclosed a copy of Cr Williams' letter which I am forwarding to you as many of the issues raised are a matter for your consideration.

I look forward to receiving notification of the outcome of the project's referral under the EPBC Act in due course.

Yours sincerely

Steven Ciobo

30 APR 2017

Parliament House Canberra ACT 2600 Australia
Telephone (02) 6277 7420 E-mail Trade.Minister@dfat.gov.au

MC17-[illegible]

From the Mayor's Office
Karen Williams
Mayor of Redland City

[1]

30 March 2017

KW:DS:fm
Contact: Mayor's Office
Ph: 3829 8235

The Honourable Steven Ciobo MP
Minister for Trade, Tourism and Investment
PO Box 6022
House of Representatives
Parliament House
Canberra ACT 2600

Email: steven.ciobo.MP@aph.gov.au

Dear Minister

I write to commend you for granting Tourism Major Project Facilitation status to the Toondah Harbour Priority Development Area project in Redland City.

The declaration indicates that you, as Minister for Trade, Tourism and Investment, acknowledge the immense economic value of this $1.4 billion project to our city and South East Queensland.

The project – a partnership between the Queensland Government, Redland City Council and Walker Group Holdings – was referred to the Federal Government more than 15 months ago for environmental assessment.

I have been quite concerned about the referral process and the six suspensions of the referral decision since December 2015.

Under federal environmental legislation, actions that are likely to have a significant impact on the environment require approval from the Federal Environment Minister, your colleague the Honourable Josh Frydenberg.

My understanding is that identifying the likelihood of significant impacts is generally undertaken on a case-by-case basis, guided by scientific analysis as part of an environmental impact assessment process.

I am advised that Walker Group has not had an opportunity to provide this evidence base as the Government says it is willing to work to find a solution, yet to date has not identified a suitable assessment pathway.

I lobbied the former Queensland Government to have Toondah Harbour declared a priority development area to fast-track the area's redevelopment. I also lobbied the current Government to support the project, which they have done.

Redland City Council
ABN 86 058 929 428

Cnr Bloomfield & Middle Sts,
Cleveland Qld 4163

PO Box 21,
Cleveland Qld 4163

Telephone 07 3829 8623
Facsimile 07 3829 8781

Mobile 0416 123 588

Email mayor@redland.qld.gov.au
www.redland.qld.gov.au

/

A project of this nature will be transformational for the Redlands, both in establishing a destination identity for the area and providing critical infrastructure for tourism in the Cleveland-Moreton Bay region.

There is no suggestion that the project should not meet all environmental requirements and be subject to detailed testing. We have always supported such scrutiny. However, it is our firm view that it should be up to the proponent to demonstrate the acceptability of the proposal through an EIS. On the surface of it, there does not appear to be scientific basis for the department to reach an alternative conclusion.

This project has been 50 years in the making. I am concerned about the impact of the continued stymieing by the Australian Government of the momentum of the PDA process and the implications for this regional community if the project is sidelined without proceeding to the assessment phase.

I trust the Federal agencies can work cooperatively with us, the State and Walkers to facilitate an outcome than enables the scientific assessment of the project to commence in the near future.

Yours sincerely

KWilliams

Mayor Karen Williams
Redland City Council

From the Mayor's Office
Karen Williams
Mayor of Redland City

FOI 180804
Document 7

30 March 2017

KW:DS:fm
Contact: Mayor's Office
Ph: 3829 8235

The Honourable Josh Frydenberg MP
Minister for the Environment and Energy
Member for Kooyong
PO Box 6022
House of Representatives
Parliament House
CANBERRA ACT 2600

Dear Minister

I write to thank you for meeting with me on 22 March during my visit to Canberra as part of the annual Council of Mayors South East Queensland delegation.

As you are aware, your colleague, Tourism Minister Steven Ciobo, recently granted Tourism Major Project Facilitation status to the Toondah Harbour Priority Development Area project in Redland City.

The declaration indicates that Minister Ciobo and his Department acknowledge the economic potential of this $1.4 billion project for our city and South East Queensland.

As we discussed during our meeting the project was referred to your department by Walker Group more than 15 months ago for environmental assessment.

As I indicated to you I have been quite concerned about the referral process and the six suspensions of the referral decision since December 2015.

Under federal environmental legislation, actions that are likely to have a significant impact on the environment require approval from the Federal Environment Minister.

My understanding is that identifying the likelihood of significant impacts is generally undertaken on a case-by-case basis, guided by scientific analysis as part of an environmental impact assessment process.

I am advised that Walker Group has not had an opportunity to provide this evidence base as the Government says it is willing to work to find a solution, yet to date has not identified a suitable assessment pathway.

I lobbied the former Queensland Government to have Toondah Harbour declared a priority development area to fast-track the area's redevelopment. I also lobbied the current State Government to support the project, which they have done.

A project of this nature will be transformational for the Redlands, both in establishing a destination identity for the area and providing critical infrastructure for tourism in the Cleveland-Moreton Bay region.

Redland City Council
ABN 86 058 929 428
Cnr Bloomfield & Middle Sts.
Cleveland Qld 4163

PO Box 21,
Cleveland Qld 4163

Telephone 07 3829 8623
Facsimile 07 3829 8781

Mobile 0416 123 588

Email mayor@redland.qld.gov.au
www.redland.qld.gov.au

There is broad support for the project across our city, with around 80 per cent indicating they wanted to see Toondah Harbour redeveloped. As you are aware, there is also a vocal group of project opponents.

There is no suggestion that the project should not meet all environmental requirements and be subject to detailed testing. We have always supported such scrutiny.

This project has been 50 years in the making. I am concerned about the implications for this regional community if the project is sidelined without proceeding to the assessment phase.

We are not asking for you to approve the project, but merely to allow Walkers to take the project to the next stage of assessment, an EIS, to provide the opportunity for them to prove their environmental credentials.

It is our firm view that the proponent should have the opportunity to demonstrate the acceptability of the proposal through an EIS. On the surface of it, there does not appear to be scientific basis for your department to reach an alternative conclusion.

Under the current use of Toondah as a ferry and barge terminal, no-one takes responsibility for the daily impacts of marine traffic and regular dredging in a RAMSAR site, nor does any agency expect companies to cease their operations.

I trust the Federal agencies can work cooperatively with us, the State and Walkers to facilitate an outcome that enables the scientific assessment of the project to commence in the near future.

Yours sincerely

KWilliams

Mayor Karen Williams
Redland City Council

FOI 180804
Document 8

30 March 2017

KW:DS:fm
Contact: Mayor's Office
Ph: 3829 8235

The Honourable Josh Frydenberg MP
Minister for the Environment and Energy
Member for Kooyong
PO Box 6022
House of Representatives
Parliament House
CANBERRA ACT 2600

Dear Minister

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The declaration indicates that Minister Ciobo and his Department acknowledge the economic potential of this $1.4 billion project for our city and South East Queensland.

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My understanding is that identifying the likelihood of significant impacts is generally undertaken on a case-by-case basis, guided by scientific analysis as part of an environmental impact assessment process.

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I lobbied the former Queensland Government to have Toondah Harbour declared a priority development area to fast-track the area's redevelopment. I also lobbied the current State Government to support the project, which they have done.

A project of this nature will be transformational for the Redlands, both in establishing a destination identity for the area and providing critical infrastructure for tourism in the Cleveland-Moreton Bay region.

There is broad support for the project across our city, with around 80 per cent indicating they wanted to see Toondah Harbour redeveloped. As you are aware, there is also a vocal group of project opponents.

There is no suggestion that the project should not meet all environmental requirements and be subject to detailed testing. We have always supported such scrutiny.

This project has been 50 years in the making. I am concerned about the implications for this regional community if the project is sidelined without proceeding to the assessment phase.

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I trust the Federal agencies can work cooperatively with us, the State and Walkers to facilitate an outcome that enables the scientific assessment of the project to commence in the near future.

Yours sincerely

Mayor Karen Williams
Redland City Council

FOI 180804
Document 9

From: Barker, James
To: s22
Subject: RE: Toondah Harbour Withdrawal of EPBC 2015/7612 [SEC=UNCLASSIFIED]
Date: Friday, 5 May 2017 11:29:45 AM

No, not yet.

From: s22
Sent: Friday, 5 May 2017 11:27 AM
To: Barker, James <James.Barker@environment.gov.au>
Subject: RE: Toondah Harbour Withdrawal of EPBC 2015/7612 [SEC=UNCLASSIFIED]

James

We are responding to a query on Toondah. To confirm, we haven't received the new application yet?

Thanks

From: Barker, James
Sent: Thursday, 4 May 2017 6:38 PM
To: s22 @environment.gov.au>
Cc: de Brouwer, Gordon <Gordon.deBrouwer@environment.gov.au>; Knudson, Dean <Dean.Knudson@environment.gov.au>; Cahill, Matt <Matt.Cahill@environment.gov.au>; Tregurtha, James <James.Tregurtha@environment.gov.au>; s22 @environment.gov.au>; s22 @environment.gov.au>; Papps, David <David.Papps@environment.gov.au>; Taylor, Mark <Mark.Taylor@environment.gov.au>; s22 @environment.gov.au>
Subject: FW: Toondah Harbour Withdrawal of EPBC 2015/7612 [SEC=UNCLASSIFIED]

Hi s22

Fyi too. This withdrawl will be reflected on the Department's website shortly (I expect tomorrow). We have not yet received a further referral.

If you are asked about it in the meantime, you could indicate that:

- The proponent has withdrawn its proposed development for Toondah Harbour in Moreton Bay, under the EPBC Act.
- The proponent has written to the Department, stating its intention to submit an alternative referral.
- When the Department gets that referral, it will be published for 2 weeks public comment, as required by the EPBC Act.
- After that comment period, unless further information is required or an extension is requested by the proponent, a decision will be made by the Minister or his delegate about whether the proposal requires further detailed assessment and approval under the EPBC Act.

From: Peter Saba [mailto:Peter.Saba@walkercorp.com.au]
Sent: Thursday, 4 May 2017 3:15 PM
To: Barker, James <James.Barker@environment.gov.au>
Cc: Cahill, Matt <Matt.Cahill@environment.gov.au>; Knudson, Dean <Dean.Knudson@environment.gov.au>; Stephen Davis <stephen.davis@davisadvisory.com.au>
Subject: Toondah Harbour Withdrawal of EPBC 2015/7612

James,

Further to our recent discussion, please find attached our formal notification to withdraw our referral (2015/7612).

Please let me know if you have any queries.

Regards,

Peter.

Peter Saba
General Manager - Queensland Development

Walker Corporation
Level 18, 150 Charlotte St Brisbane QLD 4000
T +61 7 3007 7402
M +61s47F
www.walkercorp.com.au

FOI 180804
Document 10

From: s22
To:
Cc: de Brouwer, Gordon; Knudson, Dean; Cahill, Matt; Taylor, Mark; Papps, David; s22
Subject: FYI, Toondah Harbour referral now published for public comment [SEC=UNCLASSIFIED]
Date: Thursday, 11 May 2017 4:13:58 PM

---

s22

Fyi, we have now published the referral on the Department's website at http://epbcnotices.environment.gov.au/publicnoticesreferrals/

This means that the referral decision will be due on 8 June. I've made a minor update to the points below accordingly.

Thanks
James

From: Barker, James
Sent: Tuesday, 9 May 2017 11:30 AM
To: s22 @environment.gov.au>
Cc: de Brouwer, Gordon <Gordon.deBrouwer@environment.gov.au>; Knudson, Dean <Dean.Knudson@environment.gov.au>; Cahill, Matt <Matt.Cahill@environment.gov.au>; Tregurtha, James <James.Tregurtha@environment.gov.au>; Taylor, Mark <Mark.Taylor@environment.gov.au>; Papps, David <David.Papps@environment.gov.au>; s22 @environment.gov.au>; s22 @environment.gov.au>; s22 @environment.gov.au>; s22 @environment.gov.au>
Subject: FYI, Toondah Harbour referral received [SEC=UNCLASSIFIED]

Hi s22

Fyi, we have this morning received the new referral for Toondah harbour (EPBC 2017/2939).

Once we have confirmed with Walker that EPBC Regulation requirements have been met, and the proponent pays the referral fee, it will be published on the Department's website for the 10 business day public comment period. This is likely to happen in the next few days. I'll let you know once it is made public.

In anticipation of the referral being made public, the following are some updated points if needed:

- Walker Group has submitted a referral for the development of Toondah Harbour, in Moreton Bay, Queensland.
- The referral has been published on the website of the Department of Environment and Energy for 2 weeks public comment until 8 June, as required under national environment law.
- After the comment period, unless further information is required or an extension is requested by the proponent, a decision will be made by the Minister or his delegate

about whether the proposal requires further detailed assessment and approval under the EPBC Act.

- Walker Group has withdrawn a previous referral for the proposed development.

If asked – what is the difference between the new proposal and the old one?

- The new referral includes changes to the project's footprint.
- The Department is further assessing the detail of the new proposal.

Emails contained in Document 6

s22

s22

brisbane
australia's new world city

FOI 180804
Document 11

MC17-013137

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+61 7 3006 6250
brisbanemarketing.com.au
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157 Ann Street,
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PO Box 12260, George Street,
Brisbane Qld 4003 Australia
ABN 86 094 633 262

3 0 MAY 2017

Min No: MC
Division: ESD
Link:
DLO: LLS
Date: 30/5
RECEIVED 3 0 MAY 2017
Environment and Energy Minister
☐ Covering Brief
☑ Minister Reply
☐ CoS/Adviser Reply
☐ Refer to:
☐ Departmental Reply
☐ Appropriate Action
☐ For Information
☐ Campaign ☐ Advice/Min

24 May 2017

The Hon Josh Frydenberg MP
Referrals Gateway
Environment Assessment Branch
Department of the Environment
GPO Box 787
Canberra ACT 2601

Copy sent via email: epbc.referrals@environment.gov.au

Dear Hon Josh Frydenberg MP,

2017/7939 - Walker Group Holdings Pty Limited Toondah Harbour Development

Brisbane Marketing is the city's economic development board, a wholly-owned subsidiary of Brisbane City Council, playing a key role in the ongoing evolution and success of the city. Brisbane Marketing is responsible for major events, foreign direct investment, Brisbane's Convention Bureau, profiling Brisbane as an international education destination and serving as the Regional Tourism Organisation (RTO) for Brisbane, Logan, Ipswich, Scenic Rim, Lockyer Valley, Moreton Bay, Redlands and Somerset Local Government Areas.

I am writing to advise of Brisbane Marketing's support for the Toondah Harbour Project (reference number 2017/7939), a joint initiative of Walker Group Holdings Pty Ltd, Redland City Council and Economic Development Queensland (EDQ). I encourage the Federal Government to allow this important project to progress to scientific investigations that will enable an EIS to be prepared.

Brisbane Marketing has engaged with the project proponents in our role as the RTO, and considering the agencies' core responsibilities, we understand that the project has the ability to be a major catalyst for further tourism investment, job creation and economic value for the region.

Specifically, the following benefits and opportunities that could be realised should this important project progress include:

1. **Catalyst for further tourism investment**
   Tourism plays a significant role in the Brisbane economy. With over $9 billion of private capital currently being invested or mooted in tourism related infrastructure and major projects, the sector is contributing strong economic growth. The $1.3 billion Toondah Harbour revitalization project, will provide an important catalyst that can deliver more demand generating tourism product, leading to opportunities for increased tourism visitation.

2. **Stronger connectivity to Moreton Bay & Redlands region**
   An opportunity exists to provide more strategic and direct access to the natural tourism assets including Moreton Bay Island and North Stradbroke Island. An improved and environmentally sustainable connection between Brisbane CBD and the Moreton Bay and Redlands region will deliver enhanced products and experiences to national and international visitors. The Toondah Harbour revitalisation will significantly elevate the current infrastructure, from a baron industrial facility to a cosmopolitan and activated precinct.

3. **Access to the region's natural assets**
   In 2016, Brisbane realised over 7 million visitors, with international visitors increasing by 9.4% since 2015. This growth has been generated by the strong increase in leisure visitation from China. Tourism Australia research clearly articulates that this significant inbound growth market is largely motivated to visit Australia for the aquatic and coastal environment, natural beauty and wildlife. The delivery of the Toondah Harbour development will enable Brisbane and the region to showcase our world-class natural assets and improves the visitor experience.

4. **Significant economic value driver**
   Tourism is a significant driver of Brisbane region's economy, contributing $6.3 billion to GDP and employing a total 64,700 people, or 5.5% of total jobs in the region. Beyond the tourism sector's existing value, the visitor economy has significant growth potential with current forecasts to 2020 indicating that the sector is capable of realising total visitor expenditure growth of 104% and an increased work force of over 80,000 people by 2020. Coupled with significant private investment in the pipeline, the Toondah Harbour development enables this sector's growth and visibility, and will be a major driver of new employment.

Brisbane Marketing is highly encouraged by Walker Group Holdings Pty Ltd proposal to develop Toondah Harbour and the potential for it to unlock further private investment in the tourism sector, improve connectivity to the region's existing natural assets and be a major catalyst for job creation and economic prosperity.

We strongly encourage the Federal Government to view this development on its favourable merits and allow the project to progress to the next stage of environmental investigations.

Should you have any questions please do not hesitate to contact Oriana Wyrozebska, Senior Manager Investment Attraction (Tourism Infrastructure) from my team on +61 7 3006 6266 or owyrozebska@brisbanemarketing.com.au.

Kind regards,

John Aitken (1)
CHIEF EXECUTIVE OFFICER

CC: Peter Saba, General Manager Development, Walker Corporation
CC: Mayor Karen Williams, Redland City Council

FOI 180804
Document 12

From: Barker, James
To: s22
Cc: de Brouwer, Gordon; Knudson, Dean; Cahill, Matt; Gowland, Kynan; s22 Papps, David; Taylor, Mark; Taylor, Hilton; Richardson, Geoff; Oxley, Stephen; s22
Subject: RE: Toondah Harbour, TPs [SEC=UNCLASSIFIED]
Date: Thursday, 8 June 2017 1:04:56 PM
Attachments: 2017-7939 Comms-referral decision-talking points.docx

---

Hi s22

As discussed, enclosed are some talking points, contingent on the Minister making a controlled action decision (in MS17-000774).

Happy to discuss of course.

Thanks
James

From: Barker, James
Sent: Tuesday, 6 June 2017 4:06 PM
To: s22 @environment.gov.au>
Cc: de Brouwer, Gordon <Gordon.deBrouwer@environment.gov.au>; Knudson, Dean <Dean.Knudson@environment.gov.au>; Cahill, Matt <Matt.Cahill@environment.gov.au>; s22 @environment.gov.au>; s22 @environment.gov.au>; Papps, David <David.Papps@environment.gov.au>; Taylor, Mark <Mark.Taylor@environment.gov.au>; Taylor, Hilton <Hilton.Taylor@environment.gov.au>; Richardson, Geoff <Geoff.Richardson@environment.gov.au>; Oxley, Stephen <Stephen.Oxley@environment.gov.au>; s22 @environment.gov.au>
Subject: RE: 3rd Toondah Brief [SEC=UNCLASSIFIED]

Hi s22

I've now put through a 3rd brief for Toondah Harbour (also enclosed). This brief is not time critical. This brief is contingent on the Minister's making a decision on MS17-000774 (the 'controlled action' decision brief).

Thanks
James

s22

s22

s22

TALKING POINTS

TOONDAH HARBOUR DEVELOPMENT

- I have decided that the proposed Toondah Harbour Development needs to undergo a comprehensive environmental assessment under national environment law.
  - I made this decision because I consider the proposal is likely to have a significant impact on the Moreton Bay wetland, and nationally listed threatened and migratory species.
- The proponent, the Walker Group, will now be required to undertake the detailed environmental assessment, before I decide whether or not the proposal can go ahead.
  - There will be an opportunity for public comment during the assessment of the project.
  - The environmental assessment will allow for a detailed examination of the likely environmental impacts, measures to avoid, mitigate and offset those impacts, and the economic and social benefits.
- Further information about the assessment process will be published on the Department of Environment and Energy's website, as the assessment proceeds.

If asked why the <u>original 2015</u> referral was withdrawn

- Walker Group originally referred this proposal in 2015.
- In May 2017, Walker withdrew their original referral and submitted a new proposal.
- The main change in the new proposal is to reduce the size of the development to increase a buffer between the development and the shorebird roost site at the adjacent Cassim Island.

If asked how the development will <u>impact the wetland</u>

- Walker Group's referral nominated the proposal as likely to have significant impacts on the wetland and habitat for migratory birds.
- These impacts will now be further examined through the more detailed assessment that Walker Group must now undertake.

Contact Officer: James Barker
Phone: s22

Last updated: 8 June 2017

If asked about the Ramsar Convention

- Australia is required by the Ramsar Convention to protect internationally listed wetlands, which include the Moreton Bay Ramsar site.
- The environmental impact assessment will consider likely impacts on the Ramsar site.

BACKGROUND

- Walker Group is proposing to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, sourth of Brisbane.
- The proposal was referred on 11 May 2017 and replaces their earlier referral for substantively the same project.
- The main change to the new proposal is to reduce the size of the development which will increase the buffer between the development and the shorebird high tide roost site at Cassim Island.
- The proposed development area is 73 hectares, approximately 50 hectares of this is within the Moreton Bay Ramsar wetland. The proposal includes approximately 40 hectares of land reclamation within the wetland.
- In June 2013, at the request of Redland City Council, the Queensland State Government declared Toondah Harbour a Priority Development Area (PDA) under the Queensland *Economic Development Act 2012*. As a result, the PDA is excempt from the standard planning and development assessment processes and will be assessed by Economic Development Queensland against the PDA Development Scheme.

Community Response

- 180 public submissions and 1,238 campaign were received during the public comment period on the referral. Four of these submissions supported the proposed development.

Contact Officer: James Barker
Phone: s22

Last updated: 8 June 2017

DEPARTMENT OF THE ENVIRONMENT AND ENERGY

PDR: MS17-000774

Copy to:
Secretary
Mr Knudson
Mr Cahill
Mr Papps
Mr Oxley
Mr Taylor
s22 [redacted]

Chief of Staff
s22 [redacted]

To: Minister for the Environment and Energy (For Decision)

REFFERAL DECISION - TOONDAH HARBOUR DEVELOPMENT, QUEENSLAND (EPBC 2017/7939)

Through: Matt Cahill, First Assistant Secretary, Environment Standards Division.

Timing: 8 June 2017 - statutory timeframe.

Office of the Minister for the Environment and Energy 06 JUN 2017

Recommendation:			
s47C [redacted] that you decide that the Toondah Harbour Development Queensland (EPBC 2017/7939) referral is a controlled action and that you sign the brief at **Appendix A**.			
RECEIVED 09 JUN 2017 MaPS			**Signed / Not signed**
Minister:			Date: 8/6/17
Comments:			
Clearing Officer: Sent: 5/06/17	James Barker	Assistant Secretary, Assessments and Governance Branch	Ph: 02 6274 2694 Mob: s22 [redacted]
Contact Officer:	s22 [redacted]	Director, Queensland Assessments North	Ph: 6274 s22 [redacted]

Key Points:

1. This brief is provided for you to consider whether or not further assessment of the Toondah Harbour Development (EPBC 2017/7939) is required under the *Environment Protection and Biodiversity Conservation Act 1999*.

2. The project proposes to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane. The proposal will involve the excavation of a new marina and land reclamation within Moreton Bay Ramsar wetland.

3. The Department recommends that you decide that the proposed action is likely to have a significant impact on: a Ramsar wetland of international importance, listed threatened species and communities and listed migratory species for the reasons outlined in the brief at **Appendix A**.

Appendix

A: Referral Decision Brief and Attachments

DEPARTMENT OF THE ENVIRONMENT AND ENERGY

MS17-000774

To: Minister (for decision)

Referral Decision Brief – Toondah Harbour Development, Queensland (EPBC 2017/7939)

Through: Matt Cahill, First Assistant Secretary, Environment Standards Division.

Timing: 8 June 2017 - statutory timeframe.

Recommended Decision	**NCA** ☐ **NCA(pm)** ☐ **CA** ☒
Designated Proponent	Walker Group Holdings Pty Ltd 81 001 215 069
Controlling Provisions triggered or matters protected by particular manner	World Heritage (s12 & s15A) Yes ☐ No ☒ No if PM ☐ National Heritage (s15B & s15C) Yes ☐ No ☒ No if PM ☐ Wetlands (Ramsar)(s16 & s17B) Yes ☒ No ☐ No if PM ☐ Threatened Species & Communities (s18 & s18A) Yes ☒ No ☐ No if PM ☐ Migratory Species (s20 & s20A) Yes ☒ No ☐ No if PM ☐ C'wealth marine (s23 & s24A) Yes ☐ No ☒ No if PM ☐ Nuclear actions (s21 & s22A) Yes ☐ No ☒ No if PM ☐ C'wealth land (s26 & s27A) Yes ☐ No ☒ No if PM ☐ C'wealth actions (s28) Yes ☐ No ☒ No if PM ☐ GBRMP (s24B & s24C) Yes ☐ No ☒ No if PM ☐ A water resource – large coal mines and CSG (s24D & s24E) Yes ☐ No ☒ No if PM ☐ C'wealth heritage o/s (s27B & s27C) Yes ☐ No ☒ No if PM ☐
Public Comments	Yes ☒ No ☐ Number: 180 individual and 1238 campaign. See Attachment N.
Ministerial Comments	Yes ☒ No ☐ Who: Queensland Department of Environment and Heritage Protection. See Attachment I.
Assessment Approach Decision	Yes ☐ No ☒ Bilateral Applies ☐

Recommendations:

1. Consider the information in this brief, the referral (Attachment A) and other the information in the attachments.

Considered / Please discuss

2. Agree with the recommended decision.

Agreed / Not agreed

3. If you agree to 2, indicate that you accept the reasoning in the departmental briefing package as the basis for your decision.

Accepted/Please discuss

4. Agree to the designated proponent.

Agreed / Not agreed

5. Agree to stop the clock on the assessment approach decision to allow time for the Queensland Government to confirm whether the project can be assessed under the bilateral agreement with the Commonwealth.

Agreed / Not agreed

6. Sign the notice at <u>Attachment B</u> (which will be published if you make the recommended decision).

Signed / Not signed

7. Sign the letters at <u>Attachment C</u> advising the proponent and relevant parties of your decision.

Signed / Not signed

8. Sign the draft statement of reasons at <u>Attachment D</u> having made any modification you consider necessary to ensure that the statement reflects your reasoning (we have provided this in anticipation of requests for it from third parties).

Signed / Not signed

Minister for the Environment and Energy,
The Hon Josh Frydenberg MP

Date: 8/6/7

Comments:

<u>BACKGROUND:</u>

Description of the referral

1. Toondah Harbour is an existing marine area that serves as the base for water taxi, passenger and ferry services between the mainland and North Stradbroke Island. Walker Group Holdings Pty Ltd (the proponent) is proposing to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 kilometres (km) south of Brisbane. The proposal will involve the excavation of a new marina and reclaiming land within the adjoining Moreton Bay Ramsar wetland. The Toondah Harbour project is proposed to be delivered in stages over a 15 to 20 year period.

2. The key components of the proposal are:

- project area of 73 hectares, of which approximately 50 hectares is within the Moreton Bay Ramsar wetland;
- approximately 40 hectares of reclamation within Moreton Bay Ramsar wetland;
- new ferry terminals to improve access to North Stradbroke Island;
- mixed use development including residential, retail, commercial and tourism uses;
- a marina;
- public open space and boardwalks providing foreshore access; and
- dredging of the existing Toondah Harbour marine access channel to allow for safe navigation for all vessels.

3. A referral for the project (Attachment A) was submitted under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 11 May 2017. The statutory timeframe for a decision under the EPBC Act is 8 June 2017.

4. In its referral, the proponent stated its belief that the proposal is a controlled action for the purposes of the EPBC Act and will likely have a significant impact on the ecological character of the Moreton Bay Ramsar wetland, listed threatened species and ecological communities, and listed migratory species. The proponent has stated in the referral that there are no alternatives to the location and footprint of the action.

State approval process

5. In June 2013, at the request of Redland City Council, the Queensland State Government declared Toondah Harbour a Priority Development Area (PDA) under the *Economic Development Act 2012* (Qld). As a result, the PDA is exempt from the standard planning and development assessment processes and will be assessed by Economic Development Queensland against the PDA Development Scheme. The proponent has stated that it intends to seek a declaration of the project as a 'coordinated project' under the *State Development and Public Works Organisation Act 1971* (Qld).

6. If you agree to the recommended decision, the Department will seek further information from the Queensland State Government regarding the state assessment process for the project. Subject to that advice, it may be that the project can be assessed under the bilateral agreement or, if not, your delegate will make a decision on the assessment approach.

RECOMMENDED DECISION:

7. Under section 75 of the EPBC Act you must decide whether the action that is the subject of the referral is a controlled action, and which provisions of Part 3 (if any) are controlling provisions for the action. In making your decision you must consider all adverse impacts the action has, will have, or is likely to have, on the matter protected by each provision of Part 3. You must not consider any beneficial impacts the action has, will have or is likely to have on the matter protected by each provision of Part 3.

8. The Department recommends that you decide that the proposed action is likely to have a significant impact on:

- the ecological character of the Moreton Bay Ramsar site (sections 16 and 17B);
- listed threatened species, including marine turtles and the critically endangered Eastern Curlew (sections 18 and 18A); and
- listed migratory species, including the dugong (sections 20 and 20A).

Ramsar wetlands

9. The Moreton Bay Ramsar site is located in and around Moreton Bay, east of Brisbane in Queensland (Attachment E). The Ramsar wetland supports extensive intertidal areas of sand and mud flat habitats, seagrass, mangroves and saltmarsh that provide vital habitat for dugongs, turtles and waterbirds including significant populations of migratory shorebirds. The wetland supports more than 50,000 migratory waders. At least 43 species of wading birds use the intertidal habitats, including 30 migratory species listed on international conservation agreements.

10. In addition, Moreton Bay is one of only two Ramsar sites in Australia that supports the critically endangered Eastern Curlew throughout the year, with juvenile birds not migrating until they are 2-3 years old. The ecological character of the Moreton Bay Ramsar wetland is described in *Ecological Character Description – Moreton Bay Ramsar Site* (Attachment F) and *Information sheet on Moreton Bay Ramsar Site* (Attachment G).

11. The proposed development area is immediately adjacent to and within the Moreton Bay Ramsar site.

12. The referral states that it is likely that the proposed action will result in significant impacts on the ecological character of a portion of the Moreton Bay Ramsar wetland. In particular, the proposed action will permanently remove an area of the Ramsar wetland through approximately 40 hectares of land reclamation and is likely to negatively impact the ecological character of the wetland.

13. Advice from the Department's Wetland Section (Attachment H) considers that direct impacts to the ecological character of the wetland will occur as the proposed action will result in:

- areas of the wetland within the referral area being removed or substantially modified through dredging, excavation and/or land reclamation activities;
- impacts on habitat values through the removal of seagrass, mangroves and intertidal mudflats;
- impacts on the lifecycle of an ecologically significant proportion of the population of the Eastern Curlew and Bar-Tailed Godwit, as well as other listed migratory species, such as Whimbrels and Grey-Tailed Tattler, through the removal of, or disturbance to, foraging and roosting habitat in or near the referral area; and
- changes in the hydrological regime of the wetland and consequent changes to water quality and aquatic habitats from sedimentation.

14. The referral lacks detail on the proposed development, such as the size of the marina, the number of apartments, the height of buildings and the extent of dredging required to upgrade the channel. The referral has not considered indirect impacts from the proposed action such as light pollution, the potential for increased weeds and domestic animals, and human traffic. In addition, advice from the Department's Wetland Section concludes that the impacts on the ecological character of the site will be difficult to mitigate and offset.

15. Although the referral states that a buffer zone will be included between the development and the mangroves and high tide roosting site at Cassim Island, it does not provide sufficient information for the Department to be confident that this will reduce the impacts on migratory shorebirds.

16. The Department therefore concludes that the proposed action is likely to have a significant impact on the ecological character of the Moreton Bay Ramsar wetland.

Listed migratory species

17. The Department's Environment Reporting Tool (ERT) indicates that a total of 72 listed migratory species may occur within two kilometres of the proposed action (Attachment J). Based on the location of the action and likely habitat present in the area of the proposed action, the Department considers that significant impacts are likely in relation to the following matters:

Listed migratory shorebirds

18. The referral notes that habitat used by migratory shorebirds for foraging or roosting within Toondah Harbour and roosting habitat adjoining the project area are characterised as 'important habitat' for migratory shorebirds under the *EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance*.

19. Eleven migratory shorebirds were recorded within or immediately adjacent to the project area during the proponent's field surveys. These include:

- Grey-tailed Tattler (*Tringa brevipes*);
- Ruddy Turnstone (*Arenaria interpres*);
- Great Knot (*Calidris tenuirostris*) (also listed as critically endangered);
- Red-necked Stint (*Calidris ruficollis*);
- Bar-tailed Godwit (*Limosa lapponica baueri*) (also listed as vulnerable)
- Whimbrel (*Numenius phaeopus*);
- Eastern Curlew (*Numenius madagascariensis*) (also listed as critically endangered);
- Terek Sandpiper (*Xenus cinereus*); and
- Curlew Sandpiper (*Calidris ferruginea*) (also listed as critically endangered).

20. Migratory shorebirds use two different habitat types within or adjacent to the project area, namely intertidal mudflats that provide feeding habitat when exposed at low tide, and stands of mangrove trees, offshore sandbars and shoreline saltmarsh and claypan areas that provide high tide roost sites.

21. The referral states that the proposed action is likely to have both direct and indirect impacts on migratory shorebirds through clearing of approximately 40 hectares of foraging

habitat for dredging and land reclamation, and disturbance during construction including changes to water quality during dredging and reclamation works. However, the referral also states that the project area is not considered to be a major foraging site in terms of diversity or numbers of migratory shorebirds as similar habitat is found throughout Moreton Bay, and the project site provides less than 0.001% of feeding habitat within the Ramsar wetland. As outlined below, the Department considers that the loss of this foraging habitat, combined with the indirect impacts of the proposal, is likely to have a significant impact on migratory shorebirds.

22. Surveys undertaken by the proponent mapped large areas of intertidal foraging habitats in the project area, comprising areas of mudflat, sandflat, seagrass and areas of surface coral rubble, and two high tide roost sites directly adjacent to the project area (Figure 2, Attachment 3 of Attachment A).

23. Important roosting sites - Cassim Island and Nandeebie Claypan - are in close proximity to the proposed action. It is likely that the proposed action will have indirect impacts on these roosting sites, including noise and visual disturbance as a result of increased human use of the area.

24. Survey results provided in the referral (Attachment A) confirmed that Cassim Island, located approximately 100 meters east of the project boundary, and the Nandeebie Claypan, immediately south of the project area, are important roosting habitat for migratory shorebirds based on the relatively large total numbers of migratory shorebirds using these roost sites. Up to 920 migratory shorebirds of four species known to roost in mangrove trees were recorded at Cassim Island, while up to 1,060 migratory shorebirds were recorded roosting at the Nandeebie Claypan.

25. The *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (2013) and the *EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (2017) provide that a proposed action will be likely to have a significant impact on migratory species where the proposal will substantially modify, destroy or isolate an area of important habitat for migratory species.

26. The proposed action will reduce the area of occupancy for migratory shorebird species by removing approximately 40 hectares of foraging habitat; adversely affecting important roosting habitat and modifying, destroying, isolating and decreasing the availability and quality of habitat through indirect impacts such as light, noise and human interaction.

27. In addition to the above, advice received from the Department's Migratory Species Section (Attachment H) concluded that the proposed action will seriously disrupt the lifecycle (feeding, migration and resting behaviour) of an ecologically significant population of the Eastern Curlew and Bar-tailed Godwit, as well as other listed migratory species, such as Whimbrels and Grey-tailed Tattlers, through the removal of, or disturbance to, foraging and roosting habitat in or near the referral area. Additional impacts will result from linking important offshore roosting sites with the mainland as it will interfere with the recovery of the Eastern Curlew by removing important habitat and causing an increase in ongoing disturbance.

Other Migratory species

28. Moreton Bay supports important foraging populations of Green, Hawksbill and Loggerhead Turtles and is close to the southern-most extent of their range. The *Marine*

Bioregional Plan for the Temperate East Marine Region (2012) (Attachment K) considered Moreton Bay a significant feeding ground for the Green Turtle.

29. Advice from the Department's Migratory Species Section (Attachment H) considers that light pollution, vessel disturbance and habitat modification (though dredging and infrastructure/coastal development) are known threats to migratory marine species. The Department considers it likely that the proposed action will increase these threats to migratory marine species and reduce the area of occupancy of the species.

30. Based on this advice and other information available to the Department, such as the Species Profile and Threats database and information from the referral documentation, the Department considers that the proposed action is likely to have significant impacts on other migratory species such as:

- Loggerhead Turtle *(Caretta caretta)*;
- Green Turtle *(Chelonia mydas)*;
- Hawksbill Turtle *(Eretmochelys imbricata);*
- Indo-pacific Humpback Dolphin (*Sousa chinensis*); and
- Dugong (*Dugong dugon*).

Listed threatened species and communities

31. The Department's Environment Reporting Tool (ERT) identifies 57 threatened species and one ecological community may occur within two kilometres of the proposed action (see the ERT report at Attachment J). Based on the location of the action and likely habitat present in the area of the proposed action, the Department considers a number of these species will be impacted by loss of marine, intertidal and terrestrial habitat as well as light and noise disturbance during construction and operation of the project. The Department considers that significant impacts are likely in relation to the following matters:

Eastern Curlew (*Numenius madagascariensis*) – critically endangered

32. The Department has considered the likelihood of direct and indirect impacts, the importance of habitat in, and immediately adjacent to, the project area and the lack of adequate mitigation and management measures to minimise these impacts and concluded that the proposed action is likely to have a significant impact on the critically endangered Eastern Curlew.

33. The critically endangered Eastern Curlew occurs seasonally around the Australian coastline, with up to 3500 birds estimated to visit Moreton Bay (9% of the flyway population). The Eastern Curlew habitat in the Moreton Bay wetland is internationally important as it supports more than 1% of the individuals in a population of the migratory Eastern Curlew (*EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (2017)).

34. The project site contains intertidal foraging habitat for the Eastern Curlew with seven individuals recorded during 2015 surveys (Attachment A). Important roosting sites, the Nandeebie Claypan and Cassim Island, are also immediately adjacent to the project area with up to 180 Eastern Curlew having been recorded at the Nandeebie Claypan roosting site (Attachment 6 of Attachment A). Although there are a number of available roost sites

for the Eastern Curlew within the region, the Nandeebie Claypan is considered by the Department to be an important site within Moreton Bay (Attachment 6 of Attachment A).

35. The referral proposes a buffer zone of 100 to 200 metres between the development and the mangroves and high tide roosting site at Cassim Island. However, the referral does not provide adequate information on whether they would be sufficient to manage the impacts to the Eastern Curlew. The *Conservation Advice for Numenius madagascariensis (Eastern Curlew)* (2015) states that the species is easily disturbed by human interaction within 250m.

36. The Department considers that as the proposed action will substantially modify, destroy and isolate an area of habitat for the Eastern Curlew it is likely to have a significant impact on the species.

Other listed species

37. The Department's ERT identifies the potential presence of additional threatened species or communities within two kilometres of the proposed action area. Based on information available to the Department and the nature of the proposed action that includes removal of onshore vegetation, intertidal mudflats and seagrass bed that provide habitat for threatened species, the Department considers that the proposed action is likely to have significant impacts on other threatened species such as:

- Great Knot (*Calidris tenuirosris*) – critically endangered
- Curlew Sandpiper (*Calidris ferruginea*) – critically endangered
- Bar-tailed Godwit (*Limosa lapponica baueri*) – vulnerable;
- Koala (*Phascolarctos cinereus*) (combined populations of Qld, NSW and the ACT) – vulnerable;
- Grey-headed Flying-fox (*Pteropus poliocephalus*) – vulnerable;
- Loggerhead turtle *(Caretta caretta)* – endangered;
- Green Turtle *(Chelonia mydas)* – vulnerable; and
- Hawksbill Turtle *(Eretmochelys imbricate)* – vulnerable.

PROTECTED MATTERS THAT ARE NOT CONTROLLING PROVISIONS:

World Heritage properties	The ERT did not identify any World Heritage properties located within or adjacent to the proposed action area, therefore this controlling provision does not apply.
National Heritage places	The ERT did not identify any National Heritage places located within or adjacent to the proposed action area, therefore this controlling provision does not apply.
Commonwealth marine environment	The proposed action does not occur in the vicinity of a Commonwealth marine environment therefore this controlling provision does not apply.
Commonwealth action	The referring party is not a Commonwealth agency, therefore this controlling provision does not apply.
Commonwealth land	The proposed action is not being undertaken on Commonwealth land therefore this controlling provision does not apply.
Nuclear action	The proposed action does not meet the definition of a nuclear action as defined in the EPBC Act therefore this controlling provision does not apply.
Great Barrier Reef Marine Park	The proposed action is not located in the vicinity of the Great Barrier Reef Marine Park, therefore this controlling provision does not apply.
Commonwealth Heritage places overseas	The proposed action is not located overseas, therefore this controlling provision does not apply.
A water resource, in relation to coal seam gas development and large coal mining development	The proposed action is not a coal seam gas or a large coal mining development, therefore this controlling provision does not apply.

SUBMISSIONS:

Public submissions

38. The proposal was published on the Department's website on 11 May 2017 and public comments were invited until 25 May 2017. 180 public submissions, including from the Ramsar Secretariat, and a further 1,238 campaign submissions were received during the public consultation period. Attachment N provides a summary of the public submissions.

39. The submissions raised issues including the following:

- unacceptable impacts of 40 ha of land reclamation within a Ramsar wetland;
- impacts to migratory shorebirds, seagrass, koalas, turtles and Dugongs;
- Australia's need to meet its obligations as a party to international agreements to protect migratory birds and Ramsar wetlands;
- impacts related to pollution from dredge spoil;

- the proposed development is not critical infrastructure – the local community would like to see an upgrade to the ferry terminal but do not support the construction of a marina and housing development; and
- the Ramsar Secretariat advised that the Moreton Bay Ramsar site will be placed under Article 3.2 notification. Under Article 3.2 of the Ramsar Convention "Each Contracting Party shall arrange to inform the Ramsar Secretariat…at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference".

Comments from Commonwealth Ministers

40. By letter dated 11 May 2017, the following ministers were invited to comment on the referral:

    - Senator The Hon Nigel Scullion, Minister for Indigenous Affairs
    - The Hon Darren Chester MP, Minister for Infrastructure and Transport

41. No comments were received in response to that invitation.

Comments from State Ministers

42. By letter dated 11 May 2017, the delegate for the Queensland Minister for Environment and Heritage Protection, the Hon Dr Steven Miles MP, was invited to comment on the referral. The response stated that the proposal will not be assessed using the EIS process in Chapter 3 of Queensland's *Environmental Protection Act 1994*. The response also stated that the Queensland Department of State Development reviewed the referral documentation and advised that the Coordinator-General has not received a request for declaration of this proposal as a coordinated project under Part 4 of the *State Development and Public Works Organisation Act 1971*.

ASSESSMENT APPROACH:

43. If you agree that the action is a controlled action, you must decide on the approach for assessment in accordance with section 87 of the EPBC Act. Noting that the proponent intends to lodge a formal application for declaration of the proposal as a coordinated project under Part 4 of the *State Development and Public Works Organisation Act 1971* (Qld) and the potential for assessment under the bilateral agreement, the Department recommends that this decision is postponed and made by your delegate, once the Queensland government confirms the state assessment approach.

OTHER MATTERS FOR DECISION-MAKING:

Precautionary principle

44. In making your decision under section 75, you are required to take account of the precautionary principle (section 391). The precautionary principle is that a lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage. A controlled action decision will require any uncertainties in the referral (e.g. around the potential effectiveness of mitigation measure and availability of offsets) to be clarified through further detailed assessment.

Bioregional Plans

45. In accordance with section 176(5), you are required to have regard to a bioregional plan in making any decision under the Act to which the plan is relevant. The *Marine Bioregional Plan for the Temperate East Marine Region (2012)* (Attachment J) is relevant to the proposed action.

Consultation and handling

46. The Wildlife, Heritage and Marine Division, Wetlands, Policy and Northern Water Branch, General Counsel Branch were consulted and provided advice in the preparation of this brief.

James Barker
Assessments and Governance Branch
Ph: 02 6274 2694
Mob: s22 [redacted]

Attachments

A: Referral

B: Decision notice FOR SIGNATURE

C: Letter to Walker Group Holdings FOR SIGNATURE

Letter to Queensland Minister for Environment and Heritage FOR SIGNATURE

Letter to Queensland Deputy Premier FOR SIGNATURE

Letter to Minister for Infrastructure and Development FOR SIGNATURE

Letter to Minister for Indigenous Affairs FOR SIGNATURE

Letter to Minister for Trade, Tourism and Investment FOR SIGNATURE

D: Statement of Reasons FOR SIGNATURE

E: Maps of project area, regional context, Ramsar site boundary.

F: Ecological Character Description – Moreton Bay Ramsar Site (Final Report)

G: Information sheet on Moreton Bay Ramsar Site (June 1999) http://www.environment.gov.au/water/topics/wetlands/database/pubs/41-ris.pdf

H: Line Area Advice:

Wetlands Section Advice

Migratory Species Section Advice

I: Submission from EHP

J: Department's Environmental Reporting Tool

K: Marine Bioregional Plan for the Temperate East Marine Region (2012)

L: Summary of public submissions

Australian Government
Department of the Environment and Energy

FOI 180804
Document 14a

Notification of
REFERRAL DECISION AND DESIGNATED PROPONENT – controlled action

Toondah Harbour Development, Queensland (EPBC 2017/7939)

This decision is made under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

proposed action	The development of a mixed use residential, commercial, retail and tourism precinct, including new ferry terminals and a marina at Toondah Harbour south of Brisbane, Queensland, as described in the referral received by the Department on 11 May 2017 [see EPBC Act referral 2017/7939].
decision on proposed action	The proposed action is a controlled action.
relevant controlling provisions	• Wetlands of international importance (sections 16 & 17B) • Listed threatened species and communities (sections 18 & 18A) • Listed migratory species (sections 20 & 20A)
designated proponent	Walker Group Holdings Pty Limited ABN: 8100 121 5069
Person authorised to make decision	
Name and position	The Hon Josh Frydenberg MP Minister for the Environment and Energy
Signature	
date of decision	8 June 2017

Australian Government

Department of the Environment and Energy

FOI 180804
Document 14b

Statement of Reasons for a Decision that an Action is a Controlled Action under the *Environment Protection and Biodiversity Conservation Act 1999*

I, Josh Frydenberg MP, Minister for the Environment and Energy, provide the following statement of reasons for my decision of 8 June 2017, under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), that the proposed action by Walker Group Holdings Pty Ltd to redevelop the existing facilities, including construction of a marina, new ferry terminals and residential development at Toondah Harbour, south of Brisbane, Queensland (EPBC 2017/7939)[1], is a controlled action under Part 7 of Division 2 of the EPBC Act and the controlling provisions for the action are sections 16 and 17B (wetlands of international importance), sections 18 and 18A (listed threatened species and communities) and sections 20 and 20A (migratory species).

Legislation

1. Relevant legislation is at Annexure A.[2]

Background

2. Toondah Harbour is an existing marine area that serves as the base for water taxi, passenger and ferry services between the mainland and North Stradbroke Island. Walker Group Holdings Pty Ltd (the proponent) is proposing to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 kilometres (km) south of Brisbane. The proposal will involve the excavation of a new marina and reclaiming land within the adjoining Moreton Bay Ramsar wetland. The Toondah Harbour project is proposed to be delivered in stages over a 15 to 20 year period.

3. The key components of the proposal are:

   - A project area of 73 hectares, of which approximately 50 hectares is within the Moreton Bay Ramsar wetland;
   - approximately 40 hectares of reclamation within Moreton Bay Ramsar wetland
   - new ferry terminals to improve access to North Stradbroke Island;
   - mixed use development including residential, retail, commercial and tourism uses;
   - a marina;
   - public open space and boardwalks providing foreshore access; and
   - dredging of the existing Toondah Harbour marine access channel to allow for safe navigation for all vessels.

[1] The proposed action is described in further detail in the referral received by the Department on 11 May 2017.

[2] This legislation is provided as background and context and does not form part of my reasons.

4. A referral for the project was submitted under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 11 May 2017.

5. In its referral, the proponent stated its belief that the proposal is a controlled action for the purposes of the EPBC Act and will likely have a significant impact on the ecological character of the Moreton Bay Ramsar wetland, listed threatened species and ecological communities, and listed migratory species. The proponent has stated in the referral that there are no alternatives to the location and footprint of the action.

6. Under section 75 of the EPBC Act, I determined that the proposed action is a controlled action, due to likely significant impacts on the ecological character of the Moreton Bay Ramsar wetland, listed threatened species and communities and migratory species, and that the controlling provisions for the action are sections 16 and 17B, sections 18 and 18A and sections 20 and 20A.

Evidence or other material on which my findings were based

7. My decision under section 75 was informed by a recommendation brief prepared by officers of the Department of the Environment and Energy, which had the following attachments:

A: Referral

B: Decision notice FOR SIGNATURE

C: Letter to Walker Group Holdings FOR SIGNATURE

Letter to Queensland Minister for Environment and Heritage FOR SIGNATURE

Letter to Minister for Infrastructure and Development FOR SIGNATURE

Letter to Minister for Indigenous Affairs FOR SIGNATURE

Letter to Minister for Trade, Tourism and Investment FOR SIGNATURE

D: Statement of Reasons FOR SIGNATURE

E: Maps of project area, regional context, Ramsar site boundary.

F: Ecological Character Description – Moreton Bay Ramsar Site (Final Report)

G: Information sheet on Moreton Bay Ramsar Site (June 1999)
http://www.environment.gov.au/water/topics/wetlands/database/pubs/41-ris.pdf

H: Line Area Advice:

Wetlands Section Advice

Migratory Species Section Advice

I: Submission from EHP

J: Department's Environmental Reporting Tool

K: Marine Bioregional Plan for the Temperate East Marine Region (2012)

L: Summary of public submissions

Public submissions

8. The proposal was published on the Department's website on 11 May 2017 and public comments were invited until 25 May 2017, in accordance with section 74(3) of the EPBC Act. 180 public submissions were received on the referral during the public comment period and a further 1,238 campaign submissions were received during the consultation period concluded

9. The issues raised in the public submissions including the following:

- unacceptable impacts of 40 ha of land reclamation within a Ramsar wetland;
- impacts to migratory shorebirds, seagrass, koalas, turtles and Dugongs;
- Australia's need to meet its obligations as a party to international agreements to protect migratory birds and Ramsar wetlands;
- impacts related to pollution from dredge spoil;
- the proposed development is not critical infrastructure – the local community would like to see an upgrade to the ferry terminal but do not support the construction of a marina and housing development; and
- the Ramsar Secretariat advised that the Moreton Bay Ramsar site will be placed under Article 3.2 notification. Under Article 3.2 of the Ramsar Convention "Each Contracting Party shall arrange to inform the Ramsar Secretariat... at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference".

Ministerial comments

10. By letter dated 11 May 2017, the following Ministers were invited to comment on the referral in accordance with section 74(1) of the EPBC Act:

- Senator, The Hon Nigel Scullion, Minister for Indigenous Affairs
- The Hon Darren Chester MP, Minister for Infrastructure and Transport

No comments were received in response to that invitation.

11. By letter dated 11 May 2017, the delegate of the Queensland Minister for Environment and Heritage Protection, the Hon Dr Steven Miles MP, was invited to comment on the referral in accordance with section 74(2) of the EPBC Act.

12. The delegate responsed stating that the proposal would not be assessed using the EIS process in Chapter 3 of Queensland's *Environmental Protection Act 1994*. The response also stated that the Queensland Department of State Development reviewed the referral documentation and advised that the Coordinator-General has not received a request for declaration of this proposal as a coordinated project under Part 4 of the *State Development and Public Works Organisation Act 1971*.

Findings on material questions of fact

13. In deciding whether the proposed action is a controlled action, and which provision of Part 3 of the EPBC Act are controlling provisions for the action (if any), I considered all adverse impacts the action has or will have or is likely to have on each matter protected by a provision of Part 3 of the EPBC Act. I did not consider any beneficial impacts that the proposed action has or will have, or is likely to have on each matter protected by a provision of Part 3 of the EPBC Act.

14. I considered that I had sufficient information to determine whether the proposed action is a controlled action and, if so, what provisions of Part 3 are controlling provisions for the action.

Ecological character of the Moreton Bay Ramsar wetland

15. The Moreton Bay Ramsar site is located in and around Moreton Bay, east of Brisbane in Queensland. The Ramsar wetland supports extensive intertidal areas of sand and mud flat habitats, seagrass, mangroves and saltmarsh that provide vital habitat for dugongs, turtles and waterbirds including significant populations of migratory shorebirds. The wetland supports more than 50,000 migratory waders. At least 43 species of wading birds use the intertidal habitats, including 30 migratory species listed on international conservation agreements.

16. In addition, Moreton Bay is one of only two Ramsar sites in Australia that supports the critically endangered eastern curlew throughout the year, with juvenile birds not migrating until they are 2-3 years old. I noted that the Eastern Curlew is a species recently identified for priority conservation in Australia's Threatened Species Strategy Action Plan 2015-16.

17. The referral stated that it is likely that the proposed action will result in significant impacts on the ecological character of a portion of the Moreton Bay Ramsar wetland. In particular, the proposed action will permanently remove an area of the Ramsar wetland through approximately 40 hectares of land reclamation which is likely to negatively impact the ecological character of the wetland.

18. The Department's Wetland Section advised that direct impacts to the ecological character of the wetland will occur as the proposed action will result in:

    - areas of the wetland within the referral area being removed or substantially modified through dredging, excavation and/or land reclamation activities;
    - impacts on habitat values through the removal of seagrass, mangroves and intertidal mudflats;
    - impacts on the lifecycle of an ecologically significant proportion of the population of the eastern curlew and bar-tailed godwit, as well as other listed migratory species, such as whimbrels and grey-tailed tattler, through the removal of, or disturbance to, foraging and roosting habitat in or near the referral area; and
    - changes in the hydrological regime of the wetland and consequent changes to water quality and aquatic habitats from sedimentation.

19. The referral lacks detail on the proposed development, such as the size of the marina, the number of apartments, the height of buildings and the extent of dredging required to upgrade the channel. The referral has not considered indirect impacts from the proposed action such as light pollution, the potential for increased weeds and domestic animals, and human traffic.

20. Although the referral states that a buffer zone will be included between the development and the mangroves and high tide roosting site at Cassim Island, it does not provide sufficient information to be confident that this will reduce the impacts on migratory shorebirds.

21. The Department advised that the proposed action is likely to have a significant impact on the ecological character of the Moreton Bay Ramsar wetland. In addition, advice from the Department's Wetland Section concludes that the impacts on the ecological character of the site will be difficult to mitigate and offset.

22. I agreed with the Department's advice in this regard.

23. Therefore, I concluded that the proposed action is likely to have a significant impact on the ecological character of the Moreton Bay Ramsar wetland.

Listed migratory species

24. The referral notes that habitat used by migratory shorebirds for foraging or roosting within Toondah Harbour and roosting habitat adjoining the project area are characterised as 'important habitat' for migratory shorebirds under the *EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance*.

25. Eleven migratory shorebirds were recorded within or immediately adjacent to the project area during the proponent's field surveys. These include:

- Grey-tailed Tattler (*Tringa brevipes*);
- Ruddy Turnstone (*Arenaria interpres*);
- Great Knot (*Calidris tenuirostris*) (also listed as critically endangered);
- Red-necked Stint (*Calidris ruficollis*);
- Bar-tailed Godwit (*Limosa lapponica baueri*) (also listed as vulnerable);
- Whimbrel (*Numenius phaeopus*);
- Eastern Curlew (*Numenius madagascariensis*) (also listed as critically endangered);
- Terek Sandpiper (*Xenus cinereus*); and
- Curlew sandpiper (*Calidris ferruginea*) (also listed as critically endangered).

26. Migratory shorebirds use two different habitat types within or adjacent to the project area, namely intertidal mudflats that provide feeding habitat when exposed at low tide, and stands of mangrove trees, offshore sandbars and shoreline saltmarsh and claypan areas that provide high tide roost sites.

27. The referral states that the proposed action is likely to have both direct and indirect impacts on migratory shorebirds through clearing of approximately 40 hectares of foraging habitat for dredging and land reclamation, and disturbance during construction including changes to water quality during dredging and reclamation works. However, the referral also states that the project area is not considered to be a major foraging site in terms of diversity or numbers of migratory shorebirds as similar habitat is found throughout Moreton Bay, and the project site provides less than 0.001% of feeding habitat within the Ramsar wetland. The Department considered that the loss of this foraging habitat, combined with the indirect impacts of the proposal, is likely to have a significant impact on migratory shorebirds.

28. Surveys undertaken by the proponent mapped large areas of intertidal foraging habitats in the project area, comprising areas of mudflat, sandflat, seagrass and areas of surface coral rubble, and two high tide roost sites directly adjacent to the project area.

29. The Department also noted that important roosting sites, Cassim Island and Nandeebie Claypan, are in close proximity to the proposed action. It is likely that the proposed action will have indirect impacts on these roosting sites, including noise and visual disturbance as a result of increased human use of the area.

30. The survey results provided in the referral that confirmed that Cassim Island, located approximately 100 metres east of the project boundary, and the Nandeebie Claypan, to the south of the project area, are important roosting habitat for migratory shorebirds based on the relatively large total numbers of migratory shorebirds using these roost sites. Up to 920 migratory shorebirds of four species known to roost in mangrove trees were recorded at Cassim Island, while up to 1,060 migratory shorebirds were recorded roosting at the Nandeebie Claypan.

31. The *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (2013) and the *EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (2017) provide that a proposed action will be likely to have a significant impact on migratory species where the proposal will substantially modify, destroy or isolate an area of important habitat for migratory species.

32. The proposed action will reduce the area of occupancy for migratory shorebird species by removing approximately 40 hectares of foraging habitat; adversely affecting important roosting habitat and modifying, destroying, isolating and decreasing the availability and quality of habitat through indirect impacts such as light, noise and human interaction.

33. The Department's Migratory Species Section advised that the proposed action will seriously disrupt the lifecycle (feeding, migration and resting behaviour) of an ecologically significant population of the Eastern Curlew and Bar-tailed Godwit, as well as other listed migratory species, such as Whimbrels and Grey-tailed Tattlers, through the removal of, or disturbance to, foraging and roosting habitat in or near the referral area. Additional impacts will result from linking important offshore roosting sites with the mainland as it will interfere with the recovery of the Eastern Curlew by removing important habitat and causing an increase in ongoing disturbance.

34. I agreed with the Department's advice and concluded that the proposed action is likely to have a significant impact on listed migratory shorebird species.

Other Migratory species

35. Moreton Bay supports important foraging populations of green, hawksbill and loggerhead turtles and is close to the southern-most extent of their range. The *Marine Bioregional Plan for the Temperate East Marine Region* (2012) considered Moreton Bay a significant feeding ground for the green turtle.

36. The Department's Migratory Species Section advised that light pollution, vessel disturbance and habitat modification (though dredging and infrastructure/coastal development) are known threats to migratory marine species. The Department considered it likely that the proposed action will increase these threats to migratory marine species and reduce the area of occupancy of the species.

37. Based on this advice and other information available to the Department, such as the Species Profile and Threats database and information from the referral documentation, the Department concluded that the proposed action is likely to have significant impacts on other migratory species such as:

- Loggerhead turtle *(Caretta caretta)*;
- Green Turtle *(Chelonia mydas)*;
- Hawksbill Turtle *(Eretmochelys imbricata);*
- Indo-pacific humpback dolphin (*Sousa chinensis*); and
- Dugong (*Dugong dugon*).

38. I agreed with the Department's advice.

39. In light of the matters set our in paragraphs 24 – 38, I concluded that the proposed action is likely to have a significant impact on listed migratory species.

Listed threatened species and communities

40. The Department advised that the likelihood of direct and indirect impacts, the importance of habitat in, and immediately adjacent to, the project area and the lack of adequate mitigation and management measures to minimise these impacts and concluded that the proposed action is likely to have a significant impact on the critically endangered eastern curlew.

41. The critically endangered eastern curlew occurs seasonally around the Australian coastline, with up to 3500 birds estimated to visit Moreton Bay (9% of the flyway population). The eastern curlew habitat in the Moreton Bay wetland is internationally important as it supports more than 1% of the individuals in a population of the migratory eastern curlew (*EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species 2017*).

42. The Department advised that the project site contains intertidal foraging habitat for the eastern curlew with seven individuals recorded during surveys undertaken in 2015. Important roosting sites, the Nandeebie Claypan and Cassim Island, are also immediately adjacent to the project area with up to 180 eastern curlew having been recorded at the Nandeebie Claypan roosting site. Although there are a number of available roost sites for the eastern curlew within the region, the Nandeebie Claypan is considered to be an important site within Moreton Bay.

43. I considered that the referral proposes a buffer zone of 100-200m between the development and the mangroves and high tide roosting site at Cassim Island. However, the referral does not provide adequate information on whether they would be sufficient to manage the impacts to the eastern curlew. The *Conservation Advice for Numenius madagascariensis* (eastern curlew) (2015) states that the species is easily disturbed by human interaction within 250m.

44. Based on information available to the Department and the nature of the proposed action that includes removal of onshore vegetation, intertidal mudflats and seagrass beds, the Department considers that the proposed action is also likely to have significant impacts on other threatened species such as:

- Great Knot (*Calidris tenuirosris*) – critically endangered;
- Curlew Sandpiper (*Calidris ferruginea*) – critically endangered;
- Bar-tailed Godwit (*Limosa lapponica baueri*) – vulnerable;
- Koala (*Phascolarctos cinereus*) (combined populations of Qld, NSW and the ACT) – vulnerable;
- Grey-headed Flying-fox (*Pteropus poliocephalus*) – vulnerable;
- Loggerhead turtle (*Caretta caretta*) – endangered;
- Green Turtle (*Chelonia mydas*) – vulnerable; and

- Hawksbill Turtle *(Eretmochelys imbricate)* – vulnerable.

45. In light of the matters set out in paragraphs 40 – 44, I agreed with the Department's that the proposed action was likely to have a significant impact on the Eastern Curlew and other listed threatened species.

World Heritage properties

46. The proposed action is unlikely to have a significant impact on world heritage values of a world heritage property, because the Department's Environmental Reporting Tool (ERT) did not identify any world heritage properties located within or adjacent to the proposed action area. Therefore, I decided that sections 12 and 15A cannot be controlling provisions for the action.

National Heritage places

47. The proposed action is unlikely to have a significant impact on national heritage values of a national heritage place, because the Department's Environmental Reporting Tool (ERT) did not identify any national heritage places located within or adjacent to the proposed action area. Therefore, I decided that sections 15B and 15C cannot be controlling provisions for the action.

Commonwealth marine environment

48. The proposed action is not being undertaken in a Commonwealth marine area.

49. The proposed action is unlikely to have a significant impact on the environment in a Commonwealth marine area, because it does not occur in the vicinity of a Commonwealth marine area.

50. For these reasons, I decided that sections 23 and 24A cannot be controlling provisions for the action.

Commonwealth action

51. The referring party is not a Commonwealth agency, therefore I decided section 28 cannot be a controlling provision for the action.

Commonwealth land

52. The proposed action is not being undertaken on Commonwealth land.

53. The proposed action is unlikely to have a significant impact on the environment on Commonwealth land because it is not being undertaken in the vicinity of Commonwealth land.

54. For these reasons, I decided that sections 26 and 27A cannot be controlling provisions for the action.

Nuclear action

55. The proposed action does not meet the definition of a nuclear action as defined in the EPBC Act. Therefore, I decided that sections 21 and 22A cannot be controlling provisions for the action.

Great Barrier Reef Marine Park

56. The proposed action is not being undertaken in the Great Barrier Reef Marine Park.

57. The proposed action is not being undertaken in the vicinity of the Great Barrier Reef Marine Park and, therefore, is unlikely to have a significant impact on the environment in the Great Barrier Reef Marine Park.

58. For these reasons, I decided that sections 24B and 24C cannot be controlling provisions for the action.

Commonwealth Heritage places overseas

59. The proposed action is not being undertaken outside the Australian jurisdiction. Therefore, I decided that sections 27B and 27C cannot be controlling provisions for this action.

A water resource, in relation to coal seam gas development and large coal mining development

60. The proposed action is not an action that involves coal seam gas or a large coal mining development. Therefore, I decided that sections 24D and 24E cannot be controlling provisions for this action.

Reasons for decision

61. I considered the information before me was adequate to make a decision under section 75 of the EPBC Act.

62. In making my decision I took account of submissions from relevant Commonwealth and State Ministers as well as the matters required to be taken into account under section 75 of the EPBC Act.

63. In making my decision, I took account of the precautionary principle (section 391 of the EPBC Act) which states that a lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage. I considered that a controlled action decision will require any uncertainties in the referral (e.g. around the potential effectiveness of mitigation measure and availability of offsets) to be clarified through further detailed assessment.

64. In view of my findings above, I was satisfied that the proposed action will, or is likely to have a significant impact on the ecological character of a declared Ramsar wetland (Moreton Bay), listed threatened species and listed migratory species.

65. I therefore decided that the proposed action is a controlled action and the controlling provisions are section 16 and 17B (wetlands of international importance), sections 18 and 18A (listed threatened species and communities) and sections 20 and 20A (migratory species).

Signed

....

JOSH FRYDENBERG

8 June 2017

Annexure A – Relevant EPBC Act provisions

Section 68 of the EPBC Act relevantly provides:

(1) A person proposing to take an action that the person thinks may be or is a controlled action must refer the proposal to the Minister for the Minister's decision whether or not the action is a controlled action.

(2) A person proposing to take an action that the person thinks is not a controlled action may refer the proposal to the Minister for the Minister's decision whether or not the action is a controlled action.

Section 75 of the EPBC Act relevantly provides:

(1) The Minister must decide:

(a) whether the action that is the subject of a proposal referred to the Minister is a controlled action; and

(b) which provisions of Part 3 (if any) are controlling provisions for the action.

Note: The Minister may revoke a decision made under subsection (1) about an action and substitute a new decision. See section 78.

(1AA) To avoid doubt, the Minister is not permitted to make a decision under subsection (1) in relation to an action that was the subject of a referral that was not accepted under subsection 74A(1).

Minister must consider public comment

(1A) In making a decision under subsection (1) about the action, the Minister must consider the comments (if any) received:

(a) in response to the invitation under subsection 74(3) for anyone to give the Minister comments on whether the action is a controlled action; and

(b) within the period specified in the invitation.

Considerations in decision

(2) If, when the Minister makes a decision under subsection (1), it is relevant for the Minister to consider the impacts of an action:

(a) the Minister must consider all adverse impacts (if any) the action:

(i) has or will have; or

(ii) is likely to have;

on the matter protected by each provision of Part 3; and

(b) must not consider any beneficial impacts the action:

(i) has or will have; or

(ii) is likely to have;

on the matter protected by each provision of Part 3.

Note: ***Impact*** is defined in section 527E.

(2A) For the purposes of subsection (2), if the provision of Part 3 is subsection 15B(3), 15C(5), 15C(6), 23(1), 24A(1), 24D(3), 24E(3), 26(1) or 27A(1), then the impacts of the action on the matter protected by that provision are only those impacts that the part of the action that is taken in or on a Commonwealth area, a Territory, a Commonwealth marine area or Commonwealth land:

(a) has or will have; or

(b) is likely to have;

on the matter.

(2AA) For the purposes of subsection (2), if the provision of Part 3 is subsection 24B(1) or 24C(1) or (3), then the impacts of the action on the matter protected by that provision are only those impacts that the part of the action that is taken in the Great Barrier Reef Marine Park:

(a) has or will have; or

(b) is likely to have;

on the matter.

(2B) Without otherwise limiting any adverse impacts that the Minister must consider under paragraph (2)(a), the Minister must not consider any adverse impacts of:

(a) any RFA forestry operation to which, under Division 4 of Part 4, Part 3 does not apply; or

(b) any forestry operations in an RFA region that may, under Division 4 of Part 4, be undertaken without approval under Part 9.

Designating a proponent of the action

(3) If the Minister decides that the action is a controlled action, the Minister must designate a person as proponent of the action.

Consent to designation

(4) The Minister may designate a person who does not propose to take the action only if:

(a) the person agrees to being designated; and

(b) the person proposing to take the action agrees to the designation.

Timing of decision and designation

(5) The Minister must make the decisions under subsection (1) and, if applicable, the designation under subsection (3), within 20 business days after the Minister receives the referral of the proposal to take the action.

Note: If the Minister decides, under subsection 75(1), that the action is a controlled action, the Minister must, unless the Minister has requested more information under subsection 76(3) or section 89, decide on the approach to be used for assessment of the relevant impacts of the action on the same day as the Minister makes the decision under subsection 75(1)—see subsection 88(2).

Time does not run while further information being sought

(6) If the Minister has requested more information under subsection 76(1) or (2) for the purposes of making a decision, a day is not to be counted as a business day for the purposes of subsection (5) if it is:

(a) on or after the day the Minister requested the information; and

(b) on or before the day on which the Minister receives the last of the information requested.

Running of time may be suspended by agreement

(7) The Minister and the person proposing to take the action may agree in writing that days within a period worked out in accordance with the agreement are not to be counted as business days for the purposes of subsection (5). If the agreement is made, those days are not to be counted for the purposes of that subsection.

Section 176 of the EPBC Act relevantly provides:

(1) The Minister may prepare a bioregional plan for a bioregion that is within a Commonwealth area. In preparing the plan, the Minister must carry out public consultation on a draft of the plan in accordance with the regulations.

(2) The Minister may, on behalf of the Commonwealth, co-operate with a State or a self-governing Territory, an agency of a State or of a self-governing Territory, or any other person in the preparation of a bioregional plan for a bioregion that is not wholly within a Commonwealth area.

(3) The co-operation may include giving financial or other assistance.

(4) A bioregional plan may include provisions about all or any of the following:

(a) the components of biodiversity, their distribution and conservation status;

(b) important economic and social values;

(ba) heritage values of places;

(c) objectives relating to biodiversity and other values;

(d) priorities, strategies and actions to achieve the objectives;

(e) mechanisms for community involvement in implementing the plan;

(f) measures for monitoring and reviewing the plan.

(4A) A bioregional plan prepared under subsection (1) or (2) is not a legislative instrument.

(5) Subject to this Act, the Minister must have regard to a bioregional plan in making any decision under this Act to which the plan is relevant.

391 Minister must consider precautionary principle in making decisions

Taking account of precautionary principle

(1) The Minister must take account of the precautionary principle in making a decision listed in the table in subsection (3), to the extent he or she can do so consistently with the other provisions of this Act.

Section 391 of the EPBC Act relevantly provides:

(2) The ***precautionary principle*** is that lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage.

Decisions in which precautionary principle must be considered

(3) The decisions are:

Decisions in which precautionary principle must be considered		
Item	**Section decision is made under**	**Nature of decision**
1	75	whether an action is a controlled action
2	133	whether or not to approve the taking of an action
3	201	whether or not to grant a permit
4	216	whether or not to grant a permit
5	238	whether or not to grant a permit

Decisions in which precautionary principle must be considered		
Item	**Section decision is made under**	**Nature of decision**
6	258	whether or not to grant a permit
6A	269AA	whether or not to have a recovery plan for a listed threatened species or a listed threatened ecological community
7	269A	about making a recovery plan or adopting a plan as a recovery plan
7A	270A	whether or not to have a threat abatement plan for a key threatening process
7B	270B	about making a threat abatement plan or adopting a plan as a threat abatement plan
8	280	about approving a variation of a plan adopted as a recovery plan or threat abatement plan
9	285	about making a wildlife conservation plan or adopting a plan as a wildlife conservation plan
10	295	about approving a variation of a plan adopted as a wildlife conservation plan
10A	303CG	whether or not to grant a permit
10AA	303DC	whether or not to amend the list of exempt native specimens
10B	303DG	whether or not to grant a permit
10C	303EC	about including an item in the list referred to in section 303EB
10D	303EN	whether or not to grant a permit
10E	303FN	about declaring an operation to be an approved wildlife trade operation
10F	303FO	about declaring a plan to be an approved wildlife trade management plan
10G	303FP	about declaring a plan to be an accredited wildlife trade management plan
10H	303GB	whether or not to grant an exceptional circumstances permit
11	316	about making a plan for managing a property that is included in the World Heritage List and is entirely within one or more Commonwealth areas
11A	324S	about making a plan for managing a National Heritage place

Decisions in which precautionary principle must be considered		
Item	**Section decision is made under**	**Nature of decision**
12	328	about making a plan for managing a wetland that is designated for inclusion in the List of Wetlands of International Importance kept under the Ramsar Convention and is entirely within one or more Commonwealth areas
13	338	about making a plan for managing a Biosphere reserve entirely within one or more Commonwealth areas
13A	341T	about endorsing a plan for managing a Commonwealth Heritage place
14	370	about approving a management plan for a Commonwealth reserve

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Document 14c

THE HON JOSH FRYDENBERG MP

MINISTER FOR THE ENVIRONMENT AND ENERGY

MS17-000774

The Hon Darren Chester MP
Minister for Infrastructure and Transport
Parliament House
CANBERRA ACT 2600

08 JUN 2017

Dear ~~Minister~~ Darren

This is to advise you of my decision on the referral of the proposed action, to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane.

As the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

The information that I have considered indicates that the proposed action is likely to have a significant impact on:

- wetlands of international importance (sections 16 & 17B)
- listed threatened species and communities (sections 18 & 18A)
- listed migratory species (sections 20 & 20A)

Please note that this decision only relates to the potential for significant impacts on matters protected by the Australian Government under Chapter 2 of the EPBC Act.

At this stage, a decision has not been made on the approach that must be used to assess the project.

Once a decision on the assessment approach has been made, a notice will be published on the Department's website.

A copy of the document recording this decision is enclosed.

Questions about the referral process or this decision, can be directed to the project manager, s22 [redacted] by email to s22 [redacted]@environment.gov.au, or telephone 02 6274 s22 [redacted]

Yours sincerely

Josh Frydenberg

FOI 180804
Document 14d

THE HON JOSH FRYDENBERG MP

MINISTER FOR THE ENVIRONMENT AND ENERGY

MS17-000774

The Hon Jackie Trad
Queensland Deputy Premier and
Minister for Infrastructure and Planning
PO Box 15009
CITY EAST QLD 4002

08 JUN 2017

Dear ~~Deputy Premier~~ Jackie

I am writing to advise you of my decision on the referral of the proposed action, to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane.

As the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

I note that the footprint of the proposed development is substantially within the Moreton Bay Ramsar wetland site and includes the permanent removal of an area of the wetland though the excavation of a marina and the approximately 40 hectares of land reclamation. The ecological character of this wetland is nationally and internationally protected under the Convention on Wetlands of International Importance (the Ramsar Convention).

The information that I have considered indicates that the proposed action is likely to have a significant impact on wetlands of international importance, and nationally listed threatened species and migratory species. A copy of the document recording this decision is enclosed.

Although I have decided that the proposed action will be assessed under the EPBC Act, I note that significant challenges remain in regard to the approval of this project. In particular, the requirement, under section 138 of the EPBC Act, that when deciding whether or not to approve the taking of an action, I must not act inconsistently with Australia's obligations under the Ramsar Convention. I would expect the more detailed environmental impact assessment process will consider these issues as well as other likely impacts of the proposal.

At this stage, a decision has not been made on the approach that must be used to assess the project. I have asked officials of the Department of the Environment and Energy to liaise with Queensland officials to determine whether this project can be assessed under the bilateral agreement between Queensland and the Commonwealth.

Questions about the referral process or this decision can be directed to the project manager, s22 [redacted]@environment.gov.au, telephone 02 6274 s22 [redacted]

I have also written to Queensland Minister for Environment and Heritage Protection, the Hon Steven Miles MP, to advise him of my decision.

Yours sincerely

Josh Frydenberg

THE HON JOSH FRYDENBERG MP

MINISTER FOR THE ENVIRONMENT AND ENERGY

MS17-000774

Senator the Hon Nigel Scullion
Minister for Indigenous Affairs
Parliament House
CANBERRA ACT 2600

08 JUN 2017

Nigel

Dear Senator

This is to advise you of my decision on the referral of the proposed action, to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane.

As the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

The information that I have considered indicates that the proposed action is likely to have a significant impact on:

- wetlands of international importance (sections 16 & 17B)
- listed threatened species and communities (sections 18 & 18A)
- listed migratory species (sections 20 & 20A)

Please note that this decision only relates to the potential for significant impacts on matters protected by the Australian Government under Chapter 2 of the EPBC Act.

At this stage, a decision has not been made on the approach that must be used to assess the project.

Once a decision on the assessment approach has been made, a notice will be published on the Department's website.

A copy of the document recording this decision is enclosed.

Questions about the referral process or this decision, can be directed to the project manager, s22 [redacted] by email to s22 [redacted] @environment.gov.au, or telephone 02 6274 s22 [redacted]

Yours sincerely

Josh Frydenberg

THE HON JOSH FRYDENBERG MP

MINISTER FOR THE ENVIRONMENT AND ENERGY

MS17-000774

08 JUN 2017

Mr Peter Saba
General Manager – Queensland Developments
Walker Group Holdings Pty Ltd
GPO Box 652
Brisbane QLD 4000

Dear Mr Saba

I am writing to advise you of my decision in relation to the Toondah Harbour Development, Queensland (EPBC 2017/7939) proposed by Walker Group Holdings Pty Ltd, which was referred for consideration under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

I note that the footprint of the proposed development is substantially within the Moreton Bay Ramsar wetland site and includes the permanent removal of an area of the wetland though the excavation of a marina and the approximately 40 hectares of land reclamation. The ecological character of this wetland is nationally and internationally protected under the Convention on Wetlands of International Importance (the Ramsar Convention).

I have decided under section 75 of the EPBC Act that the proposed action is a controlled action and, as such, it requires further assessment and a decision about whether approval for it should be given under the Act. A copy of the document recording this decision is enclosed. Please note that this decision only relates to the potential for significant impacts on matters protected by the Australian Government under Chapter 2 of the EPBC Act.

Although I have decided that the proposed action will be assessed under the EPBC Act, I note that significant challenges remain in regard to the approval of this project. In particular, the requirement, under section 138 of the EPBC Act, that when deciding whether or not to approve the taking of an action, I must not act inconsistently with Australia's obligations under the Ramsar Convention. I would expect the more detailed environmental impact assessment process will consider these issues as well as other likely impacts of the proposal.

I have asked my Department to liaise with the Queensland government to determine the particular assessment approach that will be used for this project, including whether it can be assessed under the bilateral agreement with Queensland.

Please note, under subsection 520(4A) of the EPBC Act and the *Environment Protection and Biodiversity Conservation Regulations 2000* your assessment is subject to cost recovery. A fee schedule will be provided to you once the decision on the assessment approach has been determined.

If you have any questions about the referral process or this decision, please contact the project manager, s22 [redacted] by email to s22 [redacted]@environment.gov.au, or telephone 02 6274 s22 [redacted]

Yours sincerely

Josh Frydenberg

FOI 180804
Document 14g

THE HON JOSH FRYDENBERG MP

MINISTER FOR THE ENVIRONMENT AND ENERGY

MS17-000774

The Hon Steven Ciobo MP
Minister for Trade, Tourism and Investment
Parliament House
Canberra ACT 2600

08 JUN 2017

Dear Minister

This is to advise you of my decision on the referral of the Toondah Harbour Development to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina. I am writing to you as this project has been granted 'Tourism Major Project Facilitation' status.

As the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

The information that I have considered indicates that the proposed action is likely to have a significant impact on:

- wetlands of international importance (sections 16 & 17B)
- listed threatened species and communities (sections 18 & 18A)
- listed migratory species (sections 20 & 20A)

Please note that this decision only relates to the potential for significant impacts on matters protected by the Australian Government under Chapter 2 of the EPBC Act.

At this stage, a decision has not been made on the approach that must be used to assess the project.

Once a decision on the assessment approach has been made, a notice will be published on the Department's website.

A copy of the document recording this decision is enclosed.

Questions about the referral process or this decision, can be directed to the project manager, [redacted] by email to [redacted]@environment.gov.au, or telephone 02 6274 [redacted]

Yours sincerely

Josh Frydenberg

THE HON JOSH FRYDENBERG MP

MINISTER FOR THE ENVIRONMENT AND ENERGY

MS17-000774

08 JUN 2017

The Hon Dr Steven Miles
Minister for Environment and Heritage Protection
GPO Box 2454
BRISBANE QLD 4001

Dear Minister Steven

I am writing to advise you of my decision on the referral of the proposed action, to develop a mixed use residential, commercial, retail and tourism precinct including new ferry terminals and a marina at Toondah Harbour, 30 km south of Brisbane.

As the Minister for the Environment and Energy, I have decided under section 75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that the proposed action is a controlled action and, as such, it requires assessment and a decision about whether approval for it should be given under the EPBC Act.

I note that the footprint of the proposed development is substantially within the Moreton Bay Ramsar wetland site and includes the permanent removal of an area of the wetland though the excavation of a marina and the approximately 40 hectares of land reclamation. The ecological character of this wetland is nationally and internationally protected under the Convention on Wetlands of International Importance (the Ramsar Convention).

The information that I have considered indicates that the proposed action is likely to have a significant impact on wetlands of international importance, and nationally listed threatened species and migratory species. A copy of the document recording this decision is enclosed.

Although I have decided that the proposed action will be assessed under the EPBC Act, I note that significant challenges remain in regard to the approval of this project. In particular, the requirement, under section 138 of the EPBC Act, that when deciding whether or not to approve the taking of an action, I must not act inconsistently with Australia's obligations under the Ramsar Convention. I would expect the more detailed environmental impact assessment process will consider these issues as well as other likely impacts of the proposal.

At this stage, a decision has not been made on the approach that must be used to assess the project. I have asked officials of the Department of the Environment and Energy to liaise with

Queensland officials to determine whether this project can be assessed under the bilateral agreement between Queensland and the Commonwealth.

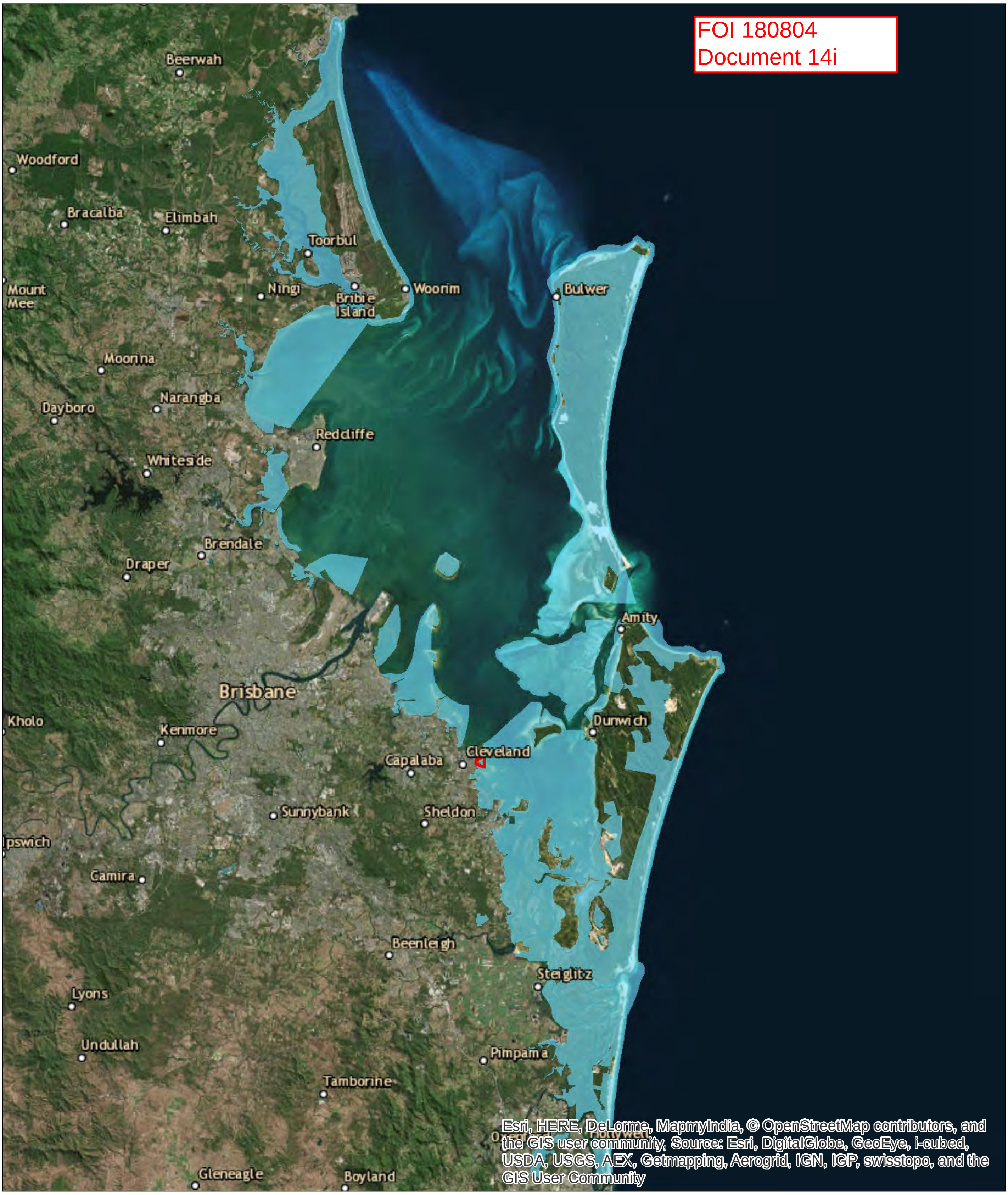
Questions about the referral process or this decision, can be directed to the project manager, s22 by email to s22 @environment.gov.au, or telephone 02 6274 s22

I have also written to Queensland Deputy Premier, the Hon Jackie Trad, to advise her of my decision.

Yours sincerely

Josh Frydenberg

FOI 180804
Document 14i



Legend

PDA Toondah Harbour

Moreton Bay RAMSAR wetland

Figure 1 *Site Context*

File ref. 8444 E Site Context A
Date *20/04/2017*
Project *Toondah Harbour*

0 5 10 20 *Kilometers*

N

Scale (A4): 1:575,379 [GDA 1994 MGA Z56]

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Layer Sources QLD GIS Layers (QLD Gov. Information Service 2014)

Legend

PDA Toondah Harbour

Referral Area

Indicative Dredge Area

Figure 2 *Site Aerial*

File ref. 8444 E Site Aerial E
Date *11/05/2017*
Project *Toondah Harbour*

0 50 100 200 300 *Meters*

N

Scale (A4): 1:8,000 [GDA 1994 MGA Z56]

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Layer Sources QLD GIS Layers (QLD Gov. Information Service 2014)

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"Where will our knowledge take you?"

Moreton Bay Ecological Character Description

Final Report

December 2008

Queensland Government
Environmental Protection Agency

Ecological Character Description – Moreton Bay Ramsar Site

FINAL REPORT

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Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Project Manager :	Greg Fisk
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Client Contact:	s22
Client Reference	

Title :	Ecological Character Description – Moreton Bay Ramsar Site
Author :	Greg Fisk, Darren Richardson s47F , s47F , s47F , s47F r, s47F
Synopsis :	This report comprises the Ecological Character Description (ECD) for the Moreton Bay Ramsar site. Prepared in accordance with the draft National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands, the report identifies the critical services, components and processes of the site and identifies limits of acceptable change, knowledge gaps and monitoring requirements in relation to these critical elements.

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Photos that appear in the Report are supplied by BMT WBM or the Queensland Environmental Protection Agency unless otherwise noted. Figures that have been reproduced (without modification) from other sources have been referenced accordingly.

Disclaimer: In undertaking this work the authors have made every effort to ensure the accuracy of the information used. Any conclusions drawn or recommendations made in the report are done in good faith and take no responsibility for how this information and report are used subsequently by others. Note also that the views expressed, and recommendations provided in this report are those of the report authors and do not necessarily reflect those of the persons or organisations that have contributed their views or other materials.

Use of terms and information sources: All definitions and terms used in this report were correct at the time of production in October 2008. The version of the *Draft National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* used in preparing this ECD was dated January 2008.

Within this report, the conservation status of a species may be described as *endangered, vulnerable, rare, migratory, near threatened* or *least concern wildlife*. These terms are used in accordance with the provisions of the Queensland *Nature Conservation Act 1992* (NC Act) and its regulations and amendments, and/or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Threatened is a common term used to collectively describe *Endangered* and *Vulnerable* species.

The terms *shorebirds* and *waders* are generic terms used to describe both resident and migratory species from the following families: Scolopacidae; Burhinidae; Haematopodidae; Recurvirostridae; Charadriidae; and Glareolidae.

The term waterbird refers to waterbird species found predominantly on freshwater ecosystems in Australia from the six major orders Anseriformes (ducks, geese and Black Swan), Podicipediformes (grebes), Pelecaniformes (Australian Pelican and cormorants), Ciconiiformes (herons, ibis, spoonbills and bitterns), Gruiformes (cranes, rails, crakes and gallinules), and Charadriiformes (waders and terns) (after Kingsford & Norman 2002).

Citation: When finalised, this report can be cited as follows:

BMT WBM. (2008). Ecological Character Description of the Moreton Bay Ramsar Site. Prepared for the Queensland Environmental Protection Agency. Brisbane.

LIST OF ABBREVIATIONS:

ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
CAMBA:	China-Australia Migratory Bird Agreement
CEA	Community, Education and Awareness
CFISH	Commercial Fisheries Information System
CPUE	Catch per unit effort
CRL	Consolidated Rutile Limited
DEWHA	Department of Environment, Water, Heritage and the Arts
DPI&F:	Queensland Department of Primary Industries and Fisheries
EAC:	East Australian Current
ECD:	Ecological Character Description
EFO	Environmental Flow Objective
EHMP:	Ecosystem Health Monitoring Program
EPA:	Queensland Environmental Protection Agency
EPBC:	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
FHA	Fish Habitat Area
GAP	Global Action on Peatlands
GBRMPA	Great Barrier Reef Marine Park Authority
GCCC	Gold Coast City Council
HAT:	Highest Astronomical Tide
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
IUCN	International Union for Conservation of Nature
JAMBA:	Japan-Australia Migratory Bird Agreement
KMC:	Knowledge Management Committee
LAT:	Lowest Astronomical Tide
LAC:	Limit(s) of Acceptable Change
LTMP, CFISH, RFISH	Long Term Monitoring Program
MARPOL	International Convention for the Prevention of Pollution from Ships
MBSIA EMS	Moreton Bay Seafood Industry Association Environmental Management Sytstem
MHWS:	Mean High Water Springs
MNP	Marine National Park
NCA:	Queensland *Nature Conservation Act 1992*
NCR:	Queensland *Nature Conservation (Wildlife) Regulations 2006*
NES	National Environmental Significance
NRM:	Natural Resource Management
NSW NPWS	New South Wales National Parks and Wildlife Service
OUM	Office of Urban Management
ORV	Off road vehilces
PIFU	Planning and Information Forecasting Unit
QPW:	Queensland Parks and Wildlife (part of the Queensland EPA)
QWSG	Queensland Wader Study Group
RCC	Regional Coordination Committee
RE:	Regional Ecosystem
REDD:	Regional Ecosystem Description Database
RFISH	Recreational Fishing Information System
RIS:	Ramsar Information Sheet
ROKAMBA:	Republic of Korea- Australia Migratory Bird Agreement
ROP	Resource Operation Plan
SDR	Seagrass Depth Range
SEP	Scientific Expert Panel
SEQ	Southeast Queensland
SEQ HWP	Southeast Queensland Healthy Waterways Partnership

SEQROC	South East Queensland Regional Organisation of Councils
SEQTOLSMA	South East Queensland Traditional Owners Land and Sea Management Alliance
SGAP	Scoety for Growing Australian Plants
sp.:	Species (singular)
spp.:	Species (plural)
TSSC	Threatened Species Scientific Commuttee
UQ	University of Queensland
WASO	Water Allocation and Security Objective
WRP:	Water Resource Plan prepared under the *Queensland Water Act 2000*

1 EXECUTIVE SUMMARY

The Moreton Bay wetland aggregation is one of 65 wetland areas in Australia that have been listed as a wetland of international importance under the *Convention on Wetlands of International Importance especially as Waterfowl Habitat* or, as it is more commonly referred to, the Ramsar Convention (the Convention). Moreton Bay was listed as a Ramsar site under the Convention in 1993 in recognition of its outstanding coastal wetland values and features.

This report provides the first version of the Ecological Character Description (ECD) for the Moreton Bay Ramsar site. The report has been prepared in accordance with the *Draft National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (January 2008) hereafter referred to as the National Framework.

Following the methodology set out in the National Framework, Table 1-1 summarises the critical services/benefits provided by the Moreton Bay Ramsar site and the underlying critical ecosystem components and processes nominated by this ECD. The critical wetland services/benefits nominated were based on the attributes of the site as identified in the Ramsar Nomination Criteria as well as identifying critical cultural and provisioning services provided by the site in terms of human use. Together, these critical wetland components and processes provide the basis for the identified services/benefits to continue to be provided by the wetland in the future.

As part of this study, the digital Moreton Bay Ramsar site boundary has been updated in accordance with the Mapping Specifications and Guidelines promulgated under the Ramsar Convention by the Australian Government. The Moreton Bay Ramsar boundary is largely confined to nearshore estuarine waters within the Bay and extends over tidal lands that are State-owned or under aligned tenures where the long term management intent for the area is consistent or complementary with the objectives of the Ramsar Convention. In general terms, the site includes the waters and tidal wetlands of Pumicestone Passage, selective areas of the Western Bay, large areas of the Southern Bay including the Broadwater, and the banks and shoals of the Eastern Bay including the ocean beaches and marine areas immediately offshore from the barrier islands. Freshwater and transitional wetland areas within the boundaries of the site are found on the sand islands of Bribie, Moreton, North Stradbroke and South Stradbroke Islands.

A key feature of the Moreton Bay Ramsar site is its large size, the diversity of wetland habitats present within it and the connectivity between wetland habitat types in areas such as Pumicestone Passage and the Southern Bay which have complex mosaics of tidal flats, saltmarsh, mangroves and seagrass assemblages. While many wetlands such as mangroves and saltmarsh are well represented across the >1100 km^2 site, other wetland habitat features have much more localised distribution such as the peatlands of Eighteen Mile Swamp on North Stradbroke Island, the dune lakes and freshwater springs and streams on the sand islands, and coral reef communities in and around Peel Island.

Despite being situated at the doorstep of a growing major capital city, there are several important reference habitats within the site that are representative of the bioregion and remain in a near natural state. The six important reference habitat areas include seagrass and shoals, tidal flats, mangroves and saltmarsh, inshore coral communities, freshwater wetlands and ocean beaches and foredunes.

The ECD defines endangered and vulnerable wetland species associated with the site as critical ecosystem (or supporting) services. These include marine fauna such as turtles and dugong, two nationally-threatened freshwater fish species (Oxleyan pygmy perch and honey blue-eye), several wetland-dependant avifauna species, and selected wetland dependant non-avian species such as water mouse, Illidge's ant blue butterfly and acid frogs that are of high conservation value at National and/or International levels. Endangered wetland vegetation communities and flora species have also been identified on the Bay islands as a critical service/benefit.

In addition to these species, important populations (that address the 1% criterion within the Ramsar Nomination Criteria) are identified in relation to migratory and resident shorebird species.

Cultural and provisioning services/benefits identified as being significant in the context of the Ramsar site include commercially and recreationally important fisheries, the significance of the site to indigenous people, and the site's importance and use for research and education and for tourism and recreational uses.

The ten (10) critical services/benefits outlined in the ECD are underpinned by a range of wetland ecosystem processes and components. Key processes identified in the study include broad and local scale hydrodynamics and coastal processes, hydrology (particularly as it relates to groundwater interaction on the Bay islands and freshwater inflows into the Pumicestone, Western Bay and Southern Bay regions), water and sediment quality, energy and nutrient dynamics (primary productivity, nutrient and carbon cycling), climate, geomorphology and a range of biological processes (such as growth, reproduction, and feeding).

Critical ecosystem components include the 22 different wetland types identified in the Ramsar site (using the Ramsar wetland classification typology) which support its noteworthy wetland flora and fauna.

The study has sought to define the natural variability and limits of acceptable change for the critical services/benefits, components and processes identified in the ECD as they relate to the site's Nomination Criteria. A summary of the limits of acceptable change (LACs) is shown in Tables 1-2 to 1-4 which should be read together in assessing any changes to the ecological character of the site. Critical habitat types within the Ramsar area as well as specific wetland species of conservation significance (and the various wetland processes that underpin them) are the focus of the limits of acceptable change. As outlined in the tables, where there are insufficient data to set a limit of acceptable change with confidence, interim limits of acceptable change are supplied with a view to triggering management investigation and action to assess if a change to ecological character has or may occur.

The study has found that while there have been observable changes to the condition of wetland habitats in some areas of the site since nomination in 1993, these changes are not perceived by the study team or the advisory committees consulted as part of the study as representing a loss to any of the ten critical services/benefits that define ecological character.

Public awareness and management responses to impacts that have occurred in the 15 year period since nomination have been considerable. Significant investment has been made toward improvement of point-source water quality, intensive environmental monitoring and the preparation and implementation of many plans and strategies that ultimately aim to conserve environmental values of the Bay in a way that is consistent with the wise use paradigm of the Ramsar Convention

Recent or continuing impacts that are notable in the context of the site and may affect future ecological character are identified as disturbance/reduction in habitat quality for migratory shorebirds, decreasing water quality in the Southern and Western Bay areas, seagrass loss in Deception Bay and the Southern Bay (and its potential affect on fisheries, dugong and turtle populations) and increasing incidence and intensity of *Lyngbya* algal blooms.

Closely related to the discussion on impacts, a range of threatening processes and activities have been identified in the ECD based on a review of literature sources, the opinions and views of the advisory committees for the project and the expert opinion of the study team. While not exhaustive, key threats that have the potential to influence ecological character have been identified and assessed in terms of the future risk. Where possible this risk has also been assessed against the perceived effectiveness of the regulatory/management regime, with the risk of the threat to ecological character reduced where the regime is seen as effective or improving.

Key threat issues identified are (in no particular order of importance):

- Harmful interactions with wetland species;
- Sustainability of fishing and harvesting;
- Sediment and nutrient input into the Bay from point and non-point sources;
- Groundwater extraction;
- Urban encroachment into the Ramsar boundary and adjacent wetland areas;
- Significant changes to wetland ecosystem processes from major infrastructure/development projects;
- Oil spills or other large scale marine pollution incident; and
- Impact on coastal wetlands from climate-change induced sea level rise and related threats.

Information gaps, monitoring recommendations and recommendations in relation to communication education and awareness messages are also identified in the ECD. Thematic information gaps identified as being most important for future monitoring for the site include:

- Additional research and monitoring expenditure to establish an ecological character baseline for the near-natural representative habitats, particularly those more localised habitats within the Ramsar site such as the freshwater wallum habitats of the Bay islands, the Eastern Bay coral reefs and peatlands such as Eighteen Mile Swamp;
- The need for better information and data sets about the presence and natural history of critical wetland species and their habitat including for example, surveys of vulnerable and endangered plant species on the Bay islands, aquatic species such as Oxleyan pygmy perch and more systematic surveys of important avifauna species and populations;

- Better information and understanding about the natural variability of critical wetland fauna populations and key attributes and controls on those populations (including whether or not any non-avian fauna species meet the 1% population requirement in Ramsar Nomination Criterion 9);

- The ecological character thresholds of particular habitats and communities to changes in key attributes/controls such as water quality and hydrology need additional investigation. Noting that any interim limits of acceptable change stated in the ECD should be revised as improved information becomes available;

- Resilience of habitats, community structure and key species to acute or prolonged impacts from water quality degradation such as nutrient enrichment, increased levels of salinity and sedimentation/turbidity (eg. similar to the approach in ANZECC for toxicants); and

- Consultation and involvement of traditional owners of the Moreton Bay Ramsar site if a greater understanding of historic and contemporary wetland values of the site to indigenous people is to be obtained and appreciated.

Monitoring needs and recommendations presented in the ECD relate broadly to obtaining data to assess future changes to ecological character (as defined by the Nomination Criteria for the site) and corresponding critical services/benefits as they relate to wetland habitats, species and populations and the cultural services discussed above. Principally, these monitoring recommendations relate to:

- Broad-scale observation/monitoring to ensure each wetland type outlined in the ECD continues to be represented across the site;

- Wetland habitat extent monitoring (noting that a precursor to being able to do this will be to establish a better correlation between EPA wetland mapping and the Ramsar Classification System);

- Habitat condition monitoring (principally in the form of monitoring underlying wetland ecosystem processes such as water quality and hydrological process or surrogate biological indicators such as crab burrow density);

- More targeted surveys of the threatened flora and fauna species (perhaps on a five year or ten year basis) to assess presence/absence or population changes of noteworthy species or communities; and

- More regular counts of roosting and feeding shorebirds with a particular emphasis on those species that meet the 1% population criteria.

In making recommendations for future monitoring of the Ramsar site, the information gaps and monitoring needs identified in the ECD were also considered in the broader context of the Southeast Queensland Healthy Waterways Partnership's Ecosystem Health Monitoring Program (EHMP) and the monitoring program being implemented to assess the effect of proposed re-zoning of the Moreton Bay Marine Park by the Queensland EPA.

To ensure close alignment between these initiatives, a special sub-group of the Southeast Queensland Healthy Waterways Partnership Scientific Expert Panel (SEP) met several times with the consultant study team and the Knowledge Management Committee to workshop and discuss synergies and commonality between the existing and proposed monitoring programmes (refer Appendix A). A separate report outlining the outcomes of these discussions has been produced by BMT WBM (2008b) as part of the ECD project.

While specific priorities and methodologies for monitoring were not sought to be developed through the workshop process, the information collected provides a basis for the next phase of monitoring and sampling design under EHMP and other monitoring regimes that is cognisant of the important/significant habitats and species, key attributes and associated stressors and threats affecting the Moreton Bay Ramsar site.

Finally, in terms of communication, education and awareness messages, the critical elements of the Ramsar site nominated in this ECD that are perhaps not being fully articulated include:

- The importance of freshwater wallum and peatland wetland habitats on the Bay islands and adjacent to Pumicestone Passage and the unique aquatic fauna that exists in these areas such the Oxleyan pygmy perch, water mouse and acid frogs. This also includes the associated critical wetland flora and communities identified in this report (noting that significant work is needed by to better identify and survey the extent and values of these endangered and vulnerable communities and species);
- In keeping with the wise use paradigm of the Ramsar Convention, promotion of the diversity of sustainable wetland-based tourism and recreational values of the Ramsar site;
- The current state of fisheries resources and the need for continued conservation of fish habitat;
- The use and significance of the site to Indigenous people; and
- The importance of Moreton Bay for migratory shorebirds.

Table 1-1 Critical Services Summary

Critical Service/Benefit	Underlying Critical Components	Underlying Critical Processes
S1. The Moreton Bay Ramsar site contains a **diversity** of wetland habitat types that are **representative** of a major coastal wetland aggregation and in many areas show a high degree of **connectivity** between habitat types **S2.** Moreton Bay Ramsar site contains several critical **wetland habitat types.** For reporting purposes, reference sites have been selected within these critical habitat types that are in a **near natural state** and are **representative** of the habitat type within the broader biogeographic region **S3.** Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered **marine/aquatic fauna** **S4.** Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered **wetland-dependent terrestrial fauna** species **S5.** Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered **wetland flora** species and endangered and of concern **wetland regional ecosystems** **S6.** Moreton Bay Ramsar site supports significant **populations** (more than 20 000 in total and over 1% of the population size of particular populations) of **migratory and resident shorebirds** **S7.** The tidal fish habitats and fish and invertebrate populations of the Moreton Bay Ramsar site support valuable **recreational and commercial fishing** activities **S8.** Moreton Bay Ramsar site has important **cultural values and significance** to indigenous peoples **S9.** Moreton Bay Ramsar site is an important site for **research and education** **S10.** Moreton Bay Ramsar site provides and supports significant **tourism and recreational uses** in the region	**Wetland habitats,** including six near-natural reference habitats as follows (links to S2): • S2A Seagrass and shoals in the Eastern Banks area • S2B Tidal flats and associated estuarine assemblages within Pumicestone Passage • S2C Mangroves and saltmarsh in the Southern Bay • S2D Coral communities of the Eastern Bay • S2E Freshwater wallum and peatland habitats on the Bay islands • S2F Ocean beaches and foredunes on Moreton Island **Wetland-dependant fauna and flora species,** including: • Marine: dugongs, green and loggerhead turtles (link to S3) • Aquatic: Oxleyan pygmy perch and honey blue eye (link to S3) • Wetland-dependant terrestrial fauna species: Little tern, beach stone-curlew, Illidge's ant blue butterfly, Australian painted snipe, acid frogs, water mouse, Australasian bittern (link to S4) • Wetland-dependant terrestrial flora species: Vulnerable and Endangered flora species including swamp orchids, knotweed and swamp daisy (links to S5) Noteworthy **flora communities** within the Ramsar site that are endangered or of concern regional ecosystems (links to S5) Noteworthy **populations** of migratory and resident shorebirds (links to S6) **Fisheries** of recreational and commercial significance and their habitats (links to S7)	**Physical Coastal Processes.** Hydrodynamic controls on habitats through tides, currents, erosion and accretion **Hydrology.** Patterns of tidal inundation and freshwater flows to wetland systems **Groundwater.** For those wetlands influenced by groundwater interaction, the level of the groundwater table and groundwater quality **Energy and Nutrient Dynamics.** Primary productivity and the natural functioning of carbon and nutrient cycling processes **Biological Processes.** Important biological processes such as growth, reproduction, recruitment, migration and dispersal **Water Quality.** Water quality that provides aquatic ecosystem values within wetland habitats **Climate.** Patterns of temperature, rainfall and evaporation **Geomorphology.** Key geomorphologic/ topographic features of the site

Table 1-2 Summary of Limits of Acceptable Change

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	Criterion 1 is based on the site containing at least one particularly notable wetland habitat type, and this wetland type is maintained in natural or near-natural condition. **Wetland Types and Extent** The ECD/RIS list twenty-two (22) wetland types within the site (using the Ramsar Classification Methodology). An unacceptable change will have occurred if it can be demonstrated that one or more of these wetland types have been lost. **Wetland Condition** A change in natural or near-natural condition at one of the six (6) reference sites[1] or more broadly across that habitat type at a whole-of-site scale are defined as follows: • **Seagrass meadow** cover and extent has declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (Eastern Bay) or has resulted in measurable changes to the local population status of dugongs and green turtles, or fisheries stocks (all seagrass areas); • **Unvegetated intertidal flats** and associated microphytobenthos and marine fauna community structure has changed to such levels that it in the medium to long-term (>5 years), can no longer be considered to be in pristine or near-pristine condition (Pumicestone Passage) or has resulted in measurable changes to avifauna populations or fisheries stocks (all tidal flat areas); • **Mangrove and saltmarsh** habitat extent and community structure has changed to such levels that in the medium to long-term (>5 years), it can no longer be considered to be in pristine or near-pristine condition (Southern Bay) or has resulted in measurable changes to avifauna populations or fisheries stocks (all mangrove and saltmarsh areas); • **Coral community** and reef habitat structure has changed to such levels that in the medium to long-term (>5 years), it can no longer be considered to be in pristine or near-pristine condition (Eastern Bay coral communities) or has resulted in measurable changes to the extent or condition of the habitat (eg. coral dominated reefs algal dominated); • **Freshwater wallum** wetland **/peatland** habitat conditions have declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (North Stradbroke or Moreton Islands) or has resulted in measurable changes to the local population status of	**Habitat Extent** At a local scale, >10% change in habitat extent, relative to natural background variability, such that it results in measurable impacts at sub-km spatial scales, and causes measurable, medium-term (>2 to 5 years) flow-on effects to key species, communities or habitat at this spatial scale. **Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4

[1] These representative habitat types and locations have been selected on the basis of their role in ecosystem functioning across the site and are important habitats for threatened species, communities and populations that are relevant to other Criteria in the table.

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	threatened flora and fauna species or communities (see Criterion 2 below); • **Ocean beach and foredune** habitat conditions have declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (Moreton Island) or has resulted in measurable changes to the local population status of avifauna or nesting usage by avifauna and marine turtles (all ocean beaches and foredune areas).	
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	Criterion 2 is based on the site containing at least one vulnerable or endangered species or threatened ecological community. The ECD/RIS lists several species/communities within the site that meet this criterion which include: • Marine Species - dugongs, green and loggerhead turtles • Freshwater Fish - Oxleyan pygmy perch and honey blue eye • Avifauna - little tern, beach stone-curlew, painted snipe, Australasian bittern • Wetland-dependant non-avian fauna - Illidge's ant blue butterfly, acid frogs and water mouse • Nationally Endangered wetland flora species including several swamp orchids, knotweed and swamp daisy An unacceptable change will have occurred if it can be demonstrated that one or more of these threatened species or threatened communities is lost within the site. In particular, a change to character would be demonstrated if the following were to occur: • The wetland becomes unsuitable as habitat for one or more threatened species or community listed in this ECD; or • Threatened animal and plant species identified in the ECD no longer occur at the site.	**Species/Populations** Detectable decline in local abundance/population of the key species. See Wetland Species Ecosystem Process Indicators – Table 4-5
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	Criterion 3 is based on the site containing a large proportion of species that are not well represented in the wider region. An unacceptable change will have occurred if it can be demonstrated that there has been a reduction in the number of species occurring within the site, and that this has resulted in a loss in biodiversity within the bio-region. In this context, a change to character would be demonstrated if the following were to occur: • Habitats have become unsuitable for wetland flora or fauna species or populations listed in the critical services of this ECD (see Criterion 2) • Noteworthy animal and plant species identified in the ECD are no longer present (see Criterion 2) • Populations of noteworthy species (see Criterion 2 above) no longer recorded in previous abundances (i.e. possible loss of genetic diversity)	**Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4 **Species/Populations** See Wetland Species Ecosystem Process Indicators – Table 4-5

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	• Overall vertebrate fauna biodiversity is measurably and significantly reduced	
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	Criterion 4 is based on the site representing critical refugia for any species, and the site maintaining critical life-cycle processes for any species. An unacceptable change will have occurred if it can be demonstrated that the site no longer provides a refugia function for important flora and fauna species (see Criterion 2) or if critical life-cycle processes are no longer being supported. The following are considered to represent the key critical life-cycle functions in the Moreton Bay Ramsar site - • Feeding and nesting habitat for green and loggerhead turtles that could impact the local population • Feeding and breeding habitat for dugong that could impact the local population • Refuge habitat for freshwater fish of conservation significance that could impact the local population • Roosting habitat for migratory waterbirds that could impact the local population • Critical overwintering habitat and a flyway staging area (both northern and southern migration routes) for migratory waterbirds	**Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4 **Species/Populations** See Wetland Species Ecosystem Process Indicators – Table 4-5
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.	The site no longer supports the required abundance of waterbirds under this Criterion	That the total number of waterbirds at the site always exceeds 20,000 individuals Greater than 10% reduction in over a 10 year period of numbers of bar-tailed godwit, Eastern curlew, or Pacific golden plover which are surrogates for assessing shorebird abundance generally.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	The site no longer supports the 1% of individuals of populations for the key species in the ECD which are: • bar-tailed godwit • whimbrel • Eastern curlew • terek sandpiper • grey-tailed tattler • curlew sandpiper	Greater than 20% reduction in any three year period over five years for any of the eight migratory shorebird species (which exceed the 1% threshold).

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	• pied oystercatcher • Pacific golden plover • lesser sand plover	
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	Long term impacts on the sustainability of populations of important commercial and recreational species that occur within the site (or in adjacent areas of the Bay) including: • bream, flathead, whiting, luderick, mullet, tailor, mackerel, sharks, baitfish, eels, pink snapper and other key finfish species; • king, tiger, endeavour, banana, greasyback and school prawns; • blue swimmer, mud, red spot, spanner and coral crabs and Callianasid shrimp (yabbies); • squid, cuttlefish, gastropods, rock oysters, bivalves and *beche-de-mer*.	A long-term loss of fish/shellfish stocks, which results in the reduction in the sustainability of key Bay fisheries, should be considered a trigger for assessing potential changes to ecological character.
Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	Medium to long-term (>5 years) reduction in the extent or condition of wetlands or other areas and a corresponding measurable impact on important spawning, nursery or migration pathways for fisheries.	At a local scale, >10% change in habitat extent, relative to natural background variability, such that it results in measurable impacts at sub-km spatial scales, and causes measurable, medium-term (>2 to 5 years) flow-on effects to key species, life-stages, communities or habitat at this spatial scale. In assessing this interim LAC, attention should be given to assessing changes in the extent of mangroves, saltmarsh, seagrass and tidal flat environments, which represent key nursery habitats to many commercially important species within the site.

Table 1-3 Summary of Limits of Acceptable Change – Critical Habitats

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Seagrass	See 'Natural Variability' column	See below Turbidity/light	Variable across site. Refer to EHMP data.	n/d	*H. ovalis*: H1. Min. light requirement = 16% SI [P,Q] H2. Duration = >30 days at 0% SI [P,S] *Z. muelleri*: H3. Duration = >30 days at 5% SI [P,Q] H4. Critical thresholds = >30% SI [Q,R]; 0.9 Kd (m^{-1}) [P,R]; 10 mg/L [P,R] H5. If site values exceed levels in H1 to H4, use default baseline turbidity values at seagrass sites as default trigger values (see SDR sites below) [J]	S1, S2, S3, S6, S8
		Seagrass depth limit/range (SDR)		n/d	Medium term (>5 years) median SDR value should not fall below the following interim default SDR values [N]: H6. Pumicestone Passage HEV = -0.8 m H7. Pumicestone Passage SMD = -1.2 m H8. Deception Bay North SMD = -3m H9. Waterloo Bay HEV = -1.9m H10. Central Bay HEV/ SMD = -2.2m H11. Eastern Bay HEV = -3.5m H12. Eastern Bay SMD = -2.2m H13. Southern Bay HEV/ SMD = -1.3m	
		Long-term change in tidal hydraulics and sedimentation patterns (short to medium term)	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008)[A].	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H14. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background [B].	
Unvegetated tidal flats	Pumicestone Passage, Waterloo Bay, Bramble Bay, Eastern Banks.	Freshwater flows	Waterway-specific & highly variable over time. Baseline hydraulic conditions as per 'Existing-case' scenarios in Moreton WRP.	n/d Quantitative environmental flow requirements of key local species and habitats unknown	H15. As a minimum, compliance with EFOs outlined in Moreton WRP for Nodes A-E	S1, S2, S3, S4, S6, S8

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		Tidal hydraulics & sedimentation patterns (short to medium term)	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008) [A].	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H16. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background [B]	
		Long term (>50 years) changes to tidal inundation and sediment dynamics patterns & processes due to sea level rise	-0.22 mm/year change over last 26 years of data collection [C]	n/d Impacts dependent on sedimentation rate relative to sea level rise	H17. A change in frequency, duration & magnitude of tidal inundation between: • MHW and MSL; • MSL and MLW • MLW and LAT • Such that it results in >10% change (above background) in the extent of unvegetated habitat at these levels, and results in [B].	
		Spionidae and Capitellidae worm densities, and sediment TOC, as indicators of organic enrichment	Highly variable in space and time	n/d	Using methods as per ANZECC, assess whether the following are exceeded: H18. Interim high range – Capitellidae or Spionidae densities >1000 individuals per m^2 H19. Interim low range – n/d	
		Crab burrow densities. This is a potential non-destructive, rapid assessment technique for assessing potential changes in crab abundances, which may be linked to changes in ecosystem condition [U]			n/d. H20. There is a need to investigate (i) whether robust and cost-effective methods can be developed, and if so (ii) proceed to establish threshold criteria based on sampling of appropriate indicator species at a range of references sites.	
Mangroves and Saltmarsh	Southern Bay Pumicestone Passage Western Bay	Freshwater flows	H21. As a minimum, compliance with EFOs outlined in Moreton WRP for Nodes A-E (see also H15) plus nodes outlined in Logan WRP (Note G) and Gold Coast (Note A) WRPs. This should be assessed using SunWater IQQM models.			S1, S2, S7, S8
		Tidal hydraulics	H22. Refer to unvegetated flats, i.e. H16			
		Tidal inundation patterns	H23. Refer to unvegetated flats, i.e. H17			
		Crab burrow densities	n/d	n/d	H24. n/d. Refer to H20	
		Mangrove die-back extent	n/d	n/d	H25. n/d. There is a need to map the	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		and hypersaline areas			distribution and extent of mangrove die-back (aerial photography & ground-truthing) to establish existing conditions. Monitoring should be undertaken on a 5 year basis. H26. Salinity should not be > 40-50 g/L (low tide) to reduce the risk of impacts to mangrove health[V]. H27. Where ambient salinity exceeds levels in H26, & mangroves and saltmarsh are demonstrated to be in good condition, derive local trigger values based on ambient/background data. [J]	
Coral Communities (Eastern Bay)	Central and Eastern Bay – Myora, Peel Island, etc	Turbidity	<1, 1, 1 NTU [E]	n/d. Tolerance limits of most local species are largely unknown.	H28. Long-term (>5 day) average turbidity should not exceed >3 NTU [H] H29. Use default baseline conditions at coral reef sites as default interim trigger values for turbidity & other attributes [J]	S1, S2, S3, S8
		pH	8.2, 8.3, 8.4 [E]			
		TN	100, 120, 160 µg/L [E]			
		TP	5, 9, 12 µg/L [E]			
		Water temperature	12.5° to 32°C (Reef flat); 16 to 28°C (Moreton Bay surface waters [F]			
		Sedimentation rates (mg/cm^2/day) [G]	Peel Is = 2 to 32 Myora = 5.9 to 16.1	n/d Tolerance limits are: • highly species-specific. • not available for local species • dependent on duration & frequency of exposure to sedimentation Available baseline sedimentation data has limited temporal coverage (1 year).	H30. Sedimentation should not exceed background variability and lead to measurable impacts to coral communities [K]	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		Coral bleaching frequency & extent	n/d Incidence of coral bleaching is not reported in EHMP.	n/d	H31. The frequency & duration of bleaching events should not increase to such levels where measurable impacts to coral communities occur [K]	
		Reef community structure (cover of numerically dominant taxa)	Site specific, and variable in time for some macrophyte species. Refer to EHMP (2006) data for a description of baseline conditions.	n/d	H32. >5% loss in hard and/or soft coral cover > background temporal variability [L]	
Wallum freshwater wetlands	Bay Islands Pumicestone Passage	Groundwater hydrology	Waterway-specific & highly variable over time. Baseline hydraulic conditions as per 'Existing-case' scenarios in Logan WRP (& underlying modelling).	n/d	H33. As a minimum, compliance with EFOs outlined in future draft Logan WRP (North Stradbroke Island) [M] H34. No changes in water levels at Blue Lake, or the Blue Lake Overflow discharge channel, such that a detectable community or ecosystem change occurs [B]	S1, S2, S4, S5, S7
		Invertebrates	20th percentile: Taxa richness = 12 PET richness = 2 SIGNAL = 3.32	n/d	H35. No change in water quality or invertebrate biotic indices, outside the bounds of natural variability. Note that water quality and biotic indices show great change among different waterbodies, hence there is a need to derive local trigger values based on ambient/background data. [J]	
		pH [I]	Blue L. = 4.9 to 5.2 Brown L. = 4.6 to 5.0			
		EC (µS/cm) [I]	Blue L. = 90 Brown L.= 90			
		Secchi (m) [I]	Blue L. = 4.9 to 6.9 Brown L. = 0.7			
		DO (% saturation) [I]	Blue L. = 86 to 95 Brown L. = 90 to 99			
		Chlorophyll a (µg/L) [I]	Blue L. = 0.6 to 2.4 Brown L. = 14			
		TP (µg/L) [I]	Blue L. = 2 to 6 Brown L. = 15			
		Water Temp (deg C) [I]	Blue L. = 19 to 26			

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Brown L. = 19 to 26			
		Turbidity (NTU) [I]	Blue L. = <1 to 1			
			Brown L. = 9			
		Ammonia (μg/L) [I]	Blue L. = 2 to 7			
			Brown L. = 9			
		Total N (μg/L) [I]	Blue L. = 90 to 130			
			Brown L. = 500			
		NOX (μg/L) [I]	Blue L. = 6 to 37			
			Brown L. = 3			
Ocean beaches and foredunes	High-energy beaches and foredunes of Br bie, Moreton and North and South Stradbroke Islands	Long-term change in tidal hydraulics and sedimentation patterns (short to medium term) leading to change in beach morphology	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008)[A] or long term aerial photograph analysis.	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H36. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater, relative to background [B].	S1, S2, S3, S4, S7
		Groundwater inflows	Highly site-specific. Groundwater flows bring nutrients into the beach system and into the swash zone and control invertebrate and nearshore phytoplankton communities	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H37. No measurable medium term (>5 years) change to groundwater supply/flows into beach systems relative to background [B].	
		Density of *Pipis* or other indicator species linked to changes in ecosystem condition	Highly variable in space and time	n/d	H38. There is a need to establish threshold criteria based on sampling of appropriate indicator species at a range of references sites. Refer to H20.	

Table 1-4 Summary of Limits of Acceptable Change – Critical Species

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Oxleyan pygmy perch	Bay Islands, Pumicestone Passage	No long-term reduction in population densities of Oxleyan pygmy perch in waterbodies, outside the range of natural variability. No reduction in the total number of waterbodies inhabited by Oxleyan pygmy perch within the site.	pH	4.2 to 7.2 [A]	n/d No experimental determination of physiological tolerances All information on habitat preferences based on environmental conditions in which this species has been recorded	H39. Long term average should not >6.5 H40. If above this value, adopt 20th, 50th & 80th percentile values of reference site conditions in which population has been recorded. The 75th confidence limit should not be > these values.	S1, S2, S3
			Dissolved Oxygen	> 2 mg/L [B]		H41. Long-term median should not be <5 mg/L. If above this value, then adopt percentile values described in H40	
			Turbidity	Clear, tannin stained waters (1 to 300 NTU) [A, B]		H42. Long-term median should not > 1 NTU. If above this value, then adopt percentile values described in H40	
			EC/Salinity	<330 µS/cm [A]		H43. Long term average should not exceed 300 µS/cm. If above this value, then adopt percentile values descr bed in H40	
			Water levels	0.2 [A, B] to 5 [C] m, depending on water body characteristics. Mean weighted depth of captures = 0.63 m [A], whereas OPP Recovery Plan indicates most OPP captures in 0.3 to 0.4 m depth range [F].		H44. n/d. Trigger value may vary depending on particular requirements and local habitat conditions, i.e. avoidance of competition with eastern Gambusia or maintenance of fish passage. Local trigger values therefore need to be developed, although water depths <0.2 m unl kely to allow maintenance of OPP populations. H45. Drying. Where adjoining permanent refugia is absent, drying of a known habitat will cause local extinction at the site.	
			Groundwater hydrology	Low flow <0.3 m/sec [A]		H46. Flow <0.1 m/second. If >, then If above this value, then adopt percentile values described in H40	
			Emergent macrophyte cover and undercut banks	60-80% emergent macrophyte cover (typically sedges), undercut banks, woody debris & root masses.		H47. >50% reduction in emergent vegetation cover, above background variability, such that it results in such that it results in a measurable, short-term (1-5 years) flow-on effects to OPP populations and/or key ecosystem functions.	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Eastern Gambusia in freshwater reaches of Little Canalpin Ck.**	Absent in freshwater reaches, but found in lower estuarine/brackish environs	n/d	H48. Presence of Eastern Gambusia in Little Canalpin Creek represents a trigger for further investigation of viability of this sub-population.	
			Oxleyan pygmy perch abundance	This species has low population densities, hence empirical limits are difficult to set. On North Stradbroke Is., average CPUE is typically 0-0.6 individuals/trap /hour*.	n/d	H49. No fish recorded during >5 sampling events, using various combinations of sampling methods (e.g. box traps, electro-fishing and seine netting), should trigger further investigations of whether waterbody continues to provide suitable OPP habitat, and the identification of drivers for change.	
Honey blue-eye	Pumicestone Passage	No long-term reduction in population densities of honey blue-eye in waterbodies, outside the range of natural variability. No reduction in the total number of waterbodies inhabited by honey blue-eye within the site.	pH	4.4 to 6.8 [A]	n/d No experimental determination of physiological tolerances All information on habitat preferences based on environmental conditions in which this species has been recorded	H50. Long term median should not be >6.5, or if above this value: H51. Adopt 20th, 50th & 80th percentile values of reference site conditions as described in H40	S1, S2, S3
			Dissolved Oxygen	> 6.8 mg/L [A]		H52. Long-term median should not be <5 mg/L. H53. If background above this value, then adopt percentile values described in H40	
			Turbidity	Clear, tannin stained waters (<17 NTU) [A]		H54. Long-term median should not > 1 NTU. H55. If background above this value, then adopt percentile values described in H40	
			EC/Salinity	<900 µS/cm [A]		H56. Long term median should not exceed 700 µS/cm. H57. If background above this value, then adopt percentile values described in H40	
			Water levels	n/d		H58. n/d. Trigger value may vary depending on particular requirements, i.e. avoidance of competition with eastern Gambusia or maintenance of fish passage. Local trigger values need to be developed. H59. Drying. Where adjoining permanent refugia is absent, drying of a known habitat will cause local extinction at the site.	
			Groundwater hydrology	Low flow <0.3 m/sec [A]		H60. Median flow velocity <0.1 m/second. H61. If background above H22, then adopt percentile values using approach described in H40	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Emergent macrophyte cover and undercut banks	High aquatic plant cover, typically sedges [A]		H62. >50% reduction in emergent vegetation cover, above background variability, such that it results in such that it results in a measurable, short-term (1-5 years) flow-on effects to Honey Blue-eye populations and/or key ecosystem functions..	
			Honey blue-eye abundance	This species typically has low population densities [A], hence empirical limits are difficult to set.	n/d	H63. No fish recorded during >5 sampling events, using various combinations of sampling methods (e.g. box traps, electro-fishing and seine netting), should trigger further investigations of whether waterbody continues to provide suitable habitat, and the identification of drivers for change.	
Dugong	Eastern Bay Pumicestone Passage Southern Bay	Detectable decline in local abundance of dugong outside the range of natural variability	Turbidity, nutrients and chlorophyll *a*	Refer to seagrass indicators in Habitat Table 4-4			S1, S2, S3, S9
			Seagrass depth limit (and extent)	Refer to seagrass in Habitat Table 4-4			
			Dugong population densities	503 ± 63 (S.E) (July) to 1019 ± 166 (S.E) (December) individuals in 1995 (Lanyon 2003) [D]. Recent population modelling suggests local population size of ~970 ±75 animals [E]	n/d	H64. A decline in dugong abundance to <800 individuals for 2-3 successive years may represent a trigger for further investigation. Note however that these figures should be considered as indicative only, as there is insufficient available information on the population dynamics and genetics of dugongs to develop a reliable interim trigger value.	
Marine Turtles: green turtle loggerhead turtle	Eastern Bay Pumicestone Passage Southern Bay	Detectable decline in green and loggerhead turtles outside the range of natural variability	Turbidity, nutrients & chlorophyll *a*	Refer to seagrass indicators in Habitat Table 4-4			S1, S2, S3, S9
			Seagrass depth limit (and extent)	Refer to seagrass in Habitat Table 4-4			
			Green and loggerhead turtle population dynamics & breeding readiness	n/d	n/d	H65. n/d. Insufficient available information on the population dynamics, growth rates and breeding readiness of turtles to develop a reliable interim trigger value.	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Wallum Acid Frogs	Wallum habitats on Bay Islands and Pumicestone Passage	Significant population declines outside the range of natural variability in either of the four acid frog species	Water quality: • non-turbid • tannin-stained • oligotrophic (low nutrient) • naturally acidic	pH 3.0-5.5 as derived from dissolved organic acids leached from humus).	n/d	H66. Significant decline in the numbers of the four acid frog species for important populations on North Stradbroke and Moreton Islands.	S4
			Absence of predatory fish	n/d	n/d	H67. Presence of Eastern Gambusia may represent a threat to local populations	S4
			Wallum wetland vegetation	n/d	n/d	H68. Greater than 5% reduction over five years of wallum wetland vegetation cover.	S4
			Ground water hydrology and freshwater flows	n/d	n/d	H69. No long-term change in groundwater hydrology such that it causes alterations to water quality, water levels and wetland flora and fauna, outside the bounds of natural variation.	S4
Beach stone-curlew	Outer Bay islands, Pumicestone Passage, mangrove habitats of southern Moreton Bay.	Significant declines in key habitat areas	Mangroves and associated intertidal flats (roost and feeding); sandy beaches (feeding), foredunes (breeding sites)	n/d	n/d	H70. Lack of observation of beach stone-curlew in any three year period over five years within the following areas: Pumicestone Passage (Toorbul north to Bells Creek); Bulwer to North Point (Cape Moreton); Cape Cliff (Cape Moreton) to Eagers Creek; Little Sandhills to Mirapool Lagoon; Amity to Point Lookout; Peel Island; Jumpinpin (includes southern end tip of North Stradbroke Island and associated mangrove islands); western side of South Stradbroke Island.	S4
Water mouse	Pumicestone Passage, North Stradbroke Island, Southern Moreton Bay (e.g. Steiglitz, Jacobs Well, Pimpama River Conservation Area, Coomera River, & South Stradbroke Island).	Significant declines in the usage of nests and the diversity of nest types used.	Relatively large areas of intertidal flats in association with mangroves (feeding), marine intertidal invertebrate prey, supralittoral wetlands, including salt marsh and sedgelands (nesting sites)	n/d	n/d	H71. Greater than 20% reduction in the number of active/recently active water mouse nests or greater than 15% reduction in usage of any one of the diversity of nest types used (following Van Dyck and Gynther 2003) over five years for important populations associated with North Stradbroke Island, southern Moreton Bay (e.g. Macleay Island, Coomera & Pimpama Rivers, South Stradbroke Island) and Pumicestone Passage (e.g. Bribie Island, Donnybrook).	S4
			Tidal conditions	n/d	n/d	H72. Any detectable long-term change to tidal regimes at spatial scales >5 km.	S4

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Australian painted snipe	Freshwater swamps of outer Bay islands (e.g. 18 Mile Swamp).	Lack of records for any 10 year period.	Densely vegetated permanent of seasonal wetlands	n/d	n/d	H73. Loss of more than 20% of the extent of vegetated freshwater wetland habitat.	S4
Australasian Bittern	Freshwater swamps of outer Bay islands (e.g. 18 Mile Swamp).	Lack of records for any 10 year period.	Densely vegetated permanent of seasonal wetlands	n/d	n/d	H74. Loss of more than 20% of the extent of vegetated freshwater wetland habitat.	S4
Little Tern	Open waters of Bay, Caloundra sandbanks, beaches & sand spits of outer Bay islands, South Stradbroke Island.	Significant decline in abundance, outside the range of natural variability.	Nearshore and offshore open waters and rivers; water quality sufficient to support abundance of surface active baitfish; high-tide roost sites.	n/d	n/d	H75. Significant decline in the numbers of Little Tern, outside the range of natural variability, over five years as determined at key roost sites (e.g. northern Pumicestone Passage; South Stradbroke Island).	S4
Illidge's ant blue butterfly	Mangrove communities of Redland Bay, Hays Inlet, Fisherman Islands, outer Bay islands, and Coomera Island	Lack of records for any three year period.	Large areas of mangroves with mature trees bearing senescing limbs and dead branchlets which support the *Crematogaster* sp. ant; also adjacent supralittoral forests.	n/d	n/d	H76. Greater than 10% reduction over five years of mangrove cover and associated intertidal habitats.	S4
Migratory Shorebirds	Intertidal sand/mud flats, rocky shores and mangrove communities throughout the site, intertidal areas of coarse rubble associated with	Decline in shorebird abundance and species diversity.	Diversity and abundance of epi/infauna of the intertidal flats; diversity of disturbance-free high tide roost spatially	n/d	n/d	H77. Greater than 10% reduction over five years of any one of the following components – mangrove cover and associated intertidal habitats; and supralittoral salt marsh habitats. H78. Any detectable long-term change to tidal regimes at spatial scales >5 km. H79. No long-term reduction in water quality and ecosystem condition in the estuarine sections of	S6

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
	central bay islands (Mud, St. Helena and Green islands) and western shores (Wellington Point and Redcliffe Peninsula), high tide roost sites throughout the site (natural and artificial).		proximate to suitable feeding grounds.			each major catchment area (as determined through the EHMP). H80. Greater than 10% reduction in over a 10 year period of numbers of bar-tailed godwit, Eastern curlew, or Pacific golden plover which are surrogates for assessing shorebird abundance generally. H81. Greater than 20% reduction in the in any three year period over five years for any of the eight migratory shorebird species (which exceed the 1% threshold).	
Threatened Flora Communities: Endangered and Of Concern Regional Ecosystems	Br bie Island, Moreton Island, Southern Moreton Bay Islands, Southern Bay	Detectable decline in extent of Regional Ecosystems. Loss of sensitive plant species and change to alternate community type. (Loss of dependent fauna).	Groundwater hydrology	Waterway-specific and variable over time.	n/d Quantitative groundwater requirements of ecosystems unknown.	H82. No significant reductions in water table depth, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. H83. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
			Fire regimes	Variable over time and between different vegetation types.	n/d Specific fire regime requirements of ecosystems unknown.	H84. No significant changes in fire frequency or intensity, relative to background variability, such that it results in such that it results in a measurable, medium-term (>5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. No significant changes in fire frequency or intensity such that ecological integrity of ecosystems is not maintained. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Geomorphology: • Erosion • Sedimentation • Soil type	Erosion and sedimentation variable over time. Soil type not variable over relevant time scale.		H85. No significant changes in erosion or sedimentation processes, or changes to soil characteristics, relative to background variability, such that it results in such that it results in a measurable, medium-term (>2 to 5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
Vulnerable and Endangered wetland plants: *O. hygrophila* *P. elatior* *P. australis* *P. bernaysii* *P. tancarvilleae*	Bay Islands: swamps, lakes and waterways	Detectable decline in local abundances of plant species.	Groundwater hydrology	Waterway-specific and variable over time.	n/d Quantitative groundwater requirements of flora species unknown.	H86. No significant reductions in water table depth, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
			Water Quality: • Toxicants • Nutrients • Turbidity • Salinity, pH	Waterway-specific and variable over time.	n/d No experimental determination of flora species water quality tolerances.	H87. No change in water quality indices outside bounds of natural variability. Adopt 20th, 50th & 80th percentile values of reference site conditions in which population has been recorded. The 75th confidence limit should not be > these values. Specific limits cannot be quantified with current knowledge – but as an interim trigger, species should continue to exist at current conservation status.	S5

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Freshwater flows and inundation	Waterway-specific and variable over time.	n/d No quantification of frequency, duration and extent of freshwater inundation requirements for flora species.	H88. No significant reductions in flow regimes, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, species should continue to exist at current conservation status.	S5
			Geomorphology: • Erosion • Sedimentation • Soil type	Erosion and sedimentation variable over time. Soil type not variable over relevant time scale.	n/d No quantification of geomorphologic requirements of flora species.	H89. No significant changes in erosion or sedimentation processes, or changes to soil characteristics, relative to background variability, such that it results in such that it results in a measurable, medium-term (>2 to 5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	

2 INTRODUCTION

This Section provides general information about the Ecological Character Description (ECD) process and the Moreton Bay Ramsar site.

2.1 Background to the Study

The Moreton Bay wetland aggregation is one of 65 wetland areas in Australia that have been listed as a wetland of international importance under the *Convention on Wetlands of International Importance especially as Waterfowl Habitat* or, as it is more commonly referred to, the Ramsar Convention (the Convention). Moreton Bay was listed as a Ramsar site under the Convention in 1993 in recognition of its outstanding coastal wetland values and features.

The Convention sets out the need for contracting parties to conserve and promote wise use of wetland resources. In this context, an assessment of ecological character of each listed wetland is a key concept under the Ramsar Convention.

Under Resolution IX.1 Annex A: 2005, the ecological character of a wetland is defined as:

> *The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.*

The definition indicates that ecological character has a temporal component, generally using the date of listing under the Convention as the point for measuring ecological change over time. As such, the description of ecological character should identify a wetland's key elements and provide an assessment point for the monitoring and evaluation of the site as well as guide policy and management, acknowledging the inherent dynamic nature of wetland systems over time.

This report provides the Ecological Character Description (ECD) for the Moreton Bay Ramsar site. In parallel with the preparation of the ECD, the Ramsar Information Sheet (RIS) for the site is being updated and the associated Ramsar maps and digital GIS boundaries of the site have been reviewed and documented in a separate report (refer BMT WBM 2008d). Additional reports have also been prepared that are companion documents to this ECD. These include:

- A report reviewing and documenting management actions relevant to the critical services/benefits, components and processes of the ECD (refer BMT WBM 2008a);
- A report documenting the discussions and outcomes of the expert panel review process for the ECD undertaken with members of the Scientific Expert Panel of the Southeast Queensland Healthy Waterways Partnership (refer BMT WBM 2008b)
- A report reviewing and documenting the relevant wetland management goals and indicators relevant to the services/benefits, components and processes of the ECD (refer BMT WBM 2008c).

These reports have been prepared over a period of ten months by the consultant study team led by BMT WBM Pty Ltd under contract with the Queensland Environmental Protection Agency (EPA). This has occurred with input from the EPA Project Management Team for the study, a Project

Steering Committee made up of officials from the Australian Government Department of Environment, Water, Heritage and the Arts (DEWHA) and Queensland Government agencies, and a Knowledge Management Committee (KMC) comprising Government and non-Government individuals with expertise and/or local research experience working within the Ramsar site. As outlined above, parts of the ECD were also subject to review and discussion as part of a workshop process with scientists from the Southeast Queensland Healthy Waterways Partnership Scientific Expert Panel (SEP). Appendix A contains a list of the representatives of each of these committees and workshop processes and provides a summary of meeting dates.

2.2 Scope and Purpose of this Study

The *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands January 2008* (hereafter referred to as the National Framework), provides a comprehensive approach to preparation of ECD studies in Australia taking into account the obligations of the Convention, domestic legislative requirements under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and best practice approaches in other jurisdictions. Refer to Section 3.2.7 for a description of the policy and legilslative framework governing the site.

Figure 2-1 shows the key steps of the ECD process from the National Framework document.

Based on the National Framework document, the key purposes of undertaking an ECD are as follows:

- Contribute to meeting the obligations of the Convention and EPBC Act for the site;
- Through a review of existing information, data and literature, supplement the description of ecological character in the Ramsar Information Sheet (RIS) for the wetland;
- Quantify, where possible, the natural variation and/or limits of acceptable change to the ecological character of the site such that it can be measured over time including as part of assessments under the EPBC Act and other impact assessment legislation at a State and local level; and
- Identify information and knowledge gaps that will assist in measuring changes to ecological character over time and prioritise future monitoring and management planning for the site.

As such, the key audiences for this document are expected to be:

- The Queensland Environmental Protection Agency as the site manager;
- Other Queensland Government Agencies (and local government) that make decisions that could affect the ecological character of the site;
- The regional natural resource management (NRM) body constituted for the area;
- The Department of Environment, Water, Heritage and the Arts in terms of decision-making under the EPBC Act; and
- Other sectors of the community with a scientific or general interest in the Moreton Bay Ramsar site.

It is understood that this ECD (including updated Ramsar Map and updated Ramsar Information Sheet) submitted by the consultant team to the EPA will be assessed as part of a whole-of-Government process. If acceptable, the ECD will then be forwarded to the Australian Government Department of Environment, Water, Heritage and the Arts (DEWHA) for consideration.

If endorsed by DEWHA, the document will then be forwarded to the Ramsar Secretariat and formally registered in the context of a supporting document under the Ramsar Convention.

Ecological Character Description

1. Introduction to the description
Site details, purpose of the description and relevant legislation

2. Describe the site
Site location, climate, maps and images, tenure, wetland criteria and types

3. Identify and describe the critical components, processes and services
3.1 Identify all possible components, processes and benefits
3.2 Of these, identify the critical components, processes and benefits responsible for determining the ecological character of the site
3.3 Describe each of the critical components, processes and benefits

4. Develop a conceptual model for the wetland
Depict the critical components and processes of the wetland (e.g. hydrology, biogeochemical processes, biota and vegetation, and their relationships)

5. Set limits of acceptable change
Determine limits of acceptable change for critical components, processes and services of the site

6. Identify threats to the ecological character of the site
use information from Steps 3-5 and other information to identify the actual or likely threats to the site

7. Describe changes to ecological character
Describe any changes to the ecological character of the site since the time of listing; include information on the current condition of the site

8. Summarise the knowledge gaps
Use information from Steps 3-7 to identify the knowledge gaps

9. Identify site monitoring needs
Use information from Steps 3-8 to identify monitoring needs

10. Identify communication and education messages
Identify any communication and education message highlighted during the development of the description

11. Compile the description of the ecological character

12. Prepare or update the Ramsar Information Sheet
Submit as a companion document to the ecological character description

Figure 2-1 Key Steps in Preparing an Ecological Character Description

(Source: National Framework document, Jan 2008)

2.3 Key Terminology

Wetland ecosystem processes, components and wetland services/benefits are core terminology used in the National Framework document for defining ecological character. The sections below outline the definitions and meanings of those terms used generally throughout the report. Specific definitions of these and other commonly used terms are contained in the Glossary in Section 9.

2.3.1 Wetland Processes

Wetland ecosystem processes are defined as the dynamic forces within the ecosystem between organisms, populations and the non-living environment. Interactions can be physical, chemical or biological. Examples include:

- Climate – rainfall, temperature, evaporation
- Hydrology – water balance, flooding and inundation regime
- Geomorphology and physical processes – topography, soils, sedimentation processes, erosion
- Energy and nutrient dynamics – primary production, decomposition, carbon cycle
- Biological Processes such as:
  - (a) Biological maintenance – reproduction, migration, dispersal, pollination
  - (b) Species interactions – competition, predation, succession, disease, infestation

2.3.2 Wetland Components

Wetland ecosystem components are the physical, chemical and biological parts or features of a wetland. Examples include:

- Physical form – wetland type, geomorphology
- Wetland soils – profiles, permeability, physico-chemical properties
- Water quality – physico-chemical properties such as salinity or pH
- Biota – flora, fauna and habitats

It is noted in the National Framework that some components may be viewed as both wetland components and wetland processes (eg. geomorphology, water quality).

2.3.3 Wetland Services/Benefits

The terms benefits and services are defined within the Millennium Ecosystem Assessment (2005) and adopted as part of the National Framework document in the context of the 'benefits that people receive from ecosystems'.

However, the National Framework notes that wetland ecosystem services and benefits are based on or underpinned by wetland components and processes and can be both of direct benefit to humans (eg. food for humans or livestock) or of indirect benefit (eg. wetland provides habitat for biota which contribute to biodiversity). In this context, benefits and services can also be short term or long term.

The National Framework breaks down wetland services/benefits into four categories. The categories and examples of services/benefits in each category are listed below:

- Provisioning services – products obtained from wetlands such as water or food
- Regulating services – water quality regulation, flood regulation and other natural functions
- Cultural services – relating to education, recreation, tourism, cultural heritage and similar values
- Supporting services – biodiversity and other ecosystem services

Figure 2-2 from the National Framework document shows a generic conceptual model of the interaction between ecosystem processes, components and services/benefits for a wetland. In general terms, the model shows how wetland ecosystem processes interact with wetland components to generate a range of wetland services/benefits. These services/benefits can be broadly applicable to all wetlands ecosystems (such as primary productivity) or specific to a given site (eg. breeding habitat for an important avifauna species or population).

2.4 Report Structure

The report has been structured largely in accordance with the key steps outlined in the National Framework and as shown in Figure 2.1. Sections 4 and 5 provide an essentially non-technical ecological description. Readers requiring more detailed information (including key citations) of ecological character (and associated limits of acceptable change) are referred to section 7 of the ECD report.

Table 2-1 Key Steps in Preparing an Ecological Character Description and Relevant Report Sections

Framework step	Report section
Introduction to ECD	2; 3.2.7
Describe Site	3
Identify and describe critical components, processes and services	4
Develop a conceptual model for the wetland	7
Set limits of acceptable change	4.3; 7
Identify threats to the ecological character of the site	5.2
Describe changes to ecological character	5.1
Summarise knowledge gaps	6.1
Identify site monitoring needs	6.2
Identify communication and education messages	6.3
Compile the description of the ecological character	7

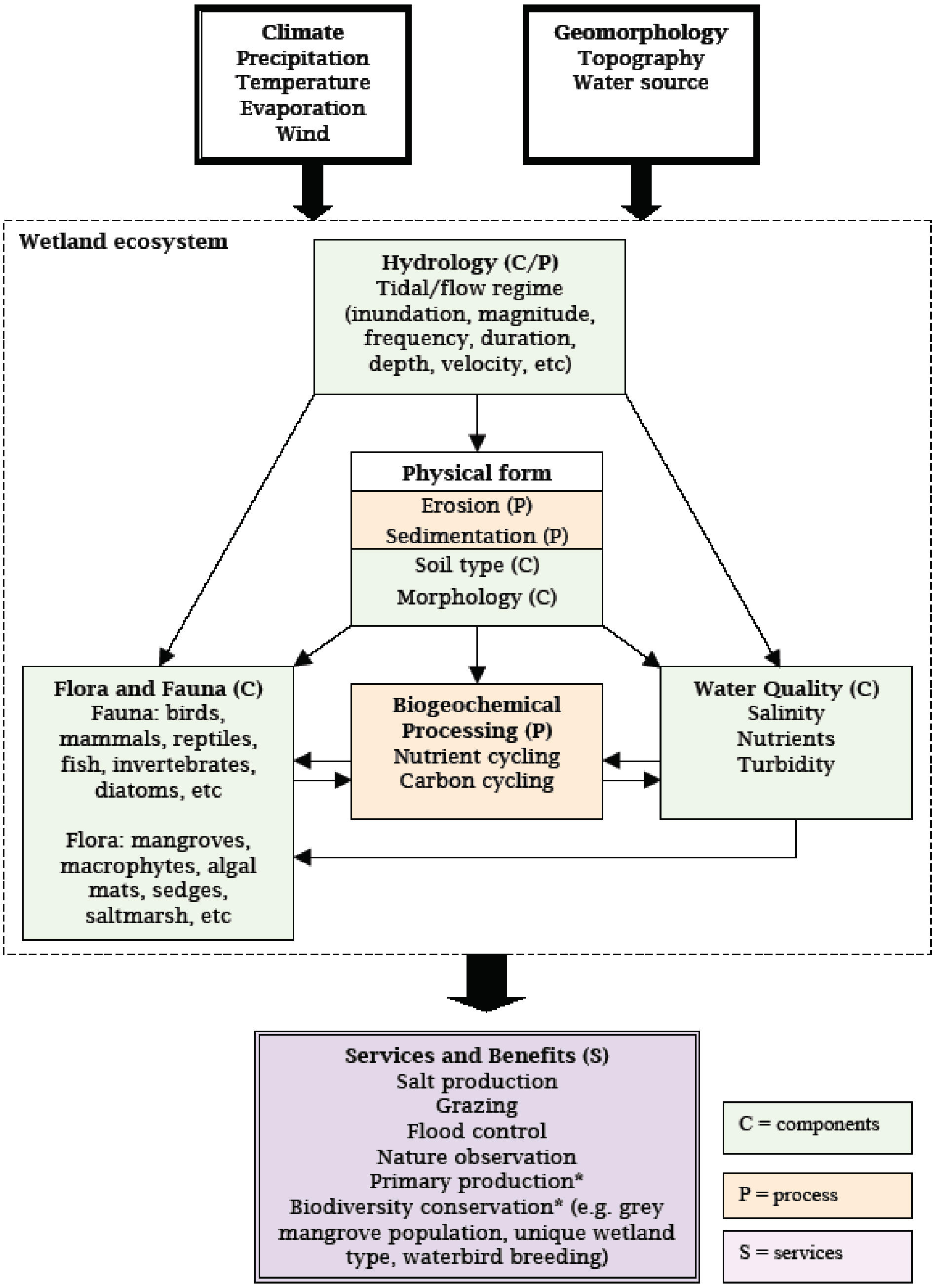


Figure 2-2 Generic conceptual model showing interactions between wetland ecosystem processes, components and services/benefits

(Source: National Framework document Jan 2008)

3 SITE CONTEXT

This Section of the report provides an overview and description of the Moreton Bay Ramsar site. The wetland habitat components of the site, the wetland processes that influence those habitats and the nomination criteria for which the site has been declared under the Convention are discussed.

These components, processes and criteria are important considerations in the selection of the critical components, processes and wetland benefits/services that make up the basis of the ECD, addressed in Sections 4 - 6 of the Report.

3.1 Site Details – Summary

Summary details of the site for the purposes of the ECD are provided in Table 3-1.

Table 3-1 Details of the Moreton Bay Ramsar site

Ramsar Site Name	Moreton Bay Ramsar site
Area	Total Area: 120 525 ha
Date of Listing	1993
Dates Used for Description	1993 (time of listing)
Justification for Date of Description	See above
Original Description Date	This is the first ECD undertaken for the site. As part of this project, the Ramsar Information Sheet (last updated in 1999) has also be updated and re-issued.
Compiler's Name	BMT WBM Pty Ltd with expert input from Austecology Pty Ltd and Converge Heritage + Community Pty Ltd under contract with the Queensland Environmental Protection Agency.
Ramsar Information Sheet	Last updated 1999 (by the Queensland EPA). Updated as part of current ECD by BMT WBM (2008).
Management Plan	There is no single plan relevant to the Ramsar site (refer Appendix B). Instead, a number of statutory management plans apply over broader areas of Moreton Bay and Southeast Queensland for which the boundaries of the Moreton Bay Ramsar site are a subset. The two primary management plans relevant to the Ramsar site are: • *Marine Park (Moreton Bay) Zoning Plan 1997* (currently under review) • *South-east Queensland Regional Coastal Management Plan (2006)* Other statutory plans/mechanisms relevant to the Ramsar site include: • National Park and other protected area management plans • The SEQ Regional Plan (2005-2026)

Ramsar Site Name	Moreton Bay Ramsar site
	• Environmental Values and Water Quality Objectives under the *Environmental Protection (Water) Policy 1997* • Fisheries Management Plans (East Coast Trawl and Coral Reef Finfish) and Fish Habitat Areas declared under the *Fisheries Act 1994* • *Water Resource (Logan Basin) Plan 2007* • *Water Resource (Moreton) Plan 2007* • *Water Resource (Gold Coast) Plan 2006* • Local Government Planning Schemes These statutory documents are supported by several key non-statutory natural resource management plans and strategies. The most notable relevant to the Ramsar site include: • The Healthy Waterways Strategy 2007-2012 • The SEQ Catchments Natural Resource Management Plan, *The Future in Balance* (2004) (currently under review) • EPA Shorebird Management Strategy 2005
Management Authority	The Ramsar site predominantly includes Queensland waters. Land areas above high water mark within the Ramsar site are largely State-owned lands managed by various State agencies and local governments as trustees of reserves and similar tenured land. There are some areas of leasehold and freehold land in the Western Bay area of the site. The Queensland Environmental Protection Agency (EPA) is the lead agency for planning and management of wetlands in Queensland noting that other Departments also play a crucial role in the management of wetland resources such as the Department of Primary Industries and Fisheries and the Department of Natural Resources and Water. EPA is considered as the nominal 'site manager' for the Moreton Bay Ramsar site.

3.2 Description of the Site

Section 3.2 and its subsections provide the general description of the site. This section is set out as follows:

- Section 3.2.1 – Describes the Ramsar site boundary
- Section 3.2.2 – Provides an overview of the wetland habitats present within the site
- Section 3.2.3 – Provides an overview of broad and local wetland processes that underpin and influence the site
- Section 3.2.4 – Provides an overview of the uses and tenure of land within and surrounding the site

- Section 3.2.5 – Provides an overview of the natural and cultural values of the site
- Section 3.2.6 – Provides an overview and summary of the policy framework for the site particularly in terms of relevant International, Commonwealth, State and regional plans and strategies

3.2.1 The Ramsar Site Boundary

Moreton Bay is located roughly mid-way along the east coast of Australia from 27 – 28 degrees latitude, placing it about 400 km south of the Tropic of Capricorn. A locality map of the Bay (with the Ramsar site boundary overlain) is shown in Figure 3-1. [2]

The broad study area for this ECD includes the Bay, its sand barrier islands and adjoining catchment areas. The Bay and its catchment areas are a component of the broader Southeast Queensland Region (or SEQ region as referred in this Report) which extends north to the Sunshine Coast (generally to northern boundary of the Sunshine Coast Regional Council), south across the Gold Coast and its hinterland to the border with New South Wales, and west to the Great Dividing Range.

Guidelines under the Ramsar Convention favour the use international or national biogeographic regions in the context of interpretation of Ramsar Nomination criteria and other aspects of the Convention. In this context, the Interim Marine and Coastal Regionalisation for Australia (IMCRA-version 4 - June 2006) have been adopted. Under this classification system, Moreton Bay lies within the Tweed-Moreton (TM) marine and coastal bioregion. From a terrestrial biogeographic perspective, the site is situated in the SEQ bioregion, based on the Interim Biogeographical Regionalisation for Australia (IBRA- version 6.1 – October 2008).

References within the report to the planning area or project area refer to those areas that are included within the nominated boundaries of the Moreton Bay Ramsar site (hereafter referred to as the Ramsar site or simply, 'the site').

As shown in Figure 3-1, the boundaries of the Ramsar site are essentially a series of discontinuous polygons that are generally limited to nearshore estuarine areas to a depth of roughly 6m below LAT (consistent with the definition of wetlands within the Convention). However, the boundary also extends selectively over State-controlled lands or similar above the high water mark in some locations including most notably, the Bay islands.

In addition, the site excludes major rivers such as the Brisbane and the Logan and in many cases does not extend up the smaller adjoining estuaries and creeks to their full tidal extent.

Specific observations about the site boundaries (moving from North to South) are as follows:

- The site includes the waters and tributaries of Pumicestone Passage;
- The site only includes selected intertidal and subtidal areas of the Western Bay;
- The site includes the Southern Bay and sandy channels of the Broadwater region;

[2] Minor modifications to the site boundary have been made as part of the current study and are documented as part of a separate mapping report (refer BMT WBM 2008d).

- The site excludes deeper marine areas and sand banks within the Central and Northern Bay;
- The site includes the ocean beach habitats of all the main sand islands and adjacent marine areas to a distance of approximately 50 m;
- The site includes all of Moreton Island, but has limited coverage on North and South Stradbroke Islands, Bribie Island and the Southern Bay Islands.

The discontinuous nature of the site is significant as most important wetland species identified in the nomination criteria for the site (refer RIS 1999 and outlined in this ECD in later sections), such as migratory shorebirds, turtles and dugong are highly mobile both within the site and across much larger habitat ranges.

Thus, while the approach within the ECD has been to identify those species and habitats that are most salient to the areas contained within the boundaries of the site (eg. core habitat), it is accepted that many of these species will only use the areas within the site from time to time. Likewise, threats and controls on these species and habitats may also be occurring outside the boundaries of the site, and as such, maintenance of ecological character can be highly reliant on other conservation and management regimes.

Figures 3-2 to 3-5 provide a 'snapshot' of the wetland habitat types, noteworthy flora and fauna that occur in the broader Moreton Bay region, water quality, coastal resource and marine park zoning, water resource planning and other planning information about the areas within the Ramsar site boundaries that will be described in the sections below. Given the size and diversity of wetland environments present in the Ramsar site, the site has been delineated into four areas for reporting purposes:

- Area 1 – Bribie Island and Pumicestone Passage
- Area 2 – Western Bay
- Area 3 – Moreton Island and Eastern Banks
- Area 4 – Stradbroke Islands and Southern Bay.

For all snap-shot descriptions note that:

- The term RE refers to regional ecosystems. Regional ecosystems are defined by Sattler and Williams (1999) as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
- Water quality condition codes are taken from Environmental Health Monitoring Program (EHMP). Refer to Section 3.2.3.4 for background to these codes.

Title:

Moreton Bay Locality Map

Figure: 3-1

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

0 10 20km

Approx. Scale

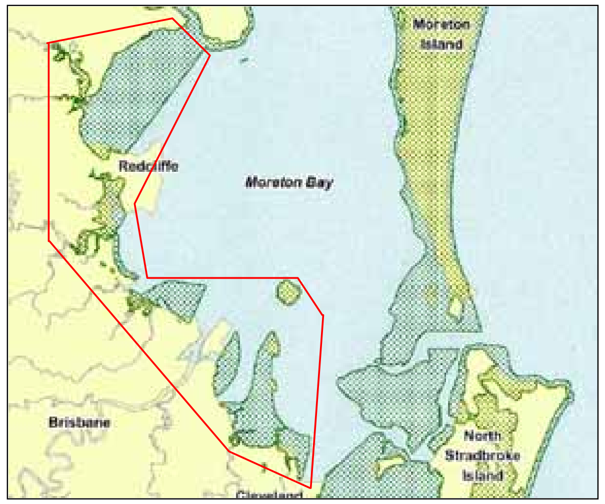
BMT WBM

www.wbmpl.com.au

Filepath : I:\B17004_I_BRH Moreton Bay Ramsar Site GWF\DRG\ECO_011_080530_Locality_Map.wor

AREA 2: WESTERN BAY

Location



Protected / Conservation Areas

Endangered Wetland REs

-

Of concern Wetland REs

12.1.1 - *Casuarina glauca* open forest on margins of marine clay plains

12.3.11 – Eucalypt open forest on alluvial plains

Areas of Significance (Source: EPA Coastal Plan)

Significant coastal dunes (<1% area covered)

Declared Fish Habitat Area (~10% area covered)

Area of special interest for whales and dolphins

Seagrass (~20% area covered)

Critical shorebird habitat (<5% area covered)

Shorebird habitat (~35% area covered)

Wetlands (significant and coastal) (~90% area covered)

National Parks and Conservation Parks:

St Helena NP

Beachmere CP

King Island CP

Marine Parks (Source: Draft Marine Parks (Moreton Bay) Zoning Plan 2008)

Marine National Park Zone (~30% area covered)

Conservation Park Zone (~20% area covered)

Habitat Protection Zone (~40% area covered)

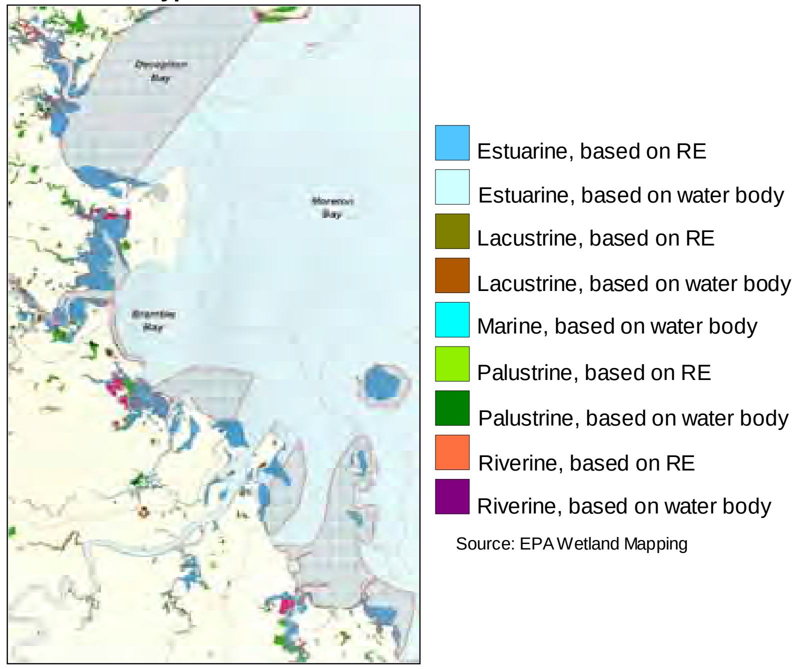
General Use Zone (~10% area covered)

Ramsar Nomination Criteria

1 2 ✓ 3 ✓ 4 ✓ 5 (✓) 6 (✓) 7 (✓) 8 (✓) 9

✓ indicates within project area; (✓) indicates within en ire Ramsar site

Ramsar Wetland types



	Marine / Coastal Wetlands	Regional example
	A – Permanent shallow marine waters (<6m)	
✓	B – Marine sub idal aquatic beds (kelp, seagrass)	
✓	C – Coral reefs	
	D – Rocky marine shores, sea cliffs	
✓	E – Sand, shingle or pebble shores; sandbars; dunes	
✓	F – Estuarine waters	
✓	G – Intertidal mud, sand or salt flats	
✓	H – Intertidal marshes, including saltmarshes	RE12.1.2
✓	I – Intertidal forested wetlands, including mangroves	REs 12.1.3, 12.1.1
	J – Coastal brackish / saline lagoons	
	K – Coastal freshwater lagoons	
	Inland Wetlands	
✓	M – Permanent rivers / streams / creeks	
✓	N – Seasonal / intermittent rivers / streams / creeks	
	O – Permanent freshwater lakes	
✓	Tp – Permanent freshwater marshes / pools	RE 12.2.15
✓	Ts – Seasonal / intermittent freshwater marshes / pools	RE 12.2.15
	U – Non-forested peatlands	
	W – Shrub-dominated wetlands; shrub swamps	
✓	Xf – Freshwater, tree-dominated wetlands and swamps	REs 12.3.5, 12.3.6
	Xp – Forested peatlands; peatswamp forests	
	Y – Freshwater Springs	
	Man-made Wetlands	
✓	9 - Canals, drainage channels and ditches	Dowse Lagoon

Note: Based on EPA we land codes; Only we land types present within Moreton Bay are listed here

Noteworthy Flora and Fauna likely to occur (Status NCA, EPBC respectively)

Terrestrial flora: *Acacia attenuata* (V,V), Hairy-joint Grass (V,V), Marbled Baloghia (V,V), Heart-leaved Bosistoa (V,V), Three-leaved Bosistoa (V,V), Leafless Tongue-orchid (V,V), Macadamia Nut (V,V), Small-fruited Queensland Nut (V,V), Lesser Swamp-orchid (E,E), Minute Orchid (V,V), *Acacia baueri* subsp. *baueri* (V,-), Toadflax (V,V), *Corchorus cunninghamii* (E,E), *Cupaniopsis shirleyana* (V,V), *Gossia gonoclada* (E,E)

Aquatic flora: Frogbit (V), *Maundia triglochinoides* (V,-)

Birds: Coxen's Fig Parrot (E,E), Ground Parrot (V,-), Paradise Parrot (PE,EX), Swift parrot (E,E), Glossy Black Cockatoo (V,-), Squatter pigeon (V,V), Powerful Owl (V,-), Red Goshawk (E,V), Southern Giant-petrel (E,E), Northern Giant Petrel (V,V), Kermadec Petrel (-,V), Australian Painted Snipe (-,V), Campbell Albatross (-,V), Black-breasted Button Quail (V,V), Regent Honeyeater (E,E), Little Tern (E,-), Beach Stone-curlew (V,-), Red-tailed Tropic Bird (V,-),

Amphibians: Wallum Sedgefrog (V,V), Southern Barred Frog (E,E), Wallum Rocketfrog (V,-), Wallum Froglet (V,-), Tusked Frog (V,-)

Mammals (terrestrial): Large-eared Pied Bat (-,V), Grey-headed Flying Fox (-,V), Long-nosed Potoroo (-,V), Water Mouse (V,V), Koala (V,-), Spotted-tailed Quoll (V,E)

Reptiles: Loggerhead Turtle (E,E), Green Turtle (V,V), Three-toed Snake-tooth Skink (R,V), Leatherback Turtle (E,V), Pacific Ridley (E,V)

Insects: Illidge's Ant Blue (V,-), Australian Fritillary (E,-), Richmond Birdwing (V,-)

Mammals (aquatic): Southern Right Whale (R,E), Humpback Whale (R,V), Dugong (V,-)

Sharks: Grey Nurse Shark (E,CE), Great White Shark (-,V), Green Sawfish (-,V), Whale Shark (-,V)

Fish: Oxleyan Pygmy Perch (V,E)

Source: Wildlife online & EPBC online searches. Note that hese searches indicate species that are likely – not necessarily known - to occur within the area. Critical wetland species known within the project area have been iden ified in the report.

Water Quality

Unit	Area	2007	2006	2005	2004
Freshwater	Caboolture Catchment	C+	B-	B-	C-
	Pine Catchment	D+	C	C	D
	Lower Brisbane Catchment	F	F	D-	F
	Redlands Catchment	F	F	F	D
Estuarine	Caboolture Estuary	D	D	D+	C-
	Pine Estuary	C-	D	D	D+
	Brisbane Estuary	D+	D-	D-	D-
	Cabbage Tree Estuary	F	F	D-	D-
	Tingalpa Estuary	D+	D	D	D-
	Epraprah Estuary	D	D	C-	NG
Marine	Deception Bay	D	C-	D+	C+
	Bramble Bay	D+	D+	D+	D
	Waterloo Bay	B+	B-	B-	B

Source: Ecosystem Heal h Monitoring Program (Healthy Waterways)

Water Resource Outcomes (Source: Water Resource (Moreton) Plan 2007)

Estuarine reaches: Minimise changes to brackish habitats

Moreton Bay and Pumicestone Channel: Minimise changes to the natural movement and delivery of sediment, and the delivery of freshwater, natural nutrients and organic matter

Boondall Wetlands: Provide freshwater flows to maintain long-term inflow patterns and ecological functions

Figure 3-3 Snapshot of Western Bay

AREA 3: MORETON ISLAND AND EASTERN BANKS

Location

Protected / Conservation Areas

Endangered Wetland REs

-

Of concern Wetland REs

12.3.8 – Swamps with *Cyperus* spp., *Schoenoplectus* spp.

Areas of Significance (Source: EPA Coastal Plan)

Significant coastal dunes (100% area covered)

Declared Fish Habitat Area (~80% area covered)

Area of special interest for whales and dolphins

Seagrass (~80% area covered)

Critical shorebird habitat (<5% area covered)

Shorebird habitat (~65% area covered)

Wetlands (significant and coastal) (~40% area covered)

National Parks and Conservation Parks:

Moreton Island NP

Marine Parks (Source: Draft Marine Parks (Moreton Bay) Zoning Plan 2008)

Marine National Park Zone (~45% area covered)

Conservation Park Zone (~15% area covered)

Habitat Protection Zone (~40% area covered)

Ramsar Nomination Criteria

1✓ 2✓ 3✓ 4✓ 5(✓) 6(✓) 7(✓) 8(✓) 9

✓ indicates within project area; (✓) indicates within entire Ramsar site

Ramsar Wetland types

Estuarine, based on RE
Estuarine, based on water body
Lacustrine, based on RE
Lacustrine, based on water body
Marine, based on water body
Palustrine, based on RE
Palustrine, based on water body
Riverine, based on RE
Riverine, based on water body

Source: EPA Wetland Mapping

	Marine / Coastal Wetlands	Regional example
✓	A – Permanent shallow marine waters (<6m)	
✓	B – Marine subtidal aquatic beds (kelp, seagrass)	
✓	C – Coral reefs	
✓	D – Rocky marine shores, sea cliffs	Cape Moreton
✓	E – Sand, shingle or pebble shores; sandbars; dunes	
✓	F – Estuarine waters	
✓	G – Inter idal mud, sand or salt flats	
✓	H – Intertidal marshes, including saltmarshes	RE12.1.2
✓	I – Intertidal forested we lands, including mangroves	REs 12.1.3, 12.1.1
	J – Coastal brackish / saline lagoons	
✓	K – Coastal freshwater lagoons	
	Inland Wetlands	
✓	M – Permanent rivers / streams / creeks	Spitfire Creek
✓	N – Seasonal / intermittent rivers / streams / creeks	
✓	O – Permanent freshwater lakes	Lake Jabiru
✓	Tp – Permanent freshwater marshes / pools	RE 12.2.15
✓	Ts – Seasonal / intermittent freshwater marshes / pools	RE 12.2.15
	U – Non-forested peatlands	
	W – Shrub-dominated wetlands; shrub swamps	
✓	Xf – Freshwater, tree-dominated wetlands and swamps	RE 12.2.5
	Xp – Forested peatlands; peatswamp forests	
	Y – Freshwater springs	
	Man-made Wetlands	
	9 - Canals, drainage channels and ditches	

Note: Based on EPA wetland codes; Only wetland types present within Moreton Bay are listed here

Noteworthy Flora and Fauna likely to occur (Status NCA, EPBC respectively)

Terrestrial flora: Marbled Baloghia (V,V), Lesser Swamp-orchid (E,E), Minute Orchid (V,V), *Acacia baueri* subsp. *baueri* (V,-), Swamp Orchid (E,E), Ball Nut (V,V)

Aquatic flora: N/A

Birds: Swift Parrot (E,E), Glossy Black Cockatoo (V,-), Tristan A batross (-,E), Campbell A batross (-,V), Southern Giant-petrel (E,E), Northern Giant Petrel (-,V), Kermadec Petrel (-,V), Australian Painted Snipe (-,V), Black-breasted Button Quail (V,V), Regent Honeyeater (E,E), Little Tern (E,-), Beach Stone-curlew (V,-), Red-tailed Tropic Bird (V,-)

Amphibians: Wallum Sedgefrog (V,V), Wallum Rocketfrog (V,-), Wallum Froglet (V,-)

Mammals (terrestrial): Long-nosed Potoroo (-,V), Grey-headed Flying Fox (-,V), Water Mouse (V,V)

Reptiles: Loggerhead Turtle (E,E), Green Turtle (V,V), Leatherback Turtle (E,V), Pacific Ridley (E,V), Three-toed Snake-tooth Skink (R,V),

Insects: Illidge's Ant Blue (V,-)

Mammals (aquatic): Blue Whale (R,E), Southern Right Whale (R,E), Humpback Whale (V,V), Dugong (V,-)

Sharks: Grey Nurse Shark (E,CE), Great White Shark (-,V), Green Sawfish (-,V), Whale Shark (-,V)

Fish: Oxleyan Pygmy Perch (V,E)

Source: Wildlife online & EPBC online searches. Note that these searches indicate species that are likely – not necessarily known - to occur within the area. Critical wetland species known within the project area have been identified in the report.

Water Quality

Unit	Area	2007	2006	2005	2004
Freshwater	-	-	-	-	-
Estuarine	-	-	-	-	-
Marine	Eastern Bay	A-	A	A	A
	Eastern Banks	A	A	A	A

Source: Ecosystem Health Monitoring Program (Healthy Waterways)

Water Resource Outcomes

Moreton Bay and Pumicestone Channel: Minimise changes to the natural movement and delivery of sediment, and the delivery of freshwater, natural nutrients and organic matter

(Source: Water Resource (Moreton) Plan 2007)

Figure 3-4 Snapshot of Moreton Island and Eastern Banks

AREA 4: STRADBROKE ISLANDS AND SOUTHERN BAY

Location

Protected / Conservation Areas

Endangered Wetland REs

-

Of concern Wetland REs

12.1.1 - *Casuarina glauca* open forest on margins of marine clay plains

12.3.11 – Eucalypt open forest on alluvial plains

Areas of Significance (Source: EPA Coastal Plan)

Significant coastal dunes (~60% area covered)

Declared Fish Habitat Area (~25% area covered)

Area of special interest for whales and dolphins

Seagrass (~10% area covered)

Critical shorebird habitat (<1% area covered)

Shorebird habitat (~70% area covered)

Wetlands (significant and coastal) (~65% area covered)

National Parks and Conservation Parks:

Blue Lake NP

Bird Island CP, Cobby Cobby Island CP, Coomera Island CP, Goat Island CP, Kangaroo Island CP, Myora CP, S. Stradbroke Island CP, South Stradbroke Island CP2, Woogoompah Island CP

Marine Parks (Source: Draft Marine Parks (Moreton Bay) Zoning Plan 2008)

Marine National Park Zone (~25% area covered)

Conservation Park Zone (~20% area covered)

Habitat Protection Zone (~55% area covered)

Ramsar Nomination Criteria

1✓ 2✓ 3✓ 4✓ 5(✓) 6(✓) 7(✓) 8(✓) 9

✓ indicates within project area; (✓) indicates within entire Ramsar site

Ramsar Wetland types

Estuarine, based on RE

Estuarine, based on water body

Lacustrine, based on RE

Lacustrine, based on water body

Marine, based on water body

Palustrine, based on RE

Palustrine, based on water body

Riverine, based on RE

Riverine, based on water body

Source: EPA Wetland Mapping

	Marine / Coastal Wetlands	Regional example
✓	A – Permanent shallow marine waters (<6m)	
✓	B – Marine subtidal aquatic beds (kelp, seagrass)	
✓	C – Coral reefs	Peel Island
✓	D – Rocky marine shores, sea cliffs	Point Lookout
✓	E – Sand, shingle or pebble shores; sandbars; dunes	
✓	F – Estuarine waters	Nerang Estuary
✓	G – Intertidal mud, sand or salt flats	
✓	H – Intertidal marshes, including saltmarshes	RE 12.1.2
✓	I – Intertidal forested wetlands, including mangroves	REs 12.1.3, 12.1.1
✓	J – Coastal brackish / saline lagoons	Lake Coombabah
✓	K – Coastal freshwater lagoons	
	Inland Wetlands	
✓	M – Permanent rivers / streams / creeks	Little Canalpin Creek
✓	N – Seasonal / intermittent rivers / streams / creeks	
✓	O – Permanent freshwater lakes	Brown Lake
✓	Tp – Permanent freshwater marshes / pools	RE 12.2.15
✓	Ts – Seasonal / intermittent freshwater marshes / pools	RE 12.2.15
✓	U – Non-forested peatlands	18 Mile Swamp
✓	W – Shrub-dominated we lands; shrub swamps	RE 12.2.12
✓	Xf – Freshwater, tree-dominated wetlands and swamps	REs 12.2.5, 12.2.7, 12.3.5
✓	Xp – Forested peatlands; peatswamp forests	18 Mile Swamp
✓	Y – Freshwater springs	Myora Springs
	Man-made Wetlands	
✓	9 - Canals, drainage channels and ditches	Couran Cove

Note: Based on EPA we land codes; Only wetland types present within Moreton Bay are listed here

Noteworthy Flora and Fauna likely to occur (Status NCA, EPBC respectively)

Terrestrial flora: *Acacia attenuata* (V,V), Marbled Baloghia (V,V), Heart-leaved Bosistoa (V,V), Three-leaved Bosistoa (V,V), Native Jute (E,E), Stinking Cryptocaria (V,V), Leafless Tongue-orchid (V,V), Macadamia Nut (V,V), Small-fruited Queensland Nut (V,V), Swamp Daisy (E,E), Swamp Orchid (E,E), Lesser Swamp Orchid (E,E), Yellow Swamp Orchid (E,E), Minute Orchid (V,V), *Thelypteris confluens* (V,-), *Acacia baueri* subsp. *baueri* (V,-), Toadflax (V,V), Shiny-leaved Coondoo (E,E)

Aquatic flora: Frogbit (-,V), *Persicaria elatior* (V,E)

Birds: Coxen's Fig Parrot (E,E), Swift parrot (E,E), Glossy Black Cockatoo (V,-), Glossy Black Cockatoo eastern (V,-), Powerful Owl (V,-), Red Goshawk (E,V), Tristan Albatross (-,E), Campbell Albatross (-,V), Southern Giant-petrel (E,E), Northern Giant Petrel (V,V), Black-throated Finch (V,E), Kermadec Petrel (-,V), Australian Painted Snipe (-,V), Black-breasted Button Quail (V,V), Regent Honeyeater (E,E), Beach Stone-curlew (V,-), Little Tern (E,-), Red-tailed Tropic Bird (V,-),

Amphibians: Wallum Sedgefrog (V,V), Southern Barred Frog (E,E), Wallum Rocketfrog (V,-), Wallum Froglet (V,-), Tusked Frog (V,-)

Mammals (terrestrial): Large-eared Pied Bat (-,V), Spotted-tail Quoll (V,E), Brush-tailed Rock Wallaby (-,V), Long-nosed Potoroo (-,V), Grey-headed Flying Fox (-,V), Water Mouse (V,V), Koala (V,-)

Reptiles: Loggerhead Turtle (E,E), Green Turtle (V,V), Leatherback Turtle (E,V), Flatback Turtle (V,V), Hawksbill Turtle (V,V), Pacific Ridley (E,V), Three-toed Snake-tooth Skink (R,V), *Ophioscincus truncatus* (R,-)

Insects: Illidge's Ant Blue (V,-), Richmond Birdwing (V,-)

Mammals (aquatic): Blue Whale (-,E), Southern Right Whale (-,E), Humpback Whale (V,V), Dugong (V,-)

Sharks: Grey Nurse Shark (E,CE), Great White Shark (-,V), Green Sawfish (-,V), Whale Shark (-,V)

Fish: Oxleyan Pygmy Perch (V,E)

Source: Wildlife online & EPBC online searches. Note that hese searches indicate species that are likely – not necessarily known - to occur within the area. Cri ical wetland species known within he project area have been identified in the report.

Water Quality

Unit	Area	2007	2006	2005	2004
Freshwater	Logan Catchment	D	D+	D	C
	Pimpama/Coomera Catchment	B-	C+	B+	C
	Nerang Catchment	A-	C+	B+	A-
Estuarine	Logan Estuary	D-	F	D-	D
	Pimpama Estuary	C+	C	C	C
	Coomera Estuary	B	A-	B+	B
	Nerang Estuary	B	B	B	B
Marine	Southern Bay	B-	D	D+	C
	Broadwater	B+	B-	C-	C-

Source: Ecosystem Health Monitoring Program (Healthy Waterways)

Water Resource Outcomes

Estuarine reaches: Minimise changes to brackish habitats

Moreton Bay and Pumicestone Channel: Minimise changes to the natural movement and delivery of sediment, and the delivery of freshwater, natural nutrients and organic matter

(Source: Water Resource (Moreton) Plan 2007; Water Resource (Gold Coast) Plan 2006)

Figure 3-5 Snapshot of Stradbroke Islands and Southern Bay

3.2.2 Overview of Wetland Types

In seeking to characterise the types of wetlands within the boundaries of the Moreton Bay Ramsar site, it is important to recognise that the site has a high level of habitat diversity, ranging from perched freshwater lakes and sedge swamps, to intertidal mudflats and mangroves to sub-tidal seagrass habitats. For this report, the Ramsar Classification System for Wetland Types (approved by Recommendation 4.7 and amended by Resolutions VI.5 and VII.11 of the Conference of the Contracting Parties) is used.

As shown in the area 'snapshots' above, detailed mapping of wetlands within the region has been undertaken by the Queensland EPA as part of a State-wide mapping programme under the Queensland Wetlands Programme. The EPA mapping method uses a combination of Queensland Regional Ecosystem (RE) vegetation mapping and water body mapping (interpreted from satellite imagery) to classify wetlands into broad categories of marine, estuarine, riverine, lacustrine and palustrine types. Although there are broad overlaps between the EPA classification and the Ramsar classification systems (lacustrine ~ lake, palustrine ~ marshes/pools, riverine ~ river channel), these systems have limited analogies due to the finer-scale of wetland categorization under the Ramsar typology which provides up to 12 marine/coastal wetland types, up to 20 inland wetland types and up to 10 human-made wetland types.

To assist in this regard, the EPA has developed and made available for the study a draft cross-referencing table that assigns particular RE types with Ramsar habitat classification types. Using this table and the EPA mapping supplied, the presence of Ramsar wetland types within the Moreton Bay Ramsar site has been refined and the following habitat types are seen as being represented:

- 11 marine/coastal wetland types;
- 10 inland wetland types; and
- 1 man-made wetland type

Further description and examples of these types is contained in the sections below.

3.2.2.1 *Marine/Coastal Wetland Types (11)*

Photos of estuarine and marine wetland environments in the Moreton Bay region (Source: EPA and BMT WBM photo library)

Type A: Permanent shallow marine waters

This wetland type incorporates marine waters that are less than six metres deep at low tide, including sea bays and straits. Within the Moreton Bay Ramsar site, shallow marine waters are located along the length of the offshore islands on the seaward boundary.

Type B: Marine subtidal aquatic beds

This wetland type is represented within the Moreton Bay Ramsar site by seagrasses that form meadows in quiet, clear, shallow waters. These seagrass beds provide food and habitat for turtles, dugong, and commercially and recreationally important fish and invertebrate populations in Moreton Bay. Within the Ramsar site, seagrass beds cover an area of 24,078 hectares and are predominantly located in Pumicestone Passage, the Eastern Banks and Southern Moreton Bay.

Type C: Coral reefs

Moreton Bay is close to the southern limit of reef-building corals. Within the Ramsar site, coral reef communities occur around Peel, St Helena, Mud and Green Islands, and from Wellington Point to Raby Bay. The presence of coral communities are limited in the Western Bay (around Mud and St Helena Island) as a result of historical coral limestone extraction which has since ceased. In total, 1,152 hectares of coral reef are present within the Ramsar site. Of particular importance is the area on the northern side of Peel Island and Myora reef in the Eastern Bay.

Type D: Rocky marine shores

This wetland type is characterised by exposed rocky marine shores, including rocky offshore islands and sea cliffs. Rocky shores provide habitats for a wide range of algae, marine invertebrates and fish species. Approximately 200 hectares of rocky shores are present within the Ramsar site, with representative examples including the rocky headlands of Point Lookout on North Stradbroke Island and Cape Moreton on Moreton Island, as well as rocky shores inside the bay such as Toorbul Point at the entrance to Pumicestone Passage.

Type E: Sand, shingle or pebble shores

This wetland type includes sand bars, spits and sandy islets, as well as dune systems and humid dune slacks. Within the Moreton Bay Ramsar site, approximately 3,000 hectares of sandy shores are present, typically located along the eastern shorelines of the Bay Islands.

Type F: Estuarine waters

This wetland type includes permanent water of estuaries and estuarine systems of deltas. Due to the protection provided by the large offshore islands, estuarine waters are widespread within the Moreton Bay Ramsar site from Pumicestone Passage to the Southern Bay.

Type G: Intertidal mud, sand or salt flats

This wetland type encompasses habitats comprised of alluvial deposits of sand and mud that accumulate on intertidal flats. Many invertebrate species inhabit these intertidal flats, and at low tides they are an important feeding ground for waders. Intertidal flats are widespread within the Moreton Bay Ramsar site, covering an area in excess of 5,000 hectares. Specific locations including Pumicestone Passage, the Western Bay, the Southern Bay and the landward shores of North Stradbroke Island.

Type H: Intertidal marshes

This wetland type is represented in the Ramsar site by saltpan vegetation on marine clay plains, as well as saline or brackish sedgelands. There is approximately 2,522 hectares of saltmarsh / saltpan complexes within the Moreton Bay region (Duke *et al*. 2003), of which approximately 85% is contained within the Ramsar site. Characteristic vegetation communities are *Sporobolus virginicus* grasslands, and samphire herblands dominated by *Sarcocornia* species and *Suaeda australis*. Saltmarsh typically occurs in the upper-intertidal zone as a band along the landward edge of the mangrove zone. Protected intertidal marshes within Moreton Bay include Bribie Island National Park, Coombabah Lake Conservation Park and Southern Moreton Bay Island National Park.

Type I: Intertidal forested wetlands

This wetland type is represented in the Ramsar site by mangrove shrublands to low closed forest on marine clay plains and estuaries, as well as tidal freshwater swamp forests such as those primarily composed of *Casuarina glauca*. Mangrove forests occupy an area of approximately 15,300 hectares in Moreton Bay (Duke and Pederson 2003), of which approximately 85% is contained within the Ramsar site. Mangroves are important roosting and sheltering sites for a variety of shorebirds, and provide nursery grounds for fish and a diversity of invertebrate fauna. Protected intertidal forested wetlands within the Ramsar site include Bribie Island National Park, Buckleys Hole Conservation Park, Coombabah Lake Conservation Park, Moreton Island National Park and Southern Moreton Bay Islands National Park.

Type J: Coastal brackish/saline lagoons

This wetland type consists of brackish to saline lagoons with at least one relatively narrow connection to the ocean. It is represented within the Moreton Bay Ramsar site by Lake Coombabah, covering 222 hectares.

Type K: Coastal freshwater lagoons

This wetland type includes freshwater lagoons. Although not listed in the current RIS, this wetland type is represented within the Moreton Bay Ramsar site by various freshwater lagoons on the Bay islands such as Ibis Lagoon and Black Snake Lagoon on North Stradbroke Island.

3.2.2.2 Inland Wetland Types (10)

Photos of freshwater and transitional wetland environments in the Moreton Bay region (Source: BMT WBM photo library)

Type L: Permanent inland deltas

While listed in the current RIS (1999), this wetland type is not considered to be present in the Ramsar site.

Type M: Permanent rivers / streams / creeks

This wetland type incorporates permanent rivers, streams and creeks. Within the Moreton Bay Ramsar site, freshwater creeks include Spitfire Creek on Moreton Island and Little Canalpin Creek on North Stradbroke Island.

Type N: Seasonal rivers / streams / creeks

This wetland type incorporates seasonal rivers, streams and creeks. This wetland type was not included in the current RIS, but is believed to be represented within Moreton Bay in the context of ephemeral freshwater and semi-tidal creeks and streams in the Pumicestone Passage area.

Type O: Permanent freshwater lakes

Permanent freshwater bodies over 8 hectares in area are included in this wetland type. Representative examples within the Moreton Bay Ramsar site include Blue Lake on North Stradbroke Island, and Lake Jabiru on Moreton Island.

Type Q: Permanent saline / brackish / alkaline lakes

While listed in the current RIS (1999), this wetland type is not considered to be present in the Ramsar site.

Type Tp: Permanent freshwater marshes / pools

This wetland type includes ponds < 8 hectares in area, as well as marshes and swamps on inorganic soils with emergent vegetation that is waterlogged for at least most of the growing season. Vegetation communities in this category include palustrine wetlands such as freshwater swamps with *Cyperus*, *Schoenoplectus* and *Eleocharis* species, or coastal sedgelands with *Baumea* and *Juncus* species. Within the Moreton Bay Ramsar site, protected areas of this wetland type include Moreton Island National Park, Blue Lake National Park and Bribie Island National Park.

Type Ts: Seasonal / intermittent freshwater marshes / pools on inorganic soils

This wetland type includes sloughs, potholes and seasonally flooded meadows. Vegetation communities associated with this wetland type are typically sedge marshes, comparable in species composition to vegetation communities of the permanent freshwater marshes / pools (Type Tp). Protected areas of this wetland type include Blue Lake National Park and Bribie Island National Park.

Type U: Non-forested peatlands

This wetland type includes shrub or open bogs, and swamps. Although not currently included in the current RIS, this wetland type is represented within the Ramsar site by Eighteen Mile Swamp on North Stradbroke Island, one of the largest of its type in Queensland.

Type W: Shrub-dominated wetlands

This wetland type includes shrub swamps and shrub-dominated freshwater marshes. It is represented within the Moreton Bay Ramsar site by seasonally waterlogged closed heathland that covers a total area of 130 hectares. Flora composing these palustrine wetlands characteristically includes *Banksia*, *Epacris* and *Leptospermum* species. Protected shrub-dominated wetlands within the Ramsar site are located in Bribie Island National Park.

Type Xf: Freshwater tree-dominated wetlands

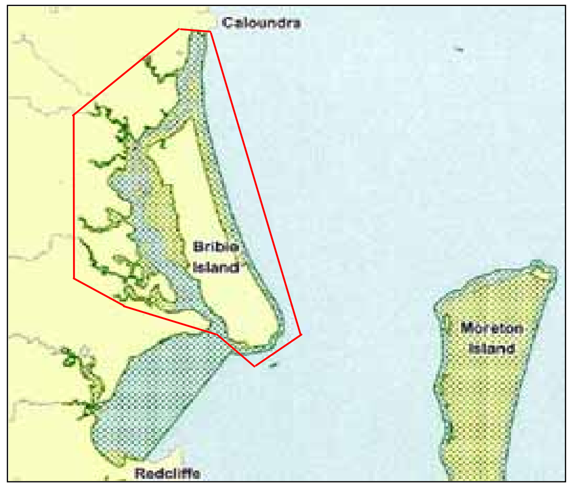
This wetland type includes freshwater swamp forests, seasonally flooded forests and wooded swamps on inorganic soils. It is represented in Moreton Bay by palustrine open forests dominated by *Melaleuca quinquenervia*, covering a total area of 8,596 hectares within the Ramsar site. The understorey varies in composition depending on the duration of water logging, and may include ferns, grasses, sedges and/or shrubs. Protected areas of freshwater tree-dominated wetlands include Bribie Island National Park, Coombabah Lake Conservation Park, Southern Moreton Bay Islands National Park, Buckley's Hole Conservation Park, Blue Lake National Park and Moreton Island National Park.

Type Xp: Forested peatlands

This wetland type incorporates peat swamp forests. Forested peatlands are present within Eighteen Mile Swamp on North Stradbroke Island. As outlined in the Ramsar Guidelines for Global Action on Peatlands (GAP), peatlands are increasingly being recognised as an important wetland resource at the global level through their role in contributing to global biodiversity, as an important carbon sink and through the retention of paleo-environmental information about previous landscapes and climate states.

AREA 1: BRIBIE ISLAND AND PUMICESTONE PASSAGE

Location



Protected / Conservation Areas

Endangered Wetland REs

12.3.1 – Riverine notophyll vine forest on alluvial plains

Of concern Wetland REs

12.1.1 - *Casuarina glauca* open forest on margins of marine clay plains

12.3.4 - *Melaleuca quinquenervia, Eucalyptus robusta* open forest; on or near coastal alluvial plains

12.3.11 – Eucalypt open forest on alluvial plains

Areas of Significance (Source: EPA Coastal Plan)

Significant coastal dunes (~30% area covered)

Declared Fish Habitat Area (~65% area covered)

Area of special interest for whales and dolphins

Seagrass (~15% area covered)

Critical shorebird habitat (~1% area covered)

Shorebird habitat (~40% area covered)

Wetlands (significant and coastal) (~95% area covered)

National Parks and Conservation Parks:

Bribie Island NP

Buckley's Hole CP

Marine Parks (Source: Draft Marine Parks (Moreton Bay) Zoning Plan 2008)

Marine National Park Zone (~10% area covered)

Conservation Park Zone (~55% area covered)

Habitat Protection Zone (~35% area covered)

Ramsar Nomination Criteria

1✓ 2✓ 3✓ 4✓ 5 (✓) 6 (✓) 7 (✓) 8 (✓) 9

✓ indicates within project area; (✓) indicates wi hin entire Ramsar site

Ramsar Wetland types

Estuarine, based on RE

Estuarine, based on water body

Lacustrine, based on RE

Lacustrine, based on water body

Marine, based on water body

Palustrine, based on RE

Palustrine, based on water body

Riverine, based on RE

Riverine, based on water body

Source: EPA Wetland Mapping

	Marine / Coastal Wetlands	Regional example
✓	A – Permanent shallow marine waters (<6m)	
✓	B – Marine sub idal aquatic beds (kelp, seagrass)	
	C – Coral reefs	
✓	D – Rocky marine shores, sea cliffs	Toorbul Point
✓	E – Sand, shingle or pebble shores; sandbars; dunes	
✓	F – Estuarine waters	
✓	G – Intertidal mud, sand or salt flats	
✓	H – Intertidal marshes, including saltmarshes	RE 12.1.2
✓	I – Intertidal forested wetlands, including mangroves	REs 12.1.3, 12.1.1
	J – Coastal brackish / saline lagoons	
✓	K – Coastal freshwater lagoons	
	Inland Wetlands	
✓	M – Permanent rivers / streams / creeks	
✓	N – Seasonal / intermittent rivers / streams / creeks	
	O – Permanent freshwater lakes	
✓	Tp – Permanent freshwater marshes / pools	RE 12.2.15
✓	Ts – Seasonal / intermittent freshwater marshes / pools	RE 12.2.15
	U – Non-forested peatlands	
✓	W – Shrub-dominated wetlands; shrub swamps	RE 12.2.12
✓	Xf – Freshwater, tree-dominated wetlands and swamps	REs 12.2.7, 12.3.4, 12.3.5, 12.3.6
	Xp – Forested peatlands; peatswamp forests	
	Y – Freshwater Springs	
	Man-made Wetlands	
✓	9 - Canals, drainage channels and ditches	Skipper Canal

Note: Based on EPA wetland codes; Only wetland types present within Moreton Bay are listed here

Noteworthy Flora and Fauna likely to occur (Status NCA, EPBC respectively)

Terrestrial flora: *Acacia attenuata* (V,V), Heart-leaved Bosistoa (V,V), Three-leaved Bosistoa (V,V), Miniature Moss-orchid (V,V), Swamp Stringybark (E,E), Small-fruited Queensland Nut (V,V), Lesser Swamp-orchid (E,E), Yellow Swamp Orchid (E,E), *Prasophyllum wallum* (V,V), Minute Orchid (V,V), *Acacia baueri* subsp. *baueri* (V,-), Stinking Cryptocaria (V,V), *Macrozamia pauli-guilielmi* (E,E)

Aquatic flora: *Maundia triglochinoides* (V,-),

Birds: Coxen's Fig Parrot (E,E), Paradise Parrot (PE,EX), Swift parrot (E,E), Glossy Black Cockatoo (V,-), Squatter pigeon (V,V), Powerful Owl (V,-), Plumed Frogmouth (V,-), Red Goshawk (E,V), Southern Giant Petrel (E,E), Northern Giant Petrel (V,V), Kermadec Petrel (-,V), Australian Painted Snipe (-,V), Campbell A batross (-,V), Beach Stone-curlew (V,-), Little Tern (E,-), Southern Emu-wren (V,-), Black-breasted Button Quail (V,V), Regent Honeyeater (E,E)

Amph bians: Wallum Sedgefrog (V,V), Southern Barred Frog (E,E), Wallum Rocketfrog (V,-), Wallum Froglet (V,-), Tusked Frog (V,-)

Mammals (terrestrial): Large-eared Pied Bat (-,V), Eastern Long-eared Bat (V,V), Grey-headed Flying Fox (-,V), Long-nosed Potoroo (-,V), Water Mouse (V,V), Spotted-tailed Quoll (V,E)

Reptiles: Loggerhead Turtle (E,E), Green Turtle (V,V), Leatherback Turtle (E,V), Hawksbill Turtle (V,V), Pacific Ridley (E,V), Three-toed Snake-tooth Skink (R,V)

Mammals (aquatic): Southern Right Whale (R,E), Humpback Whale (R,V)

Sharks: Grey Nurse Shark (E,CE), Great White Shark (-,V), Green Sawfish (-,V), Whale Shark (-,V)

Fish: Oxleyan Pygmy Perch (V,E), Honey Blue-eye (V,V)

Source: Wildlife Online & EPBC online searches. Note that these searches indicate species that are l kely – not necessarily known - to occur within the area. Critical wetland species known within the project area have been identified in the report.

Water Quality

Unit	Area	2007	2006	2005	2004
Freshwater	Pumicestone Catchment	C-	C-	C+	C
Estuarine	-	-	-	-	-
Marine	Pumicestone Passage	B-	B	C+	B

Source: Ecosystem Heal h Monitoring Program (Healthy Waterways)

Water Resource Outcomes

Estuarine reaches: Minimise changes to brackish habitats

Moreton Bay and Pumicestone Channel: Minimise changes to the natural movement and delivery of sediment, and the delivery of freshwater, natural nutrients and organic matter

(Source: Water Resource (Moreton) Plan 2007)

Figure 3-2 Snapshot of Bribie Island and Pumicestone Passage

Type Y: Freshwater springs

This wetland type includes freshwater springs and oases. Freshwater springs are a feature of North Stradbroke Island where the watertable and natural land surface intersect such that a freshwater spring develops as a result of groundwater seepage. This wetland type is closely associated with Type M, as a number of streams and creeks on North Stradbroke Island are spring-fed. Within the Moreton Bay Ramsar site, an example of this wetland type is Myora Springs.

3.2.2.3 Man-made Wetland Types (1)

Type 9: Canals, drainage channels and ditches

The Ramsar boundary along the Western Bay includes waterbodies and features that are remnant wetland or drainage channels that are now heavily modified and largely artificial in nature. Examples include the entrance at Skipper Canal on Bribie Island, the entrance channel to the canal and harbour area at Couran Cove on South Stradbroke Island and parts of Dowse Lagoon in Sandgate, covering a total of 9 hectares within the Ramsar site.

3.2.3 Overview of Wetland Processes

Wetland habitat components within the site, as identified in the section above, are influenced by a range of both broad-scale and localised wetland ecosystem processes. These processes include physical processes, chemical processes, biological processes, geologic processes and combinations thereof.

This section provides an overview of the key wetland processes occurring within and external to the Ramsar site.

3.2.3.1 Regional Climate and Hydraulic Processes

The climate and oceanographic current patterns affecting Moreton Bay are influenced by both tropical and temperature features.

The East Australian Current (EAC) typically produces a flow of warm low-nutrient waters from the Coral Sea past Moreton Bay which has a number of effects as outlined in Abal *et al.* (2005) including:

- Transport of tropical larvae;
- Maintenance of relatively consistent water temperatures; and
- Low frequency of upwelling events.

In summer, the average maximum air temperature is about 28º – 29º C and the minimum ranges from 19º to 20º C. The average maximum temperature in winter is about 20º – 21º C and the minimum average ranges from 9º to 10º C.

Winds from the south-east are the prevailing summer winds with low pressure systems bringing rain to the region generally in summer and early autumn. The tropical influences in the summer months lead to heavy, periodic rainfall that causes significant runoff and occasional floods, with considerable silt, mud and sand washed down into the Bay during large events.

Fronts move from west to east in the winter months, generally bringing cool and dry conditions. Winds during winter months generally prevail from a southwest to northwest direction.

The site is occasionally subject to the effects of tropical cyclones which originate in the Coral Sea and may travel as far south as Moreton Bay before (usually) weakening into a low pressure system or rain depression as they cross the coast.

Median annual rainfall in the region is reported as being some 1500 mm with high variability within and among years. Rainfall in dry years is roughly less than half of the rainfall in wet years (Abal *et al.* 2005). Rainfall is also spatially variable, with coastal catchments receiving greater rainfall than western (inland) catchments in the region. This occurs, in part, as a result of on-shore winds and adiabatic cooling as clouds rise over the coastal ranges causing precipitation to form.

The wind climate of Moreton Bay is driven by the synoptic winds and diurnal pattern of sea and land breezes. The sea and land breeze effect is very pronounced in the inshore areas of the site, while greater winds speeds are recorded at more exposed areas such as Cape Moreton.

The dominant processes affecting water levels in the Bay region relate to:

- Astronomical tides;
- Storm surges associated with cyclones and low pressure systems;
- Wind stresses (and generation of local 'sea' waves as discussed above); and
- Potential sea level rise associated with climate change.

From a hydraulic perspective, Moreton Bay is a semi-enclosed waterbody with ocean connections *via*:

- the sand channels of the Northern Entrance Tidal Delta between Bribie and Moreton Islands;
- the South Passage entrance between Moreton and North Stradbroke Islands; and
- an (indirect) connection through the Gold Coast Broadwater system which has a connection to the ocean at Jumpinpin and the Gold Coast Seaway.

The ocean tide penetrates into the system through these separate entrances and is significantly amplified as it moves through the Bay. Tidal currents vary from 0.2 ms^{-1} in the shallow western region to 1.0 ms^{-1} in the deep channels to the north-east. Studies have shown that the Moreton Bay tidal incursion extends southward to the Southern Bay area to the vicinity of the southern end of Russell Island. South from this point, the Bay tides interact with the inflow from Jumpinpin and the Broadwater in a complex way. This complexity results from the natural geomorphology of the area and also the influence of the constructed Gold Coast seaway, which has caused tides in the Broadwater to be only slightly less than those in the ocean (Crimp 1992).

The Central Bay region is shallower in the western and southern areas and deeper (exceeding 20 m) in the eastern parts. This pattern is disturbed by the intrusion of coastal sands which are aggregating along the banks in both the Northern Entrance Tidal Delta as well as in the vicinity of South Passage.

Several streams enter the Bay from the mainland coastal plan including the Brisbane, Caboolture, Pine, Pimpama, Coomera and Logan Rivers and other small creeks and estuaries. Waterways connecting to the Bay are tidal for part of their length with larger waterways such as the Brisbane River exhibiting tidal extent as far as 70 km upstream from the mouth. However, as previously discussed, the major rivers are not included in the boundaries of the Ramsar site.

While the tidal rivers flowing into the Broadwater contribute a significant proportion to the tidal volume of water within that part of the overall system, the contribution of the streams entering Moreton Bay proper is small compared to the total tidal prism of the Bay (Crimp 1992). However, the nutrient and sediment input from these waterways can have significant effects on water quality and associated habitats as discussed in the water quality section below.

The mainland shoreline and Bay waters are largely sheltered from ocean (swell) waves by the outer Bay islands. As a result, wind 'sea' waves dominate swell waves and will develop quickly with the onset of winds, but also diminish quickly as winds ease (Crimp 1992).

Alternatively, the eastern shorelines of the Bay islands are strongly affected by oceanic wind and wave processes, which have caused the formation of high energy sandy beaches and rocky headlands as discussed in the geology section below.

3.2.3.2 Geology and Geomorphology

Stephens (in Crimp 1992) provides an insight to the geological formation of the Bay, which is one dominated by sea level change over geologic time scales. This has led to the laying of a series of sedimentary landscapes that regulate many present day geomorphologic processes.

During the low sea level phases of the Pleistocene ice ages, the present Bay formed as a terrestrial plain traversed by stream valleys of the ancestral Brisbane and Pine Rivers. Sea levels began to rise about 17 000 years Before Present (BP) peaking at the end of the post glacial marine transgression about 6 500 years ago.

As such, the present landscape of the Bay as a marine area has existed for only about 6 500 years during which time a great deal of sedimentation and changes to the morphological features of habitats have occurred. As a result of coastal progradation, the Bay is bordered by extensive estuarine flats and mangrove swamps along its western and southern shores.

Coastal headlands and most of the islands of Moreton Bay are formed of Tertiary age basalts and freshwater shales, Mesozoic age sandstones and Palaeozoic age metamorphic rocks with laterite soils developed at the surface.

The islands themselves are essentially drowned sand dune island barriers anchored by the rocky headlands that formed by wave and wind action during several cycles of sea level change. The resultant landscape on the islands consists of coastal swamps and beach ridges and a wide array of freshwater features such as perched and window lakes, streams and springs.

The modern sedimentation pattern within the Bay itself reflects long term sedimentation patterns since the last major sea level rise and shows the Bay is essentially filling from three sides:

- fluvial sand and mud from the Brisbane River (calculated by Stephens in Crimp 1992 at a supply of about 175 000 tonnes/year averaged over the past 6 500 years);
- marine sand from the South Passage (calculated at a supply of about 200 000 m^3/year over the past 7 000 years); and
- marine sand from the Northern Passage Tidal Delta (calculated at a supply of about 600 000 m^3/year over the past 6 500 years).

The central, deeper area of the Bay remains a non-depositional area.

Figure 3-6 shows a recent satellite image of the Bay produced by SEQ Catchments and partner organisations. This figure illustrates the depositional environments of the Northern Entrance and Southern Passage as well as the Brisbane River Delta, the complex bathymetry and hydrology of the Southern Bay and the relatively static, deeper areas within the Central Bay.

Moreton Bay is situated close to the southernmost limit of reef-building corals. Coral reefs formed in shallower areas of the Bay (along the margins of the large islands and between Mud and Peel islands) around 6 500 to 4 000 years BP in locations when conditions were suitable for growth. Since this time there has been little coral reef development. Some of these nearhsore reefs have since been degraded as a result of increased sediment and nutrient runoff following clearing of the catchment and urbanisation of the region over the past 150 years and from coral limestone mining.

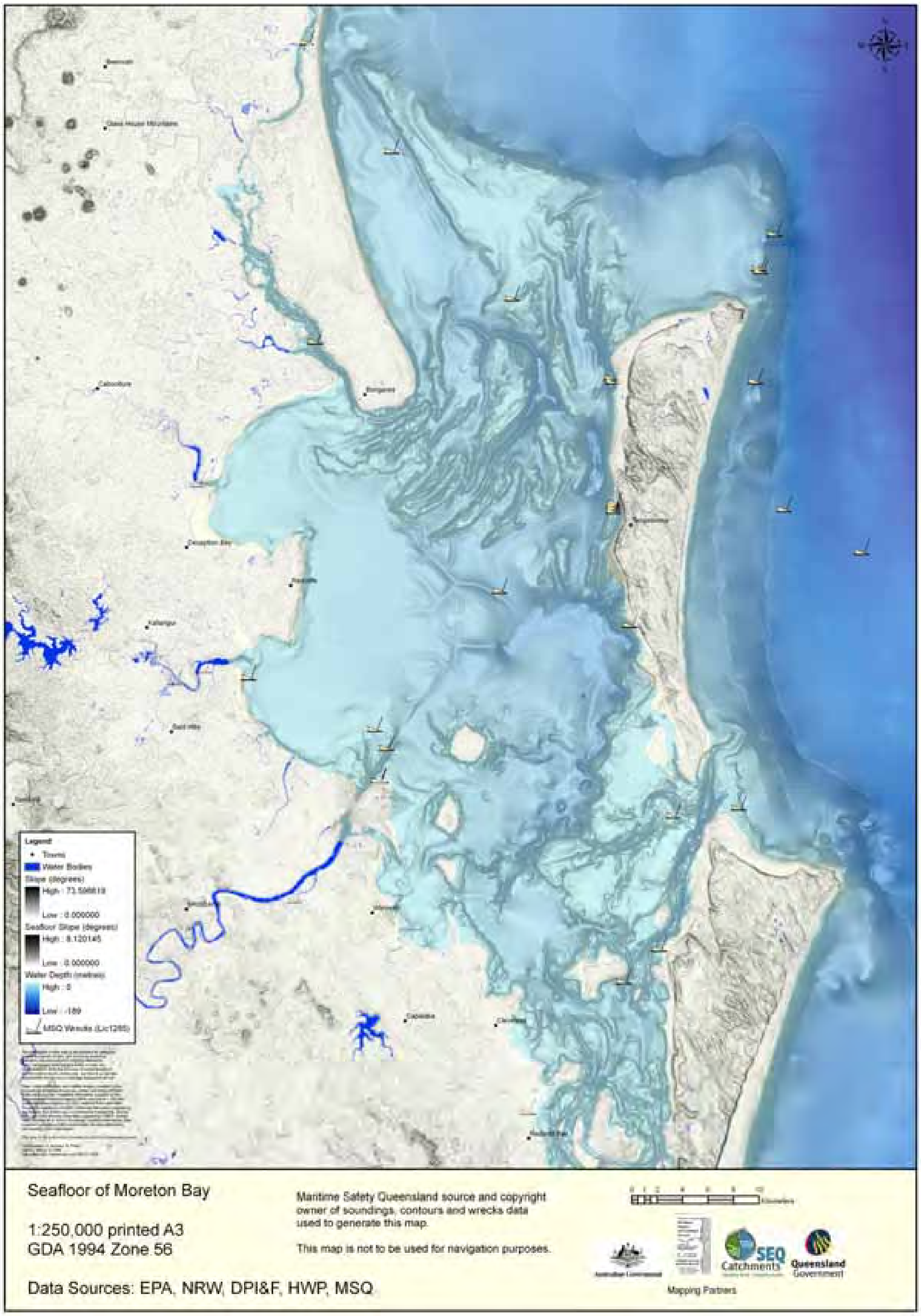


Figure 3-6 Bathymetry of Moreton Bay

Source www.seqcatchments.com.au

3.2.3.3 Freshwater Flows

Coastal catchments between the Lamington Plateau in the south, extending north along the Great Dividing Range to the D'Aguilar Range drain into Moreton Bay. The combined catchment area draining to Moreton Bay is almost 22,000 km^2. Moreton Bay also receives smaller freshwater contributions from run-off from the barrier islands (Bribie, Moreton and North and South Stradbroke) and directly from rainfall.

The northern reach of Moreton Bay comprises Pumicestone Passage, which separates Bribie Island from the mainland. The mainland catchment area draining to Pumicestone Passage consists of a series of sub-catchments which are collectively identified in the Moreton Water Resource Plan as Pumicestone Creeks (State of Queensland 2007). The Western Bay area receives inflows from a series of catchments, the most northerly of which discharges to Deception Bay from the Caboolture River. South from Deception Bay, the Pine River and Cabbage Tree Creek discharge into Bramble Bay. The Brisbane River (which includes drainage from the Upper Brisbane, Stanley, Lockyer and Bremer River subcatchments) enters Moreton Bay between Bramble Bay and Waterloo Bay and the Redlands subcatchments also flow into Waterloo Bay. Further south and the Logan, Pimpama and Coomera Rivers drain to the Southern Bay and Gold Coast Broadwater areas.

Freshwater flows to Moreton Bay are characterised by limited inflow for most of the year with episodic, large-volume floods, which typically occur over summer and autumn months. These high flow events usually contribute to increased productivity of Western Bay environments at a time when shorebirds are most abundant in the area.

The implications of freshwater flows for locally occurring wetlands are largely dependent on the type of wetland, the quantity and quality of flow and/or the wetlands location relative to the freshwater influence. In general terms, freshwater dependent wetlands, such as those in and adjacent to freshwater reaches of watercourses, are those most influenced by freshwater flow patterns. The distribution of mangrove and saltmarsh wetlands are influenced mostly by physiographic features and tidal inundation, however their species composition can be determined by prevailing salinity regimes. Mudflats and seagrass beds can be affected by settlement of freshwater-borne sediments in brackish/saline environments – the former in an advantageous sense from accretion, the latter in a deleterious sense from potential smothering and loss of seagrass beds. Excessive nutrient inputs from freshwater in-flows from point and non-point sources can also impact on seagrass beds as is evidenced by the loss of seagrass from Bramble Bay and Southern Deception Bay and a few sites in Pumicestone Passage and southern Moreton Bay.

Freshwater flows to Moreton Bay have altered over time with development of both land and water resources. Urbanisation of the catchments of the Bay have resulted in significant increases in impervious surfaces, as natural surfaces such as grassland and forested areas are replaced by concrete. These surfaces increase the flow of urban pollutants (including sediment) into nearshore habitats causing altered nutrient sources, eutrophication, and other impacts that affect habitat quality (Young *et al.* 2006).

Over recent years in particular the demand for freshwater has challenged supply and a process of water allocation is being developed. Water Resource Plans (WRPs) provide a strategic framework for the management of water resources within a nominated area by specifying Environmental Flow Objectives (EFOs) and Water Allocation and Security Objectives (WASOs) that are intended to achieve, amongst other things, desired ecological outcomes. Recently developed regional WRPs are being implemented through Resource Operation Plans (ROPs) – currently being established - which will establish detailed water resource management rules for achieving the aspirational EFOs and WASOs set out in the WRPs, as well as a monitoring framework for assessing plan performance. These plans, when implemented, will further influence freshwater flows to Moreton Bay.

3.2.3.4 Water and Sediment Quality

The following water and sediment quality description has segregated the Ramsar site into the four broad areas previously introduced. Water quality condition in this section utilises monitoring information collected as part of the Southeast Queensland Healthy Waterways Partnership Ecosystem Health Monitoring Program (EHMP). The EHMP Annual Report Card provides an overall water quality rating for each area of the Bay, assessed against water quality guidelines (based on benmarks derived from reference data) for several key physio-chemical and biological parameters. Monitoring ratings range from A (excellent – reference conditions) to F (fail – poor water quality, major ecosystem impairment). Detail on the EHMP program and the methods used to derive scorecard values are provided in EHMP technical reports (EHMP 2006).

Bribie Island and Pumicestone Passage

Pumicestone Passage can be broken into three sub-areas when water and sediment quality issues are considered, with these sub-areas largely being controlled by the interplay between catchment inflows and tidal flushing. The northern and southern sections of Pumicestone Passage are well flushed by tidal processes and as such typically exhibit high to moderate water quality, especially so in the case of the southern section. The central sections of Pumicestone Passage, located around 'The Skids', have poorer water quality due to lower rates of tidal flushing (this is an area where tidal inflows from the north and south ends of the Passage meet, creating an area with lowered rates of net water exchange). Pumicestone Passage in recent years has been ascribed EHMP report card ratings of between C^+ and B for estuarine areas and C^- to C^+ for freshwater areas.

There is little readily available, recent sediment grain size distruibution data for this area. Given tidal and catchment influences, it is expected that sediments within the northern and southern sections will be largely marine in nature, progressing to finer, more organic sediments in the central section. The presence of substantially deposits of acid sulfate soils within the catchment will almost certainly be reflected in the quality of sediments within the Passage.

In regard to wetland ecosystem processes in Pumicestone Passage, for most of the areas, natural or quasi-natural conditions still exist, though catchment land use change and large scale infrastructure development (eg. road/rail/water supply) pressures still exist. In general, intertidal wetlands above mean sea level in and adjacent to the Passage (eg. mangroves, tidal flats, saltmarsh) are strongly affected by hydrologic conditions whereby water quality is a more salient issue for sub-tidal vegetation and seagrass beds in the Passage which are undoubtedly under moderate stress.

For waters adjoining the eastern coastline of Bribie Island, water and sediment qualities will be high due to the absence of pollutant sources (e.g. point source discharges or major catchment inflows) and the high rates of tidal flows and net exchange of water.

Western Bay

The Western Bay can also be broken into three sub-areas when water and sediment quality issues are considered, with these largely being controlled by the interplay between point and diffuse (catchment) inflows and tidal processes. These sub-areas are Deception Bay, Bramble Bay and Waterloo Bay, and the respective estuarine/freshwater areas contiguous with these bays.

Bramble Bay exhibits the poorest water and sediment quality of these sub-areas, primarily due to the high rates of pollutant loading (both continual inflows of wastewater and intermittent, though high, inflows of catchment sourced pollutants), with a similar situation for the estuaries connected to Bramble Bay. EHMP report card ratings for Bramble Bay in recent years have ranged between D and D^+ while the Brisbane, Pine and Cabbage Tree Creek estuaries have respectively had D^- to D^+, D to C^- and F to D^- grades.

Deception Bay also exhibits poor water quality, for reasons similar to Bramble Bay, though in the case of Deception Bay the per-unit-area rate of diffuse and point source loading is somewhat lower. Consequent EHMP ratings in Deception Bay have been D to C^+ and for the Caboolture Estuary C^- to B^-.

Waterloo Bay is the portion of the western part of Moreton Bay with the highest water quality, primarily due to high rates of tidal flushing/water exchange caused by its close proximity to South Passage and also as there are low rates of point/diffuse pollutant loadings in this area. Waterloo Bay EHMP report cards in recent years have ranged between B- and B+. The estuaries entering Waterloo Bay exhibit poorer water quality due to their small size and proportionally higher rates of wastewater loads. In recent years, these estuaries have exhibited EHMP report card ratings of D- to D+ (Tingalpa Estuary) and D to C- (Eprapah Estuary).

In regard to wetland ‘functioning’, similar comments in regard to vegetation ‘above’ mean sea level as made for Pumicestone Passage apply, with the exception of there being far greater levels of disturbance due to anthropogenic effects. For the subtidal/seagrass areas, there are sub-area specific comments which can be made, as follows:

Deception Bay – the key factors affecting subtidal wetlands in this area are water quality related, specifically excessive nutrients and commensurate nuisance algal blooms (specifically the blue green cyanobacteria *Lyngbya*). There may well be a strong causative link between continually elevated phosphorus levels (due to regional pressures) and episodic loadings of iron (due to local pressures) and these lyngbya blooms. There have been major losses of seagrass from southern Deception Bay since declaration of the Ramsar site in 1993.

Bramble Bay – this area has seen almost the total loss of sub-tidal seagrass, undoubtedly due to excessive nutrient and sediment loads from point source and catchment loads.

Waterloo Bay – subtidal wetlands in this area are likely to be functioning in a robust manner due to the generally acceptable water quality levels.

Sediments in all of these bays and estuaries, especially Bramble and Deception Bay, are known (Dennison and Abal 1999) to be fine (silts and clays) and in most areas are highly organic. These sediments will undoubtedly comprise a major reservoir of carbon and nutrients and will be contributing to ongoing surface water quality degradation.

Moreton Island and Eastern Banks

The marine sections of this area exhibit reference/near-reference water quality conditions, as evidenced by EHMP report card ratings for recent years never falling below A-. As could be expected, this high water quality can be attributed to very high rates of tidal flow/exchange and very low rates of pollutant input. As a consequence of this, subtidal wetlands (seagrass) are found extensively and to some of the greatest depths in the entire Moreton Bay region, highlighting the unique nature of this area.

Marine sediments in this area are known (Dennison and Abal 1999) to be mostly fine to medium sand, that are mostly marine in origin. The relatively ‘clean’ nature of these sediments will be assisting in maintaining high water quality levels in the overlying water column.

The physio-chemical characteristics of freshwater lakes, creeks and marshes on Moreton Island vary among waterbodies. In common with other dune island wetland systems, these waterbodies typically have low nutrient concentrations (although some perched lakes can have high nitrogen concentrations at low water levels), low pH and electrical conductivity. Waterbodies with a peat substrate typically have low water transparency due to high concentrations of dissolved organic carbon (tannins, linols etc.), whereas waterbodies that are a predominantly fed by the regional water-table typically have clearer waters.

Stradbroke Islands and Southern Moreton Bay

Water quality in the marine sections of the Southern Bay is highly variable in space (i.e. strong east-west and to a lesser extent north-south gradients in water quality) and in time (i.e. strong influence of pulsed flood events).

The Southern Bay and the Gold Coast Broadwater had EHMP report card ratings respectively ranging from D to B- and C- to B+. In an estuarine context, EHMP report card ratings ranged from: heavily impacted (Logan/Albert, EHMP report cards F to D- in recent years), moderately impacted (Pimpama, EHMP report cards C+ to C in recent years) and slightly impacted (Coomera and Nerang, EHMP report cards respectively ranging between B and A- and constantly at a B level in recent years).

As evidenced by environmental monitoring work conducted after recent (2008) heavy flooding in the area, and previous reporting by Dennison and Abal (1999), this is a highly dynamic area in regard to water quality and wetland vegetation. The area is regularly affected by flood events which have seen the loss, and subsequent recovery of, subtidal seagrass beds.

There have also been losses of major areas of mangroves (not due to flooding) and subsequent colonization of former saltmarsh areas as a result of urban development (including on the Southern Bay islands), from sand mining activities and from natural hazards (in the case of hail damage at Cobby Cobby Island). In combination there are major concerns that the various existing processes affecting both water quality and wetland vegetation in this area, when combined with anticipated major population growth/land use change in the catchment could see (water quality driven) consistent and permanent reductions in the extent and health of wetland vegetation in this area.

Sediments in this area will range from sandy/marine in nature throughout much of Southern Moreton Bay and the Gold Coast Broadwater to highly organic silts and muds in the estuaries and less dynamic reaches of Southern Moreton Bay and the Broadwater. As per previous comments, where the sediments are fine and organic, they are highly likely to be contributing to degradation in overlying water quality levels.

Water quality conditions in freshwater environments on North Stradbroke Island are similar to that described for Moreton Island (see discussion above).

3.2.3.5 Marine and Estuarine Nutrient Cycling

Nutrient cycling in and around the wetlands of the Moreton Bay Ramsar site plays a key role, both in regard to functions within the wetlands, and to feedback processes between the wetlands and their proximate areas and the water quality within and overlying (in the case of seagrass beds) them. Nowhere in the region is this more important than in the heavily disturbed/impacted wetland areas of Bramble and Deception Bays. Detailed scientific studies of sediment quality and nutrient cycling processes in these areas (as reported in Dennison and Abal 1999) have indicated that natural denitrification processes in marine sediments are unable to reduce the rates of organic loading of benthic zones (due to a combination of point and diffuse carbon sources). Recent and ongoing efforts to reduce sewage carbon and nutrient loads to the region are being implemented to reduce these impacts.

Outside the above discussion on nutrient cycling which is essentially specific to Bramble and Deception Bays, nutrient budgeting work reported in Dennison and Abal (1999) highlights the following:

- The carbon budget of Moreton Bay is dominated by marine plants, predominantly phytoplankton in the water column. Mangroves and seagrasses constitute smaller sources of primary production in Moreton Bay (see Table 3-2);
- Nitrogen fixing and recycling within wetlands is small in comparison to point and diffuse sources; and phosphorus recycling is also small in comparison to point and diffuse sources.

3.2.3.6 Groundwater Resources

Groundwater (as reported in Dennison and Abal 1999) is not a major inflow or nutrient source to Moreton Bay as a whole and, as such, is likely to be having minimal overall impact on wetland functioning.

There are several, more localised, exceptions in this regard, which are noteworthy, as follows:

- The freshwater wetlands of Bribie Island and the western border of Pumicestone Passage, which will be heavily influenced by groundwater;
- The freshwater wetlands of Moreton Island and North Stradbroke Island, which will also be heavily influenced by groundwater; and
- The seagrass beds in and around Amity and Pelican Banks to the west of South Passage. There would appear to be a strong causative link between the dissolved iron content of groundwater upwellings in these areas and occasional occurrences of *Lyngbya* growth on the seagrass.

Recent studies undertaken by the Department of Natural Resources and Water on North Stradbroke Island (Marshall *et al.* 2006) have sought to identify and examine the groundwater dependent ecosystems, species and communities of the Island. This has been done particularly to formulate potential ecological consequences associated with groundwater extraction. However, the study found that it is not currently possible to evaluate the likelihood or magnitude of changes as a result of increased groundwater extraction in the absence of better hydrological and ecological understanding.

3.2.3.7 Biological Processes

Ecosystem functions are maintained and regulated by numerous, often interacting biological processes. While it is not possible to list and describe each of the biological processes operating within the Ramsar site, the following processes are thought to represent the most important controls operating over broad spatial scales (i.e. either whole of site, or key habitats within the site).

Primary Productivity

Primary productivity, which is the rate at which vegetative matter is produced within a habitat, is ultimately controlled by the availability of light, nutrients, temperature and salinity in estuaries. Preliminary primary productivity estimates for estuarine waters within Moreton Bay (Abal *et al.* 1998) suggest that phytoplankton contributes ~67.9% of primary productivity within the bay. The remaining one third is thought to be generated by seagrass (~16.8%) and mangroves (~15.3%). The high proportion of primary productivity by phytoplankton is a reflection of the large area of this group, whereas on productivity/area basis, seagrasses and mangroves are far more productive (Table 3-2).

The contribution of benthic micro-algae (microphytobenthos) and saltmarsh to primary productivity within the Bay has not been examined to date. In the context of the Ramsar site, which occurs in water depths below 6m and is therefore largely in the euphotic zone, it is likely that benthic microalgae are also important primary producers at this scale (Alongi 1990). Saltmarsh is also a contributor to total primary productivity in the Bay and can be highly productive on a unit area basis (Saenger *et al.* 1977; King 1981; Clarke and Jacoby 1994; Mazumder 2004).

Table 3-2 Primary productivity estimates of seagrasses, mangroves and phytoplankton in Moreton Bay (Abal *et al.* 1998)

Group	Area (ha)	Primary productivity (tonnes C/day)	% Contribution
Seagrasses	25000	105	16.8
Mangroves	13604	96	15.3
Phytoplankton	140000	424	67.9

Patterns in aquatic primary productivity in freshwater wetlands are thought to vary among wetland types. Water-table window lakes such as Blue Lake and Blue Lagoon, which having very low turbidity and colour (transparency), are nutrient poor ecosystems that are considered to be oligotrophic (Bayly 1964; Bowling 1988; Arthington *et al.* 1989; Outridge *et al*. 1989). However given the limited extent of aquatic macrophytes in these lakes compared to the total area of potential microalgae habitat, it possible that phytoplankton and benthic microalgae contribute a high proportion of total primary productivity within these lakes.

Macrophyte cover on perched lakes varies greatly among lakes, and can vary within lakes over time. For example, in 2000, Black Snake Lagoon on North Stradbroke Island had a large open water: littoral macrophyte area ratio, but due to low transparency resulting from high concentrations of tannins, is unlikely to have high microalgae productivity. Ibis Lagoon on North Stradbroke Island, a relatively permanent waterbody with high water transparency, had moderate cover of emergent macrophytes, and a high cover of benthic microalgae (periphyton). Ephemeral perched waterbodies (e.g. Mungaree Lagoon) and palustrine wetlands can have 100% aquatic macrophyte cover (WBM 2002c), and therefore primary productivity is likely be dominated by this component.

Carbon Cycling by Bacteria

As vegetative and animal matter begins to senesce and die, microbes invade the tissues and transform the organic material into more bio-available forms of carbon. While microalgae, and to a lesser extent mangroves and seagrasses, are responsible for primary productivity within estuarine and marine waters of the site, microbial breakdown is a key pathway for plant material entering the food-web in these ecosystems (Alongi 1990). This is especially true for marine macrophytes (seagrass, mangroves, saltmarsh), which with few notable exceptions (e.g. dugongs, some fish) are generally not directly grazed, but instead enter food-webs following microbial conversion of organic matter (Day *et al*. 1989). Carbon flows in sand island freshwater wetlands are not well known and require further investigation, although peatlands (such as Eighteen Mile Swamp on North Stradbroke Island) are exceedingly recognised as important sinks for carbon as actively accumulate organic matter.

In the context of energy flows through the ecosystem, some energy is lost during microbial respiration, some is leached as dissolved organic mater into the water, some is incorporated into microbial biomass, and some may be transformed to other organic compounds not incorporated in microbial cells. Of particular importance to higher trophic levels (i.e. consumers) is the conversion of detrital material into bacterial biomass, which is then in a bio-available form for animals (Day *et al.* 1989). Microbes also affect energy flow by using dissolved organic matter, which is largely unavailable to other estuarine community components (Day 1967; Nybakken 1982; Day *et al.* 1989).

Carbon cycling is intimately linked with nutrient cycling (see section above) and primary productivity. Note that autotrophic bacteria are primary producers, and also contribute to carbon cycling and nutrient flux.

Zooplankton Grazing

Grazing of phytoplankton by zooplankton is an important link in the chain of nutrient flux and energy flow in the coastal and estuarine waters of Moreton Bay (Greenwood 1998). Zooplankton has the following key roles in estuarine ecosystems:

- Transfer of energy through the food web, by transferring organic compounds derived from phytoplankton to higher trophic levels (secondary consumers), including species of direct economic significance;
- Regulation of community structure (species composition, abundance, biomass) of phytoplankton communities. In Moreton Bay, microzooplankters were responsible in one study for the majority of herbivorous grazing (ciliates in the <64µm fraction) (Dennison 1999). In this study, it was demonstrated that zooplankton grazers could account from between 10 and 100% of the total phytoplankton productivity and biomass per day. Therefore, grazing may partially control water quality at local scales.

It is also notable that the planktonic phase forms part of the life-cycle of most benthic and marine demersal fauna (meroplankton), including most species of direct fisheries significance.

While there is a relatively good information base describing estuarine marine zooplankton communities in Moreton Bay, comparatively little is known about the relationships between nutrient levels, phytoplankton dynamics and zooplankton composition, grazing and production, within different parts of the system (Greenwood 1998). No studies have examined zooplankton productivity and dynamics within dune island wetlands, although it is known that communities are depauperate and contain species that are restricted to humic, coastal waterbodies (Bayly 1964; Bensink and Burton 1975; Timms 1982; WBM 2002a,b).

Bioturbation in Estuarine Sediments

Bioturbation, a bottom-up process where biological activity (burrowing) disturbs the ocean floor, can be critical to the structural organisation of soft sediment communities. The main bioturbators include polychaete worms, burrowing crabs (particularly in mangroves) and other crustaceans (e.g. ghost nippers), rays, fish, dugongs and turtles.

Bioturbation results in the mixing of sediment layers. This mixing assists in the oxygenation of the sediment, increases rates of organic decomposition, and affects nutrient cycling processes (Day *et al*. 1989). Furthermore, bioturbation can breakdown micro-topographical features of the bed such as ripples and cross-bedding, which were demonstrated by Stephenson and Sadacharan (1983) to have an important role in structuring soft-sediment communities in Moreton Bay. Bioturbation has a strong influence on many aspects of benthic ecology including:

- physical properties of sediments;
- sediment-water biogeochemical processes, including nutrient cycling;
- seagrass productivity;
- mangrove ecosystem functioning; and

- benthic fauna community interactions, including predation, competition etc.

Other Fauna Interactions

Competition, predation, and disturbance all have an influence on freshwater and estuarine/marine community functioning. The influence of these processes on communities can vary across a range of spatial and temporal scales. Critical fauna interactions in the context of this ECD will be identified in the discussion of specific critical services in Section 7.

In general terms, the following fauna interactions are thought to be important in regulating community structure and ecosystem processes:

- Marine and Estuarine Fish - It is generally thought that populations of most fish species are regulated by non-equilibrium processes (i.e. predation, recruitment limitation) rather than density-dependent processes such as competition. While there is a large body of work examining populations controls and processes for reef fish (Hixon 1998; Levin 1998), with few exceptions there is comparatively little information describing the ultimate population controls for estuarine and coastal fish species. Since most fish species are part of an open population, the process/es that ultimately control populations can vary across multiple spatial scales, and may operate both within and external to the Ramsar site.

- Benthic macroinvertebrates – Numerous studies have examined the roles of competition, predation, larval supply, food supply and disturbance in structure in soft-sediment benthic macroinvertebrate communities. The relative importance of these processes can vary across a range of spatial and temporal scales (Seitz 1998). Of particular note, in parts of Moreton Bay it is known that a cyclic seasonal (spring) recruitment pulse occurs for many species of macroinvertebrate (Stephenson *et al*. 1978; Stephenson 1980a-c). Although not examined within empirical experimental frameworks, predation has been suggested to lead to major temporal changes in invertebrate prey abundance within Moreton Bay (Stephenson 1980b).

- Freshwater fish and decapod crustaceans – Unlike marine and estuarine fish populations, it is generally thought that many freshwater fish species (and some decapod crustacean species) on dune island wetlands form relatively discrete, closed populations (Page *et al.* 2006; Page and Hughes 2007). Biological processes operating at local (within-wetland) spatial scales may therefore be very important controls on these populations. With the notable exception of Oxleyan pygmy perch (Arthington 1996), few studies to date have examined the population ecology of these species.

3.2.4 Uses and Tenure

3.2.4.1 Uses

Urban Development

Southeast Queensland is one of the fastest growing regions in Australia with over 2.5 million people and a population that is increasing by just under 3% per annum. The latest Queensland Government projections by the Planning and Information Forecasting Unit (PIFU) estimate the current population of the Region at 30 June 2006 was 2.8 million people and is expected by 2011 to grow to between 3.0 and 3.1 million people. By 2026, this is expected to increase again to between 3.6 and 4.3 million people.

Urban and suburban developments are concentrated on the Brisbane River corridor and are rapidly expanding into areas along the North and South coast. There continues to be increasing pressure and demand for development of coastal and foreshore areas for residential and associated commercial development that can displace more appropriate coastal dependant uses.

Fishing and Collecting

The Moreton Bay region supports one of the most productive fisheries in Queensland, representing just under three percent of the Queensland coastline while annually producing about 20 percent of Queensland's commercial seafood catch by weight (RIS 1999). Vessels operating within the Moreton Bay Marine Park are reported to have landed approximately $24.1 million gross value of product each year during the three year period ending June 2006 (EPA 2007a).

The Bay is also a popular recreational fishing area. A variety of species are targeted, including yellowfin bream, whiting, tailor, flathead, Black bream, mackerel, snapper and mullet. Eight species of prawn and four species of crab are commercially important, with mud and blue swimmer crabs also being of recreational importance.

Commercial collection of fish and invertebrates for aquarium purposes occurs within the Bay as well as offshore reefs outside of the Ramsar site. Bait collection, food gathering and viewing of coral and aquarium fish species are popular recreational pursuits. Commercial oyster beds operated by licensed oyster growers, commercial baitworm and shell collection also occurs.

The boundaries of the Ramsar site are similar to those of the current Moreton Bay Marine Park excluding deeper areas in the Central Bay. Information presented within the Queensland Government document, *Have Your Say: Moreton Bay Marine Park* (2006) reports that on average 410 commercial fishing licences accessed the Marine Park annually from June 2003 to June 2006. In terms of the value of the fisheries, the report states that these vessels landed approximately $24.1 million gross value of product (that is the wharf price paid to commercial fishers) each year during this period (Queensland Government 2006).

Recreation and Tourism

The Bay is an important and well utilised area for recreational boating and water related activities, offering opportunities for a wide range of water-based recreation including fishing, sailing, power boating, water skiing, parasailing, jetskiing, sailboarding, scuba diving, bird watching, marine study and snorkelling. The southern area of the bay receives the heaviest boating use for most activities because of its sheltered waters and proximity to many boat launching facilities. Policies administered under the marine park zoning plan and Southeast Queensland regional coastal management plan closely regulate the construction of tidal canals and boat harbours including placement of private moorings and jetties in largely undeveloped natural waterways.

The three barrier islands (Moreton, North and South Stradbroke) have unspoilt beaches, topographic diversity within the dunal system and largely undisturbed natural scenery, forest and wetlands.

Sea and Air Port Facilities

The Port of Brisbane is the fastest growing capital city port on the east coast with the capability to handle a wide variety of cargoes. The Port has expanded significantly since the listing of the Ramsar site with the construction of the 230 ha Future Port Expansion reclamation area which extends from Fisherman Islands at the mouth of the Brisbane River into the Waterloo Bay. Maintenance dredging occurs within the shipping channels of the Bay as well as operational areas of the Port and Brisbane River (berths, swing basin, shipping channel) with the dredged material/spoil placed in the reclamation area.

Across the Brisbane River, the Brisbane Airport is Australia's fastest growing passenger airport with a $2.5 billion capital works programme over the next 10 years. These works involve upgrading road transport into the Airport, the expansion of the domestic and international terminals and the development of a New Parallel Runway (which was approved with conditions under the EPBC Act in August 2006) on the Brisbane Airport federal lease. The footprint of the New Runway (with the exception of proposed approach lighting) is situated outside of the boundaries of the Ramsar site in the Western Bay.

Sand Mining and Extraction

Silica and heavy mineral sands are extracted primarily from North Stradbroke Island, under commercial sand mining leases and relevant environmental authorities.

Marine sand is extracted for the construction industry in the northern bay banks near Spitfire Channel and Middle Banks. These sources are highly valued in a regional sense due to the diminishing resources available from mainland streams and terrestrial areas. A long term (20 year) Sand Extraction Strategy (underpinned by the Moreton Bay Sand Extraction Study 2001-2005) regulates the extraction of sand from the Bay for the construction industry and major infrastructure projects at the Port and Airport as outlined above.

Water Extraction

Redland Shire Council's mainland water supply is supplemented by water extracted from an unconfined aquifer on North Stradbroke Island in the vicinity of 18 Mile Swamp (Herring Lagoon).

In response to long term drought and significant water shortages in the region, large-scale groundwater extraction from North Stradbroke Island and Bribie Island is being investigated by the Queensland Water Commission as part of the SEQ Water Supply Strategy.

Marina and Boat Harbours

Several of the Bay's marinas and harbours provide bases for the transport operations which service surrounding locations and the bay islands, servicing commercial, recreational and residential demands.

3.2.4.2 Tenure

Moreton Bay lies within Queensland waters. Most of the land adjoining the Bay consists of land under the control of the Queensland Government, but there are substantial areas of privately owned land along the western shore from Pumicestone Passage to the Southern Bay and Broadwater. In some cases, the property boundaries of this leasehold and freehold land extend to the high water mark (measured at mean high water springs(MHWS)).

Each of the Bay islands has different settlement patterns which can be summarised as follows:

- Moreton Island - several very small townships, a large tourist resort and the remainder of land held as protected area;
- North Stradbroke Island – three primary townships, large mining leases, protected areas and a range of other tenures;
- South Stradbroke Island - largely protected area and other State land tenures with a large tourist resort and several isolated settlements;
- Bribie Island - several large townships on the southern section and a range of reserves and protected areas in the undeveloped northern section.

As described previously, the declared boundaries of the Moreton Bay Ramsar site are predominantly Queensland State waters (unallocated State land) to a depth of 6m below lowest astronomic tide or following the boundaries of other declared regulatory zones in marine areas such as Fish Habitat Areas under the *Fisheries Act 1994*.

Land areas above high water mark included within the Ramsar site are also largely State-owned lands managed by various State agencies or by local governments as trustees of reserves and similar tenured land. This includes national parks, conservation parks, reserves, undeveloped esplanades and unallocated State land. Areas of freehold land in the Ramsar site are controlled by local government (Brisbane City Council in the case of the Boondall wetlands). Leasehold above and below high water mark is also largely excluded.

3.2.5 Noteworthy Flora and Fauna

The freshwater, estuarine and marine wetland habitats of Moreton Bay Ramsar site support a range of noteworthy flora and fauna species and important populations. In this context, it is recognised that there are a range of migratory species (many of which are of conservation significance such as cetaceans and sharks) that may also use habitat within the boundaries of the site from time to time. However, the focus of this ECD is on those species and populations that use the areas within the site as core habitat. Further discussion on this point is contained in Section 4 of the report.

A summary of these key species and populations are as follows:

- Moreton Bay supports a high abundance of shorebirds (Bamford *et al.* 2008). During the summer months, Moreton Bay habitats support over 3500 resident and between 40,000 to 50,000 migratory shorebirds (Thompson 1990a; Driscoll 1993; Watkins 1993; Driscoll 1997). This equates to approximately 10% of maximum number of shorebirds migrating to Queensland over the summer period (Driscoll 1993; Watkins 1993; Driscoll 1997);

- Moreton Bay also supports a high diversity of shorebirds. Ten resident and 32 migratory shorebird species are regularly recorded in Moreton Bay (Thomson 1990);

- Moreton Bay supports significant numbers of individual shorebird species (Watkins 1993; Driscoll 1997; and Bamford *et al.* 2008), including bar-tailed godwit *Limosa lapponica*, whimbrel *Numenius phaeopus*, eastern curlew *Numenius madagascariensis*, terek sandpiper *Xenus cinereus*, grey-tailed tattler *Heteroscelus brevipes*, curlew sandpiper *Calidris ferruginea,* pied oystercatcher *Haematopus longirostris*, Pacific golden plover *Pluvialis fulva*, and lesser sand plover *Charadrius mongolus*;

- Moreton Bay represents the southern limit of the dugong's (*Dugong dugon*) Australian distribution (Lanyon and Morrice 1997) and currently contains one of the largest populations of dugongs on the east coast of Australia (Marsh *et al.* 1996);

- Six species of marine turtle are known to use Moreton Bay as a feeding area. Two of these species - the green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) - have resident populations in Moreton Bay within the nearshore marine areas that are within the boundaries of the Ramsar site;

- Two nationally threatened 'wallum' habitat associated fish species occur within the Moreton Bay Ramsar site: Oxleyan pygmy perch (*Nannoperca oxleyana*) and honey blue-eye (*Pseudomugil mellis*);

- Moreton Bay supports populations of ten threatened wetland-dependant fauna species. These are: Illidge's ant blue butterfly *Acrodipsas illidgei,* wallum froglet *Crinia tinnula*, wallum rocketfrog *Litoria freycineti* and wallum sedgefrog *L. olongburensis*, beach stone-curlew *Esacus neglectus*, water mouse *Xeromys myoides,* Cooloola sedgefrog *Litoria cooloolensis*, Australian painted snipe *Rostratula australis,* little tern *Sterna albifrons* and Australasian bittern *Botaurus poiciloptilus*; and

- Numerous endangered and vulnerable flora species are known to occur within the Moreton Bay region, including five nationally-listed species that are wetland-dependent. Particularly noteworthy species include the endangered swamp daisy (*Olearia hygrophila*) that is endemic to North Stradbroke Island, known only from two locations on the island; and three endangered swamp orchid species (*Phaius australis, P. bernaysii* and *P. tancarvilleae*) that are rarely seen on mainland but are more frequently encountered on the bay islands (SGAP 2005).

3.2.6 Cultural Values

Indigenous

Moreton Bay was an important area for Indigenous people in the past as well as remaining so today (Fesl and Davies 2004). On many of the islands, in particular North Stradbroke Island, there is evidence of Aboriginal presence going back 20 000 years.

There are numerous archaeological site types that have been located within the broader wetland area in and around Moreton Bay and the Bay islands. These include:

- Stone Artefact Scatters
- Shell Middens
- Burials
- Scarred Trees
- Quarries
- Axe Grinding Grooves
- Stone Arrangements
- Burial Grounds

As outlined in the geological processes section above, the entire area of Moreton Bay was exposed as a dry, flat plain during the last glacial maximum in the Pleistocene period. The floodplain would have been regularly traversed by indigenous people of that time on their way to the Bay islands which as a result of low sea levels in the region would have comprised the mainland coast. This Pleistocene landscape and the potential for indigenous artefacts to be preserved within it are discussed by Hall (1999) and the Moreton Bay Sand Extraction Study.

Historic

The shoreline of Moreton Bay was the first area in the Brisbane region to be settled by Europeans. Coochiemudlo Island was the site of the first landing by Matthew Flinders during his exploration of Moreton Bay and the Brisbane River. St Helena Island which was used as a prison and quarantine station at different periods was the first historical area in Queensland to be reserved as a National Park solely because of its historic ruins. Other areas settled by Europeans include Peel Island, used first as a quarantine station and then as a leper colony, Dunwich and Amity Point on North Stradbroke Island and Redcliffe on the mainland which was the site initially chosen for the penal colony before it was moved up the Brisbane River (RIS 1999).

Tourism and Recreational Values

Tourism and recreational values of the Moreton Bay Ramsar site predominantly relate to nature-based activities available within the Moreton Bay region. The Ramsar site includes important terrestrial and aquatic environments for tourism and recreational activities including boating, diving, spear fishing, line fishing, snorkelling, swimming, surfing, shorebird, turtle, dolphin, dugong and whale watching, bushwalking, camping, four wheel driving and sand tobogganing. In addition to the activities available, the high aesthetic and wilderness values, and indigenous and European values (discussed above) attract people to the area.

The proximity of the Moreton Bay Ramsar site to Queensland's capital city, Brisbane, highlights the importance of the site for regional residents and visitors, both for tourism and recreational purposes, and conservation and wise use of the area (i.e. management of impacts from tourism and recreation). The Bay supports a significant economic contribution from tourism and recreational activities with an estimated $500 million spent by visitors to the Moreton Bay and islands region in 2006, further contributing an estimated 5,500 jobs (EPA 2007a).

Education and Research Activities

The Bay and its flora and fauna have been, and continue to be, well studied. Queensland University, CSIRO and the Department of Primary Industries and Fisheries have research stations in the Moreton Bay region (although outside the boundaries of the Ramsar site). Other universities and colleges use Moreton Bay for research and education.

Numerous research programs and projects have been undertaken with respect to the Bay's habitats and important species that are documented in Section 8, References. In terms of recent research activities undertaken by State agencies, of particular note are the EPA's Queensland Turtle Conservation Project (see Limpus *et al*. 2006), recent studies of groundwater ecosystems on the Bay islands by the Department of Natural Resources and Water (see Marshall *et al.* 2006) and various research projects on Bay fisheries by the Department of Primary Industries and Fisheries.

The Brisbane City Council manages and operates the Boondall Wetlands Environment Centre on the Boondall Wetlands Reserve in western Moreton Bay which offers a range of displays and activities on the environmental and cultural heritage of the reserve for park visitors and organised groups. The mangrove boardwalk at Wynnum North is also a significant educational resource.

The Queensland Department of Education runs environmental education centres at Nudgee Beach, Moreton Bay (at Wynnum) and Jacobs Well for educating children on coastal and environmental matters. The Environmental Protection Agency has educational facilities on St Helena and Moreton Islands.

The Bay's resources and key components such as water quality are also extensively monitored. Under the Healthy Waterways Partnership, following design and input from stakeholders, the Ecosystem Health Monitoring Programme for estuarine and marine waters was implemented in 2000. The water quality and biological information obtained from this monthly monitoring program continues to the present day, allowing Bay resource managers and stakeholders to evaluate the ecosystem and community benefits of investment in protection and conservation measures. The EHMP forms the basis for the annual Report Card for the Bay which rates each of the Bay's major water bodies, rivers and catchment streams.

Other monitoring activities include extensive work by volunteers such as wader bird observations collected by the Queensland Wader Study Group and the Seagrass Watch programme undertaken by conservation groups in the region.

3.2.7 Policy Framework Governing the Site

The size and significance of the Moreton Bay Ramsar site is such that it is subject to a wide array of statutory and non-statutory plans and strategies that aim to manage its resources and values. A summary of the most relevant laws, plans and strategies at all relevant levels of Government is included below:

International

In addition to the Ramsar Convention itself, many of the values of the site that are salient to its listing as a Wetland of International Importance are also relevant to international obligations under other conventions and agreements. Some of the key instruments are:

- JAMBA - the Agreement between the Government of Australia and the Government of Japan for the protection of migratory birds in danger of extinction and their environment 1974.
- CAMBA - the Agreement between the Government of Australia and the Government of China for the protection of migratory birds in danger of extinction and their environment 1986.
- ROKAMBA – the Agreement between the Government of Australia and the Government of the Republic of Korea for the protection of migratory birds and their environment 2006.
- The Convention on the Conservation of Migratory species of Wild Animals (the Bonn Convention);
- The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)

National

At the National level, the Australian Government through the Department of Environment, Water, Heritage and the Arts (DEWHA) has provided guidance with respect both preparing and using ecological character descriptions. In this context, the ECD of a wetland provides a reference for the following planning and management activities:

- development and implementation of a management plan designed to maintain the ecological character of the Ramsar site;
- the design of a monitoring program to detect change in ecological character;
- assistance in reporting to the Australian Government and the Ramsar Convention about any changes in the ecological character of Ramsar sites; and
- Environmental impact assessment of the likely impact on ecological character of proposed actions, including that required under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In relation to the last point, Ramsar sites are a key component of the matters of National Environmental Significance (NES) under which assessment and approval of controlled actions under the EPBC Act must be obtained. In practice, this is undertaken through the referral of a development proposal by a proponent to the Minister administering the Act for a determination about the likelihood of impacts to a matter of NES. For development that may affect the Moreton Bay Ramsar site, the potential for changes to the ecological character of the site (as outlined in this ECD) plays a key role in the Minister's determination of the appropriate assessment process used under the Act as well as the decision to approve a development proposal and any conditions imposed under the controlled action approval.

Of note in the context of the current study, the Moreton Bay Ramsar site is identified as generating the high number of referrals under the Act for consideration by the Minister. This is a likely reflection of the size of the site as well as the large locally resident population that is rapidly urbanising surrounding areas.

State and SEQ Region

There is a plethora of legislation, policies, plans and strategies that apply directly and indirectly to the conservation and wise use of the Moreton Bay Ramsar site. At the State level, legislation such as the *Integrated Planning Act 1997*, *Environmental Protection Act 1994, Fisheries Act 1994, Nature Conservation Act 1992, Coastal Protection and Management Act 1995, Water Act 2000, Vegetation Management Act 1999, Aboriginal Cultural Heritage Act 2003, Queensland Heritage Act 1992,* and their respective regulations, are applied throughout the Ramsar site. Further, the *Marine Parks Act 2004, Nature Conservation Act 1992* and *Recreation Areas Management Act 2006* are applicable in areas within the Ramsar site designated under these Acts for protection and management (e.g. as a Marine Park, National Park, Conservation Park or Recreation Area). A more substantive discussion of the applicability of these statutes to the Ramsar site is contained in BMT WBM (2008a).

Within South East Queensland (SEQ) there are additional statutory and non-statutory plans and strategies relevant to the region. Some of these plans also apply specifically to Moreton Bay. No legislation, policies, plans or strategies specifically apply to, or manage the Moreton Bay Ramsar site, although many apply to the management of aspects influencing the Ramsar values and ecological character of the site. The most relevant plans and strategies applicable to the conservation and wise use of the Ramsar site, Ramsar values and aspects of the ecological character of the site include the following:

Statutory plans, strategies and areas

- *Marine Park (Moreton Bay) Zoning Plan 1997*;
- Southeast Queensland Regional Coastal Management Plan 2006 prepared under the *Coastal Protection and Management Act 1995*;
- Protected Area Management Plans (for national parks, conservation parks and other protected areas in the region);
- Environmental Values and Water Quality Objectives under the *Environmental Protection (Water) Policy 1997*;
- *South East Queensland Regional Plan 2005*;
- Fisheries Management Plans including the East Coast Trawl and Coral Reef Fin Fish fisheries;

- Declared Fish Habitat Areas (FHAs) under the *Fisheries Act 1994*;
- Water Resource Plans prepared under the *Water Act 2000*; and
- Local Government Planning Schemes prepared under the *Integrated Planning Act 1997*.

Non-statutory plans

- SEQ Healthy Waterways Strategy – Moreton Bay Action Plan
- The Future in Balance - SEQ Catchments
- Shorebird Management Strategy – Moreton Bay

A more detailed summary and discussion of these plans, strategies and areas is contained in Appendix B.

3.3 Ramsar Nomination Criteria

Each site nominated under the Ramsar Convention must address some or all of the Ramsar Nomination Criteria established within the text of the Convention and amended from time to time by the Conference of Parties.

Since the Moreton Bay Ramsar site was nominated in 1993, the Nomination Criteria under the Ramsar Convention have been modified. Table 3-3 presents a comparison between the pre-1999 (as listed in the current RIS and Nomination Documentation) and the post-1999 Ramsar Nomination Criteria for identifying Wetlands of International Importance (as outlined in the Convention and National Framework document).

In the table, Nomination Criteria listed on the current Ramsar Information Sheet for Moreton Bay are underlined and italicised; noting that the Moreton Bay Ramsar site currently supports criteria 1, 2, 3, 4, 5, and 6 under the 'new' (eg. post-1999) criteria.

Criteria 7, 8 and 9 listed in Table 3-3 (which relate to criteria about fishes and wetland-dependant non-avian fauna) did not exist at the time of the nomination of the Moreton Bay Ramsar site in 1993 and as such have been evaluated in the context of the current ECD study.

The evaluation has been undertaken using the guidance and other supporting information for interpretation of the Nomination Criteria provided within the *Ramsar Handbook 14*, *Designating Ramsar sites* within the Ramsar Handbooks for the Wise Use of Wetlands 3rd Edition (published by the Ramsar Secretariat).

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Table 3-3 Comparison of current and pre-1999 Ramsar nomination criteria

Notes: Underlined and italicised text indicates pre-1999 nomination criteria for the Moreton Bay Ramsar site

'New' Criteria	Pre-1999 Criteria
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	1(a) it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region *1(b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region* *1(c) it is a particularly good representative example of a wetland which plays a substantial hydrological, biological or ecological role in the natural functioning of an major river basin or coastal system, especially where it is located in a trans-border position* 1(d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	*2(a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species.*
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	*2(b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna* 2(d) it is of special value for one or more endemic plant or animal species or communities *3(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity.*
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	*2(c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle.*
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.	*3(a) it regularly supports 20,000 waterfowl.*
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	*3(c) where data on populations are available, it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterfowl.*
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	4(a) it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	4(b) it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Criterion 9: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.	None.

3.3.1 Justification for Listing – Criteria (1 – 6)

The justification for the listing of the Moreton Bay Ramsar site is made by a number of supporting statements in the current RIS (updated 1999) that relate back to the Nomination Criteria listed above. These have been reviewed and updated as part of the current ECD study and include the following:

Criterion 1

Ramsar Nomination Criterion 1 states: *A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.*

Moreton Bay is one of the largest estuarine bays in Australia enclosed by a barrier island of vegetated sand dunes.

Moreton Bay plays a substantial role in the natural functioning of a major coastal system through its protection from oceanic swells providing habitat for wetland development, receiving and channelling the flow of all rivers and creeks east of the Great Dividing Range from the McPherson Range in the south to the north of the D'Aguilar Range.

In the absence of appropriate mapping, a detailed assessment of the distribution and extent of various Ramsar wetland types is not possible at this stage (see Section 3.2.2). However, based on available information and the expert knowledge of the study team, it is known that the Moreton Bay Ramsar site contains a wide diversity of Ramsar wetland types (with up to twenty-two types represented) including several that are considered rare within the bioregion. Of particular note are the following three wetland types, all of which occur in freshwater environments, typically on sand barrier islands:

- Unforested peatland (Type U). Eighteen Mile Swamp on North Stradbroke Island contains a mosaic of unforested peatland (Type U) and forested peatland (mainly Melaleuca) (Type Xp). This wetland type is thought to be mainly resticted to offshore sand barrier islands within the biogeographic region;
- Forested peatlands (Type Xp) – see above;
- Permanent freshwater lakes (Type O). Several large, permanent freshwater lakes occur on Moreton (e.g. Lake Jabiru) and North Strabroke Island (e.g. Blue Lake, Ibis Lagoon). While Fraser Island also contains good examples of representative freshwater lakes within the biogeographic region, this habitat type is poorly represented in mainland areas within the bioregion.

Criterion 2

Ramsar Nomination Criterion 2 states: *A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.*

Numerous nationally and internationally threatended species occur within the site. Moreton Bay supports appreciable numbers of the nationally vulnerable green turtle *Chelonia mydas* and the endangered loggerhead turtle *Caretta caretta*. Wallum wetland habitats within the site provide habitat for the endangered Oxleyan pygmy perch *Nannoperca oxleyana*, and the vulnerable honey blue-eye *Pseudomugil mellis*, and is ranked among the top ten habitats of the IUCN listed dugong in Queensland.

Moreton Bay also supports a range of nationally threatened wetland-dependant fauna species including the wallum sedgefrog *Litoria olongburensis*, water mouse *Xeromys myoides,* and Australian painted snipe *Rostratula australis.* The internationally threatened (IUCN listed) Illidge's ant blue butterfly *Acrodipsas illidgei* also occurs in the site.

Numerous nationally vulnerable and endangered plant species exist within the Ramsar site, five of which are wetland-dependent species.

It should be noted that several other internationally and nationally marine species have been recorded in Moreton Bay, but are considered as either vagrants or do not have core habitats within the site. This includes for example whales and shark species that prefer more oceanic waters. Furthermore, hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*) and flatback (*Natator depressus*) turtles are seasonal visitors to the region, or do not have high abundances within site (Limpus *et al.* 2006). These species are therefore not considered as critical elements in the context of this ECD.

A range of state listed threatended species also occur within the site. Consistent with the National Framework, only national and international threatened species are to be considered under this nomination criteria. However, many State listed threatened species are considered as critical services in this ECD in the context of other Ramsar nomination criteria, particularly Criterion 3 (in the context of maintaining biodiversity valuyes at a regional scale), and Criteria 4-6.

The terrestrial fauna species list data sets for the South-east Queensland Bioregion and Moreton Bay presented in Appendix D were interrogated to provide a summary of threatened species for Moreton Bay. Table 3-4 provides a full listing of threatened species (wetland-dependent or otherwise). Of these species, the wetland-dependant species of conservation significance are regarded as providing critical ecosystem services in the context of the ECD.

Table 3-4 List of threatened terrestrial fauna species known to occur in the Moreton Bay region and their primary habitat types

Family	Scientific Name	Common Name	NCA	EPBCA	IUCN	Habitat Types (see footnote below for codes)
Pteropodidae	*Pteropus poliocephalus*	grey-headed flying-fox	C	V	V	Not wetland-dependent taxa - Open forests, wet sclerophyll forests, closed forests wherever flowering trees occur.
Muridae	*Xeromys myoides*	false water-rat	V	V	V	H & I
Myobatrachidae	*Adelotus brevis*	tusked frog	V		Near Threatened	M, N, O, Tp,Xf, & 9
Myobatrachidae	*Crinia tinnula*	wallum froglet	V		V	K, O, Tp, U, W, Xf, Xp, & 9
Hylidae	*Litoria olongburensis*	wallum sedgefrog	V	V	V	K, O, Tp, Ts, & Xp

Family	Scientific Name	Common Name	NCA	EPBCA	IUCN	Habitat Types (see footnote below for codes)
Hylidae	*Litoria cooloolensis*	Cooloola sedgefrog	R		E	O & Tp
Hylidae	*Litoria freycineti*	wallum rocketfrog	V		V	O, Tp, Ts, & Xp
Ardeidae	*Botaurus poiciloptilus*	Australasian Bittern			E	Tp & Xp
Turnicidae	*Turnix melanogaster*	black-breasted button-quail	V	V	V	Not wetland-dependent taxa - dry closed forests (esp. semi-evergreen vine thickets) & softwood scrubs.
Rostratulidae	*Rostratula australis*	Australian painted snipe	V	V		H, J, K, Tp, Ts & Xp
Burhinidae	*Esacus neglectus*	beach stone-curlew	V		Near Threatened	E, G, H, K, Tp, Ts,
Laridae	*Sterna albifrons*	little tern	E		Least Concern	A, E, & F
Lycaenidae	*Acrodipsas illidgei*	Illidge's ant blue butterfly	V		E	I & Xp

Where applicable, habitat types in Table 3-4 follow those listed under the current Ramsar Information Sheet (1999) for Moreton Bay, i.e.:

Coastal Marine Wetland Types (11)

Type A: Permanent shallow marine waters

Type B: Marine subtidal aquatic beds (seagrass beds)

Type C: Coral reefs

Type D: Rocky marine shores

Type E: Sand, shingle or pebble shores

Type F: Estuarine waters (permanent water of estuaries and estuarine systems of deltas)

Type G: Intertidal mud, sand or salt flats

Type H: Intertidal marshes (saltpan vegetation on marine clay plains, as well as saline or brackish sedgelands)

Type I: Intertidal forested wetlands

Type J: Coastal brackish/saline lagoons

Type K: Coastal freshwater lagoons (freshwater delta lagoons)

Inland Wetland Types (9)

Type L: Permanent inland deltas

Type M: Permanent rivers / streams / creeks

Type N: Seasonal rivers / streams / creeks

Type O: Permanent freshwater lakes (Permanent freshwater bodies over 8ha in area)

Type Q: Permanent saline / brackish / alkaline lakes

Type Tp: Permanent freshwater marshes / pools

Type Ts: Seasonal / intermittent freshwater marshes / pools on inorganic soils

Type U: Non-forested peatlands (Eighteen Mile Swamp)

Type W: Shrub-dominated wetlands (Br bie Island National Park)

Type Xf: Freshwater tree-dominated wetlands (open forests dominated by *Melaleuca quinquenervia*)

Type Xp: Forested peatlands (Eighteen Mile Swamp)

Man-made Wetland Types (1)

Type 9: Canals, drainage channels and ditches

Criterion 3

Ramsar Nomination Criterion 3 states: *A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.*

The Moreton Bay Ramsar site contains high biodiversity values at a bioregional scale. The site has a high level of habitat diversity (and associated species richness) at a bioregional scale, and includes most wetland types found in the bioregion. The site is thought to provide a refuge and source of propoagules for marine species within and external to bioregion. The site has the following biodiversity values for key wetland species groups:

- Moreton Bay supports ~275 species of macroalgae, which represents ~40% of the macroalgae species reported in Queensland (Phillips 1998). A large proportion of these species occur in the site, although this figure does include reef areas outside the boundaries of the site. Overall, tropical/subtropical species predominate (~64% of species), and several of which have their southernmost distribution limit in the Bay. The warmer waters within the Bay relative to oceanic water temperatures may provide refugia for tropical species. Temperate species represent ~15% of the species, although few species have their northern-most distribution limit in the Bay (Phillips 1998).

- The site contains seven species of seagrass (Abal *et al.* 1998), which includes all five species recorded in the bioregion by Coles *et al*. (1989), as well as *Halophila decipens*. Moreton Bay, like Hervey Bay to the north, provides optimal habitat conditions for seagrass species (i.e. large interdal babnks, high water clarity, relatively sheltered areas etc). Consequently, the site has a larger number of seagrass species compared to most riverine estuaries in the bioregion, which are typically comprised of one to three species (typically *Zostera muelleri*, together with *Halophila ovalis* and sometimes other species).

- The site supports seven species of mangrove (Abal *et al.* 1998). This represents 50% of the total number of mangrove species recorded in the south-east Queensland region (Duke 2006). The site represents the southernmost distribution limit of *Lumnitzera racemosa*. Six of the seven species recorded in Moreton Bay have been recorded in northern NSW (Duke 2006), and it is possible that the site provides a source of propagules to other areas within the bioregion.

- The site supports a rich terrestrial flora assemblage, with for example, 824 native plant species recorded from North Stradbroke Island alone (Queensland Herbarium 2005). Some flora species are thought to be restricted to the site, and therefore contribute to bioregional biodiversity.

- Moreton Bay supports ~3,225 species of marine invertebrates, although this figure also includes records from offshore reef sites outside the site (Davie and Hooper 1998). No comprehensive account of marine invertebrate diversity is available for the bioregion, although Davie and Hooper (1998) argue that the Bay:
  - has a wide diversity of habitats and constituent species in a relatively small area.
  - has many species that appear to be endemic (or undescribed);

  - lies on a biogeographic overlap zone and provides "…a refuga for both temperate and tropical species, some of which are apparently not found in neighbouring regions."

- Moreton Bay supports ~750 marine fish species (Johnson 1999). Comparisons with other estuaries is complicated by patterns in habitat selectivity and differences in habitat types. Shoalwater Bay, which has similar habitat types as Moreton Bay, contains ~413 species of estuarine and marine fish (Johnson 1999). Most other estuaries in the bioregion, which typically have less complex habitat and are generally smaller in area, would generally have lower species richness than Moreton Bay.

- The freshwater invertebrate and fish fauna of the site are compartiavely less well known. The sand barrier islands contain wallum/humic specialists (e.g. Oxlyan pymgmy perch *Nannopera oxleyana*; the zooplankter *Calamoecia tasmanica*, the dragonfly *Petalura gigantea* etc.) as well as species that have more generalist habitat requirements (Arthington and Watson 1982; Arthington 1996). The wallum/humic specialists are found in a small number of waterbodies within the bioregion, hence their presence at the site contributes greatly to bioregional biodiversity values.

- All six marine turtle species known to occur in Australian waters have been recorded in Moreton Bay (Limpus *et al.* 2006). With the exception of Hervey Bay, no other estuaries in the bioregion are known to contain this level of biodiversity.

- At least 42 species of shorebirds use intertidal habitats in the Bay, including 32 migratory species listed by JAMBA, CAMBA and ROKAMBA.

- The site contains approximately 59% of the total number of number mammal, reptile, amphibian and bird species known to occur in the SEQ bioregion (see Table 3-5). Refer to Appendix D for species lists.

Table 3-5 Number of terrestrial fauna species in the SEQ Bioregion and in Moreton Bay

Taxa	SEQ Species Richness	Moreton Bay species Richness (% of SEQ species)
Mammals	91	45 (49%)
Reptiles	151	52 (34%)
Frogs	49	26 (53%)
Birds*	403	290 (72%)
Total	**694**	**413 (59%)**

* excludes oceanic species that do not use habitats found in the site (e.g. petrels, albatross, skuas, some terns, jaegers, tropibirds etc.)

Criterion 4

Ramsar Nomination Criterion 4 states: *A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.*

The Ramsar site provides habitat for a range of important wetland and aquatic fauna at a critical life stage. This includes the following:

- The site is an important wintering area for migratory shorebirds.
- The site is an important breeding (nesting) area for a number of waterbirds and shorebirds. Key waterbird and shorebird species are listed in Appendix D.
- The site is an important feeding area for green and loggerhead turtles.
- The site is an important feeding and breeding area for dugong.
- The site has the most significant concentration of young and mature loggerhead turtles in Australia.
- The site represents important nursery grounds for a range of marine fish, prawns and crabs, many of which are of commercial significance.

Criterion 5

Ramsar nomination Criterion 5 states*: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.*

Moreton Bay can support more than 40,000 migratory shorebirds during the non-breeding season (Austral summer).

Table 3-6 is a summary of the total number of shorebird species known to occur in the South-east Queensland Bioregion and Moreton Bay (refer to Appendx D for a detailed list of species). This table shows that ten resident and 32 migratory shorebird species are regularly recorded in Moreton Bay (Thomson 1990; EPA 2005b). Note that the term shorebird is a generic term used to describe both resident and migratory species from the following families: Scolopacidae; Burhinidae; Haematopodidae; Recurvirostridae; Racanidae; Charadriidae; and Glareolidae.

Table 3-6 Number of shorebird species in the SEQ Bioregion and in Moreton Bay

Category	SEQ Species Richness	Moreton Bay Species Richness
INBM – International non-breeding migrant	34	34
BR – breeding resident	12	12
ANBR – Australian non-breeding resident	3	1
PBR – possible breeding resident (though no breeding records to date)	1	1
Total Species Richness	**50**	**48**
V - Vagrant	8	6

Criterion 6

Ramsar Nomination Criterion 6 states*: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.*

A total of 57 of the 66 waterbirds known from the SEQ bioregion have been recorded in Moreton Bay (see Appendix D for species list). Note that the term waterbird refers to those species found predominantly on freshwater ecosystems in Australia from the six major orders Anseriformes (ducks, geese and Black Swan), Podicipediformes (grebes), Pelecaniformes (Australian Pelican and cormorants), Ciconiiformes (herons, ibis, spoonbills and bitterns), Gruiformes (cranes, rails, crakes and gallinules), and Charadriiformes (waders and terns) (after Kingsford & Norman 2002).

The 1% species population threshold is exceeded for the following avifauna species: bar-tailed godwit *Limosa lapponica*, whimbrel *Numenius phaeopus*, Eastern curlew *Numenius madagascariensis*, terek sandpiper *Xenus cinereus*, grey-tailed tattler *Heteroscelus brevipes*, curlew sandpiper *Calidris ferruginea,* pied oystercatcher *Haematopus longirostris*, Pacific golden plover *Pluvialis fulva*, and Lesser sand plover *Charadrius mongolus* (see data in Bamford *et al.* 2008).

3.3.2 Justification for Listing – Criteria (7 - 9)

As part of the current study, it is recommended that criteria 7 and 8 are also supported by the Moreton Bay Ramsar site and should be included in the revision of the RIS.

While it is likely that Moreton Bay supports more than 1% of the individuals in a biogeographic population of several non-avian species (eg. Criterion 9), there is insufficient published data about populations across the biogeographic region to verify this (a stated requirement in the Ramsar Nomination Guidelines). On this basis, justification for inclusion of the site on the basis of Criterion 9 has not been recommended at this time but is discussed below for future consideration.

Criterion 7

Ramsar Nomination Criterion 7 states*: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages,* *species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.*

Moreton Bay contains an appreciable diversity of fish with ~750 fish species represented and over 3000 species of free living marine invertebrates (Johnson 1999).

Situated within the Moreton Tweed Marine Bioregion (IMCRA), Moreton Bay lies within a transition zone that supports both temperate and tropical fish and crustacean species. High levels of biodiversity are also supported by the unique geography and diversity of habitat types found within the site that include both nutrient-rich inshore components (made up of intertidal and shallow estuarine habitats) and more oligotrophic offshore components (made up of sandy beaches, channels, banks and bars).

Moreton Bay contains assemblages of fish that are representative of the marine and terrestrial bioregions, with at least one species with a restricted geographic distribution having core populations within the site (including Oxleyan Pygmy Perch).

Criterion 8

Ramsar Nomination Criterion 8 states*: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.*

Moreton Bay provides important habitats, feeding areas, dispersal and migratory pathways, and spawning sites for numerous fish species of direct and indirect fisheries significance. These fish have important fisheries resource values both within and external to the site.

Key fish species of significance include flat tailed mullet, sea mullet, fantail mullet, sand flathead, dusky flathead, tailor, spotted mackerel, golden lined whiting, eels, diver whiting, yellow finned bream and tarwhine. Significant nektobenthic crustacean species include banana, king, endeavour, tiger, school and greasy back prawns; mud, blue swimmer, red-spot, spanner and coral crabs; and Callianisidae shrimps. Other species of commercial significance include bait worms, squid, cuttlefish, rock oysters and beche-de-mer.

Many of the fish and crustacean species listed above spend their juvenile stages in shallow nearshore waters of the site, particularly around mangroves and seagrass habitats. These species also spawn in inshore waters, particularly near the surf zone and in sandy channels within the boundaries of the Ramsar site.

Criterion 9

Ramsar Nomination Criterion 9 states: *A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.*

Criterion 9 relates to non-avian wetland taxa including, *inter alia*, mammals, reptiles, amphibians, fish and aquatic macro-invertebrates. Some of the key non-avian wetland species within Moreton Bay that are appropriate to consider in the context of Criterion 9 would include:

- acid frogs (wallum froglet, wallum rocketfrog, wallum sedgefrog, Cooloola sedgefrog);
- water mouse;
- Illidge's ant blue butterfly;
- dugong;
- green and loggerhead turtles;
- Oxleyan pygmy perch; and
- honey blue-eye.

Furthermore, Davie and Hooper (1998) note that at least 27 marine macroinverebrate species are known only to occur in Moreton Bay. These species may be either locally endemic species (i.e. restricted to the Bay) that are either relics from more widespread habitats that have been restricted to the Moreton Bay area, or are species that may occur elsewhere outside the site but have so far remained undetected due to limited sampling effort.

In interpreting the application of Criterion 9 to these species, Ramsar Handbook 14 indicates that reliable population size limits from published sources must be included in the justification for the application of the Criterion.

Investigation of survey data for these species as part of the current study has shown such data is largely incomplete and forms an information gap. On this basis, there is not definitive data from which to determine the applicability of the Criterion. However, it is noted that expert opinion provided by various researchers to the study team as part of the study supports the view that the criterion is met by several of the species listed above. This is documented for particular species within sections 7.3 and 7.4 of this report.

4 SUMMARY OF CRITICAL SERVICES, COMPONENTS AND PROCESSES

4.1 Introduction

Section 4 of the report summarises the *critical* services/benefits, components and processes that make up the ecological character of the Ramsar site and provides the limits of acceptable change to those critical elements. The Section is set out as follows:

- Section 4.1 outlines the methodology used in the selection of the critical services/benefits, components and processes for the site;
- Section 4.2 summarises the nominated critical services and underlying critical components and processes of the Ramsar site; and
- Section 4.3 provides a summary of the limits of acceptable change developed for the site including the methodology used to derive them.

More detailed information about the critical services is presented in Section 7 of the report which provides a more complete discussion of each critical service/benefit and its underlying wetland ecosystem components and processes.

4.1.1 Methodology – Information Collation and Review Stage

The first step in ECD preparation outlined the National Framework document is to identify the wetland services/benefits, wetland components and wetland processes present in the Ramsar site. These key terms are defined in Section 2 of the Report and the Glossary (refer Section 9). This was initiated by undertaking a process of information collation and literature review.

As part of the information collation phase, literature and existing data relevant to the study area (whole-of-bay and catchment scale) and site were collated and reviewed. Relevant existing information was sourced from the following:

- Published scientific papers;
- Database records (EPBC, Wildnet, etc.);
- Mapping products supplied by the EPA (RE data, wetland mapping);
- Management plans, strategies and other policy documents;
- EIS and other applied studies that involved assessment of Ramsar values;

- Academic theses; and
- Grey literature from internet searches and other sources of data

Many articles, information and data sets were obtained from the EPA project team and by following up suggestions and recommendations about sources of information from the Project Steering Group and Knowledge Management Committees.

Each article of information was collated to a cursory level sufficient to determine its relevance to the study. The collected information was then reviewed to prioritise and identify information of direct relevance to the ECD.

As part of the information collation phase, key information gaps were identified on the basis of these reviews and further information was sought from the Knowledge Management Committee as part of its first meeting.

Key experts in relevant fields were also contacted and interviewed as part of the study as outlined in Section 9 and in Appendix A.

4.1.2 Methodology – Selection of Critical Services

Following the information collation and review phase, the study team collectively identified the potential services/benefits of the wetland. This process was based primarily upon a review of the literature and professional opinion. Wetland benefits/services were identified first as a means of facilitating the identification of the more generic wetland processes and wetland specific components (eg. wetland types and noteworthy flora and fauna species) that underpin these services.

Using the categories and list of services/benefits from the National Framework as a guide, it was apparent that the Moreton Bay Ramsar site provides a broad spectrum of services/benefits. This included: provisioning services such as provision of food in the form of fisheries and fresh water supply (through groundwater extraction), regulatory services such as erosion protection and climate regulation, cultural services such as recreational and tourism, cultural heritage, education and research and supporting ecosystem services such as biodiversity and the presence of endangered and vulnerable species.

Likewise, given the scope, areal extent and diversity of wetland environments present within the Moreton Bay Ramsar site, all wetland ecosystem processes from the National Framework were seen as occurring within the site, including a broad range of hydrological, climatic, geomorphologic, physico-chemical, biogeochemical and biological processes. It was noted that while each of these processes play a part in underpinning normal wetland functioning, many of these factors such as coastal hydrodynamics and climate operate at both regional scales and local scales.

As outlined in Section 3, a range of wetland habitat types are known to be present within the site boundaries including those designated within the coastal/marine, inland and man-made wetland categories under the Ramsar classification scheme. Within these systems, a rich diversity of wildlife exists from all the major groups of organisms (from planktonic organisms to vertebrates) which make up the key components of the wetland.

With the full range of ecosystem services/benefits, components and processes represented, there was a need to identify the most important or *critical* in the context of the Ramsar site, and the supporting critical components and processes that contribute to delivery of those services.

Following the methodology within the National Framework, the assignment of a given wetland process, component or service as *critical* was guided by the following considerations:

- The service or underlying component/process is important for supporting one or more of the Ramsar Nomination criteria under which the site was listed (refer Section 3.3); or
- The service or component/process is an important determinant of the uniqueness of the site; or
- The service or component/process may be subject to change in short to medium time frames (<100 years) and/or the change will cause potentially significant consequences (eg. change the ecological character).

To supplement these criteria, it was decided as part of the ECD process that additional consideration would be given to:

- Suggestions or recommendations regarding critical services, components or processes by Knowledge Management Committee/SEP experts (particularly where such information was documented in scientific literature) – refer Appendix A; and
- For cultural services, reference to Ramsar's 9th Conference, Resolution IX.21 – "Taking into account the cultural values of wetlands" – which identified the following cultural characteristics as relevant in the designation of Ramsar sites:

    i) Sites which provide a model of wetland wise use, demonstrating the application of traditional knowledge and methods of management and use that maintain the ecological character of the wetland;

    ii) Sites which have exceptional cultural traditions or records of former civilizations that have influenced the ecological character of the wetland;

    iii) Sites where the ecological character of the wetland depends on the interaction with local communities or indigenous peoples;

iv) *Sites where relevant non-material values such as sacred sites are present and their existence is strongly linked with the maintenance of the ecological character of the wetland.*

Following this internal prioritisation process, a list of draft critical services/benefits and underpinning components and processes was developed by the study team. Ecosystem components (such as habitats, species and populations) and ecosystem processes (such as hydrology) were identified as critical where such features or processes were seen as underpinning one or more nominated critical services.

The Nomination Criteria for the site were used as the primary consideration in selecting the draft critical services/benefits (principally relating to the wetland's ecological values) along with the selection of several cultural services such as site's fisheries values, the significance of the site to indigenous peoples, as well as the education and research and tourism and recreational values of the site. Evaluation of other ECD documents undertaken for large estuaries, such as the draft ECD prepared for the Great Sandy Straits and the ECD for the Coorong Lakes region in South Australia were also considered as part of the nomination process.

Using the draft list of critical services/benefits, the study team conducted a one day workshop with the Knowledge Management Committee (KMC). The primary purpose of the first KMC meeting was to undertake a parallel validation process of the study team's critical service selections with the committee of experts using a workshop to identify the key habitats of the site. This process served to confirm the identification of the critical services as well as to identify additional services, components or processes that were perceived to have been overlooked.

In general there were minimal changes to the draft critical services that were presented to the Knowledge Management Committee and the critical services/benefits presented in Section 4.2. However, the Committee provided significant assistance to the study team in identifying the key linkages between the services and the key wetland ecosystem components and processes and were able to provide guidance about the processes and components most important to maintenance of the service.

4.1.3 Methodology – Selection of Critical Flora and Fauna Species

The critical services/benefits presented in Section 4.2 are underpinned by the identification of several critical flora and fauna species that relate to the Nomination Criteria for the site and serve as *de-facto* indicator species for the purpose of assessing ecological character.

<u>Flora</u>

In nominating particular wetland **flora** species/communities for consideration under the critical services, the following considerations were applied –

1. Species must occur in aquatic environments (eg. macrophytes) or are otherwise considered to be wetland species; and

2. Species are listed as threatened (ie. vulnerable or endangered) at the National (threatened under EPBC Act) and/or International (i.e. IUCN) level; or

3. Communities that are classified as wetlands and designated as Endangered under the EPBC Act were considered.

Fauna

In nominating particular **fauna** species/groups for consideration under the critical services, the following considerations were applied –

1. Species must occur in aquatic or marine environments or are otherwise considered to be wetland-dependant terrestrial species (refer Glossary in Section 9 for definitions of these terms). It is acknowleged that many other terrestrial fauna (and flora) species also occur in the site that, while important to the maintaince of biodiversity values of the site, are not necessarily key wetland elements. Key threatened terrestrial species are listed in Appendix D of the ECD, and have also been considered in the context of the nomination criteria (Criterion 2 and 3). However, due to a lack of dependence on the wetland values of the site, none of these terrestrial species are viewed as critical elements in the context of this ECD report; and

2. Species should be either:

    a. designated as threatened (eg. endangered or vulnerable) at a national scale (listed as threatened under the EPBC Act) or international scale (i.e. threatened under IUCN Red List); and/or

    b. Particularly noteworthy or critical from a regional biodiversity perspective (i.e. refer to Criteria 3 or 7). This includes species that are perceived by the authors to be iconic to the site, and must also be designated as threatened under Queensland legislation (i.e. endangered or vulnerable at a State scale). In the context of this report, the key species considered here are beach stone curlew and little tern.

3. Given the boundaries of the Ramsar site are largely confined to near-shore areas, emphasis has been placed on species that use the site as core habitat, have significant population numbers and spend a large proportion of their life cycle within the site boundaries. This excludes vagrant species such as whales, sharks and some marine turtles (hawksbill, olive ridley, leatherback) that may only occur in the Ramsar site infrequently.

Based on the above, in general terms, species that are listed as migratory or marine species under the EPBC Act or listed as 'rare' under national or state species lists have not been nominated as key species under the ECD unless they otherwise meet the above criteria.

4.1.4 Methodology – Selection of Representative Habitat Types

The Moreton Bay Ramsar site contains marine, estuarine, palustrine, lacustrine and terrestrial biotopes. Several of these wetland habitats are considered, either individually or collectively, to represent particularly outstanding examples of near-natural 'reference' areas within the biogeographic region. This is important in the context of Service 2 (refer Section 4.2).

While it is acknowledged that there are numerous examples of such habitat areas within the site, for reporting purposes the study team identified six key wetland representative areas. These are:

a. Seagrass and shoals in the Eastern Banks area;

b. Intertidal flats and estuarine assemblages in the Pumicestone Passage area;

c. Mangroves and saltmarsh associated with the islands in the Southern Bay;

d. Coral communities of the Eastern Bay;

e. Freshwater wetlands (including wallum and peatlands) of Moreton and North Stradbroke Islands;

f. Ocean beaches and foredunes on Moreton Island

These wetland areas were selected on the basis that they:

- are in natural or near-natural condition (relevant to Ramsar Nomination Criterion 1);
- contain representative examples of the key habitats within the site;
- contain excellent representative examples of various wetland habitat types within the biogeographic region;
- support many or all of the ten (10) critical wetland services nominated by the ECD; and
- contain wetland habitats of recognised high conservation significance, as prescribed under legislation (protect areas) and State plans (i.e. Queensland State Coastal Plan).

The representative wetland habitat areas provide specific areas within the broader site for assessing limits of acceptable change and provide priority sites for future monitoring and research.

Further information about the representative habitat types are contained in Section 7.2 of the report.

4.2 Overview of Critical Services/Benefits

A graphic and summary table listing the critical wetland services/benefits, components and processes for the Moreton Bay Ramsar site are shown in Figure 4-1 and Table 4-1 respectively.

As outlined above, the ten (10) critical services/benefits have been developed principally through identification of key services/benefits that relate back to the key Ramsar Nomination Criteria for the Moreton Bay Ramsar site but also include several cultural and provisioning services that are seen as particularly important or noteworthy in the context of the benefits derived from the site.

In many cases there is a direct relationship between the critical services and wetland habitat types (such as seagrass meadows or mangrove swamps) or noteworthy fauna (endangered and vulnerable flora or fauna). In this way, many of these habitats and species are effective surrogate measures for maintenance of the wetland service and broader ecological character of the wetland.

Critical processes have been selected on the basis of their importance in underpinning the critical services/benefits and in considering the wetland habitat and noteworthy flora and fauna that make up the critical components.

It should be noted that the box model shown in Figure 4-1 does not seek to prioritise or provide any hierarchy to the processes, components and services presented; its role is simply to show the approach to categorisation of the critical elements in accordance with the guidance in the National Framework document.

The interaction of wetland services/benefits, processes and components is shown in Figure 4-2. As shown in the figure, there are three broad processes identified (climate, geomorphology and regional-scale hydrodynamic and hydrological processes) that together have shaped the topography, tidal flushing regime and other important aspects of the site. At the local habitat scale, there is a mix of physical and chemical processes as well as biological processes that control the wetland habitats and associated biota.

The interaction of the wetland components with the wetland processes yields a range of wetland benefits and services (shown in the yellow box in Figure 4-2) that are supporting (ecosystem services) and cultural (relevant to providing a social or economic benefit to humans).

Within the cultural services, two services – related to fisheries and indigenous significance – also have a provisioning aspect e.g. humans are taking and using direct products from the wetland.

Conceptual models have also been prepared for the six representative habitat types and can be found in Section 7.2 of the report. These models demonstrate the interaction between the wetland services, components and processes at a habitat scale.

Semi-quantitative and qualitative descriptions are provided of the critical components, processes and services of the site. While acknowledging that quantitative descriptions may provide more detailed information, it was the view of the study team that such an approach was not justified given most environmental parameters show great variation across a wide range of spatial (measured in meters to 100's of kilometres) and temporal (diel, diurnal, daily, seasonal, inter-annual) scales, and it is therefore often difficult to provide meaningful empirical data without fully explaining the context of this variability. Furthermore, with few exceptions, quantitative data are typically unavailable for most species and environmental parameters, which could lead to biases towards those attributes that are more easily or intensively studied. Consequently, the reader is referred to the original data sources (cited in this report) that have been used to describe the critical components, processes and services.

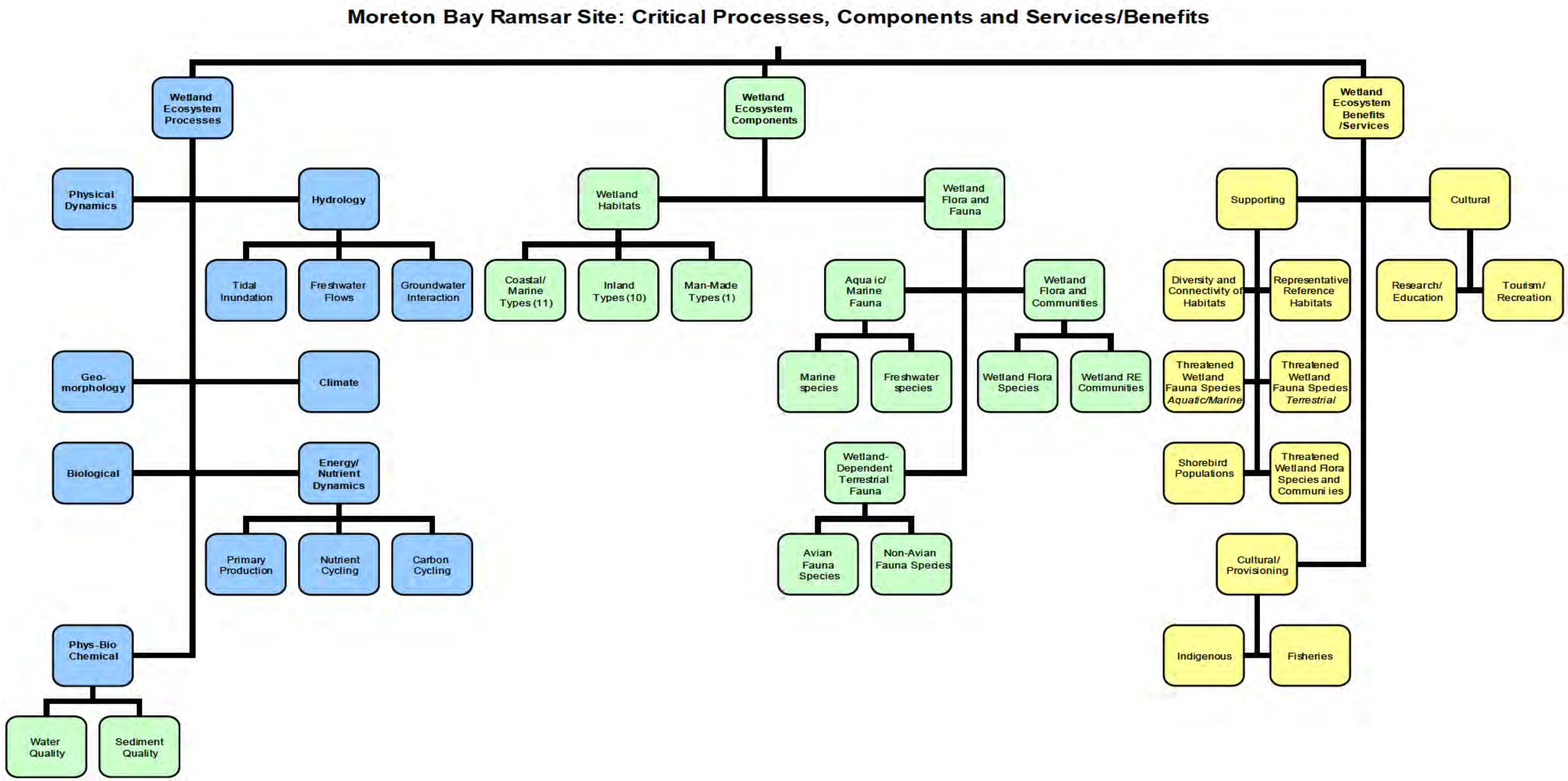


Figure 4-1 Graphical Depiction of Critical Services/Benefits, Components and Processes

Table 4-1 Summary of Critical Services/Benefits, Components and Processes

Critical Service/Benefit	Nomination Criteria and Service Type	Underlying Critical Components	Underlying Critical Processes[3]
S1. Moreton Bay Ramsar site contains a **diversity** of wetland habitat types that are **representative** of a major coastal wetland aggregation and in many areas show a high degree of **connectivity** between habitat types.	Criterion 1 *Supporting*	Across the site there are 22 Ramsar Wetland types represented Of these: • 11 are classified as coastal/marine • 10 are classified as inland waters • 1 is classified as man-made Several habitat types are highly localised (eg. rare) in the context of the bioregion and within the site itself including Type U – non-forested peatlands and Type O – permanent freshwater lakes.	Broad-scale processes including: • **Physical Coastal Processes.** Hydrodynamic controls on habitats through tides, currents, erosion and accretion • **Hydrology.** Patterns of tidal inundation and freshwater flows to wetland systems • **Groundwater.** For those wetlands influenced by groundwater interaction, the level and quality of the groundwater table • **Energy and Nutrient Dynamics.** Primary productivity and the natural functioning of carbon and nutrient cycling processes • **Biological Processes.** Important biological processes such as growth, reproduction, recruitment, migration and dispersal • **Water Quality.** Water quality that provides aquatic ecosystem values within wetland habitats • **Climate.** Patterns of temperature, rainfall and evaporation • **Geomorphology**. Key geomorphologic/topographic features of the site

Critical Service/Benefit	Nomination Criteria and Service Type	Critical Habitat Component (Reference site in parenthesis)	Underlying Critical Processes
S2. Moreton Bay Ramsar site contains several critical **wetland habitat types.**	Criterion 1 *Supporting*	S2A Seagrass and shoals (Eastern Banks Area)	• **Physical Coastal Processes**. Natural coastal processes and hydrodynamics such as current, waves, erosion and accretion (eg. hydrodynamic controls on the topography of the habitat) • **Water Quality**. Particularly, light penetration, salinity, turbidity, suspended solids, and nutrients • **Energy and Nutrient Dynamics.** Primary productivity and the functioning of carbon and nutrient cycling processes • **Biological Processes**. Biological processes that maintain and control habitat condition, including plant growth and reproduction, and grazing

[3] Note that while there are many ecosystem processes that apply, the dot points listed are those considered to be the most important/critical to the maintenance of the critical components and critical service/benefit

Reference sites have been selected within these critical habitat types that are **in a near natural state** and are **representative** of the habitat type within the broader biogeographic region.		S2B Tidal Flats and estuarine assemblages (Pumicestone Passage)	• **Hydrology.** Natural patterns of tidal inundation and freshwater flows • **Physical Coastal Processes**. Natural coastal processes and availability of habitat (eg. accretion and erosion of key intertidal habitats), as well as tidal and current velocity • **Water and Sediment Quality**. Particularly, suspended solids, nutrients, toxicants, and salinity • **Biological processes**. Biological processes that maintain and control habitat condition, including grazing, plant growth and reproduction.
		S2C Mangroves and saltmarsh (Southern Bay)	• **Hydrology.** Natural patterns of tidal inundation and freshwater flows to wetland systems • **Energy and Nutrient Dynamics.** Primary productivity and the functioning of carbon and nutrient cycling processes • **Physical Coastal Processes**. Natural coastal processes and availability of habitat (eg. accretion and erosion of key intertidal habitats), as well as tidal and current velocity • **Biological Processes**. Biological processes that maintain and control habitat condition, including grazing, plant growth and reproduction. • **Sea level rise**. Controls on mangrove colonisation into saltmarsh areas in response to sea level rises.
		S2D Coral Communities (Eastern Bay)	• **Physical Coastal Processes**. Natural coastal processes and hydrodynamics such as current, waves, erosion and accretion (eg. hydrodynamic controls on the topography/morphology of the habitat such as depth) • **Water Quality.** Particularly light penetration, salinity, turbidity, temperature, suspended solids, nutrients, and toxicants • **Energy and Nutrient Dynamics.** Primary productivity and the functioning of carbon and nutrient cycling processes are maintained • **Biological Processes**. Maintenance of essential biological processes that maintain and control habitat condition, including grazing, and plant growth and reproduction. and predation
		S2E Wallum and peatland freshwater wetlands (Bay Islands)	• **Water Quality.** Particularly pH, nutrients and dissolved oxygen • **Groundwater.** Water depth and groundwater interaction in lakes, bogs and creeks and groundwater interactions with surface water • **Climate.** Precipitation and evaporation rates will determine supply and water levels in these environments • **Geomorphology.** Topography of these features (eg. depth) is critical to their long term condition. • **Fire Regime.** Natural fire regime can control extent and condition in relation to these island wetlands
		S2F Ocean Beaches and foredunes (Moreton Island)	• **Physical Coastal Processes**. Natural coastal processes and hydrodynamics such as current, waves, erosion and accretion (eg. hydrodynamic controls on the morphology of the habitat) • **Wind-Driven Processes.** Particularly as it affects fine sediment erosion and deposition processes. • **Biological Processes**. Structural habitat and vegetation cover particularly in dune areas will affect nesting habitat.

Critical Service/Benefit	Nomination Criteria and Service Type	Underlying Critical Components		Underlying Critical Processes
		Key Wetland Habitat	Noteworthy Flora and Fauna Species	
S3. Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered marine/aquatic fauna	Criterion 2 Criterion 4 *Supporting*	Seagrass, reefs, nearshore open waters and rivers, offshore coastal environments	Dugongs, green, loggerhead, turtles	See S1 and S2A above
		Dune lakes and creeks on sand islands Wallum habitats adjacent to Pumicestone Passage	Oxleyan pygmy perch Honey blue-eye (mainland only)	See S1 and S2E above
S4. Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered wetland–dependant terrestrial fauna species	Criterion 2 Criterion 4 *Supporting*	Flats (sand, mud, and bars) Sandy Beaches Mangroves and Saltmarsh	Little tern Beach stone-curlew Water mouse Illidge's ant blue butterfly	See S1 and See 2B above
		Wallum habitats adjacent to Pumicestone Passage and on the sand islands	Wallum sedgefrog; wallum rocketfrog; wallum froglet; Cooloola sedgefrog; Australian painted snipe Australasian bittern	See S1 and S2E above
S5. Moreton Bay Ramsar site supports an assemblage of vulnerable or endangered wetland flora species and endangered and of concern wetland regional ecosystems	Criterion 2 Criterion 4 *Supporting*	Key Ramsar wetland types for wetland flora and communities include: • Intertidal forested wetlands (Type I) • Permanent streams and creeks (Type M) • Freshwater marshes and pools (Types Tp and Ts) • Freshwater tree-dominated wetlands (Type Xf).	Several vulnerable and endangered wetland flora species have been identified within the Ramsar site. These include: • Swamp Daisy • Knotweed • Lesser Swamp Orchid • Yellow Swamp Orchid • Swamp Orchid	See S1 and S2E above plus: • **Geomorphology.** Stabilisation of substrate (vegetation cover, maintenance of natural sand/sediment transport patterns) important for retention of soils • **Biological processes.** Growth, reproduction and maintenance for population viability of key plant species and communities
S6. Moreton Bay Ramsar site supports significant populations (more than 20 000 in total and over 1% of the population size of particular populations of shorebirds	Criterion 3, 5, 6 *Supporting*	Intertidal flats (sand, mud, and bars) +/- Seagrass beds Sandy Beaches Coral rubble on islands (Eastern Bay) Sparsely vegetation salt marsh and freshwater marshes (Western Bay)	Migratory Waterbirds (>20 000 and up to 50 000) Species exceeding the 1% criterion are as follows: bar-tailed godwit, whimbrel, Eastern curlew, terek sandpiper, grey-tailed tattler, curlew sandpiper, pied oystercatcher, Pacific	Broad-Scale Processes – See S1 See S2A, S2B, S2C, S2F as key shorebird habitat areas

		Underlying Critical Components		
			golden plover, and lesser sand plover.	

Critical Service/Benefit	Nomination Criteria and Service Type	Underlying Critical Components		Underlying Critical Processes
		Key Wetland Habitat	**Noteworthy Flora and Fauna Species**	
S7. The tidal fish habitats and fish and invertebrate populations of the Moreton Bay Ramsar site support valuable recreational and commercial fishing activities	Criterion 7 and 8 *Cultural and Provisioning*	Mangroves Saltmarsh Intertidal flats Supratidal channels and flats Seagrass and algal beds Coral and Rocky Reefs Shallow surf bars and banks Open expanses of shallow oceanic waters	Bream, flathead, whiting, luderick, mullet, tailor, mackerel, sharks, baitfish, eels, and pink snapper finfish King, tiger, endeavour, banana, greasyback and school prawns Blue swimmer, mud, red spot, spanner and coral crabs and Callianasid shrimp (yabbies) Squid, cuttlefish, gastropods, rock oysters, bivalves and beche-de-mer.	Broad-Scale Processes – See S1 See S2 for important fish habitats (eg. nursery, spawning, etc.)
S8. Moreton Bay Ramsar site has important cultural values and significance to indigenous peoples	Ramsar Cultural Criteria *Cultural and Provisioning*	All ~ acknowledging many traditional owner groups in the SEQ region will have close association/regularly use wetland resources within particular areas such as the Bay Islands and Southern Bay region.	Culturally important species (eg. wetland fauna species with spiritual importance and/or targeted as part of traditional fishing and hunting activities; wetland flora species with particular traditional food or medicinal significance)	Broad-Scale Processes – See S1
S9. Moreton Bay Ramsar site is an important site for research and education	N/A *Cultural*	All ~ noting that several of the key habitat types identified above have been subject to long term research and education activities	All ~ noting that several of the noteworthy species of conservation significance identified above have been subject to long term research and education activities	Broad-Scale Processes – See S1
S10. The Moreton Bay Ramsar site provides and supports significant tourism and recreational uses in the Region	N/A *Cultural*	All ~ With specific importance placed on: • Marine and estuarine waters; • Sandy beaches and dunes; and • Freshwater lakes	All ~ noting that some species of specific tourism interest such as whales that while associated with the Bay, rarely occur within the Ramsar site.	Broad-Scale Processes – See S1

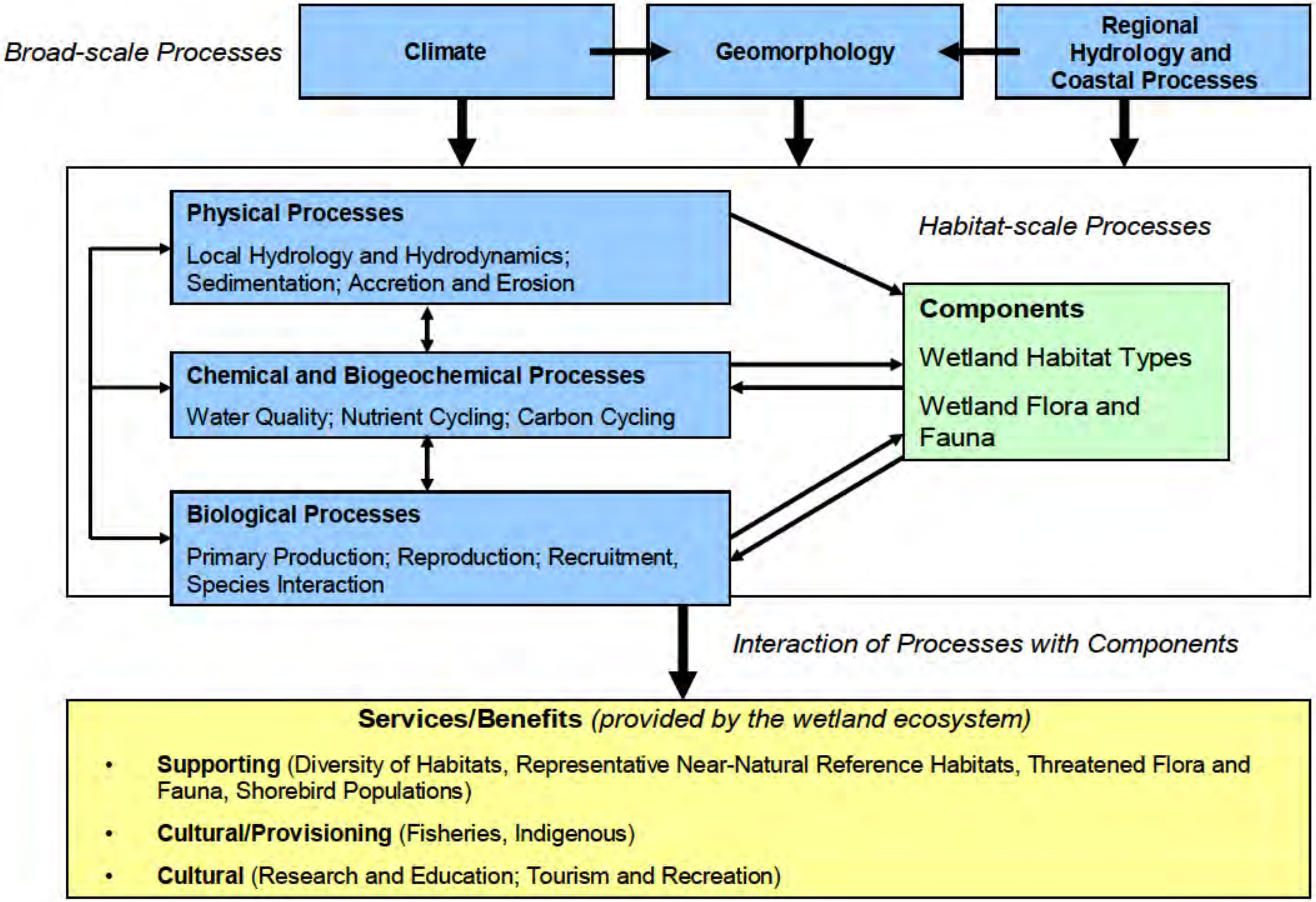


Figure 4-2 Conceptual Model Showing Interaction of Critical Elements

4.3 Overview of Limits of Acceptable Change

A key requirement of the ECD is to define the limits of acceptable change (LACs) for the critical services/benefits, components and processes of the wetland.

The approach taken for the identification of LAC's for Moreton Bay has been to outline the following:

- to align the limits of acceptable change defined under this ECD with the Ramsar Nomination Criteria under which the site has been listed under the Convention;
- to provide a qualitative description of what characterises an unacceptable change to ecological character under the relevant nomination criterion based on the critical services, components and processes;
- to identify 'interim' limits of acceptable change - where there is insufficient data to set a limit of acceptable change with confidence - based on current knowledge, data and published research about underlying critical components (habitats and species) and underlying critical processes (wetland ecosystem processes such as water quality, hydrological processes and similar).

This approach is described graphically in Figure 4-3.

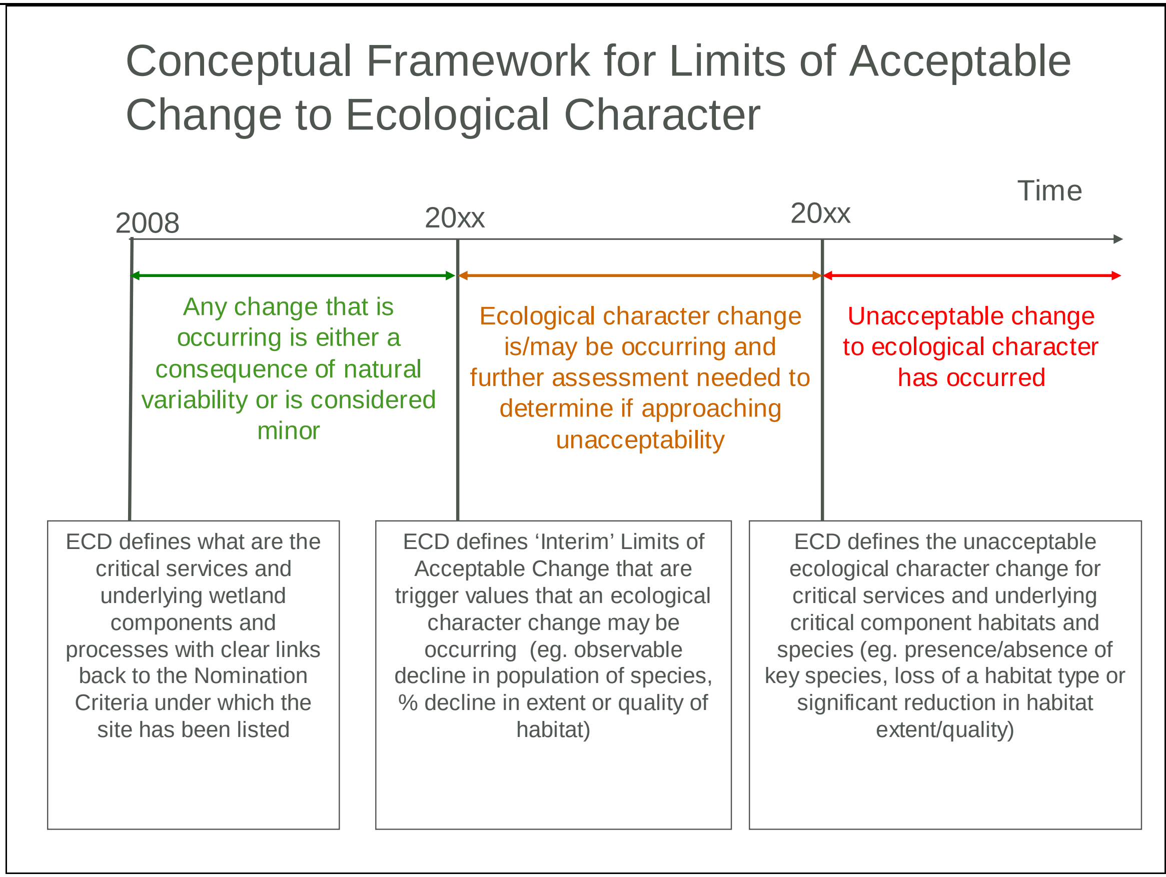


Figure 4-3 Conceptual Framework for Limits of Acceptable Change to Ecological Character

Consistent with the above, in general terms, LAC's outlined in this ECD should be interpreted and applied as follows:

- An unacceptable change to ecological character will have been deemed to occur where one (or more) of the Ramsar Nomination Criteria under which the site has been nominated no longer apply or where limits of acceptable change have been exceeded (see dot point below);
- Limits of acceptable change listed in the ECD that have a direct relationship back to ecological character include for example: the continued presence or absence of particular vulnerable or endangered species listed in the ECD, the reduction below a minimum population number for key

species, or a reduction in the overall abundance of populations or groups such as the requirement for at least 20 000 over-wintering avifauna under Ramsar Criterion 5;

- In most cases though, there will be one or more indicators of *potential* change to ecological character based on a key attribute, control or stressor on a habitat, species or population which serve as 'interim' limits of acceptable change. Observation or exceedance of an interim limit of acceptable change does not necessarily represent a significant change to ecological character of the site is occurring. Instead, exceedance of the interim limits of acceptable change provides a management trigger for further evaluation to determine if the change is characteristic of an unacceptable change or alternatively, to further evaluate if the change is the likely consequence of the broad natural variability of the site.

Interim limits of acceptable change also provide guidance to whether or not an action is or is likely to have a 'significant impact' on the ecological character of the Ramsar site in the context of EPBC Act assessments. Using the criteria presented in EPBC Act Policy Statement 1.1 – *Significant Impact Guidelines* (DEWHA 2006) particular issues addressed in the 'interim limits' of the ECD that are relevant to EPBC assessments include:

- identification of changes to wetland extent that may affect ecological character;
- identification of changes to the hydrological regime of the wetland that may affect ecological character;
- identification of the key habitats and lifecycles of important wetland flora and fauna within the site;
- identification of changes to water quality of the wetland that may affect ecological character; and
- presence of invasive species that may be harmful to ecological character

In this context, section 4.3.2 provides the limits of acceptable change identified for the Moreton Bay Ramsar site, preceded by the methodology used to derive them in section 4.3.1.

4.3.1 Derivation of Limits of Acceptable Change

Almost all Limits of Acceptable Change (LAC) outlined in this report are considered as interim limits, in recognition of the lack of empirical data describing ecological responses of biota to key regulating processes or controls. Wherever possible, the LAC have been based on existing benchmarks or guideline values used in other programs that have the key aim of protecting environmental values of relevance to this ECD. The following provides a rationale for the LAC for the selected critical components, services and processes.

Water Quality Indicators

By default, sub-regional guideline values outlined in Queensland Water Quality Guidelines (EPA 2006) have been adopted as interim LAC. The methodology to be followed to assess compliance should also be consistent with the approach outlined in EPA (2006) guidelines for assessing compliance in HEV areas.

It is recognised that there are available data describing the tolerance limits of some of the critical species identified in this ECD. These are:

- seagrasses (*Zostera muelleri, Halophila ovalis*), based on published critical threshold values including (but not limited to) values summarised by Erftemeijer and Lewis (2006);
- corals. This is based on studies in GBR, which demonstrate a threshold value that may lead to light limitation, and hence sub-lethal photo-physiological stress for *Symbiodinium* hosted by *Pocillopora damicornis* (Cooper *et al.* 2008). However, it should be noted that this species is not common in Moreton Bay (Johnson and Neil 1998a), and case studies for local species are lacking.
- reference data at which key aquatic species have been recorded (i.e. Oxleyan pygmy perch, honey blue-eye, wallum froglets etc.). While this may not necessarily represent the actual tolerance limits of these data, water quality conditions approaching or beyond the range should trigger management action to determine the causes and consequences of these changes.

Flow Regimes

By default, the mandatory Environmental Flow Objectives (EFOs) outlined in Water Resource Plans (WRP), as prescribed under the Queensland *Water Act 2000*, have been adopted here as the interim LAC. Within the context of water resource planning, mandatory EFOs are defined as flow objectives for the protection of the health of natural ecosystems for the achievement of ecological outcomes. These EFOs have therefore been developed to protect downstream ecosystem values, which is consistent with the wise use paradigm of Ramsar wetlands.

In this ECD, where freshwater flows are known or likely to represent a key controlling process for a particular ecosystems service, mandatory EFOs have been adopted as default interim triggers. Where mandatory EFOs are not met as a result of water resource activities, then further consideration needs to given to whether measurable impacts are known or are likely to occur to the service, and management actions may need to be implemented to mitigate these impacts.

According to the WRP, mandatory EFOs must be met at a number of critical sites, or nodes, within the river system. Several of these nodes occur within or directly adjacent to the Ramsar site, and have been adopted here to determine potential impacts to the site. These are listed in Table 4-2 below. Note that on 26 July 2007, the Minister for Natural Resources and Water announced his intention to amend the Logan Basin WRP to include water in a watercourse, lake, wetland, subartesian aquifer or spring in the Southern Moreton Bay Islands area. The revised Logan Basin WRP is likely to include additional EFOs of direct relevance to this ECD, particularly as it relates to water resources on North Stradbroke Island. It is recommended that the revised WRP be reviewed to assess implications of this ECD.

Table 4-2 Nodes and Mandatory EFOs adopted as interim LAC

Water Resource Plan	Mandatory EFO	Node	Node Location
Water Resource (Moreton) Plan 2007	See Schedule 7 of WRP	A	Pumicestone Creeks at end of system (AMTD 0.0km)
		B	Caboolture River at end of system (AMTD 0.0km)
		C	Pine River at end of system (AMTD 0.0km)
		E	Brisbane River end of system (AMTD 0.0km)
Water Resource (Logan Basin) Plan 2007	See Schedule 5 of WRP	G	Logan River at AMTD 0.0km
Water Resource (Gold Coast) Plan 2006	See Schedule 5 of WRP	A	Coomera River at end of system (AMTD 0.0km)
		N/A	Pimpama River

Given the current absence of EFOs for North Stradbroke Island wetland habitats, several interim trigger values were established. These interim trigger values were specifically used to protect habitat of threatened fish species, i.e. Oxleyan pygmy perch (OPP) *Nannoperca oxleyana*. Because this species forms genetically discrete populations with no interchange over the last few millennia, populations could become locally extinct if its waterbody completely dries and there is no adjoining refugia. This is a particular risk for the Little Canalpin Creek, given the small size of this waterway. Complete drying of a known habitat would result in local extinction of a genetically distinct population, and is considered to represent a change to ecological character (specifically the intent of criterion 9). Based on baseline monitoring undertaken in Little Canalpin Creek, it is known that OPP can occur in waters ~0.2 m water depth, and this may represent a useful start to developing a LAC for this location. It is known that deeper waters are used by OPP at other locations, and for this reason there is a need to develop site-specific LACs for this parameter.

It is also known that OPP prefers relatively quiescent waters, hence an increase in flow velocities above background may also result in impacts to this species. There are insufficient data to assess specific tolerances of OPP to increased flow velocities. OPP has been recorded in water velocities up to between 0.21 to 0.3 m/second (Pusey *et al.* 2004), which Cotterell (1998) suggests is likely to allow passage of all species of native fishes. It is recommended as in interim measure that flow velocities >0.1 m/second represent a preliminary trigger for management action. There is also a need to collect baseline data to determine reference conditions, and on the basis of this information, refining this interim LAC.

Tidal Hydraulics

Background/reference values for various tidal hydraulics indicators should form the basis of this LAC. If values fall outside these reference values (i.e. conditions outside background variability), there may be a change to species, communities or habitats, which may in exceptional circumstances lead to a change in ecological character, as defined by the ten (10) critical services/benefits outlined in this ECD.

It is very difficult to provide a complete list of LAC for tidal hydraulics indicators, as these values will vary from place to place, as well as over time in response in changes in tidal phase and meteorological conditions. It is also noted that while a change in conditions may occur as a result of a particular activity, these changes may not necessarily be ecologically meaningful, or lead to changes to ecological character.

In the interim, it is recommended that:

- The Moreton Bay Partnership Hydraulic Model (or its future replacement) be used to establish background/reference hydraulic (and associated sediment dynamics) conditions (based on a 2008 model configuration) of the site;

- Modelling be used to assess the potential hydraulic impacts of the development under consideration;

- There should be no measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background such that it results in a measurable, medium-term (>2 to 5 years) flow-on effects to key species, communities or habitat at this spatial scale.

In this context, it is strongly advised that there is a need to further refine these limits before they are applied in assessing impacts to ecological character.

Flora and Habitat Extent

It is difficult to set LACs for changes in habitat extent for several reasons:

- The area of some habitat types is variable over time, hence it is difficult to determine ‘baseline’ conditions for these habitats;

- Empirical relationships between habitat extent and flora and fauna abundance/ richness etc. have not been established, hence it is not generally possible at this stage to make quantitative predictions of the responses of most key species to habitat changes;

- It is known that different habitat patches with similar size and structural characteristics can have different fauna habitat values. For example, studies elsewhere demonstrate that particular patches of seagrass can contain more diverse or abundant fish assemblages than nearby, structurally similar patches. The reasons for why different habitat patches are more or less valuable to fauna are not well understood, which further hinders the development of generalised habitat area : fauna assemblage models;

- At the whole-of-site scale, habitat loss associated with a particular development proposal is often small relative to the total available area of habitat. Therefore, at a whole-of-site scale, habitat loss is often a result of incremental or cumulative changes associated with multiple developments.

There is however a need to establish interim LACs describing changes in habitat extent which, if triggered, will lead to a management response. There are two components required to derive a LAC:

1. there is a need to develop a numerical habitat-extent based trigger value;

2. there is a need to consider whether the changes in extent are ecologically meaningful in the context of the critical services/benefits.

In terms of the first component, consistent with approaches used elsewhere, interim LACs are based on the total area of habitat lost relative to a particular benchmark (i.e. percentage of the total extent of habitat lost). Studies elsewhere usually set habitat loss LACs of 0% to 10%, depending on the known perceived values of the habitat. Based on this, the following trigger values have been developed for this ECD:

- In the context of vegetated and unvegetated marine habitats, there should not be a >10% change in marine habitat extent, relative to the total area of available habitat within Moreton Bay, and also relative to natural background temporal variability, in the medium term (>2-5 years);

- For intertidal habitats, there should not be a >10% change in the total area of unvegetated habitat and the extent of habitat within the following tidal zones: Mean High Water (MHW) and Mean Sea Level (MSL); MSL and Mean Low Water (MLW); and MLW and Lowest Astronomical Tide (LAT), in the medium term (>2-5 years);

- For critical terrestrial and aquatic habitats for threatened species, >5-10% change in extent (outside the bounds of natural variability) should trigger management action.

In terms of the second component, there is also a need to take into account natural temporal variability in habitat extent, and if changes in extent are ecologically meaningful in the context of the key services. For the purpose of this assessment, two spatial scales have been delineated: (i) Regional scale, and (ii) local (measured in kilometres) scales. The regional scale considers the impacts of a habitat loss to the overall population size and conservation status of particular species. The local scale considers the significance of impacts within the site.

At broad (regional or greater) spatial scales, there should be no net change in extent and condition of a particular habitat type, relative to natural background temporal variability, such that it results in a measurable, medium-term (>2 to 5 years) flow-on effect to the declared population status (as defined under Commonwealth or State legislation) of threatened species or communities. This means that there should be no change in habitat extent such that it results in species or communities having a revised conservation status under legislation (i.e. downgrade of conservation status from rare to vulnerable, or vulnerable to endangered etc.).

It is also recognised that there is a need to establish a more conservative interim LAC to capture local scale level impacts (i.e. impacts to values within the site). It is recognised that the definition of "local-scale" may vary depending on the distribution and home-range of different species. However, for the purposes of this assessment, local scale change is defined as a change in a particular pattern or process that is measurable at spatial scales of kilometres. For example, a change in a community measure (e.g. the abundance of a plant or an animal, the diversity etc.), that is either predicted (in the context of an impact assessment study) or measured (in the context of monitoring) 1.2 km from a particular project area would be considered unacceptable. In contrast, where community structure is within the range of background variability <600 m from a particular project area, this is not considered as an unacceptable change (unless the change is measurable at the greater than regional scale discussed above, i.e. change in conservation status).

It is important to note that for most habitat types, natural temporal variability in the extent of habitats is not well known. This is a key information gap that needs attention.

Threatened and Significant Fauna Abundance

As an interim measure and based on standardised sampling methodology and effort, it is suggested that the following represent triggers for management intervention:

- Significant decline in the numbers of the four acid frog species for important populations on North Stradbroke and Moreton Islands;
- Significant decline in the numbers of little tern over five years as determined at key roost sites (e.g. northern Pumicestone Passage; South Stradbroke Island);
- Lack of observation of Beach stone-curlew in any three year period over five years within the following areas: Pumicestone Passage (Toorbul north to Bells Creek); Bulwer to North Point (Cape Moreton); Cape Cliff (Cape Moreton) to Eagers Creek; Little Sandhills to Mirapool Lagoon; Amity to

Point Lookout; Peel Island; Jumpinpin (includes southern end tip of North Stradbroke Island and associated mangrove islands); western side of South Stradbroke Island;

- Greater than 20% reduction in the number of active/recently active water mouse nests or greater than 15% reduction in usage of any one of the diversity of nest types used (following Van Dyck and Gynther 2003) over five years for important populations associated with North Stradbroke Island, southern Moreton Bay (e.g. Macleay Island, Coomera & Pimpama Rivers, South Stradbroke Island) and Pumicestone Passage (e.g. Bribie Island, Donnybrook); and

- Loss or otherwise significant reductions in the known populations of Oxleyan pygmy perch and Honey blue-eye.

Habitat Condition Indicators

For habitat condition, interim LAC used in the study are as follows:

- Sedimentation on coral reefs. Sedimentation should not exceed background variability and lead to measurable impacts to coral communities.

- Emergent macrophyte cover. Oxleyan pygmy perch and honey blue-eye are both found in structurally complex habitat, with bank undercutting and/or 60-80% aquatic plant cover (typically sedges). Should this habitat feature be lost then impacts to fish could occur. An interim limit of >50% cover of emergent macrophytes has been set. It is recognised that some sites may have naturally lower emergent macrophyte cover, but still represent an important habitat. In such cases, adopt: 20th, 50th & 80th percentile values of reference site conditions in which population has been recorded. The 75th confidence limit should not be less than these values.

Ecosystem Condition Biological Indicators

Several condition indicators based on fauna provide a basis for defining the following interim LAC:

- Seagrass depth range (SDR). SDR guideline values outlined in the Queensland Water Quality Guidelines (EPA 2006) for various sub-areas within the Bay have been adopted.

- Coral community structure. The EHMP has adopted coral community structure as a measure of ecosystem condition. Coral community structure is also directly relevant to Service 2 and to a lesser extent service 1 in this ECD. A change in coral community structure, such that key processes, functions and attributes are lost or modified, would be considered an unacceptable change.

- Coral bleaching. Coral bleaching occurs when hard coral reject their symbiotic zooxanthellae, which typically occurs under stressful conditions. An increase incidence in bleaching (above background variability), such that it results in significant long-term coral mortality, would be considered an unacceptable change in the context of changes to Services 1 and 2. There is a need to collect further reference data to assess this LAC.

- Crab burrow densities. Counts of crab burrows is a potential non-destructive, rapid assessment technique for assessing potential changes in crab abundances, which may be linked to changes in ecosystem condition. Crabs also represent an important food resource for fish and some wader birds, and represent keystone species in mangrove forests. There is a need to develop methods and limits of acceptable change for this indicator.

- Spionidae and Capitellidae worm abundance. These taxa may increase in abundance in response to organic enrichment, or decrease in abundance in response to increase toxicant loads. Polychaete abundances can also exert an influence on waterbird abundance. High range and low range limits are therefore proposed. The high range is based on ANZECC/ ARMCANZ (2000) value of >1000 individuals per m^2. A low range guideline would need to be developed. This method and LAC should be further developed based on *Method 8 Density of Capitellid Worms* in ANZECC/ARMCANZ (2000).

- Eastern Gambusia abundance. Eastern Gambusia represents a pressure of native fish and frogs. The presence of Eastern Gambusia in critical habitat of sensitive species should be a matter of management concern. In the context of this ECD presence of Eastern Gambusia in Little Canalpin Creek would represent a trigger for management concern given the limited area of this habitat, and the absence of refugia (i.e. deeper waters) for OPP to avoid interactions with Eastern Gambusia.

4.3.2 Summary of Limits of Acceptable Change

Table 4-3 below lists the Nomination Criteria for the Moreton Bay Ramsar site (column 1), qualitative indicators that describe unacceptable changes to ecological character (column 2) and more detailed indicators that have been developed as ‘interim’ limits of acceptable change to indicate that ecological change for the criteria may be affected or occuring (column 3). As mentioned previously, these ‘interim’ limits of acceptable change in column 3 have been developed to assist the site manager to identify potentially significant changes to ecological character on the site prior to an unacceptable change occurring.

In this context, observation or exceedance of an interim limit of acceptable change (column 3) does not necessarily represent a change to ecological character of the site. Instead, exceedance of the interim indicator provides a management trigger for further evaluation to determine if the change is characteristic of an unacceptable change to ecological character or alternatively, to further evaluate if the change is the likely consequence of the broad natural variability of the site.

Table 4-4 and 4-5 underpin Table 4-3 and are specific to the identification of natural variability and limits of acceptable change for particular critical wetland habitats and species nominated within the critical services/benefits of the ECD. Specifically, these tables outline the key attributes (eg. wetland ecosystem processes) that underpin the ecological condition of these habitats and species which are fundamental to the maintenance of critical services and overall ecological character of the site. Cross-references are supplied in the table, particularly to show where a particular habitat or species has relevance to one or more of the ten (10) critical services. The detailed discussion of critical services within Section 7 of the report provides further information to support these tables.

Limits of acceptable change have not been identified for the broader cultural and provisioning services identified in the ECD such as fisheries values (S7), indigenous significance (S8), research and education (S9) and tourism and recreational uses (S10). This is generally due to a lack of quantitative or comparable data sets. Also, in general, the extent to which these cultural services continue over time will depend on the maintenance of the other critical services and underlying ecosystem components and processes.

Notwithstanding, qualitative analysis of the key threats, information gaps and monitoring needs concerning these cultural services (and their maintenance) are identified and discussed in Section 7 as part of the detailed description.

Table 4-3 Summary of Limits of Acceptable Change

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	Criterion 1 is based on the site containing at least one particularly notable wetland habitat type, and this wetland type is maintained in natural or near-natural condition. **Wetland Types and Extent** The ECD/RIS list twenty-two (22) wetland types within the site (using the Ramsar Classification Methodology). An unacceptable change will have occurred if it can be demonstrated that one or more of these wetland types have been lost. **Wetland Condition** A change in natural or near-natural condition at one of the six (6) reference sites[4] or more broadly across that habitat type at a whole-of-site scale are defined as follows: • **Seagrass meadow** cover and extent has declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (Eastern Bay) or has resulted in	**Habitat Extent** At a local scale, >10% change in habitat extent, relative to natural background variability, such that it results in measurable impacts at sub-km spatial scales, and causes measurable, medium-term (>2 to 5 years) flow-on effects to key species, communities or habitat at this spatial scale. **Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4

[4] These representative habitat types and locations have been selected on the basis of their role in ecosystem functioning across the site and are important habitats for threatened species, communities and populations that are relevant to other Criteria in the table.

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	measurable changes to the local population status of dugongs and green turtles, or fisheries stocks (all seagrass areas); • **Unvegetated intertidal flats** and associated microphytobenthos and marine fauna community structure has changed to such levels that it in the medium to long-term (>5 years), can no longer be considered to be in pristine or near-pristine condition (Pumicestone Passage) or has resulted in measurable changes to avifauna populations or fisheries stocks (all tidal flat areas); • **Mangrove and saltmarsh** habitat extent and community structure has changed to such levels that in the medium to long-term (>5 years), it can no longer be considered to be in pristine or near-pristine condition (Southern Bay) or has resulted in measurable changes to avifauna populations or fisheries stocks (all mangrove and saltmarsh areas); • **Coral community** and reef habitat structure has changed to such levels that in the medium to long-term (>5 years), it can no longer be considered to be in pristine or near-pristine condition (Eastern Bay coral communities) or has resulted in measurable changes to the extent or condition of the habitat (eg. coral dominated reefs algal dominated); • **Freshwater wallum** wetland **/peatland** habitat conditions have declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (North Stradbroke or Moreton Islands) or has resulted in measurable changes to the local population status of threatened flora and fauna species or communities (see Criterion 2 below); • **Ocean beach and foredune** habitat conditions have declined to such levels that it can no longer be considered to be in pristine or near-pristine condition (Moreton Island) or has resulted in measurable changes to the local population status of avifauna or nesting usage by avifauna and marine turtles (all ocean beaches and foredune areas).	
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	Criterion 2 is based on the site containing at least one vulnerable or endangered species or threatened ecological community. The ECD/RIS lists several species/communities within the site that meet this criterion which include: • Marine Species - dugongs, green and loggerhead turtles • Freshwater Fish - Oxleyan pygmy perch and honey blue eye • Avifauna - little tern, beach stone-curlew, painted snipe, Australasian bittern • Wetland-dependant non-avian fauna - Illidge's ant blue butterfly, acid frogs and water mouse • Nationally Endangered wetland flora species including several swamp orchids, knotweed and swamp daisy An unacceptable change will have occurred if it can be demonstrated that one or more of these threatened species or threatened communities is lost within the site.	**Species/Populations** Detectable decline in local abundance/population of the key species. See Wetland Species Ecosystem Process Indicators – Table 4-5

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
	In particular, a change to character would be demonstrated if the following were to occur: • The wetland becomes unsuitable as habitat for one or more threatened species or community listed in this ECD; or • Threatened animal and plant species identified in the ECD no longer occur at the site.	
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region	Criterion 3 is based on the site containing a large proportion of species that are not well represented in the wider region. An unacceptable change will have occurred if it can be demonstrated that there has been a reduction in the number of species occurring within the site, and that this has resulted in a loss in biodiversity within the bio-region. In this context, a change to character would be demonstrated if the following were to occur: • Habitats have become unsuitable for wetland flora or fauna species or populations listed in the critical services of this ECD (see Criterion 2) • Noteworthy animal and plant species identified in the ECD are no longer present (see Criterion 2) • Populations of noteworthy species (see Criterion 2 above) no longer recorded in previous abundances (i.e. possible loss of genetic diversity) • Overall vertebrate fauna biodiversity is measurably and significantly reduced	**Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4 **Species/Populations** See Wetland Species Ecosystem Process Indicators – Table 4-5
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	Criterion 4 is based on the site representing critical refugia for any species, and the site maintaining critical life-cycle processes for any species. An unacceptable change will have occurred if it can be demonstrated that the site no longer provides a refugia function for important flora and fauna species (see Criterion 2) or if critical life-cycle processes are no longer being supported. The following are considered to represent the key critical life-cycle functions in the Moreton Bay Ramsar site - • Feeding and nesting habitat for green and loggerhead turtles that could impact the local population • Feeding and breeding habitat for dugong that could impact the local population • Refuge habitat for freshwater fish of conservation significance that could impact the local population • Roosting habitat for migratory waterbirds that could impact the local population • Critical overwintering habitat and a flyway staging area (both northern and southern migration routes) for migratory waterbirds	**Habitat Condition** See Wetland Habitat Ecosystem Process Indicators – Table 4-4 **Species/Populations** See Wetland Species Ecosystem Process Indicators – Table 4-5
Criterion 5: A wetland should be considered internationally	An unacceptable change will have occurred if the site no longer supports the required abundance of waterbirds under this Criterion	That the total number of waterbirds at the site always exceeds 20,000 individuals

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
important if it regularly supports 20,000 or more waterbirds.		Greater than 10% reduction in over a 10 year period of numbers of bar-tailed godwit, Eastern curlew, or Pacific golden plover which are surrogates for assessing shorebird abundance generally.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	An unacceptable change will have occurred if the site no longer supports the 1% of individuals of populations for the key species in the ECD which are: • bar-tailed godwit • whimbrel • Eastern curlew • terek sandpiper • grey-tailed tattler • curlew sandpiper • pied oystercatcher • Pacific golden plover • lesser sand plover	Greater than 20% reduction in any three year period over five years for any of the eight migratory shorebird species (which exceed the 1% threshold).
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	Long term impacts on the sustainability of populations of important commercial and recreational species that occur within the site (or in adjacent areas of the Bay) including: • bream, flathead, whiting, luderick, mullet, tailor, mackerel, sharks, baitfish, eels, pink snapper and other key finfish species; • king, tiger, endeavour, banana, greasyback and school prawns; • blue swimmer, mud, red spot, spanner and coral crabs and Callianasid shrimp (yabbies); • squid, cuttlefish, gastropods, rock oysters, bivalves and *beche-de-mer*.	A long-term loss of fish/shellfish stocks, which results in the reduction in the sustainability of key Bay fisheries, should be considered a trigger for assessing potential changes to ecological character.
Criterion 8: A wetland should be considered internationally	Medium to long-term (>5 years) reduction in the extent or condition of wetlands or other areas and a corresponding measurable impact on important spawning, nursery or migration pathways	At a local scale, >10% change in habitat extent, relative to natural background

Nomination Criterion	Definition of an unacceptable change to ecological character	Indicators that ecological character may be affected (eg. interim limits of acceptable change)
important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	for fisheries.	variability, such that it results in measurable impacts at sub-km spatial scales, and causes measurable, medium-term (>2 to 5 years) flow-on effects to key species, life-stages, communities or habitat at this spatial scale. In assessing this interim LAC, attention should be given to assessing changes in the extent of mangroves, saltmarsh, seagrass and tidal flat environments, which represent key nursery habitats to many commercially important species within the site.

Table 4-4 Summary of Natural Variability and LAC – Critical Habitats

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Seagrass	See 'Natural Variability' column	See below Turbidity/light	Variable across site. Refer to EHMP data.	n/d	*H. ovalis*: H90. Min. light requirement = 16% SI [P,Q] H91. Duration = >30 days at 0% SI [P,S] *Z. muelleri*: H92. Duration = >30 days at 5% SI [P,Q] H93. Critical thresholds = >30% SI [Q,R,]; 0.9 Kd (m^{-1}) [P,R;] 10 mg/L [P,R] H94. If site values exceed levels in H1 to H4, use default baseline turbidity values at seagrass sites as default trigger values (see SDR sites below) [J]	S1, S2, S3, S6, S8
		Seagrass depth limit/range (SDR)		n/d	Medium term (>5 years) median SDR value should not fall below the following interim default SDR values [N]: H95. Pumicestone Passage HEV = -0.8 m	
					H96. Pumicestone Passage SMD = -1.2 m	
					H97. Deception Bay North SMD = -3m	
					H98. Waterloo Bay HEV = -1.9m	
					H99. Central Bay HEV/ SMD = -2.2m	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
					H100. Eastern Bay HEV = -3.5m H101. Eastern Bay SMD = -2.2m H102. Southern Bay HEV/ SMD = -1.3m	
		Long-term change in tidal hydraulics and sedimentation patterns (short to medium term)	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008)[A].	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H103. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background [B].	
Unvegetated tidal flats	Pumicestone Passage, Waterloo Bay, Bramble Bay, Eastern Banks.	Freshwater flows	Waterway-specific & highly variable over time. Baseline hydraulic conditions as per 'Existing-case' scenarios in Moreton WRP.	n/d Quantitative environmental flow requirements of key local species and habitats unknown	H104. As a minimum, compliance with EFOs outlined in Moreton WRP for Nodes A-E	S1, S2, S3, S4, S6, S8
		Tidal hydraulics & sedimentation patterns (short to medium term)	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008) [A].	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H105. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater above background [B]	
		Long term (>50 years) changes to tidal inundation and sediment dynamics patterns & processes due to sea level rise	-0.22 mm/year change over last 26 years of data collection [C]	n/d Impacts dependent on sedimentation rate relative to sea level rise	H106. A change in frequency, duration & magnitude of tidal inundation between: • MHW and MSL; • MSL and MLW • MLW and LAT • Such that it results in >10% change (above background) in the extent of unvegetated habitat at these levels, and results in [B].	
		Spionidae and Capitellidae worm densities, and sediment TOC, as indicators of organic enrichment	Highly variable in space and time	n/d	Using methods as per ANZECC, assess whether the following are exceeded: H107. Interim high range – Capitellidae or Spionidae densities >1000 individuals per m^2 H108. Interim low range – n/d	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		Crab burrow densities. This is a potential non-destructive, rapid assessment technique for assessing potential changes in crab abundances, which may be linked to changes in ecosystem condition [U]			n/d. H109. There is a need to investigate (i) whether robust and cost-effective methods can be developed, and if so (ii) proceed to establish threshold criteria based on sampling of appropriate indicator species at a range of references sites.	
Mangroves and Saltmarsh	Southern Bay Pumicestone Passage Western Bay	Freshwater flows	H110. As a minimum, compliance with EFOs outlined in Moreton WRP for Nodes A-E (see also H15) plus nodes outlined in Logan WRP (Note G) and Gold Coast (Note A) WRPs. This should be assessed using SunWater IQQM models.			S1, S2, S7, S8
		Tidal hydraulics	H111. Refer to unvegetated flats, i.e. H16			
		Tidal inundation patterns	H112. Refer to unvegetated flats, i.e. H17			
		Crab burrow densities	n/d	n/d	H113. n/d. Refer to H20	
		Mangrove die-back extent and hypersaline areas	n/d	n/d	H114. n/d. There is a need to map the distribution and extent of mangrove die-back (aerial photography & ground-truthing) to establish existing conditions. Monitoring should be undertaken on a 5 year basis. H115. Salinity should not be > 40-50 g/L (low tide) to reduce the risk of impacts to mangrove health[V]. H116. Where ambient salinity exceeds levels in H26, & mangroves and saltmarsh are demonstrated to be in good condition, derive local trigger values based on ambient/background data. [J]	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Coral Communities (Eastern Bay)	Central and Eastern Bay – Myora, Peel Island, etc	Turbidity	<1, 1, 1 NTU [E]	n/d. Tolerance limits of most local species are largely unknown.	H117. Long-term (>5 day) average turbidity should not exceed >3 NTU [H] H118. Use default baseline conditions at coral reef sites as default interim trigger values for turbidity & other attributes [J]	S1, S2, S3, S8
		pH	8.2, 8.3, 8.4 [E]			
		TN	100, 120, 160 µg/L [E]			
		TP	5, 9, 12 µg/L [E]			
		Water temperature	12.5° to 32°C (Reef flat); 16 to 28°C (Moreton Bay surface waters [F]			
		Sedimentation rates ($mg/cm^2/day$) [G]	Peel Is = 2 to 32 Myora = 5.9 to 16.1	n/d Tolerance limits are: • highly species-specific. • not available for local species • dependent on duration & frequency of exposure to sedimentation Available baseline sedimentation data has limited temporal coverage (1 year).	H119. Sedimentation should not exceed background variability and lead to measurable impacts to coral communities [K]	
		Coral bleaching frequency & extent	n/d Incidence of coral bleaching is not reported in EHMP.	n/d	H120. The frequency & duration of bleaching events should not increase to such levels where measurable impacts to coral communities occur [K]	
		Reef community structure (cover of numerically dominant taxa)	Site specific, and variable in time for some macrophyte species. Refer to EHMP (2006) data for a description of baseline conditions.	n/d	H121. >5% loss in hard and/or soft coral cover > background temporal variability [L]	

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Wallum freshwater wetlands	Bay Islands Pumicestone Passage	Groundwater hydrology	Waterway-specific & highly variable over time. Baseline hydraulic conditions as per 'Existing-case' scenarios in Logan WRP (& underlying modelling).	n/d	H122. As a minimum, compliance with EFOs outlined in future draft Logan WRP (North Stradbroke Island) [M] H123. No changes in water levels at Blue Lake, or the Blue Lake Overflow discharge channel, such that a detectable community or ecosystem change occurs [B]	S1, S2, S4, S5, S7
		Invertebrates	20th percentile: Taxa richness = 12 PET richness = 2 SIGNAL = 3.32	n/d	H124. No change in water quality or invertebrate biotic indices, outside the bounds of natural variability. Note that water quality and biotic indices show great change among different waterbodies, hence there is a need to derive local trigger values based on ambient/background data. [J]	
		pH [I]	Blue L. = 4.9 to 5.2 Brown L. = 4.6 to 5.0			
		EC (µS/cm) [I]	Blue L. = 90 Brown L.= 90			
		Secchi (m) [I]	Blue L. = 4.9 to 6.9 Brown L. = 0.7			
		DO (% saturation) [I]	Blue L. = 86 to 95 Brown L. = 90 to 99			
		Chlorophyll a (µg/L) [I]	Blue L. = 0.6 to 2.4 Brown L. = 14			
		TP (µg/L) [I]	Blue L. = 2 to 6 Brown L. = 15			
		Water Temp (deg C) [I]	Blue L. = 19 to 26 Brown L. = 19 to 26			
		Turbidity (NTU) [I]	Blue L. = <1 to 1 Brown L. = 9			
		Ammonia (µg/L) [I]	Blue L. = 2 to 7 Brown L. = 9			
		Total N (µg/L) [I]	Blue L. = 90 to 130 Brown L. = 500			
		NOX (µg/L) [I]	Blue L. = 6 to 37 Brown L. = 3			
Ocean beaches and foredunes	High-energy beaches and foredunes of Br bie, Moreton and North and South Stradbroke Islands	Long-term change in tidal hydraulics and sedimentation patterns (short to medium term) leading to change in beach morphology	Highly site-specific. Adopt appropriate metrics (e.g. % exceedance values) output from Moreton Bay regional hydraulics model (existing-case 2008)[A] or long term aerial photograph analysis.	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H125. No measurable medium term (>5 years) change to hydraulic, wave &/or sedimentation patterns at spatial scales measured in km or greater, relative to background [B].	S1, S2, S3, S4, S7

Critical Habitat Type	Key Locations	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
		Groundwater inflows	Highly site-specific. Groundwater flows bring nutrients into the beach system and into the swash zone and control invertebrate and nearshore phytoplankton communities	n/d No specific information on locally relevant keystone species. Tolerances likely to vary depending on magnitude, duration & frequency of change.	H126. No measurable medium term (>5 years) change to groundwater supply/flows into beach systems relative to background [B].	
		Density of *Pipis* or other indicator species linked to changes in ecosystem condition	Highly variable in space and time	n/d	H127. There is a need to establish threshold criteria based on sampling of appropriate indicator species at a range of references sites. Refer to H20.	

Table 4-5 Summary of Natural Variability and LAC – Critical Species

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Oxleyan pygmy perch	Bay Islands, Pumicestone Passage	No long-term reduction in population densities of Oxleyan pygmy perch in waterbodies, outside the range of natural variability. No reduction in the total number of waterbodies inhabited by Oxleyan pygmy perch within the site.	pH	4.2 to 7.2 [A]	n/d No experimental determination of physiological tolerances All information on habitat preferences based on environmental conditions in which this species has been recorded	H128. Long term average should not >6.5 H129. If above this value, adopt 20^{th}, 50^{th} & 80^{th} percentile values of reference site conditions in which population has been recorded. The 75^{th} confidence limit should not be > these values.	S1, S2, S3
			Dissolved Oxygen	> 2 mg/L [B]		H130. Long-term median should not be <5 mg/L. If above this value, then adopt percentile values described in H40	
			Turbidity	Clear, tannin stained waters (1 to 300 NTU) [A, B]		H131. Long-term median should not > 1 NTU. If above this value, then adopt percentile values descr bed in H40	
			EC/Salinity	<330 µS/cm [A]		H132. Long term average should not exceed 300 µS/cm. If above this value, then adopt percentile values described in H40	
			Water levels	0.2[A, B] to 5[C] m, depending on water body characteristics. Mean weighted depth of captures = 0.63 m [A], whereas OPP Recovery Plan indicates most OPP captures in 0.3 to 0.4 m depth range [F].		H133. n/d. Trigger value may vary depending on particular requirements and local habitat conditions, i.e. avoidance of competition with eastern Gambusia or maintenance of fish passage. Local trigger values therefore need to be developed, although water depths <0.2 m unlikely to allow maintenance of OPP populations. H134. Drying. Where adjoining permanent refugia is absent, drying of a known habitat will cause local extinction at the site.	
			Groundwater hydrology	Low flow <0.3 m/sec [A]		H135. Flow <0.1 m/second. If >, then If above this value, then adopt percentile values descr bed in H40	
			Emergent macrophyte cover and undercut banks	60-80% emergent macrophyte cover (typically sedges), undercut banks, woody debris & root masses.		H136. >50% reduction in emergent vegetation cover, above background variability, such that it results in such that it results in a measurable, short-term (1-5 years) flow-on effects to OPP populations and/or key ecosystem functions.	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Eastern Gambusia in freshwater reaches of Little Canalpin Ck.**	Absent in freshwater reaches, but found in lower estuarine/brackish environs	n/d	H137. Presence of Eastern Gambusia in Little Canalpin Creek represents a trigger for further investigation of viability of this sub-population.	
			Oxleyan pygmy perch abundance	This species has low population densities, hence empirical limits are difficult to set. On North Stradbroke Is., average CPUE is typically 0-0.6 individuals/trap /hour*.	n/d	H138. No fish recorded during >5 sampling events, using various combinations of sampling methods (e.g. box traps, electro-fishing and seine netting), should trigger further investigations of whether waterbody continues to provide suitable OPP habitat, and the identification of drivers for change.	
Honey blue-eye	Pumicestone Passage	No long-term reduction in population densities of honey blue-eye in waterbodies, outside the range of natural variability. No reduction in the total number of waterbodies inhabited by honey blue-eye within the site.	pH	4.4 to 6.8 [A]	n/d No experimental determination of physiological tolerances All information on habitat preferences based on environmental conditions in which this species has been recorded	H139. Long term median should not be >6.5, or if above this value: H140. Adopt 20th, 50th & 80th percentile values of reference site conditions as described in H40	S1, S2, S3
			Dissolved Oxygen	> 6.8 mg/L [A]		H141. Long-term median should not be <5 mg/L. H142. If background above this value, then adopt percentile values described in H40	
			Turbidity	Clear, tannin stained waters (<17 NTU) [A]		H143. Long-term median should not > 1 NTU. H144. If background above this value, then adopt percentile values described in H40	
			EC/Salinity	<900 µS/cm [A]		H145. Long term median should not exceed 700 µS/cm. H146. If background above this value, then adopt percentile values described in H40	
			Water levels	n/d		H147. n/d. Trigger value may vary depending on particular requirements, i.e. avoidance of competition with eastern Gambusia or maintenance of fish passage. Local trigger values need to be developed. H148. Drying. Where adjoining permanent refugia is absent, drying of a known habitat will cause local extinction at the site.	
			Groundwater hydrology	Low flow <0.3 m/sec [A]		H149. Median flow velocity <0.1 m/second. H150. If background above H22, then adopt percentile values using approach described in H40	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Emergent macrophyte cover and undercut banks	High aquatic plant cover, typically sedges [A]		H151. >50% reduction in emergent vegetation cover, above background variability, such that it results in such that it results in a measurable, short-term (1-5 years) flow-on effects to Honey Blue-eye populations and/or key ecosystem functions..	
			Honey blue-eye abundance	This species typically has low population densities [A], hence empirical limits are difficult to set.	n/d	H152. No fish recorded during >5 sampling events, using various combinations of sampling methods (e.g. box traps, electro-fishing and seine netting), should trigger further investigations of whether waterbody continues to provide suitable habitat, and the identification of drivers for change.	
Dugong	Eastern Bay Pumicestone Passage Southern Bay	Detectable decline in local abundance of dugong outside the range of natural variability	Turbidity, nutrients and chlorophyll *a*	Refer to seagrass indicators in Habitat Table 4-4			S1, S2, S3, S9
			Seagrass depth limit (and extent)	Refer to seagrass in Habitat Table 4-4			
			Dugong population densities	503 ± 63 (S.E) (July) to 1019 ± 166 (S.E) (December) individuals in 1995 (Lanyon 2003) [D]. Recent population modelling suggests local population size of ~970 ±75 animals [E].	n/d	H153. A decline in dugong abundance to <800 individuals for 2-3 successive years may represent a trigger for further investigation. Note however that these figures should be considered as indicative only, as there is insufficient available information on the population dynamics and genetics of dugongs to develop a reliable interim trigger value.	
Marine Turtles: green turtle loggerhead turtle	Eastern Bay Pumicestone Passage Southern Bay	Detectable decline in green and loggerhead turtles outside the range of natural variability	Turbidity, nutrients & chlorophyll *a*	Refer to seagrass indicators in Habitat Table 4-4			S1, S2, S3, S9
			Seagrass depth limit (and extent)	Refer to seagrass in Habitat Table 4-4			
			Green and loggerhead turtle population dynamics & breeding readiness	n/d	n/d	H154. n/d. Insufficient available information on the population dynamics, growth rates and breeding readiness of turtles to develop a reliable interim trigger value.	

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
Wallum Acid Frogs	Wallum habitats on Bay Islands and Pumicestone Passage	Significant population declines outside the range of natural variability in either of the four acid frog species	Water quality: • non-turbid • tannin-stained • oligotrophic (low nutrient) • naturally acidic	pH 3.0-5.5 as derived from dissolved organic acids leached from humus).	n/d	H155. Significant decline in the numbers of the four acid frog species for important populations on North Stradbroke and Moreton Islands.	S4
			Absence of predatory fish	n/d	n/d	H156. Presence of Eastern Gambusia may represent a threat to local populations	S4
			Wallum wetland vegetation	n/d	n/d	H157. Greater than 5% reduction over five years of wallum wetland vegetation cover.	S4
			Ground water hydrology and freshwater flows	n/d	n/d	H158. No long-term change in groundwater hydrology such that it causes alterations to water quality, water levels and wetland flora and fauna, outside the bounds of natural variation.	S4
Beach stone-curlew	Outer Bay islands, Pumicestone Passage, mangrove habitats of southern Moreton Bay.	Significant declines in key habitat areas	Mangroves and associated intertidal flats (roost and feeding); sandy beaches (feeding), foredunes (breeding sites)	n/d	n/d	H159. Lack of observation of beach stone-curlew in any three year period over five years within the following areas: Pumicestone Passage (Toorbul north to Bells Creek); Bulwer to North Point (Cape Moreton); Cape Cliff (Cape Moreton) to Eagers Creek; Little Sandhills to Mirapool Lagoon; Amity to Point Lookout; Peel Island; Jumpinpin (includes southern end tip of North Stradbroke Island and associated mangrove islands); western side of South Stradbroke Island.	S4
Water mouse	Pumicestone Passage, North Stradbroke Island, Southern Moreton Bay (e.g. Steiglitz, Jacobs Well, Pimpama River Conservation Area, Coomera River, & South Stradbroke Island).	Significant declines in the usage of nests and the diversity of nest types used.	Relatively large areas of intertidal flats in association with mangroves (feeding), marine intertidal invertebrate prey, supralittoral wetlands, including salt marsh and sedgelands (nesting sites)	n/d	n/d	H160. Greater than 20% reduction in the number of active/recently active water mouse nests or greater than 15% reduction in usage of any one of the diversity of nest types used (following Van Dyck and Gynther 2003) over five years for important populations associated with North Stradbroke Island, southern Moreton Bay (e.g. Macleay Island, Coomera & Pimpama Rivers, South Stradbroke Island) and Pumicestone Passage (e.g. Bribie Island, Donnybrook).	S4
			Tidal conditions	n/d	n/d	H161. Any detectable long-term change to tidal regimes at spatial scales >5 km.	S4
Australian painted	Freshwater swamps	Lack of	Densely	n/d	n/d	H162. Loss of more than 20% of the extent of	S4

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
snipe	of outer Bay islands (e.g. 18 Mile Swamp).	records for any 10 year period.	vegetated permanent of seasonal wetlands			vegetated freshwater wetland habitat.	
Australasian Bittern	Freshwater swamps of outer Bay islands (e.g. 18 Mile Swamp).	Lack of records for any 10 year period.	Densely vegetated permanent of seasonal wetlands	n/d	n/d	H163. Loss of more than 20% of the extent of vegetated freshwater wetland habitat.	S4
Little Tern	Open waters of Bay, Caloundra sandbanks, beaches & sand spits of outer Bay islands, South Stradbroke Island.	Significant decline in abundance, outside the range of natural variability.	Nearshore and offshore open waters and rivers; water quality sufficient to support abundance of surface active baitfish; high-tide roost sites.	n/d	n/d	H164. Significant decline in the numbers of Little Tern, outside the range of natural variability, over five years as determined at key roost sites (e.g. northern Pumicestone Passage; South Stradbroke Island).	S4
Illidge's ant blue butterfly	Mangrove communities of Redland Bay, Hays Inlet, Fisherman Islands, outer Bay islands, and Coomera Island	Lack of records for any three year period.	Large areas of mangroves with mature trees bearing senescing limbs and dead branchlets which support the *Crematogaster* sp. ant; also adjacent supralittoral forests.	n/d	n/d	H165. Greater than 10% reduction over five years of mangrove cover and associated intertidal habitats.	S4
Migratory Shorebirds	Intertidal sand/mud flats, rocky shores and mangrove communities throughout the site, intertidal areas of coarse rubble associated with central bay islands	Decline in shorebird abundance and species diversity.	Diversity and abundance of epi/infauna of the intertidal flats; diversity of disturbance-free high tide roost spatially proximate to	n/d	n/d	H166. Greater than 10% reduction over five years of any one of the following components – mangrove cover and associated intertidal habitats; and supralittoral salt marsh habitats. H167. Any detectable long-term change to tidal regimes at spatial scales >5 km. H168. No long-term reduction in water quality and ecosystem condition in the estuarine sections of each major catchment area (as determined through	S6

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
	(Mud, St. Helena and Green islands) and western shores (Wellington Point and Redcliffe Peninsula), high tide roost sites throughout the site (natural and artificial).		suitable feeding grounds.			the EHMP). H169. Greater than 10% reduction in over a 10 year period of numbers of bar-tailed godwit, Eastern curlew, or Pacific golden plover which are surrogates for assessing shorebird abundance generally. H170. Greater than 20% reduction in the in any three year period over five years for any of the eight migratory shorebird species (which exceed the 1% threshold).	
Threatened Flora Communities: Endangered and Of Concern Regional Ecosystems	Br bie Island, Moreton Island, Southern Moreton Bay Islands, Southern Bay	Detectable decline in extent of Regional Ecosystems. Loss of sensitive plant species and change to alternate community type. (Loss of dependent fauna).	Groundwater hydrology	Waterway-specific and variable over time.	n/d Quantitative groundwater requirements of ecosystems unknown.	H171. No significant reductions in water table depth, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. H172. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
			Fire regimes	Variable over time and between different vegetation types.	n/d Specific fire regime requirements of ecosystems unknown.	H173. No significant changes in fire frequency or intensity, relative to background variability, such that it results in such that it results in a measurable, medium-term (>5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. No significant changes in fire frequency or intensity such that ecological integrity of ecosystems is not maintained. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Geomorphology: • Erosion • Sedimentation • Soil type	Erosion and sedimentation variable over time. Soil type not variable over relevant time scale.		H174. No significant changes in erosion or sedimentation processes, or changes to soil characteristics, relative to background variability, such that it results in such that it results in a measurable, medium-term (>2 to 5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
Vulnerable and Endangered wetland plants: *A. baueri* *M. triglochinoides* *O. hygrophila* *P. elatior* *P. australis* *P. bernaysii* *P. tancarvilleae* *T. confluens*	Bay Islands: swamps, lakes and waterways	Detectable decline in local abundances of plant species.	Groundwater hydrology	Waterway-specific and variable over time.	n/d Quantitative groundwater requirements of flora species unknown.	H175. No significant reductions in water table depth, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	S5
			Water Quality: • Toxicants • Nutrients • Turbidity • Salinity, pH	Waterway-specific and variable over time.	n/d No experimental determination of flora species water quality tolerances.	H176. No change in water quality indices outside bounds of natural variability. Adopt 20th, 50th & 80th percentile values of reference site conditions in which population has been recorded. The 75th confidence limit should not be > these values. Specific limits cannot be quantified with current knowledge – but as an interim trigger, species should continue to exist at current conservation status.	S5

Critical Species/ Community Type	Key Locations	Description of unacceptable adverse ecological change(s) to this species	Key Attributes and Controls	Natural Variability of the Habitat (Ecological Character Maintained)	Specific (quantitative) limits for unacceptable changes (LAC)	Interim Trigger (if n/d in specific column)	Related Critical Services
			Freshwater flows and inundation	Waterway-specific and variable over time.	n/d No quantification of frequency, duration and extent of freshwater inundation requirements for flora species.	H177. No significant reductions in flow regimes, relative to background variability, such that it results in such that it results in a measurable, medium-term (> 5 years) flow-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, species should continue to exist at current conservation status.	S5
			Geomorphology: • Erosion • Sedimentation • Soil type	Erosion and sedimentation variable over time. Soil type not variable over relevant time scale.	n/d No quantification of geomorphologic requirements of flora species.	H178. No significant changes in erosion or sedimentation processes, or changes to soil characteristics, relative to background variability, such that it results in such that it results in a measurable, medium-term (>2 to 5 years) low-on effects to key species, communities, habitats and/or key ecosystem functions at spatial scales measured in hectares or greater. Specific limits cannot be quantified with current knowledge – but as an interim trigger, communities should continue to exist at current conservation status.	

5 CHANGES TO ECOLOGICAL CHARACTER AND THREATS

5.1 Changes to Ecological Character

5.1.1 Changes/Impacts Observed Since Nomination

The National Framework requires ECD studies to assess the extent to which the ecological character of the wetland has changed, with a specific point of reference or baseline from the date of nomination into the Ramsar List of Wetlands of International Importance.

Following a review of scientific literature and planning documents relevant to the Moreton Bay Ramsar site, the study team engaged the Steering Committee and Knowledge Management Committee members about their views regarding potential changes to ecological character that have occurred since listing of the site in 1993. In particular, the study team sought advice about impacts to those aspects of the site nominated as critical services/benefits and underlying components and processes as outlined in the previous sections of this report.

In general terms, the literature reviewed and experts have not identified any significant or overarching changes during this fifteen year period but recognise that a number of long term threats are having an incremental and cumulative effect on ecological character. Likewise, no views were expressed from the information sources reviewed or from the committee members to merit consideration that the ecological character of the site had significantly diminished with respect to the critical services/benefits outlined in this study.

Some of the issues that were raised in the context of perceived impacts and potential changes to ecological character of the Ramsar site were as follows (not reported in any order):

- Increased occurrence and severity of *Lyngbya* blooms in southern Deception Bay and the Eastern Banks;
- Localised die-off of seagrass communities in Deception Bay (resulting from increased turbidity caused by fine sediment re-suspension) and in the Broadwater (resulting from changes to hydrodynamics and habitat modification as a result of the construction of the Gold Coast Seaway opening) and in some cases, the corresponding replacement of these habitats with macroalgal communities (eg. *Caulerpa* sp.). Abal *et al.* (2005) provides a quantitative measure of change to seagrass abundance for the whole Bay (not just the Ramsar site), noting that there have been significant declines in abundance of seagrass over time measured in a time frame between 1987 and 1997/2000, with a net change of - 2219 ha in the Northern area of the Bay and - 84 ha in the Southern area (note that these figures account for seagrass additions);
- Localised die-back of mangrove communities (eg. Southern Bay, Brisbane River delta area) from a range of natural and potentially anthropogenic causes;
- Loss/reduction of saltmarsh areas since 2003 (estimated 2500 ha) due to a combination of development pressure and sea level rise leading to subsequent colonisation of saltmarsh areas by mangroves in the Western and Southern Bay areas (Hegerl and Tarte, pers. comm. 2008);
- Observed fluctuations in dugong and turtle populations suspected to be from a range of natural and anthropogenic causes;

- Observed decreases in the number of visiting migratory waterbirds (noting that this is likely related to a variety of off-site circumstances such as changes to extent of habitat and condition of habitats throughout the Flyway);
- Increased pressure on wetland values through increased visitation and use of the site (such as the bay island National Parks);
- Groundwater extraction for domestic water supply and associated impacts on Eighteen Mile Swamp on North Stradbroke Island (including the increased susceptibility of the peatlands to irreversible impacts from fire);
- Wetland habitat modification (principally of adjacent wetland areas outside the site) and direct fishing effort resulting in impacts on commercial and recreational fisheries (see threats section below); and
- Changes in the location and an overall reduction in the quality of shorebird roosting sites in the Western and Southern Bay (principally mainland habitats) as a result of habitat loss, modification and increases in frequency of disturbance.

From this list of impacts observed over the period from 1993 - 2008, the following six impacts are seen as having the greatest significance in the context of the critical services/benefits and therefore, implications for future ecological character:

Use and quality of habitat for migratory waterbirds

While difficult to quantify without more complete data sets, there is a general view by professional and amateur ornithologists and regular observers that there have been observed decreases in the number of visiting migratory waterbirds to the site (R. Jaensch, pers. comm.. 2008). As outlined above, this is likely to be the result of multiple stressors off and on site. Off-site impacts that are likely contributing to this decline are the quality and availability of habitat in other nations along the Australasian Flyway as well as the condition of Australia's inland wetland habitats. See Nebel *et al.* (2008) for a discussion on long term survey results which show a consistent declines in waterbird abundance. On-site changes in the location and an overall reduction in the quality of bird roosting sites in the Western and Southern Bay (principally mainland habitats) as a result of habitat loss, modification and increases in frequency of disturbance are also likely contributing factors.

Seagrass loss in Deception Bay and Southern Bay

Large-scale seagrass dieback in southern and eastern Deception Bay in recent years has resulted in the loss of a significant area of *Zostera* as well as sub-tidal *Halophila* species preferred by dugong and turtles as a food resource. Losses of seagrass abundance have also occurred in the southern Broadwater, Peel Island and areas around Coochiemudlo Island. The impacts of this habitat loss on local populations of dugong and turtle species and on broader fishery productivity are poorly understood. However, it would be reasonable to suggest that the loss has put additional pressure on other suitable dugong and turtle feeding areas within the Bay and could have lead to changes in fish and prawn recruitment success and possibly productivity. Further investigations are required to determine whether this could be considered to represent a change to ecological character.

Lyngbya

As outlined in the 2007 Healthy Waterways Action Plan for Algal Blooms, the toxic marine cyanobacterium *Lyngbya majuscula* has formed large (10 km^2 in Deception Bay), persistent and annually recurring blooms in Moreton Bay since around 1998. While historical research suggests blooms have occurred in the region for at least the last 100 years, there has been an increase in intensity and frequency of lyngbya blooms since the mid 1990's, with blooms occurring each summer across several locations within Moreton Bay, including Deception Bay in the Western Bay and on the Eastern Banks.

Results from the SEQ Healthy Waterway Partnership's Lyngbya Research and Management Program 2005-2007 identify that the key environmental factors for lyngbya growth in Deception Bay are a combination of increases in bioavailable nutrients (including iron, phosphorus, nitrogen and dissolved organics) and suitable light, salinity and temperature regimes. Specifically, the research has found that the disturbance and subsequent oxidation of Acid Sulfate Soils is of concern, as it leads to the release of nutrients such as iron. The cause of lyngbya blooms in the Eastern Banks region is less understood although the natural infiltration of nutrient-rich groundwater from the islands into surface waters are postulated as a likely trigger during favourable climatic conditions.

Lyngbya can impact on Ramsar values through the smothering of seagrass beds by dense blooms which has been found to lower the density and extent of seagrass in the affected areas. Likewise, high density blooms of lyngbya covering mangrove mudflats have been linked to malformation and mortality of mangrove seedlings. Harmful algal blooms of cyanobacteria species (including lyngbya) may also release toxins that cause illness or even mortality of marine fauna. Lyngbya can have an equally significant economic impact on wetland tourism and recreational activities in the Bay during summer bloom periods making coastal waters unfit for primary contact and beaches unuseable.

Water quality in the Western Bay

As mentioned in Section 3, the rates of organic loading of benthic zones (due to a combination of point and diffuse carbon sources) in the Western Bay are at greatest threat from continued poor water quality with the process of denitrification in the sediments 'poised' to turn off. If this were to occur, there would be potentially very serious consequences, as water column nutrient levels would increase. This would in turn encourage greater water column primary productivity, which would further affect subtidal vegetation in the Ramsar wetlands, and a potentially continual cycle of ecosystem decay could be initiated. It should be noted that recent and ongoing efforts to reduce sewage carbon and nutrient loads to the region may assist in reducing the potential for this scenario to develop.

Water quality in the Southern Bay

In terms of long term trends in water quality, the Healthy Waterways Strategy indicates that the area within the Bay of most concern is the steadily decreasing grade of the Southern Bay area; in 2002 it rated as "good", however by 2006 it had declined to "poor". This decline is linked with the increasingly poor water quality in the Logan and Albert River estuaries. While the most recent Report Card has seen an improvement in grade back to a B-, this is reported as being due, in part, to the application of less stringent water quality guidelines to the area. Future urban expansion adjacent to the Southern Bay is indicative that much greater pressure on the water quality (and associated wetland values such as seagrass) in this region is likely in coming years.

5.1.2 Management Responses Since Listing

It is important in the context of Moreton Bay to highlight that the impacts discussed in the previous section (and those that pre-date Ramsar listing) signalled a significant public appreciation of environmental threats to the Bay. This fuelled the impetus for significant Government investment in planning, management and monitoring of the Bay over the past two decades.

The early 1990's saw the genesis of a number of major planning and management regimes relevant to the Bay and its resources. Some of the key responses during this early period included:

- Declaration of the Bay as a marine park under the Queensland *Marine Parks Act 1982* and promulgation of the Moreton Bay Strategic Plan 1993 by the then Department of Environment and Heritage (note that the marine park would be zoned several years later in 1997);
- Alignment of the Moreton Bay Water Quality Study and Brisbane River Management Group activities toward the formation of the Healthy Waterways Partnership and significant investment and improvement in wastewater discharges by local authorities;
- The prohibition and removal of commercial fishing activities from Pumicestone Passage by the then Queensland Department of Primary Industries/Queensland Fisheries Management Authority; and
- Increased emphasis and funding to improve rural land management through integrated catchment management by the then Department of Natural Resources and Department of Primary Industries.

By the 2000's, the management response to the conservation and sustainable management of the Bay saw further progress. Significant investments were made in water quality monitoring (EHMP), urban wastewater treatment and stormwater management, improved rural land management and preparation of numerous statutory land use plans and strategies recognising the Bay's environmental values by State Government, local governments and the regional NRM bodies (many of which still apply and are outlined in this report). This was underpinned by significant investment in projects by the community through funding programs like Coastcare and Coast and Clean Seas as well as investment by the private sector to both monitor and improve environmental practices.

Discussions with Committee members also highlighted some perceived positive effects on ecological character as a result of mitigation schemes and works. Particular examples include creation of shorebird habitat at Boondall through placement of dredge spoil, rehabilitation of mangroves at the Kerkins Levee site in Pimpama, and saltmarsh restoration at both Hays Inlet and Bulimba Creek (J Beumer, pers. comm. 2008).

Despite the significant investment to date and demonstrable improvement in ecosystem health in some localised areas, there is recognition by stakeholders that more broad scale improvement of highly modified aquatic ecosystems will be a long term process in the Bay and its waterways. Further, the maintenance of current values (by stopping the further decline of these systems) will continue to be challenging given the economic and infrastructure growth the region is experiencing.

5.2 Overview of Threats

A range of threats have been identified in the summary tables for the critical services/benefits contained in Section 7 of this report. In analysing this list, a number of common threats to ecological character can be derived.

In general, threats can be categorised between threats occurring *within* the boundaries of Ramsar site and those that are occurring *outside* the site boundaries that because of their scale or intensity can have an adverse impact on ecological character.

This categorisation is important given the nature of the boundaries of the site which are essentially a series of discontinuous polygons that are limited to nearshore estuarine areas and extend selectively over State controlled lands or similar above the high water mark. In addition, the site excludes major rivers such as the Brisbane and the Logan and in most cases does not extend up the smaller adjoining estuaries and creeks to their full tidal extent.

It is also important to recognise that many important wetland species identified in the critical services/benefits (birds, some fish, turtles, and dugong) are highly mobile both within the site and across much larger habitat ranges. As such there is an inherent difficulty in using a management regime like the Ramsar Convention to effectively manage threats and impacts to such fauna.

For this reason, most management regimes (including the EPBC Act) tend to focus on regulating activities that will or may have an impact on the values of the site without necessarily occurring within the boundaries of the site or involving direct disturbance.

Through the expert panel process undertaken with the Scientific Expert Panel (refer Appendix A), threats and stressors at a habitat-scale and species-scale within the estuarine and marine areas of Moreton Bay were developed. Table 5-1 provides a summary of the outputs of these discussions focussing on those habitats and species relevant to the Ramsar site.

Table 5-1 Threats and Stressors on Key Habitats and Species

Habitat Type	Stressors/Threats *(note that the items are not listed in any order of priority)*
Seagrass meadows	Anchoring/propeller damage; Fishing (bait collection); Algal Growth (*caulerpa* and *lyngbya*); Dredging; Fishing (trawling); Water pollution (run-off); Climate change
Mangroves and Saltmarsh	Direct clearing or filling; Water pollution (nutrients and hydrocarbons); Adjacent works (eg. urban development); Off road vehicle driving (tyre tracks); Climate change; Algal growth/weed infestation
Tidal flats	Fishing (netting); Fishing (bait collection); Direct clearing or filling; Adjacent works (ie. dredging, urban development); Climate change; Water pollution (nutrients)
Rocky shores	Fishing (bait collection); Recreational use and collection (trampling); Climate change; Water pollution (run-off and sedimentation)
Ocean beaches and foredunes	Fishing (line and netting); Fishing (bait collection); Works (extraction, structures, nourishment projects); Human use (off road vehicle driving); Introduced predators; Climate change; Water pollution (nutrients)
Inshore coral communities	Fishing (line and netting); Anchoring; Aquarium fish collection; Human use (recreational and tourism diving); Dredging and placement of spoil; Water pollution (land based runoff); Climate change; Water pollution (vessel based); Algal growth
Inshore mud (sub-tidal areas with predominantly muddy substrate)	Dredging and placement of spoil; Fishing (trawling); Water pollution (plumes and runoff; Changes to fluvial flow regime
Inshore sand (sub-tidal channels, banks and bars with predominantly sandy substrate)	Works (sand extraction; dredging; training river mouths); Fishing (netting, line, trawling and crabbing)
Wallum freshwater habitats (including peat swamps)	Urban development; Fire regimes; Introduced species and weeds; Groundwater extraction; Climate Change; Water pollution (run-off).
Species Type	Stressors/Threats (not listed in any order of priority)
Dugong	Harassment; Fishing (traditional hunting); Boat strike; By-catch and entanglement; Water pollution; Climate change;
Marine turtles	Rubbish and plastic ingestion; Fishing (traditional hunting); By-catch and entanglement; Boat strike; Introduced predators (particularly for nesting); Water pollution; Climate Change; Off road vehicle driving; Algal blooms (*lyngbya*)

Shorebirds	Human disturbance (visual and noise and habitat modification); Introduced and native predators; Climate change
Little tern	Human disturbance (visual and noise, habitat modification and direct mortality from beach driving); Introduced and native predators; Climate change; Line fishing (impact on food source)
Water mouse	Human disturbance (habitat modification); Introduced and native predators
Illidge's ant blue butterfly	Human disturbance (habitat modification in mangrove areas)
Acid frogs	Habitat loss and fragmentation; Altered hydrological regimes (water diversion); Water pollution; Weed and mosquito control; Introduced predators (Eastern Gambusia); Fire regimes; Climate Change
Painted snipe and Australasian bittern	Habitat modification (drainage of wetlands); Altered hydrological regimes (water diversion); clearance of wetland vegetation (particularly dense sedge) and overgrazing
Oxleyan pygmy perch and honey blue-eye	Human disturbance (habitat modification); Water pollution; Groundwater extraction; Introduced predators (Eastern Gambusia); Algal blooms

Given the diverse range and varying magnitude of threats and stressors at a habitat or species scale, further analysis was needed in order to identify the most prominent threats to the Ramsar site, particularly at the whole of site scale.

Accordingly, the study team sought to identify and group threats into categories considering the following criteria:

- The degree of salience or relevance to the nominated critical services, components and processes in the ECD;
- The propensity of the threat to affect a broad area;
- The propensity of the threat to impact the site cumulatively over time.

In this context, threats were considered both in terms of stressors or threats occurring within the boundaries of the site and those that were external to the site boundaries.

The key threats derived from this analysis are set out in section 5.2.1 – 5.2.8 and are summarised into the following categories:

- Harmful interaction with wetland species;
- Sustainability of fishing and harvesting;
- Sediment and nutrient input into the Bay from point and non-point sources;
- Groundwater extraction;

- Urban encroachment into the Ramsar boundary and adjacent wetland areas;
- Significant changes to wetland ecosystem processes from major infrastructure/development projects;
- Oil spills or other large scale marine pollution incident;
- Altered fire regimes; and
- Impact on coastal wetlands from climate-change induced sea level rise and related threats.

In characterising the nine (9) key threats identified above, a qualitative risk assessment matrix has been used to assist in assignment and prioritisation of risk. This involves assessing the likelihood and severity of potential impacts based on a range of threat categories. Description and assignment of risk levels using this framework is summarised in Tables 5-2 to 5-6 below.

As part of this risk assessment it is also important in a highly managed environment like Moreton Bay to consider the effectiveness of National, State and local laws and policies to regulate and reduce risks to wetland values from threatening processes. Thus, the final residual risk for each threat has been presented with this regulatory/management adjustment.

Table 5-2 Spatial Application of Impact Categories

Spatial Application of Impact
Broad Scale - Impacts will occur at a Whole-of-Ramsar -site scale, with marked impacts to populations/sub-populations of key flora and fauna listed in the critical services
Regional Scale – Impacts will occur beyond the local scale (eg. potentially across several habitat types) with some impacts to populations/sub-populations of key flora and fauna listed in the critical services
Local Scale – Impacts will be at an individual habitat or community scale (eg. within a habitat type) but will not have any measurable effect on population or subpopulations of key flora and fauna listed in the critical services
Individual Scale – Impacts will be at an individual species level and will not affect population or subpopulations of key flora and fauna listed in the critical services

Table 5-3 Duration of Impact Categories

Duration/Irreversibility of Impact
Permanent or otherwise Long Term and Irreversible
Medium Term Impact
Short Term Impact

Notes:

- ***Permanent/Long Term*** *= Recovery of habitat or population measured in decades or irreversible*
- ***Medium Term*** *= Recovery of habitat or population measured in years*
- ***Short Term =*** *Recovery of habitat or population measured in days to months*

Table 5-4 Impact Risk Category Table

Impact Risk Category	
High	Irreversible Impacts at the Broad Scale or Regional Scale Medium Term Impact at the Broad Scale
Medium	Irreversible Impact at a Local Scale Medium Term Impacts at the Regional Scale Short Term impact at a Broad Scale
Low	Irreversible Impact at the Individual Scale Medium Term Impact at a Local scale Short Term impact at a Regional Scale
Very Low	Medium Term Impact at the Individual Scale Short Term Impact at a Local Scale

Table 5-5 Likelihood that the Impact could lead to a significant/marked change to Ecological Character

Likelihood that impact to ecological character will occur from the threat	High Impact Level	Medium Impact Level	Low Impact Level	Very Low Impact Level
Likely or Certain	4 – High Risk	4 – High Risk	3 – Medium Risk	2 – Low Risk
Possible	4 – High Risk	3 – Medium Risk	2 – Low Risk	1 – Very Low Risk
Not Likely	3 – Medium Risk	2 – Low Risk	1 – Very Low Risk	1 – Very Low Risk

Notes:

- ***Likely/Certain*** *indicates that a significant or marked change to ecological character (eg. one or more limits of acceptable change have been compromised) is likely or certain to occur from a particularly threatening process*
- ***Possible*** *indicates that while change could occur to a Ramsar value or Service, this change may not necessarily be one that represents a significant or marked change to ecological character (eg. limits of acceptable change have not been compromised)*
- ***Not Likely*** *indicates that a change could occur but this change is not seen as having any material impact on ecological character (eg. change does not compromise limits of acceptable change)*

Table 5-6 Management Regime Adjustment to Residual Risk

Perceived Effectiveness of Management Regime (eg. application of EPBC, State laws, Local laws) to reduce risk of threat having significant/marked change to ecological character	
Highly Effective	Reduce Risk Rating by One – Two Rankings
Effective	Reduce Risk Rating by One Ranking
Somewhat Effective	Unmitigated Risk becomes residual risk

Notes:

- ***Highly Effective*** *is indicative that there is an existing regulatory or management regime in place for the threat and implementation is comprehensive and effective.*
- ***Effective*** *is indicative that there is an existing regulatory or management regime in place for the threat and implementation is considered to be effective but is likely limited by extent, jurisdiction, resources or a similar issue.*
- ***Somewhat Effective*** *is indicative that there may not be a regulatory or management regime in place for the threat or otherwise that the existing regime is considered to be somewhat ineffective.*

5.2.1 Harmful Interactions with Wetland Species

Growing population in the region has led to increased usage and access within, across and through the various wetland habitats of the Ramsar site for a range of commercial and non-commercial activities.

These activities present a further threat to critical wetland services/benefits and ecological character. Human presence and use of wetland habitats can have indirect impacts on the quality of the habitat for important wetland species, particularly where such disturbance is occurring at a critical or sensitive life stage (eg. nesting). While isolated incidents are unlikely to result in marked or observable changes to ecological character in the short term, the cumulative impacts of these activities on particular habitats or on the populations of important species are perhaps of greater concern.

Specific threats within this category include:

- Beach driving and other human usage resulting in on-going disturbance to shorebird nesting, roosting and feeding areas;
- Disturbance to shorebirds (roosting and breeding) that can occur as a direct result of human recreational activities including: 4WD vehicles on beaches (Moreton and North/South Stradbroke Islands); boating/kite surfing/jet skin around feeding and roost sites (e.g. Days gutter, Amity banks, Jumpinpin, Caloundra sand banks), pedestrian activity (with or without companion animals) through or in close proximity to shorebird roost sites;
- Localised wetland habitat degradation through trampling of reed beds in areas with high levels of human visitation (e.g. Blue Lake – North Stradbroke Island; Blue Lagoon - Moreton Island), which has the potential to impact seriously on local acid frog populations;
- Interaction between important marine fauna and commercial and recreational fishing activities including provision of food resources from by-catch; and
- Increase potential for boat strike/disturbance of dugongs and turtles through increased commercial shipping, major dredging activities and recreational boating activities (including jet-skis).

Management of these threats in a manner consistent with the objectives of the Ramsar Convention (eg. so as to maintain ecological character) is reliant on the application of legislative powers and management measures by the various State Government agencies and Local Governments as well as those industries directly involved. Funding and resources to undertake planning, day to day management and enforcement functions are key management challenges in the context of these activities.

Threat: Harmful Interactions with Wetland Species	Risk Level
Threats under this category include beach driving, by-catch, boat strike and similar and their likelihood to cause a significant/marked change to ecological character	Beach Driving – Low and Possible– 3
	By-Catch – Low and Possible – 2
	Boat Strike – Low and Possible - 2
	Others – Low and Possible - 2
Critical Services of the ECD relevant to this threat	S2a and 2f, S3, S4, S6, S7
Overall Unmitigated risk	Risk Level 2 – Low Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	A range of regulatory regimes apply. However, these threats generally relate to day to day management activities and are difficult to enforce. Education programs and similar have been implemented with some success.
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.2 Sustainability of Fishing and Harvesting

The Queensland Department of Primary Industries and Fisheries (DPI&F) manages the state's fisheries resources. DPI&F, through the *Fisheries Act 1994*, has implemented a range of programs and strategies that aim to manage fisheries in a sustainable manner. This includes gear/vessel restrictions, fish size limits, area and seasonal closures, and bag limits for recreational fish species. For most species, there are no overall total quotas (total allowable catch). Note that revised limits are to come into force in 2008/2009.

There are several key fisheries of relevance to the Moreton Bay Ramsar site (Table 5-7). The key fisheries of relevance to the site are the East Coast Otter Trawl, Inshore Finfish, Rocky Reef, Mud Crab, Blue Swimmer Crab, Spanner Crab and Beche-de-mer fisheries. Most of these fisheries are accredited under the EPBC Act, in line with the *Guidelines for the Ecologically Sustainable Management of Fisheries* (Department of the Environment and Water Resources 2007).

In addition to the above strategies, there are a range of monitoring programs in place to assess potential impacts of the fishery and the effectiveness of fisheries management arrangements. Monitoring activities include reviews of commercial logbook data, recreational fishery diaries, boat ramp surveys, and a range of fisheries dependent and independent sampling programs. Stock assessments for Queensland fisheries resources are also undertaken on a 3 yearly basis (e.g. Tanimoto *et al.* 2006; O'Neil and Leigh 2006; Allen *et al.* 2006). It should be noted however that in general terms, it is difficult to quantify trends in the abundance of most fisheries species based on available information, and impacts of fisheries activities, at local spatial scales.

Annual status reports are prepared by DPI&F for each major fishery, which considers fisheries management arrangements, trends in long-term catch and effort data, and an assessment of the sustainability of the fishery based on catch-effort data (see Table 5-7). The status of the fishery is examined on a state-wide and regional basis, and in most cases, does not consider finer spatial scale trends (i.e. site specific data for Moreton Bay). The broad spatial scale of monitoring (and associated reporting) is appropriate in the context of fisheries management, as few fish stocks are likely to be restricted to local geographic area (such as Moreton Bay, or sites with the Bay). However, this approach does prevent an understanding of trends in the relative abundance of key fisheries in time at spatial scales relevant to the ECD.

Table 5-7 Status of key fisheries operating within Moreton Bay

Fishery	Status	Source
Inshore finfish	Potential issues regarding sustainability of fishery for some shark species. No other issues raised, although data are of insufficient resolution to determine any issues at a regional scale.	DPI&F (2007b)
East coast trawl fishery	Major changes in catch, effort and overall harvest over time, reflecting changes in fisheries management arrangements. Insufficient data at this stage to assess status of key resources.	DPI&F (2007g)
Rocky reef fishery	The Rocky Reef Fin Fish Fishery is under review following concerns from the commercial, recreational and charter fishing sectors about the sustainability of rocky reef fish stocks.	DPI&F (2007f)
Mud crab	Relatively stable Catch Per Unit Effort (CPUE) at both the State and East Coast Regional scales (2001-2006). No fisheries independent data from the Long Term Monitoring Program (LTMP) presented in this report to validate these trends. LTMP data, which provides fishery-independent relative abundance (CPUE) data (DPI&F 2006), shows that the Moreton Bay region had highly variable mud crab abundance over time (2000-2005), unlike the other areas in the State. The reasons for this are unclear.	DPI&F (2007d, 2006)
Blue swimmer crab	Commercial CPUE within Moreton Bay has remained relatively stable from 1999 onwards, excluding a peak in 2001. The lowest reported catch occurred in 2005 & 2006, and was thought to be linked to a decline in the number of days fished, together with a possible reduction crab numbers due to drought conditions. RFISH surveys conducted in 2002 & 2005 indicate that the recreational harvest has remained fairly stable over this period.	DPI&F (2007e)
Spanner crab	Trend of increasing CPUE in the south coast (Managed Area A) region between 1990 and 1997. Independent estimates from DPI&F's Long Term Monitoring Program (LTMP) from 2000-2003 also support the suggestion of an increase in spanner crab abundance.	DPI&F (2007a)
Beche-de-mer	Static CPUE in 2003-2005, decline in distribution and abundance in 2006. Given that a small proportion of population is harvested, DPI&F argues that reduction is unlikely a fishery effect.	DPI&F (2007c)

This mix of zoning and fishery management tools (administered through the Fisheries Act) aim to ensure fisheries are managed in an ecologically sustainable manner. The Moreton Bay Zoning Plan prepared under the Queensland *Marine Parks Act 2004* also regulates fishing activities in the Bay by restricting the type of fishing that can be undertaken in different zonal areas. Based on the draft zoning map released in 2008 by the Queensland Government, increased regulation of commercial and recreational fishing is also likely to occur through proposed amendments to the zoning plan.

Threat: Sustainability of fishing and harvesting	**Risk Level**
Threats from fishing activities and their likelihood to cause a significant/marked change to ecological character	Medium and Possible
Critical Services of the ECD relevant to this threat	S7
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective (and improving) – Reduce Risk Level by One
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.3 Water Quality Inputs

Considerable investment has been made over the past 15 years to improve point source discharges from regional sewage treatment plants, noting that the improvement and upgrade of existing facilities remains a priority as populations grow. However, it is diffuse sources of pollution that constitute the largest threat to long term ecosystem health in the Bay.

As part of the SEQ Healthy Waterways Strategy 2007-2012, the SEQ Healthy Waterways Partnership has identified the need to set sustainable load targets to assess whether or not waterways of the Bay will meet water quality objectives and protect environmental values. Scenario modelling has been undertaken as part of the development of the Strategy to predict the impact of population growth and subsequent land use change on annual pollutant loads. With a 'business as usual' approach, the Strategy predicts that by 2026, there will be a 14% increase in Nitrogen, 21% increase in Phosphorous and 17% increase in Total Suspended Solids loads to Moreton Bay. This increase is broken down between increases from point sources, diffuse urban, diffuse rural and diffuse natural sources of these nutrients and sediments of which land based sources of pollution represent the greatest threat to long term ecosystem health. As mentioned in the impacts section previously, two areas of the Ramsar site of particular concern in terms of future water quality include Bramble Bay in the Western Bay region and the Southern Bay area. Lyngbya blooms remain an important indicator of the water quality of run off in the Western Bay area.

The investigation and implementation of new water infrastructure in the region in the form of reverse osmosis wastewater recycling and desalination plants present a new point source threat, generally involving the discharge of concentrated pollutants (generally high salinity and high nutrients) associated with the purification process. However, all new wastewater recycling and desalination projects are likely to trigger State and possible Commonwealth assessment under relevant environmental impact legislation, further reducing their potential to cause unacceptable impacts to Ramsar values. Where reverse osmosis technology is being used to treat existing STP discharges such as is proposed at Luggage Point, there may be a net improvement in water quality from the current discharge accepting that a range of positive and negative impacts would need to be assessed (eg. loss of flows into the system, different concentration/proportions of nutrients, increased salinity, etc.).

Threat: Diffuse-sources of water pollution	Risk Level
Threats from diffuse sources of pollution	High and Possible
Critical Services of the ECD relevant to this threat	All, possibly excluding S4, S5, S7 and S9
Overall Unmitigated risk	Risk Level 4 – High Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective (and improving) – Reduce Risk Level by One
Residual Risk Rating	Risk Level 3 – Medium Risk

Threat: Point-source of water pollution	Risk Level
Threats from point sources of pollution	Medium and Possible
Critical Services of the ECD relevant to this threat	All, possibly excluding S4, S5 and S9
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective (and improving) – Reduce Risk Level by Two
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.4 Groundwater Extraction

Groundwater extraction in the Moreton Bay region principally occurs on North Stradbroke Island with several bores located in and around the three major townships and extraction from Herring Lagoon near 18 Mile Swamp. These bores are operated by Redlands Shire Council to service both on- and off- island potable water supply. Other bores on the island provide water for industrial use by Consolidated Rutile Limited in its sand mining operations, though almost all of this water is recycled back to the aquifer through the mining processes.

More significant groundwater extraction from the Bay Islands has recently been investigated by the Queensland Government and local governments as part of the SEQ Regional Water Supply Strategy on North Stradbroke Island and Bribie Island.

The Eastern Pipeline Inter-Connector project investigated the feasibility of extracting groundwater from North Stradbroke Island and water from Leslie Harrison Dam, for the purpose of supplying water to Logan City Council. Extensive hydrological models of groundwater on the island were developed and continue to be refined and analysed by local and State Government in the context of the potential impacts of the project on Blue Lake and other wetlands on the island. However, the Queensland Premier, the Hon. Anna Bligh MP stated in October 2007 that,

> *'the Environmental Impact Study on the Eastern Pipeline Inter-connector Project {will} not proceed until alternatives are explored. I am determined to ensure that every piece of infrastructure we build is not only built on time and on budget, but is environmentally sustainable.'* (from www.qwc.qld.gov.au)

Investigations to extract up to 10 ML/day from the groundwater resources of Bribie Island continue with that project (as of March 2008) moving to construction of test and monitoring bores, construction of associated pipeline infrastructure and water treatment facilities (Moreton Bay Regional Council 2008 Progress Report from www.qwc.qld.gov.au).

As has been the case with the major proposals to date, new water extraction proposals will likely be subject to environmental impact assessment processes at the State and Commonwealth level.

Redland Shire Council's mainland water supply is supplemented by water extracted from an unconfined aquifer on North Stradbroke Island in the vicinity of 18 Mile Swamp (Herring Lagoon). The extent to which this water extraction has affected the peatlands of the Swamp has not been extensively studied or quantified although it is noted that the extraction is regulated, has been previously assessed and is operating under lawful permit. The greatest potential impact identified as part of the literature search and as part of discussions with Knowledge Committee Members relates to the effect the reduction in the groundwater table has on the wetness of upper layers of the peatland, and the increased susceptibility of the wetland to irreversible impacts from fire.

Threat: Groundwater Extraction	**Risk Level**
Threats from groundwater extraction	Medium and Possible
Critical Services of the ECD relevant to this threat	S1, S2e, S3, S4, S5
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective – Reduce Risk Level by One
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.5 Habitat Loss Due to Urban Encroachment

The development of urban areas, often with minimal buffer areas to coastal wetlands, can result in disturbance to shorebird feeding and roosting habitat and degradation of aquatic habitat through uncontrolled recreational access, contaminated stormwater and litter.

Given that the Ramsar site is generally over state land and waters, the risks from urban expansion causing direct habitat loss within the boundaries is unlikely. However, removal or degradation of coastal wetlands situated outside the Ramsar site can result in indirect, cumulative loss of overall fish habitat values that can affect fisheries values (refer Service 7) and other important wetland fauna and populations that rely on overall ecosystem health.

The effect of urban encroachment is particularly noteworthy for transitionary wetland habitats such as *Melaleuca* and *Casuarina* swamps and supratidal saltmarsh areas that provide fish habitat as well as other wetland services (eg. habitat for water mouse and other species listed in Service 4). These habitats are afforded less protection than intertidal marine plants under Queensland legislation and often are not of sufficient size to be mapped as remnant under the Vegetation Management Act (thus avoiding protection under that Act). Saltmarsh habitats are particularly at risk given the additional impact of climate change which will make these habitats more susceptible to mangrove intrusion as sea levels rise. In many areas, the natural succession of saltmarsh areas landward in response to rising sea levels will be blocked or otherwise inhibited by existing coastal development.

The placement of human populations close to wetlands also places pressure on wetland resources through day to day management issues. Managing the introduction of increased domestic pets and feral animals into wetland ecosystems including within the foreshores of the Ramsar site is a particular issue in the Western and Southern Bay areas where a large proportion of the population accesses the foreshore.

Likewise, the encroachment of urban areas in close proximity to wetlands increases the risk of fire and the need for implementation of fire management strategies (such as controlled burns, etc.) that while reducing risks to human populations, can have acute temporary and potentially long term impacts on wetland flora and fauna.

Threat: Urban Encroachment	Risk Level
Threats from urban encroachment	Low and Likely
Critical Services of the ECD relevant to this threat	S1, S4, S6, S7, S8, S10
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective – Reduce Risk Level by One
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.6 Major Infrastructure Projects

Large-scale projects can affect the hydrologic, hydrodynamic or water quality conditions of the Bay and associated Ramsar site at broader spatial scales. Examples of major projects that have previously been undertaken or proposed in the context of Moreton Bay include:

- reclamation or capital dredging of tidal areas;
- large-scale placement of contaminated dredge material;
- construction and operation of major water desalination facilities;
- construction and operation of major dams on rivers and streams that input into Moreton Bay; and
- sea cage or other intensive aquaculture facilities.

While potentially causing more significant impacts, the likelihood that these projects will affect the ecological character of the Ramsar site is reduced by the regulatory processes and environmental impact assessment processes that would be needed prior to approval and operation. In this regard, any project that could cause impacts to the Ramsar site (and ecological character) would generally need to be considered to be in the National or State interest.

Threat: Major Infrastructure	Risk Level
Threats from major infrastructure	High and Possible
Critical Services of the ECD relevant to this threat	All
Overall Unmitigated risk	Risk Level 4 – High Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective – Reduce Risk Level by One
Residual Risk Rating	Risk Level 3 – Medium Risk

5.2.7 Oil Spills and Other Incidents

The Port of Brisbane and associated heavy industrial uses of the Australia Trade Coast lie at the doorstep of the Ramsar site. Oil spills are a potential risk to the marine environment associated with the shipping industry and on-shore petrochemical industries, with national and local plans formulated to respond rapidly to clean up spills and minimise impacts.

In March 2003, almost 2000 tonnes of light crude oil seeped from a ruptured pipeline at Lytton near the mouth of the River. This spill was controlled through a multi-agency effort such that impacts on the Ramsar site and Bay environment were largely avoided except at highly localised scales.

Introduction of exotic organisms through ballast water or on the hulls of foreign ships are a further potential threat to the Ramsar site, acknowledging that the Port of Brisbane and related agencies (AQIS, etc) implement strict controls to manage the translocation of potentially harmful organisms.

Threat: Oil Spill or other incident	Risk Level
Threats from oil spill or other incident	Medium and Possible
Critical Services of the ECD relevant to this threat	All, possibly excluding S4, S5 and S9
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Effective – Reduce Risk Level by One
Residual Risk Rating	Risk Level 2 – Low Risk

5.2.8 Altered Fire Regimes

Changes in land-use over time have led to modified natural fire regimes, and continue to alter fire regimes. Furthermore, predicted changes in climate are also likely to result in changes to fire regimes. Altered fire regimes threaten vegetation communities as regeneration processes are directly impacted, and often controlled, by fire. Consequently, fires experienced at inappropriate (too high or too low) frequencies, intensities or seasonality may lead to substantial changes in community composition and/or structure. Alterations to fire regimes threaten terrestrial vegetation communities within the site, with wallum freshwater habitats including peat swamps notably susceptible. In turn, threats may be exerted on fauna species that are dependent on these habitats, with the acid frogs of particular importance.

While management activities of protected vegetation communities may incorporate controlled burning, the possibility to reduce risks associated with altered fire regimes is limited by the lack of knowledge regarding specific fire requirements of vegetation communities and species.

Threat: Fire Regimes	Risk Level
Threats from climate change	Medium and Possible
Critical Services of the ECD relevant to this threat	S1, S2e, S4 and S5
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Somewhat Effective
Residual Risk Rating	Risk Level 3 – Medium Risk

5.2.9 Climate Change

The potential impacts of climate change on the natural values of the Moreton Bay Ramsar site and the natural capacity of the system to cope with the change will vary depending on the nature of the impact as well as the location and type of wetland habitat.

In the context of current trends, recent projections of sea level rise have been made by the National Tidal Centre (as reported in the 2007 Queensland State of the Environment Report) as 1.2mm/yr.

Potential impacts of climate change on coastal ecosystems are summarised in Voice *et al.* (2006). The most salient potential threats to the Moreton Bay Ramsar site include:

- Sea level rise and shoreline erosion (noting that the response to this may be the proliferation of works to armour the foreshore and further impact on natural values);
- Changes in wind and wave climate causing changes in local erosion rates;
- Increased coastal flooding and saltwater intrusion by higher mean sea levels;
- Changes to freshwater flows regimes caused by changes in rainfall and runoff rates that can affect the condition of wetland environments such as mangroves and saltmarsh;
- Progressive inland migration of coastal ecosystems likely leading to increased pressure on saltmarsh communities from mangrove colonisation (noting in many areas there are physical barriers to such migration as a result of the presence of coastal development);
- The possibility of coral reef bleaching from increased sea temperature and coral degradation through water acidification; and
- Increased frequency/intensity of coastal storms and increased damage to coastal property.

Estuaries like Moreton Bay are considered as being particularly susceptible to climate change given their propensity to multiple stressors of which climate change becomes an additional or exacerbating factor.

Climate change impacts on the cultural values of the Ramsar site are also noteworthy. Many of the natural assets of the site important for tourism and recreation such as coral reefs, sandy beaches, fisheries and flora and fauna in protected areas will also be adversely affected by climate change leading to more direct and measurable economic flow-on effects should they be perceived as being altered or degraded.

Currently, there is significant investment and adaptation to climate change being implemented across a broad spectrum of planning and management activities by resource managers. As such, the assessment of the local risks of climate change within the region and the management response to climate change is expected to improve over time.

Threat: Climate Change	**Risk Level**
Threats from climate change	Medium and Possible
Critical Services of the ECD relevant to this threat	All
Overall Unmitigated risk	Risk Level 3 – Medium Risk
Effectiveness of Regulatory/Management Regime to reduce Risk	Somewhat Effective (improving) – No change at present
Residual Risk Rating	Risk Level 3 – Medium Risk

6 INFORMATION GAPS, MONITORING AND EDUCATION

6.1 Information Gaps

The ECD preparation process promotes the identification of information gaps about the Ramsar site that are principally derived through interrogation of the nominated ecosystem services, components and processes and associated understanding of natural variability and limits of acceptable change.

This section summarises the key information gaps identified from the detailed description of ecological character provided in Section 7 for each critical service/benefit and reflects the discussions and outcomes of the SEP expert panel process in relation to key habitats and species within Moreton Bay (refer Appendix A).

6.1.1 Summary of Information Gaps

In general, data and information gaps have been identified in this ECD in two ways:

1) In relation to the natural variability and limits of acceptable change for critical wetland habitats and species (as outlined in the summary tables in Section 4) particularly for those attributes/controls where no data (*nd*) is stipulated; and

2) In the context of the discussion of each of the ten (10) critical services/benefits (refer Section 7).

Service 1: Diversity of Habitats

- The lack of a definitive baseline for assessment of changes in spatial extent of habitats over time is a significant information gap in the context of setting limits of acceptable change and assessing ecological character changes over time.
- In this context, there needs to be further alignment between the Ramsar Wetland Classification System and EPA's wetland mapping methodology such that more exact spatial data can be obtained or developed about the extent of relevant wetland types. Steps include -
    - Greater identification, description and mapping of the Ramsar wetland types at a local spatial scale;
    - Identification of how the Ramsar typology can be nested within the EPA's standard mapping methodology either as particular REs (for wetland types with vegetation) or as sub-categories within the broader classification set (eg. palustrine, lacustrine, riverine, estuarine and marine).

Service 2: Representative Habitats

- Noting the above inconsistencies in mapping techniques prevent direct comparisons between existing data-sets over time, for each of the representative habitats more systematic information is required on background variability in wetland habitat extent, condition and linkages to controlling or impacting processes.

- As outlined in section 4.3.1, there is a broad information gap around the issue of pontenial changes to ecological character as a result of changes to habitat extent or species populations. While response curves to particular stressors in particular habitats may be able to be developed, broader limits of change (such as acceptable habitat loss as a percentage of the total habitat area present in the Bay) are difficult to apply holistically at a habitat or species population scale.

- Key areas for further assessment for each of the representative habitats include:

  - For Eastern Banks and other seagrass habitats – extent of habitat (both in terms of areal extent and depth limits for key species); gross productivity (in terms of biomass and density); and community composition and structure (in terms of presence/abundance of dugong and turtle as well as commercially and recreationally important fisheries)

  - For Pumicestone Passage and other tidal flats habitats – extent of habitat (areal); habitat condition measured through Total Organic Carbon in the sediments; and community composition and structure using indicators such as polychaete density, abundance of benthic microalgae, and crab burrow density

  - For the Southern Bay and other mangrove and saltmarsh habitats– extent of habitat (areal); extent or trends in dieback; community composition and structure in terms of ratio of mangroves to saltmarsh over time; presence/abundance of commercially and recreationally important fish species.

  - For Coral Communities – Habitat condition (in terms of the recruitment and fecundity of coral species); extent of bleaching or other mortality; and community composition/structure (such as the relative abundance of coral versus macroalgae, the ratio of massive to branching corals and individual coral populations over time).

  - For Bay Island Wallum habitats, as outlined in Marshall *et al.* 2006 -

    i. Further development of groundwater modelling techniques to take into account ecological assets and impacts from potential changes to groundwater levels

    ii. Implementation of real time aquifer, surface water and ecological monitoring to confirm the thresholds critical to ecological assets are not exceeded

    iii. Targeted research on the nature of groundwater dependency of wetland ecosystems, species and communities

  - For Ocean Beach and Foredune Habitats - More systematic survey of key species (birds and turtle) populations over time including usage and quality of nesting sites; further research of the impact of ORV usage on sandy beach invertebrate communities; long term changes to beach morphology.

<u>Service 3: Aquatic/marine fauna</u>

Marine Species

- Present-day and historical marine vegetation mapping done at relevant spatial scale (minimum 1:25,000) and temporal (at least every 5 years, preferably with analysis of seasonal changes).

- Information on factors controlling temporal changes in seagrass.

- Natural variability in dugongs and green and loggerhead turtles and factors controlling these changes.
- Sustainability of dugongs, green turtles and loggerhead turtles given existing pressures and management arrangements.
- Health/condition status of turtles, and identification of factors causing disease.

Freshwater Species

- Environmental flow requirements of wallum fish species.
- Impacts of introduced species on wallum fish species.
- Up-to-date assessment of the distribution, population status and site-specific threats to wallum-habitat fish species, including an assessment of any changes of population status.

<u>Service 4: Wetland-dependant terrestrial fauna</u>

- Natural population variability for all species and factors controlling these changes.
- Sustainability of beach stone-curlew pairs (and breeding success) (particularly related to impacts of recreational activities) and water mouse populations (in relation to development or degradation of habitat adjoining the site).
- Extent of populations of acid frogs and water mouse outside/adjoining study area boundaries.
- Systematic information to assess background variability in wetland community structure and linkages to controlling processes; environmental flow requirements of acid frogs; impacts of introduced species (on acid frogs, beach stone-curlew, and little tern) and congeneric competitors (to acid frogs).
- Locations and sustainability of little tern nesting sites (primarily in southern parts of site). Longer-term variability in patterns of usage of little tern roost sites.
- The need for monitoring and survey data collected for shorebirds is collated in a consistent manner, with data held in relevant databases that can be accessed to inform decision-making.

<u>Service 5: Wetland-dependant terrestrial flora and communities</u>

- Systematic surveys of flora and mapping of significant species is lacking.
- Research to understand groundwater dependencies for communities and species is very limited.
- Research to identify species tolerance to salinity and desiccation is lacking.

<u>Service 6: Shorebird Populations</u>

- Indices/trends for shorebird abundance and diversity over time, patterns of roost and feeding habitat usage, particularly in terms of the proportion of shorebird aggregate feeding outside the Ramsar site boundaries.

- Natural population variability for all species and factors controlling these changes.
- Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh.
- Information on natural population variability of invertebrate prey and factors controlling temporal changes.
- Current distribution and categorisation of roost habitats (e.g. size, level of disturbance, position in relation to HAT and feeding grounds) within and adjacent to study area boundaries.

Service 7: Fisheries

- Present-day and historical marine vegetation mapping done at relevant spatial scale (minimum 1:25,000) and temporal (at least every 5 years, preferably with analysis of seasonal changes).
- Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh.
- Natural variability in fish and shellfish stocks, and factors controlling these changes.
- Specific environmental flow requirements of estuarine vegetation and fisheries species.
- Sustainability of current recreational and commercial fisheries management practices.
- Values and functions of proposed no-take ‘green zones’ in the future Marine Park Zoning Plan.
- Estimates of the abundance of key fisheries species over time at a local (Moreton Bay) spatial scale.
- Impacts of fisheries activities on abundances in Moreton Bay.
- Assessment of impacts of climate change on commercially and recreationally important fish stocks such as changes to migration patterns and initiation of critical life stage processes.

Service 8: Indigenous

- While some values and resources have been identified, further articulation of the values and cultural significance of the site are seen as only able to be set and measured through consultation with Traditional Owners.

Service 9: Research and Education

- A range of science priorities for Moreton Bay have been identified as part of the 2007-2012 Healthy Waterways Strategy (Moreton Bay Action Plan component). In addition to these priorities, the information gaps and monitoring recommendations of this ECD are seen as essential for monitoring the ecological character of the Ramsar site.

Service 10: Tourism and Recreational Uses

- Reliable visitor statistics, including tourist expenditure and other economic contributions.
- Carrying capacity of the Ramsar site for activities and locations.

- The importance placed on the Ramsar site and values by visitors when undertaking tourism and recreational activities and experiences.

6.1.2 Priority Information and Data Gaps

In analysing this expansive list, the following thematic information gaps are identified as priority areas:

- Additional research and monitoring expenditure to establish an ecological character baseline for the near-natural representative habitats, particularly those more localised habitats within the Ramsar site such as the freshwater wallum habitats of the Bay islands, the Eastern Bay coral reefs and peatlands such as Eighteen Mile Swamp;

- The need for better information and data sets about the presence and natural history of critical wetland species and their habitat including for example, surveys of vulnerable and endangered plant species on the Bay islands, aquatic species such as Oxleyan pygmy perch and more systematic surveys of important avifauna species and populations;

- Better information and understanding about the natural variability of critical wetland fauna populations and key attributes and controls on those populations (including whether or not any non-avian fauna species meet the 1% population requirement in Ramsar Nomination Criterion 9);

- The ecological character thresholds of particular habitats and communities to changes in key attributes/controls such as water quality and hydrology need additional investigation. Noting that any interim limits of acceptable change stated in the ECD should be revised as improved information becomes available;

- Resilience of habitats, community structure and key species to acute or prolonged impacts from water quality degradation such as nutrient enrichment, increased levels of salinity and sedimentation/turbidity (eg. similar to the approach in ANZECC for toxicants); and

- Consultation and involvement of traditional owners of the Moreton Bay Ramsar site if a greater understanding of historic and contemporary wetland values of the site to indigenous people is to be obtained and appreciated.

6.2 Monitoring Needs

6.2.1 Summary of Monitoring Needs

A broad range of monitoring recommendations are provided in this ECD based on the information gaps and monitoring recommendations provided under each critical service and critical process summary table.

Similar to the above section on data and information gaps, monitoring needs can be derived from the ECD in two primary areas:

1. In relation to the natural variability and limits of acceptable change as they relate to the Ramsar Nomination Criteria and underlying critical wetland habitats and species of the site

particularly for those attributes/controls where no data (*nd*) is stipulated and an interim limit of acceptable change is presented; and

2. In the context of the detailed discussion of each of the ten (10) critical services/benefits (refer Section 7 of the report).

Limits of Acceptable Change

Some level of monitoring will be needed to assess the suitability of interim limits of acceptable change (versus natural variability) and to assess if unacceptable changes as outlined in the summary table for LAC (refer Table 4-3) are being approached or are occurring. Principally, this monitoring will need to relate to:

- Broad-scale observation/monitoring to ensure each wetland type outlined in the ECD continues to be represented across the site;
- Wetland habitat extent monitoring (noting that a precursor to being able to do this will be to establish a better correlation between EPA wetland mapping and the Ramsar Classification System);
- Habitat condition monitoring (principally in the form of monitoring underlying wetland ecosystem processes such as water quality and hydrological process or surrogate biological indicators such as crab burrow density);
- More targeted surveys of the threatened flora and fauna species (perhaps on a five year or ten year basis) to assess presence/absence or population changes of noteworthy species or communities; and
- More regular counts of roosting and feeding shorebirds with a particular emphasis on those species that meet the 1% population criteria.

In the context of assessing whether or not ecological character is being maintained, the following monitoring objectives and measures are recommended in Table 6-1.

Table 6-1 Monitoring Changes to Ecological Character

Basis of Monitoring	Objectives of Monitoring	Indicator/Measure	Frequency	Priority
Nomination Criterion 1	Ensure current diversity of wetland types are maintained	Establish reference sites for each Ramsar wetland type and record observations about extent and condition	Annually	High
	Monitor extent of Ramsar wetland types (all)	Correlate and map Ramsar wetland types within broader EPA mapping product Establish baseline extent for each habitat type based on the revised mapping Re-map at regular intervals and assess extent and determine if changes are part of natural variability or represent anthropogenic change	Undertake as part of planned updates of EPA wetland mapping	Medium
	Monitor extent and condition of key habitats including reference habitats	Establish reference sites for each key habitat type (eg. seagrass, tidal flats, etc) and monitor extent and condition – refer Table of LACs for key habitat attributes (refer Table 4-4) Continue and augment EHMP monitoring for water quality and seagrass habitat extent with consideration of additional sampling locations and indicators based on this ECD	Monthly - Annually Monthly	Medium - High High
Nomination Criterion 2	Determine presence/absence of threatened wetland species	Undertake more detailed surveys of species and communities within the Ramsar site Assess presence/absence with consideration of relevant LAC	Species specific – generally studies will need be undertaken every 5 – 10 years and may need to be undertaken over	High

Basis of Monitoring	Objectives of Monitoring	Indicator/Measure	Frequency	Priority
			several seasons	
	Assess condition/change to populations	Undertake more detailed surveys of species populations and communities within the Ramsar site Assess any changes to population (eg. breeding success, mortality rates, health etc.) and any applicable underlying wetland processes (eg. water quality of key habitats – refer relevant species-based LACs in Table 4-5)	See above	Medium
Nomination Criterion 3	Loss of biodiversity	Utilise indicator/measures from Criteria1 and 2	See above	Medium
Nomination Criterion 4	Use of the site as refugia habitat	Survey and monitor the following key refugia functions: 1) Feeding habitat for green and loggerhead turtles 2) Feeding and breeding habitat for dugong 3) Refuge habitat for freshwater fish of conservation significance 4) Roosting habitat for migratory shorebirds 5) Critical overwintering habitat and flyway staging area (both northern and southern migration routes) for migratory shorebirds	Specific monitoring programs for each refugia function to be developed – monitoring to occur during key usage periods	High
Nomination Criterion 5	Use of the site by at least 20 000 waterbirds	Ensure regular surveys of waterbird usage of the site during key visitation periods Use of surrogate species (bar-tailed godwit, Eastern curlew and Pacific golden plover) for overall abundance	Undertake annual counts of waterbird usage of the site	High
Nomination	The site supports	Undertake more detailed surveys of	Specific	High

Basis of Monitoring	Objectives of Monitoring	Indicator/Measure	Frequency	Priority
Criterion 6	the 1% of individuals of populations for the key avifauna species in the ECD	1% candidate species of avifauna listed in the ECD	monitoring programs for each species to be developed	
Nomination Criterion 7	Long term impacts on the sustainability of populations of important commercial and recreational fishery species that occur within the site	Continue to fund and implement monitoring of fisheries by the Department of Primary Industries and Fisheries (eg. CFISH [Commercial Fisheries Information System] and RFISH [Recreational Fishing Information System].	As per current programs	Medium
Nomination Criterion 8	Assess reduction in the extent or condition of wetlands or other areas and a corresponding measurable impact on important spawning, nursery or migration pathways for fisheries	Identify reference sites for key spawning, nursery and migration pathways within the Ramsar site In assessing the interim LAC, attention should be given to assessing changes in the extent of mangroves, saltmarsh, seagrass and tidal flat environments, which represent key nursery habitats to many commercially important species within the site	Medium to long term (>5 years)	Medium

Critical Services/Benefits

In addition to undertaking monitoring to assess potential changes to ecological character as discussed above, a summary of more specific monitoring needs identified under each critical service (as summarised in Section 7) is contained below. In most cases, these recommendations provide additional detail and context to the information already presented above in Table 6-1.

Service 1: Diversity of Habitats

While preliminary work has been done in this ECD, assignment of more detailed definitions and provision of spatial data for each of the wetland types in the Ramsar site (using the Ramsar Classification System) is needed such that a baseline for each wetland type represented in the site can be monitored over time. This needs to be closely aligned to the Queensland Wetlands Mapping Project.

Service 2: Representative Habitats

2a (Eastern Banks) Examination of long-term changes in seagrass based on aerial photograph interpretation and review of existing information.

2a (Eastern Banks) Additional EHMP/Seagrass Watch monitoring sites in representative areas subject to different wind/wave regimes.

2b (Pumicestone Passage) Examination of long-term changes in extent of tidal flats based on aerial photograph interpretation and review of existing information.

2c (Southern Bay) Examination of long-term changes in mangroves and saltmarsh based on aerial photograph interpretation and review of existing information.

2d (Coral Reefs) Additional EHMP monitoring sites in representative areas subject to different wind/waves regimes.

2d (Coral Reefs) Monitoring of coral growth (individual colonies) over time.

2e (Freshwater wetlands on Bay Islands) Additional EHMP monitoring sites in representative sites within North Stradbroke Island and Moreton Island.

2e (Freshwater wetlands on Bay Islands) Development of locally specific ecosystem condition objectives. Additional measures recommended by Marshall *et al.* (2006) related to assessing changes to ecological assets as a result of future water extraction include -

- Further development of groundwater modelling
- Implementation of real time aquifer, surface water and ecological monitoring to confirm the thresholds critical to ecological assets are not exceeded
- Targeted research on the nature of groundwater dependency.

2f (Moreton Island Ocean Beach) Examination of long-term changes in habitat extent using aerial photograph interpretation and review of existing information.

2f (Moreton Island Ocean Beach) Schlacher *et al.* (2008) also recommends research into the implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity and the effects of cumulative impacts from multiple stressors and disturbances on the structure, function, and recovery dynamics of sandy beach ecosystems.

<u>Service 3: Aquatic/marine fauna</u>

Fauna population monitoring at appropriate spatial and temporal scales.

Marine vegetation monitoring.

Continuation and expansion of EHMP to monitor key species identified in the ECD.

<u>Service 4: Wetland-dependant terrestrial fauna</u>

Acid frogs - Identify key populations and for those populations, monitor presence/absence, breeding evidence (tadpoles and metamorphs), and maintenance of parapatry (speciation) between acid frog congener species during optimum breeding conditions until markers/trends of population variability are evident. Quarterly monitor water quality for key population sites (salinity, pH range 3-5, dissolved oxygen, nitrate levels (maintain <0.7 mg/L) and other toxicants (e.g. monomeric Aluminium and surfactants)). Assess impacts of fire on habitat of key frog populations from fires.

Beach stone-curlew – Monitor habitat usage and breeding success at key habitat sites (bi-annual).

Little tern – Identify locations and sustainability of Little Tern nesting sites (primarily in southern parts of site) (yearly). Monitor abundance and pattern of usage at key roosts within northern Pumicestone Passage and northern sector of South Stradbroke Island (annual).

Water mouse – Identify full extent of water mouse habitat within and outside the site and monitor nest activity and diversity of nest types as surrogate for species distribution and abundance (annual and during breeding period).

Continuation and expansion of EHMP to monitor key species identified in the ECD

<u>Service 5: Wetland flora and communities</u>

Systematic flora surveys would quantify the representation of wetland communities and species of conservation significance within the Ramsar site. This would assist in prioritising targeted areas for conservation and management actions, and in specifying limits of acceptable change more accurately (i.e. in terms of percentage area for RE's or population numbers for species).

<u>Service 6: Shorebird populations</u>

Early and late summer monitoring events at key roost sites and feeding grounds (to be conducted annually) to target bar-tailed godwit, Eastern curlew and Pacific golden plover (species which currently exceed the 1% threshold and which may provide useful surrogate for numbers of other shorebirds using the site and of habitat usage).

Annual audit of roost sites (condition and use).

Monitor habitat usage and breeding success (bi-annual) of pied oystercatcher (key resident species) on outer bay islands.

<u>Service 7: Fisheries</u>

Fish stock monitoring based on DPI&F state-wide LTMP, CFISH (Commercial Fisheries Information System) and RFISH (Recreational Fishing Information System) programmes.

Marine vegetation monitoring.

Continuation and expansion of EHMP to monitor key commercial and recreational species identified in the ECD.

Service 8: Indigenous

No specific monitoring needs for this Service were recorded.

Service 9: Research and Education

No specific monitoring needs for this Service were recorded.

Service 10: Tourism and Recreational Uses

Reliable visitor statistics, including tourist expenditure and other economic contributions.

Number of visitors participating in each activity/location and the resultant environmental impacts and potential indicators for monitoring.

Importance/awareness of Ramsar site and values for visitors.

6.2.2 Monitoring Alignment

In making recommendations for future monitoring of the Ramsar site, the information gaps and monitoring needs identified in the ECD were also considered in the broader context of the Southeast Queensland Healthy Waterways Partnership's Ecosystem Health Monitoring Program (EHMP) and the monitoring program being implemented to assess the effect of proposed re-zoning of the Moreton Bay Marine Park by the Queensland EPA.

To ensure close alignment between these initiatives, a special sub-group of the Southeast Queensland Healthy Waterways Partnership Scientific Expert Panel (SEP) met several times with the consultant study team and the Knowledge Management Committee to workshop and discuss synergies and commonality between the existing and proposed monitoring programmes (refer Appendix A). A separate report outlining the outcomes of these discussions has been produced by BMT WBM (2008b) as part of the ECD project and is summarised here.

To facilitate the determination of monitoring priorities and identify possible efficiencies, there were two key hypothesis questions posed to the workshop project group for discussion:

1. What species/habitats/processes are salient to all three programs (eg. Ramsar, Marine Park and EHMP) and should be monitored in order to most cost effectively assess if health/character is being maintained (or improved by management interventions)?

2. What is the most effective and efficient sampling design in the context of overall information needs for management?

Key indicators seen by the group as relevant to the Moreton Bay Ramsar site (as well as the other two programs) are outlined below:

In relation to **habitats**, the following indicators were identified as high priorities:

- Areal extent of seagrass meadows (though use of the light penetration and depth surrogate is seen as most appropriate);

- Gross production of seagrass meadows;
- Presence abundance of key species in seagrass meadows (particularly dugong and green turtles);
- Areal extent of mangroves and saltmarsh;
- Ratio of mangroves to saltmarsh;
- Abundance and diversity of key species within mangrove and saltmarsh habitats;
- Areal extent of dieback of mangroves and saltmarsh and changes over time;
- Areal extent of tidal flats;
- A range of indicators presented relevant to inshore coral communities;
- Bird nesting/feeding usage (including birds of prey) in ocean beaches and foredunes; and
- Abundance/diversity of benthic invertebrates across several habitat types (ocean beaches and foredunes, tidal flats and inshore mud and sand habitats).

In relation to **species**, the following indicators were identified as high priorities:

- Monitoring indicators related to dugong;
- Monitoring indicators related to marine turtles (green and loggerhead);
- Monitoring indicators related to migratory and resident shorebird species including little tern; and
- Monitoring indicators related to water mouse.

Key **ecosystem processes** identified as critical across a range of wetland habitat types included:

- Hydrodynamic controls including sedimentation and inundation patterns;
- Water quality; and
- Biogeochemical processes.

Key **stressors and threats** identified to habitats and species in Moreton Bay were:

- For habitats - Dredging/placement of dredge spoil and related marine works, various forms of fishing, water pollution and climate change were the most common stressor/threats listed.
- For species – Climate change, habitat modification, and by-catch/entanglement were the most common stressor/threats listed.

While specific priorities and methodologies for monitoring were not sought to be developed through the workshop process, the information presented in the analyses above provides a basis for the next phase of monitoring and sampling design under EHMP and other monitoring regimes that is cognisant of the important/significant habitats and species, key attributes and associated stressors and threats affecting the Moreton Bay Ramsar site.

6.3 Communication, Education and Awareness Messages

6.3.1 Existing CEA Messages

This section reviews the key communication, education and awareness messages (CEA) related to the Moreton Bay Ramsar site and identifies perceived gaps.

The role of the Healthy Waterways Partnership over the past decade in raising public awareness about the environmental values of the Bay has been significant. These communication and education messages include many of the values and services identified by the ECD as being critical such as:

- The ecosystem values of wetland to important fauna such as birds, turtles and dugong;
- The impacts of human uses and activities on Bay water quality and amenity; and
- The use of best practice measures and water quality technology to manage runoff.

The Annual Ecosystem Health Monitoring Programme Report Card produced by the Healthy Waterways Partnership remains a powerful tool to convey the current condition of waterways to the public and to elected officials that is now being pursued in a number of other areas and jurisdictions such as the Port Curtis area in Central Queensland and as part of the Great Barrier Reef Water Quality Protection Plan.

The Report Card provides a snapshot of both current information as well as trend information over time across a broad area of the Bay. Of note in the context of the current study is the predominant emphasis on physico-chemical parameters in the estuarine and marine Report Card. The inclusion of more biotic indicators in the form of key habitats and key fauna would better align the Estuarine and Marine Components with similar indicators used in the Freshwater Components of Western Catchments as well as recognise key fauna and habitat values important to the Bay's Ramsar designation.

Community education and monitoring programs also remains a key facet of NRM investment programmes in the region such as the long running 'Seagrass Watch' and emerging complementary programmes for mangrove and saltmarsh.

Educational facilities such as the Boondall Wetland Centre and Nudgee Beach Environmental Education Centre located in the Western Bay utilise the resources, values and threats to the Bay as key components of their curriculum and activities.

6.3.2 Gaps

As identified in Section 3 of the report, the Moreton Bay Ramsar site is recognised in a wide array of plans and strategies for the Bay and region. As site manager, the EPA has a number of brochures and information sheets about the site that are available to the public.

A general observation about CEA messages for Moreton Bay is the sense of overlap regarding planning instruments and which Government authorities are involved in management. As such, alignment under a common banner (such as the Healthy Waterways Partnership) and the promotion of consistent messages about conservation and management of the Bay are a continuing priority for resource managers, recognising that there will always be a wide range of plans and legislation that apply and these instrument need to be implemented in a coherent and integrated way.

To this end, in parallel with the ECD project, a Conceptual Framework for the ecological health and character of Moreton Bay has been developed as an outcome of the SEP workshop process that seeks to align the management and monitoring goals of this ECD, the Healthy Waterways Strategy and the Moreton Bay Marine Park Zoning Plan. The Framework (documented in BMT WBM 2008b) is a useful first step in trying to look at the Bay's habitats and species more holistically and to recognise where and how the various planning and regulatory instruments under the three conservation/management initiatives can be better aligned.

More specific areas or issues where the critical elements of the Ramsar site nominated in this ECD are perhaps not being fully articulated in the context of current CEA messages include:

- The importance of freshwater wallum and peatland wetland habitats on the Bay islands and adjacent to Pumicestone Passage and the unique aquatic fauna that exists in these areas such the Oxleyan pygmy perch, water mouse and acid frogs. This also includes the associated critical wetland flora and communities identified in this report (noting that significant work is needed by to better identify and survey the extent and values of these endangered and vulnerable communities and species);

- In keeping with the wise use paradigm of the Ramsar Convention, promotion of the diversity of sustainable wetland-based tourism and recreational values of the Ramsar site;

- The current state of fisheries resources and the need for continued conservation of fish habitat;

- The use and significance of the site to Indigenous people; and

- The importance of Moreton Bay for migratory shorebirds.

Each of these items is discussed below:

<u>Freshwater wetlands and associated systems</u>

The relative isolation and near-naturalness of the freshwater wetland habitats found on the Bay islands remain, at least anecdotally, a scarce-known resource outside of SEQ, although recent investigations as part of the Queensland Water Commission groundwater resource development on North Stradbroke Island has raised the profile of the values and threats to a greater audience. It is likely that the public is aware many of the larger more prominent water bodies such as Blue Lake are within protected areas but less knowledge that a diversity of freshwater wetland environments made up of dune lakes, palustrine depressions, and creeks and streams are within the boundaries of the Ramsar site.

Peatlands such as Eighteen Mile Swamp are also of growing importance at a global scale with Ramsar Contracting Parties calling for further cooperation on their conservation through a global action plan to conserve their unique biodiversity, paleo-geologic significance and their role as a major storehouse for carbon.

Sustainable Tourism

If Moreton Bay is to be differentiated as a sustainable tourism destination, Whitmore and De Lacy (2005) as part of their report on Sustainable Tourism in Moreton Bay identify the need for and recommend the establishment of a 'destination management committee of stakeholders' to develop Moreton Bay as a sustainable, 'Platinum Plus' Destination. This is underpinned by a range of recommendations to conduct tourism future modelling and visioning for the Bay, ensuring environmental sustainability through industry compliance and certification programmes and investigating a 'Tourism in Protected Areas" initiative between Tourism Queensland and Queensland Parks and Wildlife. Acknowledging the impacts that increased tourism and recreational use of the Bay can bring, sustainable tourism and recreational use of the Bay remains a critical part of its cultural services and promotion of this industry is seen as an important driving economic force in the future for continued conservation efforts within and external to the Ramsar site. In this context, nomination of the site as a Ramsar wetland should be heavily embraced as part of any future promotional push.

Fisheries and Fish Habitat

As discussed in the critical services section, there is a strong social (eg. cultural) as well as economic value associated with the fisheries of the Bay which is shared by commercial fishers, recreational fishers and indigenous fishers. It is likely that all of these groups embrace the notion that fisheries and fishing effort should be ecologically sustainable such that there are sufficient fish resources to support commercial, recreational and indigenous fishing activity now and in the future with some degree of intergenerational equity (eg. the fisheries of commercial, recreational or indigenous significance are maintained over time for the use and enjoyment of future generations).

In this context there have been improvements in the management of fisheries by the industry (such as the Moreton Bay Seafood Industry Association Environmnetal Management System (EMS) initiative and promotion of sustainable practices such as biodegradable bait bags by the recreational fishing industry as well as through the involvement and recognition of fisheries management practices by indigenous people in traditional fishing activities and Government regulatory and management responses to conserve fish habitat and fish populations.

Maintaining this critical service over time will depend on building upon the positive initiatives of these various groups with a vested interest in maintaining the health of the Bay and its fisheries over time.

Indigenous Values and Significance

As outlined in the Cultural Heritage Report by Converge Heritage and Community prepared as part of the ECD contained in Appendix C, the Ramsar site is likely to hold significant cultural values to the relevant Traditional Owner group/s that use the site. These values may include physical and non-physical cultural heritage areas and objects, oral knowledge, such as stories, animals and plants, and the natural environment itself;

Traditional Owners are already taking an active role in managing Ramsar areas as part of their management of the wider Moreton Bay area, and they would likely wish to increase this role if offered the opportunity. The Traditional Owners have already formed an encompassing organization (SEQTOLSMA) which may prove to be a vehicle through which consultation and planning for the future could be organized. However, only through consultation with the individual Traditional Owner groups could this be ascertained.

Migratory Shorebirds

As demonstrated throughout this ECD, the assemblage of diverse habitats of the Bay makes it one of Eastern Australia's most significant coastal ecosystems. This diversity of habitat types present in the Bay and within the boundaries of the Ramsar site (sheltered estuary versus active systems such as beaches and sandy channels) in close proximity are especially important for migratory species that use the Bay such as birds and turtles that will utilise different habitats within the Bay for feeding versus roosting/breeding/nesting.

Despite its proximity to one of Australia's fastest growing regions, Moreton Bay continues to be one of Australia's top 12 shorebird habitats and is in the top three in Queensland (EPA 2005b). Likewise, the site is a critically important stop along the East Asian-Australasian Flyway and many species that utilise Moreton Bay are recognised in the bilateral agreements for shorebird conservation between Australia and Japan, China and the Republic of Korea.

These values and obligations justify continued promotion and investment in effective education and communication activities with respect to shorebirds and shorebird habitats. To this end, a range of community education actions are already outlined in the EPA Shorebird Management Strategy and should continue to be implemented.

7 DETAILED ECOLOGICAL CHARACTER DESCRIPTION

Sections 4 – 6 of this report summarises the ten (10) nominated critical services/benefits of the Moreton Bay Ramsar site and provides information about the underpinning ecosystem components and processes, natural variability and limits of acceptable change, threats, information gaps and monitoring needs and recommendations associated with the ecological character of the site.

The broader, more detailed assessment of the critical elements of the Ramsar site on which the summary sections were based is presented in this section. The information is presented through a combination of text and tabular information using a standard template prepared for each nominated service/benefit. The standard reporting template is shown in Table 7-1.

Table 7-1 Reporting Template for Critical Services

Summary Table	Critical Service # and Name
Reason for inclusion	Relates back to the Ramsar Nomination Criteria or similar justification for selection as a critical service
Type of Service	From the National Framework document, list if the service relates to a supporting, cultural, regulatory, provisioning service or combination thereof
Description of Service	Quantified description of the service (using literature sources or similar)
Spatial application (if relevant)	Whether or not the element applies to a specific component of the site (such as a wetland type) a locality (such as one of the bay islands) or to the site as a whole
Critical component habitat types underpinning the service (if applicable)	If applicable, lists the key or noteworthy wetland types underpinning the wetland service/benefit
Critical component species that underpin the service (if applicable)	If applicable, lists the noteworthy or indicator species (such as species of conservation significance) underpinning the wetland service/benefit
Critical wetland processes underpinning the service	Lists the key wetland ecosystem processes underpinning the wetland service/benefit
Natural variability (if relevant)	Describes the natural variability of the relevant service and its underlying components/processes if known
Principal threats	Lists the key threats to the service or its underlying components or processes
Data quality underpinning this critical service	List the level of confidence in the data or information used in defining the limit (see below)
Information gaps	Cognisant of the information provided in the rows above, this section lists out the information gaps for the critical service and any underlying components and processes
Recommended monitoring	Based on the information gaps, this section sets out proposed monitoring to be carried out in relation to the critical elements

As outlined in the methodology in Section 4, following the assignment of the critical processes, components and services of the wetland, information and data gaps related to these critical elements were analysed. As part of this task, an assessment of the quality/value of the main information and data sources was undertaken using the definitions described in Table 7-2. These definitions are used in the ECD, particularly with respect to describing natural variability and the limits of acceptable change, to identify the basis on which the suggested measures have been developed and to provide a qualitative degree of confidence about the accuracy of the proposed measure.

Table 7-2 Data Quality/Quantity Review Definitions

Level Code	Description
1	Data are current, have been collected using a robust sampling design (adequate replication in time and space) and are likely to be accurate.
2	Data have been collected with respect to the research issue but there are one or more of the following limitations in the data: ➢ Limited sampling effort in time (e.g. does not consider inter-annual or seasonal variations); ➢ Limited sampling effort in space (e.g. inadequate replication at different spatial scales, or mismatch in spatial scale with issue under investigation); ➢ Potential/likely inaccuracies in collected data (e.g. due to methods of data collection, reporting etc.); ➢ Data are not current (e.g. significant changes in environmental conditions since survey undertaken).
3	Semi-quantitative assessment based on general scientific principles and limited data
4	Best scientific judgement or wholly qualitative assessment

Using the approach set out above, sections 7.1 to 7.10 outline the detailed description of the ten (10) critical services/benefits identified.

7.1 Service 1 ~ Diversity, Representativeness and Connectivity

Photos showing various wetland habitats in Moreton Bay (Source: EPA photo library)

The wetland types of the Moreton Bay Ramsar site are extremely diverse, ranging from perched freshwater lakes and sedge swamps, to intertidal mudflats and mangroves and sub-tidal seagrasses, to oceanic, high-energy beaches. An overview of the twenty-two (22) Ramsar wetland types present in the boundaries of the site and some examples of these wetlands are cited in Section 3 of this report.

As outlined previously, the study team sought to divide the Ramsar site into four geographic areas that shared common components and processes. As identified previously, the key areas used for reporting were: a) Bribie Island and Pumicestone Passage; b) Western Bay; c) Moreton Island and Eastern Banks; and d) Stradbroke Islands and the Southern Bay.

As part of this sub-regional analysis, the Ramsar wetland types were identified and listed for each of these areas in order to identify any trends in terms of the abundance and representativeness of different habitat types across the broader area. From this analysis, the following characterisation of the site in terms of the diversity of wetland habitat types can be made:

- A number of wetland habitats types are **common** across the breadth of the site (all four areas) and therefore best represented. These include: Type B (marine sub-tidal aquatic beds), Type D (rocky marine shores),Type E (sand, shingle or pebble bars; sandbars and dunes), Type F (estuarine waters), Type G (intertidal mud, sand or salt flats), Type H (intertidal marshes including saltmarsh), Type I (intertidal forested wetlands including mangroves), Type M (permanent rivers, creeks and streams), Type N (seasonal/intermittent rivers, creeks and streams) Type Tp (permanent freshwater marshes), Type Ts (seasonal/intermittent freshwater marshes) and Type Xf (freshwater, tree-dominated wetlands and swamps).

- Wetland habitats that are **well represented** in 3 of the 4 areas include: Type A (permanent shallow marine waters), Type J (coastal brackish/saline lagoons), and Type K (coastal freshwater lagoons) all of which are absent in the Western Bay.

- Wetland habitat that are **localised** (occurring in 2 or less of the areas) include: Type C (coral reefs) which are present in the Southern and Eastern Bay only; Type O (permanent freshwater lakes) which are present on the offshore sand islands, Type W (shrub dominated wetlands) characteristic of RE 12.2.12 which have been mapped by the Queensland Herbarium in the Bribie/Pumicestone and Southern Bay areas, and Type Y (freshwater springs) which generally are associated with freshwater habitats on the outer sand islands.

- Wetland habitat that are **highly localised** (occurring in 1 area only) include Type U (non-forested peatlands) of which 18 Mile Swamp on North Stradbroke Island is the site's most notable example.

In general there is a much greater diversity of wetland types present on the Bay islands than elsewhere within the boundaries of the site, in part due to the complexity of dune, freshwater wallum and peatland, and transitional terrestrial habitats present in those locations as well as the array of traditional estuarine wetland communities such as mangroves, saltmarsh and sand and mud flats in intertidal areas

In a number of areas within the Ramsar site, there is also a high degree of connectivity between the terrestrial, intertidal and subtidal habitat types. For example, the southern part of Pumicestone Passage contains a complex mosaic of mangroves, seagrass, unvegetated shoals and deeper waters in close proximity to each other. This combination and diversity of habitat types may represent potentially important nursery habitat for many fish (Laegdsgaard and Johnson 1995; Tibbetts and Connolly 1998) and prawn (Young 1978) species of commercial significance. Similar comments have been made with regard to the relationship between saltmarsh, mangrove and seagrass in the Southern Bay.

In this context, there is an emerging view that fish and nektobenthic crustacean community structure in mangroves and unvegetated habitats is influenced by their proximity to seagrass beds (e.g. Jelbart 2004, Olds 2002). Some documented examples of the beneficial interaction between wetland habitats illustrating this connectively include:

Despite being devoid of seagrass, Melville and Connolly (2003) demonstrated that organic matter, particularly from seagrasses, was important as the base of food webs for fish species of commercial significance on adjacent unvegetated mudflats in Moreton Bay.

Studies by Olds (2002) in Moreton Bay and Jelbart (2004) in central NSW both found that seagrass beds (particularly dense beds – Olds 2002) in close proximity to mangroves tend to contain more abundant nekton assemblages than seagrass remote from mangroves. Both studies also found that the suite of species inhabiting seagrass varied with distance from mangroves.

Given the size and complexity of habitats present in the Ramsar site, while there is a range of local scale relevant processes, it is the broad scale processes that are seen as important to maintaining the overall diversity of habitat types. These include:

- Physical Coastal Processes. Natural (equilibrium) hydrodynamic controls on habitats through tides, currents, erosion and accretion;

- Hydrology. Natural patterns of tidal inundation and freshwater flows to wetland systems;

- Groundwater. For those wetlands influenced by groundwater interaction, the groundwater table;

- Energy and Nutrient Dynamics. Primary productivity and the proper functioning of carbon and nutrient cycling processes;
- Water Quality. Water quality that provides aquatic ecosystem values within wetland habitats;
- Climate. Patterns of temperature, rainfall and evaporation; and
- Geomorphology. Key geomorphologic/topographic features of the site

Table 7-3 Critical Service 1

Summary Table	Critical Service (S1)
Reason for Inclusion	The diversity of habitats as a critical service is underpinned by Ramsar Nomination Criterion 1.
Type of Service	Supporting
Description of Service (quantify if possible)	Using the Ramsar wetland type classification system, the Moreton Bay Ramsar site contains 22 different types of wetlands in the coastal/marine, inland wetland and man-made categories. The different types represented and examples of each are listed in Section 3 of the report.
Spatial Application (if relevant)	Section 3 lists the wetland types present in the site.
Critical habitat components underpinning this service	All habitat types, noting that based on a broad qualitative assessment of wetland types across the site, wetlands of the following types are less widespread/common than other wetland types represented on the site: • Type C (coral reefs); • Type O (permanent freshwater lakes); • Type W (shrub dominated wetlands); • Type U (non forested peatlands); • Type Y (freshwater springs).
Critical species underpinning this service	Not applicable; this service relates primarily to habitat. Other services address particular species and populations.
Critical processes underpinning this service	Broad-scale wetland processes as listed above; noting that individual wetland habitats will be influenced by a range of local/site specific processes.
Natural Variability (if relevant)	The geomorphology and biotic components of the wetland habitats of the Bay have formed over thousands of years, in a sedimentary environment that is characterised by major fluctuations in sea level. Near natural and representative environments that remain in the Bay (refer Service 2 below) are indicative that there is natural stability in the system that will retain these habitats in the long term in the absence of anthropogenic influences. Notwithstanding, wetland environments can show significant seasonal/local variation depending on key drivers such as rainfall, hydrological inputs, nutrients, and sedimentation. Particular habitats will be more susceptible to temporary disturbance (be it natural or of anthropogenic origin) than others. For example, seagrass, coral reefs, dune lakes and similar environments are highly dependant on stable water quality conditions whereas mangroves and saltmarsh communities can be highly resilient to water quality impacts but are more susceptible to changes to hydrology and inundation patterns.
Principal threats	Key threats to the overall diversity of habitats present in the site include: • Major changes to the Bay hydrodynamics in terms of coastal processes and other

Summary Table	Critical Service (S1)
	hydrodynamic controls on habitat • Major changes to the Bay hydrology in terms of freshwater flows and inputs from rivers and streams • Long term and significant changes to water quality – particularly the assimilative capacity of the western and southern bay to carry out essential nutrient cycling processes and the broadening of catchment-based water quality impacts into the central and eastern bay • Localised die-back and other impacts particularly if the wetland type is one of the less widespread types in the Ramsar site (refer list above) • Inadequate buffers between human settlement and wetland areas and associated edge effects • Changes to the groundwater table and groundwater interaction with surface water in freshwater lakes and creeks on the sand islands including increased susceptibility to fire (particular impact for peatlands) • Climate change and exacerbation of current mangrove intrusion into traditional saltmarsh habitats as a result of sea level rise
Data quality underpinning this critical service	Level 3 – The wetland habitat types identified and analysed as part of this Service rely on the interpretation of a number of sources of information including the EPA wetland mapping data layer (which is itself based on a combination of RE and waterbody data).
Information gaps	There needs to be further guidance about the identification of the Ramsar wetland types such that more exact spatial data can be obtained or developed. This should be compatible where possible with State mapping methodologies such as that employed by the EPA. In the meantime, the EPA dataset (using RE types as surrogates for vegetated Ramsar wetland types) provides a baseline for measuring the extent of various wetland types across the site.
Recommended monitoring	Assignment of more detailed definitions and provision of spatial data for each of the wetland types in the Ramsar site such that a baseline extent for each wetland type represented in the site can be monitored over time (and natural variation analysed).

7.2 Service 2 ~ Near-Natural Wetland Habitat Reference Sites

As discussed in Service 1, the Moreton Bay Ramsar site contains a range of marine, estuarine, palustrine, lacustrine and terrestrial biotopes.

Among the 22 wetland types listed as being represented, several key wetland habitat types are seen as most critical to the ecological character of the site based on the range of wetland services/benefits supported. These include for example, core habitat for threatened flora and fauna species (refer Services 3, 4 and 5), supporting important populations of shorebirds (Service 6), and supporting cultural values such as fisheries habitat and productivity, indigenous significance, education and research values and tourism and recreation values (refer Services 7-10).

The six key habitats identified and are as follows:

a. Seagrass and sandy shoals
b. Unvegetated intertidal flats (and associated adjacent estuarine assemblages)
c. Mangrove and saltmarsh communities
d. Coral communities
e. Freshwater wetlands (including both wallum and peatlands)
f. Ocean beaches and foredunes

Several of these wetland habitats are considered, either individually or collectively, to represent particularly outstanding examples of near-natural 'reference' areas within the biogeographic region. It is acknowledged that there are numerous examples of such habitat areas within the site, however for reporting purposes six key reference sites have been identified as follows:

- Seagrass and shoals - Eastern Banks area
- Intertidal flats and estuarine assemblages - Pumicestone Passage
- Mangrove and saltmarsh communities - Southern Bay
- Coral communities - Eastern Bay
- Freshwater wetlands (including wallum and peatlands) - Moreton and North Stradbroke Islands
- Ocean beaches and foredunes - Moreton Island

These representative areas were selected on the basis that they:

- are in natural or near-natural condition based on existing ecosystem health and other monitoring data;
- contain representative examples of key habitats within the site;

- contain excellent representative examples of various wetland habitat types within the IMCRA and IBRA biogeographic regions; and

- contain wetland habitats of recognised high conservation significance, as prescribed under legislation (protect areas) and State management plans (i.e. State Coastal Plan).

Table 7-4 provides summary information on these points underpinning the six reference sites.

A more detailed description of each of the six habitat types and the selected reference site are contained in the sections below.

Table 7-4 Ramsar wetland types, ecosystem condition ratings and statutory conservation values in each representative wetland area

Attribute	(A) Eastern Banks seagrass & shoals	(B) Pumicestone Passage intertidal flats	(C) Southern Bay mangroves and saltmarsh	(D) Eastern Bay coral communities	(E) Moreton & North Stradbroke Is. freshwater wetlands	(F) Moreton Island ocean beaches and foredunes
Ramsar wetland types	B, E, F, G, H, I	B, D, E, F, G, H, I	B, D, E, F, G, H, I	B, C, F	M, N, O, Tp, Ts, W, Xf, Xp, U, Y	A, D , E
Ecosystem Condition[5]	• 'A to A-' (Excellent) • Excellent water quality • Intact natural habitats present; deep & stable seagrass & healthy and diverse coral in some parts • *Lyngbya* present	• 'B to C+' (Good) • Fair water quality, with generally poorer water quality in the northern reaches • Intact & stable natural habitats with extensive mangrove forests & stable seagrass meadows • *Lyngbya* present	• 'B- to D' (Good) • Fair to poor water quality, strongly influenced by floods • Shallow & unstable seagrass meadows in main channel closest to the coast but expansive meadows in Canaipa Passage • *Lyngbya* present	• Note – Following is for Eastern Bay, which includes reef areas. • ' A to A-' (Excellent) • Excellent water quality • Intact natural habitats remain; deep & stable seagrass and healthy & diverse coral in some parts • *Lyngbya* present	• No EHMP monitoring data	• No EHMP data. Based on adjacent habitats, excellent water quality expected throughout. • Intact natural habitats present including presence & usage by endangered & vulnerable shorebirds • Principle impact from Off Road Vehicle Usage
Statutory Conservation Zones						
High Ecological Value area[6]	E1B	PLE1, PLE1, PME1	Part – S1, B1	C1 (also incl. Waterloo Bay)	M1 (All Moreton Island) ST1A, ST1B (Part of North Stradbroke Is.)	E1C (coastal waters along northern Moreton Island & northern coastline of North Stradbroke Island)
Marine National Park (Draft)	Part – MNP14; MNP20	MNP02; MNP01	Part – MNP27; MNP26; MNP28; MNP29; MNP30	Part – MNP22	N/A	MNP05-07; MNP 16
National Park	N/A	N/A (adjacent to Bribie Island NP)	Southern Moreton Bay Islands NP	N/A (adjacent to Teerk Roo Ra (Peel Island) National Park)	Moreton Is. NP Blue Lake NP	Moreton Island National Park
Fish Habitat Area (FHA)[7]	Moreton Banks FHA; Amity-Myora Banks FHA	Pumicestone Channel FHA	Pimpama FHA; Coomera FHA; Jumpinpin-Broadwater FHA	Peel Island FHA; Amity-Myora Banks FHA	N/A	N/A
State Coastal Plan	State Significance (natural resources) – Significant Coastal Wetlands; Coastal Biodiversity	State Significance (natural resources) – Significant Coastal Wetlands; Significant Coastal Dunes; Coastal Biodiversity	State Significance (natural resources) – Significant Coastal Wetlands; Coastal Biodiversity	State Significance (natural resources) – Significant Coastal Wetlands; Coastal Biodiversity	State Significance (natural resources) – Significant Coastal Wetlands; Significant Coastal Dunes; Protected Areas etc.; Coastal Biodiversity	State Significance (natural resources) – Significant coastal dunes, wetlands; and coastal biodiversity

[5] Based on EHMP reporting – EHMP (2007) Report Card.
[6] Sub-zones outlined in plans within Schedule 1 of EPP Water - Moreton Bay, North Stradbroke, South Stradbroke, Moreton and Moreton Bay Islands Environmental Values and Water Quality Objectives published by the department in March 2007; Pumicestone Passage Environmental Values and Water Quality Objectives published by the department in March 2007
[7] See discussion in Beumer *et al*.. (1997). Declared Fish Habitat Areas in Queensland. Brisbane, DPI Fisheries.

A. Eastern Banks Seagrass and Shoals

Photo of *H. Ovalis* (Source: EPA photo l brary)

This area is located on the tidal delta west of South Passage, which extends from Moreton Island and North Stradbroke Island west and south west almost to Peel Island. The Eastern Banks area encompasses Coonungai, Boolong, Pelican, Chain, Maroom, Warragamba Banks; South Passage; Rous and Rainbow Channels; and the various gutters and passages within the shoal complex. Maxwell (1970) describes this area as *"…a large, complex system of banks and ridges separated by channels and re-entrants of 2-3 fathoms (~ 3.6 to 5.5 m) depth. It is flanked on the east and west by deeper water."*

These banks provide large areas of potential and actual seagrass habitat. Seagrass mapping undertaken by EHMP in 2004 indicates that the seagrass meaadows within this area represented the largest contiguous/semi-contiguous seagrass meadow in Moreton Bay. Most of the seagrass is comprised mainly of *Zostera muelleri, Halophila ovalis* and *H. spinulosa*. This seagrass provides an important food resource for green turtles and dugongs (Poiner *et al.* 1989; Marsh 1990; Abal *et al.* 1998; Dennison 2001).

Carruthers *et al.* (2002) proposed a number of generalised models of key seagrass processes and controls that vary across various biotopes, namely estuary, coastal, deepwater or reef. The wider eastern and northern Moreton Bay area supports potential coastal and deepwater seagrass habitat. In general terms, coastal habitats can be both intertidal and subtidal (depth <15m) and are primarily controlled by physical disturbance by waves and currents, while light availability is typically the dominant control on deepwater seagrass habitat (depth >15m) (Carruthers *et al.* 2002).

Seagrass distribution and extent is generally thought to be controlled by the following key processes (Edgar 2001; Carruthers *et al.* 2002):

- Physical Coastal Processes (waves and currents). Turbulent wave action and currents can result in physical disturbance of seagrass. Shallow, exposed banks tend to be exposed to greater wave turbulence (particularly during storms) than deeper, sheltered waters, and seagrass beds in shallow waters can be more patchy and comprised of species such as *Halophila ovalis*, which is capable of rapid re-colonisation (Rasheed 2004). The maintenance of suitable substrates for seagrass is also dependent on the maintenance of existing hydraulic and wave processes, and associated sediment transport regimes.

- Water Quality. Water quality conditions, particularly water clarity and concentrations of nutrients, also regulate seagrass distribution and extent (Young and Kirkman 1975; Dennison *et al.* 1993; Abal and Dennison 1996; Udy and Dennison 1998). Some species of *Halophila* are able to survive in areas with 5% surface light (Udy and Levy 2005). The Eastern Bay has low ambient turbidity and nutrient concentrations, reflecting the high degree of tidal flushing and limited influence of riverine discharges (EHMP 2006). This high water clarity allows seagrass to occur in deeper waters than in the more turbid southern and western Moreton Bay, with *Zostera* extending to 3 m (Seagrass Watch unpublished data) and *Halophila spinulosa* and *H. ovalis* occurring at water depths of 12 m (Dr James Udy unpublished data). In a recent survey (BMT WBM unpublished data) in northern Moreton Bay *H. ovalis* was found at depths of approximately 14m and 20m.

- Energy and Nutrient Dynamics. This section of the study area has characteristically low rates of phytoplankton productivity, reflecting the low nutrient status of waters. Seagrass represents a key primary producer in this area.

- Grazing. Grazing by dugongs and green turtles also has a major influence on seagrass communities, by altering species composition, distribution and sediment nutrient cycling processes (Perry 1997; Aragones and Marsh 2000). Grazing of benthic invertebrates by loggerhead turtles (Preen 1996) and fish (including rays) also results in the disturbance of bed sediments, altering sediment-nutrient patterns and processes. Grazing results in increased sediment aeration, burial of detritus, and increased sulfate reduction and nitrogen fixation (Perry 1997). Areas grazed by dugongs typically can also have lower shoot biomass but higher productivity than ungrazed areas (Perry 1997). Given the high densities of dugong and turtles within the Amity/Eastern Banks area (Lanyon 1997), grazing is likely to be a significant control on ecosystem functioning in this area.

- Other Biological Processes. A wide range of biological processes are important to the maintenance of ecosystem functions and values, including growth and reproduction, use of the site as a nursery habitat, recruitment, feeding and predation. No studies to date have assessed the relative importance of these processes in regulating marine flora and fauna communities within this section of the site (see Section 3 of the report for a general discussion).

Together with limited ongoing anthropogenic disturbances, these and other patterns and processes together maintain extensive, 'healthy' seagrass meadows within the Eastern Banks area. Table 7-5 summarises the key attributes of this critical service.

The primary value of this feature for shorebirds is linked to the intertidal exposure of sandbanks which roost opportunities in close proximity to large areas of feeding intertidal habitat on the south-western side of Moreton Island and those along the north-western side of North Stradbroke Island. The relatively large feeding grounds, which include exposed seagrass, may be particularly important for species such as Eastern Curlew, Bar-tailed Godwit and Grey-tailed Tattler.

A conceptual model of this key reference habitat is shown in Figure 7-1.

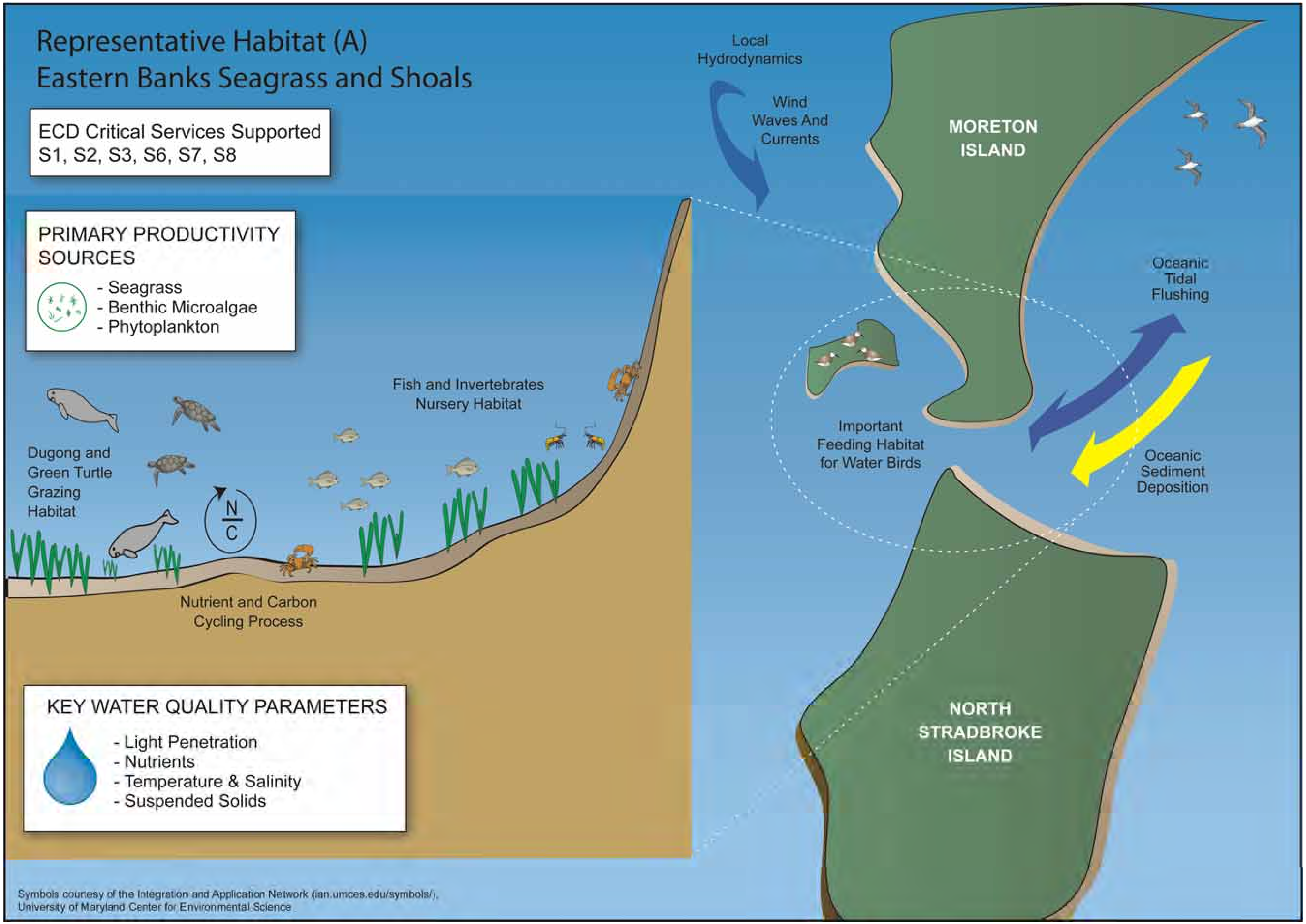


Figure 7-1 Conceptual Model of Eastern Banks

Table 7-5 Critical Service 2A - Eastern Banks Seagrass & Shoals

Summary Table	**Critical Service (S2A)**
Reason for Inclusion	Representative near-natural reference site for shoals and coastal/deepwater seagrass. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Eastern Banks area in eastern Moreton Bay
Critical habitat components underpinning this service	Seagrass; shoals
Critical species underpinning this service	See S3 (dugongs, turtles)
Critical processes underpinning this service	• Currents and waves • Turbidity and water quality • Nutrient cycling • Grazing • Other biological processes (growth, reproduction, nursery habitat, predation, feeding, recruitment)
Natural Variability (if relevant)	Seagrass – No major changes in distribution, extent and structure are known to have occurred in the last 5 years. Long-term changes unknown. Possible cyclic, seasonal changes in distribution and extent due to seasonal changes in wind patterns. Episodic catastrophic storms may also lead to short-term reductions in seagrass cover.
Principal threats	Activities that alter water quality, particularly nutrients, algal biomass and turbidity.
Data quality underpinning this critical service	Level 1-2 - based on Seagrass Watch cover data, seagrass mapping data (EHMP 2004; (Hyland *et al.* 1989); SDR data (EHMP monitoring)
Information gaps	More systematic information is required on background variability in wetland habitat extent and linkages to controlling processes. Note inconsistencies in mapping techniques prevent direct comparisons between existing data-sets, and therefore long-term changes in seagrass.
Recommended monitoring	Examination of long-term changes in seagrass based on aerial photograph interpretation and review of existing information Additional EHMP/Seagrass Watch monitoring sites in representative areas subject to different wind/waves regimes.

B. Pumicestone Passage Tidal Flats and associated Estuarine Wetland Assemblages

Photo of intertidal flats in the vicinity of Pumicestone Passage (Source: BMT WBM photo l brary)

Pumicestone Passage is a narrow passage-type estuary that separates the mainland and Bribie Island and contains a wide diversity of estuarine wetland habitat types that are generally considered to be in 'good' condition. Pumicestone Passage is a relatively shallow waterbody (<2 m deep at Mean Sea Level for >80% of its area, QDEH 1993), which supports shallow sub-tidal sandy channels, intertidal flats (both with and without seagrass), and fringing mangrove, saltmarsh and freshwater/brackish wetland communities. It is one of four major passage-type estuaries in Queensland (Queensland Department of Environment and Heritage 1993).

The distribution, extent and configuration of structural habitats present in the Passage are ultimately controlled by geomorphologic processes operating over a range of time scales. Contemporary hydraulic (i.e. tidal forces, groundwater and pulsed stream flow events) and sedimentary processes also interact to regulate local conditions, for example:

- sedimentary processes that configure creek and channel mouth deltas. There is a tendency for sediment deposition at the mouth of tributary creeks during the dry season and scouring during flood events. Sand bar formation processes and patterns at the entrances of the Passage are a function of entrance morphology, tidal and freshwater discharge velocities and oceanic swell patterns near the mouths (Queensland Department of Environment and Heritage 1993). An extensive sand bar occurs at the northern entrance (near Caloundra) due to low tidal discharge, exposure to oceanic swell and shallow depths. The southern entrance does not contain an extensive bar system due to stronger tidal currents, its greater width and depth, and protection from swells;

- sedimentary processes that configure the extent and distribution of shoals and channels, and sediment characteristics. Sediment loading on the Passage is a function of oceanic process (tidal inflows and waves), which dominate at the entrances of the Passage, and tributary discharges. The entrances are comprised predominantly of fine to coarse sands, which are predominantly of marine origin, whereas finer silts and clays derived from fluvial sources dominate further up the estuary (Queensland DEH 1993);

- the frequency and extent of tidal inundation, which together with the competing influence of freshwater inflows, controls the extent and distribution of littoral wetland components (i.e. mangroves, saltmarsh, freshwater wetlands, seagrass, benthic algae etc.);

- tidal flushing and associated water quality characteristics of estuarine waters. The average nett tidal flow in the passage is in a northerly direction, although currents also run in a southerly direction, discharging into Deception Bay (WBM 2005). Residence/flushing (E-folding) times within the passage are estimated to be in the order of days at the south end, and up to 4 to 6 weeks through the middle sections of the Passage (WBM 2005). Tidal exchange at the northern entrance is curtailed by the oceanic sand bar at the mouth of the Passage (Queensland Department of Environment and Heritage 1993); and

- biogeochemical cycles within sediments and overlying waters.

The physico-chemical characteristics of waters (water quality), which are in part controlled by hydraulic processes, is a key control on wetland ecology. EHMP (2007) noted that water quality within the Passage was degraded in places, with generally poorer quality water (higher nutrients and turbidity) in the northern and central reaches compared with the southern reaches. Several small creeks discharge into the Passage, which are known to contain high levels of nitrogen, sediments and tannins, and are considered to be of 'fair' quality (EHMP 2007).

Turbidity is a particularly important control, particularly in terms of regulating the depth distribution and extent of seagrass, macroalgae and micro-phytobenthos. Less well known are the direct physiological and behavioural effects of turbidity on aquatic fauna (e.g. fish larvae behaviour to turbid waters, reduced predation success, interference of feeding efficiencies of filter feeders etc.). Turbidity within western Moreton Bay, and most likely Pumicestone Passage, is controlled by re-suspension of sediments by waves and currents, pulses of turbid freshwater inflows, and to a lesser extent, phytoplankton biomass.

Nutrients also represent a stressor, with slightly elevated TN, TP and chlorophyll *a* concentrations recorded within the Passage. Nutrient loading regimes are linked to transportation, deposition and resuspension of particulate material. Nutrient sources include Deception Bay, which is the receiving waters for the Caboolture River and other sources, stormwater runoff from the adjacent catchment, oceanic inputs, groundwater inflows, sediment fluxes and a range of point sources including wastewater treatment plants, gravel washing plants etc.

Important biogenic habitat components include littoral freshwater wetlands, saltmarsh, mangroves, seagrass and microalgae. The 2007 EHMP report card (EHMP 2007) describes Pumicestone Passage as containing *'intact and stable natural habitats throughout with extensive mangrove forests and stable seagrass meadows'.* The degree of 'stability' in seagrass and mangroves over longer timescales (timescales measured in 10's of years) than assessed by EHMP has not been quantified and requires further investigation.

In terms of spatial distribution of seagrass, the most recent broad scale data comes from EHMP 2004, which was derived from a survey conducted in Autumn 2002 *Zostera muelleri (=capricorni)* was the most abundant and widespread species, followed by *Halophila ovalis.* In the southern region of the Passage *Halophila spinulosa* was recorded, together with a small meadow of *Cymodocea serrulata*. The total area of seagrass within the Passage was ~1200ha, with the most extensive meadows located at Tripcony Bight and the south-western intertidal areas of the Passage. Seagrass cover was low (sparse cover of *H. ovalis*) in the area north of Tripcony Bight, possibly reflecting poorer water clarity. The average maximum seagrass depth was approximately 1m. To the south of Pumicestone Passage in Deception Bay there has been an almost complete loss of seagrass in the last decade (Abal *et al.* 1998), as a result of high turbidity and *Lyngbya* blooms (EHMP 2007).

As discussed in Critical Service 3 (see next section), the deeper water in southern Pumicestone Passage is thought to be an important year-round dugong habitat (Lanyon 1997; Lanyon *et al.* 2005). Grazing by dugongs is likely to influence seagrass communities, in much the same way as discussed above for the Eastern Banks. In terms of maintenance of reference habitat values, the other most notable biological processes are likely to be growth and reproduction of littoral vegetation (mangroves, saltmarsh, freshwater wetlands), seagrasses, phytoplankton and benthic microalgae.

The extensive tidal flats in the Pumicestone area also represent important estuarine wetland habitats for waterbirds and other important wetland fauna as described in Critical Services 4 and 6.

A conceptual model for this critical habitat is shown in Figure 7-2. Table 7-6 summarises the key attributes of this critical service.

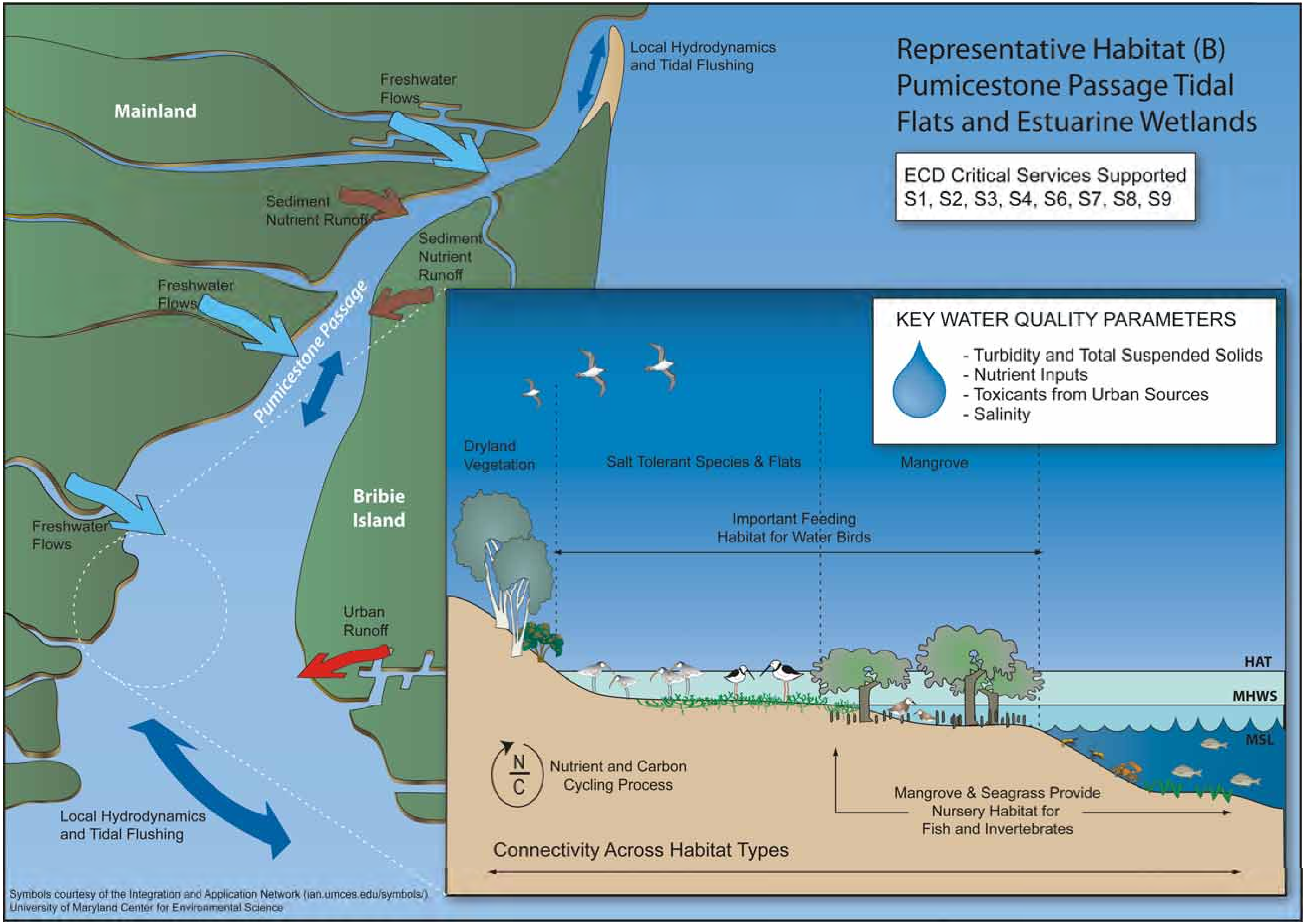
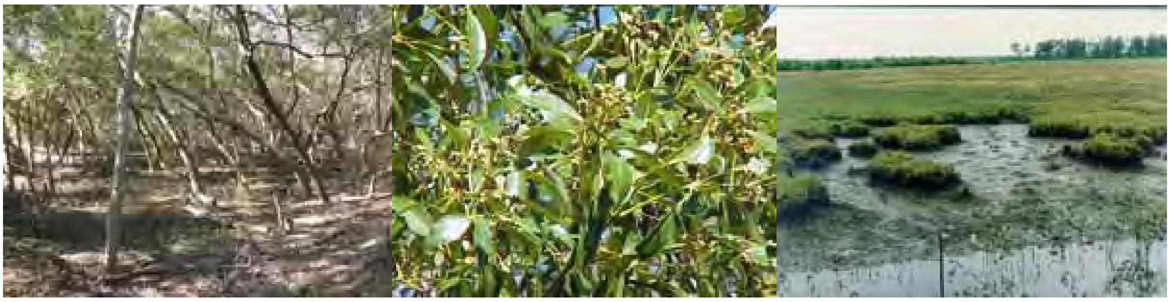


Figure 7-2 Conceptual Model of Pumicestone Passage Flats and Estuarine Wetland Assemblages

Table 7-6 Critical Service 2B - Pumicestone Passage Tidal Flats and Estuarine Wetland Assemblages

Summary Table	Critical Service (S2B)
Reason for Inclusion	Representative near-natural reference site for nearshore tidal flats and adjacent vegetated habitats such as seagrass. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Pumicestone Passage is located in north-western Moreton Bay
Critical habitat components underpinning this service	Intertidal flats and shoals; seagrass
Critical species underpinning this service	See S3 (dugongs, turtles), S4 (wetland dependant terrestrial fauna) and S6 (shorebirds)
Critical processes underpinning this service	Currents and natural coastal processes Hydrology/freshwater flows Water and sediment quality (turbidity and nutrient cycling) Other biological processes (growth and reproduction of marginal freshwater assemblages, mangroves, saltmarsh, seagrasses and algae)
Natural Variability (if relevant)	Flats and Shoals – No data available to assess changes in distribution and extent Seagrass – Based on EHMP data, no major changes in distribution, extent and structure of seagrass communities are known to have occurred in the last 5-10 years. Long-term changes unknown. Possible cyclic, seasonal changes in distribution and extent due to seasonal changes in wind patterns and freshwater flows. Episodic catastrophic storms may also lead to short-term reductions in seagrass cover.
Principal threats	Land use activities that alter water quality, particularly nutrients, algal biomass and turbidity.
Data quality underpinning this critical service	Level 1-2 - semi-quantitative based on Seagrass Watch data, seagrass mapping data (EHMP 2004; (Hyland *et al.* 1989).
Information gaps	More systematic information is required on background variability in seagrass habitat extent and linkages to controlling processes. See notes for Eastern Banks (Table 7-5)
Recommended monitoring	Examination of long-term changes in seagrass based on aerial photograph interpretation and review of existing information Examination of long-term changes in tidal flat extent (particularly in terms of impacts from sea level rise)

C. Southern Bay Mangroves and Saltmarsh



Photos of grey mangrove/saltmarsh environments in the Moreton Bay region (Source: BMT WBM photo library)

Southern Moreton Bay is bounded in the east by the dune-island barriers of North and South Stradbroke Islands, and low-lying fluvial dominated coastal plain and mangrove islands to the west. The central and eastern sections of southern Moreton Bay contain a complex network of mangroves and saltmarsh on low-lying silt and sand islands interspersed by tidal channels. These features represent important estuarine wetland habitats for wader birds and species of direct fisheries significance.

The geomorphologic processes that maintain mangrove-colonised islands in the Southern Bay vary spatially, and over a range of time scales (geological to years) (Lockhart *et al.* 1998). Fluvial deposits from the Logan River, together with some inputs of marine sands, have formed a bayhead delta with a series of associated islands. These islands have been colonised by mangroves, which have increased in extent in recent decades (Lockhart *et al.* 1998). The relict Jumpinpin flood-tide delta to the south also contains a series of mangrove-colonised mud and sand islands. The relict delta has a marine origin, whereas fluvial deposits in this area are predominantly restricted to the mouths of the Logan, Coomera and Pimpama Rivers (Lockhart *et al.* 1998). These fluvial-dominated river mouth environments also contain large areas of mangroves.

Hydraulic processes (tides, waves and freshwater flows) control, and are controlled by, geomorphologic processes and patterns. These patterns are described in Section 3. The distribution of mangroves and saltmarshes is ultimately determined by patterns of tidal inundation. Since the opening of the Jumpinpin Bar in 1898, tidal levels within the Southern Bay are relatively similar to those experienced in the ocean. An increase in sea levels would be expected to result in a retreat in the seaward extent of mangroves, and possible loss of mangroves on low-lying islands if sedimentation rates are lower than the rate of rise.

Mapping of mangroves based on aerial photography from 1944, 1987 and 1997 indicated that the mangrove areas associated with the Coomera and Pimpama Rivers have been markedly influenced by agricultural practices and changes to hydraulic regimes (WBM 2001). Approximately 1043 hectares of mangroves were mapped in the Coomera/Pimpama Rivers region in 1944, compared to 1241 hectares in 1997. Increases in mangrove area have occurred mostly on Coomera and Woogoompah Islands, with a general movement of mangroves landward. The trend of mangroves becoming established in more landward regions is probably related to alterations in the tidal regime of the region associated with the opening of the Jumpinpin Bar. Davie (pers. comm. in WBM 2001) notes that mangroves have been, and are presently, replacing saltmarsh and paperbark communities and that an equilibrium has apparently not occurred.

Mangrove losses in the area since 1944 totalled 60 hectares, and were all recorded between 1987 and 1997. All losses were associated with clearing, with the largest loss recorded in the upper Pimpama River (49 hectares). No data are available to assess changes in saltmarsh extent in this area.

In Moreton Bay in general, there has been a loss of saltmarsh vegetation of ~3051 ha between 1974 and 2002, most of which has been due to filling and reclamation works (Centre for Marine Studies 2006).

Mangroves and saltmarshes are not particularly sensitive to water quality modifications, although changes in the supply of suspended sediments can affect depositional patterns and habitat availability for mangroves.

The freshwater flow requirements of mangroves are not well understood. Freshwater pulses are thought to represent a source of sediment (and nutrients) required to maintain mangrove and saltmarsh habitat. In response to physiological tolerances and species interactions, freshwater inputs can also influence vertical ‘zonation’ patterns of saltmarsh species and may also control horizontal zonation patterns of mangroves (ie. replacement of *Avicennia* by *Aegiceras* in upstream areas).

A reduction in freshwater flows can also lead to higher ambient salinities in rivers, possibly leading to the upstream expansion of mangroves in rivers that do not have a tidal barrage, and possible loss of saltmarsh.

Figure 7-3 shows a conceptual model of this critical reference habitat. Table 7-7 summarises the key attributes of this critical service.

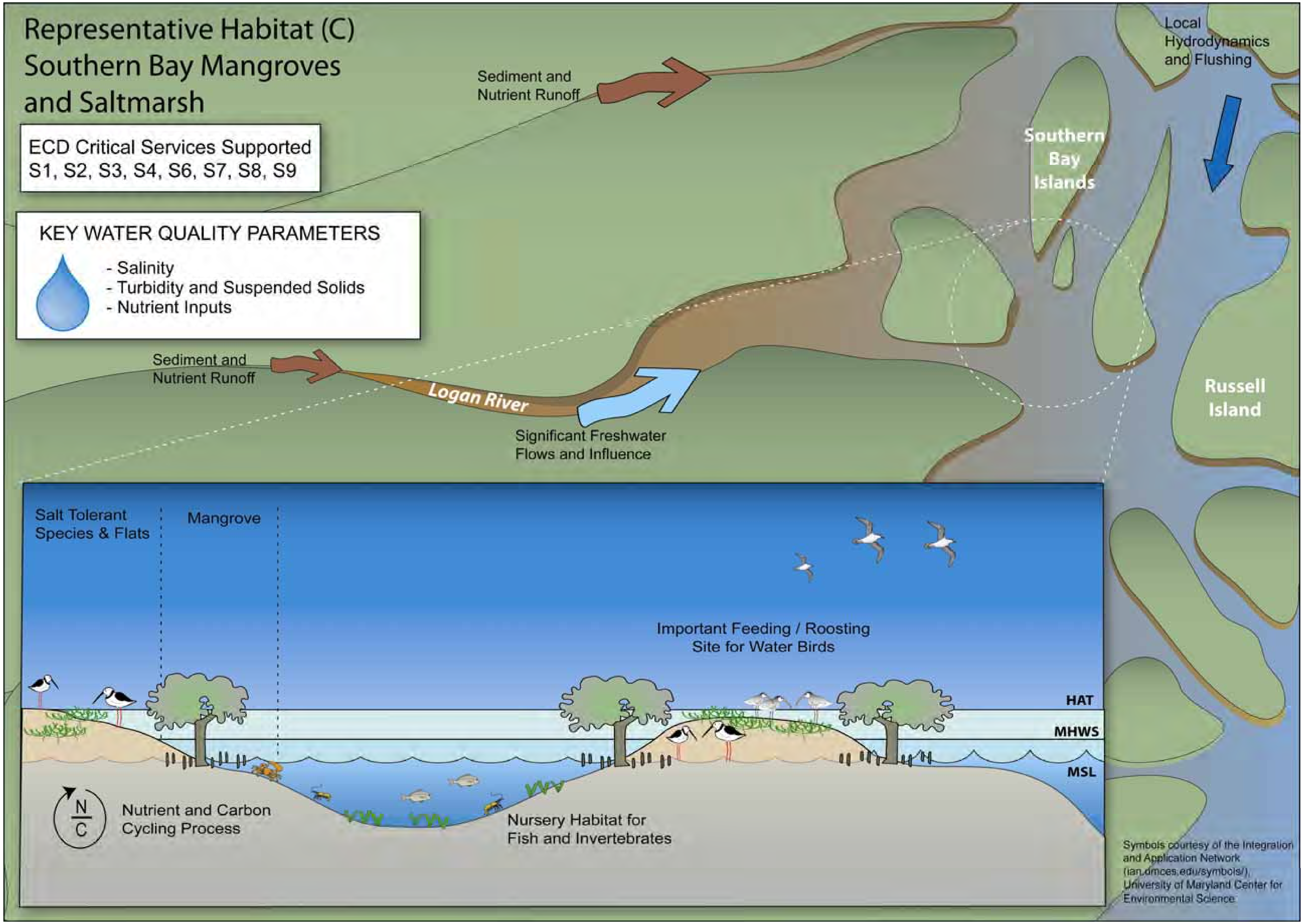


Figure 7-3 Conceptual Model of Southern Bay Mangroves and Saltmarsh

Table 7-7 Critical Service 2C - Southern Bay Mangroves and Saltmarsh

Summary Table	Critical Service (S2C)
Reason for Inclusion	Representative near-natural reference site for mangroves and saltmarsh communities. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Southern Moreton Bay
Critical habitat components underpinning this service	Mainland littoral habitats, mangrove-colonised islands
Critical species underpinning this service	Mangrove and saltmarsh species
Critical processes underpinning this service	Tidal hydraulics – currents, waves and sea level rise Freshwater flows – Source and delivery of sediment Physical (geomorphologic) coastal processes that maintain mangrove islands Energy and nutrient dynamics Other biological processes (growth, reproduction, recruitment, and possibly competition?)
Natural Variability (if relevant)	Mangrove losses reported following storms No studies have examined broad-scale changes in mangrove extent across the Southern Moreton Bay area. Large increases in mangrove extent were recorded in the Pimpama and Coomera catchments associated with changed agricultural practices and tidal inundation patterns over the last 60 years (WBM 2001). Landward increases in mangrove extent have resulted in the loss of saltmarsh in many areas within the Pimpama and Coomera catchments. Overall, there has been a large reduction in saltmarsh over the last 50 years as outlined in the text above in the Southern Moreton Bay area from a range of natural and anthropogenic factors.
Principal threats	Mangroves/saltmarsh - Clearing; reclamation and filling; and sea-level rise; Competition between species types. The combination of sea level rise with limited coastal land area for saltmarsh migration places these habitats at particular risk.
Data quality underpinning this critical service	Level 1-3 (Dowling 1986; Hyland and Butler 1989; WBM 2001; EPA 2005a)
Information gaps	More systematic information is required on background variability in mangrove and saltmarsh habitat extent and linkages to controlling processes.
Recommended monitoring	Examination of long-term changes in mangroves and saltmarsh based on aerial photograph interpretation and review of existing information

D. Eastern Bay Coral Reef Communities

Photo of typical coral reef flat in Central Moreton Bay (Source: BMT WBM photo library)

Coral communities occur on relict carbonate (coral) reefs throughout the Moreton Bay. The coral communities of Eastern Moreton Bay, namely northwest Peel Island, Goat Island, Bird Island, Myora Reef and Lazaret Gutter, are considered to be in near natural condition.

Living corals form a thin veneer over predominantly unconsolidated Holocene carbonate deposits that are interspersed patches of soft sediment and seagrass. The seaward edge of hard corals is delineated by the edge of hard substrate (Harrison *et al.* 1991), which typically occurs in water depths <3 m (Lovell 1975). The upper limit of corals typically occurs in the upper subtidal zone, but may occasionally extend into the lower intertidal zone (Johnson and Neil 1998b).

Tidal exchange through South Passage, and then Rainbow and Rous channels, dominates flow movement around the Peel Island reefs. Tidal flows maintain relatively clear, nutrient poor waters at these reefs (EHMP 2007), which is essential to the maintenance of corals and many other reef species. Oceanic exchange through South Passage is also thought to be important in the dispersal of larvae among reefs (Harrison *et al.* 1998), but is not thought to have a major influence of sea surface temperatures in the Bay (Johnson and Neil 1998a,b). The wide variability in sea surface temperatures within the Bay (compared to oceanic waters) is thought to prevent the colonisation of many coral species found in the wider region (Johnson and Neil 1998a,b).

Peel Island receives limited fluvial sediment inputs and has lower proportion of fine sediment material compared to Western Bay reefs (Johnson and Neil 1998a,b). However, re-suspension of fine sediments by wind, particularly during the summer months, can increase turbidity and sedimentation rates at these reef sites (Johnson and Neil 1998a,b). Major flood events, which result in reduced salinity and high turbidity, can also result in coral mortality on these reefs. However, floods are not thought to be a major determinant of spatial patterns in coral community structure within the Bay (Johnson and Neil 1998a,b).

Reef communities in this section of the Bay are numerically dominated by bare substrate, hard coral. Macroalgae cover is relatively low, in contrast to reef communities in the Western Bay (Harrison *et al*.

1991; Harrison *et al.* 1995; EHMP 2006). The actual controls on reef community structure have not been examined to date. However, grazing (e.g. by sea urchins), inter-species competition and possibly nutrient availability, could have a strong influence on these spatial patterns of macroalgae and other reef components. In order to develop LAC, further work is required to assess the proximal controls of reef communities, and the spatial and temporal scales at which that these controls operate.

Figure 7-4 shows a conceptual model of this critical reference habitat. Table 7-8 summarises the key attributes of this critical service.

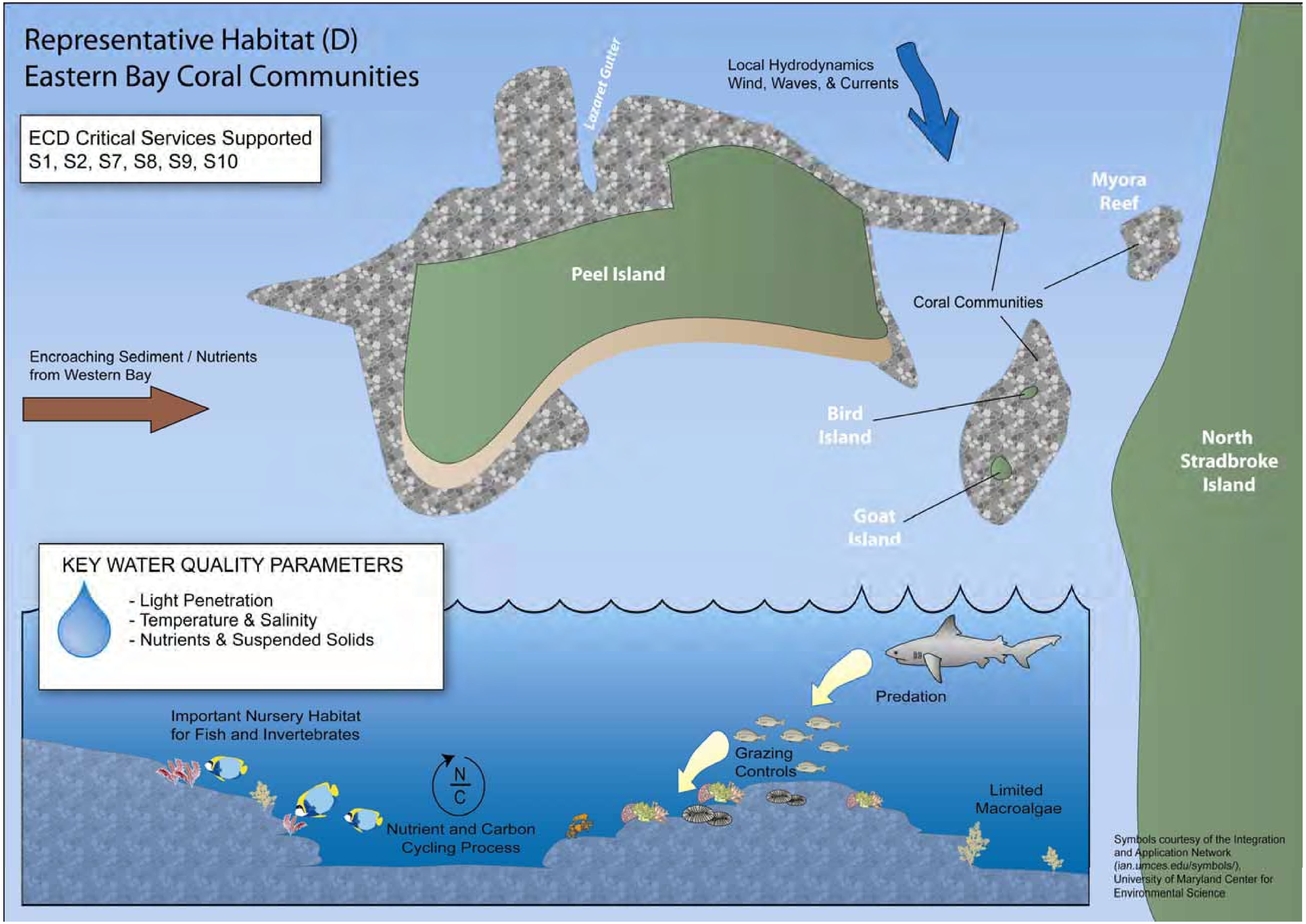


Figure 7-4 Conceptual Model of Coral Reef Communities

Table 7-8 Critical Service 2D - Eastern Bay Coral Reef Communities

Summary Table	**Critical Service (S2D)**
Reason for Inclusion	Representative near-natural reference site for coral reef communities. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Eastern Moreton Bay, including northwest Peel Island, Goat Island, Bird Island, Myora Reef and Lazaret Gutter
Critical habitat components underpinning this service	Coral reef
Critical species underpinning this service	Coral reef associated flora and fauna
Critical processes underpinning this service	Physical Coastal Processes (Currents and waves) Water quality (particularly turbidity and nutrients, but also toxicants, salinity and nutrient cycling processes) Grazing Other biological processes
Natural Variability (if relevant)	No major changes in distribution, extent and structure are known to have occurred in the last 5-10 years. Long-term changes unknown. Possible cyclic, seasonal changes in distribution and extent due to seasonal changes in wind patterns. Episodic catastrophic storms may also lead to short-term reductions in some reef flora and fauna.
Principal threats	Activities that alter water quality, particularly nutrients, algal biomass and turbidity.
Data quality underpinning this critical element	Level 1-2 - based on EHMP monitoring data and previous reef surveys (Harrison *et al*. 1991; Harrison *et al*. 1995)
Information gaps	More systematic information is required to assess background variability in coral reef community structure and linkages to controlling processes.
Recommended monitoring	Additional EHMP monitoring sites in representative areas subject to different wind/waves regimes. Monitoring of coral growth (individual colonies) over time.

E. Freshwater Wetlands of North Stradbroke and Moreton Islands

Photo of Blue Lake overflow creek on North Stradbroke Island (Source: BMT WBM photo library)

The Moreton Bay Ramsar site includes several near natural freshwater wetlands on Moreton and North Stradbroke Islands. A list of wetland types and key representative examples of each type are provided in Table 7-9. Several wetland habitat types are represented, as described below. Table 7-10 summarises the key attributes of this critical service.

Lacustrine wetlands (lakes)

These include both perched lakes and water table window lakes.

Perched lakes are fed by seepage from a perched aquifer system that has formed above relatively shallow sand layers, has a low permeability and which lie above the regional water-table. These waterbodies typically have distinctive water quality characteristics including (Kalf 1998):

- brown coloured water and associated with this, a shallow euphotic zone;
- low dissolved oxygen levels near the lake bed;
- low pH resulting from accumulation of humic material in the water;
- low to moderate concentrations of bio-available nutrients (dystrophic conditions); and
- variable water levels depending on the amount of rainfall, evaporation and seepage through the perching layer.

Perched lakes are the most common lake type on both islands.

Water-table window lakes form between dunes in depressions that extend at or below the upper surface of the regional water-table. Water quality and hydraulic characteristics typical of water-table window lakes include (Kalf 1998):

- high water clarity;
- low electrical conductivity, dominated by sodium and chloride ions;
- high transparency;
- slightly acidic pH;
- low nutrient concentration and productivity (oligotrophic conditions), with low levels of organic matter; and
- relatively constant water levels.

Blue Lake on North Stradbroke Island and Blue Lagoon on Moreton Island are examples of water table window lakes. Note that recent hydraulic and environmental investigations by DNRW suggest that Blue Lake is not entirely fed by regional water table, but instead is partially perched above the regional aquifer.

Palustrine (marshes and freshwater peat swamps)

Palustrine wetlands are natural low-lying areas from which groundwater emerges above the ground surface level. Hydrology, morphology and water quality processes may vary greatly among wetlands. Some palustrine wetlands, such as Eighteen Mile Swamp and most wetlands on the northern and western sides of North Stradbroke Island, are predominantly fed by the regional groundwater table, and therefore have water quality and hydrological characteristics that are similar to water table window lakes. Palustrine wetlands that are contiguous with nearby perched lakes are often fed by the local groundwater table of the perched lake. From a hydrological perspective, these wetlands are analogous to perched lakes, but are typically shallower and have a higher vegetation cover than lakes (e.g. sections of Ibis Lagoon, Mugaree and Jaragill Lagoons on North Stradbroke Island).

Freshwater Creeks

There are three basic types of creeks and drainages on Moreton and North Stradbroke Island:

- Coastal drainages, which are drainages with a defined channel that discharge directly into the sea. The largest of these watercourses on North Stradbroke Island is Freshwater Creek, which discharges through Eighteen Mile Swamp and ultimately to Swan Lagoon at the southern end of the island. On the western side of North Stradbroke Island, Laycock (1975) noted that stream flows occur to the north of Dunwich in Aranarawai Creek, Cooroon Cooroonpah Creek, Campebah Creek, Myora Springs, Yerrol Creek, and One Mile Creek. Similarly to the south of Dunwich stream flows occur to Canalpin Creek, Little Canalpin Creek and several other smaller, unnamed creeks.
- Coastal seeps are groundwater expressions that do not have a defined channel which discharge directly into the sea. Several seeps occur on the west coast of North Stradbroke Island, such as those associated with the Canalpin Swamp system.

- Internal drainages. These are creeks and drainages that flow into and out of wetlands and lakes. The most notable example on North Stradbroke Island is the Blue Lake Overflow. Several other internal drainages are also associated with perched lakes and palustrine wetlands.

Important Wetland Controls

Geomorphologic processes (and associated aeolian and to a lesser extent hydraulic processes), mostly operating over geological timescales, control such factors as landform and waterbody configuration, elevation and drainage patterns (Benussi 1975; Heidecker 1984). This in turn controls patterns in connectivity and among waterbodies, and associated with this patterns in the genetic exchange, generic diversity, species composition, and species richness of waterbodies (Page *et al*. 2006). For example, the presence of a high sand ridge separating the eastern and western sides of North Stradbroke Island, together with a higher degree of interconnectivity between waterbodies on the east side of the island (i.e. Eighteen Mile Swamp complex), are thought to explain differences in fish populations and communities between these areas.

- Climate, rainfall and groundwater hydrology. These wetlands are groundwater dependent ecosystems. The key processes and patterns that control wetland hydrological characteristics are rainfall (and hence regional climate), evaporation, infiltration, groundwater flows, and in some creeks (e.g. Blue Lake Overflow, Little Canalpin Creek, Spitfire Creek), surface expression of groundwater. All freshwater waterbodies are fed by groundwater exfiltration, with the degree of influence of the regional versus the local groundwater table dependent on whether the waterbody is 'perched' above the regional groundwater table (Laycock 1975; Lee-Manwar *et al.* 1980; James 1984). Eighteen Mile Swamp on North Stradbroke Island and Blue Lagoon on Moreton Island represent surface water expressions of the regional groundwater table, although local perched waterbodies may also exist. Blue Lake is also fed by the regional watertable, but in contrast to previous views (Lee-Manwar *et al.* 1980), also has its own perched layer, and is therefore considered a semi-perched lake (DNRW unpublished data).

- Water chemistry. The physico-chemical properties of waters are controlled mainly by soil properties, rainfall, groundwater processes and surface-groundwater interactions. *In-situ* cycling of nutrients is also important in perched lakes with a bed comprised of humic material, whereas interactions between tidal processes and freshwater flows influence the water quality characteristics of many coastal seeps, creeks and palustrine wetlands. These properties exert a strong influence on resident aquatic fauna and flora communities and key ecosystem patterns and processes. In particular:

- Clear, dystrophic[8] waters that characterise water-table window lakes and palustrine wetlands have flora and fauna communities that are distinctly different from those found in tannin-stained, humic perched lake systems (Bayly 1964; Bensink and Burton 1975; Arthington 1984);

- Water chemistry, particularly low pH, humic waters, provide habitats for several species that are uniquely adapted to such conditions e.g. Oxleyan pygmy perch (Arthington 1996), the zooplankter *Calamoecia tasmanica* (Timms 1982), several dragonfly (Arthington and Watson 1982) and caddisfly species (Neboiss 1978), and 'acid' frogs (Ingram and Corben 1975).

[8] tannin stained, humic

- Rainfall patterns and groundwater flows have a profound influence on dissolved oxygen concentrations of certain creeks (e.g. Little Canalpin Creek) and wetlands. Rainfall and groundwater processes also control concentrations of dissolved and particulate iron, which can influence habitat structure in some areas due to the creation of a layer of iron 'flocs' on the lake bed.

- Fire regimes. Fire regimes play an important role in the life cycle of many plant species, and consequently exert a strong influence on wetland vegetation (e.g. Gill 1981). Reproductive mechanisms of vegetation that are dependent on fire include promotion of germination, triggering of seed release and stimulation of flowering, as well as promotion of vegetative sprouting; while key processes include the influence of fire over nutrient availability and opening up of the canopy. Changes to fire regimes over time, primarily post European-settlement, may result in changes in vegetation community structure (see Fensham 1997; Watson 2001), although the extent to which modified fire regimes have altered the community structure of Bay island wetlands has not been comprehensively addressed. Fire is a particularly acute threat to peatland wetlands as these systems either cannot or are extremely slow to regenerate following a fire event. The risk of fire is exacerbated during periods of lowered groundwater levels.

- Soil types, including the age of underlying sand deposits, also directly control wetland vegetation communities. Smaller scale heterogeneities arise from variations in topography and elevation, the layering of new soil horizons and the mosaic of past and contemporary fire regimes (Westman 1975). Many of these controlling elements are interrelated. For example, soils in gullies are often deeper and richer in nutrients when compared to soils along slopes.

Wetland habitats of both islands are largely undisturbed. Past sand mining activities have resulted in localised, but long-term modifications to the landscape (and waterbodies) of several wetlands. This includes the creation of a Lacustrine system (i.e. Keyholes and Yarraman Lakes) within the Eighteen Mile Swamp complex, which are located outside the boundaries of the Ramsar site. Water extraction also occurs from the Eighteen Mile Swamp system to supplement the Redland Shire water supply, as well as to supply water for sand mining operations on the island.

Figure 7-5 shows a conceptual model of these freshwater wetland reference habitats. Table 7-10 contains a summary of the critical service attributes.

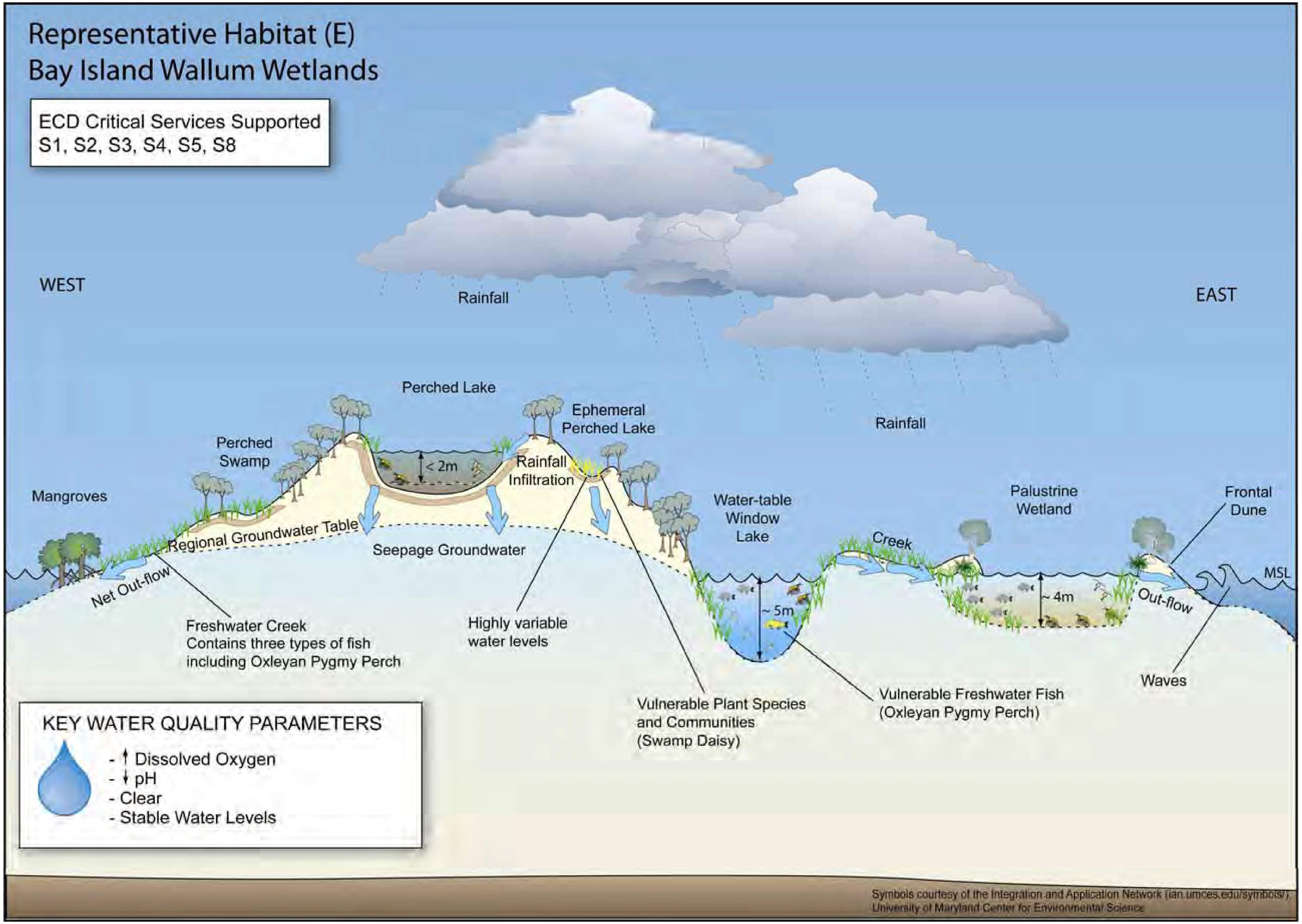


Figure 7-5 Conceptual Model of Bay Island Wallum

Table 7-9 Key examples of freshwater wetland types

Major wetland type (EPA)	Wetland sub-type	Ramsar types	Notable examples:	
			Moreton Is.	**N. Stradbroke Is.**
Lacustrine	Perched lakes	K – Coastal freshwater lagoon O – Permanent f/w lakes (>8ha) P – Seasonal f/w lakes (>8 ha) Also found in association with: M – Permanent creeks N – Intermittent creeks Tp – Permanent f/w marshes/ pools on inorganic soils Ts – Intermittent marshes/ pools on inorganic soils U – Non-forested peatlands W – Shrub-dominated wetlands Xf – F/w, tree-dominated wetlands Xp – Forested peatlands Y – Freshwater springs	Jabiru Lake; Mirapool Lagoon; Honeyeater Lake	Welsby; Tortoise; Blaksley; Shag; Black Snake; Ibis; Tea Tree; Native Companion; Duck; and South Lagoons
	Water table window lakes	O and K, also associated with M, N, Tp, Ts, U, Xf, Xp, Y	Blue Lagoon	Blue Lake
Freshwater Creeks	Coastal drainages	M, N. Also see types cross-referenced above	Eagers, Craven's & Spitfire, Ben-Ewa Creeks; Drainages associated with Jabiru Swamp	Freshwater Creek (Eighteen Mile Swamp); North-western drainages: Aranarawai, Cooroon Cooroonpah, Campebah Creek, Yerrol, One Mile Creeks; Myora Springs. South-western drainages: Little Canalpin & Canalpin Creek, Creeks; numerous small, unnamed creeks.

Major wetland type (EPA)	Wetland sub-type	Ramsar types	Notable examples:	
			Moreton Is.	N. Stradbroke Is.
	Coastal seeps	Y. Also see types cross-referenced above	Unnamed seeps associated with major swamp systems	
	Internal drainages	M, N. Also see types cross-referenced above	Cowan; Shrapnel; Monash Gullys	Blue Lake Overflow and unnamed inflow drainages; Unnamed drainages at Brown Lake.
Palustrine	Peat marshes, fed by either perched lakes, regional watertable or freshwater creeks	M, N, Tp, Ts, U, W, Xf, Xp, Y	Bulwer (Comboyuro to Cowan Cowan); Eagers and Jabiru Swamps	Eighteen Mile; Flinders Beach; Amity; Kounpee; Canalpin; Little Canalpin; Horseshoe Swamps
	Groundwater dependent woodlands, forests & shrublands. Includes Casuarina woodland; Woodland/open forest of Casuarina equisetifolia; Livistona/Melaleuca forest; Open-forest/ woodland of Melaleuca quinquenervia; Notophyll vine forest	W, Xf, Xp. Also see types cross-referenced above	Associated with major waterbodies listed above.	

Table 7-10 Critical Service 2E – Freshwater Wetlands of Moreton and North Stradbroke Islands

Summary Table	Critical Service (S2E)
Reason for Inclusion	Representative near-natural reference site for freshwater wetlands. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Moreton Island and North Stradbroke Island
Critical habitat components underpinning this service	Peat swamp, window water-table lakes, perched lakes, freshwater creeks
Critical species underpinning this service	Wetland vegetation associated flora and fauna. Vulnerable species including Oxleyan Pygmy Perch (refer Service 3) and Swamp Orchid (refer Service 5).
Critical processes underpinning this service	Geomorphic processes (predominantly aeolian and marine) Groundwater hydrology Water quality Fire regimes Energy and nutrient dynamics (including soil and sediment nutrient processes)
Natural Variability (if relevant)	Vegetation communities show a high degree of variability over multiple spatial and temporal scales Water levels usually stable in Blue Lake, but show marked variability in many other wetlands (WBM 2002a;b)
Principal threats	Extraction of groundwater, water quality modifications, fire
Data quality underpinning this critical service	Level 2 – North Stradbroke Island EHMP monitoring data with limited spatial and temporal context Quantitative baseline flora and fauna survey results are available for parts of North Stradbroke Island, most of which is not current (Arthington 1984; Arthington 1996; WBM 2002a;b; WBM 2003) Level 3-4 – Moreton Island Very few baseline data describing aquatic flora, fauna and their habitats at Moreton Island
Information gaps	More systematic information is required to assess background variability in wetland community structure and linkages to controlling processes.
Recommended monitoring	Additional EHMP monitoring sites in representative sites within North Stradbroke Island and Moreton Island Development of locally specific ecosystem condition objectives.

F. Ocean Beaches and Foredunes of Moreton Island

Photo of Moreton Island beach coastline (Source: EPA photo library)

Ocean beaches within the Moreton Bay Ramsar site occur along the eastern coastlines of Bribie Island, Moreton Island, North Stradbroke and South Stradbroke Islands. These beaches can generally be characterized as dissipative in nature, with high waves >2 m, fine sand and the presence of offshore bars.

In looking at the Ramsar site as a whole, the ocean beaches of the planning area are quite distinct from the estuarine habitat assemblages of the Bay both in terms of geomorphologic form and function. In particular, the composition, diversity, and abundance of fauna communities on beaches are likely to be more strongly controlled by physical factors (e.g. wave climates, sediment properties) than by the biological interactions.

The intertidal zone of ocean beaches is dominated by wave action causing the sand to be in a constant state of disturbance. The coastal processes cause organic nutrients to continually re-suspend, meaning there is limited food available, particularly compared to more sheltered estuarine areas. While the environment limits the presence of larger invertebrates, beach ecosystems can contain significant species diversity when smaller invertebrate forms (i.e. the interstitial micro- and meiofauna) are included in surveys. Beaches also provide unique ecological services, such as filtration of large volumes of seawater, not covered by any other ecosystem (Schlacher *et al.* 2008).

Above the active surf zone, macrobenthic organisms are a key structural and functional component of sandy beach ecosystems, with benthic invertebrates playing roles in both the cycling of nutrients and as serving as prey species for larger crustaceans, fish and birds. Foredunes situated landward of the active surf zone provide important habitat for range of fauna species including nesting by shorebirds and marine turtles and roosting by coastal birds of prey.

Of the beach environments of the Ramsar site, the ocean beach environments of Moreton Island are seen as the most representative and near natural of the site which is supported by a long term conservation management regime over the site as a national park. The ocean beach of the island provides critical habitats (nesting, roosting and foraging sites) for migratory and resident birds of

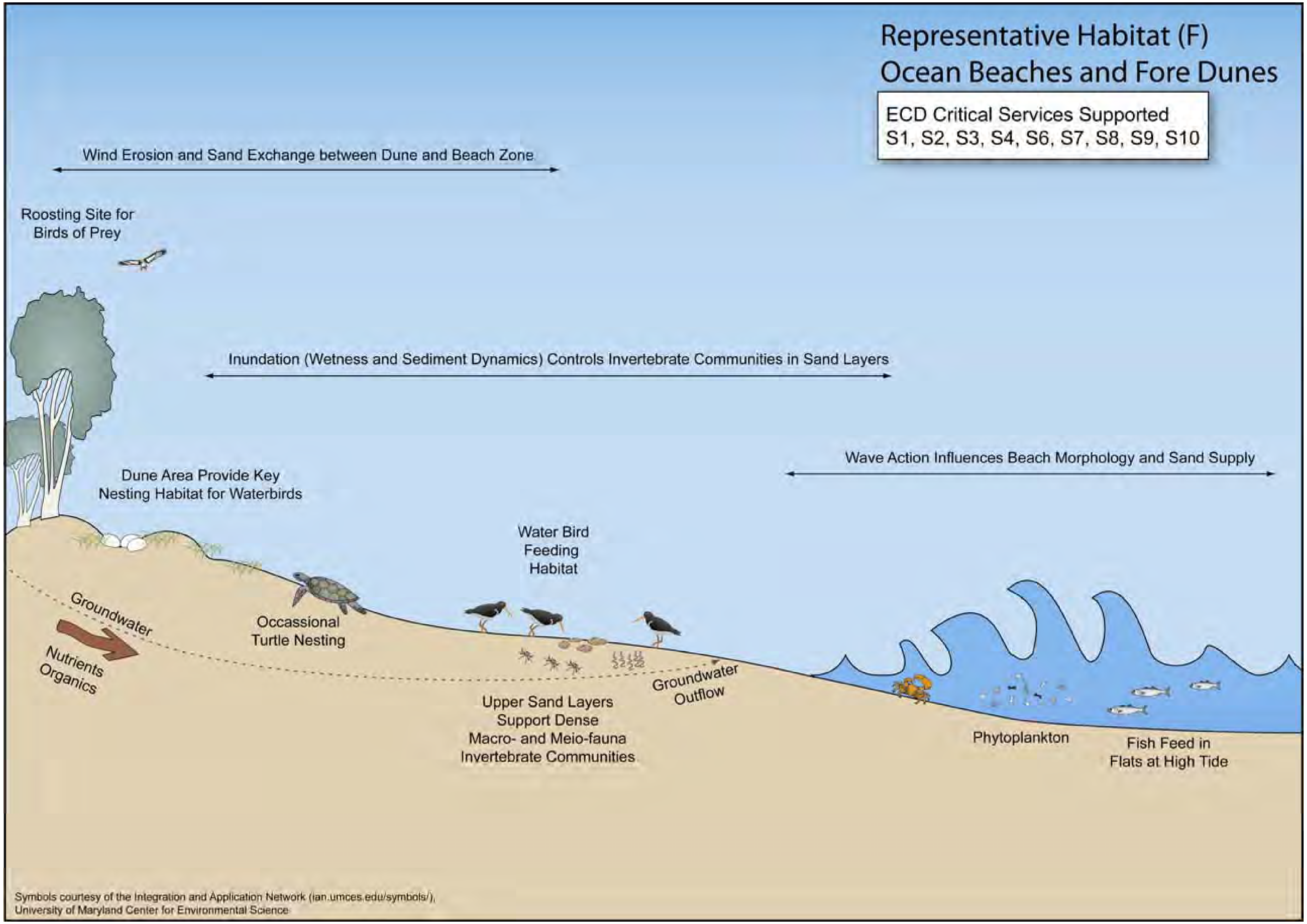


Figure 7-6 Conceptual Model of Moreton Island Ocean Beaches and Foredunes

Table 7-11 Critical Service 2F – Ocean Beaches and Foredunes of Moreton Island

Summary Table	Critical Service (S2F)
Reason for Inclusion	While there a number of ocean beaches represented in the site, the ocean beaches of Moreton Island have been selected as a representative near-natural reference site, underpinned by Ramsar Criteria 1.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Moreton Island ocean beaches and foredunes
Critical habitat components underpinning this service	Sandy Beach, Dune systems, Marine Waters
Critical species underpinning this service	See S3 (turtles), S4 (principally little tern and other avifauna), S7 (shorebirds)
Critical processes underpinning this service	Waves and current and their effect on sediment deposition and shoreline morphology including erosion and accretion Changes to tidal regimes/tidal drainage patterns Sediment stability, compactness and structure (eg. most animals surviving within upper sand layers) Wind erosion (stabilisation)
Natural Variability (if relevant)	Seasonal changes in distribution and extent of the habitat due to coastal processes. Episodic catastrophic storms may also lead to short-term reductions in available habitat.
Principal threats	Activities that disturb or otherwise reduce the quality of habitat for important fauna (nesting and feeding birds and turtles) Crushing of invertebrate species and communities from sediment disruption (principally by Off Road Vehicles) Removal and damage to dune vegetation (reducing habitat quality and increasing susceptibility to wind erosion)
Data quality underpinning this critical service	Level 3-4: There is emerging research into the impact of ORV on sandy beach ecosystems that demonstrates the diversity and abundance of species within beach ecosystems are adversely affected by ORV use compared to control sites.
Information gaps	• More systematic survey of key species (birds and turtle) populations over time including usage and quality of nesting sites • Further research of the impact of ORV usage on sandy beach invertebrate communities.
Recommended monitoring	• Examination of long-term changes in habitat extent using aerial photograph interpretation and review of existing information • Schalcher *et al.* (2007) also recommends research into the implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity. Effects of cumulative impacts from multiple stressors and disturbances on the structure, function, and recovery dynamics of sandy beach ecosystems are also recommended.

conservation significance and to a lesser extent turtles (noting the ocean beaches of South Stradbroke Island are recognised as being more significant for turtle nesting). The prominent bird species include the pied oystercatcher (*Haematopus longirostis*), the little tern (*Sterna albifrons*) and the beach stone-curlew (*Esacus neglectus*) with the beach and adjoining dune areas important breeding and chick rearing areas with close access to marine feeding zones. Mirapool Lagoon in the southeastern corner of Moreton Island and Heath Island area on the Island's northern coast are recognised vital feeding and roosting site for waders in both the National Park and Marine Park Zoning Plans (EPA 2007b).

The principal impacts to wetland values that occur in ocean beach environments are from off-road vehicle usage. Research on the impacts on wetland fauna from beach driving have traditionally focused on disturbance to rare and vulnerable species such as birds and turtles, particularly in the context of disturbance to breeding activities and nests. However, recent research on the impacts of off road vehicles (ORV) on beach ecosystems by Schlacher *et al.* (2008) demonstrated that macrobenthic assemblages on heavy traffic ORV beaches contained significantly fewer species at much reduced abundances than beaches without vehicles present. This was particularly marked in the upper and middle part of the beach where vehicle usage is highest. As identified above, these species provide an important prey source for a range of higher order vertebrates (such as shorebirds and birds of prey) that are of direct relevance to the Ramsar site.

Figure 7-6 shows a conceptual model of this critical reference habitat. Table 7-11 summarises the key attributes of this critical service.

7.3 Service 3 ~ Marine/Aquatic Fauna

Photos of marine turtle, dugong and Oxleyan pygmy perch (Source: BMT WBM photo library)

For the purposes of this assessment, species of conservation significance are considered to be those that are listed as endangered or vulnerable under National (EPBC Act 1999) or state (Nature Conservation (Wildlife) Regulation 2006) legislation. The definition has also been extended to include marine mammal and reptile species that are protected under the EPBC Act 1999.

Dugongs

Dugongs have a global IUCN listing of "vulnerable to extinction" (IUCN 1996) and the Queensland dugong population is considered as "vulnerable" under the Queensland *Nature Conservation (Wildlife) Regulation 2006*.

Moreton Bay represents the southern limit of the dugong's Australian distribution (Lanyon and Morrice 1997) and currently contains one of the largest populations of dugongs on the east coast of Australia (Marsh *et al.* 1996). A study estimated the Moreton Bay dugong population to be comprised of approximately 500 individuals (Great Barrier Reef Marine Park Authority (GBRMPA) 2003) compared with an estimated population of 503 ± 63 (S.E) (July) to 1019 ± 166 (S.E) (December) individuals in 1995 (Lanyon 2003). However as noted by GBRMPA (2003), there were differences in sampling techniques, which preclude direct comparisons between the two studies. Recent population modelling estimates that the Moreton Bay dugong 'population' is ~970 ±75 animals (Dr Janet Lanyon, pers. comm. 2008). It should be noted, however that this figure should be considered as indicative only, subject to further investigations. A range of studies are either underway or are planned to gain a more detailed appreciation of dugong movement patterns (within and external to the site), population dynamics, genetics and ecology within the site (Dr Janet Lanyon, pers. comm. 2008).

Dugongs are believed to move in and out of Moreton Bay in ranging movement patterns, but principally through the South Passage and not the northern delta region (Lanyon and Morrice, 1997). There is uncertainty regarding the movement patterns of dugongs within and external to the site (Dr Janet Lanyon, pers. comm. 2008). Dugong densities appear to be concentrated around the extensive seagrass beds associated with the Moreton Banks area (located 10-12 km to the south) in the Eastern Bay (Lanyon and Morrice, 1997), with relatively few individuals sighted in other portions of Moreton Bay. However, areas containing dugong foraging habitat (i.e. seagrass areas) have been recognised as far north as Tangalooma Point on the west coast of Moreton Island. The importance of the Moreton/Eastern Banks area to this species has been recognised by the Environmental Protection Agency in the *Marine Parks (Moreton Bay) Zoning Plan 1997*, with the area designated as a Conservation Zone and the implementation of "go slow zones" in areas such as Moreton Banks.

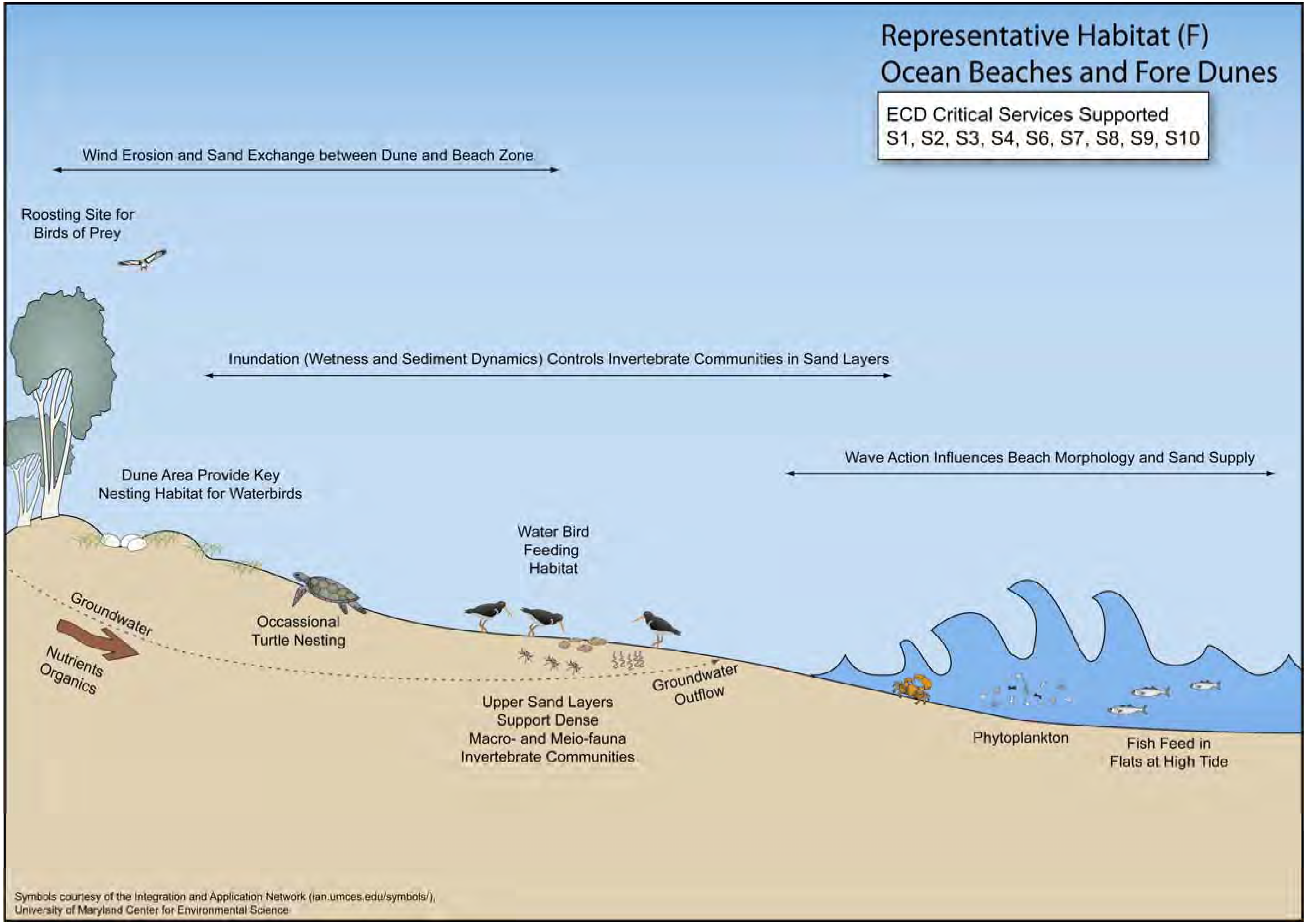


Figure 7-6 Conceptual Model of Moreton Island Ocean Beaches and Foredunes

Table 7-11 Critical Service 2F – Ocean Beaches and Foredunes of Moreton Island

Summary Table	Critical Service (S2F)
Reason for Inclusion	While there a number of ocean beaches represented in the site, the ocean beaches of Moreton Island have been selected as a representative near-natural reference site, underpinned by Ramsar Criteria 1.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Moreton Island ocean beaches and foredunes
Critical habitat components underpinning this service	Sandy Beach, Dune systems, Marine Waters
Critical species underpinning this service	See S3 (turtles), S4 (principally little tern and other avifauna), S7 (shorebirds)
Critical processes underpinning this service	Waves and current and their effect on sediment deposition and shoreline morphology including erosion and accretion Changes to tidal regimes/tidal drainage patterns Sediment stability, compactness and structure (eg. most animals surviving within upper sand layers) Wind erosion (stabilisation)
Natural Variability (if relevant)	Seasonal changes in distribution and extent of the habitat due to coastal processes. Episodic catastrophic storms may also lead to short-term reductions in available habitat.
Principal threats	Activities that disturb or otherwise reduce the quality of habitat for important fauna (nesting and feeding birds and turtles) Crushing of invertebrate species and communities from sediment disruption (principally by Off Road Vehicles) Removal and damage to dune vegetation (reducing habitat quality and increasing susceptibility to wind erosion)
Data quality underpinning this critical service	Level 3-4: There is emerging research into the impact of ORV on sandy beach ecosystems that demonstrates the diversity and abundance of species within beach ecosystems are adversely affected by ORV use compared to control sites.
Information gaps	• More systematic survey of key species (birds and turtle) populations over time including usage and quality of nesting sites • Further research of the impact of ORV usage on sandy beach invertebrate communities.
Recommended monitoring	• Examination of long-term changes in habitat extent using aerial photograph interpretation and review of existing information • Schalcher *et al.* (2007) also recommends research into the implications of habitat loss and fragmentation as well as weakened linkages across critical ecotones and habitats for the conservation of sandy beach biodiversity. Effects of cumulative impacts from multiple stressors and disturbances on the structure, function, and recovery dynamics of sandy beach ecosystems are also recommended.

Dugongs are principally herbivores and have been shown to be highly selective feeders, preferring certain species of seagrass to others. Preen (1995b) reported dugongs showing a preference for grazing on seagrass from the genus *Halophila*, three species of which (*H. ovalis, H. spinulosa* and *H. decipiens*) are found in Moreton Bay. This is despite the dominance in biomass of another species of seagrass (*Zostera*) in the region. Dugongs in Moreton Bay are also reported to feed deliberately on invertebrates such as ascidians. This omnivory is thought to be a response to nutritional stress caused by seasonality in abundance of seagrasses in Moreton Bay (Preen 1995a).

Marine Turtles

Six species of marine turtle are known to use Moreton Bay as a feeding area. Two of these species – the green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) turtles, have relatively high abundances within the site, while the hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*) and flatback (*Natator depressus*) turtles are seasonal visitors to the region, or do not have high abundances within site (Limpus *et al.* 2006). For this reason, emphasis in this critical service (and the ECD as a whole) is on the two most common species.

Moreton Bay is not an important turtle breeding area, with most turtles in the Bay believed to have originated from rookeries on the central and north Queensland coast and Islands. Loggerhead turtles nest at low densities on the local sand islands of Bribie, Moreton, and North and South Stradbroke.

The distribution and abundance patterns of turtles within Moreton Bay are thought to be greatly influenced by the availability of suitable food resources. Green turtles in Moreton Bay feed directly on seagrasses and algae (Brand-Gardner *et al.* 1999) with most concentrated numbers of these fauna (c.f. dugongs) also centred on the important foraging areas at Moreton/Eastern Banks. By comparison, loggerhead turtles are carnivorous, and feed on jellyfish, crustaceans, echinoderms, and bivalve molluscs from seagrasses and reef areas (Limpus *et al.* 1994).

'Population' estimates of turtles in Moreton Bay in 1995 range from 800 and 900 individuals (Lanyon 1997). However, the authors acknowledge that this is likely to be an underestimate due to bias inherent in the survey methodology. It should also be noted that the term 'local population' is a misnomer, given the large home range of these species. The number of green turtles is consistently higher in the Eastern and Southern Bay than elsewhere due to the presence of extensive (seagrass) foraging areas (Limpus *et al.* 2006). With the exception of green turtles, there is a paucity in data to describe key or preferred foraging habitats for the remaining marine turtles in Moreton Bay, possibly due to the lower resident numbers of these species.

Marine turtles are protected under the *Nature Conservation Act 1992*, with the loggerhead listed as Endangered, and the green turtle listed as Vulnerable. The green and loggerhead are also listed as threatened under the EPBC Act 1999.

Oxleyan pygmy perch and honey blue-eye

Two nationally threatened 'wallum-habitat' associated fish species occur within the Moreton Bay Ramsar site: Oxleyan Pygmy Perch (*Nannoperca oxleyana*) and Honey Blue-eye (*Pseudomugil mellis*). Both species are listed as Vulnerable under *Nature Conservation (Wildlife) Regulation 2006*, and Endangered under the IUCN red list. Under the Commonwealth's *Environmental Protection and*

Table 7-7 Critical Service 2C - Southern Bay Mangroves and Saltmarsh

Summary Table	Critical Service (S2C)
Reason for Inclusion	Representative near-natural reference site for mangroves and saltmarsh communities. Underpinned by Ramsar Criteria 1, in the context that it contains representative habitat with a high degree of inter-connectivity between habitat types.
Type of Service	Supporting
Description of Service (quantify if possible)	Habitat types are in a near-natural condition.
Spatial Application (if relevant)	Southern Moreton Bay
Critical habitat components underpinning this service	Mainland littoral habitats, mangrove-colonised islands
Critical species underpinning this service	Mangrove and saltmarsh species
Critical processes underpinning this service	Tidal hydraulics – currents, waves and sea level rise Freshwater flows – Source and delivery of sediment Physical (geomorphologic) coastal processes that maintain mangrove islands Energy and nutrient dynamics Other biological processes (growth, reproduction, recruitment, and possibly competition?)
Natural Variability (if relevant)	Mangrove losses reported following storms No studies have examined broad-scale changes in mangrove extent across the Southern Moreton Bay area. Large increases in mangrove extent were recorded in the Pimpama and Coomera catchments associated with changed agricultural practices and tidal inundation patterns over the last 60 years (WBM 2001). Landward increases in mangrove extent have resulted in the loss of saltmarsh in many areas within the Pimpama and Coomera catchments. Overall, there has been a large reduction in saltmarsh over the last 50 years as outlined in the text above in the Southern Moreton Bay area from a range of natural and anthropogenic factors.
Principal threats	Mangroves/saltmarsh - Clearing; reclamation and filling; and sea-level rise; Competition between species types. The combination of sea level rise with limited coastal land area for saltmarsh migration places these habitats at particular risk.
Data quality underpinning this critical service	Level 1-3 (Dowling 1986; Hyland and Butler 1989; WBM 2001; EPA 2005a)
Information gaps	More systematic information is required on background variability in mangrove and saltmarsh habitat extent and linkages to controlling processes.
Recommended monitoring	Examination of long-term changes in mangroves and saltmarsh based on aerial photograph interpretation and review of existing information

Biodiversity Conservation (EPBC) Act 1999, Oxleyan pygmy perch is listed as Endangered, whereas honey blue-eye is listed as Vulnerable.

Table 7-12 lists localities where Oxleyan pygmy perch and honey blue-eye have previously been recorded, and the habitat attributes of the sites in which these species were recorded. There are several mainland and island waterbodies within the Ramsar site in which Oxleyan pygmy perch has been recorded. Honey blue-eye by contrast has not been recorded on the Moreton Bay islands, but has been recorded in several waterways that discharge into Pumicestone Passage.

Honey blue-eye and Oxleyan pygmy perch are both typically found in the coastal lowland "wallum" ecosystem and are often found in the same waterways (Arthington and Marshall 1993; Arthington 1996). Both species are thought to be restricted to acidic (pH 4.4 - 6.8) freshwater lakes, pools and small streams with dense, aquatic vegetation (such as emergent sedges and submerged sedges), along the margins (Allen and Ivantsoff 1982; Arthington and Marshall 1993; Arthington 1996; Kuiter *et al.* 1996; Pusey *et al.* 2004). Both species are found in clear and tannin-stained waters (Arthington and Marshall 1993) with sandy or muddy bottoms (Allen 1989), typically where there is little or no flow (Arthington and Marshall 1993; Arthington 1996). Oxleyan pygmy perch are restricted to freshwaters (Arthington 1996, Pusey *et al.* 2004), whereas honey blue-eye occurs in slightly brackish and freshwater environments (Semple 1991).

Both species are considered as nationally threatened. In response, recovery plans have been prepared for both species which provide basic life history and population distribution information, identify key threats and recommendations for management of the species and their habitats (Arthington and Marshall 1993; Arthington 1996).

It should be noted that the mainland waterbodies that Oxleyan pygmy perch and honey blue-eye have been recorded are, in most cases, brackish reaches within the Moreton Bay Ramsar site. Within the context of the Ramsar site boundaries, these mainland waterbodies are therefore unlikely to represent critical habitat for these essentially freshwater species.

Table 7-13 provides the summary of key attributes related to this critical service.

Table 7-12 Localities Known to Support Oxleyan Pygmy Perch and Honey Blue-eye and Habitat Conditions

	Oxleyan Pygmy Perch	**Honey Blue-eye**
Mainland Localities	Searys Ck, Carland Ck, Noosa River & tributaries, Coondoo/Tiana Ck, **Mellum Ck**, trib of Blue Gum Ck, **Burpengary Ck**, Marcus Ck [D], Coochin Creek [E]	Big Tuan Ck, Lake Cooloola, Noosa River, Marcus Ck, Scrubby Ck, Kangaroo Ck, Schnapper Ck, Carland Ck, **Mellum Ck**, **Tibrogargan Ck** [D]
Island Localities	**Spitfire Ck** and **Jabiru Ck** (Moreton Island) [A]; **Bribie Island** [A]; **Eighteen Mile Swamp** [G]; **Blue Lake** [H]; **Blue Lake Overflow** [G]; **Little Canalpin Ck** [F]	-
Localities not recorded by Arthington (1996); Arthington and Marshall (1993)	Waraba Ck, Tibrogargan Ck, Coonowrin Ck, Coochin Ck, Obi Obi Ck; Mooloola R., Tingalpa Ck, Currumbin Ck [D]	Seary Ck, Lake freshwater, Kin Kin Ck, Castaways Ck, Obi Obi Ck, Mooloola River, Coochin Ck, Coonowrin Ck, Waraba Ck, Tingalpa Ck, Currumbin Ck [D]; North and South Stradbroke, Bribie, Moreton Islands
Water Quality[A,B]	pH 4.2 to 7.2 Conductivity <330 μS/cm DO > 2 mg/L Clear, tannin stained waters	pH 4.4 to 6.8 Conductivity <900 μS/cm DO > 6.8 mg/L Clear, tannin stained waters
Habitat	Wallum habitat, often with Melaleuca Structurally complex habitats: • 60-80% aquatic plant cover (typically sedges) • Undercut banks • Leaf litter or fallen timber	Wallum habitat High aquatic plant cover, typically sedges Low flow environments (<0.3 m/sec)

A = Pusey, *et al.* (2004); B = EPBC database; C = Arthington (1996); D = Arthington and Marshall (1993); E = unpublished AGFA records; F = WBM (2002a); G = WBM (2002a); H = BMT WBM (2007); **Bold** – waterbodies located in, or have a direct connection to, the Ramsar site

Table 7-13 Critical Service 3

Summary Table	**Critical Service (S3)**
Reason for Inclusion	Key services provided by the site in regards to threatened fauna complies with Ramsar Nomination Criteria 2 in that the site supports vulnerable fauna and Ramsar Nomination Criteria 4 in respect to provision of critical refuge.
Type of Service	Supporting – Nationally threatened species, contributes to biodiversity
Description of Service (quantify if possible)	The site supports records of, and habitat suitable for, threatened aquatic fauna species. Dugong, two species of marine turtle, and two 'wallum-habitat' fish species are identified as critical elements.
Spatial Application (if relevant)	This service applies to the whole site. Refer to text for important localities and habitats for these species.
Critical habitat components underpinning this service	Seagrass (dugongs and green turtles), reefs (loggerhead turtles), wallum freshwater wetland habitats (Oxleyan pygmy perch, honey blue-eye).
Critical species underpinning this service	**Food** Freshwater littoral and pelagic micro- and macro-invertebrates - Oxleyan pygmy perch, honey blue-eye Seagrass (*Halophila* species and *Halodule uninervis*) - Dugongs and green turtles Soft sediment epifauna and infauna – Loggerhead turtles Reef biota (algae, sponges, soft coral) – Loggerhead turtles Jellyfish – Loggerhead turtles **Habitat** Emergent macrophytes - Oxleyan pygmy perch, honey blue-eye
Critical processes underpinning this service	Maintenance of biophysical habitat extent, diversity and interconnectivity Maintenance of tidal and wave regimes that drives biophysical habitat patterns and processes Maintenance of water quality conditions, particularly with respect to its influence on estuarine vegetation communities (i.e. seagrass, algae etc.) Maintenance of groundwater and surface flow regimes to wallum wetland habitats
Natural Variability (if relevant)	Patterns in abundances of all fauna species are known to vary across a range of spatial and temporal scales.
Principal threats	Habitat loss due to development - Oxleyan pygmy perch, honey blue-eye Water quality degradation - Oxleyan pygmy perch, honey blue-eye, dugong, green turtle Fishing (by-catch) – Turtles Boat strike (including jetskis) – Dugongs, turtles Water extraction – Wallum wetland fish species Disease, possibly linked to *Lyngyba* – Turtles Entanglement and ingestion of marine debris – Turtles Toxicants – Turtles, possibly other marine fauna.
Data quality underpinning this critical service	Service – Level 2-3 (population survey data outdated, insufficient scale) Components – Level 2 (outdated, insufficient scale) Processes – Level 1-2 (water quality); 2 (freshwater flows); 2 (tidal data)
Information gaps	**Marine** Present-day and historical marine vegetation mapping done at relevant spatial scale (minimum 1:25,000) and temporal (at least every 5 years, preferably with analysis of seasonal changes);

Summary Table	Critical Service (S3)
	Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh; Natural variability in dugongs and turtles, and factors controlling these changes; Sustainability of dugongs and turtles given existing pressures and management arrangements; and Health/condition status of turtles, and identification of factors causing disease. **Freshwater** Environmental flow requirements of wallum fish species Impacts of introduced species on wallum fish species Up-to-date assessment of the distribution, population status and site-specific threats to wallum-habitat fish species, including an assessment of any changes of population status.
Recommended monitoring	Fauna population monitoring at an appropriate spatial and temporal scales Marine vegetation monitoring Continuation and expansion of EHMP to include key habitats

7.4 Service 4 ~ Wetland-Dependant Terrestrial Fauna

Photos of little tern (*Ray Viljoen*), beach stone-curlew (*Ray Viljoen*) and water mouse (*Bruce Cowell*)
All copyright © Queensland Museum

There are records for nine threatened wetland-dependant terrestrial fauna within the Moreton Bay Ramsar site. These are: Illidge's ant blue butterfly *Acrodipsas illidgei,* wallum froglet *Crinia tinnula*, wallum rocketfrog *Litoria freycineti*, wallum sedgefrog *L. olongburensis*, beach stone-curlew *Esacus neglectus*, water mouse *Xeromys myoides,* Cooloola sedgefrog *Litoria cooloolensis*, Australian painted snipe *Rostratula australis,* little tern *Sterna albifrons*. A tenth, the Australasian bittern *Botaurus poiciloptilus*, has not been recorded currently for the site but could be present due to suitable habitat. The following provides a profile of ecological characteristics, habitat usage in Moreton Bay, and potential threatening process for each of the species.

Illidge's Ant Blue Butterfly

Illidge's ant blue butterfly *Acrodipsas illidgei* is listed as Endangered under the IUCN Red List, and is also listed as *Vulnerable* at a State scale under the provisions of the NCA.

Illidge's ant blue butterfly appears to be restricted to a small number of coastal localities from the Mary River Heads, south-eastern Queensland to Brunswick Heads, northern New South Wales (Sampson 1993; Sands and New 2002). Whilst single specimens have been recorded in non-coastal environments (Toowoomba - Lane 1991 and Braby 2000; and near Leyburn - Sands and Sands 2005), there is insufficient information relating to these records to add to the knowledge of the butterfly's ecology (D. Sands, pers. comm. 2008).

Site localities within Moreton Bay are: Hayes Inlet (1974; DeBaar in Sands and New 2002); Southport (Samson 1989); Redland Bay (Hagan 1980); Coomera Island (1999; Breitfuss and Dale 2004); and Fisherman's Islands (D. Sands, pers. comm. 2008).

Large and undisturbed mangal communities are considered to be the primary habitat for this butterfly. The vast majority of known habitats all characterised by the presence of well-spaced, mature mangrove trees bearing senescing limbs and dead branchlets which support the *Crematogaster* sp. ant (prey of Illidge's ant blue larvae). In these habitats, tree phenology and architecture appears to be important (D. Sands, pers. comm. 2008).

Adults of the Illidge's ant blue feed on the nectar of flowers (e.g. eucalypts, mangroves, *Parsonsia* spp.) (D. Sands, pers. comm. 2008). After mating, females deposit their eggs singly or in small groups at the edge of hollows in dead twigs or under bark of old trees of *Avicennia marina* when occupied by a common Black ant (*Crematogaster* sp.; *laeviceps* group) (Smales and Ledward 1942; Samson 1989).

Detection of Illidge's ant blue butterfly is highly problematic, even for highly experienced personnel, as the density of adults is very low and the butterfly has the propensity to remain settled on the upper branches of mangroves and flies infrequently (D. Sands, pers. comm. 2008). It is quite likely that new habitats will eventually be discovered if persistent searches of other potential habitats are undertaken, particularly on the islands of Moreton Bay (D. Sands, pers. comm. 2008). It is highly probable that Moreton Bay supports in excess of 1% of the population of Illidge's ant blue (D. Sands, pers. comm. 2008) but a lack of definitive data about the bioregional population limits its application.

Acid Frogs

For the purposes of this report, wallum or acid frogs (after Ingram and Corben 1975) include wallum froglet *Crinia tinnula*, wallum rocketfrog *Litoria freycineti*, wallum sedgefrog *L. olongburensis*¸ and Cooloola sedgefrog *Litoria cooloolensis*. The wallum froglet, wallum rocketfrog, wallum sedgefrog are listed as *Vulnerable* under the provisions of the NCA. The wallum sedgefrog is the only species listed nationally as *Vulnerable* under the EPBCA. All four species are listed as threatened by the World Conservation Union (IUCN 2006).

Wallum froglets *Crinia tinnula* occur primarily in heathland, paperbark (*Melaleuca*) swamps and sedge swamps in areas of sandy soil which support waters that are typically tannin-stained, highly acidic (i.e. <5.5 pH) and non-turbid (Cogger 2000; Straughan and Main 1966; Ingram and Corben 1975; Meyer *et al.* 2006). Other habitats include adjoining eucalypt forest and woodland in areas of sandy soil overlaying clay and sandstone (Hines *et al.* 1999). Waterbodies used for breeding are typically oligotrophic (low nutrient), naturally acidic (pH 3.0-5.5 as derived from dissolved organic acids leached from humus), and free of predatory fish (Hines *et al.* 1999). Primary breeding habitat is associated with shallow ephemeral swamps and soaks, though also known to breed in artificial habitats such as dams and flooded ditches (Hines *et al.* 1999; Anstis 2002).

In Queensland, the frogs are restricted to the coastal lowlands and offshore islands ("wallum" landscapes of Coaldrake 1961) of the south-east (Czechura 1995; Meyer *et al.* 2006). Site localities within Moreton Bay include Bribie, Moreton and North Stradbroke Islands (both public and private land tenure) (Neilson 2000; Greenloaning Biostudies 2000; EPA 2008b). National Parks on all three islands are listed as supporting important populations of wallum froglet (Meyer *et al.* 2006). Other localities include wallum habitats adjoining Pumicestone Passage and several small islands within the southern sector of Moreton Bay (EPA 2008b).

Wallum sedgefrogs *Litoria olongburensis* are known from a variety of ephemeral and semi-permanent, low-nutrient, well-vegetated swamps of coastal wallum (Liem and Ingram 1977; Emhann 1997; Hines *et. al.* 1999). Within these habitats, areas of sedges, reeds, grasses and/or Bungwell fern (*Blechnum indicum*) which are inundated with shallow acid, low-nutrient waters (e.g. up to 1.5m in depth) are regarded as important breeding habitat attributes (Liem and Ingram 1977; Hines *et. al.* 1999; Meyer *et al.* 2006; DEWHA 2008a). Wallum sedgefrogs are typically more common in and around ephemeral acid swamps, though also known to occur along slow-flowing creeks and acid lakes in wallum landscapes (Liem and Ingram 1977; Ehmann 1997; DEWHA 2008a). Aquatic sites at the base of sedges area also important microhabitats for amplexus and egg laying (Ehmann 1997;

Meyer *et al.* 2006). Fish are largely absent from habitat occupied by the species (E. Meyer pers. comm. 2002 in DEWHA 2008a).

The wallum sedgefrog is primarily restricted to the coastal lowlands of south-east Queensland and north-east New South Wales (Tyler 1997; Meyer *et al.*. 2006). The main localities for wallum sedgefrog within the study area are similar to the wallum froglet, on Bribie, Moreton and North Stradbroke Islands (both public and private land tenure) (EPA 2008b). National Parks on all three islands are listed as supporting important populations of wallum sedgefrog (Meyer *et al.* 2006). Other localities include fragmented wallum habitats adjacent Pumicestone Passage (mainland) (EPA 2008b).

The wallum rocketfrog *Litoria freycineti* is a ground dwelling species associated with coastal wet heath, though also occurs around sedge swamps, slow moving streams, perched lakes and within nearby *Melaleuca* and *Banksia* woodlands on sandstone and sandy soils (Ingram and Corben 1975; Hines *et al.* 1999; Meyer *et al.* 2006). The wallum rocketfrog breeds after rain in spring and summer in ephemeral swamps and pools and males call from wet ground near water, amidst sedges and eggs are laid in shallow water (Straughan and Main1966; Anstis, 2002; Barker *et al.* 1995; Meyer *et al.* 2006).

The wallum rocketfrog occurs in lowland coastal south-east Queensland and eastern New South Wales from Fraser Island south to Jervis Bay (Hines *et al.* 1999; Meyer *et al.* 2006). The main localities for wallum rocketfrog within the study area are similar to those of wallum froglets and wallum sedgefrogs as already discussed.

The Cooloola sedgefrog is typically more abundant around perched lakes with emergent sedges and reeds (Ehmann, 1997; Meyer *et al.* 2006). The lakes in which *L. cooloolensis* breeds are typically oligotrophic and acidic (pH<5.5). (Ehmann, 1997; James 1996; Meyer 2004; Meyer *et al.* 2006). As with the wallum sedgefrog, there are a small number of records of Cooloola sedgefrogs breeding in disturbed habitat and have also been recorded from dams within disturbed habitat, though, whether these sites provide suitable breeding habitat is unknown (Meyer *et al.* 2006).

The Cooloola sedgefrog is known only from Fraser Island and the Cooloola sandmasses, with a disjunct population on North Stradbroke Island (Hines *et al.* 1999; Meyer *et al.* 2006). On North Stradbroke Island, most sites are on leased or unallocated state land (Meyer *et al.* 2006). Monitoring suggests that populations on leased land are stable, though numbers are known to have declined dramatically following the introduction of the *Gambusia holbrooki* in 2002 (Neilson 2000; E. Meyer unpub. data; in Meyer *et al.* 2006). Site records include Brown Lake; Blue Lake, Ibis Central and Ibis West Lagoons within mining leases, Duck Lagoon, Native Companion Lagoon, Welsby Lagoon, Shag Lagoon, Tortoise Lagoon, Lake Kounpee, Lake Yarraman, Spanner Lake, Swallow Lagoon, Eighteen Mile Swamp, Yarraman Swamp, Flinders Swamp, Kounpee Swamp and Creaking Tree Swamp (Ingram and Corben 1975; Neilson 2000; Queensland Museum 2008; Meyer *et al.* 2006; EPA 2008b).

The Moreton Bay Area (including Bribie, Moreton and North Stradbroke Islands) provides important habitat for all three wallum-dependent acid frog species. Given the extent of wallum habitat within Moreton Bay, the study area is likely to support significantly more than 1% of the total population of each of these species (E. Meyer, pers. comm. 2008). In the case of the wallum sedgefrog, this figure could well exceed 10% (E. Meyer, pers. comm. 2008). However, specific data to support the Nomination Criteria have not been collected.

Given the importance of the Moreton Bay Area for acid frogs, the loss of habitat (in particular that of the wallum sedgefrog) should not exceed 5% of the area occupied by these species. In addition, water quality within areas of suitable habitat must be maintained at current levels (or better). Of particular importance in this regard is the maintenance of acidic and oligotrophic conditions in areas of breeding habitat (i.e., wallum swamps and lakes). Wallum swamp and lake waters should therefore remain acidic (within the pH range 3-5) while nitrate levels should not exceed 0.7 mg/L (E. Meyer, pers. comm. 2008). Levels of other toxicants including monomeric Aluminium and surfactants must also remain low. Also important, in terms of habitat suitability, is the maintenance of parapatry between acid frog and congeneric sibling species (i.e., the beeping froglet *Crinia parinsignifera*, common sedgefrog *Litoria fallax* and striped rocketfrog *Litoria nasuta*) in undisturbed wallum habitat.

Beach Stone-Curlew

Beach stone-curlew *Esacus neglectus* is listed as *Vulnerable* under the provisions of the NCA.

Beach stone-curlews occur exclusively within coastal environments using a variety of sheltered and open beaches (sandy, muddy or rocky), often around mouths of rivers and beaches associated with mangroves (Marchant and Higgins 1993). Beach stone-curlews forage within exposed intertidal areas and feed predominately on crabs and other marine invertebrates (Clancy 1986; Marchant and Higgins 1993).

Beach stone-curlews characteristically roost amongst mangroves, grassy treed areas within foredunes, or where there is suitable vegetation cover above the high tide mark (Clancy 1986; Geering *et al.* 2007). Nest sites are typically located landward side of sandy beaches, often within low foredunes in the same area year after year (September to November) (Marchant and Higgins 1993). This species is mainly nocturnal or crepuscular[9] and adult birds appear to be sedentary (Marchant and Higgins 1993; Geering *et al.* 2007). Beach stone-curlews feed predominately on crabs and other marine invertebrates in the intertidal zone (Clancy 1986; Marchant and Higgins 1993).

Beach stone-curlews are distributed along coastal environments throughout Eastern and Northern Australia, from the Manning River in New South Wales to Onslow in Western Australia (Marchant and Higgins 1993). The species was considered to be ‘not common’ on North Stradbroke Island by Vernon and Martin (1975) and more recently, rare in Moreton Bay and restricted mainly to outer islands with extensive areas of mangroves or long sandy beaches (Agnew and Stewart 1998).

The main localities for beach stone-curlew within the study area include Bribie, Moreton and North Stradbroke Islands (EPA 2008b). Other site records derive from Fisherman Islands, Peel Island, Southport Spit, South Stradbroke Island, and Pumicestone Passage (GCCC 2008; EPA 2008b).

Whilst beach stone-curlews can still be found in coastal locations where human activity is relatively high, the lack of young birds in such areas suggests that reproduction is being affected by human disturbance (Freeman 2003). Breeding success may also be significantly reduced from predation by cats, dogs and feral pigs and disturbance resulting form recreation activities (e.g. beach-combing,

[9] Active at dawn and/or dusk

dog-walking, boating and 4WD vehicles (Roberts 1957; Garnett 1992; Marchant and Higgins 1993; Garnett and Crowley 2000).

Water Mouse

The water mouse *Xeromys myoides* is listed as *Vulnerable* under the provisions of the NCA and EPBC Act (where it is listed as false water rat).

The water mouse has been recorded in coastal saltmarsh, mangrove and adjacent freshwater wetland habitats in the Queensland, Northern Territory and New Guinea. In Queensland, the water mouse has been recorded on the mainland from the Proserpine region, at Mackay, an area south of Gladstone, and from south-east Queensland between Hervey Bay and the Coomera River (50km south-east of Brisbane) (EPA 2008b). Non-mainland sites include Fraser Island, Bribie Island, North Stradbroke Island and South Stradbroke Island (EPA 2008b).

The species has been recorded in various coastal and freshwater vegetation assemblages. In southeast Queensland (including Moreton Bay), these include sedgeland (an often well defined zone to about 1m and composed mainly *Juncus* and *Baumea* spp.), chenopod shrubland (including succulents and dwarf shrubs growing on soils that dry out and crack between inundations), *Sporobolus virginicus* grassland (marine couch meadows found closest to the extreme high water spring tide mark and associated with freshwater drainage), and mangrove communities (with variation in structural type and complexity and comprising of one or more mangrove species) (Van Dyck and Gynther 2003; EPA 2008b).

The water mouse is likely to require relatively large areas of intertidal flats where it forages by following tidal waters to the low water mark and forage until advancing waters inundate the mangrove community (Van Dyck 1997). The diet of the water mouse largely comprises marine intertidal crustaceans, pulmonate snails, marine gastropods and other invertebrates (Van Dyck 1997; Gynther and Janetzki 2008).

The water mouse is probably entirely nocturnal, sheltering during the day and between tidal cycles in constructed nesting mounds adjacent to foraging habitat. Nesting structures recorded in south-east Queensland include:

- free-standing termitarium-like mounds (often in sedgeland and *Sporobolus* grassland, though also in mangroves),
- excavated nests within supralittoral banks (often built amongst peat and roots in bank), and
- mounds built against tree bases (often surrounding a natural cavity within living or dead trees and within the mangrove zone or at/near marine/terrestrial boundary) (Van Dyck and Gynther 2003).

Nests often occupy naturally elevated ground and utilise the bases of fallen trees or logs for consolidation of the nest structure (Van Dyck 1997; Van Dyck and Durbidge 1992; Van Dyck and Gynther 2003). Once constructed, nests are continuously added to, with the larger mounds or nests having potential to provide significant historical information about populations and habitats over time (Van Dyck 1997).

EPA (2008b) identifies that in south-east Queensland, high density water mouse populations occur within the Great Sandy Strait (including Tin Can Bay), Pumicestone Passage and southern Moreton Bay (including the western shores of North and South Stradbroke Islands). A large percentage of the water mouse population in the Moreton Bay area occurs in intertidal habitats within the Moreton Bay Ramsar site (EPA 2008b). Within Moreton Bay, the species has been recorded at the following locations: Pumicestone Passage (Gallagher Point, White Patch, Bukllock Creek CP, Donnybrook), North Stradbroke Island (Amity, Chiggil Chiggil, Rainbow Channel, Canalpin Creek, Myora Springs, Two Mile, Deanbilla, Stockyard), Steiglitz, Jacobs Well, Pimpama River Conservation Area, Coomera River, South Stradbroke Island (Van Dyck 1997; Van Dyck and Gynther 2003; GCCC 2008; EPA 2008b). Habitats along the western side of North Stradbroke Island and those within the southern part of the bay (Macleay Island to Coomera) appears to be a stronghold for the water mouse.

The water mouse is a relatively recent discovery to science, so no known reduction in historical range can be accurately compared to current distribution estimates (EPA 2008b). It is highly probable that Moreton Bay supports in excess of 1% of the population of Water Mouse (I. Gynther, pers. comm.. 2008).

Australian Painted Snipe

Australian painted snipe *Rostratula australis* is listed as *Vulnerable* under the provisions of the NCA and EPBC Act.

The Australian painted snipe is a secretive, crepuscular species that occurs on well vegetated shallow, permanent or seasonal wetlands, usually freshwater but occasionally brackish (Marchant and Higgins 1993; Geering *et al.* 2007). This species is has also been recorded in the following habitats: inundated grasslands, saltmarsh, dams, rice crops, sewage farms and bore drains (Marchant and Higgins 1993; Geering *et al.* 2007). Australian painted snipes require dense vegetation cover for roosts (often tall grass) and forage on soft muds and in shallow water for seeds and invertebrates, including crustaceans and molluscs invertebrates (Marchant and Higgins 1993; Geering *et al.* 2007). Occurrence is erratic and unpredictable (often in response to local rainfall), seldom remaining long in any locality (Marchant and Higgins 1993; Geering *et al.* 2007).

Australian painted snipes have a patchy distribution throughout Australia, with most records being in the south-east (Marchant and Higgins 1993) and within its range, inland swamps with temporary water regimes are considered a stronghold (Geering *et al.* 2007). Records are erratic, the species being absent from areas in some years and common in others. Nests are located on the ground in swamps and grassland and nesting in Queensland mainly occurs during and after the wet season, e.g. December to May (Marchant and Higgins 1993; R. Jaensch, pers. comm..2008). A breeding stronghold occurs within the Murray-Darling region, though breeding recorded throughout eastern and northern Australia (Marchant and Higgins 1993; Geering *et al.* 2007).

Within the study area, this species has been recorded from North Stradbroke Island and mainly freshwater and brackish wetlands (e.g. Eighteen Mile Swamp - Vernon and Martin 1975; Black Snake Lagoon - Lewis Environmental Consultants 1995; Lytton, Luggage Point and Nudgee wetlands EPA 2008b).

Little Tern

The little tern *Sterna albifrons* is listed as *Endangered* under the provisions of the NCA.

Little terns inhabit sheltered coastal environments of estuaries, river mouths, inlets and harbours, particularly those which support sand spits and exposed sandbanks (Higgins and Davies 1996). Little terns feed singly or in small groups on fish taken from the water surface, although often roosting in large flocks on beaches or sand spits with other terns (Smith 1990; Higgins and Davies 1996). Nesting is colonial (often traditional sites) with preferred nesting habitat characterised by sandy substrate on flat or gently sloping topography, usually within 150m of water, preferably between the high tide mark and littoral vegetation (Smith 1990; Higgins and Davies 1996). An abundance of shells, small pebbles & sparse clumping vegetation cover may be critical factors in breeding success (Smith 1990).

Internationally, the little tern has a wide but patchy distribution in Europe, Africa, Asia and Australia (Higgins and Davies 1996). The subspecies *Sterna albifrons sinensis* (Little Tern (western Pacific)) is the only form of the species that occurs in Australia (TSSC 2007). There appears to be three separate populations of subspecies *sinensis* in Australia: a Northern Australian population (it is unclear whether the breeding birds are sedentary, migratory or both); an Asian population (non-breeding spring-summer migrants to Australia); and a South-eastern Australian population (spring-summer breeding migrants to southern Australia, including south-eastern Queensland (north to Bundaberg)) (NSW NPWS 2003; TSSC 2007). The small size of the south-east Australian breeding population is likely to be masked by the presence of relatively large numbers of migrants from breeding sites in Asia in summer (Garnett 1992).

At least two populations are likely to occur in south-east Queensland (both Asian and Australian breeding populations), though birds can not be distinguished from each other (Agnew and Stewart 1998). Within inshore and offshore waters of North Stradbroke Island, little terns were considered a common summer migrant, being most numerous March to May (Smyth and Corben 1984). Within Moreton Bay, little terns are considered common, particularly in summer when migrant birds are present (Agnew and Stewart 1998).

The south-eastern Australia breeding population is estimated to be around 1,000 breeding birds, and based on 1998 data, 62 birds bred in Queensland (TSSC 2007). Garnett and Crowley (2000) reported 40 known breeding colonies in Queensland, though only 27 known to have been used recently.

Significant counts of little terns have been recorded in the northernmost section of Pumicestone Passage. On sandbanks near the Caloundra bar, counts of greater than 11,000 birds, principally *Sterna albifrons sinensis*, have been recorded (Chan and Dening 2007). The north-eastern beaches and sand spit of the South Stradbroke Island are also support important roost sites (Sonnenburg 2006; Searle 2006).

Australasian Bittern

Australasian bittern *Botaurus poiciloptilus* is listed as is listed as *Endangered* (IUCN 2007).

The Australasian bittern inhabits terrestrial and estuarine wetlands, though preferring permanent freshwater wetlands which support a combination of tall, dense vegetation (e.g. bullrushes *Typha* spp. and spikerushes (*Eloacharis* spp.) and short dense vegetation including sedges, rushes and reeds (Marchant and Higgins 1990; Garnett and Crowley 2000). This shy and cryptic bird, roosts, feeds and breeds within dense vegetation cover (Marchant and Higgins 1990). Garnett and Crowley (2000) considered that their comparatively specialised habitat requirements, this species may be more sensitive to overall habitat loss than are many wetland species.

The Australian population is estimated to be around 2,500 birds, most of which are in the Murray Darling basin and adjacent coastal areas (Garnett and Crowley 2000; IUCN 2007). Whilst there are no current records for the site, birds may possibly occur within large densely vegetated wallum swamps of Moreton and North Stradbroke Islands which appear potentially suitable. The combination of the species' cryptic habits and the difficulty of accessing and surveying favoured habitats means that this species is may have been overlooked by general fauna surveys of potential habitat.

Table 7-14 outlines a summary of the key attributes of the critical service.

Table 7-14 Critical Service 4

Summary Table	**Critical Service (S4)**
Reason for Inclusion	Key services provided by the site in regards to threatened fauna comply with the Ramsar Nomination Criteria 2, in that the site supports endangered and vulnerable fauna, Criteria 4, in respect to support for animal species at critical life stages in their life cycles.
Type of Service	Supporting – threatened fauna species.
Description of Service (quantify if possible)	The site supports records of, and habitat suitable for, nine threatened wetland-dependant terrestrial fauna as outlined in the text. A tenth species, the Australasian bittern has not been recorded currently but may utilise the site due to suitable habitat.
Spatial Application (if relevant)	This service applies to the whole site, though important localities and habitats are the outer sand islands (Bribie, Moreton and North Stradbroke Islands), estuarine environments of Pumicestone Passage and southern Moreton Bay, and inshore waters. Refer to species accounts for important localities.
Critical habitat components underpinning this service	• Mangrove forests and associated intertidal areas (Illidge's ant blue butterfly, beach stone-curlew and water mouse) • Freshwater and wallum wetland habitats (acid frogs, water mouse, Australasian bittern and Australian painted snipe) • Nearshore and offshore open waters and rivers (little tern) • Supralittoral wetlands, including salt marsh and sedgelands (water mouse and Australian painted snipe) and adjacent forest (Illidge's ant blue butterfly and beach stone-curlew) • High tide roost sites, including open beaches (beach stone-curlew and little tern).
Critical species underpinning this service	Food - crustaceans and molluscs invertebrates of freshwater/brackish wetlands (Australian Painted Snipe), invertebrates of freshwater wetlands (acid frogs), intertidal crustaceans, pulmonate snails, marine gastropods and other invertebrates (water mouse, beach stone-curlew), nectar of flowers, including mangroves, eucalypts, *Parsonsia* spp. (Illidge's ant blue butterfly), small surface active schooling fish (little tern). Habitat - mangroves supporting *Crematogaster* sp. Ant (Illidge's ant blue butterfly); shallow wallum wetlands (permanent or ephemeral) which support highly acidic, non-turbid, oligotrophic waters (acid frogs); shallow wallum wetlands with emergent macrophytes (wallum sedgefrog); broad intertidal areas within mangrove forests (beach stone-curlew, water mouse); and densely vegetated wetlands (Australian painted snipe).
Critical processes underpinning this service	Maintaining the service over time is most dependant on the following: • Water Quality. In regards to all three wallum-dependent acid frog species - maintenance of water quality of island wetlands (esp. pH, nutrients and dissolved oxygen). In regards to little tern - maintenance of water quality (light, salinity, turbidity, suspended solids, nutrients). • Hydrology (freshwater wetlands). In regards to all three wallum-dependent acid frog species - maintenance of the water table (water depth and groundwater interaction in lakes, swamps and creeks) and groundwater interactions with surface water. "Perched" wetland systems are dependent of direct rainfall recharge and sub-surface infiltration from surrounding dunal systems.

Summary Table	Critical Service (S4)
	• Hydrology (tidally influenced wetlands). In regards to beach stone-curlew and water mouse – maintenance of natural patterns of tidal inundation and freshwater flows to intertidal and supralittoral wetland systems. • Climate. In regards to all three wallum-dependent acid frog species - precipitation and evaporation rates will determine supply and water levels in terrestrial wetland environments. The level of rainfall is important in terms of the high dune system supply which subsequently links into the permanent lakes and swamps. • Fire Regime. In regards to all wallum-dependent acid frog species - natural fire regime in relation to island wetlands is maintained. • Biological/Biophysical Processes. In regards to Illidge's ant blue butterfly, all three wallum-dependent acid frog species, beach stone-curlew, Australian painted snipe and water mouse - maintenance natural vegetation patterns, extent, health, and interconnectivity is critical to their long term condition. In regards to all threatened taxa - maintenance of key biological processes occurring at the site such as growth, reproduction, recruitment, feeding and predation.
Natural Variability (if relevant)	Patterns in abundances of all fauna species are thought to vary across a range of spatial and temporal scales. There are significant constraints to assessment of Illidge's ant blue butterfly, Australian painted snipe and water mouse due to their highly cryptic nature. Potentially the most detailed data set relates to migratory shorebirds, though such data is not currently in a form which enables detailed analysis. Population data for the remaining species is not comprehensive.
Principal threats	Habitat loss, fragmentation and degradation due to development (all species), water quality degradation (all species), changes to freshwater inflows to wallum wetlands (acid frogs), groundwater extraction (acid frogs, Australasian bittern, and Australian painted snipe).
Data quality underpinning this critical service	Service – Level 2-3 (population survey data outdated, insufficient scale). Components – Level 2 (outdated, insufficient scale). Processes – Level 1-2 (water quality); 2 (freshwater flows); 2 (tidal data).
Information gaps	• Natural population variability for all species and factors controlling these changes. • Sustainability of beach stone-curlew pairs (and breeding success) (particularly related to impacts of recreational activities) and water mouse populations (in relation to development or degradation of habitat adjoining the site). • Extent of populations of acid frogs and water mouse outside/adjoining study area boundaries. • Systematic information to assess background variability in wetland community structure and linkages to controlling processes; environmental flow requirements of acid frogs; impacts of introduced species (acid frogs, beach stone-curlew, little tern) and congeneric competitors (to acid frogs). • Locations and sustainability of little tern nesting sites (primarily in southern parts of site). Longer-term variability in patterns of usage of little tern roost sites.
Recommended monitoring	Acid frogs - Identify key populations and for those populations, monitor presence/absence, breeding evidence (tadpoles and metamorphs), and maintenance of parapatry between acid frog and congeneric sibling species during optimum breeding conditions until markers/trends of population variability are evident. Quarterly monitor water quality for key population sites (salinity, pH range 3-5, dissolved oxygen, nitrate levels (maintain <0.7 mg/L) and other toxicants (e.g. monomeric Aluminium and surfactants)). Assess impacts of fire on habitat of key frog populations from fires. Beach stone-curlew – Monitor habitat usage and breeding activity within key habitat areas (annual). Little tern – Identify locations and sustainability of nesting sites (primarily in southern parts of site) (yearly). Monitor abundance and pattern of usage at key roosts within northern Pumicestone Passage and northern sector of South Stradbroke Island (annual). Water mouse – Identify full extent habitat within and outside the site and monitor nest activity and diversity of nest types as surrogate for species distribution and abundance (annual and during breeding period).

7.5 Service 5 ~ Wetland Flora Communities and Species

Photos of Swamp Orchid (© Shane Ruming), Freshwater wetland North Stradbroke Island (Source: BMT WBM Photo Library) and Lesser Swamp Orchid (© Shane Ruming)

The Moreton Bay Ramsar site supports a diverse array of vegetation communities. While none of the wetland communities present within the site are listed nationally, one and four wetland RE's present are listed at the State-level as Endangered and Of Concern respectively (EPA 2007c, 2008a; refer Table 7-15). The Endangered wetland RE is riverine gallery rainforest (RE 12.3.1), and is represented in Bribie Island National Park. One Of Concern wetland RE is estuarine open forest (RE 12.1.1), and is represented in Bribie Island National Park and in the southern Bay. The three remaining Of Concern RE's are all palustrine in nature, including two open forest wetlands (RE's 12.3.4 and 12.3.11) and one sedgeland swamp (RE 12.3.8). These wetlands are predominantly located on the Bay islands.

Numerous endangered and vulnerable flora species are known to occur within Moreton Bay; including five nationally-listed species that are wetland-dependent (refer Table 7-16). Particularly noteworthy species include the endangered swamp daisy (*Olearia hygrophila*) that is endemic to North Stradbroke Island, known only from two locations on the island; and three endangered swamp orchid species (*Phaius australis, P. bernaysii* and *P. tancarvilleae*) that are rarely seen on the mainland but are more frequently encountered on the Bay islands (SGAP 2005).

Categories of critical processes underlying this service were identified as hydrologic (tidal regime; freshwater inundation regime; groundwater), geomorphologic (age of the underlying sand deposits; sedimentation; erosion) and biologic (reproduction). Variations in processes within these three categories have the potential to substantially alter the flora of Moreton Bay. For example, hydrologic changes such as variation in water quality may impact flora species that are sensitive to nutrient levels, and changes in the depth of the water table may significantly impact the survival of wetland flora; geomorphologic changes may impact flora communities due to changes in substrates; and changes to reproductive processes may significantly impact the persistence of species over time.

Currently, flora communities and species of conservation significance are under threat from a range of processes, principally invasion by exotic weed species and changes to hydrology and water quality. Additional threats on a more localised scale include damage to vegetation by feral animals such as pigs and goats, inappropriate fire regimes and destruction of plants by recreational activities (QPWS 2007).

Knowledge of the biology and ecology of important plant species, such as *O. hygrophila*, is extremely limited (Bostock and Thomas 1992). In particular, research has neglected, been unable to definitively address groundwater dependencies for communities and species in Moreton Bay, or understand species tolerance to salinity and desiccation (refer Marshall et. al. 2006 in relation to recent studies of groundwater dependant ecosystems on North Stradbroke Island).

Quantifying specific limits of acceptable change should - at a minimum - aim to maintain the biodiversity and integrity of natural ecosystems, and ensure that Endangered and Vulnerable flora communities and species within the site persist into the future. Further, species of significance should maintain their current conservation status (i.e. not be upgraded from Rare to Vulnerable, Vulnerable to Endangered, Endangered to Critically Endangered). In order to more precisely quantify limits of acceptable change through the estimation of thresholds, it is necessary to address various shortcomings in the current knowledge. This includes conducting systematic flora surveys and mapping significant flora. This would assist in specifying acceptable percentages regarding reductions in spatial extent for vegetation communities or in population numbers for flora species. Additionally, systematic surveys and mapping would assist in prioritising targeted areas for conservation and management actions, as well as monitoring strategies. Research on aspects such as groundwater dependency, tolerance to desiccation and reproductive dynamics would enable the development of relatively accurate predictions of future extents of vegetation communities and viability of populations.

Table 7-17 contains a summary of the key attributes of this critical service.

Table 7-15 Threatened wetland ecological communities occurring within the Moreton Bay Ramsar site

RE	Status*	Description	Protected areas
12.3.1	Endangered	Gallery rainforest (notophyll vine forest) on alluvial plains	Bribie Island NP
12.1.1	Of concern	*Casuarina glauca* (Swamp Oak) open forest on margins of marine clay plains; may also include *Melaleuca quinquenervia* (Broadleaved Paperbark) and/or mangroves	Bribie Island NP, Broadwater CP, Southern Moreton Bay Islands CP, Coombabah CP
12.3.4	Of concern	*Melaleuca quinquenervia, Eucalyptus robusta* (Swamp Mahogany) open forest on or near coastal alluvial plains	Bribie Island NP
12.3.8	Of concern	Freshwater swamps with *Cyperus* spp. and *Schoenoplectus* spp.; associated with floodplains	Moreton Island NP
12.3.11	Of concern	Open forest to woodland of *Eucalyptus siderophloia* (Grey Ironbark), *E. tereticornis* (Queensland Blue Gum) and *Corymbia intermedia* (Pink Bloodwood) on alluvial plains	Bribie Island NP

*Conservation status under the *Vegetation Management Act 1999*

Table 7-16 Nationally Endangered wetland flora species occurring within the Moreton Bay Ramsar site

Scientific name	Common name	EPBC*	NCA*
Olearia hygrophila	Swamp Daisy	E	E
Persicaria elatior	Knotweed	E	V
Phaius australis	Lesser Swamp Orchid	E	E
Phaius bernaysii	Yellow Swamp Orchid	E	E
Phaius tancarvilleae	Swamp Orchid	E	E

*EPBC = *Environment Protection and Biodiversity Conservation Act 1999*

NCA = *Nature Conservation Act 1992*

E = Endangered

V = Vulnerable

Table 7-17 Critical Service 5

Summary Table	**Critical Service (S5)**
Reason for Inclusion	• Supports Vulnerable or Endangered species (Criterion 2). • Supports a plant species at a critical stage of its life cycle (Criterion 4).
Type of Service	Supporting
Description of Service (quantify if possible)	Supports one Endangered and four Of Concern wetland RE's, as well as five nationally Endangered wetland plant species.
Spatial Application (if relevant)	Applicable to various habitats across the site as a whole, but predominantly the Bay islands.
Critical habitat components underpinning this service	With respect to the Ramsar Wetland Types, the following are the key habitat types for the critical flora species and communities: intertidal forested wetlands (Type I), permanent streams and creeks (Type M), freshwater marshes and pools (Types Tp and Ts) and freshwater tree-dominated wetlands (Type Xf).
Critical species underpinning this service	*Acacia baueri* subs. *baueri, Maundia triglochinoides, Olearia hygrophila, Persicaria elatior, Phaius australis, Phaius bernaysii, Phaius tancarvillea* and *Thelypteris confluens*.
Critical processes underpinning this service	• Hydrologic: tidal regime, freshwater inundation regime, groundwater • Geomorphologic: sedimentation, soil erosion • Biologic: reproduction
Natural Variability (if relevant)	Communities and species will continue to exist under normal hydrological regimes, geomorphologic processes and climatic conditions.
Principal threats	• Weed invasion • Changes to hydrology and water quality
Data quality underpinning this critical service	• Flora communities: Level 2, quantitative based on current RE mapping (EPA 2008a) and a range of general papers and studies. • Flora species: Level 3, semi-quantitative based on online species searches (as opposed to systematic surveys) and a range of non-specific papers and studies.
Information gaps	• Systematic surveys of flora and mapping of significant species is lacking. • Research to understand groundwater dependencies for communities and species is very limited. • Research to identify species tolerance to salinity and desiccation is lacking.
Recommended monitoring	Systematic flora surveys would quantify the representation of wetland communities and species of conservation significance within the Ramsar site. This would assist in prioritising targeted areas for conservation and management actions, and in specifying limits of acceptable change more accurately (i.e. in terms of percentage area for RE's or population numbers for species).

7.6 Service 6 ~ Shorebird Populations

Photos of various shorebird species (source: BMT WBM Photo L brary)

The significance of Moreton Bay, including Pumicestone Passage, as a site of national and international significance for migratory shorebirds has been widely described (Thompson 1990a; Driscoll 1993; Watkins 1993; Hulsman *et al.* 1993; Driscoll 1997; Bamford and Watkins 2003; EPA 2005b; Geering *et al.* 2008; Bamford *et al.* 2008). Moreton Bay is also significant for a large waterbird population (Nichols and Maher 1999).

Moreton Bay supports a high abundance of shorebirds. During the summer months, Moreton Bay habitats support over 3500 resident and between 40,000 to 50,000 migratory shorebirds (Thompson 1990a; Driscoll 1993; Watkins 1993; Driscoll 1997; EPA 2005b). This equates to approximately 10% of maximum number of shorebirds migrating to Queensland over the summer period (Driscoll 1993; Watkins 1993; Driscoll 1997).

Moreton Bay also supports a high diversity of shorebirds. Ten resident and 32 migratory shorebird species are regularly recorded in Moreton Bay (Thomson 1990; EPA 2005b). Nationally, 18 species are considered resident, at least 36 migratory shorebird species are regularly recorded, and a further 21 are considered vagrant species (occasionally recorded-less than five records annually) in Australia (Priest *et al.* 2002; Birds Australia 2008).

Moreton Bay supports significant numbers of individual waterbird species, e.g. Eastern curlew *Numenius madagascariensis* (3000 to 5000 birds, approximating 20% percent of the species' population) and grey-tailed tattler *Tringa brevipes* (>10,000 birds, approximating 50% percent of the species' population) (Driscoll 1997; Finn *et al.* 2002; EPA 2005b). Bamford *et al.* (2008) considers Moreton Bay to be the third most significant site for Eastern curlew within the East Asian–Australasian Flyway.

Existing data demonstrates that the 1% species population threshold has been exceeded for the following species: bar-tailed godwit *Limosa lapponica*, whimbrel *Numenius phaeopus*, Eastern curlew *Numenius madagascariensis*, terek sandpiper *Xenus cinereus*, grey-tailed tattler *Heteroscelus brevipes*, curlew sandpiper *Calidris ferruginea,* pied oystercatcher *Haematopus longirostris*, Pacific golden plover *Pluvialis fulva*, and lesser sand plover *Charadrius mongolus* (Lane 1987; Thomson 1993; Driscoll 1997; Finn *et al.* 2002; QWSG 2008 unpublished data; Geering *et al.* 2007; Birds Australia 2008; Bamford *et al.* 2008).

In respect of migratory shorebirds, four main roost types and key habitat types have been identified (Thompson 1990a and 1992). These are:

- Open sandy islands or beaches – Moreton, Bribie and North Stradbroke Islands. Only two similar roosts known on, or adjacent to, the western side of Moreton Bay. These types of roosts are used by most species.

- Salt and clay pans - within and adjacent to mangrove communities. Birds may find cover under mangrove trees or shelter within clumps of samphire and sedge. These roosts are used by most species.

- Inland freshwater marshes - restricted to the western side of the Bay and used by some species at all stages of the tidal cycle.

- Mangroves - the preferred roosting sites for grey-tailed tattler, whimbrel, and terek sandpiper, though often used by other also used by others less frequently, e.g. curlew sandpiper and common greenshank *Calidris nebularia*.

112 roost sites have been identified in Moreton Bay, though only 15 are considered to be suitable roosts above the highest astronomical tide (HAT) (Lawler 1995; Miller 1997; Nichols and Maher 1999). A significant number of these roosts are considered threatened by development and by their definition beyond the boundary of the marine park (Nichols and Maher 1999; EPA 2005b). The largest roost sites occur at the Port of Brisbane and Manly Boat Harbour (adjacent to western side of Ramsar site), Mirapool on Moreton Island, and within Pumicestone Passage (i.e. Toorbul) (Driscoll 1997). In response to loss of more natural roost sites, there are a variety of sites where shorebirds are using artificial structures and substrates. Notable amongst these sites, are the purpose built roosts, i.e Kakadu Beach (Bribie Island), Empire Point (near Raby Bay) and at the Port of Brisbane (Fisherman Islands, Brisbane River mouth).

Shorebird feeding habitat varies throughout Moreton Bay, with the primary differences relate to intertidal substrate type, i.e. being predominately finer, muddier sediment associated with the western side of the bay in contrast to the sandier sediment along shores on the eastern side of the bay. Notable, though of limited extent, are smaller areas of coarse coral and rock rubble around the islands of central Moreton Bay (Mud, St. Helena and Green islands), Wellington Point and Redcliffe Peninsula These feeding substrate differences influence the relative numbers and shorebird species which occur throughout the bay (Driscoll 1997). Feeding substrates along the western side of the bay exhibit greater levels of variation as they are influenced to a greater extent by human influence (e.g. sewage outfalls, direct stormwater discharges, sediment, etc.) (Thomson 1990 and 1992; Driscoll 1997).

The expansive flats at the southern end of Moreton Island and the western side of North Stradbroke Island to Russell Island hold the highest concentrations of waders anywhere in the Bay (Driscoll 1997). Whilst areas of intertidal flats adjoining the outer islands are less common than those adjoining mainland areas, they are the preferred habitat of several species (e.g. Eastern curlew, bar-tailed godwit *Limosa lapponica*) and support a higher proportion of adult birds for some species (Thomson 1990b; Finn 2008).

Major feeding areas within the western side of the bay include: Pumicestone Passage (i.e. Tripcony Bight and between Donnybrook and Toorbul), Deception Bay, Hays Inlet and shoreline between Nudgee south to Redland Bay (Driscoll 1997). Within the southern part of the bay, feeding habitat is characterised by relatively narrow intertidal flats associated with an extensive network of channels and waders occur in much lower densities (Driscoll 1997).

Threats to shorebirds and their habitats in Moreton Bay include:

- Water pollution – includes any pollution (point and/or diffuse source) which might negatively impact on invertebrate prey populations, e.g. sediment inputs which can smother intertidal substrates, increases water turbidity leading to reductions in epibenthic algae and seagrass; organic nutrient inputs (e.g. sewage discharge, urban nutrient runoff) leading to eutrophication (resulting in excessive macro-algal growth) and alteration of intertidal invertebrate species composition; and episodic pollution events such as oil spills (particularly relevant to habitats adjacent to Brisbane River mouth). It should be noted that some polychaete worms and bivalve molluscs have benefited from nutrient enrichment, which in turn has provided food to support greater densities of curlew sandpiper and great knot, but other species such as grey-tailed tattler, which prefer to forage in areas of seagrass, have declined dramatically (e.g. Bramble Bay and Luggage Point; see Thomson 1993; Harding and Wilson 2008).

- Alterations to hydrodynamics – permanent changes to tidal regimes (current speed and direction) can impact on current velocity (increases and decreases) which in turn affect intertidal and roost habitats (through changes in erosion and deposition rates).

- Roost habitat loss – Whilst the form and location of many roost sites are subject to natural changes over time (e.g. Eastern banks), Moreton Bay has previously experienced an unquantified but considerable loss of habitat as a result development of the coastal zone (e.g. marina and canal developments, and reclamation for industrial lands) (EPA 2005b). Whilst a large proportion of roost sites are currently within protected land tenure, there are sites which occur on privately owned lands which are not subject to the same level of protection.

- Human associated disturbance – In southeast Queensland, management of anthropogenic disturbances is regarded as a key issue for shorebird conservation management, particularly at high tide roost sites (Nichols and Maher 1999). Shorebirds are particularly vulnerable to disturbance from direct impacts at nesting areas to indirect impacts on food sources and at roost sites, and activity can impact on shorebirds more than 200m away (Thompson 1992). Disturbance to shorebirds (generated human activity and by companion animals) can result from poor separation between coastal recreational activities and/or urban development and roost sites (e.g. Mirapool, Manly Boat Harbour). Disturbance to both migratory and resident shorebirds (roosting and breeding) can occur as a direct result of human activities, e.g. recreational activities such as 4WD vehicles on beaches (Moreton and North Stradbroke Islands) and boating around feeding and roost sites (e.g. Days gutter, Amity banks). For resident shorebirds, this disturbance and also lead to reduced breeding success through nest destruction or abandonment, or succumbing to predators associated with humans, such as dogs, black rats *Rattus rattus*, silver gulls *Larus novaehollandiae* or ravens *Corvus* spp. (Priest *et al.* 2002). Nests of a variety of resident shorebirds (e.g. pied oystercatcher and red-capped plover) are frequently disturbed by vehicles on ocean beaches in south-east Queensland (EPA 2005b). As many of these species occur at low densities in an essentially linear habitat, local extinctions could easily become regional ones (Garnett and Crowley 2000; EPA 2005b).

Table 7-18 Critical Service 6

Summary Table	**Critical Service (S6)**
Reason for Inclusion	Key services provided by the site in regards to migratory shorebirds complies with Ramsar Nomination Criteria 3, 4 and 5 in regards to shorebird abundance and diversity, provision of over-wintering and flyway staging habitat, and Criteria 6, in regards to exceeding the 1% species population threshold for nine shorebird species.
Type of Service	Supporting – migratory shorebirds
Description of Service (quantify if possible)	The site supports: • high shorebird diversity and represents almost 90% of the migratory shorebird species regularly occurring in Australia and approximately 55% shorebird species resident in Australia. • high shorebird abundance with a variety of counts (individually &/or collectively) which provide evidence that in excess of 20,000 shorebirds occur within habitats of the site each year. Population counts for the site equate to approximately 10% of maximum number of shorebirds migrating to Queensland over the summer period. • nine shorebird species (eight migratory and one resident species) for which the 1% species population threshold is exceeded. • critical overwintering habitat and a flyway staging area (both northern and southern migration routes) for migratory shorebirds.
Spatial Application (if relevant)	Intertidal sand/mud flats, rocky shores and mangrove communities throughout the site, intertidal areas of coarse rubble associated with central bay islands (Mud, St. Helena and Green islands) and western shores (Wellington Point and Redcliffe Peninsula), high tide roost sites throughout the site (natural and artificial).
Critical habitat components underpinning this service	Expansive intertidal flats; a diversity of feeding substrates (e.g. soft muds and sands, substrates supporting seagrass, coral and rock rubble); and a diversity of disturbance-free high tide roost sites (e.g. above and below HAT, clay pans, saltmarsh, exposed sand banks, mangroves, rocky shores) which are spatially proximate to suitable feeding grounds.
Critical species underpinning this service	Food - A diversity and abundance of epi/infauna of the intertidal flats, e.g. polychaete worms, bivalve molluscs, and crustacea. Habitat – Mangroves (roost sites and nutrient inputs to associated intertidal areas); seagrass associated with intertidal areas (preferred feeding habitat for Grey-tailed Tattler; often supports a richer prey base for shorebirds generally).
Critical processes underpinning this service	• Tidal influences - maintenance of natural patterns of tidal inundation. Tidal inundation influences intertidal feeding habitat characteristics, i.e. overall extent, bioproductivity and daily availability to shorebirds. Tidal and wave regimes influence the biophysical processes in the development and maintenance of feeding and roost habitats. • Freshwater flow regimes – Pine, Brisbane, Pimpama and Coomera Rivers contribute the bulk of fluvial sediment to the western side of the bay. These sediments influence intertidal habitat suitability for shorebirds with comparatively higher influence on intertidal areas adjacent to and nearby river mouths. • Biological Processes - Primary and secondary bioproductivity of seagrass, algae and micro- and macro-invertebrates within intertidal habitats are crucial processes in supporting adequate shorebird food requirements. • Water quality – Required for maintenance of high primary and secondary bioproductivity on intertidal feeding areas.
Natural Variability (if relevant)	76% of the shorebirds regularly occurring within the site are migratory, though a small proportion remains in the bay during the non-breeding period (austral winter). The populations of migratory species fluctuate seasonally and the reasons for such changes are not well understood. Fluctuations may be influenced by local factors and/or influenced by external factors (impacts to breeding habitat and sites essential for migration within the East Asian-Australasian Flyway). Declines in shorebirds abundance and species composition have been recorded within the site (e.g. Fisherman Islands; Driscoll 1996 and 1998), though the sampling periods have been relatively short and do not provide conclusive evidence as to any particular factor, i.e. links to habitat loss and/or habitat alterations and/or an overall decline in the bay's shorebird population. Whilst local databases are data rich, data is not currently in a form which can be readily analysed.
Principal threats	• Water quality degradation – Point and/or diffuse source pollution which negatively impacts on epibenthic algae, seagrass, and invertebrate prey populations. This includes: sediment, organic nutrient inputs (e.g. sewage discharge, urban nutrient runoff), toxins (including persistent herbicides and biocides), and episodic pollution

Summary Table	Critical Service (S6)
	events such as oil spills. • Alterations to hydrodynamics – Changes to tidal regimes (current velocity and direction) which influence changes in erosion and deposition patterns, particularly in relation to establishment and maintenance of intertidal habitats. • Anthropogenic disturbances - Disturbance to shorebirds on feeding grounds and at roost sites generated human activity and companion animals. • Roost habitat loss – Whilst a large proportion of roost sites are currently within protected land tenure, there are sites which occur on privately owned lands which are vulnerable and not subject to the same level of protection. In addition, there is an imperative to maintain a suitable geographic spread of a combination of non-HAT and HAT roost sites which are spatially proximate to suitable feeding grounds. • External factors - Loss of roost and feeding habitat and birds within the Flyway.
Data quality underpinning this critical service	Service – Level 2-3 (potential inaccuracies in collected data, limited capacity to interrogate data). Components – Level 2 (outdated, insufficient scale). Processes – Level 1-2 (water quality); 2 (tidal data).
Information gaps	• Indices/trends for shorebird abundance and diversity over time, patterns of roost and feeding habitat usage. • Natural population variability for all species and factors controlling these changes. • The proportion of the site's shorebird population which is associated with feeding and roosting outside the Ramsar site boundary. • Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh. • Information on natural population variability of invertebrate prey and factors controlling temporal changes. • Current distribution and categorisation of roost habitats (e.g. size, level of disturbance, position in relation to HAT and feeding grounds) within and adjacent to study area boundaries. • Data on shorebird numbers and changes in populations within other parts of the Flyway.
Recommended monitoring	• Early and late summer monitoring events at key roost sites and feeding grounds (to be conducted annually) to target bar-tailed godwit, Eastern curlew and Pacific golden plover (species which currently exceed the 1% threshold and which may provide useful surrogate for numbers of other shorebirds using the site and of habitat usage). • Annual audit of roost sites (condition and use). • Monitor habitat usage and breeding activity (annual) within key habitat areas on outer bay islands

7.7 Service 7 ~ Fisheries

Photos sourced from BMT WBM Photo Library

The Moreton Bay Ramsar site supports high fisheries resource values, including:

- Provision of shelter and food resources for fish, crustaceans (crabs, prawns) and other shellfish (including oysters) of high commercial and recreational fisheries value;
- High value commercial and recreational fishing industries;
- Indigenous cultural values (noting that these values are addressed as part of Service 8 and are not addressed further below).

Habitats

The site supports a wide diversity of habitats utilised by species of direct fisheries values, including mangroves, saltmarsh, seagrass, unvegetated sand and mud flats, estuarine creeks, offshore channels and reef environments. In general terms, fisheries productivity of an estuary is thought to be a function of its geomorphic conditions, which is a function of the degree of infilling (e.g. Roy *et al*. 2001; Saintilan 2004). From an estuary geomorphology perspective, Moreton Bay is classified as a wave-dominated estuary that is comprised of four types of depositional environment or estuary zones (Rochford 1951; Roy *et al*. 2001):

- **Marine tidal delta**, which extends along the Eastern Bay. The geomorphology of this zone is dominated by wave action and is well flushed by marine waters. Structural habitat complexity is lower than found in fluvial delta environments in Western Moreton Bay, but nonetheless, this zone contains significant fish habitat resources in the form of seagrass beds (i.e. Amity Banks) and 'unvegetated' sandy banks;
- **Central mud basin**, which includes deeper areas between the marine tidal deltas of Eastern Moreton Bay, and fluvial delta environments of Western Moreton Bay. This zone is not well represented in the Ramsar site;
- **Fluvial delta**. The central western foreshore of Moreton Bay contains numerous fluvial deltas associated with the rivers and creek systems draining the Moreton Bay catchment. Southern Moreton Bay is dominated by fluvial deltas of the Logan, Coomera and Pimpama Rivers. Fluvial

delta zones typically contain the most complex physical settings and habitat types of the four estuary zones, including mud flats, mangroves, saltmarsh, seagrass, and creek channels;

- **Riverine channel and alluvial plain**. This zone is situated in areas where the alluvial plains are intersected by the river channel. This zone typically has limited structural habitat complexity, and has highly variable salinities that are a function of tidal flows and river discharges. This habitat zone type is not well represented within the Moreton Bay Ramsar site, the possible exception being upstream sections of the Coomera River.

At broad spatial scales (regional), the fluvial delta environments of Western and Southern Moreton Bay can be considered to represent structurally complex environments compared to other three estuary zones in the broader Moreton Bay region. These nearshore environments also have relatively high species richness of macroinvertebrates and fish compared to other environments in the Bay (e.g. Stephenson *et al.* 1970; Davie and Hooper 1998).

The western side of Moreton Bay contains a range of mangrove-lined creeks and rivers (and associated saltmarsh communities) of varying complexity and size, several of which are protected as Fish Habitat Areas. From north to south, the major tidal creeks and rivers within the site include Caboolture River, Burpengary Creek, Hays Inlet, Pine River, Cabbage Tree Creek, Nundah Creek, Nudgee Creek, Jubilee Creek, Brisbane River and Boggy Creek, Crab Creek, Tingalpa Creek, Eprapah Creek; Logan-Albert River; Pimpama River and Coomera River. By contrast, the sand islands that form the eastern edge of Moreton Bay do not contain rivers or major creek systems.

The mangroves, saltmarsh and tidal channels found on these fluvial delta environments and creek environments provide important fisheries habitat and foraging areas. For example, saltmarsh communities within the study site are inundated tidally during high water spring events, and are known from case-studies elsewhere to provide functional habitats and foraging areas for a range of fish (typically small-bodied non-commercial species) and nektobenthic crustaceans (including Penaeid prawns and non-commercial crab species) of indirect and direct fisheries value (e.g. Morton *et al.* 1987; Mousalli and Connolly 1998, Muzumder *et al.* 2006). Intertidal environments provide shelter and/or foraging areas for fish and nektobenthos during high tide, whereas adjacent sub-tidal creek channel environments provide low tide refugia and feeding areas (Crowley and Tibbetts in Tibbetts and Connolly 1998)[10].

Extensive seagrass meadows occur within the site. Within nearshore areas, the most extensive meadows occur (from north to south) at Pumicestone Passage, adjacent to Fisherman Islands south of the Brisbane River mouth, Wynnum, Cleveland, and shoal environments throughout southern Moreton Bay. These meadows are strongly influenced by light limitation due to turbidity (Abal and Dennison 1996; Abal *et al.*. 1998). Extensive seagrass beds also occur along the western edge of Moreton Island, most notably the Eastern Banks marine delta complex and around Peel Island.

Recent studies have examined the importance of mangroves, seagrasses and saltmarsh as autotrophic nutritional sources for fish in adjacent unvegetated environments (Melville and Connolly 2003, Guest and Connolly 2004, Melville and Connolly 2005). Despite being devoid of seagrass, Melville and Connolly (2003) demonstrated that organic matter, particularly from seagrasses, was important as the base of food webs for fish species of commercial significance on adjacent

[10] The authors also note however that conditions (poss bly stochastic) encountered during movements may increase feeding opportunities and reduce predation rate.

unvegetated mudflats in Moreton Bay. Benthic microalgae also contributed a relatively high proportion of the nutrition of the species examined.

There are few empirical data describing the values of the Ramsar sites' reefs as a fisheries habitat. Advice from DPI Fisheries (Brad Zeller, pers. comm. 2008) indicates that several species of direct fisheries value utilise these reefs, most notably pink snapper at Peel Island.

Hydraulic Habitats and Flows

Flows of fresh water can have important effects on the physical and biological characteristics of estuaries and nearshore waters (Loneragan and Bunn 1999). River discharges provide nutrients and organic matter to estuaries, contributing to their high production (Loneragan and Bunn 1999).

It is known that many important life-history aspects of estuarine fish and crustaceans appear to be linked to flows (including migratory patterns, spawning, and movements of fish between different habitat types). However, globally, there is very little information on actual flow requirements of estuarine fish (Gillanders and Kingsford 1992; Loneragan and Bunn 1999; Connolly *et al.*. 2006).

Based on the analyses of commercial catch data and total flows in the Logan River estuary, Loneragan and Bunn (1999) demonstrated an increase in production of some fisheries with increased flow. They found that total (annual) flows explained 69% of total (annual) flathead catch in the estuary, and that this relationship was statistically significant. Loneragan and Bunn (1999) also found a positive link between freshwater discharge in the Logan River and fisheries production in the Logan River estuary, largely based on commercial catch data of prawns (bay, king, school, greasy, tiger and banana) and crabs (mud crabs and blue swimmer crabs). This is due, in part, to nutrients and organic matter being transported to the estuary during flows (Loneragan and Bunn 1999).

Key Species

Estuarine fish communities can show enormous variation over a range of spatial and temporal scales. This has been demonstrated even at small spatial and temporal scales for estuarine fish communities in the area (Stephenson 1980c; Sumpton and Greenwood 1990; Quinn 1992; Laegdsgaard and Johnson 1995; Tibbetts and Connolly 1998; Loneragan and Bunn 1999). Because of this, it is very difficult to make generalisations regarding the processes that control patterns in community structure.

Numerous estuarine fish species commonly occur in the site that are of value to commercial and/or recreational fishers, including but not limited to those listed in Table 7-19.

Key fish species of commercial and recreational significance within the site include snub-nosed garfish, river garfish, flat tailed mullet, sea mullet, fantail mullet, sand flathead, dusky flathead, tailor, spotted mackerel, golden lined whiting, eels, diver whiting, yellow finned bream and tarwhine. Numerous nektobenthic crustacean species of recreational and commercial interest also occur in the site, including banana, king, endeavour, tiger, school and greasy back prawns; mud, blue swimmer, red-spot, spanner and coral crabs; and Callianisidae shrimps. Other species of commercial significance include bait worms, squid, cuttlefish, rock oysters and beche-de-mer.

Fish and shellfish use different habitat types during different stages of their ontogenetic development (Table 7-19). Most require a combination of estuarine habitats to complete their life-cycle. For example, juvenile mullet are commonly found in freshwater reaches of tidal creeks and around shoals, whereas adults are typically more common in riverine channel habitats. Other species only occupy estuaries during their juvenile phase, such as king prawns, snapper and tarwhine, whereas other species, such as Australian bass, migrate from their primary freshwater habitat into the estuary to spawn. Species such as school prawns, luderick, yellowfin bream, flathead and whiting spend most of their life-cycle in estuaries, only moving to nearshore areas to spawn (Kailola *et al*.. 1993). These estuary residents are among the most important species from a commercial and/or recreational fisheries perspective.

Table 7-19 shows that important fisheries species commonly found within the Ramsar site are not found exclusively in any one habitat type during any part of their life-cycle. Rather, these species have relatively plastic habitat requirements, and are typically found in a variety of habitat types. Banana prawns were the only habitat specialists recorded in the study site, and are typically found in mangrove during their juvenile stages (Staples *et al*.. 1985). In general terms, most of the species listed in the table below spend their juvenile stages in shallow nearshore waters, particularly around seagrass and mangroves, whereas most species tend to spawn in inshore waters, particularly near the surf zone. Adults of most species tend to occur across a variety of habitats.

Table 7-19 Key fisheries species present in the Moreton Bay Ramsar site, and their primary habitats at different stages of their life-cycle (Data: Kailola *et al*.. 1993)

Species	Estuary					Coastal/Oceanic		
	Mangroves*	Seagrass*	Shoals*	Channels and Mud basin*	Freshwater*	Inshore*	Offshore	Reef/seawall*
TELEOSTI								
Long-finned eel					Juv., Ad.		Spw.	
Dusky flathead	Juv., Ad.	Spw.,Juv., Ad.	Spw., Juv., Ad.,	Ad., Juv.		Spw.		
Sand whiting	Juv., Ad.	Juv., Ad.	Juv., Ad.	Juv., Ad.		Spw.	Spw., Ad.	
Diver whiting		Juv. Ad		Ad.		Spw.		
Tailor		Juv., Ad.	Juv., Ad.	Juv.,Ad.		Spw., Juv., Ad.		
Yellowfin bream	Juv., Ad.	Juv., Ad.	Juv., Ad.			Spw., Ad.		Ad.
Mulloway	Ad.	Juv., Ad	Juv. Ad	Juv., Ad.		Ad. Spw.		
Luderick	Juv. Ad.	Juv. Ad.	Ad.	Ad.		Ad. Spw.	Ad.	Ad.
Sea mullet	Juv. Ad.	Juv.	Juv.	Juv., Ad.	Juv.	Spw.	Spw.	
Flat-tail mullet	Juv. Ad.	Ad.	Ad.	Ad.	Spw.	Ad.	Ad.	
Tiger mullet	Juv. Ad.	Ad.	Ad.	Ad.	Spw.	Ad.	Ad.	
CRUSTACEA								
Blue swimmer crab	Juv., Ad.	Juv., Ad.	Juv., Ad.	Ad.		Ad., Spw.	Ad.	
Mud crab	Juv., Ad.	Juv.	Juv.				Spw.	
King prawn	Juv.	Juv.	Juv.	Juv.		Ad.	Ad., Spw.	
Greasyback prawn	Juv.	Juv.	Juv., Ad.	Juv., Ad.		Spw.		
School prawn		Juv.	Juv., Ad.	Juv., Ad.			Spw.	
Banana prawn	Juv., Ad.	Ad.	Juv., Ad.	Ad.		Ad., Spw		

Note: Juv. = Juvenile, Ad. = Adult, Spw. = Spawning; * denotes habitat type found in the Ramsar site

Fishing Activities

Commercial fisheries in Moreton Bay include inshore and ocean beach net, otter and beam trawl, crab (pot), line and several collection based fisheries (i.e. bait worm, aquarium and development *beche-de-mer* collection). Commercial harvest methods occur within the Moreton Bay Ramsar site: gill, seine, fixed netting; beam trawling, otter trawling; line fishing; crab potting; pearl and rock oyster culture; and the above mentioned collection based fishing methods. Recreational fishing methods include line fishing; bait collecting; cast netting; crabbing; limited prawn netting and spear fishing. Limited charter (line) fishing occurs within the site, being mostly situated in offshore areas outside the site. Indigenous fishing is considered in Service 9 below.

Within the broader Moreton Bay Marine Park, commercial vessels landed approximately $24.1 million gross value of product (GVP) annually in the three year period ending 30 June 2006 (Environmental Protection Agency 2007). Over this same period, approximately 410 commercial fishing licenses were assessed annually in the Marine Park (Environmental Protection Agency 2007). Note that the Marine Park includes large areas outside the Ramsar site. Williams (2002) found that the total Moreton Bay catch represented ~12% of the State's total catch in the period 1988-2000.

Within the broad South East Queensland region, recreational fishing was reported to have generated $194 million in related expenditure annually in 2000-2001 (Environmental Protection Agency 2007). There are insufficient data to assess the current status of fish catch and effort with the site, and its impacts on fish stocks.

Access is a key control on fishing activities. The term access includes physical access constraints (which can vary over time in response to weather conditions, seasonal factors etc.), and regulatory constraints associated with fisheries management regulations (i.e. closed areas, seasonal closures, gear limitations etc.). Social factors also have a major influence on fishing activities, including disposable income, time constraints, holiday periods etc.

Table 7-20 Critical Service 7

Summary Table	Critical Service (S7)
Reason for Inclusion	Meets Ramsar criteria 3, 4 and 8
Type of Service	Supporting – Biodiversity and ecosystem functioning Cultural – Indigenous cultural values and tourism Provisioning – Food for indigenous, recreational and commercial fisheries
Description of Service (quantify if possible)	The site provides important habitat for species of direct economic significance, as well as regionally important fisheries.
Spatial Application (if relevant)	Whole of site. Most fish stocks do not reside exclusively within the site, hence factors external to the site are likely to control stock sizes.
Critical habitat components underpinning this service	Mangroves; Saltmarsh; Intertidal flats; Supratidal channels and flats; Seagrass and algal beds; Coral and Rocky Reefs; Shallow surf bars and banks; Open expanses of shallow oceanic waters
Critical species underpinning this service	Seagrass, mangroves, saltmarsh (habitats) Harvested species including: • Finfish - Bream, flathead, whiting, luderick, mullet, tailor, mackerel, sharks, baitfish, eels, and pink snapper • Prawns - King, tiger, endeavour, banana, greasyback and school prawns • Other decapod crustacea - Blue swimmer, mud, red spot, spanner and coral crabs and callianasid shrimp (yabbies) • Others - Squid, cuttlefish, gastropods, rock oysters, bivalves and beche-de-mer.
Critical processes underpinning this service	Maintenance of biophysical habitat extent, diversity and interconnectivity Maintenance of freshwater flow regimes Maintenance of tidal and wave regimes that drives biophysical habitats patterns and

Summary Table	Critical Service (S7)
	processes Maintenance of water quality conditions, particularly with respect to its influence on estuarine vegetation communities (i.e. seagrass, algae etc.)
Natural Variability (if relevant)	Patterns in fish and shellfish community structure may vary across a range of spatial and temporal scales. Fisheries productivity (catch) varies in response to this and other factors (i.e. regulations, weather conditions etc).
Principal threats	Over-harvesting Incremental habitat loss due to human population growth Water use and modifications to freshwater flow regimes Water quality degradation Lyngbya blooms
Data quality underpinning this critical service	Service – Level 3 (fish catch data) Components – Level 2 (outdated, insufficient scale) Processes – Level 1-2 (water quality); 2 (freshwater flows); 2 (tidal data)
Information gaps	Present-day and historical marine vegetation mapping done at relevant spatial scale (minimum 1:25,000) and temporal (at least every 5 years, preferably with analysis of seasonal changes); Information on factors controlling temporal changes in seagrass, mangrove and saltmarsh; Natural variability in fish and shellfish stocks, and factors controlling these changes; Specific environmental flow requirements of estuarine vegetation and fisheries species; Priority areas for habitat rehabilitation and possible offsets areas; Sustainability of current recreational and commercial fisheries management practices Values and functions of proposed no-take 'green zones' in the future Marine Park Zoning
Recommended monitoring	Fish stock monitoring based on DPI&F state-wide LTMP, CFISH (Commercial Fisheries Information System) and RFISH (Recreational Fishing Information System) programmes

7.8 Service 8 ~ Indigenous Cultural Significance

BMT WBM commissioned Converge Heritage + Community Pty Ltd (previously trading as ARCHAEO Cultural Heritage Services Pty Ltd) to conduct a desktop assessment of indigenous cultural values associated with the Moreton Bay Ramsar areas. This assessment forms part of the ECD with the full report prepared by Converge Heritage + Community contained in Appendix C.

As identified in Section 3 of this report, Resolution IX.21 of the Ramsar Convention, entitled “Taking into account the cultural values of wetlands” was adopted at Ramsar’s ninth conference. This important change to global policy statements of the Ramsar Convention provides a strong mandate for taking into consideration the indigenous cultural values of the Moreton Bay Ramsar areas in the current study.

The scope of the cultural heritage assessment undertaken as part of the ECD is limited to being desktop, and will be based only on documentation that is already in the public arena. Specifically, consultation with indigenous groups is not part of the scope. This assessment provides:

- Contextual information;
- A discussion of the relationship between indigenous groups and land;
- A summary of available information about cultural connections with Ramsar areas;
- Case studies that demonstrate that significant cultural values may be associated with Moreton Bay Ramsar areas;
- Available information on how cultural values are being sustained; and
- An assessment of the limits of acceptable change if cultural values in Ramsar areas are to be protected and managed.

As outlined in Section 3 (refer section on cultural resources) and Appendix C, while environmental, ethnographic and archaeological evidence may indicate the richness of the Moreton Bay environment during the past 6,000 or so years that would have been an important and sustaining resource for Aboriginal groups, these observations only give partial insights into the relationship between those Aboriginal groups and the land in which they lived and indeed continue to live. Often, the ethnographic reports provide a commentary on what the observer has found interesting, thus emphasizing a perspective that tends to focus on resources, rather than placing on the public record, an understanding of the complex cultural and social network that existed, and continues to exist amongst Aboriginal people of Southeast Queensland.

Approximately one third of Queensland’s Aboriginal and Torres Strait Islander population lives in Southeast Queensland (South East Queensland Regional Plan 2005). Many of these people have moved to the region. As contemporary residents, these people are often referred to as “historically associated”, and may be regarded as stakeholders in the region similar to the non-indigenous population. In contrast, those Aboriginal people who are descendants of ancestors who lived in Southeast Queensland before non-indigenous settlement identify as Traditional Owners. Each of these groups is an important stakeholder in the community of Southeast Queensland, but Traditional

Owners have additional and different aspirations to non-indigenous and historically associated indigenous stakeholders. Through their lineage, Traditional Owners inherit responsibilities under traditional law and custom to manage their land (often referred to as country), as well as a connection to country that is a cultural and spiritual relationship. This is best summed up in the words of Southeast Queensland's Traditional Owners:

> *As the current Aboriginal Traditional Owners in South East Queensland we have inherited a responsibility to look after our country. This responsibility has been handed to us by our ancestors, whose spirits continue to guide our decisions. We in turn have a responsibility to manage our country to the best of our abilities and to teach our youth the values and skills and provide them with the knowledge that they will need to manage our country with and after us….*
>
> *Cultural resources are all the tangible and intangible things in our land and sea country that are essential to our wellbeing: land, water, plants and animals (biodiversity), coastal and marine things, the air (atmosphere), and community. As Aboriginal people, we have such a deep and integral connection and set of relationships with these 'natural' elements that we consider them as cultural entities., Our identity as well as our cultural, spiritual and material wellbeing is entwined with the country and its health; without strong and healthy country, our people cannot be strong and healthy (SEQTOLSMA 2008: 8)*

In the absence of consultation as part of this ECD study, two important points should be made. Firstly, the statements of SEQTOLSMA would suggest that those Traditional Owners relevant to the Ramsar areas of Moreton Bay will have strong views on what will be considered their country or cultural resource, and will wish to take part in management decisions. Secondly, a further consideration is that the Traditional Owners relevant to Ramsar areas may have valuable historical knowledge of what these areas were like in the past, and what management strategies would be preferred. These points are best demonstrated through some case studies that are provided below:

Case Study 1 – Blue Lake, North Stradbroke Island

In 2007, consideration was given by the Queensland Government to the potential to harvest fresh water from aquifers on North Stradbroke Island for the water grid being developed across Southeast Queensland. Consultation was commenced with the Minjerribah Moorgumpin Elders in Council, the Aboriginal Cultural Heritage Body for North Stradbroke Island. During initial consultation, the Elders expressed deep concern about the project, as it potentially could impact directly on water levels in Blue Lake, a natural freshwater lake on the island. The Elders were particularly worried about such impacts because of the high levels of cultural significance associated with the lake. What constitutes the lake's cultural significance cannot be reported here, without consultation with and the permission of the Elders. Suffice to say that the Elders were extremely relieved when the project was abandoned because of general public concern.

This case study illuminates Traditional Owners' responsibilities and connection with country. Other people in the North Stradbroke community were concerned about the environmental impact of water harvesting on Blue Lake, a known and much appreciated natural part of the island. But the Traditional Owners' concerns were amplified by their cultural connection to the lake which is a significant Aboriginal area in the meaning of the *Aboriginal Cultural Heritage Act 2003* (ACH) Act.

Case Study 2 – Traditional Hunting Guidelines

An excellent example of on-going traditional responsibilities and customs working today is provided by the Quandamooka people.

The Quandamooka people of the Moreton Bay area are continuing their ages old traditional hunting, which provides an important part of their diet. Working with the Queensland Environmental Protection Agency (EPA), the Quandamooka people have developed Traditional Hunting Guidelines to ensure that hunting practices are sustainable. With the new zoning plan in Moreton Bay Marine Park the Quandamooka people are looking to progress the Traditional Hunting Guidelines into a Traditional Use of Marine Resources Agreement (TUMRA) which will be the new best practice. Quandamooka people have demonstrated their commitment to making the Agreement work through six years of sound management since the establishment of the traditional Hunting Guidelines (SEQTOLSMA 2008: 13).

Case Study 3 – Native Title's Rights and Interests

Whether or not native title is relevant from the perspective of land tenure in the Ramsar areas of Southeast Queensland is not a discussion for this assessment. Rather, the point being made is that the rights and interests detailed in the various native title claims in the Moreton Bay area give an indication of Traditional Owners' perspectives about their traditional responsibilities and rights. While the native title process may result in these claimed rights and interests only being relevant where native title has not been extinguished, from the Traditional Owners' perspectives, it is likely that they would prefer these rights and interests to be relevant in all of their country.

Consistent in the native title rights and interests claimed in all of the claim applications that cover parts of the Ramsar areas are the following themes:

- Access to enter and remain on lands and waters;
- Use and enjoy land and waters, including traditional hunting and gathering;
- Protection and management of the resources of lands and waters;
- Capacity to exercise customary rights and discharge traditional responsibilities;
- Recognition as Traditional Owners

The themes enunciated by the claimed rights and interests show that there is no differentiation between land and water – both are country – and all country requires protection and management.

Case Study 4 – SEQTOLSMA

The Moreton Bay region is home for a number of Traditional Owner groups as listed in Appendix C. These include the Kabi Kabi families, Jagera and Turrbal families, Quandamooka (Ngugi, Noonucle, Gorenpul) families, Yugambeh (eight groups) and Ngarang-Wal/Kombumeri families.

Other Traditional Owner groups include the Jinibara and Mulinjarlie families, but these groups are sub-coastal and may not necessarily have Ramsar areas in their traditional countries.

In 2005, representatives of all but two of these groups commenced negotiations about forming a body "to establish more comprehensive and meaningful Traditional Owner involvement and ownership in improving the condition of the region's natural resources", and "to promote more comprehensive and effective engagement of Traditional Owners in cultural (natural) resource management" (SEQTOLSMA 2008, p. iv). The outcome is the development of an on-going body of Traditional Owner representatives who have now developed a plan, called OUR PLAN, for the future (SEQTOLSMA 2008). Actions relevant to Ramsar areas that have been nominated by OUR PLAN include: the development of a Memorandum of Agreement with SEQ Catchments; developing alliances and partnerships at all levels of government and with the wider community; and becoming fully engaged in planning, decision-making and delivery of on-ground works (SEQTOLSMA 2008: 26).

The foundation of SEQTOLSMA is an important initiative that has the capacity to provide a central body with which consultation and management planning can be developed. SEQTOLSMA does not reduce the responsibilities of Traditional Owners, and recognizes that within the organization, certain Traditional Owners speak for parts (their country) of Southeast Queensland. In regard to the Ramsar areas of Moreton Bay, no one Traditional Owner will speak for them all; rather specific areas will be associated with certain groups, as shown discussed in Appendix C. In large part, this arrangement also reflects the requirements of the Queensland *Aboriginal Cultural Heritage Act 2003* in regard to cultural heritage decision-making by Aboriginal Parties.

Taking these arrangements into account, SEQTOLSMA offers an opportunity for the development of overarching management planning for Ramsar areas, with the additional capacity for relevant Traditional Owners to have input into those areas that are within their countries.

While there has been little to no assessment to date that is available in the public record about the indigenous cultural values of the Ramsar area in Moreton Bay, hints are provided by the initiatives detailed in the case studies above. These case studies also underline that the Traditional Owners of Southeast Queensland are continuing their traditional responsibilities.

In the absence of guidance from Traditional Owners on this matter, it is reasonable to predict the following:

- Each of the Ramsar areas (eg. areas within the broader site boundaries) will hold significant cultural values to the relevant Traditional Owner group/s. These values may include physical and non-physical cultural heritage areas and objects, oral knowledge, such as stories, animals and plants, and the natural environment itself;

- The values of each of the Ramsar areas may be different to the others, e.g., the environmental, spiritual and cultural nature of Pumicestone Passage may have been different to those of North Stradbroke Island, and thus require differences in traditional management;

- Traditional Owners are already taking an active role in managing Ramsar areas as part of their management of the wider Moreton Bay area, and that they will wish to increase this role if offered the opportunity; and

- The Traditional Owners have already formed an encompassing organization (SEQTOLSMA) which may prove to be a vehicle through which consultation and planning for the future could be organized. Only through consultation with the individual Traditional Owner groups could this be ascertained.

A summary table has not been prepared for this service based on the discussion outlined above. Further articulation of the values and cultural significance of the site are seen as only able to be set and measured through consultation with Traditional Owners. Limits of acceptable change will only become apparent, if indeed they do, after a detailed understanding about cultural values and how they are being sustained is achieved.

7.9 Service 9 ~ Research and Education

Boondall Bird Hide and field survey photos sourced from www.nudgeebheec.eq.edu.au
Field photo (far right) BMT WBM Photo Library

The size and accessibility of the Bay (being situated at the doorstep of a capital city) makes it an ideal resource for research and education activities.

The Bay and its flora and fauna have been, and continue to be, the subject of numerous scientific studies and investigations by leading academics in Australia and around the world. As demonstrated by this ECD, the Bay provides a wide range of issues and habitats for natural science and social science researchers and industry research activities.

Queensland University, CSIRO and the Department of Primary Industries and Fisheries have research stations in the Moreton Bay region (although situated outside the boundaries of the Ramsar site). Many other research institutions use Moreton Bay for research and education.

Major studies and investigations have been undertaken by the Queensland Environmental Protection Agency with respect to the coastal wetlands (as part of the SEQ Coastal Wetlands Study) in the region. A range of other studies have also been undertaken to support various plans and strategies such as survey and mapping of rocky intertidal areas, shorebird roosting sites, seagrass areas and offshore reef mapping.

In terms of recent research activities undertaken by State agencies, of particular note are the EPA's Queensland Turtle Conservation Project (see Limpus *et al.*. 2006), recent studies of groundwater ecosystems on the Bay islands by the Department of Natural Resources and Water (see Marshall *et al.*. 2006) and various research projects on Bay fisheries by the Department of Primary Industries and Fisheries.

Well-documented environmental impact studies of the Bay's habitats, fauna and hydrology provide an insight into the natural variability present within the systems of the Bay as well as their resilience to change. These documents build upon the significant knowledge provided by the research and scientific community, often augmenting these studies with the collection of data and analysis at more localised scales.

The wetlands of Moreton Bay are also an integral component of a number of environmental education facilities in the region. Some examples include the following:

- Boondall Wetlands lies on the western edge of Moreton Bay between Nudgee Beach, Boondall and Shorncliffe and includes more than 1000 hectares of tidal flats, mangroves, saltmarshes, melaleuca wetlands, grasslands, open forests and woodlands. Brisbane City Council manages and operates the Boondall Wetlands Environment Centre which offers a range of displays and activities on the environmental and cultural heritage of the reserve for park visitors and organised groups. The mangrove boardwalk at Wynnum North is also a significant educational resource.

- The Department of Education (Education Queensland) operates environmental education centres at Nudgee Beach, Moreton Bay (at Wynnum) and Jacobs Well for educating children on coastal and environmental matters. The Bay is an important environmental and historical education resource for these centres. The Environmental Protection Agency also has educational facilities on St Helena and Moreton Islands.

The third component of this service relates to environmental monitoring activities. Since 2000, the Healthy Waterways Partnership's Ecosystem Health Monitoring Program (EHMP) has undertaken monthly monitoring of over 250 estuarine and marine sites including sites throughout Moreton Bay. Data are collected for a range of water quality and biological parameters. The results of this monitoring are reported annually via the Ecosystem Health Report Card and Technical Report (EHMP 2007).

Monitoring being undertaken under the auspices of the EHMP is augmented by strong and long-standing volunteer monitoring programmes in Moreton Bay. Two examples include:

- *Wader Birds.* The Queensland Wader Study Group (QWSG) is a special interest group within Birds Queensland. It was formed to further research on both migratory and resident waders (shorebirds) in Queensland, and to work for their conservation. The QWSG undertakes regular counts of waders around Moreton Bay that provides a measure of the abundance of the birds and provides the long term population trend data used in planning and management.

- *Seagrass.* Seagrass Watch is an initiative that uses trained volunteers to help monitor seagrass meadows along the Queensland coast. Originally developed by the Queensland Department of Primary Industries and Fisheries, Seagrass Watch has now spread to neighbouring countries in Asia and the Pacific. Seagrass Watch has been operating for a number of years in the Bay, undertaken by conservation groups and their volunteers using funding from the Natural Heritage Trust (NHT) and other sources. There are current plans to extend this programme to also include Mangrove Watch and Saltmarsh Watch components.

Over the next five years, science priorities relating to Moreton Bay have been identified as part of the Healthy Waterways Strategy 2007-2012. These priorities are to:

- understand processes in receiving waters (freshwater, storages, estuaries and Moreton Bay);

- understand challenges specific to coastal and beach ecosystems (e.g. coastal algal blooms, population growth in coastal areas);

- understand movement, cycling and transformations of nutrients and toxicants and look at relative importance of inputs versus remobilisation to focus management actions;

- understand "cause and effect" relationships between management actions, Water Quality Objectives and Environmental Values; and

- understand climate change implications for water quality, ecosystem health, and efficacy of management actions.

While the maintenance of all the critical components and processes outlined above are important, those that underpin maintaining the diversity of wetland habitats present in the site and key representative habitats (Services 1 and 2), the maintenance of important species (Service 3,4,5) and the maintenance of significant shorebird populations (Service 6) are seen as most critical to supporting the research and education service outlined here.

Table 7-21 Critical Service 9

Summary Table	**Critical Service (S9)**
Reason for Inclusion	Moreton Bay's location, condition and conservation significance make it a vitally important resource in the context of research and education. In addition to countless studies by the academic community, the Bay and its wetlands are important components of environmental education programmes and facilities in the Region and the subject of millions of dollars of funding from State and local government for environmental monitoring under EHMP over the past 8 years.
Type of Service	Cultural
Description of Service (quantify if possible)	Key aspects of this Service recognise the importance of the site for: Research activities by universities, colleges and science organisations such as CSIRO Environmental Education Facilities and Curricula (Boondall, Nudgee, etc) Environmental Monitoring (EHMP and volunteer monitoring programmes by the Queensland Wader Study Group and community conservation groups).
Spatial Application (if relevant)	This service applies to the whole site.
Critical habitat components underpinning this service	While many habitats have been studied, research undertaken with respect to seagrass, mangroves and saltmarsh is especially noteworthy.
Critical species underpinning this service	While many species and habitats have been studied, the research undertaken on turtles and shorebirds in Moreton Bay is especially noteworthy.
Critical processes underpinning this service	Broad-Scale Processes as outlined in Critical Service 1 and Critical Service 2.
Natural Variability (if relevant)	Not Applicable.
Principal threats	Not Applicable. Moreton Bay has been an important site for research and education activities over the past 30 years and continues to be so. The global and national emphasis on climate change and related impacts to coastal areas is seen as a driving force for research and education over the next 5 – 10 years and will likely dominate the focus of future studies involving the Bay and its resources. However it is expected that long term monitoring and research programmes relating to water quality, habitat quality and important species/populations in the Bay will continue.
Data quality underpinning this critical element	Not Applicable
Information gaps	A range of science priorities for Moreton Bay have been identified as part of the 2007-2012 Healthy Waterways Strategy (Moreton Bay Action Plan component). In addition to these priorities, the information gaps and monitoring recommendations of this ECD are seen as essential for monitoring the ecological character of the Ramsar site.
Recommended monitoring	No specific recommendations. However, developing a system or database to record previous and current research and monitoring data related to key wetland assets of the site remains a priority. In particular, improved management of data from shorebird counts and surveys is a high priority.

7.10 Service 10 ~ Tourism and Recreational Uses

Photos supplied from the EPA Photo Library

Tourism and recreation in Moreton Bay is largely built upon the attraction of the area's natural assets, with activities undertaken in the area being predominantly nature-based. No data are available on visitation to, and activities undertaken specifically within the Ramsar site, but a recent study estimates the annual visitation to Moreton Bay at 1,666,805, inclusive of domestic overnight and day-trip and international visitors (refer Table 7-22 below). The source of these visitors is 24% domestic overnight, 74% domestic day-trip and 2% international visitors, with the peak months of tourist activity in the school holiday periods of December/January, April and September. For the purposes of the ECD, it is acceptable to assume that the majority of visitors will use an area within the Ramsar boundary at some point during their visit, either undertaking activities or passing through the site.

Table 7-22 Estimates for visitor arrivals using Bureau of Tourism Research (grouped for 1999-2002)

	Domestic Overnight*	Domestic Day-trip*	International Visitors*	Total Visitation*
Caboolture	131,000	408,500	5,158	544,658
Redcliffe	33,000	268,500	5,217	306,717
Brisbane	75,250	236,250	17,823	329,323
Redland	158,750	318,250	11,257	488,257
Total Moreton Bay	**397,000**	**1,231,000**	**38,805**	**1,666,805**

*All figures are the average per year over 4 years.
Source: Adapted from Whitemore and De Lacy (2005). Note that the area covered is larger than the Moreton Bay Ramsar site.

The high percentage of visitation by domestic day-trip visitors indicates that most visitors are from the local region (Brisbane and SEQ generally) (Table 7-22). The proximity of the Moreton Bay Ramsar site to Brisbane signifies an important consideration for management of the site as the regional population continues to increase. It also denotes a significant economic contribution to the region, providing an estimated 18,000 jobs through tourism within Moreton Bay electorates[11] (Whitmore and De Lacy 2005), with 5,500 jobs within the Moreton Bay and islands area (EPA 2007a). Expenditure from visitation to the Moreton Bay and islands region is estimated at approximately $500 million annually (based on 2006 data; EPA 2007a).

While the wide variety of tourism and recreational activities undertaken within the Moreton Bay Ramsar site are predominantly nature-based, occurring in both terrestrial and aquatic environments, there are specific components and processes that impact on the quality of the experience, and which continue to attract visitors and return visitors to the region. Further, many activities are primarily

[11] Note this figure is for a larger area than the Moreton Bay Ramsar site.

undertaken in specific environments (e.g. four wheel driving on the eastern sandy beaches of Bribie, Moreton and North Stradbroke Islands, canoeing/kayaking in inshore areas) indicating that some ecosystem components and process may be more important for tourism and recreation in particular locations within the Ramsar site. Activities and supporting ecosystem components and processes are described in Table 7-23.

Table 7-23 Underlying services, components and processes for the wetland service (tourism and recreation) in the Moreton Bay Ramsar site

Activity	Ecosystem Components	Ecosystem Processes
Boating / sailing / canoeing / kayaking	Pleasant weather conditions Good water quality	Climate Water quality
Diving / snorkeling	Good water quality Pleasant weather conditions Rich and diverse marine fauna Healthy wetland habitats	Water quality Climate Flora / fauna Biological maintenance
Recreational Spear fishing / Line fishing	Abundant target fish species	Flora / fauna Biological maintenance Species interaction
Swimming / surfing / surf-lifesaving	Good water quality Pleasant weather conditions	Water quality Climate
Wildlife-watching	Rich and diverse wildlife Near pristine wetland habitats	Climate Biogeochemical and nutrient cycling Water quality Flora / fauna Biological maintenance Species interaction
Bush walking / Camping / Picnics	Range of wetland types Rich and diverse wildlife Pleasant weather conditions Near pristine wetland habitats Cultural heritage items and places	Climate Biogeochemical and nutrient cycling Geomorphology Water quality Flora / fauna Biological maintenance Species interaction
Four wheel driving / Sand tobogganing	Pleasant weather conditions Relevant wetland types (predominantly sandy beaches)	Climate Geomorphology

The high level of nature-based activities within the Moreton Bay Ramsar site is supported by the bulk of the site being situated within National Parks, Conservation Parks, Recreation Areas or Marine Park. These areas are managed under State legislation, and management and zoning plans which aim to conserve and manage the areas in a predominantly natural state.

Limits of acceptable change for tourism-related critical services are reported to "relate to thresholds that significantly reduce tourism economic activity" (e.g. loss of beaches, reduction in reef size, perceived adverse changes to 'eco-values') (Voice *et al.* 2006). That is, if tourism and recreational activities impact on other critical services (e.g. aquatic wetland fauna of conservation significance), the subsequent degradation or change in these critical services is likely to cause a change in tourism and recreation within the Ramsar site.

Table 7-24 Critical Service 10

Summary Table	**Critical Service (S10)**
Reason for Inclusion	Uniqueness - diversity of activities and experiences in a range of locations, close to major city/capital city (e.g. "Moreton Bay is the only place in the world where you can see dugong within view of a city skyline." (Whitmore and De Lacy 2005).
Type of Service	Cultural
Description of Service (quantify if possible)	Predominantly nature-based tourism and recreational activities undertaken in a range of wetland environments. The annual visitation to Moreton Bay is approximately 1,666,805.
Spatial Application (if relevant)	Whole Ramsar site, though certain activities are focused in specific environments within the site (e.g. four wheel driving on sandy beaches).
Critical habitat components underpinning this service	All – variety of activities undertaken in different environments. Predominant habitats used are beaches, marine waters, estuarine waters, freshwater lakes, sand dunes and intertidal flats.
Critical species underpinning this service	Fauna - all, although predominately megafauna and wader birds. Flora – all.
Critical processes underpinning this service	Refer Table 7-23.
Natural Variability (if relevant)	Limits of acceptable change for components and processes elsewhere in the ECD. Combination of climate, maintenance of habitat quality, quality and supply of tourism/recreation product (e.g. supply, management of industry, disposable income, cost of activities)
Principal threats	Impacts from tourism and recreational activities to other critical services. Subsequent impacts to tourism and recreational activities from degraded critical services.
Data quality underpinning this critical service	No reliable visitor statistics, including tourist expenditure and other economic contributions (Whitmore and De Lacy 2005). Importance of Ramsar values to tourism and recreational experiences.
Information gaps	Reliable visitor statistics, including tourist expenditure and other economic contributions. Carrying capacity of the Ramsar site for activities and locations. The importance placed on the Ramsar site and values by visitors when undertaking tourism and recreational activities and experiences.
Recommended monitoring	Reliable visitor statistics, including tourist expenditure and other economic contributions. Number of visitors participating in each activity/location and the resultant environmental impacts and potential indicators for monitoring. Importance/awareness of Ramsar site and values for visitors.

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9 GLOSSARY

Acceptable change, means the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. Acceptable variation is that variation that will sustain the service, component or process to which it refers.

Aquatic/marine fauna, the context of this report relates to fauna species that spend all or the majority of their life cycle in or underwater. As such this grouping primarily relates to fish, marine reptiles, aquatic mammals such as dugong and cetaceans, and aquatic/marine invertebrates.

Congener, species within the same genus.

Ecological character, defined under Resolution IX.1 Annex A: 2005 of the Ramsar Convention as, the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.

IBRA bioregion, refers to Interim Biogeographic Regionalisation for Australia (IBRA). IBRA is a biogeographic regionalisation of Australia developed by the Australian Government's Department of the Environment, Water, Heritage and the Arts. It was developed for use as a planning tool, for example for the establishment of a National Reserve System.

IMCRA bioregion, refers to the Interim Marine and Coastal Regionalisation for Australia (Mesoscale) to the 200 meter isobath and derived from biological and physical data, (eg. coastal geomorphology, tidal attributes, oceanography, bathymetry and intertidal invertebrates). IMCRA is the marine equivalent of IBRA.

National Framework document, refers to the Draft National Framework and Guidance for Describing the Ecological Character of Australia’s Ramsar Wetlands (DEWHA 2008b) and its successive documents as endorsed by the Natural Resource Management (NRM) Ministerial Council.

Parapatry speciation is a form of speciation that occurs due to variations in mating frequency of a population within a continuous geographical area.

Ramsar criteria, refers to the nine criteria for the listing of a site as internationally significant under the provisions of the Ramsar Convention.

Regional ecosystems are defined by Sattler and Williams (1999) as vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.

Values, means the perceived benefits to society, either direct or indirect that result from wetland functions. These values include human welfare, environmental quality and wildlife support.

Wallum, refers to freshwater wetlands and associated vegetation communities occurring on low nutrient sandy soils. While nutrient poor, these soils support a range of vegetation types including melaleuca (paperbark) woodland, sedgeland and heath (the dominant vegetation type on soils of this type). Acidic (pH < 6.0) swamps and lakes are typically found amidst heath vegetation and sedges where water collects above organic hardpan layers and provide essential breeding habitat for 'acid frogs' and other specially adapted species (Meyer *et al.*. 2005).

Wetlands, is used in this report in the context of the definition under the Ramsar Convention which includes, *areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres*.

Wetland-dependant terrestrial fauna, in the context of this report relates to fauna species that occur within or otherwise are dependant on wetland habitats but do not spend the majority of their life cycle underwater (eg. non-aquatic species). As such this grouping primarily relates to birds, amphibians such as frogs, non-aquatic mammals such as water mouse, non-aquatic reptiles and terrestrial invertebrates.

Wetland flora, in the context of this report relates to flora species that are characterised as wetland or wetland-dependant species or populations.

Wetland ecosystem components, as defined in the ECD National Framework document, are the physical, chemical and biological parts or features of a wetland

Wetland ecosystem processes, as defined in the National Framework document, are the dynamic forces within the ecosystem between organisms, populations and the non-living environment. Interactions can be physical, chemical or biological.

Wetland ecosystem benefits or services (includes the term ecosystem services), as defined in the National Framework document, are the benefits that people receive from wetland ecosystems. In general, benefits and services are based on or underpinned by wetland components and processes and can be direct (eg. food for humans or livestock) or indirect (eg. wetland provides habitat for biota which contribute to biodiversity).

APPENDIX A: CONSULTATION DETAILS

Project Committees

This study was overseen and reviewed by two groups established by the Queensland EPA: the project Steering Committee and project Knowledge Management Committee.

These groups were comprised of the following persons:

Project Steering Group

Gay Deacon, Chair	Queensland Environmental Protection Agency
Peter Macdonald	Queensland Environmental Protection Agency
Gayle Partridge	Australian Government Department of Environment, Water, Heritage and the Arts
John Beumer	Queensland Department of Primary Industries and Fisheries
Todd Kelly	Queensland Environmental Protection Agency
Paul Sanders	Queensland Department of Natural Resources and Water
Dave Rissik	Queensland Environmental Protection Agency
Di Tarte	Southeast Queensland Healthy Waterways Partnership

Project Knowledge Management Committee

Gay Deacon, Chair	Queensland Environmental Protection Agency
John Bennett	Queensland Environmental Protection Agency
Brad Zeller	Queensland Department of Primary Industries and Fisheries
Nicola Udy	Queensland Environmental Protection Agency
Sel Sultmann	Queensland Environmental Protection Agency
Roger Jaensch	Wetland International Oceania
Warren Lee Long	Wetland International Oceania
Rod Connolly	Griffith University