Port Phillip Bay (Western Shoreline) and Bellarine Peninsula

Ramsar Site Management Plan

VICTORIA State Government | Environment, Land, Water and Planning

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Annette Hatten, DELWP

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Abbreviations

CAMBA	China–Australia Migratory Bird Agreement
CEPA	Communication Education Participation and Awareness
CCMA	Corangamite Catchment Management Authority
CPS	Components, processes and services
DEDJTR	Department of Economic Development, Jobs, Transport and Resources (Victorian Government)
DELWP	Department of Environment, Land, Water and Planning, formerly Department of Environment and Primary Industries (Victorian Government)
DEPI	Department of Environment and Primary Industries, now Department of Environment, Land, Water and Planning (Victorian Government)
DEWHA	Department of Environment, Water, Heritage and the Arts, now Department of the Environment and Energy (Australian Government)
DoEE	Department of the Environment and Energy (Australian Government)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities, now Department of the Environment and Energy (Australian Government)
ECD	Ecological Character Description
EPA Victoria	Environment Protection Authority Victoria
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
GMA	Game Management Authority
IUCN	International Union for Conservation of Nature
JAMBA	Japan–Australia Migratory Bird Agreement
LAC	Limits of Acceptable Change
MAs	Management Actions
MCA	Multiple Criteria Analysis
MERI	Monitoring, Evaluation, Reporting and Improvement
PPWCMA	Port Phillip and Westernport Catchment Management Authority
RCT	Resource Condition Target
RIS	Ramsar Information Sheet
RMP	Ramsar Management Plan
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SC	Steering Committee
SRW	Southern Rural Water
SAG	Stakeholder Advisory Group
VWMS	Victorian Waterway Management Strategy

1 Introduction

The *Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Strategic Management Plan* (Parks Victoria 2003) established a framework for the maintenance of this site's unique ecological character through conservation and wise use. The plan is now over a decade old and there has been significant progress in both our understanding of the ecological character and strategic direction in management of the site and Ramsar wetlands in Australia. A consultative and collaborative process was undertaken to review and update the Ramsar site management plan. The outputs of this review process are documented in two products:

1. A revised Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan (**this document**), including a full description of the plan's development and technical appendices, and
2. A Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan summary document for a general audience that briefly outlines the process and details the management strategies and responsibilities.

This Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan (herein referred to as the 'RMP') sits within a framework for the management of aquatic ecosystems within Australia and the State of Victoria. At the national level, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) establishes the basis for managing Ramsar sites. In Victoria the *Victorian Waterway Management Strategy* (VWMS; Department of Environment and Primary Industries 2013) guides the management of rivers, estuaries and wetlands, and the renewal of the *Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Strategic Management Plan* addresses Action no. 12.3 of the VWMS. The RMP also aligns with Action 3.4 and 3.9 in *Water for Victoria* by improving waterway health and knowledge of waterways and catchments. There are 12 Ramsar sites in Victoria and management planning for seven of these are embedded within Regional Waterway Strategies that were developed in 2014/15. The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site, due to its size and complexity, was considered to require a standalone management plan.

1.1 Purpose of the management plan

1.1.1 Ecological character

The *Convention on Wetlands of International Importance Especially as Waterfowl Habitat* (Ramsar, Iran, 2 February 1971) encourages the designation of sites containing representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity, to the List of Wetlands of International Importance (Ramsar List). These sites are commonly known as Ramsar sites. The Ramsar Convention, as it is commonly known, is an international intergovernmental treaty with the broad aims of halting and, where possible, reversing, the worldwide loss of wetlands and to conserve those that remain through wise use and management (DSEWPAC 2012).

Under the terms of the Convention contracting parties nominate wetlands to be designated as Wetlands of International Importance, with nominated sites required to meet at least one of nine listing criteria. The act of designating a wetland as a Ramsar site carries with it certain obligations, including managing the site to maintain its "ecological character" and to have procedures in place to detect if any threatening processes are likely to, or have altered, the "ecological character". Definitions for "ecological character" and "change in ecological character" are as follows (Ramsar Convention 2005):

> *"Ecological character is the combination of the ecosystem components, processes and benefits/services [CPS] that characterise the wetlands at a given point in time" and*
>
> *"…change in ecological character is the human induced adverse alteration of any ecosystem component, process and or ecosystem benefit/service."*

Ramsar: A network of sites

There is a network of over 2000 Ramsar wetlands across the globe that is dedicated to sustaining biodiversity and wise use. One of the important functions, and a primary purpose for the establishment of the Convention, is to protect sites in different countries that are important for migratory birds.

The migratory birds that visit Australia are part of the East Asian–Australasian Flyway and most of them migrate from breeding grounds in North-east Asia and Alaska to non-breeding grounds in Australia and New Zealand, covering the journey of more than 10,000 kilometres twice in a single year.

The lifecycle of most international migratory shorebirds involves (Bamford et al. 2008):

- breeding from May to August (northern hemisphere)
- southward migration to the southern hemisphere (August to November)
- feeding and foraging in the southern hemisphere (August to April), and
- northward migration to breeding grounds (March to May).

During both northward and southward migration, birds may stop at areas on route to rest and feed. These stopovers are referred to as “staging” areas and are important for the birds’ survival. In addition, birds on their first southward migration that have not yet reached breeding maturity may remain in Australia over the southern winter period.

Other migratory species that are supported by the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site include species such as the double-banded plover, which migrates between New Zealand and Australia spending the non-breeding (winter) season on Australian shores.

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site regularly supports 20 species that are international migrants and listed under migratory agreements with China, Japan and the Republic of Korea. Important habitats within the site include the extensive intertidal mudflats and saltmarsh where migratory shorebirds feed. High tide roosting sites, where shorebirds can rest are also important.

Migratory shorebirds in Australia need to build up their energy reserves for the homeward journey. This means that they not only require abundant food sources, but they need to minimise their activity. Disturbance of shorebirds when roosting or feeding may result in a significant loss of energy. This may even compromise their ability to lay down sufficient fat reserves to complete the return journey to breeding grounds. Disturbance of migratory shorebirds may occur as a result of four-wheel driving on beaches or in saltmarsh and intertidal areas, unleashed dogs, recreational fishing (in some instances); boating, jet skiing, kite-surfing and any activity in the intertidal zone that causes significant noise or light. Migratory shorebirds are also susceptible to predation by introduced foxes and cats.

Populations of many migratory shorebirds species are in decline, primarily through loss of habitat in breeding and staging areas outside Australia. This makes them more vulnerable while in Australia and increases the importance of maintaining habitat and conditions at overwintering sites. Residents and visitors to the Ramsar site need to work together to help protect and conserve these important species.

Under Article 3.2 of the Ramsar Convention a notification of change is required if the ecological character of a site has changed, is changing, or *is likely* to change as the result of human activities. The Australian Government has established a number of principles to guide notifications in Australia (Department of the Environment, Water Heritage and the Arts 2009):

- Assessment of change will be undertaken with respect to *critical* components, processes and benefits/services of the ecological character of the site.
- An assessment of change to support a notification must be based on best available science.
- The fact that a site was undergoing human-induced ecological character change at the time of listing does not preclude the need for an assessment, and possible notification of change, if there is evidence of significant ongoing adverse ecological change.
- Where the natural variability of a site cannot reasonably be established for the critical component process, benefit or service against which change is being assessed, a notification, if made, will only be on the basis of *'is likely to'* change.
- A notification will not be made where the apparent character change has been identified as arising from the use of inadequate data sets at the time of listing.
- A notification will not be made where climate change is the principal cause of identified ecological character change.

1.1.2 Objectives of the management plan

The primary purpose of the RMP is to maintain ecological character and promote wise use of the site. Wise use is defined as (Ramsar Convention 2005):

> *"the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development".*

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site supports a number of environmental, economic, social and cultural values (see section 2.4). Socio-economic and cultural values of the site (e.g. tourism, recreation) result from maintaining the condition of the Ramsar site. This RMP has adopted the principle that by maintaining (or improving) ecological character, the socio-economic and cultural values associated with the Ramsar site will also be conserved, within the concept of wise use. Therefore, the primary objective of the RMP is:

"***To maintain, and where necessary improve, the ecological character of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site and support wise and sustainable use***".

1.1.3 Ramsar documentation

Ramsar site management to maintain ecological character is reliant on a number of key documents and processes as illustrated in Figure 1. The key documents are:

Ramsar Information Sheet (RIS) - compiled for each site it documents the essential information related to the site and its management. The Administrative Authority of each Contracting Party submits the RIS to the Ramsar Secretariat. In the case of Australia this is the Australian Government Department of the Environment and Energy (DoEE). The Parties have committed to providing updated RIS information for their Ramsar sites every six years, or on the occasion of any significant change in a site's ecological character. The most recent RIS for Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site was compiled in 1999 and is currently being updated.

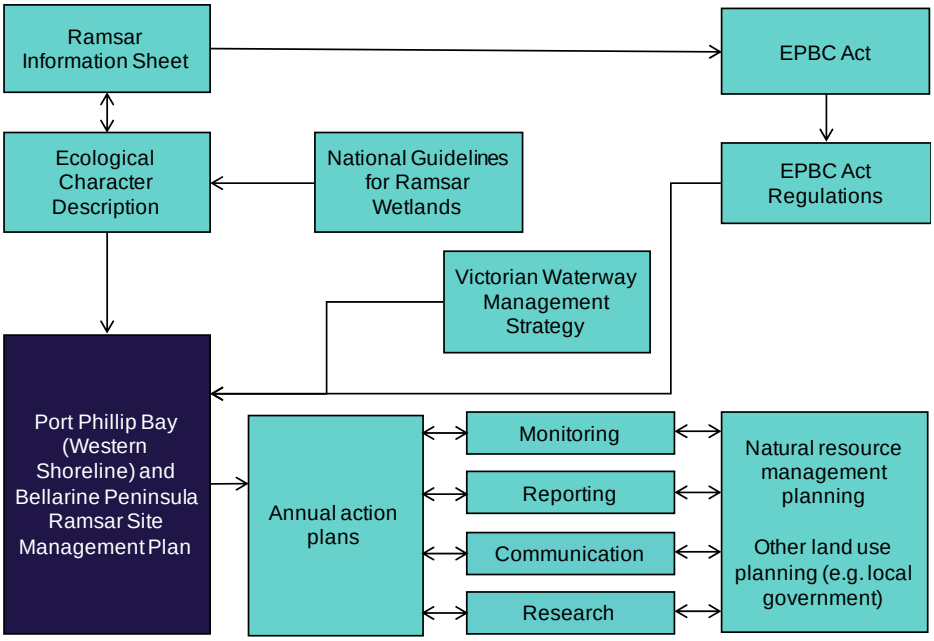


Figure 1: The RMP in context of other requirements for the management of Ramsar sites (adapted from DEWHA 2008).

Ecological Character Description (ECD) – provides a more detailed and quantitative description of ecological character for a Ramsar site. The ECD establishes a benchmark, at the time of listing, which in the case of Port Phillip Bay (Western Shoreline) and Bellarine Peninsula is 1982. The ECD identifies the critical components, processes and services of the site (critical CPS) and sets limits of acceptable change (LAC). The Australia Government has developed a standard method for describing ecological character (Department of the Environment, Water, Heritage and the Arts 2008). The ECD for Port Phillip Bay (Western Shoreline) and Bellarine Peninsula is currently being finalised.

Ramsar Management Plan (RMP) – documents the management strategies required to protect and restore the ecological character of a Ramsar site. In Australia, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) establishes the framework for management of Australian Ramsar sites, and Schedule 6 of *Environment Protection and Biodiversity Conservation Regulations 2000* outlines the principles relevant to the preparation of Ramsar site management plans (Text Box 1).

Ramsar Rolling Review – DoEE has developed a three-year Ramsar Rolling Review program for reporting the status of the ecological character of Australia's Ramsar sites. The broad aims of the Ramsar Rolling Review program are to:

- Review and report on the status of the ecological character of Australia's Ramsar sites.
- Be a tool to assist managing sites in order to maintain their ecological character, improving links between ecological character, site management plans and monitoring programs for critical CPS and associated threats.
- Provide input to a database of baseline and threat data.
- Record updates as knowledge gaps are addressed and refine LAC.
- Highlight issues and facilitate assessment of a potential change of character, focussing on proactive management before the situation requires notification.
- Identify broad trends or common threats across site and jurisdiction boundaries.

1 General principles

1.01 The primary purpose of management of a declared Ramsar wetland must be, in accordance with the Ramsar Convention:

(a) to describe and maintain the ecological character of the wetland, and

(b) to formulate and implement planning that promotes:

(i) conservation of the wetland, and

(ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.

1.02 Wetland management should provide for public consultation on decisions and actions that may have a significant impact on the wetland.

1.03 Wetland management should make special provision, if appropriate, for the involvement of people who:

(a) have a particular interest in the wetland, and

(b) may be affected by the management of the wetland.

1.04 Wetland management should provide for continuing community and technical input.

2 Management planning

2.01 At least one management plan should be prepared for each declared Ramsar wetland.

2.02 A management plan for a declared Ramsar wetland should:

(a) describe its ecological character, and

(b) state the characteristics that make it a wetland of international importance under the Ramsar Convention, and

(c) state what must be done to maintain its ecological character, and

(d) promote its conservation and sustainable use for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem, and

(e) state mechanisms to deal with the impacts of actions that individually or cumulatively endanger its ecological character, including risks arising from:

(i) physical loss, modification or encroachment on the wetland, or

(ii) loss of biodiversity, or

(iii) pollution and nutrient input, or

(iv) changes to water regimes, or

(v) utilisation of resources, or

(vi) introduction of invasive species, and

(f) state whether the wetland needs restoration or rehabilitation, and

(g) if restoration or rehabilitation is needed-explain how the plan provides for restoration or rehabilitation, and

(h) provide for continuing monitoring and reporting on the state of its ecological character, and

(i) be based on an integrated catchment management approach, and

(j) include adequate processes for public consultation on the elements of the plan, and

(k) be reviewed at intervals of not more than 7 years.

3 Environmental impact assessment and approval

3.01 This principle applies to the assessment of an action that is likely to have a significant impact on the ecological character of a Ramsar wetland (whether the action is to occur inside the wetland or not).

3.02 Before the action is taken, the likely environmental impact of the action on the wetland's ecological character should be assessed under a statutory environmental impact assessment and approval process.

3.03 The assessment process should:

(a) identify any part of the ecological character of the wetland that is likely to be affected by the action, and

(b) examine how the ecological character of the wetland might be affected, and

(c) provide adequate opportunity for public consultation.

3.04 An action should not be approved if it would be inconsistent with:

(a) maintaining the ecological character of the wetland, or

(b) providing for the conservation and sustainable use of the wetland.

3.05 Approval of the action should be subject to conditions, if necessary, to ensure that the ecological character of the wetland is maintained.

3.06 The action should be monitored by the authority responsible for giving the approval (or another appropriate authority) and, if necessary, enforcement action should be taken to ensure compliance with the conditions.

Text Box 1: Australian Ramsar Management Principles (Environment Protection and Biodiversity Conservation Regulations 2000; https://www.legislation.gov.au/Series/F2000B00190).

1.2 Relevant policy and legislation

1.2.1 International

Ramsar Convention

The Convention on Wetlands of International Importance, otherwise known as the Ramsar Convention, was signed in Ramsar Iran in 1971 and came into force in 1975. It provides the framework for local, regional and national actions, and international cooperation, for the conservation and wise use of wetlands. Wetlands of International Importance are selected on the basis of their international significance in terms of ecology, botany, zoology, limnology and/or hydrology.

Migratory bird bilateral agreements and conventions

Australia is party to a number of bilateral agreements, initiatives and conventions for the conservation of migratory birds, which are relevant to the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. The bilateral agreements are:

- Japan–Australia Migratory Bird Agreement (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;
- China–Australia Migratory Bird Agreement (CAMBA) - The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986;
- Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA) - The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment, 2006; and
- The Bonn Convention on Migratory Species (CMS) - The Bonn Convention adopts a framework in which countries with jurisdiction over any part of the range of a particular species co-operate to prevent migratory species becoming endangered. For Australian purposes, many of the species are migratory birds.

1.2.2 National

Native Title Act 1993

This *Act* provides for the recognition and protection of native title, as "It establishes ways in which future dealings affecting native title may proceed and to set standards for those dealings". It provides for, or permits, the validation of past acts, and intermediate period acts, invalidated because of the existence of native title.

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The *EPBC Act* regulates actions that will have or are likely to have a significant impact on any matter of national environmental significance, which includes the ecological character of a Ramsar wetland (*EPBC Act* 1999 s16(1)). An action that will have or is likely to have a significant impact on a Ramsar wetland will require an environmental assessment and approval under the *EPBC Act*. An 'action' includes a project, a development, an undertaking or an activity or series of activities.

The *EPBC Act* establishes a framework for managing Ramsar wetlands, through the Australian Ramsar Management Principles (*EPBC Act* 1999 s335), which are set out in Schedule 6 of the Environment Protection and Biodiversity Conservation Regulations 2000. These principles are intended to promote national standards of management, planning, environmental impact assessment, community involvement, and monitoring, for all of Australia's Ramsar wetlands in a way that is consistent with Australia's obligations under the Ramsar Convention (see Text Box 1). Some matters protected under the *EPBC Act* are not protected under local or state/territory legislation, for example, many migratory birds are not specifically protected under State legislation. Species listed under international treaties JAMBA, CAMBA and CMS have been included in the List of Migratory species under the Act. Threatened species and communities listed

under the *EPBC Act* may also occur, or have habitat in the Ramsar site; some species listed under State legislation as threatened are not listed under the *EPBC Act* as threatened, usually because they are not threatened at the national (often equivalent to whole-of-population) level. The Regulations also cover matters relevant to the preparation of management plans, environmental assessment of actions that may affect the site, and the community consultation process.

1.2.3 Victorian

The Environment Protection Act 1970

This *Act* establishes the Environment Protection Authority and makes provision for the Authority's powers, duties and functions. These relate to improving the air, land and water environments by managing waters, control of noise and control of pollution. State Environment Protection Policies (SEPPs) are subordinate legislation made under the provisions of the *Act*. SEPP (Waters of Victoria) sets water quality objectives to protect the beneficial uses of surface waters. SEPP (Waters of Victoria) is currently under review.

Environment Effects Act 1978

This Act establishes the processes for assessment of proposed projects (works) that are capable of having a significant effect on the environment. The Act establishes the role of the Minister for Planning to decide whether an Environmental Effects Statement (EES) is required. The roles and responsibilities of the EES process are described in the Ministerial guidelines for Assessment of Environmental Effects under the Environment Effects Act 1978 (DSE 2006). The guidelines specify the criteria for referring a project to the Minister for decision on the requirement for an EES. These include effects of potential long-term change to the ecological character of a Ramsar site.

National Parks Act 1975

This *Act* makes provision for the establishment of protected areas designed to ensure the preservation of the natural environment including wilderness areas and remote and natural areas. This includes the protection and preservation of indigenous flora and fauna and of features of scenic or archaeological, ecological, geological, historic or other scientific interest in those parks. It allows for the study of ecology, geology, botany, zoology and other sciences relating to the conservation of the natural environment in those parks; and for the responsible management of the land in those parks.

Wildlife Act 1975

This *Act* ensures procedures are in place to protect and conserve Victoria's wildlife and prevent any taxa of wildlife from becoming extinct. The *Act* also provides for the establishment of State Game Reserves. Regulations under the *Act* ensure that the consumptive use or other interactions with flora and fauna in Victoria does not threaten the sustainability of wild populations, while facilitating cultural and recreational pursuits in a humane, safe, ethical and sustainable manner.

Crown Land (Reserves) Act 1978

This *Act* provides the framework for the administration and management of Crown land reserves including nature conservation reserves. The *Act* also deals with the making of regulations, committees of management and leasing and licensing.

Flora and Fauna Guarantee Act 1988

This *Act* provides a legislative and administrative framework for the conservation of biodiversity in Victoria. The *Act* provides for the listing of threatened taxa, communities and potentially threatening processes. It requires the preparation of action statements for listed species, communities and potentially threatening processes and sets out the process for implementing interim conservation orders to protect critical habitats. The *Act* also seeks to provide programs for community education in the conservation of flora and fauna and to encourage co-operative management of flora and fauna.

Water Act 1989

This *Act* establishes rights and obligations in relation to water resources and provides mechanisms for the allocation of water resources. This includes the consideration of environmental water needs of rivers and wetlands as well as for human uses such as urban water supply and irrigation.

Catchment and Land Protection Act 1994 (CaLP Act)

This *Act* sets up a framework for the integrated management and protection of catchments. It establishes processes to encourage and support community participation in the management of land and water resources and provides for a system of controls on noxious weeds and pest animals.

Fisheries Act 1995

This *Act* provides a framework for the regulation, management and conservation of Victorian fisheries. It deals with commercial and recreational licences, fish culture, noxious aquatic species, research and development, the declaration and management of fisheries reserves; and the preparation of management plans for individual fisheries, declared noxious aquatic species and fisheries reserves.

Aboriginal Heritage Act 2006 and Aboriginal Heritage Amendment Act 2016

These Acts provides for the protection and management of Victoria's Aboriginal heritage through establishing the Victorian Aboriginal Heritage Council to advise the Minister in the management of cultural heritage and registered Aboriginal parties; addressing cultural heritage management plans, cultural heritage permits and agreements; and, including enforcement provisions and processes for handling dispute resolution, which includes the review of certain decisions through the Victorian Civil and Administrative Tribunal (VCAT).

Planning and Environment Act 1987

This *Act* sets out procedures for preparing and amending the Victoria Planning Provisions and planning schemes, obtaining permits under schemes, settling disputes, enforcing compliance with planning schemes, and other administrative procedures.

1.2.4 Regional strategies and plans

Port Phillip and Western Port Regional Catchment Strategy 2014

The Port Phillip and Western Port Regional Catchment Strategy is a statutory document under the Catchment and Land Protection Act 1994 (CaLP Act) that provides the overarching framework for land, water and biodiversity management in the Port Phillip and Western Port region.

Healthy Waterways Strategy

The Healthy Waterways Strategy (Melbourne Water 2013) outlines Melbourne Water's role in managing rivers, estuaries and wetlands in the Port Phillip and Westernport region. This strategy focuses on investing in areas that the community values and that will protect and improve environmental values and increase liveability.

Corangamite Regional Catchment Strategy 2013-2019

The Corangamite Regional Catchment Strategy is a statutory document under the *Catchment and Land Protection Act 1994* (CaLP Act) that provides the overarching framework for land, water and biodiversity management in the Corangamite region.

Corangamite Waterway Strategy 2014-2022

The purpose of the Corangamite Waterway Strategy 2014-2022 (CWS) is to provide a framework and regional work program for the Corangamite Catchment Management Authority (CMA), in partnership with other agencies, industry and community groups to maintain or improve the condition of rivers, estuaries and wetlands of the Corangamite region.

Port Phillip Bay Environmental Management Plan (EMP) 2017-2027

The Port Phillip Bay EMP provides a framework for government, industry and community groups to work together in managing the Bay and its catchment. The plan covers portions of the Ramsar site including Swan Bay, Mud Islands and the western shoreline. The plan has three goals to guide future action and investment over the next 10 years:

- stewardship of the Bay is fostered across community, industry and government
- the health and community enjoyment of the Bay is enhanced by best practice water quality management
- the Bay's habitats and marine life are thriving

1.3 Developing the plan

The Corangamite Catchment Management Authority (Corangamite CMA) was commissioned to facilitate the renewal the 2003 *Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Strategic Management Plan* with funds provided by DELWP. The project was based on a robust and transparent method to analyse and prioritise values and threats within the Ramsar site, with the aim of maintaining and where possible, restoring the ecological character of the site, within a coordinated and collaborative framework for management. Further detail on the methods used is provided in the sections below:

- Risk assessment – section 3.1
- Identification of priority values – section 3.2
- Identification of priority threats – section 3.3
- Management strategies – section 4.

1.3.1 Principles of the planning process

Throughout the development of this RMP, a number of principles were adopted and underpinned the planning process, consistent with the guiding principles of the VWMS (Department of Environment and Primary Industries 2013):

- Stakeholder involvement – this plan has been developed with the input of a broad range of stakeholders through every phase (see section 1.3.2).
- Evidence-based approach – best available knowledge has been used to underpin the development of this RMP including the risk assessment and prioritisation of values and threats.
- Precautionary principle – lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation.
- Building on existing activities – there are a large number of activities already being implemented within the catchment and the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site to maintain and improve condition and ecosystem services. This RMP seeks to build on these existing activities rather than duplicate effort.
- Adaptive management – the RMPs life is for seven years, with a mid-term review after three years. A monitoring program has been included and the principles of monitor, evaluate, report and improve have been adopted.

1.3.2 Stakeholder involvement

The importance of stakeholder engagement in the development of management plans for Ramsar sites is recognised by the Convention and in the Australian Ramsar Management Principles (Text Box 1). In terms of the development of this RMP, stakeholders were involved in every step of the process. A stakeholder engagement strategy was developed prior to the commencement of the project and refined as necessary (see Appendix A).

The major groups involved in the development of this RMP were:

- **Steering Committee (SC):** Representatives of agencies primarily responsible for the management of the Ramsar site (Corangamite CMA, Port Phillip and Westernport CMA, DELWP, Parks Victoria, Melbourne Water, EPA Victoria and DoEE).
- **Stakeholder Advisory Group (SAG):** Representatives of State Government agencies, local government and Non-Government Organisations with an interest and responsibility in managing aspects of Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site were engaged and invited to participate in workshops related to identifying priority values and threats and strategic management actions. Over thirty groups and agencies were represented (see Appendix A).
- **Community:** Broader community and stakeholder engagement through the Corangamite CMA network and webpage.

2 Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site

2.1 Location

Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is located on the western shoreline of Port Phillip Bay between the major cities of Melbourne and Geelong and on the Bellarine Peninsula (Figure 2). The site covers 22,650 hectares and comprises six distinct areas that include Point Cook/Cheetham, Werribee/Avalon, Point Wilson/Limeburners Bay, Swan Bay, Mud Islands, and the Lake Connewarre complex. The site includes freshwater wetlands, estuaries, intertidal shorelines, sub-tidal beds, inland saline wetlands and a wastewater treatment facility. Extensive areas of coastal saltmarsh and seagrass occur within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site, with smaller areas of freshwater vegetation within the Lake Connewarre complex.

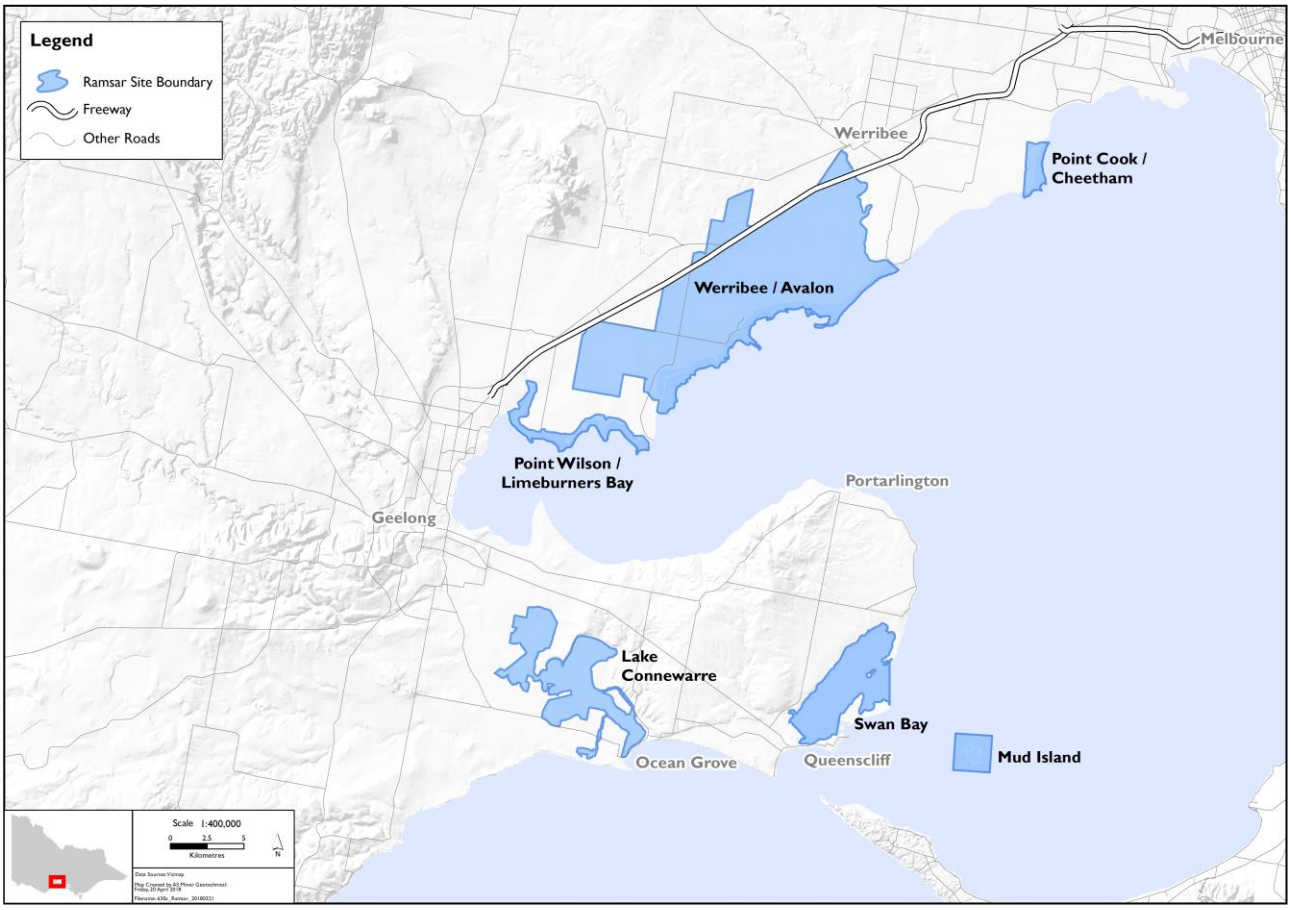


Figure 2: Map of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site.

2.2 Land status and site managers

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is composed of six areas that are managed primarily by DELWP, Parks Victoria, Melbourne Water and the Department of Defence (Table 1). There are also a number of different agencies with responsibilities associated with managing aspects of the site, and these are summarised in Table 2.

Table 1: Land tenure within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site and the associated land managers.

Area	Land tenure	Legal status	Management
Point Cooke / Cheetham			
Eastern Point Cook Coastal Park including the south-eastern Cheetham Wetlands	Crown Land Reserves	*Crown Land (Reserves) Act 1978*	Parks Victoria
Port Phillip Bay nearshore waters	Point Cooke Marine Sanctuary	*National Parks Act 1975*	Parks Victoria
Port Phillip Bay nearshore waters	Unreserved Crown Land	*Land Act 1958*	DELWP
Werribee / Avalon			
Werribee – land near Farm Road	Freehold	Private land	Private residential
Western Treatment Plant	Freehold	Private land	Melbourne Water
Port Phillip Bay foreshore adjacent to Western Treatment Plant north of Little River	Port Phillip Bay Coastal Reserve	*Crown Land (Reserves) Act 1978*	Melbourne Water
Port Phillip Bay nearshore waters	Unreserved Crown Land	*Land Act 1958*	DELWP
Port Phillip Bay foreshore adjacent to Western Treatment Plant south of Little River	Port Phillip Bay Coastal Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria
Werribee River Regional Park	Nature Conservation Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
The Spit Nature Conservation Reserve	Nature Conservation Reserve – Wildlife Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Avalon Airfield	Commonwealth Land	*Airports Act 1996*	Avalon Airport
Point Wilson / Limeburners Bay			
Point Wilson Explosives Area	Commonwealth Land	*Defence Act 1903, and Explosives Act 1961*	Department of Defence
Foreshore adjacent to Avalon Saltworks	Public Purposes Reserve	*Crown Land (Reserves) Act 1978*	DELWP
Port Phillip Bay nearshore waters	Unreserved Crown Land	*Land Act 1958*	DELWP
Avalon Beach to Limeburners Bay	Port Phillip Bay Coastal Reserve	*Crown Land (Reserves) Act 1978*	Parks Victoria City of Greater Geelong
Limeburners Lagoon (Hovells Creek) Flora and Fauna Reserve	Nature Conservation Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria City of Greater Geelong
Swan Bay			
Swan Bay component of the Port Phillip Heads Marine National Park	Marine National Park	*National Parks Act 1975*	Parks Victoria

Area	Land tenure	Legal status	Management
Stingaree Bight	Declared Naval Waters	*Control of Naval Waters Act 1918*	Department of Defence
Mud Islands			
Mud Islands component of the Port Phillip Heads Marine National Park	Marine National Park	*National Parks Act 1975*	Parks Victoria
Lake Connewarre and Reedy Lake			
Lake Connewarre State Game Reserve	Natural Features Reserve – Wildlife Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria
Portion of land on eastern and southern side of Lake Connewarre	Nature Conservation Reserve – Wildlife Reserve	*Crown Land (Reserves) Act 1978 and Wildlife Act 1975*	Parks Victoria

Table 2: Lead management agencies and their key responsibilities (Parks Victoria 2003).

Agency	Overarching responsibility	Responsibility in the Ramsar Site
Parks Victoria	Responsible for the management of Victoria's protected area system including both terrestrial and marine parks and reserves. As Local Port Manager also responsible for piers, jetties, and navigational aids in local port waters.	Manage many high value conservation areas including Point Cooke, Cheetham, Swan Bay, Mud Islands, Lake Connewarre, coastal crown land reserves.
Department of Environment, Land Water and Planning (DELWP)	Strategic direction for park and reserve management; flora and fauna management and implementation of the Ramsar Convention in Victoria; catchment and water management, forest management, coastal and local port management; leasing, licensing and management of public land, strategic and statutory land use planning including the administration of the Victorian Planning Provisions.	Policy advice for the management of the Port Phillip (Western Shoreline) and Bellarine Peninsula Ramsar Site. Appointment and oversight of Committees of Management on Crown foreshore reserves, including assistance with the preparation of Coastal Management Plans. Administer *Coastal Management Act 1995* for use and development of coastal Crown land.
Victorian Fisheries Authority	Provides strategic direction for fisheries management and research.	Manage recreational and commercial fishing for the Ramsar site in accordance with *Fisheries Act 1995*.
Environment Protection Authority Victoria	Responsibility for and coordination of all activities relating to the discharge of waste into the environment and the generation, storage, treatment, transport and disposal of industrial waste and the emission of noise and for preventing or controlling pollution and noise and protecting and improving the quality of the environment.	Licence sewage and other discharges. Monitor and report on environmental quality as required under SEPP (Waters of Victoria).
Department of Defence	Management of Commonwealth land	Manage the declared naval waters of Swan Bay.
Central Coastal Board	Develop a coastal action plan and guidelines for coastal planning and management; provide advice to Minister and Council on coastal development within the region.	Develop and oversee the implementation of the Central Coastal Board Action Plan and increase public awareness of the Victorian Coastal Strategy and action plan.
Melbourne Water	Provision of water and sewage services and the management of water supply storages and	Supply drinking and recycled water and manage Melbourne's water supply

Agency	Overarching responsibility	Responsibility in the Ramsar Site
	catchments. Waterway Management in the PPWCMA region. Environmental Water delivery with Victorian Environment Water Holder in Tarago/Bunyip.	catchments, sewage treatment, and the waterways and drainage systems in the Port Phillip Bay catchment. Manage the Western Treatment Plant.
City of Wyndham City of Greater Geelong Borough of Queenscliffe	Manage foreshores adjoining urban areas. Ensure orderly, sustainable development within the catchment to and within the boundary of the Ramsar site, through strategic land-use planning, improvement to and administration of the Planning Scheme.	Working with community and other agencies in the control of pest plants and animals, domestic animal control, managing buffer zones, water quality and fostering complimentary management practices. Consideration of the potential effects on ecological character in assessing planning applications.
Port Phillip & Westernport CMA Corangamite CMA	Advise State Government on catchment management, and land and water resource issues and priorities. Encourage cooperation between land and water managers. Promote community awareness on catchment management issues.	Develop and implement Regional Catchment Management Strategies. Prepare and implement Action Plans. Manage surrounding catchment and inflowing streams and drainage.

2.3 Ramsar criteria met

At the time that Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site was first nominated as a Wetland of International Importance, the criteria for identifying wetlands of international importance were the "Cagliari criteria", adopted at the first conference of contracting parties in Cagliari, Italy in 1980. The original nomination documentation considered that this Ramsar site met four of these criteria as shown in Table 3. However, no specific justification for these criteria was provided.

Table 3: Criteria for Identifying Wetlands of International Importance as at listing date, 1982. Criteria for which Port Phillip Bay (Western Shoreline) and Bellarine Peninsula was listed are highlighted (Forests Commission 1983).

Basis	No.	Description
Criteria for waterfowl	1a	It regularly supports 10,000 ducks, geese and swans; or 10,000 coots or 20,000 shorebirds
	1b	It regularly supports 1% of the individuals in a population of one species or subspecies of waterfowl
	1c	It regularly supports 1% of the breeding pairs in a population of one species or subspecies of waterfowl
Criteria based on plants and animals	2a	It supports an appreciable number of rare, vulnerable or endangered species or subspecies of plant or animal
	2b	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
	2c	It is of special value as the habitat of plants or animals at a critical stage of their biological cycle
	2d	It is of special value for one or more endemic plant or animal species or communities.
Representative wetlands	3	It is a particularly good example of a specific type of wetland characteristic of its region.

The criteria under which a Ramsar site can be designated have gone through a series of changes, with the most recent major revisions occurring at the 9th Ramsar Conference in Kampala, Uganda 2005, when a ninth criterion was added. The most recent assessment of the site against Ramsar criteria indicated that at the time of listing in 1982, the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site would have met six of the nine criteria as follows.

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

This criterion is only applied to ***wetland dependent*** flora and fauna, and those listed as vulnerable, endangered or critically endangered under national legislation (EPBC Act) or internationally (IUCN Red List). The site regularly supports one ecological community and 12 fauna species listed under the EPBC Act and or IUCN Red List:

- Coastal saltmarsh – vulnerable ecological community (EPBC Act)
- Australasian bittern (*Botaurus poiciloptilus*) – endangered (EPBC Act and IUCN)
- Australian fairy tern (*Sternula nereis nereis*) – vulnerable (EPBC Act)
- Bar-tailed godwit (*Limosa lapponica baueri*) – vulnerable[1] (EPBC Act) and near threatened (IUCN)
- Curlew sandpiper (*Calidris ferruginea*) – critically endangered (EPBC Act) and near threatened (IUCN)
- Eastern curlew (*Numenius madagascariensis*) – critically endangered (EPBC Act) and endangered (IUCN)
- Great knot (*Calidris tenuirostris*) – critically endangered (EPBC Act) and endangered (IUCN)
- Hooded plover (*Thinornis rubricollis rubricollis*) – vulnerable (EPBC Act)
- Lesser sand plover (*Charadrius mongolus*) – vulnerable (EPBC Act)
- Red knot (*Calidris canutus*) – endangered (EPBC Act) and near threatened (IUCN)
- Orange-bellied parrot (*Neophema chrysogaster*) – critically endangered (EPBC Act and IUCN)
- Australian grayling (*Prototroctes maraena*) – vulnerable (EPBC Act) and near threatened (IUCN)
- Growling grass frog (*Litoria raniformis*) – vulnerable (EPBC Act) and endangered (IUCN)

While there are records of Australian painted snipe (*Rostratula australis*) from the Lake Connewarre complex (1978, 1981, 1990, 2011, 2013) and Ryan's Swamp at the Western Treatment Plant (Maarten Hulsebosch pers. comm.) this is insufficient to indicate that the site regularly supports this species.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their lifecycles or provides refuge during adverse conditions.

The basic description of this criterion implies a number of common functions/roles that wetlands provide including supporting fauna during migration and breeding. Over 35 waterbirds listed under international migratory agreements have been recorded within the Ramsar site. This number includes species that, in Australia, are residents (e.g. eastern great egret) and vagrant seabirds for which the site does not provide significant habitat (e.g. Arctic jaeger; *Stercorarius parasiticus*). There are 20 species of international migratory shorebirds that are regularly supported (in at least two thirds of seasons) by the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. The site provides both feeding and high tide roost sites for these species. In addition at least 49 species of wetland dependent bird species have been recorded breeding within the site; this includes large breeding colonies of several species on Mud Islands (Menkhorst 2010). The seagrass areas of Swan Bay are known to be important breeding and nursery areas for marine fish (Hamer et al. 2011a, Jenkins et al. 2011). In addition, the Western Treatment Plant supports breeding of native frogs including the growling grass frog (Renowden 2006, Smith et al. 2008). The lagoons of the Western Treatment Plant annually support large numbers of waterfowl, most notably, Australian shelduck (Loyn et al. 2014). Over 30,000 birds of this species have been recorded in primary moult at this site (Bob Swindley pers. comm.).

[1] Note that the Bar-tailed godwit subspecies *Limosa lapponica menzbieri* is listed as critically endangered. While it is possible that this species may occur in the Ramsar site, the sub species *baueri* is more common on the east coast of Australia and likely to comprise the majority of records in Victorian Ramsar sites (Dan Weller, Birdlife Australia pers. comm.).

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

Waterbird counts across the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site are very high (mostly due to the large numbers of birds supported by the Western Treatment Plant). Counts of shorebirds have been consistently > 20,000 from 1981 to 2017 (data from BirdLife Australia) and counts of waterfowl are generally > 80,000. These counts do not include the substantial numbers of waterbirds that nest on Mud Islands, where count data are sporadic and not able to be analysed over longer time frames. However, 2009 surveys of Mud Islands indicated 50,000 nests of silver gulls (*Chroicocephalus novaehollandiae*); 57,000 nests of straw-necked ibis (*Threskiornis spinicollis*) and 7600 nests of Australian white ibis (*Threskiornis molucca*) (Menkhorst 2010). This makes it likely that total annual waterbird numbers are in excess of 300,000 across the Ramsar site.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Assessment of this criterion must be made using the most recent official population estimates (Wetlands International 2012). Data provided by BirdLife Australia and from the DELWP annual summer waterfowl counts, indicate that 12 species meet this criterion:

- Australasian shoveler (*Anas rhynchotis*)
- Australian fairy tern (*Sternula nereis nereis*)
- Australian shelduck (*Tadorna tadornoides*)
- Blue-billed duck (*Oxyura australis*)
- Chestnut teal (*Anas castanea*)
- Curlew sandpiper (*Calidris ferruginea*)
- Double-banded plover (*Charadrius bicinctus*)
- Hoary-headed grebe (*Poliocephalus poliocephalus*)
- Musk duck (*Biziura lobata*)
- Pink-eared duck (*Malacorhynchus membranaceus*)
- Red-necked stint (*Calidris ruficollis*)
- Sharp-tailed sandpiper (*Calidris acuminata*).

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.

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site 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.

The seagrass beds in Swan Bay in particular are known to be important feeding and nursery areas for a number of fish species, including the commercially important King George whiting (*Sillaginodes punctatus*) (Jenkins et al. 2011, Jenkins and Kent 2011). Over 50 species have been recorded in Swan Bay, including estuarine and marine species. Of particular note is the importance of areas such as Swan Bay as nursery habitat for species such as snapper (*Chrysophrys auratus*) for coastal Victorian waters (Hamer et al. 2011b).

Reedy Lake, Lake Connewarre and the Barwon River estuary are also important areas for native fish and over twenty species have been recorded in these areas (Dahlhaus et al. 2007a). In addition, the Barwon River estuary is an important migratory route for native fish that travel between fresh and marine waters to spawn. These include short-finned eels (*Anguilla australis*), common galaxias (*Galaxias maculatus*), broad-finned galaxias (*Galaxias brevipinnis*), Australian grayling and pouched lamprey (*Geotria australis*) (Ryan et al. 2010).

2.4 Ecological character and values

2.4.1 Critical components, processes and services

The Australian Government has developed and implemented a framework for describing the ecological character of Ramsar sites (Department of the Environment, Water, Heritage and the Arts 2008). This framework requires the identification and description of critical components, processes and services. These are defined as characteristics of the Ramsar site:

1. that are important determinants of the sites unique character;
2. that are important for supporting the Ramsar criteria under which the site was listed;
3. for which change is reasonably likely to occur over short to medium time scales (less than 100 years); and/or
4. that will cause significant negative consequences if change occurs.

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site draft ECD (DELWP in prep.) identifies components, process and services that are critical to the ecological character of the Ramsar site. These are described briefly below, more detail on each can be found in the draft ECD.

Geomorphology / ecological connectivity

Connectivity between freshwater and estuarine areas and estuaries and the marine environment are an important process for the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. In particular, this is important in the Lake Connewarre complex where the Ramsar site connects the upper Barwon River catchment with the Barwon River estuary and Bass Strait. Although flow paths have been altered from natural (mostly prior to Ramsar listing), hydrological connections between wetlands, river, estuary and the sea are maintained. Lake Connewarre is under tidal influence and maintains a constant connection to the estuary and Bass Strait, in the Southern Ocean. This connectivity is important for ecosystem functioning and to a number of migratory fish. Fish that are known to migrate through the freshwater, estuarine and marine habitats of the Ramsar site include: short-finned eel, common galaxias, spotted galaxias, tupong, Australian grayling and the pouched lamprey (Lloyd Environmental et al. 2006).

Hydrology

There are four sub-components that comprise the hydrology of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site:

- tides (for all coastal and marine areas in the site)
- river flows (Barwon River, Little River, Werribee River and Hovells Creek)
- groundwater (particularly important for maintaining water regimes at the Lake Connewarre complex), and
- artificial water regimes (Western Treatment Plant[2] and Cheetham Wetlands).

Saltmarsh

Each of the six areas that form the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site contain coastal saltmarsh, with a total area of 1225 hectares within the Ramsar site boundary (Boon et al. 2011b). Saltmarsh occupies the area of the site between seagrass and terrestrial vegetation at higher elevation. The saltmarsh of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is diverse, with the saltmarshes in Lake Connewarre complex being recognised in particular for their complexity (Boon 2011). Coastal saltmarsh is listed as a vulnerable ecological community under the EPBC Act and is important habitat for fish, when inundated as well as for feeding and roosting waterbirds, when tides are low.

[2] It should be noted that while the draft ECD identifies hydrology as a critical component, nutrients from the Western Treatment Plant have also been shown to be very important in maintaining ecological character.

Seagrass

Seagrass is an important component of the ecological character of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site at three areas: Pt. Wilson / Limeburners Bay; Swan Bay (Figure 3) and Mud Islands. The coastal areas within the Werribee / Avalon and Point Cooke areas are dominated by bare substrate or macroalgae rather than seagrass, with drift algae a distinctive feature of the Werribee / Avalon coastline (Light and Woelkerling 1992).

There are two species of seagrass in Port Phillip Bay which are a feature within the Ramsar site (Jenkins et al. 2015):

- *Zostera nigricaulis* – occurs only in subtidal areas where exposure to the air is limited.
- *Zostera muelleri* – generally occurs in the intertidal zone, requiring periods of exposure to maintain health and growth.

A third species, *Halophila ovalis* occurs generally in deeper water and there may be patches around Point Wilson, but there are few deep water areas within the Ramsar boundary. Seagrass in some areas of the Ramsar Site has remained relatively stable with respect to extent and condition (e.g. Swan Bay) while in other areas, there is considerable variability over time (Jenkins et al. 2015).

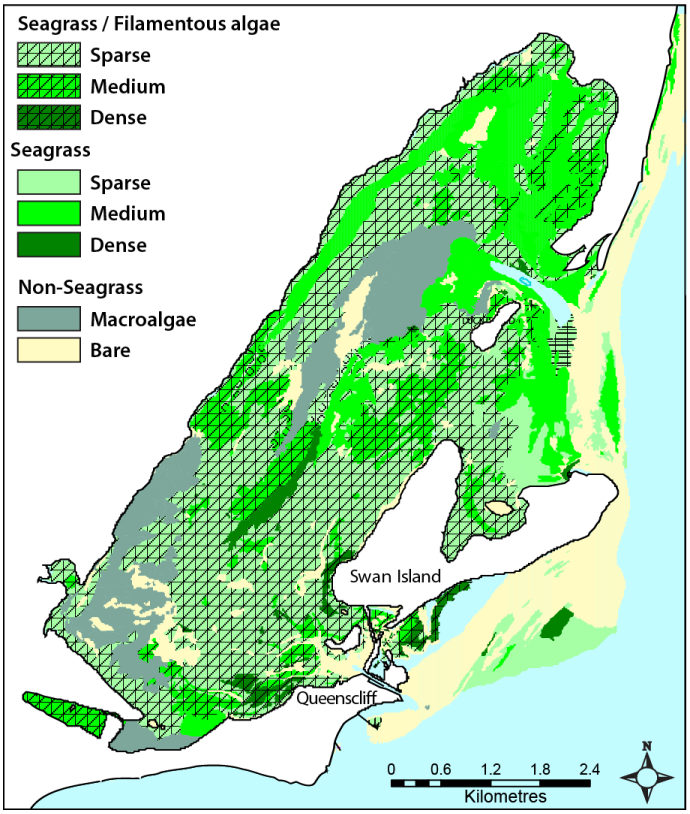


Figure 3: Seagrass in Swan Bay (Blake and Ball 2001).

Mangroves

The mangrove areas of Port Phillip Bay comprise a single species, *Avicennia marina,* and there are small areas of mangrove in Limeburner's Bay (four hectares) and the Barwon River estuary (40 hectares). The inundated roots and pneumatophores of mangroves provide good habitat for fish and invertebrates and play a role in stabilising the soft sediments in the site.

Freshwater vegetation

Freshwater vegetation in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is limited largely to Reedy Lake in the Lake Connewarre Complex, with smaller areas within the Western Treatment Plant, particularly at Paul and Belfrages Wetland (Australian Ecosystems 2016). Reedy Lake supports a habitat mosaic of open water, emergent freshwater vegetation (reed and sedge beds), submerged vegetation (e.g. *Myriophyllum* spp.) and lignum shrubland (Ecological Associates 2014, Corangamite CMA 2015).

Fish diversity and abundance

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site provides a variety of habitats for fish ranging from freshwater species (in Reedy Lake) as well as estuarine and marine species in seagrass and saltmarsh habitats. Twelve freshwater fish species have been recorded within the Ramsar site (Billows and Gwyther 2007) including the nationally threatened Australian grayling that migrates through the Barwon River estuary into the Southern Ocean as part of its lifecycle. Over 60 species of marine and estuarine fish have been recorded in saltmarsh and seagrass habitats of the Ramsar site. The seagrass areas are home to a large number of pipefish (which are listed as marine under the EPBC Act) the most common of which is the spotted pipefish (*Stigmatopora argus*). Other species include bridled leather jacket (*Acanthaluteres spilomelanurus*), the spot-shoulder weed fish (*Heteroclinus perspicillatus*) and the cobbler (*Gymnapistes marmoratus*). Swan Bay is also considered to be a significant nursery for King George whiting (Jenkins et al. 1997, Hamer et al. 2011b).

Waterbird diversity and abundance

A total of 129[3] waterbird[4] species have been recorded within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site, and the site regularly supports 20 species of waders from the East Asian-Australasian Flyway listed under the international migratory bird agreements JAMBA, CAMBA and ROKAMBA. The Ramsar site provides significant foraging area for a variety of shorebird species, particularly along the shoreline of the Werribee / Avalon sector, where productivity is high. There are also important roosting (resting) sites within the Ramsar site (for example Figure 4).

Red-necked stints at Point Wilson (A. Morrison).

[3] Note that this number includes several pelagic seabirds such as albatross, which are not regularly supported by the Ramsar site.

[4] Waterbirds are defined under the Ramsar Convention as species of birds that are ecologically dependent on wetlands.

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site supports very large numbers of shorebirds across all sectors of the Ramsar site. In addition to shorebirds, the site provides habitat for a variety of waterbird groups or guilds including ducks and swans; grebes; large wading birds such as herons, ibis and spoonbills; gulls and fish-eating birds such as cormorants, pelicans and terns. Waterfowl counts at the Western Treatment Plant alone often exceed 100,000. The site supports > 1% of the population of 11 species of waterbird, this includes regularly supporting more than half the total population of blue-billed ducks (DELWP unpublished).

Figure 4: Foraging and roosting habitat in Swan Bay and Mud Islands for migratory waders (Rogers et al. 2010)

Waterbird breeding

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is important for waterbird breeding for a wide variety of species. Beach-nesting birds such as red-capped plover breed at the Cheetham Wetlands (Brett Lane and Associates 2009) and Swan Bay, where there is a nesting colony for the threatened Australian fairy tern on Sand Island. Waterfowl such as Black swans, Pacific black ducks and chestnut teals are known to regularly breed at the Western Treatment Plant, which also supports a breeding colony of pied cormorant (*Phalacrocorax varius*). Reedy Lake within the Lake Connewarre Complex is an important breeding site for the colonial nesting species such as Australian white ibis, straw-necked ibis and royal spoonbills (*Platalea regia*). The most significant waterbird breeding location in the site is Mud Islands, which supports large numbers of nesting birds including white-faced storm petrels (*Pelagodroma marina*), Australian pelicans, cormorants, ibis, terns and silver gulls (Menkhorst 2010) .

Threatened wetland species

Threatened species regularly supported by the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site include 10 species of bird, one frog and one fish species.

Bar-tailed godwit (*Limosa lapponica baueri*), curlew sandpiper (*Calidris ferruginea*), **eastern curlew (*Numenius madagascariensis*), great knot (*Calidris tenuirostris*), lesser sand plover (*Charadrius mongolus*) and red knot (*Calidris canutus*)** are international migratory species that spend the non-breeding season in the southern hemisphere. They arrive in late spring, spend the summer feeding on invertebrates in intertidal mudflats and depart for the northern hemisphere in February to March. Juveniles of all species who arrive in the Ramsar site spend their first one or two winters before heading to the northern hemisphere to breed. Although the species have similar life histories, they are physically very different. The eastern curlew is the largest of the shorebirds with a wingspan of over one metre and a weight of nearly one kilogram. The red knot and bar-tailed godwits are smaller, but still large shorebirds. In contrast the curlew sandpiper is a small bird, with a weight of just 60 grams (Higgins and Davies 1996).

Australian fairy tern (*Sternula nereis nereis*) is an Australian resident, fish eating bird species. They feed close inshore upon small schooling fish. In the Ramsar site, anchovies and pilchards are likely to comprise the majority of their diet. There are regular observations of breeding on Mud Islands (e-bird.org) and they are regularly recorded foraging in the Werribee / Avalon section of the Ramsar site (DELWP unpublished data).

Australasian bittern (*Botaurus poiciloptilus*) is a shy and cryptic wading species. Habitat preferences are for permanent, densely vegetated freshwater wetlands (Higgins and Marchant 1990). It is a diurnal forager and actively hunts prey items such as frogs and fish as well as a variety of terrestrial animals such as rodents and snakes (Menkhorst 2012). In the Ramsar site, there are regular, but sparse records from the Western Treatment Plant (Menkhorst 2012), Reedy Lake and Hospital Swamp in the Lake Connewarre Complex (e-bird.org).

Australasian bittern at the Western Treatment Plant (P. Menkhorst).

Hooded plover (*Thinornis rubricollis*) is an Australian resident, invertebrate eating bird species. The majority of the important nesting sites for hooded plover are outside the Ramsar site boundary, (Maguire et al. 2014), however, there are regular observations from Swan Bay, where the species forages.

Orange-bellied parrot (*Neophema chrysogaster*) is endemic to south-eastern Australia, breeding in south-western Tasmania in a narrow section of coast and migrating to the coasts of Victoria and South Australia for the non-breeding period of April-October. At the time of listing (1982) the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site supported a significant number of these critically endangered birds. Numbers of orange-bellied parrots on mainland Australia have declined in recent years, although the Werribee section, Swan Bay and Lake Connewarre complex in the Ramsar site are some of the few mainland areas that continue to support the species (Department of Environment, Land, Water and Planning 2016).

Growling grass frog (*Litoria raniformis*) is usually found amongst emergent vegetation such as rushes and sedges within or at the edges of still or slow-flowing waterbodies. Within the Ramsar site it is found in the slow moving waterways and decommissioned lagoon ponds at the Western Treatment Plant (Melbourne Water unpublished) and the margins of Reedy Lake (Dahlhaus et al. 2007b).

Australian grayling (*Prototroctes maraena*) reside in the Barwon River upstream of the Ramsar site (Hall 1989). This diadromous species migrates to and from marine environments as part of its lifecycle (Crook et al. 2006, Schmidt et al. 2011). It is likely that larvae of the Australian grayling drift downstream through the Barwon River estuary into the Southern Ocean, with return upstream migration in spring of juveniles (Jenkins 2011).

2.4.2 Additional values

Rocky reefs

Rocky reefs comprise a small area within the Ramsar site, around Point Cooke and Point Wilson / Limeburner's Bay. Within the Ramsar site boundary, they are largely intertidal and typically colonised by mat forming brown algae Neptune's necklace (*Hormosira banksia*) and the green algae sea lettuce (*Ulva* spp.). Molluscs such as limpets and mussels dominate the fauna community, which may include a diverse array of invertebrates (Hart et al. 2005). They provide feeding habitat for a variety of waterbirds.

Socio-economic and cultural values

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site includes parts of the Port Phillip Heads Marine National Park and the Point Cooke Marine Sanctuary. The Ramsar site is important to at least two indigenous language groups, Mud Islands is part of *Country* of the Boonwurrung and the remainder of the site is part of *Country* of the Wathaurong. The site contains the Western Treatment Plant which treats a significant proportion of Melbourne's wastewater and produces recycled water.

Although Port Philip Bay is an important commercial and recreational fishery, fishing is not permitted in segments of the Ramsar site located within marine national parks (e.g. Swan Bay and Mud Islands within Port Phillip Heads Marine National Park). Recreational fishing is popular in parts of the Lake Connewarre System and Limeburner's Bay and Lake Connewarre supports a commercial eel fishery. Sailing and boating are popular past-times, particularly in the sheltered waters of Swan Bay. The site is valued for its educational facilities including the Western Treatment Plant and the Queenscliff Marine and Freshwater Discovery Centre on Swan Bay. Based on figures presented in Carnell (2015) and the total area of saltmarsh and seagrass within the Ramsar site, the blue carbon value of the Ramsar site is in the order of $2.5 million. Tourism in the Geelong coast (including the Bellarine Peninsula) is estimated at $475 million annually (Worley Parsons 2013). Using the data presented in Worley Parsons (2013) and the area of wetland types in the Ramsar site, the annual total non-commercial ecosystem service value of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is $230 million per annum.

2.5 Status of ecological character and Limits of Acceptable Change (LAC)

The mechanism against which change in ecological character is assessed is via comparison with Limits of Acceptable Change (LAC). LAC are defined by Phillips (2006) as:

> *"…the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. This may include population measures, hectares covered by a particular wetland type, the range of certain water quality parameter, etc. The inference is that if the particular measure or parameter moves outside the 'limits of acceptable change' this may indicate a change in ecological character that could lead to a reduction or loss of the values for which the site was Ramsar listed. In most cases, change is considered in a negative context, leading to a reduction in the values for which a site was listed".*

The following should be considered when developing and assessing LAC:

- LAC are a tool by which ecological change can be measured. However, LAC do not constitute a management regime for the Ramsar site.

- Exceeding or not meeting LAC does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting LAC may require investigation to determine whether there has been a change in ecological character.
- While the best available information was used to prepare the ECD and define LAC for the site, a comprehensive understanding of site character may not be possible as, in many cases, only limited information and data is available for these purposes. The LAC may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.
- LAC can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland. The formal process for this is via the Ramsar Rolling Review, which is a three yearly assessment of ecological character at each Ramsar site (Butcher et al. 2011).
- The LAC for Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site were established in the draft ECD for critical components, processes and services (DELWP unpublished). The most recent assessment against these updated LAC is provided in (Table 4).

Table 4: Summary of assessment against LAC for the Port Phillip (Western Shoreline) and Bellarine Peninsula Ramsar Site.

Critical CPS	Limit of Acceptable Change	2016 Assessment
Hydrology	Connectivity between the Barwon River and the Southern Ocean is not impeded between March and November for more than two consecutive years.	Connectivity has been maintained through operational fishways. **LAC is met.**
Hydrology	Reedy Lake to be wet for no longer than 10 continuous years, or dry for more than five. 75% of aerobic treatment lagoons with permanent water at the Western Treatment Plant 75% of lagoons at Cheetham with permanent water.	Reedy Lake dried during the Millennium drought, filled in 2007 and dried again in 2015 (Corangamite CMA 2015). **LAC is met.**
Seagrass	Seagrass extent will not decline below 1500 hectares for a period of greater than 20 continuous years.	Mapping from 2000 indicate a total of 2900 hectares of seagrass within the Ramsar site boundary in 2000. A recent assessment indicated that seagrass cover in Swan Bay had changed little from 2008 to 2012 (Ball et al. 2014). **LAC is met.**
Saltmarsh	Total saltmarsh extent will not decline below 900 hectares.	The most recent assessment of saltmarsh extent in the Ramsar site (Boon et al. 2011) indicates 1225 hectares. There is no evidence of a significant decline in saltmarsh extent. **LAC is met.**
Mangrove	Total mangrove extent will not decline below 40 hectares.	The most recent assessment of mangrove extent in the Ramsar site indicates 52 hectares. **LAC is met.**
Freshwater vegetation	A habitat mosaic will be maintained at Reedy Lake that comprises open water, emergent native vegetation (sedges, rushes and reeds) and lignum shrubland with no habitat comprising more than 70 percent of the total wetland area for more than five successive years.	Assessments of vegetation in 2014, indicated 50% emergent vegetation (sedges and reeds); 30% open water; 10% lignum shrubland and 10% other communities (Ecological Associates 2014). **LAC is met.**
Waterbird abundance	Abundance of waterbirds will not decline below the following (calculated as a rolling five-year average of maximum annual	Data from Birdlife Australia (shorebirds) and DELWP (non-shorebirds) indicates the following annual maximum counts (2011 – 2015):

Critical CPS	Limit of Acceptable Change	2016 Assessment
	count; percentages calculated based on the latest Wetlands International Waterbird Population Estimates): • Total shorebirds - 17,000 • Total non-shorebirds – 45,000 • Curlew sandpiper – 3% • Double-banded plover – 1% • Red-necked stint – 2% • Sharp-tailed sandpiper – 2% • Australasian shoveler – 3% • Australian shelduck – 1% • Blue-billed duck – 25% • Chestnut teal – 4% • Hoary-headed grebe – 1% • Musk duck – 2% • Pink-eared duck – 1%	• Total shorebirds - 22,900 • Total non-shorebirds – 110,000 • Curlew sandpiper – <1% (1400) • Double-banded plover – 1.5% (900) • Red-necked stint – 2% (6500) • Sharp-tailed sandpiper – 1.7% (2600) • Australasian shoveler – 3% (3200) • Australian shelduck – 1.9% (19,000) • Blue-billed duck – 25% (2500) • Chestnut teal – 9% (8900) • Hoary-headed grebe – 1.7% (17,000) • Musk duck – 3% (700) • Pink-eared duck – 2% (20,000) **LAC is met for most species and total shorebirds and non-shorebird. LAC is exceeded for total shorebirds, curlew sandpiper and sharp-tailed sandpiper**[5]
Waterbird breeding	Annual breeding at Mud Islands of: Pied cormorant > 40 pairs Straw-necked ibis > 10,000 pairs Australian white ibis > 5, 000 pairs White-faced storm-petrel > 1000 pairs Crested tern > 1000 pairs Silver gull > 30,000 pairs Annual breeding at Western Treatment Plant of: Pied cormorant > 300 pairs	The only comprehensive recent count of nesting waterbirds at Mud Island was in 2009 (Menkhorst 2010): Pied cormorant 50 pairs Straw-necked ibis 56,000 nests Australian white ibis 7500 nests White-faced storm-petrel 1000 nests Crested tern 1300 nests Silver gull > 30,000 nests Nesting pied cormorants increased at the Western Treatment Plant to approximately 1000 nests in 2010-2012 (Loyn et al. 2014). **LAC is met**
Threatened species: shorebirds	Australian fairy tern, bar-tailed godwit, eastern curlew, great knot, hooded plover, lesser sand plover and red knot recorded within the site in three out of five seasons.	Data from 2011 – 2015 indicate presence of the six species (BirdLife Australia): Australian fairy tern – three years Bar-tailed godwit – four years Eastern curlew – five years Great knot – three years Hooded plover – three years **Lesser sand plover – zero years** Red knot – four years **LAC is met for all species except lesser sand plover**[5]
Threatened species: orange-bellied parrot	Numbers of orange-bellied parrots on mainland Australia have decline in recent years. This decline is not related to factors within the Ramsar site. The LAC for orange bellied parrot is therefore related to	See LAC for saltmarsh

[5] The declines in waterbirds and exceedances in LACs were not considered to be related to human activities at the Ramsar site but reflected reduced Flyway-wide populations. The most likely cause was habitat loss in the staging areas used for migration, in particular the tidal flats of the Yellow Sea (Rogers *et al.* 2009).

Critical CPS	Limit of Acceptable Change	2016 Assessment
	maintaining suitable habitat and covered by the LAC for saltmarsh.	
Threatened species: Australian grayling	Australian grayling continues to be supported in the Barwon River system.	No recent records sourced. **Insufficient data to assess LAC.**
Threatened species: Growling grass frog	At Western Treatment Plant > 200 growling grass frogs in 3 out of 5 years.	Over 200 growling grass frog recorded in three of the five years from 2012 to 2016 (Melbourne Water unpublished). **LAC is met.**

Establishing the benchmark: "At the time of listing"

The Ramsar Convention establishes the benchmark for the ecological character of listed wetlands as:

"at the time of designation as a Ramsar Wetland of International Importance" (Resolution VI.1 Annex Para 2.1).

This is an important concept for understanding the goal of maintaining ecological character and assessing change in character. Aquatic ecosystems are rarely static and stable, Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is no exception. There are ongoing changes, many of which commenced prior to designation, with a continuing trajectory of change. Establishing a benchmark, against which change in ecological character can be assessed, is a task for the Ecological Character Description, using Limits of Acceptable Change. Maintaining the site's ecological character in a changing environment is a challenge for Ramsar site management.

Sometimes changes in identified critical components, processes and services are due to factors that are outside the Ramsar boundary and beyond the control of site managers. The decline in several shorebirds and the orange-bellied parrot in the Ramsar site are examples of this. There have been a large number of investigations into the decline of shorebirds in the East Asian-Australasian Flyway, with habitat declines particularly at staging areas in the Yellow Sea recognised as the most significant impact factors (MacKinnon et al. 2012, Murray et al. 2015, Hua et al. 2015). In terms of the orange-bellied parrot a decline in habitat extent and quality has been implicated (DELWP 2016).

Ramsar site managers need to work to maintain habitat and food resources for these species at the local scale to maximise their chances of long term recovery and survival. There is a comprehensive program in place for the recovery of the orange-bellied parrot and the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is playing an important role.

Eleven orange-bellied parrots that were bred in captivity were released at the Western Treatment Plan during April 2017. A loose flock of released and wild birds formed which actively foraged on the plentiful supply of wild food. It is hoped that future efforts will restore this population of critically endangered birds (OBP Recovery Team).

Image: Orange-bellied parrot in saltmarsh (Chris Tzaros).

3 Priority threats and values

Priority threats and values for management in the next seven years were identified through a process that was based on a risk assessment.

3.1 Risk assessment method

The risk assessment process adopted for this project is consistent with the ISO 31000:2009, *Risk management – Principles and guidelines* and the Standards Australia Handbook: *Environmental risk management – principles and process* (HB 203-2000; Standards Australia and Standards New Zealand 2006). The risk assessment approach follows a structured and iterative process, with the following steps:

1. Establish the context – existing values and environmental conditions
2. Identify risks – threats and associated potential impacts, and
3. Analyse risks – assign likelihoods and consequences to determine level of risk.

3.1.1 Establishing the context

A review of existing published and unpublished information relevant to the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site was undertaken to identify and summarise the important environmental, social and economic values; current condition and potential threats to ecological character. The spatial scale of the risk assessment was established as each of the six areas of the Ramsar site and included consideration of activities in the catchment that could impact ecological character.

The purpose of the risk assessment was to identify priority values and threats as the basis for identifying strategic actions in the RMP. The risk assessment was underpinned by scientific studies, local knowledge and expert opinion. The process of prioritising values and threats and how the risk assessment contributed to this is illustrated in Figure 5.

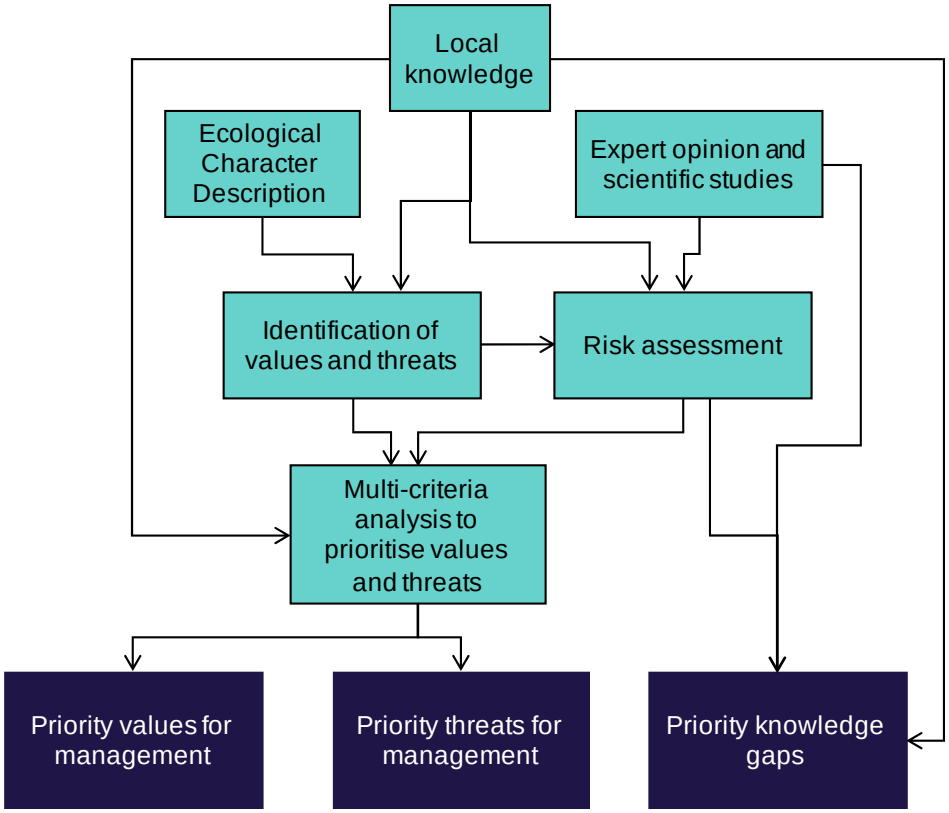


Figure 5: Process of prioritising values and threats and the role of the risk assessment.

The risk assessment was based on a desktop review of existing information, supplemented by expert scientific and broader stakeholder knowledge. The risk assessment undertaken in the current project drew heavily on three previous assessments:

- risks identified and assessed through the Port Phillip Bay Environmental Management Plan (DELWP 2017), which included an expert scientific panel,
- the Better Bays and Waterways program (Melbourne Water 2009) which assessed risks to water quality both in the catchments and in the Bay, and
- a series of reports assessing the risk of climate change to some of Victoria's marine environments (Klemke and Arundel 2013).

3.1.2 Identifying risks

The risk assessment process is consistent with the Australian/New Zealand Standard: Risk Management (AS/NZS 4360:2004; Standards Australia and Standards New Zealand 2004) and the Standards Australia Handbook: Environmental risk management - principles and process (HB 203-2000; Standards Australia and Standards New Zealand 2006).

The approach uses a hierarchical process to identify potential risks as follows:

- Threats – activities in the Ramsar site or catchment that could affect ecological character
- Stressors – the physical or chemical changes that could arise as a result of an activity
- Effects – the potential responses caused by the stressors.

This allows for clear identification of the underlying causes of risks and threats to ecological character of the Ramsar site, separating the threat from the impact.

3.1.3 Analysing risks

Impact pathways were developed that integrated each level of the hierarchy and these formed the basis of a formal risk analysis process. Likelihood and consequence were assigned to each impact pathway in its entirety. See below for an example for an impact pathway:

Threat	Stressor	Effect
Recreation: boats, kite surfing	Increased disturbance	Decreased breeding success of beach-nesting birds

Questions were put to stakeholder and agency technical staff to estimate the likelihood and consequence, for example: what is the likelihood that agricultural practices in the catchment will result in increased nutrients, increased algal growth and that this will result in a decline in seagrass health? What are the consequences of this with respect to the ecological character of the Ramsar site?

The risk assessment was based on a few key principles:

- Assessment of likely impacts in the next 30 - 35 years,
- Assessment based on the current management regime continuing, and
- Evidence based approach using scientific data and expertise coupled with local knowledge.

Likelihood and consequence are described in Table 5 and Table 6, respectively, with the risk matrix (Table 7) showing how they combine to score the overall risk.

Table 5: Likelihood

Almost certain	Likely	Possible	Unlikely	Rare
Is expected to occur in most circumstances	Will probably occur in most circumstances	Could occur	Could occur but not expected	Occurs only in exceptional circumstances

Table 6: Consequence

Category	Insignificant	Minor	Moderate	Major	Extreme
Ecosystem Function (need to consider resilience and resistance)	Alteration or disturbance to ecosystem within natural variability. Ecosystem interactions may have changed but it is unlikely that there would be any detectable change outside natural variation	Localised measurable changes to the ecosystem components without a major change in function (no loss of components or introduction of new species that affects ecosystem function). Recovery (if relevant) in less than 1 year.	Widespread measurable changes to the ecosystem components without a major change in function (no loss of components or introduction of new species that affects ecosystem function). Recovery (if relevant) in 1 to 2 years.	Widespread measureable changes to the ecosystem components with a major change in function. Recovery (i.e. within historic natural variability) in 3 to 10.	Long term and possibly irreversible damage to one or more ecosystem function. Recovery, if at all, greater than 10 years.
Habitat, communities	Alteration or disturbance to habitat within natural variability. Less than 1% of the area of habitat affected or removed.	1 to 5% of the area of habitat affected in a major way or removed.	5 to 30% of the area of habitat affected in a major way or removed.	30 to 90% of the area of habitat affected in a major way or removed.	Greater than 90% of the area of habitat affected in a major way or removed.
Species	Population size or behaviour may have changed but it is unlikely that there would be any detectable change outside natural variation / occurrence.	Detectable change to population size and / or behaviour, with no detectable impact on population viability (recruitment, breeding, recovery) or dynamics.	Detectable change to population size and / or behaviour, with no impact on population viability (recruitment, breeding, recovery) or dynamics.	Detectable change to population size and / or behaviour, with an impact on population viability and or dynamics.	Local extinctions are imminent / immediate or population no longer viable.
Social	Short-term interruptions in recreational use (days) and perception as a high amenity place to visit unaltered.	Recreational activities restricted and perceptions of amenity altered in a localised area for short-term (< 1 year)	Recreational activities restricted and perceptions of amenity altered in a localised area for > 1 year.	Long-term disruption to recreational activities and perceptions of amenity altered at a regional scale for 1 to 5 years.	Long-term disruption to recreational activities and perceptions of amenity altered for a regional scale for > 10 years.

Table 7: Risk matrix

Consequence						
Likelihood		**Insignificant**	**Minor**	**Moderate**	**Major**	**Extreme**
	Almost certain	Negligible	Medium	High	Extreme	Extreme
	Likely	Negligible	Medium	Medium	High	Extreme
	Possible	Negligible	Low	Medium	High	High
	Unlikely	Negligible	Low	Low	Medium	Medium
	Rare	Negligible	Negligible	Negligible	Low	Medium

3.1.4 Stakeholder involvement

A draft risk assessment was developed based on best available information by a team of wetland scientists in consultation with experts on various aspects of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. A series of meetings were held with site managers to review and refine the risk assessments and identify any additional threats and stressors relevant to each section of the Ramsar site. An updated draft risk assessment was provided to the Steering Committee (SC) and Stakeholder Advisory Group (SAG) members for review. A one-day priorities workshop was held at the Western Treatment Plant on June 1, 2017. Workshop participants were asked to review the impact pathways, likelihood and consequence ratings in their area of interest or expertise. Critical knowledge gaps were identified and documented for inclusion in the management plan. The revised risk assessment was circulated to the SC and SAG members for any further comments, prior to finalisation. The full risk assessment can be found in Appendix B.

3.2 Priority values for management

A multi-criteria analysis was used to prioritise values for the RMP. The objective of the prioritisation was to identify the highest priorities for management for the next seven years (i.e. the life of the plan). Criteria for prioritising values are related to:

- meeting Ramsar site management obligations to maintain ecological character
- importance to the broader community
- values that have been identified as being at high risk from multiple threats, and
- values that are currently in decline.

A one-day priorities workshop was held at the Western Treatment Plant on June 1, 2017. Workshop participants were asked to apply the above criteria to identify the highest priority values for management in the next seven years. The outcomes of this workshop with respect to priority values is provided in Table 8.

Pied oyster catcher in saltmarsh (A. Morrison).

Table 8: Values at each location in the Ramsar site (those shaded are identified as the highest priority).

Values	Location					
Ecological values	**Cheetham**	**Werribee**	**Pt Wilson**	**Swan Bay**	**Mud Is.**	**Lake Conn.**
Hydrology (including connectivity)	X	X	X			X
Intertidal flats	X	X	X	X	X	X
Intertidal reefs	X		X			
Seagrass		X	X	X	X	X
Coastal saltmarsh	X	X	X	X	X	X
Mangroves			X			X
Freshwater aquatic vegetation		X				X
Waterbird diversity and abundance	X	X	X	X	X	X
Waterbird breeding	X	X	X	X	X	X
Diversity and abundance of fish		X	X	X	X	X
Threatened species: Australasian bittern		X				X
Threatened species: beach nesting birds	X	X	X	X	X	X
Threatened species: shorebirds	X	X	X	X	X	X
Threatened species: orange bellied parrot		X	X	X		X
Threatened species: growling grass frog		X				X
Threatened species: Australian grayling						X
Socio-economic and cultural values						
Recreational fishing			X	X		X
Commercial fishing						X
Water based recreation (swimming, boating)		X	X	X	X	
Beside water recreation (camping, bushwalking, nature observation)	X	X	X	X		X
Aboriginal cultural heritage	X	X	X	X	X	X
Game hunting		X	X			X
Tourism	X	X	X	X		X
Education	X	X	X	X	X	X

3.3 Priority threats for management

The outputs of the risk assessment were used to identify the highest priority threats for management in the next seven years using two approaches. Firstly, all identified individual risk pathways that were assessed as high or extreme were considered a priority for management in the life of the plan. Secondly, risks were assessed cumulatively looking at the pressures and stressors across all risk pathways and identifying risks that may individually be medium, but combined have a significant cumulative impact. Priority threats in each section of the Ramsar site are provided in Table 9 and described briefly below. The relationship between values and threats is illustrated in Figure 6.

Table 9: Priority threats at each location in the Ramsar site (those shaded are identified as the highest priority).

Threats	Location					
	Cheetham	Werribee	Pt Wilson	Swan Bay	Mud Is.	Lake Conn.
Climate change: sea level rise impacting on intertidal vegetation and waterbird habitat	X	X	X	X	X	X
Climate change: increased temperature increases the frequency and severity of avian disease	X	X			X	
Climate Change: increased intensity of storms resulting in erosion of shoreline habitats	X	X		X	X	
Changed operations at the Western Treatment Plant decreasing nutrients and carbon	X	X	X			
Toxicants from catchment inflows and stormwater	X	X	X	X		X
Emerging contaminates of concern from the Western Treatment Plant	X	X	X			
Stormwater results in decreased salinity and altered water regimes						X
Urban development: direct habitat removal and loss of buffer	X	X	X	X		X
Litter (including micro-plastics) effects biota	X	X	X		X	
Invasive species: foxes and cats predating on waterbirds	X	X	X	X		X
Invasive species: salt tolerant weeds impacting saltmarsh and waterbird habitat	X	X	X	X	X	X
Invasive species: non-native grazing animals (rabbits and deer) impacting vegetation and habitat		X	X			X
Invasive species: silver gulls and ibis impacting breeding of other bird species (terns and petrels)					X	
Recreation: boats, jets skis, kite surfers disturbing waterbird feeding, breeding and roosting	X	X	X	X	X	X
Recreation: walkers, horse-riding disturbing waterbird feeding, breeding and roosting	X	X	X	X	X	X
Recreation: vehicles damaging saltmarsh			X			X
Duck hunting impacts to non-target species		X	X			X

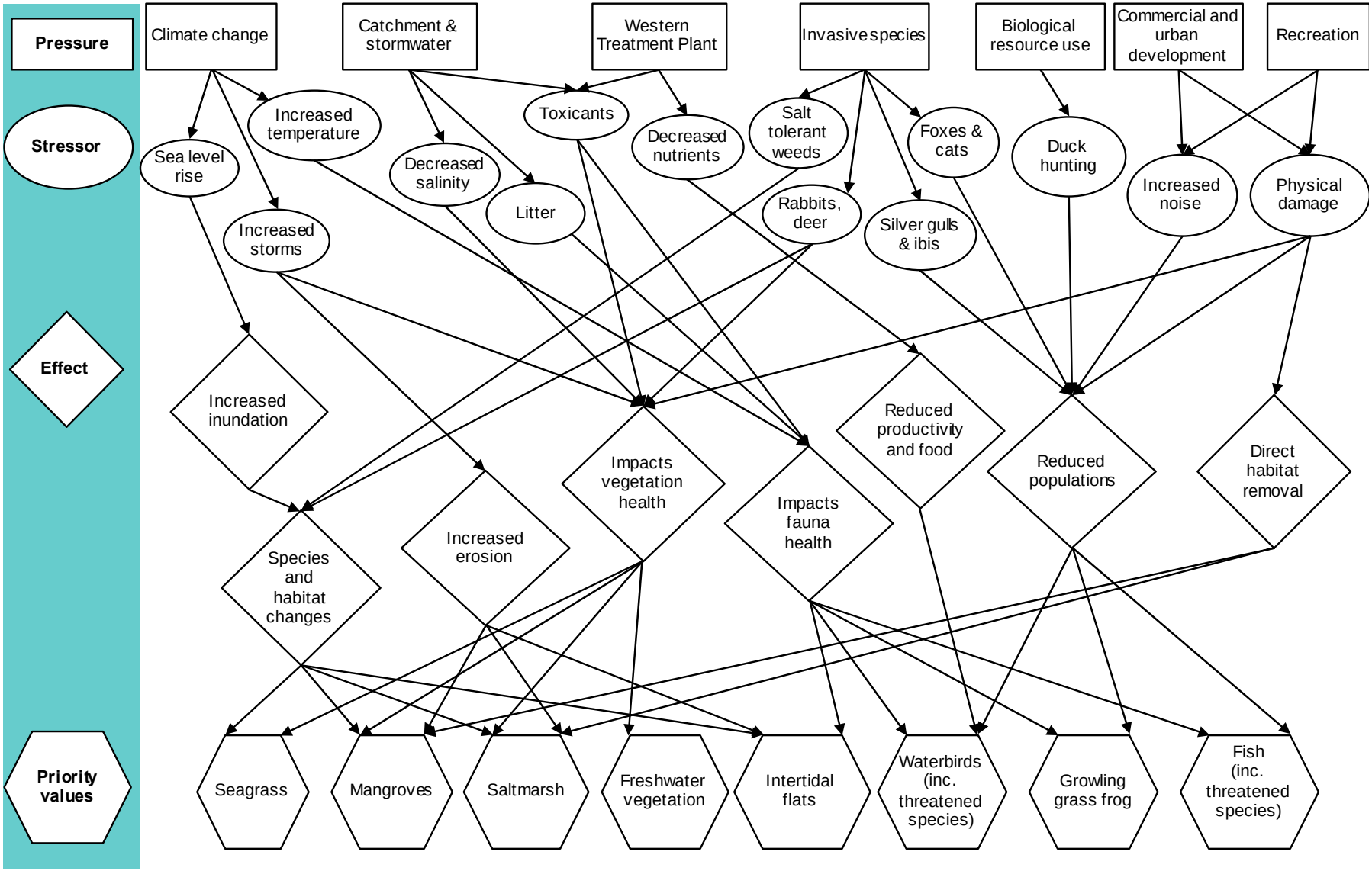


Figure 6: Stressor model illustrating the major linkages between high priority threats (pressures and stressors) and high priority values.

3.3.1 Climate change

Climate change risks were informed by the most recent climate projections for the Southern Slopes (Victoria West) using statistical downscaling models (Timbal et al. 2016). In general, the climate in Australia has exhibited the following trends (CSIRO and Bureau of Meteorology 2017):

- a 30 % increase in carbon dioxide concentrations since 1956 (316 ppm to 408 ppm)
- an increase in mean surface temperature of around 1 °C since 1910
- an increase in the duration, frequency and intensity of extreme heat events
- a decline in winter rainfall in south eastern Australia of around 19 % since 1970, and
- an increase in sea levels exacerbated by high tides and storm surges.

The future climate in the Port Phillip Bay region is predicted to be hotter, drier and with more frequent and intense storms. Three stressors related to climate change were identified as priority threats to the ecological character of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site as described below.

Stressor: Sea level rise

There is *very high* confidence in continued increased sea level. Sea levels have risen around the Australian coastline at an average rate of 2.1 mm/year over 1966–2009; including an accelerated rise of 3.1 mm/year over 1993–2009. Predictions of sea level rise are highly dependent on the modelled scenario (based on human response to climate change), but are likely to be between 0.4 and 0.6 m higher (from 1950 baseline) by 2090 and if a collapse in the marine based sectors of the Antarctic ice sheet were initiated, these projections could be several tenths of a metre higher by late in the century (Timbal et al. 2016).

Sea level rise was considered to be a high priority threat across all sectors of the Ramsar site with the greatest impacts to saltmarsh, intertidal habitats and waterbirds. Saltmarsh and mangrove community composition and extent is largely determined by the frequency and depth of tidal inundation (Boon et al. 2011). Sea level rise in areas such as Port Phillip Bay that has significant barriers to landward migration (roads, walls, etc.) has the capacity to have severe impacts on the EPBC listed ecological community of temperate coastal saltmarsh (Saintilan and Rogers 2013). A 30 cm rise in sea level would see most of the saltmarsh in Port Phillip Bay permanently inundated and there is already evidence of mangrove encroachment into saltmarsh communities (Boon, in prep.). Waders and beach nesting birds are particularly vulnerable to sea level rise (Robinson et al. 2009) and any loss in intertidal habitat (mudflats, saltmarsh) would affect waterbird diversity and abundance within the site. This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.

Stressor: Increased temperature

There is very *high confidence* in substantial increases for daily mean, maximum and minimum temperature across Victoria. Within the Southern Slopes (Vic West) region, average maximum temperatures are predicted to increase 0.6 to 1.4 °C in winter and 0.5 to 1.1 °C in summer by 2030 (Timbal et al. 2016). In addition, the frequency of extreme warm days is expected to increase dramatically. While direct effects on biota are predicted for the long-term, the risk assessment identified an increased risk of avian disease such as avian botulism under warmer conditions (Traill et al. 2009). There have been increased incidences of avian disease recorded at the Western Treatment Plant, but the exact causal factors are unknown. For this reason, avian disease has also been identified as a knowledge gap (see section 3.4).

Stressor: Increased frequency and intensity of storms

There is a *high confidence* of an increase in the frequency and intensity of storms. In addition to mean sea level rise, impact studies need to consider that extreme coastal sea levels are exacerbated by rising sea levels and are caused by a combination of factors including astronomical tides, storm surges and wind-waves (Timbal et al. 2016).

Within the Ramsar site this was considered to be the greatest threat to areas that are already experiencing erosion, such as the eastern shoreline of the Cheetham wetlands segment.

3.3.2 Urban development

The population of Greater Melbourne is predicted to increase from 4.3 million in 2013 to 7.8 million in 2051 (Department of Transport, Planning and Local Infrastructure 2016).This is adding pressure to many areas of the Ramsar site, particularly around the Cheetham Wetlands, Western Treatment Plant and Lake Connewarre complex, where significant urban development continues. While stressors related to increased recreation and stormwater are described below, there is also pressure related to a loss of wetland buffers as urban encroachment moves, in some places, to the boundary of the Ramsar site (Figure 7).

Figure 7: Cheetham wetlands (Ramsar boundary in pink) in 2003 (left) and 2017 (right) showing increased urban development.

3.3.3 Wastewater, stormwater and catchment inflows

Western Treatment Plant

There were two identified high risks from the Western Treatment Plant. The first relates to a potential reduction in nutrients and particulate carbon from the licenced outlets to the intertidal zone. In 2007/08 the total nitrogen discharge reached its lowest discharge of 1239 tonnes / annum, which is significantly lower than the preferred operating range of 2000 – 3000 tonnes /annum. While it may seem counter intuitive to suggest that a reduction in treated wastewater discharge is a threat to ecological character, there has been significant scientific research on the importance of the productivity driven by discharges from the Western Treatment Plant on shorebird diversity and abundance (Rogers et al. 2007, Loyn et al. 2014, Parry 2015).

The second pathway relates to chemicals of emerging concern. Monitoring in PPB off the shore of the Western Treatment Plant, indicates that concentrations of heavy metals are mostly within SEPP (ANZECC) water quality objectives, and that they pose a low risk to Port Phillip Bay (GHD 2011, Parry 2015). However, studies from elsewhere indicate that urban treated sewage contains a range of chemicals such as steroid hormones that could pose a risk to the marine environment (Ying et al. 2002). Studies in fish indicate effects on immune systems and reproduction (Milla et al. 2011) and reproduction (Goksøyr 2006). The issue of chemicals of emerging concern in the Western Treatment Plant is also identified as a knowledge gap both with respect to the concentration of chemicals and their potential effects on biota**.**

Stormwater and catchment inflows

Stormwater and catchment inflows are considered together in the risk assessment as often the source of sediments, nutrients or toxicants discharging into the Ramsar site are from both sources (or stormwater flowing into a river, which then discharges into the Ramsar site). There are over 300 stormwater drains that flow directly into Port Phillip Bay, several within the Ramsar site boundary, particularly in the Point Wilson / Limeburner's Bay segment.

The greatest risk, however, was to the Lake Connewarre complex from urban stormwater discharge. The Armstrong Creek Urban Growth Area has a plan for 22,000 homes on 2500 ha of previous farm land in an area immediately adjacent to the Ramsar Site. A storm water management strategy for the Armstrong Creek Urban Growth Zone recommends construction of retention wetlands to address this threat. The City of Greater Geelong has drafted Planning Scheme Amendment C357 (http://planning-schemes.delwp.vic.gov.au/updates-and-amendments/amendment?id=EDC97ED2A6FEF14ECA25804B000DE019) to facilitate the construction of the wetlands. The Amendment proposes to apply a Public Acquisition Overlay across approximately 523 hectares of flood prone land to facilitate the construction and commissioning of stormwater management infrastructure. The land to be acquired is referred to as the Sparrovale Regional Wetlands. Funding arrangements are detailed in the amendment. The diversion of storm water from the Armstrong Creek system into the Sparrovale Regional Wetlands is expected to reduce the volumes of storm water being discharged into the Connewarre complex portion of the Ramsar site mitigating potential environmental impacts to ecological character. Upon approval of the amendment, Council will be responsible for commencing negotiations with the current landholders regarding the timing of acquisition.

Concerns were raised during stakeholder consultation about the potential effect of stormwater and catchment inflows on the ecological character of Swan Bay. This has been identified as a knowledge gap.

Litter was identified as a significant risk at Mud Islands as this section of the Ramsar site seems to act as a natural litter trap in the Bay (Corangamite CMA, personal communication). Recent surveys of the Lower Yarra and Maribyrnong rivers indicated a large amount of litter and micro-plastics on beaches of Port Phillip Bay (Blake and Charko 2014). This is consistent with an Australia wide study of micro-plastics in oceanic waters, which found levels in Australia similar to those in the Caribbean, but lower than in the Mediterranean (Reisser et al. 2013). Micro-plastics are of particular concern as ingestion by biota (directly or through the food chain) is recognised as a significant problem for a range of aquatic biota, particularly birds. Ingestion not only interferes with food consumption (having a gut full of indigestible plastic results in diminished feeding and eventual starvation), but also from the release of toxicants in the digestive system from the small plastic particles. The potential effect of micro-plastics on biota within the Ramsar site is not known, but the importance of this sector for waterbird breeding increases the risk.

3.3.4 Recreational activities

The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is close to the cities of Melbourne and Greater Geelong, making it a popular destination for recreational activities. As mentioned above, the population in urban areas is predicted to increase. This is likely to increase recreational pressure on beaches and coastal areas. There are several identified priority threats related to recreational activities in the Ramsar Site.

Integrated Water Management Framework for Victoria

Integrated water management (IWM) is a collaborative approach to planning, bringing together organisations that influence the management of all elements of the water cycle including that of:

- waterways and bays
- wastewater management
- alternative and potable water supply
- stormwater management and
- water treatment

The framework aims to build collaborative solutions to the management and delivery of water in cities, towns and rural areas. An example of this is the management of stormwater in areas in and adjacent to the Ramsar site which is located close to the two largest cities in Victoria, Melbourne and Geelong, with significant current and planned future development. This poses an increased the level of risk to the site's ecological character if not managed carefully.

Several of the wetlands within the Ramsar site are threatened by stormwater discharges, altering both water regimes and salinity (e.g. Hospital Swamp and Lake Murtnaghurt in the Lake Connewarre Complex). IWM provides opportunities to maintain and restore ecological character by innovative water management. For example, using the planned Sparrovale Regional Wetlands to process stormwater from the Armstrong Creek development will reduce the impact from excessive freshwater discharge to the Ramsar site, and provide complementary aquatic habitat.

The Barwon Region Integrated Water Cycle Management (IWCM) Network was established in 2012. It is a commitment by the region's lead organisations in urban and water planning to work together to apply IWCM. Collaborating agencies include Barwon Water, Borough of Queenscliffe, City of Greater Geelong, Colac Otway Shire and Surf Coast Shire, who have agreed to:

- strengthen the existing relationships between the region's key urban and water planners
- work collaboratively to promote IWM approaches at policy and program levels and through actions
- work cooperatively to raise awareness of the role of water in the region's liveability, sustainability and productivity.

Armstrong Creek Development.

Disturbance of shorebirds and beach nesting birds

Increased noise from shore based or nearshore boating activities (including jet skis, kite surfing, kayaking and other water based activities) and the presence of domestic dogs on beaches have all been identified as high risks to waterbirds both in the Ramsar site and elsewhere. There is growing evidence that disturbance of waterbirds by human activities (walking, boating, vehicles) can have significant negative impacts on both feeding behaviour and habitat use. A database collated from a large number of scientific studies of flight

initiation distances (FID, the distance between the activity and the bird taking flight) indicates that nesting birds can be disturbed by human activities at very short distances (e.g. mean FID for nesting pelicans was only 21 m and for ducks 32 m from pedestrians) (Livezey et al. 2016). FIDs for non-nesting species were typically greater (e.g. 60 metres for ducks from pedestrians). Birds are disturbed at closer distances by dogs and watercraft as opposed to pedestrians, but interestingly, non-motorised watercraft such as canoes and paddleboards had equal or smaller FIDs compared to motorised vessels (Glover et al. 2015, Livezey et al. 2016). The consequences for individuals and populations can be significant, with decreased time spent feeding, increased energy spent in flying away from disturbances, nest abandonment and ultimately population declines all cited as potential effects (Glover et al. 2011, Martín et al. 2015).

Vehicles in the intertidal zone:

Vehicle damage to coastal saltmarsh communities has been reported from many areas in Port Phillip Bay (Boon et al. 2011b). Saltmarsh communities are slow to recover from disturbance and damage can be subtle (stem breakage) to long lasting and severe (e.g. wheel ruts). While the extent of vehicle access to intertidal areas has been addressed by Parks Victoria actions, there is access and damage to the high value saltmarsh communities in the Lake Connewarre complex.

3.3.5 Biological resource use: duck hunting

Hunting is permitted in parts of the Ramsar site, including the areas of the Lake Connewarre complex that are designated as a Game Reserve and the foreshore reserves along the shoreline near Werribee, Avalon and Point Wilson / Limeburner's Bay. Duck hunting is permitted during the season (March to June), which overlaps with the presence of both orange-bellied parrots and migratory shorebirds. Duck hunting is regulated under the *Wildlife (Game) Regulations 2012* which sets daily bag limits, these may be varied under the Wildlife Act 1975 in response to conditions. The regulatory framework is overseen by the Game Management Authority and aims to ensure that duck hunting is undertaken sustainably in Victoria. Of concern are the potential impacts to non-target species including both orange-bellied parrots and shorebirds. In the 2016 season, there were reports of some waders injured through shooting at game reserves outside the Ramsar site (Menkhorst and Purdey 2016). Disturbance of feeding shorebirds, particularly in priority locations such as the shoreline near Werribee / Avalon, was identified by stakeholders as a potential issue.

3.3.6 Invasive species

Four different groups of invasive species have been identified as a high priority threat to the ecological character of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site.

Salt-tolerant weeds

There are a number of salt tolerant weed species that have been recorded in Port Phillip Bay or have the potential to invade. Of most concern are tall wheat grass (*Thinopyrum ponticum*), cord-grass (*Spartina* spp.) and sea lavender *(Limonium hyblaeum*). There are examples from Western Port where tall wheat grass has severely impacted saltmarsh and bird habitat, with control proving very difficult (Hirst and Boon 2016) similar impacts could be realised in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site.

The impacts of these weeds are not just to saltmarsh communities, but also the biota that use saltmarsh and intertidal flats as habitat. Elsewhere, the increase of dense emergent vegetation such as the invasive species *Spartina*, into saltmarsh has rendered habitat completely unsuitable for feeding, roosting and nesting by waterbirds. Were this to occur in the Ramsar site, the abundance and diversity of waders would be reduced and a reduction in breeding by beach nesting species such as red-capped plover and fairy terns would occur.

Foxes and cats

The Port Phillip and Westernport CMA Invasive Plants and Animals Strategy (Port Phillip and Westernport CMA 2011) identifies predation by foxes and cats as a significant threat to shorebirds and beach nesting birds, with foxes remaining widespread throughout the Ramsar site. There is also evidence that black rats and ravens are a significant threat to nesting birds, with predation on eggs. The areas at greatest risk were in the Lake Connewarre complex.

Grazing animals (rabbits, deer)

Rabbits are widespread through the coastal areas of Port Phillip Bay and damage native vegetation by grazing and digging. Grazing risks were greatest, however, from the impact of deer in the Lake Connewarre complex where the feral animals are numerous and can cause extensive damage to saltmarsh and other habitats.

Silver gulls and ibis at Mud Islands

Silver gulls (*Larus novaehollandiae*), Australian white (*Threskiornis molucca*) and straw-necked (*T. spinicollis*) ibis are native species and nest in substantial numbers at Mud Islands (Menkhorst 2010). While this may contribute to the ecological character of the Ramsar site, they are also having an impact on other nesting birds, particularly white-faced storm petrel (*Pelagodroma marina*). Silver gulls predate on eggs and chicks of other species and are known to steal food from many other waterbirds, including migratory waders (Smith 1992). There is evidence that ibis arrive at Mud Islands earlier than white-faced storm petrels, which are then left with fewer and less optimal nest locations (Underwood and Bunce 2004, 2005).

3.4 Additional risks

In addition to the threats identified through the risk assessment process, the Steering Committee and Stakeholder Advisory Group considered that there were a number of areas critical to the management of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site that require improvement. These included:

- The level of awareness of the values and Ramsar status of Port Phillip Bay (Western Shoreline) and Bellarine Peninsula, by broad sections of the community.
- Integration of agency and non-governmental organisation (NGO) efforts.
- Adequate resourcing to implement the management plan and maintain the ecological character of the site.

These were considered in the development of management strategies and the approach to governance at the site.

3.5 Identified knowledge gaps

Throughout the risk assessment and process for identifying priority values and threats for management, a number of key knowledge gaps were identified:

1. Chemicals of emerging concern (e.g. pharmaceuticals): sources, concentrations and risk to the Ramsar site
2. Micro-plastics: risk to ecological character
3. Effect of mosquito control chemicals on waterbirds through the food chain
4. Water quality of stormwater discharges in key locations, including Swan Bay
5. Potential impacts of stormwater discharge on Hospital Swamp
6. Impacts of duck hunting on disturbance of shorebirds and orange-bellied parrot
7. Freshwater inflows to Swan Bay - magnitude and effects on ecology
8. The benefits of surrounding wetland systems on the ecological character of the Ramsar site (Swan Bay in particular)
9. Causes and effects of pathogens and disease on waterbirds (e.g. botulism, avian cholera)
10. The impacts of introduced marine pests on ecological character.

4 Site management strategies

4.1 Method

There are two types of indicators that are relevant to the management of the Ramsar site:

1. **Limits of Acceptable Change (LAC)** are set in the Ecological Character Description (ECD) and are based on the conditions at the time of listing. LACs can be updated based on new knowledge that improves confidence in the LACs. These are the thresholds at which ecological character may be compromised.
2. **Resource Condition Targets (RCTs)** are established in the RMP and are the aspirational condition for each of the identified priority values (i.e. where do we want / expect the condition of each priority value to be at the end of this management plan?). These will help to assess the effectiveness of the management plan in maintaining (or improving) ecological character.

How each of these three levels of indicators fit into the planning and development process is illustrated in Figure 8. As part of Ramsar management planning, LAC were previously developed for the site and are documented in the draft ECD. These are formal instruments against which change in ecological character is assessed and reported to the Convention every three years. RCTs were developed by expert opinion and local knowledge, with consideration of the LAC and expected natural variability for each value.

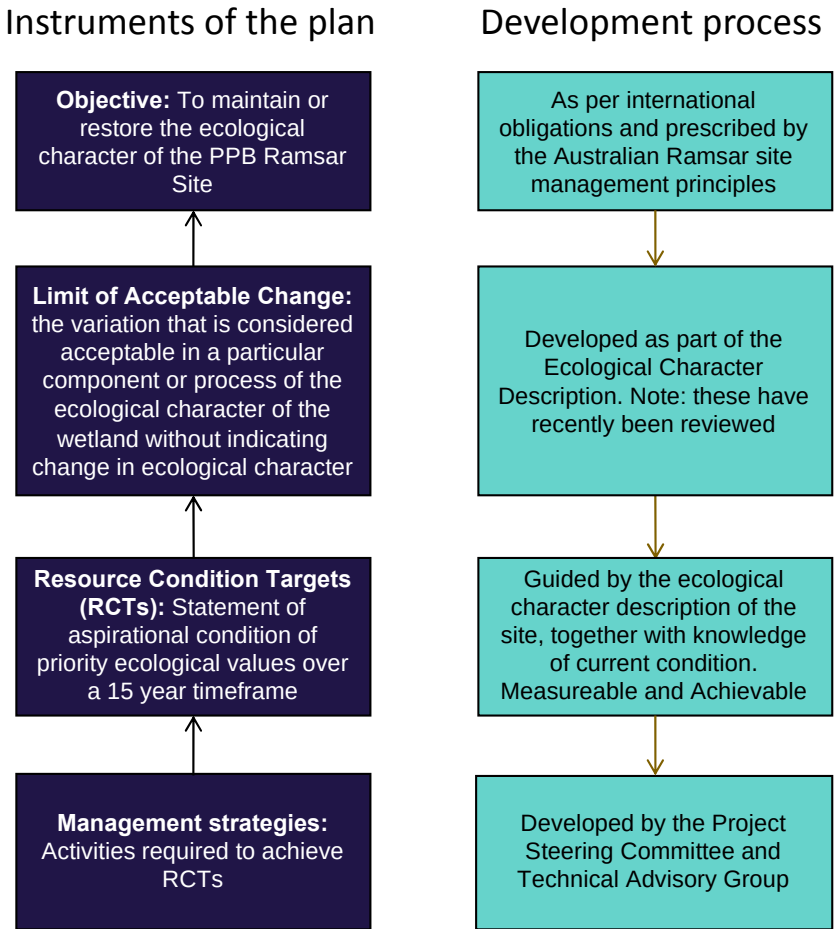


Figure 8: Relationships between the different instruments of the plan and their development process.

4.1.1 Review of the 2003 plan

The 2003 Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Strategic Management Plan contained 10 management objectives and 91 associated site management strategies. These were reviewed with respect to progress towards implementation and / or achieving the stated strategy, and relevance to current priority values and threats at the site (Appendix C). Strategies in the 2003 management plan that

were relevant to identified priority values and threats were used to inform the development of management strategies for this current management plan.

4.1.2 Stakeholder involvement

Resource Condition Targets were developed and refined by the Steering Committee. Management strategies to address priority values, threats and knowledge gaps were developed by the Steering Committee and Stakeholder Advisory Group in a one-day workshop held at the Western Treatment Plant on July 20, 2017. The outputs of the workshop were used to assign management strategies to one of five themes.

- Theme 1: Protecting flora and fauna
- Theme 2: Adapting to climate change
- Theme 3: Managing water quality and water regimes
- Theme 4: Improving our understanding
- Theme 5: Communication, Education, Participation and Awareness (CEPA).

Where possible, integration with existing programs was sought, with relevant programs identified. Responsibilities for each management strategy were identified.

4.2 Achievements from the 2003 plan

A large amount of on-ground work and research has been undertaken within the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site since the release of the 2003 Ramsar site management plan. A summary of this work, highlighting significant achievements related to maintaining ecological character is provided here for each management agency. It should be noted that a large amount of collaborative work is undertaken in Port Phillip Bay through multi-agency programs. These are described below under the relevant lead agency, with key partner organisations identified.

4.2.1 Central Coastal Board

The Central Coast Board has developed a Coastal Action Plan for the coast of the Port Phillip and Western Port region, released in 2015. The plan may make progress towards the development of an 'Index of Coastal Condition' or similar that could better describe and assess the environmental value of coastal areas. If implemented this may lead to monitoring arrangements being revised. The Victorian Coastal Strategy (2014) is the overarching planning instrument under which the Regional Coastal Plan sits. As such it addresses the main statewide coastal issues and 16 regional issues. The statewide issues are:

- managing for population growth,
- adapting to climate change,
- valuing the natural environment, and
- integrating marine planning.

4.2.2 EPA Victoria

EPA Victoria together with Melbourne Water developed and implemented the Better Bays and Waterways Plan. EPA Victoria have been monitoring water quality at six sites in Port Phillip Bay (adjacent to the Ramsar boundary) for over 30 years and also monitors the health of beaches in the summer months. Research into water quality and inflows from catchments is ongoing and a recent citizen science program targeted at micro-plastics has been implemented (http://www.epa.vic.gov.au/about-us/news-centre/news-and-updates/news/2016/august/05/help-shed-light-on-tiny-plastics-around-port-phillip-bay).

4.2.3 Department of Environment, Land, Water and Planning

The Department of Environment, Land, Water and Planning has continued to coordinate the implementation of the Ramsar Convention requirements in Victoria. In 2013, the department released the Victorian Waterway Management Strategy, which sets out Victoria's policy on the management of Ramsar sites, and

waterways generally. The Department has contributed to both research and on-ground works in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site:

- Waterbird research and monitoring by the Arthur Rylah Institute in partnership with BirdLife Australia and Victorian Field and Game Association – investigation of trends in waterbird numbers and likely causes of trends at the Western Treatment Plant (Loyn et al. 2014). Annual summer waterfowl counts at selected wetlands, including the Western Treatment Plant and the Lake Connewarre complex (DELWP unpublished) and breeding birds and Mud Islands (Menkhorst 2010).
- Maintaining and updating Ramsar documentation including the Ramsar Rolling Review, updated Ramsar Information Sheet and development of a MERI framework for Victorian Ramsar sites.
- Developing the Ecological Character Description for the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site (DELWP in prep.).
- Oversight of the Ramsar Coordinating Committee.

4.2.4 Melbourne Water

Melbourne Water has played an extensive role in managing the Western Treatment Plant as well as contributing to the health of the Bay in general. In terms of the Western Treatment Plant, Melbourne Water has been managing the site to maintain ecological character since listing in 1982 using an adaptive management approach. Melbourne Water has commissioned numerous research projects to improve understanding and management of the site including: waterfowl activity budgets (Mustoe and Waugh 2006, Mustoe 2009), shorebird foraging and nutrient relationships (Rogers et al. 2007, Parry et al. 2013, Morris et al. 2017), intertidal zones and invertebrates (Parry 2015) and disturbance of birds by people (Glover et al. 2011, Guay and Weston 2012; Guay et al 2016). In addition, ongoing management has been implemented at the site, some of which is described in Table 10.

Table 10: Some of the works implemented at the Western Treatment Plant to maintain ecological character (extracted from Steele and Harrow 2014).

Commitment	Implementation
Trigger point for growling grass frog reached in 2009. T-Section Pond 4 will be managed as an additional growling grass frog pond.	Drawdown of T-Section Pond 4 to promote vegetation growth before flooding during growling grass frog breeding period (2011 and 2012).
Recommendation of Western Treatment Plant Biodiversity Conservation Advisory Committee.	3SE Pond 8 vegetation clearance (April/May 2010).
Trial multiple outlets for effluent to enrich mudflats	Multiple outlets to nourish intertidal mudflats constructed and installed after extensive trials and design (December 2016).
Recommendation of Western Treatment Plant Biodiversity Conservation Advisory Committee	(a) Ponds 4 and 5 drawn down (2008), sludge removed, and bunds removed (March/April 2010) to restore tidal exchange and rehabilitate saltmarsh; (b) Creation of Q4 Wetland (April 2010); (c) Pond 6 and part of Pond 7 cleaned and opened to tidal exchange (April 2016).
Response to targeted monitoring of waterfowl	Partially treated effluent loads restored to Lake Borrie to promote waterbird food resources (May 2015).
Recommendation of Western Treatment Plant Biodiversity Conservation Advisory Committee	35E Pond 9 desilt (2008/09).
Growling grass frog management plan (Organ 2003)	Overwintering harbour (timber and rock) introduced to growling grass frog ponds SW-9, 5W-10 (2011).
Melbourne Water investigations	Lower ford on Little River adapted to allow fish passage (July 2016).

At the broader scale, Melbourne Water developed, and is implementing, the Healthy Waterways Strategy which informs the management of rivers, estuaries and wetlands in the Port Phillip and Westernport region.

The Healthy Waterways Strategy defines Melbourne Water's current role, in partnership with the community and stakeholders, in managing rivers, estuaries and wetlands from 2013/14 to 2017/18. This strategy focuses on investing in areas that the community values and that will protect and improve environmental values and increase liveability (Melbourne Water 2013). Whilst largely aimed at catchment scale management, the priorities for improving health of the catchments of Port Phillip Bay will provide benefits to the Ramsar site values.

4.2.5 Parks Victoria

Parks Victoria has continued on-ground actions specifically addressing threats to flora and fauna in parks and reserves in the Ramsar site. The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site contains parts of the Port Phillip Heads Marine National Park and the Point Cooke Marine Sanctuary. Parks Victoria continues to work in collaboration with other agencies to manage pest plants and animals within the portions of the Ramsar site that they manage as well as contributing to research and knowledge management through the Research Partners Program (Table 11). Examples of Parks Victoria actions and programs in the Ramsar site include:

- development of management plans for the Port Phillip Heads Marine National Park and Pointe Cooke Marine Sanctuary (Parks Victoria 2006, 2007),
- development and implementation of the hydrological management at Cheetham Wetlands (Brett Lane and Associates 2009),
- monitoring and benchmarking of values within marine national parks,
- development of the Port Phillip Bay (Western Shoreline) site Pest Plant and Animal Management Plan,
- completed study of community perceptions *Understanding attitudes towards the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site*, and
- active partner in the Ramsar Protection Program.

Table 11: Summary of Parks Victoria Research Partners Panel projects 2007 -2016 relevant to Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site.

Project	Actions and research partners
Integration of research and management	Developing conceptual models, University of Melbourne Monitoring the outcomes of an adaptive experimental management program in Victoria's Marine National Parks and Marine Sanctuaries, University of Melbourne Predation on the exotic starfish *Asterias amurensis* by the native starfish *Coscinasterias muricata,* Marine Ecological Solutions
Parks in the landscape	How much habitat and in what configuration maintains natural levels of connectivity in southeast Australian native birds, Monash University
Performance evaluation	Engaging communities in monitoring park values and threats, Monash University Monitoring ecological impacts under severe uncertainty, University of Melbourne Fox Adaptive Experimental Management Project, Arthur Rylah Institute Sea Search: Community-based monitoring of Marine Protected Areas (MPAs) in Victoria - Post-graduate project, Deakin University Birds as indicators of environmental condition (Stage 1), BirdLife Australia Soft Sediment data assessment and future monitoring design, Primary Industries Research Victoria Birds as indicators of environmental condition (Stage 2), Birds Australia

4.2.6 Port Phillip and Westernport CMA

The Port Phillip and Westernport CMA region includes the northern parts of the Ramsar site, including the Cheetham and Werribee / Avalon sectors of the Ramsar site. The CMA has implemented a variety of

strategic and on-ground actions aimed at maintaining the ecological character of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Significant programs include:

- Regional Catchment Strategy (Port Phillip and Westernport CMA 2014) – set targets for environmental assets in the Port Phillip and Western Port region that would improve ecological condition and increase resilience. The key components, which are the focus of the strategy, include native vegetation, native animals, waterways and wetlands, hinterland, coasts and the bays. With regards to the Ramsar site the targets set for coastal zones and marine water quality, whilst not directly addressing priority values or threats, will contribute to maintaining the ecological character of the Ramsar site, notably seagrass condition and provision of habitat for fish.
- Regional Invasive Plant and Animal Strategy (Port Phillip and Westernport CMA 2011) – contains five objectives and 15 actions relating to the management of invasive pants and animals.
- Ramsar Protection Program – provides federal and state funding to partner organisations for the implementation of on-ground works in pest plant and animal control fencing, revegetation, targeted community engagement and collaboration with Traditional Owners.

4.2.7 Corangamite CMA

The Corangamite CMA region includes the Swan Bay, Mud Islands, Lake Connewarre complex and Point Wilson / Limeburner's Bay sectors of the Ramsar site. The CMA has implemented a variety of strategic and on-ground actions aimed at maintaining the ecological character of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Significant programs include:

- Saltmarsh Protection Project – aims for long term protection and enhancement of Victorian saltmarsh communities, including areas within and adjacent to the Ramsar site. Funding supports land managers in the management and conservation of saltmarsh communities and other fringing communities known to provide critical habitat to orange-bellied parrots.
- Seasonal watering proposals and environmental water management in the Lake Connewarre complex, with active water regime maintenance in Reedy Lake and Hospital Swamp to maintain and improve ecological character by providing habitat for fish, frogs and waterbirds and controlling the native invasive species typha.
- Barriers to fish passage – a review of fish barriers in the Barwon, Moorabool and Leigh rivers was conducted to determine priorities for mitigation works. There were 845 potential barriers identified, a subset of which was assessed and prioritised for action. This resulted in a fishway being installed at the tidal barrage (an artificial barrier between the Barwon River and the estuary of the Lake Connewarre complex).

4.3 Targets

A total of 10 RCTs have been defined for the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site (Table 12). These have helped to guide the identification of management strategies and provide a goal for monitoring the ecological character of the site and determining when additional interventions may be required. RCTs were derived from expert and local knowledge and are applicable to the life of the management plan (next seven years). It should be noted that for several priority values there was insufficient data to derive quantitative RCTs and qualitative descriptions are provided as a guide. Further information about RCTs and the relationship to LAC and current condition is provided in Appendix D.

Table 12: Resource Condition Targets for the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site.

Resource Condition Target	Relevant priority values
Maintain connectivity between the Barwon River and the Southern Ocean.	Hydrology, fish, Australian grayling
Maintain Cheetham Wetlands according to the hydrological management manual. That is, in spring: 3% of ponds in a dry state, 67% shallow and suitable for migratory shorebird foraging and 30% deep for longer legged shorebirds.	Hydrology, waterbirds
Maintain condition and extent of seagrass within the Ramsar site (i.e. >2900 hectares)	Seagrass
Maintain condition and extent of saltmarsh within the Ramsar site (i.e. >1200 hectares)	Coastal saltmarsh
Maintain condition and extent of mangroves within the Ramsar site (i.e. >50 hectares)	Mangrove
Maintain diversity of freshwater emergent vegetation at Reedy Lake.	Freshwater vegetation.
Maintain abundance of waterfowl (i.e. maximum total annual abundance is > 80,000). Maintain abundance of shorebirds (i.e. maximum total annual abundance is > 20,000).	Waterbird abundance
Maintain abundance of nesting birds at the Western Treatment Plant (> 500 pairs of pied cormorant). Mud Islands: Maintain breeding colonies of White-faced storm petrels, and crested terns (noting that abundance is a knowledge gap).	Waterbird breeding
Re-establish orange-bellied parrots within the Ramsar site. Maintain Australian fairy tern, bar-tailed godwit, eastern curlew, great knot, hooded plover, lesser sand plover and red knot within the site.	Threatened species: birds
Maintain population of growling grass frog in the Western Treatment Plant.	Threatened species: Growling grass frog.

4.4 Theme 1: Protecting flora and fauna

Pest plants and animals, recreational activities, direct habitat removal through residential development and biological resource use were all identified as high priority threats to the plants and animals of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. While there has been a large and coordinated program to control predators and pest plants within the Ramsar site, this work needs to be maintained. Similarly, while the relevant authorities assess individual development proposals, a coordinated approach to assessing the effect of multiple actions and developments may be required to adequately maintain ecological character. Essential to this will be careful consideration of appropriate management of buffers between the Ramsar site and adjacent activities and land uses.

Eight management strategies have been identified to protect flora and fauna (Table 13). The relationship between management strategies, priority threats and priority values is provided in Appendix E.

Table 13: Management strategies and responsible organisations for protecting flora and fauna.

Management strategy	Responsibility	Linkages to existing programs / activities	Relevant locations
1.1 Manage human access to minimise disturbance at waterbird and seabird breeding colonies in the Port Phillip Bay Ramsar site during the breeding season.	Parks Victoria		Mud Islands, Lake Connewarre complex
1.2 Work with the community, tour operators and other stakeholders to minimise impacts to shorebirds and nesting birds from recreational boating activities.	Parks Victoria DELWP	Port Phillip Bay Environmental Management Plan (EMP)	Mud Islands Swan Bay
1.3 Monitor priority locations for marine pests and respond rapidly to new introductions.	Parks Victoria DEDJTR EPA Victoria	Port Phillip Bay Parks Victorian Marine Invasive Species Guide	All coastal areas
1.4 Develop and implement measures to control carp within the Barwon River, Reedy Lake and Hospital Swamp.	CCMA Parks Victoria	Corangamite Waterway Strategy	Lake Connewarre complex
1.5 Continue to implement pest plant and animal control in priority locations for species identified as a significant threat to ecological character (i.e. salt tolerant weeds in saltmarsh; cats and foxes in orange-bellied parrot, shorebird and nesting bird habitats).	Parks Victoria Melbourne Water CMAs Councils	Coastal Tender and Saltmarsh Protection Project PPWCMA Ramsar Protection Program Biodiversity Conservation and Ramsar Management Plan for the Western Treatment Plant	All
1.6 Identify and prioritise litter hotspots within the Ramsar site and undertake prevention and remediation activities.	EPA Victoria Parks Victoria Councils	Port Phillip Bay EMP	All coastal areas
1.7 Investigate options for addressing cumulative impacts of land use change and development on ecological character.	DELWP Councils	DELWP Wetland Buffer Guidelines Planning schemes	All
1.8 Develop advice to assist local government and other agencies to manage development within the Ramsar site buffers to protect the ecological character of the Ramsar site.	DELWP	DELWP Wetland Buffer Guidelines Planning schemes	All

Working together to protect Ramsar values

Trust for Nature has developed a Priority Zone Plan for the Bellarine Peninsula that includes mechanisms to maintain the ecological character of two segments of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site: the Lake Connewarre complex and Swan Bay. The plan recognises inappropriate development and the associated pressures of pest plants and animals and increased recreational use as major threats to the Ramsar site.

Trust for Nature is a not-for-profit organisation that works to protect native flora, fauna and ecosystems on private land. Tools that they use to implement private land conservation include: legal agreements with private landowners via permanent conservation covenants on title; purchase of land supporting threatened habitats (and species) and protection of the land with conservation covenants before on-selling it via a Revolving Fund program.

In addition to working with local authorities and other natural resource management organisations to protect and improve conservation values across the Bellarine Peninsula, Trust for Nature has identified private properties greater than 10 hectares in size surrounding the Lake Connewarre complex as a priority for its private land conservation efforts and initiatives.

4.5 Theme 2: Adapting to climate change

Climate change was identified as a priority threat for management in the next seven years based largely on the effects of sea level rise on coastal vegetation communities (saltmarsh) as well as on habitat for shorebirds. Longer term impacts from increased frequency and intensity of storms were also considered a high priority threat.

Although it is not possible to directly influence the drivers of climate change in a management plan for a single Ramsar site, planning for resilience and adaptation to climate change is crucial and requires immediate action to maintain ecological character into the future. The issue of maintaining ecological character in a changing climate and with the inevitable changes in species distributions is being considered by the Convention (and in many other forums) both in Australia and internationally (Pittock et al. 2010, Gitay et al. 2011, Finlayson et al. 2013). Central to the management of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site will be management of buffers and identification of locations where shoreline habitats (e.g. saltmarsh, intertidal flats) can migrate inland as sea levels rise. This may include incentive programs for private landholders adjacent to the Ramsar site.

Three management strategies have been identified to facilitate adaption to climate change (Table 14). The relationship between management strategies, priority threats and priority values is provided in Appendix E.

Table 14: Management strategies and responsible organisations for adapting to climate change.

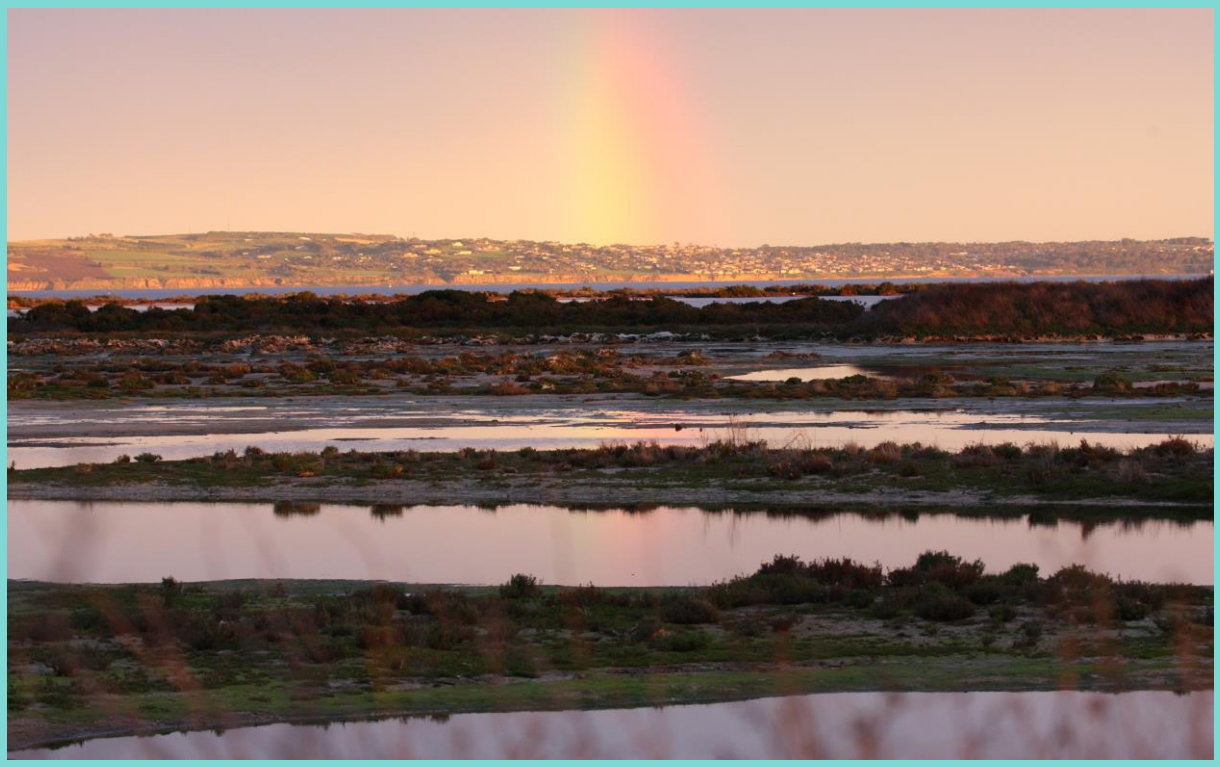
Management strategy	Responsibility	Linkages to existing programs / activities	Relevant locations
2.1 Identify and assess options for managing risk to coastal habitats (saltmarsh, seagrass and intertidal flats) from sea level rise and implement as appropriate.	DELWP Councils CMAs	Priority Zone Plan for Bellarine Peninsula DELWP Climate change vulnerability assessment and adaptive capacity of coastal wetlands	All
2.2 Identify opportunities for artificial habitat creation within and adjacent to the Ramsar site to compensate for potential habitat loss due to sea level rise and implement as appropriate.	DELWP CMAs	DELWP Climate change vulnerability assessment and adaptive capacity of coastal wetlands Western Treatment Plant Coastal Management Strategy	All
2.3 Identify sites at most risk from extensive shoreline erosion and implement appropriate interventions.	DELWP	Bellarine Peninsula - Corio Bay Cheetham Local Coastal Hazard Assessment	

Preparing for sea level rise: Western Treatment Plant Western Lagoon

During the 1960s the Melbourne and Metropolitan Board of Works constructed a nine-pond lagoon for the treatment of sewage – the Western Lagoon – over 40 hectares of coastal saltmarsh. This location's remaining coastal saltmarsh and sedgefields later became a key overwintering area for the critically endangered orange-bellied parrot and habitat for other listed species, such as Lewin's rail and Altona skipper butterfly. But the presence of sewage ponds degraded adjacent habitat through the constant seepage of freshwater.

Therefore, when the Western Lagoon was decommissioned as a sewage treatment system in 2004 planning began to rehabilitate the site by restoring tidal exchange and consequently re-establishing coastal saltmarsh in several of the former sewage ponds. This major project was also planned as a test of the effectiveness of coastal 'retreat' or 'adaptation'. It was seen as an opportunity to learn how the land and vegetation responded to the removal of bunds and tidal inflows across former constructed assets. Ponds 4 and 5 (12 ha) were cleaned of sludge and breached to the sea during 2010. Pond 6 and part of Pond 7 (4 ha) were treated similarly during May 2016.

Results have been exceptionally promising. Coastal saltmarsh plants are re-establishing themselves and the former ponds were highly attractive to migratory shorebirds for a period before the vegetation started to establish. There have been no worrying areas of gully type erosion.



Early restored coastal saltmarsh at Western Lagoon, a former sewage treatment pond system, (Photograph: Chris Lunardi, Melbourne Water).

4.6 Theme 3: Managing water quality and water regimes

Priority threats associated with water quality are related to nutrients, sediments and toxicants from catchment inflows and stormwater. The greatest threat was to the Lake Connewarre complex, with discharges of stormwater directly from adjacent urban development impacting on the salinity of the system. There is already evidence of flow on effects to biota with changes in vegetation communities and a potential localised loss in condition and extent of saltmarsh. Chemicals of emerging concern such as pharmaceuticals discharged in treated wastewater from the Western Treatment Plant, were identified as a knowledge gap.

With respect to water regimes, there are several locations within the Ramsar site, where water regimes are maintained artificially, such as at Cheetham Wetlands, the Western Treatment Plant and smaller areas such as Snake Island in the Point Wilson / Limeburner's Bay sector. These water regimes need to be continually monitored and managed to maintain ecological character. Finally, water regimes at the freshwater Reedy Lake are now augmented by environmental water allocations (see case study below).

Five management strategies have been identified to manage water quality and water regimes (Table 14). The relationship between management strategies, priority threats and priority values is provided in Appendix E.

Table 14: Management strategies and responsible organisations for managing water quality and water regimes.

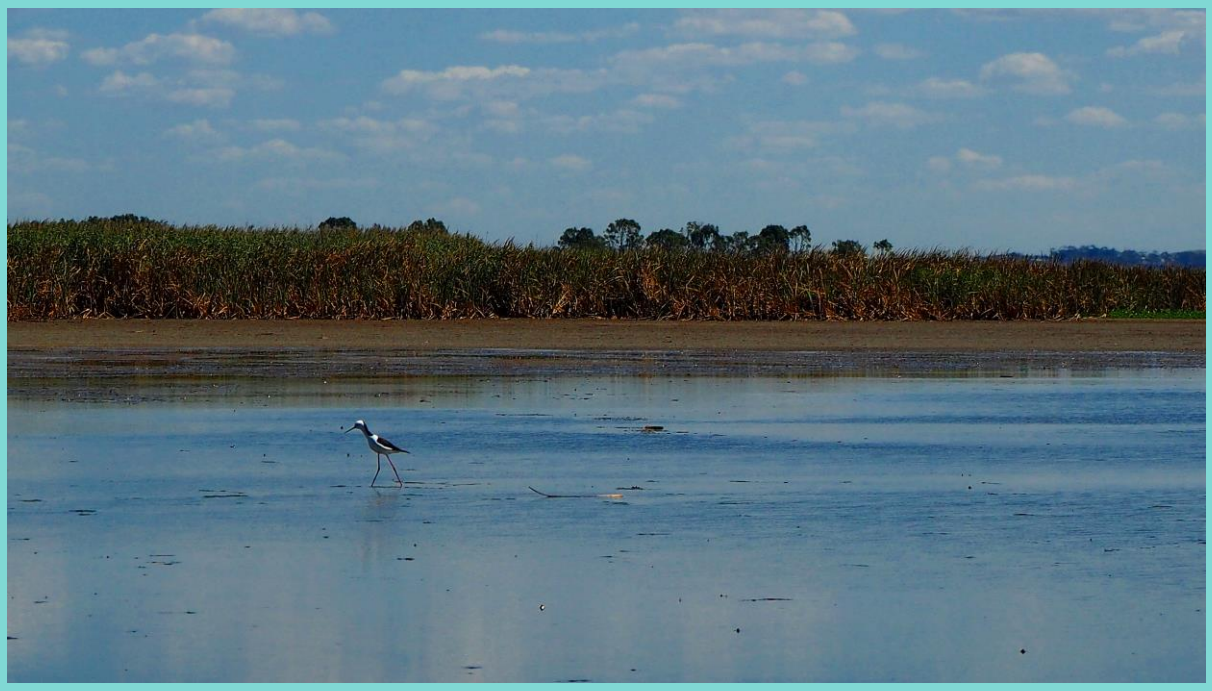
Management strategy	Responsibility	Linkages to existing programs / activities	Relevant locations
3.1 Continue to implement the actions in the Melbourne Water Stormwater and Corangamite Waterway strategies aimed at managing nutrient, sediment and toxicant discharges to the Ramsar site.	Melbourne Water CCMA	Healthy Waterways Strategy 2018 Corangamite Waterways Strategy Integrated Water Management Framework	All
3.2 Maintain appropriate concentrations and loads of nutrients (nitrogen and total organic carbon) in Western Treatment Plant discharges to adjacent intertidal mudflats to support ~12,000 shorebirds over summer.	Melbourne Water	Monitoring for a specific management objective: protection of shorebird foraging habitat adjacent to a waste water treatment plant	Werribee
3.3 Continue to adaptively implement water regime management in artificial habitats within the Ramsar site.	Melbourne Water Parks Victoria	Cheetham Wetlands Hydrology Manual Environmental flow recommendations to support significant biodiversity values at the Western Treatment Plant	Cheetham Werribee Pt Wilson (Snake Island)
3.4 Continue to develop and implement environmental water management at Reedy Lake and Hospital Swamp.	CCMA Parks Victoria	Barwon Wetlands Seasonal Watering Proposals	Lake Connewarre complex
3.5 Assess the risk to water quality in Swan Bay from inflowing streams.	EPA Victoria City of Greater Geelong		Swan Bay

Reedy Lake: Restoring wetting and drying

Reedy Lake was once (before being part of the Ramsar site) an intermittent wetland system that naturally had cycles of wet and dry. Since the 1970s, however, the lake remained almost permanently inundated. This altered the soil and water chemistry allowing the extent of tall reed communities to nearly double. While reed beds form an important part of the lake's ecosystem, their continued expansion reduced habitat diversity as they took over areas that previously supported different vegetation types and open water. In turn, this reduced the diversity of fauna such as waterbirds and frogs that could be supported by the wetland.

The Corangamite CMA, together with DELWP, the Victorian Environmental Water Holder, Parks Victoria and community groups, has developed and is currently implementing a scientifically validated four-year environmental water management regime at Reedy Lake that allows the system to periodically dry. The new regime involves delivering water in winter/spring and then lowering water levels over summer until the Barwon River level increases in autumn. The intent of implementing this new regime is to reduce the extent of tall reeds and restore the ecological health of Reedy Lake.

Although this program has been going for just one year (instigated in 2016/17) there are already signs of improved ecosystem health. As part of implementing the new watering regime, a monitoring program has been established to determine the ecological response (GHD, 2017 unpublished draft). This project is designed to monitor the influence of the new watering regime on flora, fauna and surface/groundwater quality. Early results indicate an improvement in wader habitat and coastal saltmarsh, while also identifying that the drying regime did not generate acid sulphate soils.



4.7 Theme 4: Improving our understanding

Port Phillip Bay is a well-studied environment and there has been a long history of environment studies of the Bay and its values. Despite this, 10 priority knowledge gaps were identified during the development of the RMP (section 3.4). Some of these are addressed through monitoring activities (see section 5) and five management strategies have been developed to address the remainder (Table 15).

Table 15: Management strategies and responsible organisations for improving our understanding.

Management strategy	Responsibility	Linkages to existing programs / activities	Relevant locations
4.1 Investigate the risks to ecological character from micro-plastics	EPA Victoria	Port Phillip Bay EMP	All shoreline locations
4.2 Investigate the risks to waterbirds and fish associated with aerial spraying for mosquitoes in intertidal habitats	City of Greater Geelong EPA Victoria		Swan Bay, Point Wilson, Lake Connewarre complex
4.3 Improve our understanding of the effects of chemicals of emerging concern on ecological character	EPA Victoria Melbourne Water	Port Phillip Bay EMP	Werribee / Avalon
4.4 Assess the impact of duck hunting on disturbance of non-target species, particularly shorebirds and orange-bellied parrot.	DELWP GMA	Current project assessing impacts of disturbance on waterbirds from duck hunting (DELWP, DEDJTR, GMA)	Lake Connewarre complex, Werribee / Avalon, Point Wilson / Limeburner's Bay
4.5 Investigate the threat from, and potential mitigation actions for, avian disease on waterbird populations within the Ramsar site	DELWP		Werribee / Avalon, Mud Islands

Mud Islands (PPWCMA).

4.8 Theme 5: Communication, Education, Participation and Awareness (CEPA)

The Ramsar Convention's Program on Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. The CEPA Program calls for coordinated international and national wetland education, public awareness and communication. The Program also encourages the promotion of training in the fields of wetland research and management.

While there are some excellent CEPA programs already in place in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site, the lack of awareness in the broader community of wetland values and the Ramsar Convention was raised by the Stakeholder Advisory Group and Steering Committee as a significant issue for the site (see text box below).

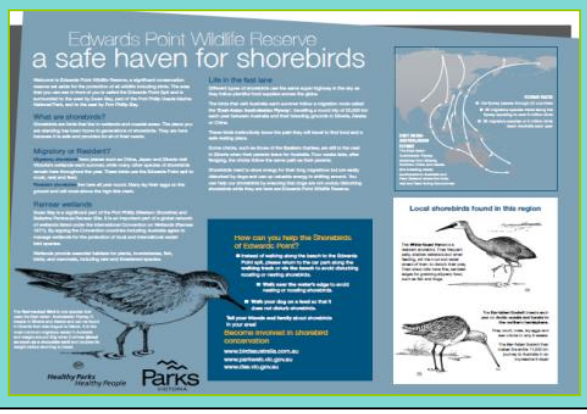
Three management strategies have been identified to improve CEPA (Table 16). The relationship between management strategies, priority threats and priority values is provided in Appendix E.

Table 16: Management strategies and responsible organisations for CEPA.

Management strategy	Responsibility	Linkages to existing programs / activities	Relevant locations
5.1 Develop and implement a Port Phillip Bay Ramsar site wetland information and interpretation program.	PV DELWP Councils CMAs	Port Phillip Bay EMP	All
5.2 Work with Aboriginal groups to improve understanding of Aboriginal values associated with the Ramsar site and develop opportunities for Aboriginal involvement in Ramsar site management.	CMAs DELWP PV	Wetland Wardens Port Phillip Bay EMP DELWP Aboriginal Inclusion Plan 2016	All
5.3 Build capacity and collaboration with community and industry groups by supporting citizen science and on-ground community action in Ramsar site management.	CMAs DELWP PV NGOs	PPWCMA Ramsar Protection Program Port Phillip Bay EMP	All

Understanding attitudes towards the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site

Parks Victoria and the Port Phillip and Westernport CMA commissioned a study on attitudes to Ramsar site values in Port Phillip Bay, with targeted interviews of over 400 residents that live near the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. The study found that while a large proportion of interviewees regularly used parts of the Ramsar site for recreation, less than 15 % were aware of the term “Ramsar”. The results of the study were used to implement a program designed to increase community awareness of the values of Ramsar sites and their importance in a global context.



5 Monitoring

5.1 Framework

Consistent with the *Victorian Waterway Management Strategy* (VWMS), the Ramsar Convention and the Australian Ramsar Management Principles, this Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan (RMP) adopts an adaptive management approach. The RMP sits within the broader framework of the VWMS (Department of Environment and Primary Industries 2013) as a component of regional waterway management planning (Figure 9). The RMP will be renewed every seven years and is underpinned by a monitoring program that reports on the condition of the system with respect to change in ecological character and progress towards meeting Resource Condition Targets (RCTs).

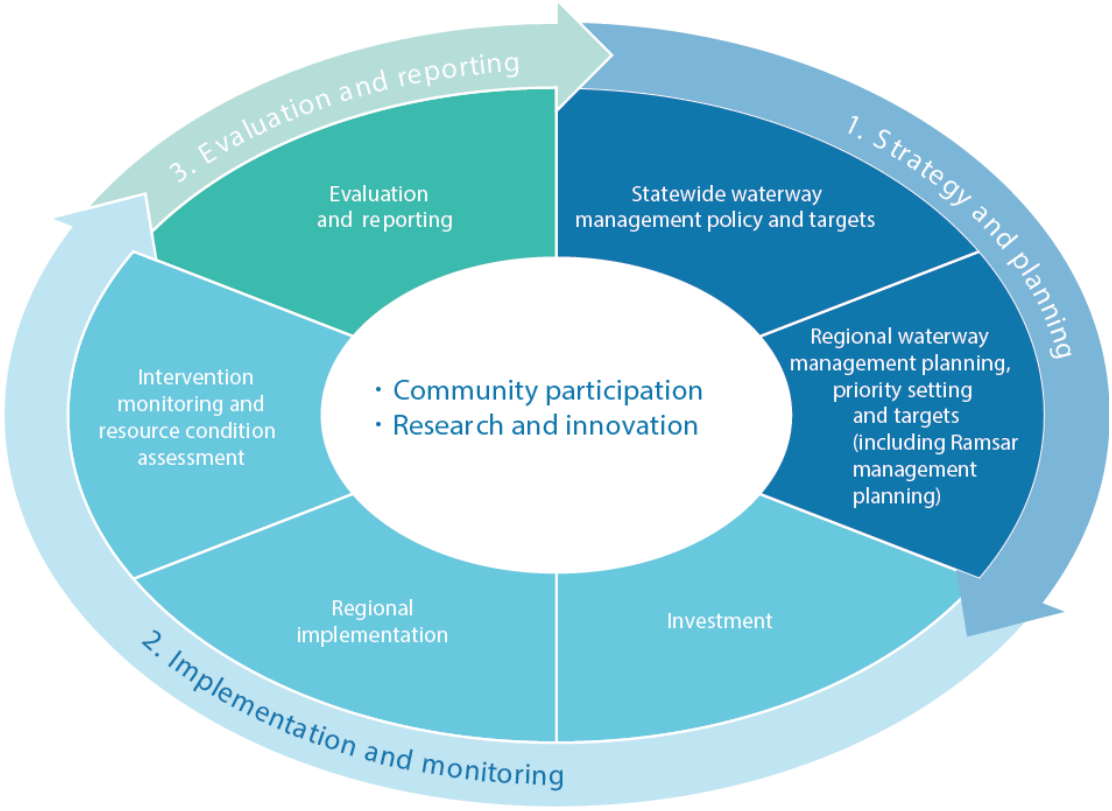


Figure 9: The adaptive management cycle of the Victorian Waterway Management Program, noting that this Ramsar management plan is a part of the regional waterway management planning process (adapted from Department of Environment and Primary Industries 2013).

5.2 Condition monitoring

Monitoring recommendations to assess progress towards RCTs and change in ecological character (i.e. evaluate critical components, processes and services against LAC) are provided in Table 17. Consistent with the principles of the RMP, responsible agencies have been identified, as have links to existing, relevant programs. It should be noted that many of the existing programs have limited funding and timelines and a full assessment of ongoing monitoring against monitoring needs will be required as part of implementation planning. To this end, DELWP is developing a Monitoring Evaluation Reporting and Improvement (MERI) framework for the management of Ramsar sites across Victoria.

Melbourne Water Ramsar Monitoring Program

The 1996 Port Phillip Bay Environmental Study recommended a reduction in nitrogen to ensure the health of the bay. To achieve this Melbourne Water significantly upgraded the Western Treatment Plant to remove more nitrogen and improve the quality of the water discharged to Port Phillip Bay. To manage the impacts on biodiversity, a Strategic Compliance Plan was put in place in 2003. That plan set the goals to research, monitor and manage any impacts of the environmental improvement project on EPBC-listed Matters of National Environmental Significance, including Ramsar. The plan has gone through several audits and reviews, and represents over a decade of monitoring and adaptive management aimed at maintaining the ecological character of this section of the Ramsar site. The plan targeted six populations:

- Growling grass frog
- Migratory shorebirds
- Waterfowl
- Pied cormorant
- Straw-necked ibis
- Whiskered tern

The plan describes monitoring methods, sets quantitative management triggers and provides recommended management actions in the event that a management trigger is reached. Since 2003, Melbourne Water has commissioned over 150 planning, research, monitoring and evaluation projects covering everything from orange-bellied parrot habitat, to intertidal infauna, tracking of growling grass frogs to waterbird abundance and population dynamics.

In response to the outcomes of these projects, Melbourne Water has implemented extensive on-ground works associated with wetland habitat at the Western Treatment Plant. Highlights include the following:

- Significant areas were set aside to provide precautionary “compensatory” habitat for waterbirds and growling grass frogs. These include three large decommissioned sewage treatment lagoons: Lake Borrie, Western and T-Section; the Austen Road ponds, Paradise Road pond; and a number of other ‘habitat ponds’ to provide high tide foraging areas for migratory shorebirds, including 270S Borrow Pit, 35E Pond 8, 35E Pond 9, 95E South Pond, 95E North Pond, 115E Borrow pit and associated cells, and 5W Ponds 9 to 11.
- Contingency planning provided for rapid responses to any observed impacts on significant biodiversity values during the construction phase of the EIP, such as a re-introduction of sewage to Lake Borrie,
- Comprehensive Site Environmental Management Plans were prepared and enforced during all construction works
- Smaller multiple outlets were trialled and then later installed to ensure nutrients are provided directly to shorebird foraging intertidal zones, and protecting them against lower flows during drought periods.

Table 17: Monitoring requirements for the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site.

Program	Indicators and method	Frequency	Responsibility	Linkages to existing programs / activities	Locations
Water quality	Salinity, dissolved oxygen, water clarity, nutrients (dissolved and total) and chlorophyll-a	Monthly and event based (i.e. more frequent sampling following large storm events)	EPA Victoria Melbourne Water	Current water quality monitoring by EPA and Melbourne Water	All
Seagrass	Extent mapping and condition consistent with Ball et al. (2014).	Mapping every five years. Condition every two years	Parks Victoria DELWP	Ball et al. (2014) mapped seagrass communities at Swan Bay and Mud Islands	Swan Bay, Mud Islands, Pt Wilson
Saltmarsh and mangrove	Extent of saltmarsh and mangroves (as per (Boon et al. 2011a). Condition against EVC benchmarks	Mapping every 10 years. Condition every five years	DELWP Parks Victoria CMAs	Boon et al. (2011) mapped saltmarsh communities.	All
Freshwater aquatic vegetation	Extent and community composition	Every two years	CCMA	Seasonal Watering Proposals	Lake Connewarre complex
Waterbird abundance	Bi-annual counts; BirdLife Australia standard methods, DELWP annual summer waterfowl count methods.	Twice yearly	DELWP Parks Victoria	Current: Shorebirds 2020 Annual summer waterfowl	All
Waterbird breeding	Annual surveys of nest numbers and breeding success (i.e. fledgling)	Annual	DELWP Parks Victoria		Werribee Mud Islands
Threatened bird species: Orange-bellied parrot	Annual surveys (as per orange-bellied parrot recovery plan)	Annual	DELWP		Werribee Lake Connewarre complex
Threatened bird species: Australasian bittern	BirdLife Australia standard methods	Annual	DELWP	Threatened species recovery programs	Werribee
Threatened species: Growling grass frog	Melbourne Water standard methods	Annual	Melbourne Water	Melbourne Water EPBC compliance	Werribee
Native fish: abundance and trends	Abundance and diversity	Annual	CCMA Parks Victoria	Parks Victoria Marine National Parks Monitoring Program	Swan Bay Lake Connewarre

5.3 Intervention monitoring

Intervention monitoring assesses the effectiveness of management actions in achieving desirable or stated outcomes and is an important part of an adaptive management approach. While there is solid scientific evidence for some management actions other management actions often lack sufficient scientific evidence to indicate outcomes and decisions are made on assumptions and expert opinion.

A targeted intervention monitoring and evaluation program will be developed as part of implementation planning to assess the effectiveness of management actions in terms of measureable effects on ecosystem condition, rather than just operational outputs (e.g. determining the effectiveness of a given management activity on nest success instead of simply reporting the number of baits or traps set for predators). The results of intervention monitoring will be used to inform future management actions so that the most effective and efficient programs are implemented to maintain the ecological character of the Ramsar Site. The site will have a monitoring, evaluation, monitoring and improvement (MERI) plan to guide this process.

5.4 Evaluation and reporting

The Ramsar Rolling Review is designed to assess the status of the ecological character of Ramsar sites in Australia every three years (in line with international reporting requirements). An assessment of Victoria's Ramsar sites was conducted in 2015 – 2016 (DELWP unpublished). This process collates information across monitoring and management projects in Ramsar sites to assess against Limits of Acceptable Change (LAC). The output is an evaluation of ecological character and a report to site managers, DELWP and the Australian Government. This process fulfils the requirements of reporting for the Ramsar Convention.

A committee will oversee the implementation of the RMP and will coordinate monitoring and evaluation of the plan (see Section 6.2) as per the site MERI plan (see Section 5.3), this will include reporting against RCTs. The committee will oversee the development of annual action plans that will track activities and outputs from year to year.

6 Governance and implementation

6.1 Governance

Coordination of Ramsar site management in Victoria is the responsibility of the Victorian Government, through DELWP. Relevant international, national and Victorian state policy and legislation is listed in Section 1.2. This RMP is an integral component of a continuing program to develop and implement a current management framework for Victoria's Ramsar sites.

Central to this, and the management of all Ramsar sites, is the involvement of stakeholders and the broader community in the management of the site. A broad range of stakeholders participated in the development of this plan (see Appendix A) and several public forums were held during the public consultation period. The Communication, Education, Participation and Awareness (CEPA) activities in Theme 5 (see section 4.8) will be augmented by regular opportunities for all stakeholders with an interest in the management of the site to become involved and be kept informed.

6.2 Ramsar Coordinating Committee

A Ramsar Coordinating Committee comprising representatives of key stakeholder groups will be convened. This integrated approach builds on previous and current collaboration practice in the region, evident most recently in the strong participation of delivery partners in the development of the RMP.

The Ramsar Coordinating Committee will be responsible for coordinating specific aspects of implementation within the themes of the RMP. These responsibilities will include developing:

- annual action plans,
- targeted investment proposals,
- integrated delivery arrangements,
- coordinated monitoring and evaluation of implementation, including integrated reporting against targets, and
- reviewing Management Plan progress bi-annually.

6.3 Resourcing implementation

Investment proposals to support actions of RMP will be developed as investment opportunities arise. Project investment proposals will be prepared through the Ramsar Coordinating Committee in conjunction with delivery partners and will be structured to reflect the themes within the RMP, and the regional programs of partner managing agencies.

Implementation of the RMP will be influenced by available funding and resources. The implementation approach will ensure coordination and prioritisation of management actions so that maximum benefit is achieved with the resources that are available.

Annual priorities and programs will be developed to best match the funding cycles of investors. Throughout the implementation of the RMP, the Ramsar Coordinating Committee will work to use the best available information tools to support the establishment of annual priorities.

Partners will seek funding for implementation of this plan through the:

- Victorian Waterway Management Program
- relevant initiatives of the State and Federal Governments
- existing agency budgets, and
- contributions of industries and communities.

6.4 Ramsar administration

The development of the plan identified a number of administrative matters to resolve. These are described, with a brief rationale in Table 18.

Table 18: Matters related to the administering of the Ramsar Convention and the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site.

Management strategies	Responsibility	Rationale
6.1 Review the Ramsar site boundary.	DELWP DoEE Ramsar Coordinating Committee	The Ramsar site boundary was delineated at the time of listing in 1982 and more recently described in detail (Department of Environment and Primary Industries 2013). Since 1982, there have been some changes to land management and an increased understanding of the aquatic ecosystems in the region and their values. A review of the boundary to consider the addition of adjoining areas is proposed.
6.2 Apply the appropriate State and Commonwealth environmental impact assessment and approval processes for activities that have the potential to impact on the Ramsar site and other Matters of National Environmental Significance (MNES).	DELWP DoE Ramsar Coordinating Committee	Under the EPBC Act, actions that have, or are likely to have, a significant impact on a MNES require approval from the Australian Government Minister for the Environment (the Minister). The responsibility for referral of an action lies with the proponent. The Minister decides whether assessment and approval is required under the EPBC Act. Ramsar sites are one of the nine MNES and so assessments would be required for any activity that is likely to impact on the ecological character of the site, whether inside the site or in the catchment. The text box on the next page explains the process for assessing major projects.
6.3 Undertake a regular review of the status of the ecological character of the Ramsar site. This review should include new and emerging issues as well as the current listed values and threats.	DELWP	An assessment is undertaken every three years and reports on the status of ecological character of the Ramsar site. As new knowledge on the values and threats within the Ramsar site becomes available (e.g. new species supported in a changing climate), this should be incorporated into the sites ecological character and management planning. Site status reports are provided at the Water and Aquatic Ecosystems Sub-committee meetings, a national forum focussed on implementation of the Ramsar Convention.
6.4 Update the 1993 management plan for the Lake Connewarre State Game Reserve	PV	The management plan for the Lake Connewarre State Game Reserve is over two decades old and is in need of renewal.
6.5 Develop action plans for this strategy.	Ramsar Coordinating Committee	This plan has identified high level strategies for a number of agencies. An action plan, based on a formal prioritisation process and available resources is required on an annual basis. These action plans will explicitly consider intervention monitoring and monitoring to assess progress towards RCTs as part of an adaptive management program.

Changing the boundary of a Ramsar site

The Victorian Waterway Management Strategy (Department of Environment and Primary Industries 2013) contains a clear policy for nominating new Ramsar sites and changing the boundary to existing sites. The Australian Government makes the final decision regarding the listing of a new Ramsar site or extending the boundaries of an existing site and requires the endorsement of the Victorian Government. National guidance outlines the process for listing a new Ramsar site and the ongoing obligations and administrative requirements. DELWP is responsible for assessing the evidence for any proposal to list a new Ramsar site or extending the boundaries of an existing site.

Extending the boundary is a formal and protracted process and the benefits of boundary extensions must be weighed against the value of allocating resources to on-ground actions or other activities.

Policy 12.6

Investigations to list a new Ramsar site or extend the boundaries of an existing site may be initiated in response to proposals by the community or other parties and will consider the following factors:

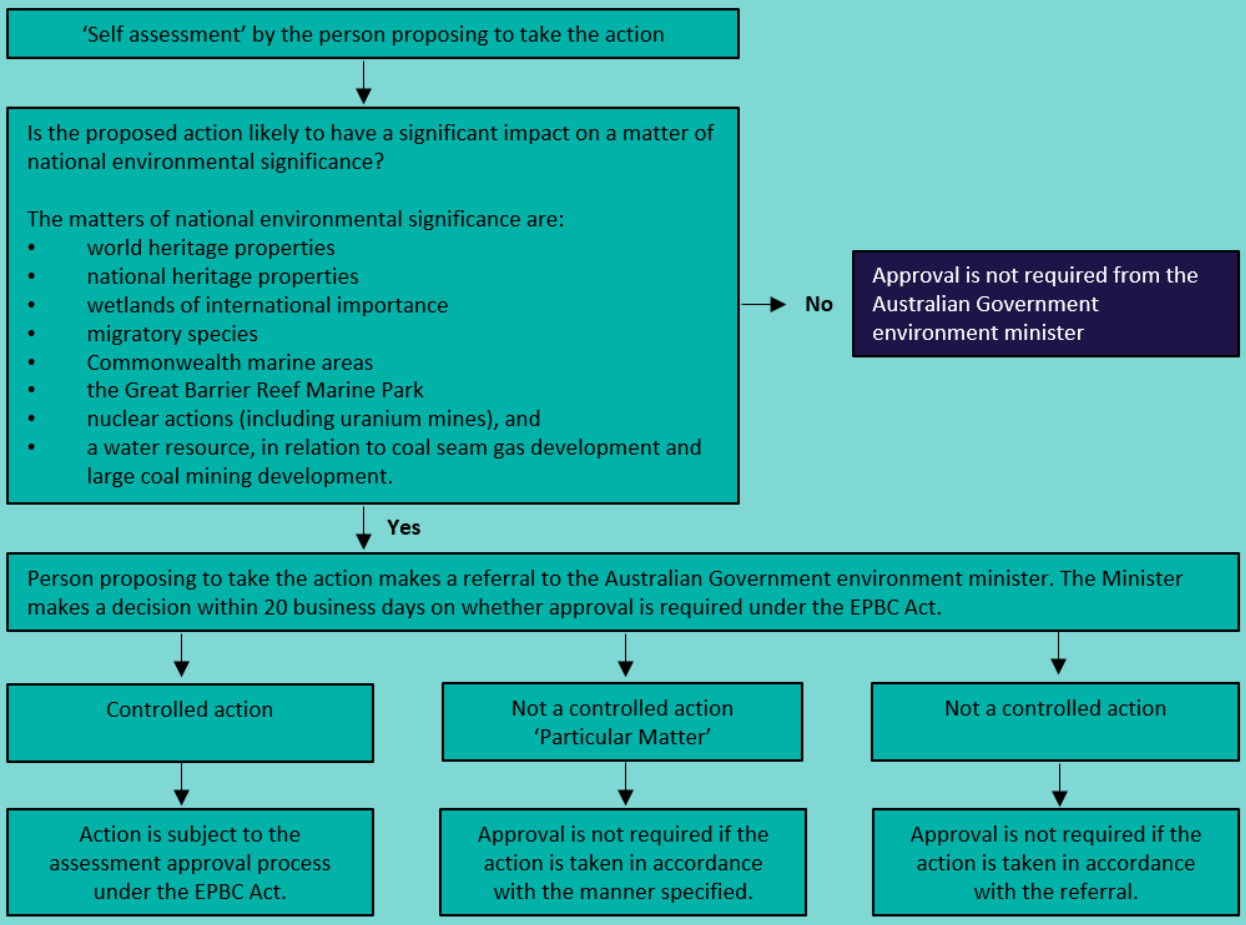
- the Ramsar Convention criteria for identifying wetlands of international importance met by the wetland
- the Ramsar Convention *Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance of the Convention on Wetlands* and any national strategic direction on priorities for Ramsar site listing
- agreement by the land manager and key stakeholders involved in the management of the wetland and the actions they propose to meet relevant Ramsar obligations
- the current degree of protection of the wetland and the opportunities for increasing the level of protection by listing the wetland as a new Ramsar site
- alternative legislative and management frameworks for management of the wetland
- the level of threat to the wetland, and the contribution that listing would make to improving the management of threats
- the feasibility and cost-effectiveness of maintaining the ecological character of the wetland in the long-term
- the contribution that listing would make to awareness raising and community education in relation to the values of the wetland and wetland conservation in general
- the level of community support for listing
- the national and international documentation and administrative requirements.

The Victorian Government will recommend listing of a new Ramsar site or extending the boundaries of an existing site to the Australian Government where:

- there is agreement by the owner or manager of the wetland
- there is compelling evidence that listing will provide clear benefits in:
  - protecting highly significant wetland values relating to the Ramsar criteria for listing
  - raising the wetland profile
  - increasing the level of support for conservation and wise use measures that cannot be achieved through other mechanisms.

Assessing the impact of major projects on Ramsar sites

Under the EPBC Act, a person must not take an action that has, will have or is likely to have a significant impact on any of the matters of environmental significance without approval from the Australian Government Minister for the Environment. In this context, an 'action' is a project, a development, an undertaking, an activity or a series of activities, or an alteration of any of these things. The EPBC Act referral process comprises several steps:



Although the EPBC referral process begins with "self assessment" there are strict penalties for not referring an action. A person who takes an action that is likely to have a significant impact on a matter of national environmental significance, without first obtaining approval, can be liable for a civil penalty of up to $900,000 for an individual and $9 million for a body corporate, or for a criminal penalty of seven years imprisonment.

DELWP administers the statutory environmental impact assessment system for major projects in Victoria with potentially significant environmental effects. This includes referrals to the Minister for Planning for Environmental Effects Statements (EES) under the *Environment Effects Act 1978* as well as assessment and approvals for major transport projects under the *Major Transport Projects Facilitation Act 2009*. In addition, Victoria has a bilateral agreement with the Commonwealth for environmental impact assessments that avoids duplication of assessment processes. It essentially allows the Commonwealth to use the assessments made by Victoria to inform decisions about impacts to matters of national environmental significance (which includes Ramsar sites) under the EPBC Act.

This is a very simplified summary of the process, for more information see the following of the DELWP website: http://delwp.vic.gov.au/planning/environmental-assessment#sthash.WiF9gy5u.dpuf and the Australian Government Department of Environment http://www.environment.gov.au/protection/environment-assessments/assessment-and-approval-process

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Appendix A: Stakeholder engagement strategy

Context and scope

Port Phillip Bay (Western Shoreline) and Bellarine Peninsula is one of Australia's 65 Ramsar sites, designated in 1982 and a management plan was developed for this site in 2003[6]. There has been significant progress in both our understanding of the ecological character of the site and strategic direction in management of the site and Ramsar wetlands in Australia in the past decade. Under the Australian Ramsar Site Management Principles, management plans are reviewed every seven years. The plan for the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site is past due for review and is undergoing a renewal process.

The Australian Ramsar management principles (*Environment Protection and Biodiversity Conservation Regulations 2000* (Cth.) – Schedule 6) provide guidance about stakeholder involvement in management of Ramsar sites. Specifically:

> *'1.02 Wetland management should provide for public consultation on decisions and actions that may have a significant impact on the wetland.*
>
> *1.03 Wetland management should make special provision, if appropriate, for the involvement of people who:*
>
> *(a) have a particular interest in the wetland; and*
>
> *(b) may be affected by the management of the wetland.*
>
> *1.04 Wetland management should provide for continuing community and technical input.'*

The implementation of this Stakeholder Engagement Strategy will reflect these principles in the renewal of the Ramsar Site Plan. The objective of this Stakeholder Engagement Strategy is to provide opportunities for the broadest range of stakeholders to contribute to the renewal of the RMP.

Method

The philosophy behind the approach to communication and engagement is grounded in the IAP2 framework (Figure 10), which is consistent with the Victorian Waterway Management Strategy. Different sections of the community have been targeted at different levels in the IAP2 framework. To reflect their different levels of interest, time commitments and preferences.

It is anticipated that this plan will be flexible and be updated throughout the project as issues related to communication and engagement emerge.

[6] DSE, 2003, Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site: Strategic Management Plan, Department of Sustainability and Environment, East Melbourne.

Increasing level of public impact

INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
Public Participation Goal:				
To provide the public with balanced and objective information to assist them in understanding the problems, alternatives and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision, including the development of alternatives and the identification of the preferred solution.	To place final decision-making in the hands of the public.
Promise to the Public:				
We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for direct advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.
Example Tools:				
fact sheets web sites open houses.	public comment focus groups surveys public meetings.	workshops deliberate polling.	citizen advisory committees consensus-building participatory decision-making.	citizen juries ballots delegated decisions.

Figure 10: IAP2 Public participation spectrum.

In the first instance stakeholders are considered in four groups:

1. Steering Committee

Representatives of agencies that have a significant role in the management of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site:

- Commonwealth Department of the Environment and Energy
- Corangamite CMA
- DELWP
- Melbourne Water
- Parks Victoria
- Port Phillip and Western Port CMA
- Victorian EPA

2. Stakeholder Advisory Group

Representatives of organisations with knowledge of and an interest in the management of the Ramsar site:

- Australasian Waders Study Group
- Avalon Airport
- Barwon Coast Committee of Management

- Barwon Water
- Bellarine Bayside Committee of Management
- Bellarine Catchment Network (formerly Swan Bay Integrated Catchment Management Committee)
- Bellarine Landcare Group
- BirdLife Australia
- Borough of Queenscliffe
- Central Coastal Board
- City of Greater Geelong
- Deakin University (Paul Carnell)
- Department of Defence
- Environment Victoria
- Field and Game Australia
- Friends of Mud Islands
- Friends of Point Gellibrand
- Friends of Greenwich Bay
- Friends of the Bluff
- Friends of Edwards Point
- Geelong Environment Council
- Geelong Field Naturalists Club
- Hobsons Bay City Council
- Marine Discovery Centre
- Mountain View Quarries
- Nature Conservancy
- Northwestern Shorelines
- Orange-bellied Parrot Recovery Program
- Ridley Corp
- Southern Rural Water
- Swan Bay Environment Association
- Trust for Nature
- Victorian Fisheries Association
- Victorian National Parks Association
- Victorian Waders Study Group
- Wadawurrung (Wathaurong Aboriginal Corporation)
- Wurundjeri Tribe Land and Compensation Cultural Heritage Council
- Wyndham City Council

3. Delivery partners

Those with on ground experience in the management of the site who will be partially responsible for implementing actions from the Ramsar Site Management Plan

- BirdLife Australia
- Borough of Queenscliffe
- Central Coastal Board
- City of Greater Geelong
- Commonwealth Department of Energy and the Environment
- Corangamite CMA
- DELWP
- Field and Game Australia
- Geelong Field Naturalists
- Friends of Mud Islands
- Parks Victoria
- Port Phillip and Western Port CMA
- Swan Bay Environment Association
- Victorian EPA
- Wadawurrung (Wathaurong Aboriginal Corporation)
- Wurundjeri Tribe Land and Compensation Cultural Heritage Council

4. Broader community

Members of the public and broader community will be informed about the project and have the opportunity to input to the plan in the public consultation phase.

Implementation

Stakeholder Group	Lead	Level of Engagement	Purpose	Tools	Engagement Objectives	Key Messages
Project Manager	Consultant	Empower	Effective project delivery	Regular meetings Email project updates (fortnightly)	Ensure clarity of scope and process Encourage maximum partner input Ensure alignment with Government requirements Adhere to project plan and manage variations	
Steering Committee	Consultant	Empower	High ownership of Plan and involvement in development High agency commitment to implementation	Regular meetings (minutes) Workshops Risk meetings	Provide material for reporting back to agencies Maximise communication with project manager	Importance in integrating the plan with existing activities Ownership of management strategies and implementation
Stakeholder Advisory Group	Consultant	Collaborate	To ensure local knowledge and expertise informs the plan	Values and threats workshop Central database of relevant information	Ensure early understanding and opportunity for input Connect with external networks and expertise Obtain confirmation of identified values and threats	Their knowledge and support is valued We need them to confirm the values of and threats to the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. There is a Plan and it is being updated. The purpose of the Plan is to assign clear responsibilities for agencies. Implementation is ongoing by agencies Values are being maintained/protected/restored
Delivery partners	Consultant	Empower	High ownership of Plan and involvement in development High agency commitment to implementation	Management strategies workshop Review of plan	To ensure best management actions and strategies are prioritized for each area.	Importance in integrating the plan with existing activities Ownership of management strategies and implementation
Community	CCMA	Consult	Increased understanding of role of Ramsar Plan Increased appreciation of value of Site	Website – regular updates on the plan Public comment period: forums and meetings	Maintain confidence in management of the Site Increase knowledge Keep updated with project progress Provide feedback	There is a Plan The plan is being updated Implementation is ongoing by agencies Values are being maintained/protected/restored

Appendix B: Risk assessment

Risk assessment for the **Cheetham Wetlands / Point Cooke** sector of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Cells highlighted in blue provide a description of the pressure / stressor that is applicable to the relevant impact pathways that follow. A full explanation of the risk assessment process, including descriptors for likelihood and consequence, is provided in section 3.1. It should be noted that this risk assessment represents risk under current management arrangements. Were management of the site to change (e.g. through a reduction in funding for existing activities) some risks would be increased.

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
Western Treatment Plant	Increased nutrients					The WTP nutrient discharge to Port Phillip Bay has been studied in great detail as part of the 1996 Port Phillip Bay Environmental Study and more recently the Port Phillip Bay Environmental Management Plan. These studies show a low risk to the bay if the nutrient discharge is limited to 3100 tonnes per annum (tpa). Melbourne Water is committed to upgrading the treatment process as population increases to ensure this limit is met. Normal discharge ranges from 2000 - 3000 tpa, but historical higher loads of up to 4000 tpa have not shown any detrimental effect on Ramsar values.
Western Treatment Plant	Increased nutrients	Adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	A study of near-shore sediments compared chlorophyll-a and organic matter concentrations at sites increasing distance from the Western Treatment Plant outfall and found no detectable effect of the outfall (Preston 2003). Of more concern has been decline in nutrients and coupled loss of productivity and abundance of infauna adjacent to the Western Treatment Plant (e.g. Rogers et al. 2007). If there is no effect close to the outfall, the effect on the shoreline sediments of the Cheetham segment is also likely to be minimal.
Western Treatment Plant	Increased nutrients	Adversely affects intertidal reef	Unlikely	Minor	Low	A study of near-shore sediments compared chlorophyll-a and organic matter concentrations at sites increasing distance from the Western Treatment Plant outfall and found no detectable effect of the outfall (Preston 2003). Of more concern has been decline in nutrients and coupled loss of productivity and abundance of infauna adjacent to the Western Treatment Plant (e.g. Rogers et al. 2007). If there is no effect close to the outfall, the effect on the intertidal reefs of the Cheetham segment is also likely to be minimal.
Western Treatment Plant	Increased nutrients	Adversely affects saltmarsh communities	Unlikely	Minor	Low	Coastal saltmarsh is vulnerable to increased nutrients, and nitrogen in particular and has been found in long-term experiments overseas to be associated with saltmarsh loss (Deegan et al. 2012). The

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
						effects on saltmarsh communities in Port Phillip Bay are largely unknown, but risk is assessed on the basis that the site already is exposed to elevated nutrient loads.
Western Treatment Plant	Increased nutrients	Impacts waterbird abundance and diversity			#N/A	Extensive work has been conducted on the linkages between nutrients, productivity and shorebirds at important shorebird areas in Port Phillip Bay (Rogers et al. 2007, Loyn et al. 2014). The issue is not one of increased nutrients, but decreased nutrients having a negative impact. *Not a plausible impact pathway*
Western Treatment Plant	Increased nutrients	Impacts waterbird breeding			#N/A	One of the reasons that the Western Treatment Plant supports such a large number of breeding birds is the high productivity. *Not a plausible impact pathway*
Western Treatment Plant	Increased nutrients	Impacts threatened species			#N/A	Threatened species at this segment are shorebird would only be affected by a decrease in nutrients. *Not a plausible impact pathway*
Catchment inflows (including stormwater)						The Cheetham Wetlands are adjacent to large urban developments in and around Point Cook and Sanctuary Lakes. The Wyndham City Council has a stormwater management system that seeks to ensure that impacts to receiving waterways are minimised. Discussions with Parks Victoria (Bernie McCarrick) indicated that stormwater was not a problem in the site and that current management arrangements were sufficient to maintain ecological character.
Catchment inflows (including stormwater)	Altered hydrology	Impacts hydrological regime	Unlikely	Moderate	Low	The hydrology of Cheetham Wetlands is highly managed by Parks Victoria with the system of pumps and processes in place to maintain the desired hydrological regime (Brett Lane and Associates 2009). This is unlikely to change into the future.
Catchment inflows (including stormwater)	Altered hydrology	Adversely affect subtidal and intertidal flats	Unlikely	Moderate	Low	Although technically not intertidal, there are artificial habitats in Cheetham that fill this ecological niche and so are considered here. Impacts are based on low level of impact to hydrology.
Catchment inflows (including stormwater)	Altered hydrology	Adversely affects saltmarsh	Unlikely	Moderate	Low	Based on low impacts to hydrology
Catchment inflows (including stormwater)	Altered hydrology	Adversely affects waterbird diversity and abundance	Unlikely	Moderate	Low	Based on low impacts to hydrology
Catchment inflows (including stormwater)	Altered hydrology	Adversely affects threatened species	Unlikely	Moderate	Low	Based on low impacts to hydrology

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Increased nutrients					The Cheetham Wetlands are adjacent to large urban developments in and around Point Cook and Sanctuary Lakes. The Wyndham City Council has a stormwater management system that seeks to ensure that impacts to receiving waterways are minimised. Discussions with Parks Victoria (Bernie McCarrick) indicated that stormwater was not a problem in the site and that current management arrangements were sufficient to maintain ecological character.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect subtidal and intertidal flats	Unlikely	Minor	Low	Based on advice from Parks Victoria
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect intertidal reefs	Unlikely	Minor	Low	There are no major discharges of stormwater or river inflows near to the intertidal reef at Cheetham (within the Ramsar site boundary) - the effects of increased nutrients are more likely felt at locations closer to major discharges.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects saltmarsh	Unlikely	Minor	Low	Based on advice from Parks Victoria
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects waterbird diversity and abundance			#N/A	Extensive work has been conducted on the linkages between nutrients, productivity and shorebirds at important shorebird areas in Port Phillip Bay (Rogers et al. 2007, Loyn et al. 2014). The issue is not one of increased nutrients, but decreased nutrients having a negative impact. *Not a plausible impact pathway*
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects threatened species	Rare	Negligible	Negligible	The threatened species at Cheetham include curlew sandpiper and Australian fairy tern, although they occur in low numbers and impacts to their populations through nutrients is considered low.
Catchment inflows (including stormwater)	Increased sediments					The Cheetham Wetlands are adjacent to large urban developments in and around Point Cook and Sanctuary Lakes. The Wyndham City Council has a stormwater management system that seeks to ensure that impacts to receiving waterways are minimised. Discussions with Parks Victoria (Bernie McCarrick) indicated that stormwater was not a problem in the site and that current management arrangements were sufficient to maintain ecological character.
Catchment inflows (including stormwater)	Increased sediments	Adversely affect subtidal and intertidal flats	Unlikely	Minor	Low	Based on advice from Parks Victoria

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Increased sediments	Adversely affect intertidal reefs	Unlikely	Minor	Low	There are no major discharges of stormwater or river inflows near to the intertidal reef at Cheetham (within the Ramsar site boundary) - the effects of increased sediments are more likely felt at locations closer to major discharges.
Catchment inflows (including stormwater)	Increased sediments	Adversely affects saltmarsh	Unlikely	Minor	Low	Based on advice from Parks Victoria
Catchment inflows (including stormwater)	Increased sediments	Adversely affects waterbird diversity and abundance	Unlikely	Minor	Low	Based on advice from Parks Victoria
Catchment inflows (including stormwater)	Increased sediments	Adversely affects threatened species	Unlikely	Minor	Low	Based on advice from Parks Victoria
Western Treatment Plant	Chemicals of emerging concern					Monitoring at the outfall indicates that concentrations of heavy metals are mostly within SEPP (ANZECC) water quality objectives, and that they pose a low risk to Port Phillip Bay (GHD 2011, Parry 2015). However, studies from elsewhere indicate that urban treated sewage contains a range of chemicals such as steroid hormones that could pose of risk to the marine environment (Ying et al. 2002). Studies in fish indicate effects on immune systems and reproduction (Milla et al. 2011) and reproduction (Goksøyr 2006). The issue of CECs in the Western Treatment Plant is a knowledge gap both with respect to the concentration of chemicals and their potential effects on biota, including how far spread that effect might be. Effect at Cheetham is to the shoreline area only.
Western Treatment Plant	Chemicals of emerging concern	Adversely affect subtidal and intertidal flats	Possible	Moderate	Medium	Studies on the effects of endocrine disruptors on invertebrates are less common than those of fish, but there is evidence of effects on reproduction in a number of species including mussels (Porte et al. 2006).
Western Treatment Plant	Chemicals of emerging concern	Adversely affect intertidal reefs	Possible	Moderate	Medium	Studies on the effects of endocrine disruptors on invertebrates are less common than those of fish, but there is evidence of effects on reproduction in a number of species including mussels (Porte et al. 2006).
Western Treatment Plant	Chemicals of emerging concern	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
						from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing.
Western Treatment Plant	Chemicals of emerging concern	Adversely affects threatened species	Possible	Moderate	Medium	Impacts to birds as above. Remains a knowledge gap.
Catchment inflows (including stormwater)	Toxicants					The Cheetham Wetlands are adjacent to large urban developments in and around Point Cook and Sanctuary Lakes. The Wyndham City Council has a stormwater management system that seeks to ensure that impacts to receiving waterways are minimised. Discussions with Parks Victoria (Bernie McCarrick) indicated that stormwater was not a problem in the site and that current management arrangements were sufficient to maintain ecological character. The urban areas are serviced by deep sewage and so the potential toxicants would be those related to road-run off and garden pesticides and herbicides. Stormwater can enter the system through Skeleton Creek, where water pumps operate, it is possible that any toxicants in that stormwater could accumulate in the Cheetham Ponds, although this remains a knowledge gap.
Catchment inflows (including stormwater)	Toxicants	Adversely affect subtidal and intertidal flats	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Catchment inflows (including stormwater)	Toxicants	Adversely affect intertidal reefs	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Catchment inflows (including stormwater)	Toxicants	Adversely affects saltmarsh	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Catchment inflows (including stormwater)	Toxicants	Adversely affects waterbird diversity and abundance	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Catchment inflows (including stormwater)	Toxicants	Adversely affects threatened species	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Urban development and recreation	Litter (including micro-plastics)					Discussions with Parks Victoria indicated that litter from urban areas in general and building sites specifically can be a problem in the site. Litter traps have been installed.

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
Urban development and recreation	Litter (including micro-plastics)	Adversely affect subtidal and intertidal flats	Possible	Minor	Low	Possible impacts to invertebrates through ingestion of micro-plastics. Unlikely to be a significant problem in the artificial wetlands, but maybe on the shorelines.
Urban development and recreation	Litter (including micro-plastics)	Adversely affect intertidal reefs	Possible	Minor	Low	Possible impacts to invertebrates through ingestion of micro-plastics.
Urban development and recreation	Litter (including micro-plastics)	Adversely affects waterbird diversity and abundance	Likely	Minor	Medium	There are some incidences of entanglement of birds at the Cheetham site (Bernie McCarrick, Parks Victoria, pers. comm.)
Urban development	Habitat removal					Increasing populations lead to an expansion of residential and commercial areas in the catchment and adjacent to the Ramsar site. Although an assessment of specific projects is outside the scope of this risk assessment, the general nature of development and direct habitat removal is considered. Of particular concern is that residential and commercial development in many areas is close to the site reducing buffers.
Urban development	Habitat removal	Adversely affects saltmarsh	Possible	Moderate	Medium	Historical large scale clearing of saltmarsh due to land clearing and reclamation resulted in large losses of extent of saltmarsh (Boon et al. 2011). However, the recent EPBC listing of coastal saltmarsh as a vulnerable community affords the vegetation class more protection from future developments.
Urban development	Habitat removal	Indirect effects to sea and shorebirds (loss of food and habitat)	Possible	Minor	Low	Based on assessment of saltmarsh, noting that birds are mobile and can move to other intertidal areas.
Shipping and navigation (oil spills)	Hydrocarbons					The Ports of Geelong and Melbourne in Port Phillip Bay receive the highest number of shipping visits of all the Victorian ports. The possibility of a major oil spill in the Bay is slight, however, small spills are a common occurrence. Estimations of the frequency of oil spills indicate that a spill of 5 L or less occurs almost daily, while spills of more than 100 L occur less than once a month. The only major spill in Port Phillip Bay was in 1903 (1100 tonnes) and there have only been 20 spills of > 100 tonnes in Australia in the last 100 years (AMSA https://www.amsa.gov.au/environment/major-historical-incidents/). Risk management measures are in place to minimise the risk of a major spill and respond in the event to minimise impacts (Melbourne Water 2009). The risk assessment below is based on a spill of over 100 tonnes, with the likelihood

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
						assessed as "Rare" based on historic records of oil spills in Australia. At this location it is relevant only to the shoreline component of the site.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects saltmarsh	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affect intertidal reefs	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects intertidal flats	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Direct oiling of wildlife: Sea and shore birds	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Indirect effects to sea and shorebirds (loss of food and habitat)	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity					Areas of CASS have been mapped around Port Phillip Bay. If disturbed due to prolonged drying of wetland areas or physical disturbance of the soil surface, then sulphuric acid is formed and can liberate metals from the sediments. The risk from altered pH was considered in by workshop participants to be too small and

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
						localised to be considered given the buffering potential of seawater. However, the release of heavy metals was considered to be a risk, albeit localised and of low likelihood due to current strategies and policies in place to minimise disturbance of CASS (Department of Sustainability and Environment 2009). Risks at Cheetham would be largely due to disturbance of soils in adjacent urban areas.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity	Adversely affect subtidal and intertidal flats	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity	Adversely affect intertidal reefs	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects saltmarsh	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects waterbird diversity and abundance	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects threatened species	Unlikely	Minor	Low	Toxicants are mostly sediment bound and only likely to become a problem if released into bio-available forms.
Invasive species	Introduced marine pests (current species)					Over 100 non-native marine species in exist in Port Phillip Bay, many with a long history. There is an argument that the biota of the Bay has not been "natural" for more than 100 years (Hewitt et al. 1999). Current introduced marine species cover all taxonomic groups from algae to invertebrates and fish. Parks Victoria indicated that marine pests were a significant risk to Marine National Parks based on stakeholder perceptions (Carey et al. 2007). Impacts to biota have been assessed based on trajectories of change over the past decade. This risk is to the shoreline portion of the site only. Identified as a knowledge gaps with respect to impacts on ecological character.
Invasive species	Introduced marine pests (current species)	Adversely affects intertidal and sub-tidal flats	Unlikely	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
						evidence of a trajectory of change. Port Phillip Bay EMP expert technical panel advice.
Invasive species	Introduced marine pests (current species)	Adversely affects intertidal reefs	Possible	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change. Port Phillip Bay EMP expert technical panel advice. There is some evidence of the impacts of native sea urchins on sub-tidal reefs, but these are outside the Ramsar site boundary.
Invasive species	Introduced marine pests (current species)	Affects waterbird diversity and abundance	Unlikely	Minor	Low	Through food chain impacts only. Port Phillip Bay EMP expert technical panel advice.
Invasive species	Introduced marine pests (current species)	Affects waterbird breeding	Unlikely	Minor	Low	Through food chain impacts only. Port Phillip Bay EMP expert technical panel advice.
Invasive species	Introduced marine pests (current species)	Impacts threatened species	Unlikely	Minor	Low	Through food chain impacts only. Port Phillip Bay EMP expert technical panel advice.
Invasive species	Salt tolerant weeds					There are a number of salt tolerant weed species that have been recorded in Port Phillip Bay or have the potential to invade. Of most concern are tall wheat grass (*Thinopyrum ponticum*), cord-grass (*Spartina* spp.) and sea lavender *(Limonium hyblaeum*). There are examples from Western Port where tall wheat grass has severely impact saltmarsh and bird habitat, with control proving very difficult (Hirst and Boon 2016) similar impacts could be realised in Port Phillip Bay. Discussions with Parks Victoria indicate that active weed control is ongoing and that the risks are moderate under current management arrangements (Bernie McCarrick, pers. comm.).
Invasive species	Salt tolerant weeds	Adversely affect subtidal and intertidal flats	Possible	Moderate	Medium	Based on advice from Parks Victoria
Invasive species	Salt tolerant weeds	Adversely affects saltmarsh	Possible	Moderate	Medium	Based on advice from Parks Victoria

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Salt tolerant weeds	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	Based on advice from Parks Victoria
Invasive species	Salt tolerant weeds	Affects waterbird breeding	Possible	Moderate	Medium	Based on advice from Parks Victoria
Invasive species	Salt tolerant weeds	Adversely affects threatened species	Possible	Minor	Low	Based on advice from Parks Victoria
Invasive species	Predators (foxes and cats)					The proximity of Cheetham wetlands to urban centres increases the exposure of the site to cats and foxes. Discussions with Parks Victoria indicate that impacts are minor under the current management regime (Bernie McCarrick, pers. comm.).
Invasive species	Predators (foxes and cats)	Adversely affects waterbird diversity and abundance	Almost certain	Minor	Medium	Based on advice from Parks Victoria
Invasive species	Predators (foxes and cats)	Affects waterbird breeding	Almost certain	Minor	Medium	Based on advice from Parks Victoria
Invasive species	Predators (foxes and cats)	Adversely affects threatened species	Likely	Minor	Medium	Based on advice from Parks Victoria
Invasive species	Grazing animals (rabbits)					Rabbits are present in the site, but damage under current management arrangements is minor (Bernie McCarrick, pers. comm.).
Invasive species	Grazing animals (rabbits)	Adversely affects saltmarsh	Almost certain	Minor	Medium	Based on advice from Parks Victoria
Invasive species	Grazing animals (rabbits)	Adversely affects waterbird diversity and abundance	Possible	Minor	Low	Based on advice from Parks Victoria
Invasive species	Grazing animals (rabbits)	Adversely affects threatened species	Possible	Minor	Low	Based on advice from Parks Victoria
Recreational activities	Passive recreation (dogs, walkers, horses)					Cheetham Wetlands are not open to the public and the Ramsar section of the site is largely inaccessible. There are walkers, cyclists and other recreational past times occurring along walkways outside the site, but impacts to birds within Cheetham are minor.

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird diversity and abundance	Possible	Minor	Low	Based on advice from Parks Victoria
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird breeding	Possible	Minor	Low	Based on advice from Parks Victoria
Recreational activities	Passive recreation (dogs, walkers, horses)	Impacts threatened species	Possible	Minor	Low	Based on advice from Parks Victoria
Climate change						Regional climate projections have recently been released by CSIRO for sub-cluster regions in Australia. The relevant region for Port Phillip Bay is "Southern Slopes Victoria West" http://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=SSVWC&tooltip=true&popup=true. These are provided for each relevant stressor below. The risks are based on the recently completed marine vulnerability under climate change (Klemke and Arundel 2013). An expert panel reviewed the potential effects of climate change on Port Phillip Bay values in 2015 (Hale and Brooks 2015) these have been used here to assess the likely risks in the next 30 - 35 years.
Climate change	Increased carbon dioxide					Atmospheric carbon dioxide is increasing and has increased in recent decades and recently exceeded 400 ppm (http://www.esrl.noaa.gov/gmd/ccgg/trends/).
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects saltmarsh	Possible	Minor	Low	Score of 'minor' impact based on rationale that selection amongst C3/C4 plants will exert little overall adverse effect on saltmarshes. Might result in shifts across plant groups (e.g. grasses neutral effect; C3 taxa, such as shrubs, herbs and mangroves, advantaged)
Climate change	Increased temperature					Surface water temperatures are predicted to increase by 0.5 degrees Celsius by 2030 with a very high degree of confidence. There will also be an increase in the frequency of extreme temperature days (Grose et al. 2015).
Climate change	Increased temperature	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	An assessment of climate change related increased temperature impacts to intertidal and subtidal flats indicated moderate vulnerability and adaptive capacity (Morris 2013). However, the

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
						greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects intertidal reefs	Unlikely	Minor	Low	An assessment of climate change related increased temperature impacts to intertidal and subtidal rocky reefs indicated high vulnerability and low adaptive capacity (Bellgrove et al. 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects saltmarsh	Unlikely	Moderate	Low	Saintilan and Rogers (2013) hypothesised that temperature has an influence in the diversity of saltmarsh communities, with increased diversity at mean minimum daily temperatures of < 8 ºC, and increased germination success of southern Australian saltmarsh species at lower temperatures. The increase in mean temperature coupled with an increased frequency in extreme temperature days could be expected to decrease the diversity of saltmarsh communities. The effects, however, may be expected in the longer term rather in the next 30 - 35 years.
Climate change	Increased temperature	Adversely affects waterbirds	Likely	Moderate	Medium	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios. Temperature effects the timing of migration in many shorebirds, which may influence recruitment and survival (Robinson et al. 2009) in the long term. There is however a risk of increased incidence of disease such as avian botulism and avian cholera under hotter conditions (Traill et al. 2009). Incidents of botulism in the site have anecdotally increased in recent years in parts of the Ramsar site.
Climate change	Increased temperature	Adversely affects waterbird breeding	Likely	Moderate	Medium	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios. There is however a risk of increased incidence of disease such as avian botulism and avian cholera under hotter conditions (Traill et al.

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
						2009). Incidents of botulism in the site have anecdotally increased in recent years in parts of the Ramsar site.
Climate change	Increased temperature	Adversely affects threatened species	Likely	Moderate	Medium	Temperature effects the timing of migration in many shorebirds, which may influence recruitment and survival (Robinson et al. 2009) in the long term. There is however a risk of increased incidence of disease such as avian botulism and avian cholera under hotter conditions (Traill et al. 2009). Incidents of botulism in the site have anecdotally increased in recent years in parts of the Ramsar site. Both avian botulism and cholera are known to also affect shorebirds resulting in death.
Climate change	Sea level rise					Sea levels are predicted to increase by 0.08 to 0.18 m by 2030 with a very high degree of confidence (Grose et al. 2015). Although the hydrology of Cheetham is highly managed, there is some potential for breach of ponds under sea level rise. Recent studies indicate that the likely loss of important bird habitat at Cheetham by 2040 is 33% (Roy 2015).
Climate change	Sea level rise	Adversely affects intertidal and subtidal flats	Likely	Major	High	Intertidal mudflats are highly vulnerable to sea level rise and have a low adaptive capacity (Morris 2013). At Cheetham this may be managed in some locations by active hydrology management.
Climate change	Sea level rise	Adversely affects intertidal reefs	Likely	Major	High	Intertidal reefs are highly vulnerable to sea level rise and have a low adaptive capacity (Morris 2013). The effect may be greater in the long term.
Climate change	Sea level rise	Adversely affects saltmarsh	Likely	Major	High	Saltmarsh and mangrove community composition and extent is largely determined by tidal depth (Boon et al. 2011). There is already evidence of mangroves expanding at the expense of saltmarsh communities in southern Australia (Boon in prep).
Climate change	Sea level rise	Adversely affects waterbirds	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Sea level rise	Adversely affects waterbird breeding	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Sea level rise	Adversely affects threatened species	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Ocean acidification					pH is predicted to decrease by 0.07 to 0.08 pH units by 2030 with a medium degree of confidence (Grose et al. 2015). Cheetham is inundated with pumped sea water and so any change in ocean pH will be translated to the site.
Climate change	Ocean acidification	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Assessed as being highly vulnerable, particularly for organisms with a calcified outer shell (Morris 2013). However, possibly a longer term risk, rather than in the next two decades.
Climate change	Ocean acidification	Adversely affects intertidal reefs	Unlikely	Minor	Low	Assessed as being highly vulnerable, particularly for organisms with a calcified outer shell (Morris 2013). However, possibly a longer term risk, rather than in the next two decades.
Climate change	Ocean acidification	Adversely affects waterbirds	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects waterbird breeding	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects threatened species	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines					Extreme events (storms and high rainfall events) are predicted to occur with high confidence (Grose et al. 2015). Erosion of shorelines in Port Phillip Bay is currently occurring due to both natural processes and in some instances exacerbated by artificial structures such as groynes and beach armouring (Bird 2011). There is evidence of shoreline erosion in parts of the Cheetham site currently (Bernie McCarrick, Parks Victoria, pers. comm.) and this could be expected to increase under a changing climate.
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects intertidal and subtidal flats	Likely	Major	High	Based on advice from Parks Victoria

Threat	Stressor	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects seagrass	Likely	Major	High	Hirst A.J. Khageswor G. Ball D. and R. Lee (2017) Determination of the physical drivers of seagrass distribution and abundance in Port Phillip Bay, Australia, using a spatial autoregressive lag model. *Marine and Freshwater Research*
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects intertidal reefs	Likely	Major	High	Based on advice from Parks Victoria
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects saltmarsh	Likely	Major	High	Based on advice from Parks Victoria
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	Based on advice from Parks Victoria
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Affects waterbird breeding	Possible	Moderate	Medium	Based on advice from Parks Victoria
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects threatened species	Possible	Moderate	Medium	Based on advice from Parks Victoria

Risk assessment for the **Werribee / Avalon** sector of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Cells highlighted in blue provide a description of the threat / stressor that is applicable to the relevant impact pathways that follow. A full explanation of the risk assessment process, including descriptors for likelihood and consequence, is provided in section 3.1. It should be noted that this risk assessment represents risk under current management arrangements. Were management of the site to change (e.g. through a reduction in funding for existing activities) some risks would be increased.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Western Treatment Plant	Increased nutrients					The WTP nutrient discharge to Port Phillip Bay has been studied in great detail as part of the 1996 Port Phillip Bay Environmental Study and more recently the Port Phillip Bay Environmental Management Plan. These studies show a low risk to the bay if the nutrient discharge is limited to 3100 tonnes per annum (tpa). Melbourne Water is committed to upgrading the treatment process as population increases to ensure this limit is met. Normal discharge ranges from 2000 - 3000 tpa, but historical higher loads of up to 4000 tpa have not shown any detrimental effect on Ramsar values.
Western Treatment Plant	Increased nutrients	Adversely affects freshwater vegetation	Unlikely	Minor	Low	The freshwater wetlands in the site are managed to maintain waterbird habitat including freshwater emergent vegetation.
Western Treatment Plant	Increased nutrients	Adversely affects seagrass	Unlikely	Minor	Low	Seagrass in Corio Bay has been stable in terms of extent and condition over time, despite the proximity to Western Treatment Plant inflows of nutrients (Jenkins et al. 2015).
Western Treatment Plant	Increased nutrients	Adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	A study of near-shore sediments compared chlorophyll-a and organic matter concentrations at sites increasing distance from the Western Treatment Plant outfall and found no detectable effect of the outfall (Preston 2003). Of more concern has been decline in nutrients and coupled loss of productivity and abundance of infauna adjacent to the Western Treatment Plant (e.g. Rogers et al. 2007). If there is no effect close to the outfall, the effect on the shoreline sediments is also likely to be minimal.
Western Treatment Plant	Increased nutrients	Adversely affects saltmarsh communities	Unlikely	Minor	Low	Coastal saltmarsh is vulnerable to increased nutrients, and nitrogen in particular and has been found in long-term experiments overseas to be associated with saltmarsh loss (Deegan et al. 2012). The effects on saltmarsh communities in Port Phillip Bay are largely unknown, but risk is assessed on the basis that the site already is exposed to high nutrient loads.
Western Treatment Plant	Increased nutrients	Impacts waterbird abundance and diversity			#N/A	Extensive work has been conducted on the linkages between nutrients, productivity and shorebirds at important shorebird areas in Port Phillip Bay (Rogers et al. 2007, Loyn et al. 2014). The issue is not one of increased nutrients, but decreased nutrients having a negative impact. *Not a plausible impact pathway*

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Western Treatment Plant	Increased nutrients	Impacts waterbird breeding			#N/A	One of the reasons that the Western Treatment Plant supports such a large number of breeding birds is the high productivity. *Not a plausible impact pathway*
Western Treatment Plant	Increased nutrients	Impacts threatened species	Unlikely	Minor	Low	Threatened species at the site (e.g. Australasian bittern and growling grass frog) utilise inland habitats and are not affected by ocean discharge. They are adapted to the current nutrient regime and the likelihood of impact from an increase in nutrients is low. The shorebird species would only be affected by a decrease in nutrients.
Western Treatment Plant	Decreased nutrients and carbon					This pathway has been included, however the advice from Melbourne Water that a decline in nutrient discharge is possible, but not likely. Of greatest concern is the reduction in particulate organic carbon from the 145W drain, which is an important driver of the food chain at the Little River Estuary, which is a major feeding site for shorebirds (G. Parry, pers. comm.).
Western Treatment Plant	Decreased nutrients and carbon	Results in increased algal growth, adversely affects waterbird feeding (general)	Possible	Major	High	The impact of potential decrease in nutrients (< 2000 tonnes N / year) and carbon has been identified for feeding waterbirds (Rogers et al. 2007) and a risk (GHD 2011). Given the significance of the Werribee sector for bird abundance, the impacts would be to the ecological character of the entire site.
Western Treatment Plant	Decreased nutrients and carbon	Impacts waterbird breeding	Possible	Moderate	Medium	The greatest impacts are to shorebird feeding, not to waterfowl or beach nesting birds. There may, however be some flow on effects to breeding.
Western Treatment Plant	Decreased nutrients and carbon	Impacts threatened species	Possible	Major	High	The impact of potential decrease in nutrients (< 2000 tonnes N / year) and carbon has been identified for feeding waterbirds (Rogers et al. 2007) and a risk (GHD 2011). Given the significance of the Werribee sector for bird abundance, the impacts would be to the ecological character of the entire site.
Catchment inflows (including stormwater)	Increased nutrients					There are several major rivers and over 300 stormwater drains that flow directly into Port Phillip Bay (City of Port Phillip 2010). Better Bays and Waterways (Melbourne Water 2009) contains some modelled predictions of approximately 20% increase in total nitrogen loads from the catchment by 2030. These figures are currently being reviewed. However, in this sector of the Ramsar site, the influence of catchment inflows are likely masked by the discharges from the Western Treatment Plant. These risks are largely to the shoreline areas only as the freshwater wetlands are maintained with treated water.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects freshwater vegetation	Unlikely	Minor	Low	The freshwater wetlands in the site are managed to maintain waterbird habitat including freshwater emergent vegetation.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects seagrass	Unlikely	Minor	Low	Greatest impact to areas adjacent to major inflows.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect subtidal and intertidal flats	Possible	Minor	Low	Greatest impact to areas adjacent to major inflows.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect saltmarsh	Possible	Minor	Low	Coastal saltmarsh is vulnerable to increased nutrients, and nitrogen in particular and has been found in long-term experiments overseas to be associated with saltmarsh loss (Deegan et al. 2012). The effects on saltmarsh communities in Port Phillip Bay are largely unknown.
Catchment inflows (including stormwater)	Increased nutrients	Affects waterbird diversity and abundance			#N/A	Extensive work has been conducted on the linkages between nutrients, productivity and shorebirds at important shorebird areas in Port Phillip Bay (Rogers et al. 2007, Loyn et al. 2014). The issue is not one of increased nutrients, but decreased nutrients having a negative impact. *Not a plausible impact pathway*
Catchment inflows (including stormwater)	Increased nutrients	Affects waterbird breeding			#N/A	One of the reasons that the Western Treatment Plant supports such a large number of breeding birds is the high productivity. *Not a plausible impact pathway*
Catchment inflows (including stormwater)	Increased nutrients	Impacts threatened species	Unlikely	Minor	Low	Threatened species at the site (e.g. Australasian bittern and growling grass frog) utilise inland habitats and are not affected by ocean discharge. They are adapted to the current nutrient regime and the likelihood of impact from an increase in nutrients is low. The shorebird species would only be affected by a decrease in nutrients.
Catchment inflows (including stormwater)	Increased sediments					There are several major rivers and over 300 stormwater drains that flow directly into Port Phillip Bay (City of Port Phillip 2010). Better Bays and Waterways (Melbourne Water 2009) contains some modelled predictions of approximately 30% increase in total sediment loads from the catchment by 2030. These figures are currently being reviewed. However, in this sector of the Ramsar site, the influence of catchment inflows are likely masked by the discharges from the Western Treatment Plant. These risks are

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						largely to the shoreline areas only as the freshwater wetlands are maintained with treated water.
Catchment inflows (including stormwater)	Increased sediments	Adversely affects freshwater vegetation	Unlikely	Minor	Low	The freshwater wetlands in the site are managed to maintain waterbird habitat including freshwater emergent vegetation.
Catchment inflows (including stormwater)	Increased sediments	Reduced light (TSS and deposition) adversely affects seagrass	Unlikely	Minor	Low	Greatest impact to areas adjacent to major inflows.
Catchment inflows (including stormwater)	Increased sediments	Reduced light (TSS and deposition) adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	Greatest impact to areas adjacent to major inflows.
Catchment inflows (including stormwater)	Increased sediments	Affects waterbird diversity and abundance	Unlikely	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Catchment inflows (including stormwater)	Increased sediments	Affects waterbird breeding	Unlikely	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Catchment inflows (including stormwater)	Increased sediments	Impacts threatened species	Unlikely	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Residential and commercial development (dredging)	Increased sediments					Potentially two sets of impact pathway associated: Maintenance dredging and a new capital dredging program. Maintenance dredging shown to have very localised (in space and time) impacts on suspended sediments (Hale 2006). Possibly not significant enough to consider. The EMP project team have indicated that they would like to include a capital dredging program. However, as many of the risks are highly dependent on the characteristics of the sediments to be dredged and the values in proximity to dredging, it is not possible to assess anything other than increased TSS (which is applicable to all dredging programs). Risks have been derived

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						from the Channel Deepening Project (CDP). Any proposed capital dredging would have a specific assessment as part of an impact assessment. This risk is to the shoreline areas only, with no affect on the inland wetlands.
Residential and commercial development (dredging)	Increased sediments	Reduced light (TSS and deposition) adversely affects seagrass	Unlikely	Minor	Low	Although this is a generic dredging project, information from the Channel Deepening Project (CDP) can inform the assessment. Monitoring before, during and after dredging indicated no detectable impacts to seagrass health or extent (Hirst et al. 2012). Seagrass in Port Phillip Bay started to decline at some sites in 1998, and effects of prolonged drought coupled with exposure the longshore drift has been hypothesised as a potential cause (Ball et al. 2014). Any effects of CDP were possibly masked by the impacts of the Millennium drought.
Residential and commercial development (dredging)	Increased sediments	Reduced light (TSS and deposition) adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	Microphytobenthos (MPB) are found on most of the soft seabed throughout the Bay, with the areas of highest productivity offshore from the Western Treatment Plant and in shallow water depths. MPB are naturally highly variable in time and extent and have an estimated turnover rate of approximately 50 times per year (Harris et al. 1996). CDP risk assessment concluded that effects to MPB would be negligible and to benthic invertebrates would be localised with recovery on 12 to 24 months (CEE 2007).
Residential and commercial development (dredging)	Increased sediments	Impacts to fish and reduced visibility adversely affects feeding waterbirds	Unlikely	Minor	Low	CDP risk for seabirds was assessed as very low for most species and medium for gannets and terns (Brett Lane and Associates 2004). The effects on the species that use the shoreline in this segment would be low.
Residential and commercial development (dredging)	Increased sediments	Impacts to fish and reduced visibility adversely affects breeding waterbirds	Unlikely	Minor	Low	CDP risk for seabirds was assessed as very low for most species and medium for gannets and terns (Brett Lane and Associates 2004). The effects on the species that use the shoreline in this segment would be low.
Residential and commercial development (dredging)	Increased sediments	Adversely affects threatened species	Unlikely	Minor	Negligible	The threatened species that use the Werribee shorelines are shorebird species that are not likely to be negatively impacted by sediments.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Residential and commercial development (Avalon airport)	Increased noise and bird strike					The Avalon Airport Environment Strategy recognises the important values of the Ramsar site and contains provisions to minimise impacts to waterbirds through restrictions on flying near sensitive avifauna habitat and maintaining altitudes (300 – 500m) over roosting shorebird areas during the summer season.
Residential and commercial development (Avalon airport)	Increased noise and bird strike	Affects waterbird diversity and abundance	Possible	Minor	Low	See above.
Residential and commercial development (Avalon airport)	Increased noise and bird strike	Affects waterbird breeding	Possible	Minor	Low	See above.
Residential and commercial development (Avalon airport)	Increased noise and bird strike	Impacts threatened species	Possible	Minor	Low	See above.
Western Treatment Plant	Chemicals of emerging concern such as pharmaceuticals and personal care products					Monitoring at the outfall indicates that concentrations of heavy metals are mostly within SEPP (ANZECC) water quality objectives, and that they pose a low risk to Port Phillip Bay (GHD 2011, Parry 2015). However, studies from elsewhere indicate that urban treated sewage contains a range of chemicals such as steroid hormones that could pose of risk to the marine environment (Ying et al. 2002). Studies in fish indicate effects on immune systems and reproduction (Milla et al. 2011) and reproduction (Goksøyr 2006). The issue of CECs in the Western Treatment Plant is a knowledge gap both with respect to the concentration of chemicals and their potential effects on biota.
Western Treatment Plant	Chemicals of emerging concern	Adversely affects invertebrates reducing condition, abundance and diversity	Possible	Moderate	Medium	Studies on the effects of endocrine disruptors on invertebrates are less common than those of fish, but there is evidence of effects on reproduction in a number of species including mussels (Porte et al. 2006).
Western Treatment Plant	Chemicals of emerging concern	Impacts to fish and invertebrates adversely affects waterbirds through the food chain	Likely	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing. Risk considered higher at this section of the Ramsar sites than elsewhere in the Bay.
Western Treatment Plant	Chemicals of emerging concern	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Likely	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing. Risk considered higher at this section of the Ramsar sites than elsewhere in the Bay.
Western Treatment Plant	Chemicals of emerging concern	Impacts threatened species	Likely	Major	High	Impacts to birds as above, but perhaps increased risk to susceptible species such as frogs (growling grass frog). Remains a knowledge gap.
Catchment inflows (including stormwater)	Toxicants (includes metals as well as herbicides and pesticides)					Concentrations of toxicants are occasionally elevated in the water column of the lower Yarra and Maribyrnong Rivers from urban and industrial stormwater (Melbourne Water 2009). There are over 300 stormwater drains that discharge directly to the Bay that carry road run-off and urban (and peri-urban) pollutants. Chemicals of emerging concern remain a significant knowledge gap. However, there are concerns at the Western Treatment Plant from the use of pesticides and herbicides in surrounding farmlands, washing into the important wetland bird habitats.
Catchment inflows (including stormwater)	Toxicants	Toxicants adversely affects invertebrates reducing condition, abundance and diversity	Possible	Moderate	Medium	Toxicants are mostly sediment bound and impact is restricted.
Catchment inflows (including stormwater)	Toxicants	Impacts to fish and invertebrates adversely affects waterbirds through the food chain	Possible	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Toxicants	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Possible	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing.
Catchment inflows (including stormwater)	Toxicants	Impacts threatened species	Possible	Major	High	Impacts to birds as above, but perhaps increased risk to susceptible species such as frogs (growling grass frog). Remains a knowledge gap.
Catchment inflows (including stormwater)	Litter (including microplastics)					Recent surveys of the Lower Yarra and Maribyrnong rivers indicated a large amount of litter and micro plastics and micro-plastics on beaches of Port Phillip Bay (Blake and Charko 2014). This is consistent with an Australia wide study of micro-plastics in oceanic waters, which found levels in Australia similar to those in the Caribbean, but lower than in the Mediterranean (Reisser et al. 2013). EPA Victoria has a citizen science program aimed at assessing the magnitude of the problem in Port Phillip Bay.
Catchment inflows (including stormwater)	Litter (including microplastics)	Adversely affects invertebrates reducing condition, abundance and diversity	Likely	Moderate	Medium	There is evidence of ingestion and digestion of micro-plastics by marine invertebrates. Accumulation of microplastic particles in marine invertebrates could potentially cause blockages throughout the digestive system, suppressing feeding due to satiation (Wright et al. 2013).
Catchment inflows (including stormwater)	Litter (including microplastics)	Affects waterbird diversity and abundance	Almost certain	Minor	Medium	There are regular reported entanglements of seabirds in marine debris. Seabirds and shorebirds are also susceptible to ingestion of micro-plastics with effects on nutrition and toxicity reported (Sutherland et al. 2012).
Catchment inflows (including stormwater)	Litter (including microplastics)	Affects waterbird breeding	Possible	Minor	Low	Impacts to birds breeding in the site is considered low except for minor impacts for species that feed on shorelines or in the open sea.
Catchment inflows (including stormwater)	Litter (including microplastics)	Impacts threatened species	Possible	Minor	Low	May impact threatened shorebird species in this sector.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Shipping and navigation (oil spills)	Hydrocarbons					The Ports of Geelong and Melbourne in Port Phillip Bay receive the highest number of shipping visits of all the Victorian ports. The possibility of a major oil spill in the bay is slight, however, small spills are a common occurrence. Estimations of the frequency of oil spills indicate that a spill of 5 L or less occurs almost daily, while spills of more than 100 L occur less than once a month. The only major spill in Port Phillip Bay was in 1903 (1100 tonnes) and there have only been 20 spills of > 100 tonnes in Australia in the last 100 years (AMSA https://www.amsa.gov.au/environment/major-historical-incidents/). Risk management measures are in place to minimise the risk of a major spill and respond in the event to minimise impacts (Melbourne Water 2009). The risk assessment below is based on a spill of over 100 tonnes, with the likelihood assessed as "Rare" based on historic records of oil spills in Australia. Risk is to the shoreline portion of this segment only.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects seagrass	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects saltmarsh	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects intertidal flats	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Direct oiling of wildlife: waterbird diversity and abundance	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic,

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Indirect effects to waterbirds (food webs, breeding)	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Affects threatened species	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity					Areas of CASS have been mapped around Port Phillip Bay. If disturbed due to prolonged drying of wetland areas or physical disturbance of the soil surface, then sulphuric acid is formed and can liberate metals from the sediments. The risk from altered pH was considered in by workshop participants to be too small and localised to be considered given the buffering potential of seawater. However, the release of heavy metals was considered to be a risk, albeit localised and of low likelihood due to current strategies and policies in place to minimise disturbance of CASS (Department of Sustainability and Environment 2009). Risks at Werribee would be largely due to disturbance of soils in adjacent urban, rural and industrial areas.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects freshwater vegetation	Unlikely	Minor	Low	The freshwater wetlands in the site are managed to maintain waterbird habitat including freshwater emergent vegetation.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects seagrass	Unlikely	Minor	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects saltmarsh	Unlikely	Minor	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects invertebrates reducing	Unlikely	Moderate	Low	Expected localised inshore impacts only.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
		condition, abundance and diversity				
CASS	Metals liberated as a result of oxidation of CASS and acidity	Affects waterbird diversity and abundance	Unlikely	Minor	Low	Through food chain impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Affects waterbird breeding	Unlikely	Minor	Low	Through food chain impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Impacts threatened species	Unlikely	Minor	Low	Through food chain impacts only.
Invasive species	Introduced marine pests (current species)					Over 100 non-native marine species exist in Port Phillip Bay, many with a long history. There is an argument that the biota of the Bay has not been "natural" for more than 100 years (Hewitt et al. 1999). Current introduced marine species cover all taxonomic groups from algae to invertebrates and fish. Parks Victoria indicated that marine pests were a significant risk to Marine National Parks based on stakeholder perceptions (Carey et al. 2007). Impacts to biota have been assessed based on trajectories of change over the past decade. Finer details on individual species and impacts will be addressed in the science review. This risk is to the shoreline portion of the site only.
Invasive species	Introduced marine pests (current species)	Adversely affects seagrass	Unlikely	Minor	Low	Baywide monitoring of seagrass health in Port Phillip Bay (2008 to 2011) indicated little change in health over this time (Hirst et al. 2012); indicating a degree of stability under current conditions While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests (current species)	Adversely affects intertidal and sub-tidal flats	Unlikely	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests (current species)	Affects waterbird diversity and abundance	Unlikely	Minor	Low	Through food chain impacts only.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Introduced marine pests (current species)	Affects waterbird breeding	Unlikely	Minor	Low	Through food chain impacts only.
Invasive species	Introduced marine pests (current species)	Impacts threatened species	Unlikely	Minor	Low	Through food chain impacts only.
Invasive species	Salt tolerant agricultural weeds					There are a number of salt tolerant weed species that have been recorded in Port Phillip Bay or have the potential to invade. Of most concern are tall wheat grass (*Thinopyrum ponticum*), cord-grass (*Spartina* spp.) and sea lavender *(Limonium hyblaeum*). There are examples from Western Port where tall wheat grass has severely impact saltmarsh and bird habitat, with control proving very difficult (Hirst and Boon 2016) similar impacts could be realised in Port Phillip Bay. Weeds are managed at the Western Treatment Plant by Melbourne Water.
Invasive species	Salt tolerant agricultural weeds	Adversely affects saltmarsh	Possible	Moderate	Medium	Weeds are controlled in the Western Treatment Plant portion of the site by Melbourne Water. While current conditions remain good, there is the chance of salt tolerant weeds spreading in the future.
Invasive species	Salt tolerant agricultural weeds	Affects waterbird diversity and abundance	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for waterbirds in intertidal areas.
Invasive species	Salt tolerant agricultural weeds	Affects waterbird breeding	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits breeding habitat for beach nesting birds.
Invasive species	Salt tolerant agricultural weeds	Impacts threatened species	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for threatened shorebirds in intertidal areas.
Invasive species	Predators (foxes and cats)					Foxes and cats are present in the Ramsar site and currently controlled by Melbourne Water programs.
Invasive species	Predators (foxes and cats)	Adversely affects waterbird diversity and abundance	Almost certain	Minor	Medium	Based on advice from Melbourne Water
Invasive species	Predators (foxes and cats)	Affects waterbird breeding	Almost certain	Minor	Medium	Based on advice from Melbourne Water
Invasive species	Predators (foxes and cats)	Adversely affects threatened species	Likely	Minor	Medium	Based on advice from Melbourne Water

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Grazing animals (rabbits)					Rabbits are present in the site, but damage under current management arrangements is minor.
Invasive species	Grazing animals (rabbits)	Adversely affects saltmarsh	Almost certain	Minor	Medium	Based on advice from Melbourne Water
Invasive species	Grazing animals (rabbits)	Adversely affects waterbird diversity and abundance	Possible	Minor	Low	Based on advice from Melbourne Water
Invasive species	Grazing animals (rabbits)	Adversely affects threatened species	Possible	Minor	Low	Based on advice from Melbourne Water
Recreational activities						Increased populations in and around Melbourne will add pressure to recreational areas of the Ramsar Site, particularly of beaches and on water activities (Deloitte 2016). The beach adjacent to the Western Treatment Plant is not as popular with recreational activities as other locations in the Bay.
Recreational activities	Vehicles in intertidal areas	Adversely affects saltmarsh	Possible	Minor	Low	Coastal saltmarsh is an EPBC listed species and is vulnerable to impacts and slow to recover from damage. Damage arising from vehicular access is widespread around Port Phillip Bay, but not common in this section of the Ramsar site
Recreational activities	Vehicles in intertidal areas	Adversely affects intertidal flats	Possible	Minor	Low	Intertidal areas are vulnerable to damage from vehicles, but access is difficult and not common in this section of the Ramsar site.
Recreational activities	Vessels	Affects waterbird diversity and abundance	Likely	Minor	Medium	There is growing evidence that disturbance of waterbirds by human activities (walking, boating, vehicles) can have significant negative impacts on both feeding behaviour and habitat use. A database collated from a large number of scientific studies of flight initiation distances (FID, the distance between the activity and the bird talking flight) indicates that nesting birds can be disturbed by human activities at very short distances (e.g. mean FID for nesting pelicans was only 21 m and for ducks 32 m from pedestrians) (Livezey et al. 2016). FIDs for non-nesting species were typically greater (e.g. 60 metres for ducks from pedestrians). Birds are disturbed at closer distances by dogs and watercraft as opposed to pedestrians, but interestingly, non-motorised watercraft such as canoes and paddleboards had equal or smaller FIDs compared to motorised vessels (Glover et al. 2015, Livezey et al. 2016). The consequences for individuals and populations can be significant, with decreased time spent feeding, increased energy spent in flying away from disturbances, nest abandonment and ultimately population declines

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						all cited as potential effects (Glover et al. 2011, Martín et al. 2015). An increasing population is highly likely to result in an increase in recreational users of Port Philip Bay, which has the potential to impact on waterbird abundance and diversity. Access to this area of the Ramsar site is not common.
Recreational activities	Vessels	Affects waterbird breeding	Likely	Minor	Medium	See above
Recreational activities	Vessels	Impacts threatened species	Likely	Minor	Medium	See above
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird diversity and abundance	Likely	Minor	Medium	Shorebirds and nesting seabirds are vulnerable to disturbance from walkers and dogs. As the population increases, it is expected that this pressure will also increase, with some significant shorebird sites located near to Melbourne and Geelong. Advice from BirdLife Australia indicates that this stretch of shoreline is not a popular spot for recreational use.
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird breeding	Likely	Minor	Medium	See above
Recreational activities	Passive recreation (dogs, walkers, horses)	Impacts threatened species	Likely	Minor	Medium	See above
Biological resource use	Hunting					Shooting is banned completely on the Melbourne Water property [Western Treatment Plant], but the seaward boundary of that property is the 'high water mark', so the beach is not within the Western Treatment Plant. Shooting of game species can legally occur in Port Phillip Bay and on the Foreshore Reserve during the proclaimed shooting season. Although shooting is only permitted seaward, there are incidences of shooting across the treatment ponds to “flush” waterfowl that can then be shot over the foreshore.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Biological resource use	Hunting	Affects waterbird diversity and abundance	Almost certain	Moderate	High	It is certain that shooting birds results in a decrease in bird abundance. Impacts to target species are controlled by bag limits. This risk is based on effects to non-target species through mis-identification and disturbance of shorebirds and orange-bellied parrots, with an overlap between the start of duck hunting season and presence of shorebirds in the site.
Biological resource use	Hunting	Affects waterbird breeding	Possible	Moderate	Medium	Effect on breeding birds is not known.
Biological resource use	Hunting	Impacts threatened species	Almost certain	Moderate	High	As per effects on abundance, with threatened species in this segment being shorebirds.
Climate change						Regional climate projections have recently been released by CSIRO for sub-cluster regions in Australia. The relevant region for Port Phillip Bay is "Southern Slopes Victoria West" http://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=SSVWC&tooltip=true&popup=true. These are provided for each relevant stressor below. The risks are based on the recently completed marine vulnerability under climate change (Klemke and Arundel 2013). An expert panel reviewed the potential effects of climate change on Port Phillip Bay values in 2015 (Hale and Brooks 2015) these have been used here to assess the likely risks in the next 30 - 35 years.
Climate change	Increased carbon dioxide					Atmospheric carbon dioxide is increasing and has increased in recent decades and recently exceeded 400 ppm (http://www.esrl.noaa.gov/gmd/ccgg/trends/).
Climate change	Increased carbon dioxide	Adversely affects freshwater vegetation	Unlikely	Minor	Low	May competitively advantage some weed species.
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects seagrass	Unlikely	Negligible	Negligible	Predicted that increased CO_2 may benefit seagrass (Morris 2013).
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects saltmarsh	Possible	Minor	Low	Score of 'minor' impact based on belief that selection amongst C3/C4 plants will exert little overall adverse effect on saltmarshes. Might result in shifts across plant groups (e.g. grasses neutral effect; C3 taxa, such as shrubs, herbs and mangroves, advantaged)

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased temperature					Surface water temperatures are predicted to increase by 0.5 degrees Celsius by 2030 with a very high degree of confidence. There will also be an increase in the frequency of extreme temperature days (Grose et al. 2015).
Climate change	Increased temperature	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	An assessment of climate change related increased temperature impacts to intertidal and subtidal flats indicated moderate vulnerability and adaptive capacity (Morris 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects seagrass	Unlikely	Minor	Low	Assessment of impacts of climate change related temperature increases on seagrass and soft sediment habitats in Victoria indicated low vulnerability, but high uncertainty in embayments. (Morris 2013).
Climate change	Increased temperature	Adversely affects saltmarsh	Unlikely	Moderate	Low	Saintilan and Rogers (2013) hypothesised that temperature has an influence in the diversity of saltmarsh communities, with increased diversity at mean minimum daily temperatures of < 8 ºC, and increased germination success of southern Australian saltmarsh species at lower temperatures. The increase in mean temperature coupled with an increased frequency in extreme temperature days could be expected to decrease the diversity of saltmarsh communities. The effects, however, may be expected in the longer term rather in the next 30 - 35 years.
Climate change	Increased temperature	Adversely affects freshwater wetland vegetation / habitat	Possible	Minor	Low	Australian woody wetland vegetation is characterised by a few widely distributed species that have broad temperature tolerances (James et al. 2016). The non-woody species may be more vulnerable to temperature extremes and it is possible that invasive native species such as typha and phragmites will out compete other sedge communities.
Climate change	Increased temperature	Adversely affects waterbird abundance and diversity	Likely	Major	High	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios. There is however, a concern related to increased outbreaks of avian diseases (botulism and cholera) as a result of increased temperatures, with increased frequencies and bird deaths already observed elsewhere (Traill et al. 2009) and at the Western

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						Treatment Plant (Melbourne Water pers. comm.). The risk at this segment is considered higher due to the high percentage of the population of several species supported by the site, with a large outbreak at risk of affecting a large proportion of the population.
Climate change	Increased temperature	Adversely affects waterbird breeding	Likely	Major	High	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios. Risk is from increased frequency and severity of disease (see above).
Climate change	Increased temperature	Adversely affects threatened species	Likely	Major	High	Temperature effects the timing of migration in many shorebirds, which may influence recruitment and survival (Robinson et al. 2009). There is also a risk of increased incidence of disease such as avian botulism and avian cholera under hotter conditions (Traill et al. 2009) both diseases are known to also affect shorebirds resulting in death.
Climate change	Sea level rise					Sea levels are predicted to increase by 0.08 to 0.18 m by 2030 with a very high degree of confidence (Grose et al. 2015). Recent studies indicate a potential loss of bird habitat in this sector of 34% by 2040 (Roy 2015).
Climate change	Sea level rise	Adversely affects seagrass	Likely	Major	High	Intertidal seagrass is highly vulnerable to sea level rise and has a low adaptive capacity (Morris 2013).
Climate change	Sea level rise	Adversely affects intertidal and subtidal flats	Likely	Major	High	Intertidal mudflats are highly vulnerable to sea level rise and have a low adaptive capacity (Morris 2013). There are significant landward barriers to migration in this segment.
Climate change	Sea level rise	Adversely affects saltmarsh	Likely	Major	High	Saltmarsh and mangrove community composition and extent is largely determined by tidal depth (Boon et al. 2011). There is already evidence of mangroves expanding at the expense of saltmarsh communities in southern Australia (Boon in prep).
Climate change	Sea level rise	Adversely affects freshwater wetland vegetation / habitat	Unlikely	Extreme	Medium	Melbourne Water has plans in place to protect the lagoons and bird habitat from rising sea levels. The likelihood of a breach is low, but the consequences would be high
Climate change	Sea level rise	Adversely affects waterbird abundance and diversity	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Sea level rise	Adversely affects waterbird breeding	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Sea level rise	Adversely affects threatened species	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Ocean acidification					pH is predicted to decrease by 0.07 to 0.08 pH units by 2030 with a medium degree of confidence (Grose et al. 2015).
Climate change	Ocean acidification	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Assessed as being highly vulnerable, particularly for organisms with a calcified outer shell (Morris 2013). However, possibly a longer term risk, rather than in the next two decades.
Climate change	Ocean acidification	Adversely affects waterbird abundance and diversity	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects waterbird breeding	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects threatened species	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)					Time spent in drought is projected, with medium confidence, to increase over the course of the century (Grose et al. 2015). During the millennium drought, the salinity of the Bay increased to greater than that of sea water (Lee et al. 2012). Decreased nutrient inputs to the Bay occurred over this period exacerbated by redirection of Western Treatment Plant outflows to inland reuses.
Climate change	Increased frequency and duration of droughts	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts	Adversely affects seagrass	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment and recent investigation of seagrass in the Bay (Jenkins et al. 2015).

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and duration of droughts	Adversely affects saltmarsh	Possible	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts	Adversely affects waterbird abundance and diversity	Possible	Moderate	Medium	Extensive work has been conducted linking nitrogen discharge from the Western Treatment Plant to food availability for shorebirds (e.g. Rogers et al. 2007). However, effects more likely to be felt in the longer term.
Climate change	Increased frequency and duration of droughts	Adversely affects waterbird breeding	Possible	Moderate	Medium	As above, with flow on effects of reduced habitat and productivity.
Climate change	Increased frequency and duration of droughts	Adversely affects threatened species	Possible	Moderate	Medium	Primarily to shorebird species that feed near outfalls.
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines					Extreme events (storms and high rainfall events) are predicted to occur with high confidence (Grose et al. 2015). Erosion of shorelines in Port Phillip Bay is currently occurring due to both natural processes and in some instances exacerbated by artificial structures such as groynes and beach armouring (Bird 2011).
Climate change	Increased frequency and intensity of storms	Adversely affects seagrass	Possible	Major	High	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects intertidal and subtidal flats	Possible	Major	High	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects saltmarsh	Possible	Major	High	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects waterbird abundance and diversity	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects waterbird breeding	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects threatened species	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.

Risk assessment for the **Point Wilson / Limeburner's Bay** sector of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Cells highlighted in blue provide a description of the threat / stressor that is applicable to the relevant impact pathways that follow. A full explanation of the risk assessment process, including descriptors for likelihood and consequence, is provided in section 3.1. It should be noted that this risk assessment represents risk under current management arrangements. Were management of the site to change (e.g. through a reduction in funding for existing activities) some risks would be increased.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Western Treatment Plant	Increased nutrients					The WTP nutrient discharge to Port Phillip Bay has been studied in great detail as part of the 1996 Port Phillip Bay Environmental Study and more recently the Port Phillip Bay Environmental Management Plan. These studies show a low risk to the bay if the nutrient discharge is limited to 3100 tonnes per annum (tpa). Melbourne Water is committed to upgrading the treatment process as population increases to ensure this limit is met. Normal discharge ranges from 2000 - 3000 tpa, but historical higher loads of up to 4000 tpa have not shown any detrimental effect on Ramsar values.
Western Treatment Plant	Increased nutrients	Adversely affects seagrass	Unlikely	Minor	Low	Seagrass in Corio Bay has been stable in terms of extent and condition over time, despite the proximity to Western Treatment Plant inflows of nutrients (Jenkins et al. 2015).
Western Treatment Plant	Increased nutrients	Adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	A study of near-shore sediments compared chlorophyll-a and organic matter concentrations at sites increasing distance from the Western Treatment Plant outfall and found no detectable effect of the outfall (Preston 2003). Of more concern has been decline in nutrients and coupled loss of productivity and abundance of infauna adjacent to the Western Treatment Plant (e.g. Rogers et al. 2007). If there is no effect close to the outfall, the effect on the sediments in this sector is also likely to be minimal.
Western Treatment Plant	Increased nutrients	Adversely affects saltmarsh	Possible	Minor	Low	Coastal saltmarsh is vulnerable to increased nutrients, and nitrogen in particular and has been found in long-term experiments overseas to be associated with saltmarsh loss (Deegan et al. 2012). The effects on saltmarsh communities in Port Phillip Bay are largely unknown.
Western Treatment Plant	Increased nutrients	Adversely affects mangroves	Possible	Minor	Low	The effects of nutrients on mangrove communities in Port Phillip Bay are largely unknown. Reduction in below-ground biomass of mangroves in response to increased nutrients, possibly making them more susceptible to storm damage and toppling over is the most likely impact pathway.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Western Treatment Plant	Increased nutrients	Results in a decline in seagrass adversely affects fish abundance and diversity	Unlikely	Minor	Low	Seagrass in Port Phillip Bay is an important fish habitat and species richness would be expected to decrease with any seagrass loss (Macreadie et al. 2009). The risk rating is due to the low risk to seagrass from this pressure - stressor.
Western Treatment Plant	Increased nutrients	Results in increased algal growth, adversely affects waterbird feeding (general)			#N/A	Extensive work has been conducted on the linkages between nutrients, productivity and shorebirds at important shorebird areas in Port Phillip Bay (Rogers et al. 2007, Loyn et al. 2014). The issue is not one of increased nutrients, but decreased nutrients having a negative impact. *Not a plausible impact pathway*
Western Treatment Plant	Increased nutrients	Impacts waterbird breeding			#N/A	High productivity favours waterbird breeding. *Not a plausible impact pathway*
Western Treatment Plant	Increased nutrients	Impacts threatened species	Possible	Negligible	Negligible	Threatened species at this location comprise orange-bellied parrot and shorebirds such as curlew sandpiper. Risk has been derived from impacts to habitat.
Catchment inflows (including stormwater)	Increased nutrients					There are several major rivers and over 300 stormwater drains that flow directly into Port Phillip Bay (City of Port Phillip 2010). Better Bays and Waterways (Melbourne Water 2009) contains some modelled predictions of approximately 20% increase in total nitrogen loads from the catchment by 2030. These figures are currently being reviewed. There are several drains that discharge directly into this sector, but the main sources of catchment nutrients to the Bay are from the Yarra and Patterson Rivers, which would not be significant influences to this sector of the Ramsar site.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects seagrass	Possible	Moderate	Medium	Greatest impact to areas adjacent to major inflows, but observations of localised impact to seagrasses in Limeburner's Bay (Parks Victoria).
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect subtidal and intertidal flats	Possible	Minor	Low	Greatest impact to areas adjacent to major inflows.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect saltmarsh	Possible	Minor	Low	Surface runoff from nearby residential areas. There is considerable information to show the adverse effect of catchment-derived nutrients on coastal saltmarshes (see Boon et al. 2011).
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects mangroves	Possible	Negligible	Negligible	The effects of nutrients on mangrove communities in Port Phillip Bay are largely unknown. Reduction in below-ground biomass of mangroves in response to increased nutrients, possibly making

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						them more susceptible to storm damage and toppling over is the most likely impact pathway.
Catchment inflows (including stormwater)	Increased nutrients	Result in a decline in seagrass and adversely affects fish abundance and diversity	Possible	Minor	Low	As for seagrass - localised impacts.
Catchment inflows (including stormwater)	Increased nutrients	Affects waterbird diversity and abundance			#N/A	Extensive work has been conducted on the linkages between nutrients, productivity and shorebirds at important shorebird areas in Port Phillip Bay (Rogers et al. 2007, Loyn et al. 2014). The issue is not one of increased nutrients, but decreased nutrients having a negative impact. *Not a plausible impact pathway*
Catchment inflows (including stormwater)	Increased nutrients	Affects waterbird breeding			#N/A	High productivity favours waterbird breeding. *Not a plausible impact pathway*
Catchment inflows (including stormwater)	Increased nutrients	Impacts threatened species	Unlikely	Negligible	Negligible	Threatened species at this location comprise orange-bellied parrot and shorebirds such as curlew sandpiper. Risk has been derived from impacts to habitat.
Catchment inflows (including stormwater)	Increased sediments					There are several major rivers and over 300 stormwater drains that flow directly into Port Phillip Bay (City of Port Phillip 2010). Better Bays and Waterways (Melbourne Water 2009) contains some modelled predictions of approximately 30% increase in total sediment loads from the catchment by 2030. These figures are currently being reviewed. There are several drains that discharge directly into this sector, but the main sources of catchment sediments to the Bay are from the Yarra and Patterson Rivers, which would not be significant influences to this sector of the Ramsar site.
Catchment inflows (including stormwater)	Increased sediments	Reduced light (TSS and deposition) adversely affects seagrass	Possible	Moderate	Medium	Seagrass in parts of the Bay is known to be light limited and may be further impacted by increased suspended sediments (Bulthuis 1983). Particularly from large flood events.
Catchment inflows (including stormwater)	Increased sediments	Reduced light (TSS and deposition) adversely affects	Unlikely	Minor	Low	Greatest impact to areas adjacent to major inflows.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
		subtidal and intertidal flats				
Catchment inflows (including stormwater)	Increased sediments	Reduced light and increased TSS adversely affects fish	Rare	Minor	Negligible	Direct impacts to fish gills are observed at high TSS loads, with larval fish considered the most vulnerable (Jenkins and McKinnon 2006). Sediments from catchment inflows are not expected to reach these levels.
Catchment inflows (including stormwater)	Increased sediments	Affects waterbird diversity and abundance	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Catchment inflows (including stormwater)	Increased sediments	Affects waterbird breeding	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Catchment inflows (including stormwater)	Increased sediments	Impacts threatened species	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Residential and commercial development (dredging)	Increased sediments					Potentially two sets of impact pathway associated: Maintenance dredging and a new capital dredging program. Maintenance dredging shown to have very localised (in space and time) impacts on suspended sediments (Hale 2006) and was considered not significant enough to consider. Risks associated with a capital dredging program are highly dependent on the characteristics of the sediments to be dredged and the values in proximity to dredging. Therefore, it's not possible to assess anything other than increased TSS (which is applicable to all dredging programs). Risks have been derived from the Channel Deepening Project (CDP). Any proposed capital dredging would have a specific assessment as part of an impact assessment.
Residential and commercial development (dredging)	Increased sediments	Reduced light (TSS and deposition) adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	CDP risk assessment concluded that effects to intertidal areas would be negligible and to benthic invertebrates would be localised with recovery on 12 to 24 months (CEE 2007a).
Residential and commercial development (dredging)	Increased sediments	Reduced light (TSS and deposition) adversely affects seagrass	Possible	Moderate	Medium	Although this is a generic dredging project, information from the Channel Deepening Project (CDP) can inform the assessment. Monitoring before, during and after dredging indicated no detectable impacts to seagrass health or extent (Hirst et al. 2012).

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						Seagrass in Port Phillip Bay started to decline in 1998 at some sites in 1998, and effects of prolonged drought coupled with exposure the longshore drift has been hypothesised as a potential cause (Ball et al. 2014). Any effects of CDP were possibly masked by the impacts of the Millennium drought.
Residential and commercial development (dredging)	Increased sediments	Reduced light and increased TSS adversely affects fish	Unlikely	Minor	Low	Interannual variation for all fish species, except eastern shovelnose stingaree in the west region and sand flathead in the shallow, intermediate and deep regions, were within expected variability for Port Phillip Bay during the reporting period 2008-2011 (Hirst et al. 2012). No impact to fish or fisheries was detected during CDP.
Residential and commercial development (dredging)	Increased sediments	Impacts to fish and reduced visibility adversely affects feeding waterbirds	Unlikely	Minor	Low	CDP risk assessment for seabirds was very low for most species and medium for gannets and terns (Brett Lane and Associates 2004). The effects on the species that use the shoreline in this segment would be low.
Residential and commercial development (dredging)	Increased sediments	Impacts to fish and reduced visibility adversely affects breeding waterbirds	Unlikely	Minor	Low	CDP risk assessment for seabirds was very low for most species and medium for gannets and terns (Brett Lane and Associates 2004). The effects on the species that use the shoreline in this segment would be low.
Residential and commercial development (dredging)	Increased sediments	Adversely affects threatened species	Rare	Negligible	Negligible	The threatened species that use the Point Wilson shorelines are shorebird species that are not likely to be negatively impacted by sediments.
Residential and commercial development (Avalon airport)	Increased noise and bird strike					The Avalon Airport Environment Strategy recognises the important values of the Ramsar site and contains provisions to minimise impacts to waterbirds through restrictions on flying near sensitive avifauna habitat and maintaining altitudes (300 – 500m) over roosting shorebird areas during the summer season.
Residential and commercial development (Avalon airport)	Increased noise and bird strike	Affects waterbird diversity and abundance	Possible	Minor	Low	See above.
Residential and commercial development (Avalon airport)	Increased noise and bird strike	Affects waterbird breeding	Possible	Minor	Low	See above.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Residential and commercial development (Avalon airport)	Increased noise and bird strike	Impacts threatened species	Possible	Minor	Low	See above.
Western Treatment Plant	Chemicals of emerging concern such as pharmaceuticals and personal care products					Monitoring at the outfall indicates that concentrations of heavy metals are mostly within SEPP (ANZECC) water quality objectives, and that they pose a low risk to Port Phillip Bay (GHD 2011, Parry 2015). However, studies from elsewhere indicate that urban treated sewage contains a range of chemicals such as steroid hormones that could pose of risk to the marine environment (Ying et al. 2002). Studies in fish indicate effects on immune systems and reproduction (Milla et al. 2011) and reproduction (Goksøyr 2006). The issue of CECs in the Western Treatment Plant is a knowledge gap both with respect to the concentration of chemicals and their potential effects on biota.
Western Treatment Plant	Chemicals of emerging concern	Adversely affects fish reducing condition, abundance and diversity	Unlikely	Moderate	Low	Studies in fish indicate effects on immune systems and reproduction (Milla et al 2011) and reproduction (Goksoyor 2006). However, these are mostly under laboratory conditions, where the concentrations of chemicals animals are exposed to is likely higher than that in Port Phillip Bay.
Western Treatment Plant	Chemicals of emerging concern	Adversely affects invertebrates reducing condition, abundance and diversity	Possible	Moderate	Medium	Studies on the effects of endocrine disruptors on invertebrates are less common than those of fish, but there is evidence of effects on reproduction in a number of species including mussels (Porte et al. 2006).
Western Treatment Plant	Chemicals of emerging concern	Impacts to fish and invertebrates adversely affects waterbirds through the food chain	Possible	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing.
Western Treatment Plant	Chemicals of emerging concern	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Possible	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Western Treatment Plant	Chemicals of emerging concern	Impacts threatened species	Possible	Moderate	Medium	Impacts to birds as above. Remains a knowledge gap.
Catchment inflows (including stormwater)	Toxicants (includes metals as well as chemicals of emerging concern)					There are over 300 stormwater drains that discharge directly to the Bay that carry road run-off and urban (and peri-urban) pollutants. Chemicals of emerging concern remain a significant knowledge gap. There are several major drains that enter Port Phillip Bay near Point Wilson / Limeburners Bay and the proximity to Corio Bay and potential contaminated sediments has been considered.
Catchment inflows (including stormwater)	Toxicants	Toxicants adversely affects fish reducing condition, abundance and diversity	Possible	Moderate	Medium	Toxicants are mostly sediment bound and not bio-available.
Catchment inflows (including stormwater)	Toxicants	Toxicants adversely affects invertebrates reducing condition, abundance and diversity	Possible	Moderate	Medium	Toxicants are mostly sediment bound and not bio-available.
Catchment inflows (including stormwater)	Toxicants	Impacts to fish and invertebrates adversely affects waterbirds through the food chain	Possible	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing.
Catchment inflows (including stormwater)	Toxicants	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Possible	Moderate	Medium	Very few studies on effects of pharmaceuticals on birds, but one study indicated that antidepressants had an effect on the behaviour of starlings (Bean et al. 2014). In addition, the GHD (2011) risk assessment for the Western Treatment Plant indicated that waterbirds were at greater risk from toxicants as many feed directly from the treatment ponds, rather than other organisms that are exposed only to dilute concentrations in the Bay after mixing.
Catchment inflows (including stormwater)	Toxicants	Impacts threatened species	Possible	Moderate	Medium	Impacts to birds as above. Remains a knowledge gap.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Mosquito control	Toxicants (s-methoprene and *Bacillus thuringiensis israelensis*)					The City of Geelong undertakes aerial mosquito control in known mosquito breeding locations, which includes Limeburners Bay, Swan Bay and the Lake Connewarre complex. The two agents used are natural products that are targeting specific insect groups. This includes both mosquito and midge larvae (chironomids) the latter of which are significant prey items for many waterbirds in general and migratory shorebirds specifically. An EPBC referral was assessed in 2005 and the practice permitted, with some restrictions. Since that time, however, research has suggested that the risk to shorebird prey items may be higher than initially thought.
Mosquito control	Toxicants (s-methoprene and *Bti*)	Toxicants adversely affects invertebrates reducing condition, abundance and diversity	Almost certain	Minor	Medium	These insecticides are designed to impact on invertebrate populations and affect a wider number of species than the two target species (Antunes-Kenyon et al. 2001). The effects, however, for most taxonomic groups are short lived ((Lagadic et al. 2014).
Mosquito control	Toxicants (s-methoprene and *Bti*)	Toxicants adversely affects fish reducing condition, abundance and diversity	Unlikely	Minor	Low	Studies in Australia and overseas have indicated that the two substances at the concentrations recommended for field applications are not toxic to fish (Hurst et al. 2007).
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts to fish and invertebrates adversely affects waterbirds through the food chain	Possible	Minor	Low	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). This remains a knowledge gap.
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Possible	Minor	Low	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). This remains a knowledge gap.
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts threatened species	Possible	Minor	Low	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). This remains a knowledge gap.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Litter (including microplastics)					Recent surveys of the Lower Yarra and Maribyrnong rivers indicated a large amount of litter and micro plastics and micro-plastics on beaches of Port Phillip Bay (Blake and Charko 2014). This is consistent with an Australia wide study of micro-plastics in oceanic waters, which found levels in Australia similar to those in the Caribbean, but lower than in the Mediterranean (Reisser et al. 2013). EPA Victoria has a citizen science program aimed at assessing the magnitude of the problem in Port Phillip Bay.
Catchment inflows (including stormwater)	Litter (including microplastics)	Adversely affects fish reducing condition, abundance and diversity	Likely	Moderate	Medium	Impact pathways for fish include entanglement and ingestion of plastics (Hammer et al. 2012). Studies from the northern hemisphere indicate that fish species, regardless of feeding habit, ingest micro-plastics (Lusher et al. 2013). Although the long-term effects are not fully understood, there is evidence of transfers of toxic chemicals, liver disease (Rochman et al. 2013) and blocking of the digestive tract leading to starvation (Gregory 2009).
Catchment inflows (including stormwater)	Litter (including microplastics)	Adversely affects invertebrates reducing condition, abundance and diversity	Likely	Moderate	Medium	There is evidence of ingestion and digestion of micro-plastics by marine invertebrates. Accumulation of microplastic particles in marine invertebrates could potentially cause blockages throughout the digestive system, suppressing feeding due to satiation (Wright et al. 2013)
Catchment inflows (including stormwater)	Litter (including microplastics)	Affects waterbird diversity and abundance	Almost certain	Moderate	High	There are regular reported entanglements of seabirds in marine debris. Seabirds and shorebirds are also susceptible to ingestion of micro-plastics with effects on nutrition and toxicity reported (Sutherland et al. 2012).
Catchment inflows (including stormwater)	Litter (including microplastics)	Affects waterbird breeding	Possible	Moderate	Medium	Impacts to birds breeding in the site is considered low except for minor impacts for species that feed on shorelines or in the open sea.
Catchment inflows (including stormwater)	Litter (including microplastics)	Impacts threatened species	Possible	Moderate	Medium	May impact threatened shorebird species in this sector.
Urban development	Habitat removal					Increasing populations lead to an expansion of residential and commercial areas in the catchment and adjacent to the Ramsar site. Although an assessment of specific projects is outside the scope of this risk assessment, the general nature of development and direct habitat removal is considered. Of particular concern is that residential and commercial development in many areas is close to the site reducing buffers.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Urban development and recreation	Habitat removal	Adversely affects saltmarsh	Possible	Moderate	Medium	Historical large scale clearing of saltmarsh due to land clearing and reclamation resulted in large losses of extent of saltmarsh (Boon et al. 2011). However, the recent EPBC listing of coastal saltmarsh as a vulnerable community affords the vegetation class more protection from future developments.
Urban development and recreation	Habitat removal	Adversely affects Mangroves	Possible	Moderate	Medium	Mangrove habitat can be lost directly from land claiming, clearance for industrial or marina developments, and other effects of urbanisation
Urban development and recreation	Habitat removal	Indirect effects to sea and shorebirds (loss of food and habitat)	Possible	Minor	Low	Based on assessment of saltmarsh, noting that birds are mobile and can move to other intertidal areas.
Shipping and navigation (oil spills)	Hydrocarbons					The Ports of Geelong and Melbourne in Port Phillip Bay receive the highest number of shipping visits of all the Victorian ports. The possibility of a major oil spill in the bay is slight, however, small spills are a common occurrence. Estimations of the frequency of oil spills indicate that a spill of 5 L or less occurs almost daily, while spills of more than 100 L occur less than once a month. The only major spill in Port Phillip Bay was in 1903 (1100 tonnes) and there have only been 20 spills of > 100 tonnes in Australia in the last 100 years (AMSA https://www.amsa.gov.au/environment/major-historical-incidents/). Risk management measures are in place to minimise the risk of a major spill and respond in the event to minimise impacts (Melbourne Water 2009). The risk assessment below is based on a spill of over 100 tonnes, with the likelihood assessed as "Rare" based on historic records of oil spills in Australia.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects seagrass (direct and shading)	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects saltmarsh	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects mangroves	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects intertidal flats	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Direct oiling of wildlife: waterbird diversity and abundance	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Indirect effects to waterbirds (food webs, breeding)	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Affects threatened species	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity					Areas of CASS have been mapped around Port Phillip Bay. If disturbed due to prolonged drying of wetland areas or physical disturbance of the soil surface, then sulphuric acid is formed and can liberate metals from the sediments. The risk from altered pH was considered in by workshop participants to be too small and localised to be considered given the buffering potential of seawater. However, the release of heavy metals was considered

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						to be a risk, albeit localised and of low likelihood due to current strategies and policies in place to minimise disturbance of CASS (Department of Sustainability and Environment 2009). Risks are from disturbance of soils in adjacent areas (e.g. Avalon Saltworks).
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects saltmarsh	Possible	Minor	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects mangroves	Unlikely	Minor	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects invertebrates reducing condition, abundance and diversity	Possible	Moderate	Medium	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Affects waterbird diversity and abundance	Unlikely	Minor	Low	Through food chain impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Affects waterbird breeding	Unlikely	Minor	Low	Through food chain impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Impacts threatened species	Unlikely	Minor	Low	Through food chain impacts only.
Invasive species	Introduced marine pests (current species)					Over 100 non-native marine species exist in Port Phillip Bay, many with a long history. There is an argument that the biota of the Bay has not been "natural" for more than 100 years (Hewitt et al. 1999). Current introduced marine species cover all taxonomic groups from algae to invertebrates and fish. Parks Victoria indicated that marine pests were a significant risk to Marine National Parks based on stakeholder perceptions (Carey et al. 2007). Impacts to biota have been assessed based on trajectories

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						of change over the past decade. Finer details on individual species and impacts will be addressed in the science review.
Invasive species	Introduced marine pests (current species)	Adversely affects intertidal and sub-tidal flats	Unlikely	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests (current species)	Adversely affects seagrass	Possible	Minor	Low	Baywide monitoring of seagrass health in Port Phillip Bay (2008 to 2011) indicated little change in health over this time (Hirst et al. 2012); indicating a degree of stability under current conditions While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests (current species)	Adversely affects diversity, abundance or condition of fish	Possible	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests (current species)	Affects waterbird diversity and abundance	Possible	Minor	Low	Through food chain impacts only.
Invasive species	Introduced marine pests (current species)	Affects waterbird breeding	Possible	Minor	Low	Through food chain impacts only.
Invasive species	Introduced marine pests (current species)	Impacts threatened species	Possible	Minor	Low	Through food chain impacts only.
Invasive species	Salt tolerant agricultural weeds					There are a number of salt tolerant weed species that have been recorded in Port Phillip Bay or have the potential to invade. Of most concern are tall wheat grass (*Thinopyrum ponticum*), cord-grass (*Spartina* spp.) and sea lavender *(Limonium hyblaeum*). There are examples from Western Port where tall wheat grass has severely impact saltmarsh and bird habitat, with control proving very difficult (Hirst and Boon 2016) similar impacts could be realised in Port Phillip Bay.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Salt tolerant agricultural weeds	Adversely affects saltmarsh	Almost certain	Moderate	High	Paul Boon (pers. comm.)
Invasive species	Salt tolerant agricultural weeds	Adversely affects mangroves	Possible	Moderate	Medium	Paul Boon (pers. comm.)
Invasive species	Salt tolerant agricultural weeds	Affects waterbird diversity and abundance	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for waterbirds in intertidal areas.
Invasive species	Salt tolerant agricultural weeds	Affects waterbird breeding	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits breeding habitat for beach nesting birds.
Invasive species	Salt tolerant agricultural weeds	Impacts threatened species	Likely	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for threatened shorebirds in intertidal areas and impacts to saltmarsh could affect the threatened orange-bellied parrot.
Invasive species	Predators (foxes and cats)					Foxes and cats are present in the Ramsar site and currently controlled by Parks Victoria programs.
Invasive species	Predators (foxes and cats)	Adversely affects waterbird diversity and abundance	Almost certain	Moderate	High	Based on advice from Parks Victoria and BirdLife Australia
Invasive species	Predators (foxes and cats)	Affects waterbird breeding	Almost certain	Minor	Medium	Based on advice from Parks Victoria and BirdLife Australia
Invasive species	Predators (foxes and cats)	Adversely affects threatened species	Likely	Minor	Medium	Based on advice from Parks Victoria and BirdLife Australia
Invasive species	Grazing animals (rabbits)					Rabbits are present in the site, but damage under current management arrangements is minor (Bernie McCarrick, pers. comm.).
Invasive species	Grazing animals (rabbits)	Adversely affects saltmarsh	Almost certain	Minor	Medium	Based on advice from Parks Victoria and BirdLife Australia
Invasive species	Grazing animals (rabbits)	Adversely affects waterbird diversity and abundance	Possible	Minor	Low	Based on advice from Parks Victoria and BirdLife Australia
Invasive species	Grazing animals (rabbits)	Adversely affects threatened species	Possible	Minor	Low	Based on advice from Parks Victoria and BirdLife Australia

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Recreational activities						Increased populations in and around Melbourne will add pressure to recreational areas of the Ramsar Site, particularly of beaches and on water activities (Deloitte 2016).
Recreational activities	Vehicles in intertidal areas	Adversely affects saltmarsh	Possible	Moderate	Medium	Coastal saltmarsh is an EPBC listed species and is vulnerable to impacts and slow to recover from damage. Damage arising from vehicular access is widespread around Port Phillip Bay, but not common in this section of the Ramsar site
Recreational activities	Vehicles in intertidal areas	Adversely affects intertidal flats	Possible	Moderate	Medium	Intertidal areas are vulnerable to damage from vehicles, but access is difficult and not common in this section of the Ramsar site.
Recreational activities	Vessels	Affects waterbird diversity and abundance	Almost certain	Moderate	High	There is growing evidence that disturbance of waterbirds by human activities (walking, boating, vehicles) can have significant negative impacts on both feeding behaviour and habitat use. A database collated from a large number of scientific studies of flight initiation distances (FID, the distance between the activity and the bird talking flight) indicates that nesting birds can be disturbed by human activities at very short distances (e.g. mean FID for nesting pelicans was only 21 m and for ducks 32 m from pedestrians) (Livezey et al. 2016). FIDs for non-nesting species were typically greater (e.g. 60 metres for ducks from pedestrians). Birds are disturbed at closer distances by dogs and watercraft as opposed to pedestrians, but interestingly, non-motorised watercraft such as canoes and paddleboards had equal or smaller FIDs compared to motorised vessels (Glover et al. 2015, Livezey et al. 2016). The consequences for individuals and populations can be significant, with decreased time spent feeding, increased energy spent in flying away from disturbances, nest abandonment and ultimately population declines all cited as potential effects (Glover et al. 2011, Martín et al. 2015). An increasing population is highly likely to result in an increase in recreational users of Port Phillip Bay, which has the potential to impact on waterbird abundance and diversity. Access to this area of the Ramsar site is not common.
Recreational activities	Vessels	Affects waterbird breeding	Almost certain	Minor	Medium	See above
Recreational activities	Vessels	Impacts threatened species	Almost certain	Minor	Medium	See above

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Recreational activities	Passive recreation (dogs, walkers, horses)	Adversely affects saltmarsh	Almost certain	Moderate	High	Already evidence of horse riding in the foreshore causing damage to saltmarsh. Coastal saltmarsh is an EPBC listed species and is vulnerable to impacts and slow to recover from damage.
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird diversity and abundance	Almost certain	Minor	Medium	Shorebirds and nesting seabirds are vulnerable to disturbance from walkers and dogs. As the population increases, it is expected that this pressure will also increase, with some significant shorebird sites located near to Melbourne and Geelong. Advice from BirdLife Australia indicates that this stretch of shoreline is not a popular spot for recreational use.
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird breeding	Almost certain	Minor	Medium	See above
Recreational activities	Passive recreation (dogs, walkers, horses)	Impacts threatened species	Almost certain	Minor	Medium	See above
Biological resource use	Recreational fishing					A survey of recreational fishers in Victoria indicates that for some species, the recreational catch is many times higher than the commercial catch (Ford and Gilmour 2013). There are policies and rules in place (size and bag limits) to limit the impact of recreational fishing on fish stocks. Risk assessment is on the basis of an increasing population resulting in an increase in recreational fishing. Although rules such as bag limits may change to ensure sustainable stocks.
Biological resource use	Recreational fishing	Adversely affects invertebrates (pipis from intertidal)	Almost certain	Minor	Medium	It is prohibited for the public to take any invertebrates (except squid, octopus and worms) from the intertidal areas in Port Phillip Bay. This would limit this activity to illegal take only. However, poaching is considered a significant risk (informed by Parks Victoria).
Biological resource use	Recreational fishing	Adversely affects fish abundance and diversity	Almost certain	Minor	Medium	Assessments of the stocks of target species have indicated a sustained population for King George Whiting and snapper; but a continuing decline in sand flathead populations (Bruce et al. 2012). Population projections over the next 40 years, would suggest that increasing recreational fishing effort in the Bay is likely.
Biological resource use	Hunting					Although not a designated Game Reserve, hunting is permitted on Crown Land along beaches and foreshores providing that the

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						shots are fired out to sea. BirdLife advice that this is relatively common in this part of the Ramsar site during duck season.
Biological resource use	Hunting	Affects waterbird diversity and abundance	Almost certain	Moderate	High	It is certain that shooting birds results in a decrease in bird abundance. Impacts to target species are controlled by bag limits. This risk is based on effects to non-target species through mis-identification and disturbance of shorebirds, with an overlap between the start of duck hunting season and presence of shorebirds in the site.
Biological resource use	Hunting	Affects waterbird breeding	Possible	Moderate	Medium	Effect on breeding birds is not known.
Biological resource use	Hunting	Impacts threatened species	Almost certain	Moderate	High	As per effects on abundance, with threatened species in this segment being shorebirds and orange-bellied parrot.
Climate change						Regional climate projections have recently been released by CSIRO for sub-cluster regions in Australia. The relevant region for Port Phillip Bay is "Southern Slopes Victoria West" http://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=SSVWC&tooltip=true&popup=true. These are provided for each relevant stressor below. The risks are based on the recently completed marine vulnerability under climate change (Klemke and Arundel 2013). An expert panel reviewed the potential effects of climate change on Port Phillip Bay values in 2015 (Hale and Brooks 2015) these have been used here to assess the likely risks in the next 30 - 35 years.
Climate change	Increased carbon dioxide					Atmospheric carbon dioxide is increasing and has increased in recent decades and recently exceeded 400 ppm (http://www.esrl.noaa.gov/gmd/ccgg/trends/).
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects seagrass	Unlikely	Negligible	Negligible	Predicted that increased CO_2 may benefit seagrass (Morris 2013).
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects saltmarsh	Possible	Minor	Low	Score of 'minor' impact based on belief that selection amongst C3/C4 plants will exert little overall adverse effect on saltmarshes. Might result in shifts across plant groups (e.g. grasses neutral effect; C3 taxa, such as shrubs, herbs and mangroves, advantaged)

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased carbon dioxide	Adversely affects mangroves			#N/A	Mangroves likely to be advantaged - not a plausible pathway.
Climate change	Increased temperature					Surface water temperatures are predicted to increase by 0.5 degrees Celsius by 2030 with a very high degree of confidence. There will also be an increase in the frequency of extreme temperature days (Grose et al. 2015).
Climate change	Increased temperature	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	An assessment of climate change related increased temperature impacts to intertidal and subtidal flats indicated moderate vulnerability and adaptive capacity (Morris 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects seagrass	Unlikely	Minor	Low	Assessment of impacts of climate change related temperature increases on seagrass and soft sediment habitats in Victoria indicated low vulnerability, but high uncertainty in embayments. (Morris 2013).
Climate change	Increased temperature	Adversely affects saltmarsh	Unlikely	Moderate	Low	Saintilan and Rogers (2013) hypothesised that temperature has an influence in the diversity of saltmarsh communities, with increased diversity at mean minimum daily temperatures of < 8 ^{o}C, and increased germination success of southern Australian saltmarsh species at lower temperatures. The increase in mean temperature coupled with an increased frequency in extreme temperature days could be expected to decrease the diversity of saltmarsh communities. The effects, however, may be expected in the longer term rather in the next 30 - 35 years.
Climate change	Increased temperature	Adversely affects mangroves			#N/A	Mangroves likely to be advantaged - not a plausible pathway.
Climate change	Increased temperature	Adversely affects fish abundance and diversity	Possible	Minor	Low	An assessment of climate change related increased temperature impacts to marine fish indicated high vulnerability and low adaptive capacity of larval stages (Hirst and Hamer 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects waterbird diversity and abundance	Unlikely	Minor	Low	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						predicted for south eastern Australia under climate change scenarios.
Climate change	Increased temperature	Adversely affects waterbird breeding	Unlikely	Minor	Low	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios.
Climate change	Increased temperature	Adversely affects threatened species	Unlikely	Minor	Low	Temperature effects the timing of migration in many shorebirds, which may influence recruitment and survival (Robinson et al. 2009). Impacts to orange-bellied parrots through saltmarsh impacts.
Climate change	Sea level rise					Sea levels are predicted to increase by 0.08 to 0.18 m by 2030 with a very high degree of confidence (Grose et al. 2015). Recent studies indicate a potential loss of bird habitat in this sector of 34% by 2040 (Roy 2015).
Climate change	Sea level rise	Adversely affects seagrass	Likely	Major	High	Intertidal seagrass is highly vulnerable to sea level rise and has a low adaptive capacity (Morris 2013).
Climate change	Sea level rise	Adversely affects intertidal and subtidal flats	Likely	Major	High	Intertidal mudflats are highly vulnerable to sea level rise and have a low adaptive capacity (Morris 2013).
Climate change	Sea level rise	Adversely affects saltmarsh	Likely	Major	High	Saltmarsh and mangrove community composition and extent is largely determined by tidal depth (Boon et al. 2011). There is already evidence of mangroves expanding at the expense of saltmarsh communities in southern Australia (Boon in prep).
Climate change	Sea level rise	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Low vulnerabilities of fish to sea level rise (adults and larvae) (Hirst and Hamer 2013).
Climate change	Sea level rise	Adversely affects waterbird diversity and abundance	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Sea level rise	Adversely affects waterbird breeding	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Sea level rise	Adversely affects threatened species	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting. Impacts to orange-bellied parrots through saltmarsh impacts.
Climate change	Ocean acidification					pH is predicted to decrease by 0.07 to 0.08 pH units by 2030 with a medium degree of confidence (Grose et al. 2015).
Climate change	Ocean acidification	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Assessed as being highly vulnerable, particularly for organisms with a calcified outer shell (Morris 2013). However, possibly a longer term risk, rather than in the next two decades.
Climate change	Ocean acidification	Adversely affects fish abundance and diversity	Rare	Negligible	Negligible	Low to moderate vulnerability (Hirst and Hamer 2013).
Climate change	Ocean acidification	Adversely affects waterbird diversity and abundance	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects waterbird breeding	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects threatened species	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)					Time spent in drought is projected, with medium confidence, to increase over the course of the century (Grose et al. 2015). During the millennium drought, the salinity of the Bay increased to greater than that of sea water (Lee et al. 2012). Decreased nutrient inputs to the Bay occurred over this period.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects seagrass	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment and recent investigation of seagrass in the Bay (Jenkins et al. 2015).

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects saltmarsh	Possible	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects mangroves	Possible	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Evidence that the Millennium drought had a positive effect of snapper recruitment, but adverse effect on some deep water species (e.g. spiky globe fish, eagle rays) due to reduced productivity from lower nutrients in the central part of the bay (Hirst in prep.)
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	Extensive work has been conducted linking nitrogen discharge from the Western Treatment Plant to food availability for shorebirds (e.g. Rogers et al. 2007). However, effects more likely to be felt in the longer term.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects waterbird breeding	Possible	Minor	Low	Extensive work has been conducted linking nitrogen discharge from the Western Treatment Plant to food availability for shorebirds (e.g. Rogers et al. 2007). However, effects more likely to be felt in the longer term.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects threatened species	Possible	Moderate	Medium	Extensive work has been conducted linking nitrogen discharge from the Western Treatment Plant to food availability for shorebirds (e.g. Rogers et al. 2007). However, effects more likely to be felt in the longer term.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines					Extreme events (storms and high rainfall events) are predicted to occur with high confidence (Grose et al. 2015). Erosion of shorelines in Port Phillip Bay is currently occurring due to both natural processes and in some instances exacerbated by artificial structures such as groynes and beach armouring (Bird 2011).
Climate change	Increased frequency and intensity of storms	Adversely affects intertidal and subtidal flats	Possible	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects saltmarsh	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	Based on Port Phillip Bay B EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects waterbird breeding	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects threatened species	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.

Risk assessment for the **Swan Bay** sector of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Cells highlighted in blue provide a description of the threat / stressor that is applicable to the relevant impact pathways that follow. A full explanation of the risk assessment process, including descriptors for likelihood and consequence, is provided in section 3.1. It should be noted that this risk assessment represents risk under current management arrangements. Were management of the site to change (e.g. through a reduction in funding for existing activities) some risks would be increased.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Western Treatment Plant	All stressors					Studies from the south of the Bay (including sampling sites at Swan Bay and Mud Islands) indicate that the nutrients from the Western Treatment Plant do not enter the food chain at this location. It is equally likely that chemicals of emerging concern from the Western Treatment Plant do not spread to south in concentrations above detectable limits. Not considered a plausible impact pathway for Swan Bay.
Catchment inflows (including stormwater)	Increased nutrients					There are several major rivers and over 300 stormwater drains that flow directly into Port Phillip Bay (City of Port Phillip 2010). Better Bays and Waterways (Melbourne Water 2009) contains some modelled predictions of approximately 20% increase in total nitrogen loads from the catchment by 2030. These figures are largely about discharges from major rivers in the north and east of the Bay. Discharges to Swan Bay are from local urban and rural sources. They have been identified by the City of Greater Geelong as a high risk (City of Greater Geelong 2015).
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects seagrass	Likely	Moderate	Medium	Recent studies have indicated that the dominant sources of nutrients to seagrass in Swan Bay is from internal cycling. Seagrass in Swan Bay has remained stable in terms of extent and condition, with small areas of increased cover in the decade 2000 to 2011 (Jenkins et al. 2016).
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect subtidal and intertidal flats	Likely	Moderate	Medium	No evidence of impacts from increased nutrients despite increases in urban areas surrounding Swan Bay in the last decade
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect saltmarsh	Possible	Moderate	Medium	Surface runoff from nearby residential areas. There is considerable information to show the adverse effect of catchment-derived nutrients on coastal saltmarshes (see Boon et al. 2011).
Catchment inflows (including stormwater)	Increased nutrients	Result in a decline in seagrass and adversely affects fish abundance and diversity	Possible	Moderate	Medium	As for seagrass - localised impacts.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Increased nutrients	Affects waterbird diversity and abundance			#N/A	Extensive work has been conducted on the linkages between nutrients, productivity and shorebirds at important shorebird areas in Port Phillip Bay (Rogers et al. 2007, Loyn et al. 2014). The issue is not one of increased nutrients, but decreased nutrients having a negative impact. *Not a plausible impact pathway*
Catchment inflows (including stormwater)	Increased nutrients	Affects waterbird breeding			#N/A	High productivity favours waterbird breeding. *Not a plausible impact pathway*
Catchment inflows (including stormwater)	Increased nutrients	Impacts threatened species	Rare	Minor	Negligible	Threatened species at this location comprise shorebirds such as curlew sandpiper. Increased productivity is likely to favour these species.
Catchment inflows (including stormwater)	Increased sediments					There are several major rivers and over 300 stormwater drains that flow directly into Port Phillip Bay (City of Port Phillip 2010). Better Bays and Waterways (Melbourne Water 2009) contains some modelled predictions of approximately 30% increase in total sediment loads from the catchment by 2030, although these are largely a result of discharges from rivers in the north and east of the Bay. Discharges to Swan Bay are from local urban and rural sources. They have been identified by the City of Greater Geelong as a high risk (City of Greater Geelong 2015).
Catchment inflows (including stormwater)	Increased sediments	Reduced light (TSS and deposition) adversely affects seagrass	Likely	Moderate	Medium	Seagrass in the south east of the Bay is known to be light limited and may be further impacted by increased suspended sediments (Bulthuis 1983). Particularly from large flood events.
Catchment inflows (including stormwater)	Increased sediments	Reduced light (TSS and deposition) adversely affects subtidal and intertidal flats	Possible	Moderate	Medium	Greatest impact to areas adjacent to major inflows.
Catchment inflows (including stormwater)	Increased sediments	Reduced light and increased TSS adversely affects fish	Rare	Minor	Negligible	Direct impacts to fish gills are observed at high TSS loads, with larval fish considered the most vulnerable (Jenkins and McKinnon 2006). Sediments from catchment inflows are not expected to reach these levels.
Catchment inflows (including stormwater)	Increased sediments	Affects waterbird diversity and abundance	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Increased sediments	Affects waterbird breeding	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Catchment inflows (including stormwater)	Increased sediments	Impacts threatened species	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Residential and commercial development (dredging)	Increased sediments					Potentially two sets of impact pathway associated: Maintenance dredging and a new capital dredging program. Maintenance dredging shown to have very localised (in space and time) impacts on suspended sediments (Hale 2006) and was considered not significant enough to consider. Risks associated with a capital dredging program are highly dependent on the characteristics of the sediments to be dredged and the values in proximity to dredging. Therefore, it's not possible to assess anything other than increased TSS (which is applicable to all dredging programs). Risks have been derived from the Channel Deepening Project (CDP). Any proposed capital dredging would have a specific assessment as part of an impact assessment.
Residential and commercial development (dredging)	Increased sediments	Reduced light (TSS and deposition) adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	Microphytobenthos (MPB) are found on most of the soft seabed throughout the Bay, with the areas of highest productivity offshore from the Western Treatment Plant and in shallow water depths. MPB are naturally highly variable in time and extent and have an estimated turnover rate of approximately 50 times per year (Harris et al. 1996). CDP risk assessment concluded that effects to MPB would be negligible and to benthic invertebrates would be localised with recovery on 12 to 24 months (CEE 2007a).
Residential and commercial development (dredging)	Increased sediments	Reduced light (TSS and deposition) adversely affects seagrass	Possible	Moderate	Medium	Although this is a generic dredging project, information from the Channel Deepening Project (CDP) can inform the assessment. Monitoring before, during and after dredging indicated no detectable impacts to seagrass health or extent (Hirst et al. 2012). Seagrass in Port Phillip Bay started to decline in 1998 at some sites in 1998, and effects of prolonged drought coupled with exposure the longshore drift has been hypothesised as a potential cause (Ball et al. 2014). Any effects of CDP were possibly masked by the impacts of the Millennium drought.
Residential and commercial development (dredging)	Increased sediments	Reduced light and increased TSS adversely affects fish	Unlikely	Minor	Low	Internal variation for all fish species, except eastern shovelnose stingray in the west region and sand flathead in the shallow, intermediate and deep regions, were within expected variability for Port Phillip Bay during the reporting period 2008-2011 (Hirst et al. 2012). No impact to fish or fisheries was detected during CDP.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Residential and commercial development (dredging)	Increased sediments	Impacts to fish and reduced visibility adversely affects feeding waterbirds	Unlikely	Minor	Low	CDP risk assessment for seabirds was very low for most species and medium for gannets and terns (Brett Lane and Associates 2004).
Residential and commercial development (dredging)	Increased sediments	Impacts to fish and reduced visibility adversely affects breeding waterbirds	Unlikely	Minor	Low	CDP risk assessment for seabirds was very low for most species and medium for gannets and terns (Brett Lane and Associates 2004).
Residential and commercial development (dredging)	Increased sediments	Adversely affects threatened species	Rare	Negligible	Negligible	The threatened species that use the Swan Bay shorelines are shorebird species that are not likely to be negatively impacted by sediments.
Catchment inflows (including stormwater)	Toxicants (includes metals as well as chemicals of emerging concern such as pharmaceuticals and personal care products)					There are over 300 stormwater drains that discharge directly to the Bay that carry road run-off and urban (and peri-urban) pollutants. Chemicals of emerging concern remain a significant knowledge gap. There are discharges from nearby urban areas into Swan Bay, and preliminary investigations from Fredrick Mason Creek indicate that there may be transport of toxicants into the system from adjacent land uses (Coutin 2018). The overall effect of toxicants and whether they are discharged into Swan Bay at levels sufficient to result in impacts to ecological character has been identified as a knowledge gap.
Catchment inflows (including stormwater)	Toxicants	Toxicants adversely affects fish reducing condition, abundance and diversity	Possible	Moderate	Medium	Results from elsewhere in Port Phillip Bay indicate that toxicants are mostly sediment bound and impact is restricted to the inshore areas.
Catchment inflows (including stormwater)	Toxicants	Toxicants adversely affects invertebrates reducing condition, abundance and diversity	Possible	Moderate	Medium	Results from elsewhere in Port Phillip Bay indicate that toxicants are mostly sediment bound and impact is restricted to the inshore areas.
Catchment inflows (including stormwater)	Toxicants	Impacts to fish and invertebrates adversely affects	Possible	Moderate	Medium	Results from elsewhere in Port Phillip Bay indicate that toxicants are mostly sediment bound and impact is restricted to the inshore areas.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
		waterbirds through the food chain				
Catchment inflows (including stormwater)	Toxicants	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Possible	Moderate	Medium	Results from elsewhere in Port Phillip Bay indicate that toxicants are mostly sediment bound and impact is restricted to the inshore areas.
Catchment inflows (including stormwater)	Toxicants	Impacts threatened species	Possible	Moderate	Medium	Impacts to birds as above. Remains a knowledge gap.
Mosquito control	Toxicants (s-methoprene and *Bacillus thuringiensis israelensis*)					The City of Greater Geelong undertakes aerial mosquito control in known mosquito breeding locations, which includes Limeburners Bay, Swan Bay and the Lake Connewarre complex. The two agents used are natural products that are targeting specific insect groups. This includes both mosquito and midge larvae (chironomids) the latter of which are significant prey items for many waterbirds in general and migratory shorebirds specifically. An EPBC referral was assessed in 2005 and the practice permitted, with some restrictions. Since that time, however, research has suggested that the risk to shorebird prey items may be higher than initially thought.
Mosquito control	Toxicants (s-methoprene and *Bti*)	Toxicants adversely affects invertebrates reducing condition, abundance and diversity	Almost certain	Minor	Medium	These insecticides are designed to impact on invertebrate populations and affect a wider number of species than the two target species (Antunes-Kenyon et al. 2001). The effects, however, for most taxonomic groups are short lived (Lagadic et al. 2014).
Mosquito control	Toxicants (s-methoprene and *Bti*)	Toxicants adversely affects fish reducing condition, abundance and diversity	Unlikely	Minor	Low	Studies in Australia and overseas have indicated that the two substances at the concentrations recommended for field applications are not toxic to fish (Hurst et al. 2007).
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts to fish and invertebrates adversely affects waterbirds through the food chain	Possible	Minor	Low	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). This remains a knowledge gap.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Possible	Minor	Low	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). This remains a knowledge gap.
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts threatened species	Possible	Minor	Low	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). This remains a knowledge gap.
Urban development and recreation	Litter (including microplastics)					Recent surveys of the Lower Yarra and Maribyrnong rivers indicated a large amount of litter and micro plastics and micro-plastics on beaches of Port Phillip Bay (Blake and Charko 2014). This is consistent with an Australia wide study of micro-plastics in oceanic waters, which found levels in Australia similar to those in the Caribbean, but lower than in the Mediterranean (Reisser et al. 2013). EPA Victoria has a citizen science program aimed at assessing the magnitude of the problem in Port Phillip Bay. Advice from Parks Victoria is that litter is not a problem in Swan Bay compared to other areas.
Urban development and recreation	Litter (including microplastics)	Adversely affects fish reducing condition, abundance and diversity	Possible	Moderate	Medium	Impact pathways for fish include entanglement and ingestion of plastics (Hammer et al. 2012). Studies from the northern hemisphere indicate that fish species, regardless of feeding habit, ingest micro-plastics (Lusher et al. 2013). Although the long-term effects are not fully understood, there is evidence of transfers of toxic chemicals, liver disease (Rochman et al. 2013) and blocking of the digestive tract leading to starvation (Gregory 2009).
Urban development and recreation	Litter (including microplastics)	Adversely affects invertebrates reducing condition, abundance and diversity	Possible	Moderate	Medium	There is evidence of ingestion and digestion of micro-plastics by marine invertebrates. Accumulation of microplastic particles in marine invertebrates could potentially cause blockages throughout the digestive system, suppressing feeding due to satiation (Wright et al. 2013)
Urban development and recreation	Litter (including microplastics)	Affects waterbird diversity and abundance	Possible	Moderate	Medium	There are regular reported entanglements of seabirds in marine debris. Seabirds and shorebirds are also susceptible to ingestion of micro-plastics with effects on nutrition and toxicity reported (Sutherland et al. 2012). This is more common in the wider Bay than in Swan Bay.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Urban development and recreation	Litter (including microplastics)	Affects waterbird breeding	Possible	Moderate	Medium	Impacts to birds breeding in the site is considered low except for minor impacts for species that feed on shorelines or in the open sea.
Urban development and recreation	Litter (including microplastics)	Impacts threatened species	Possible	Moderate	Medium	May impact threatened shorebird species in this sector.
Urban development	Habitat removal					Increasing populations lead to an expansion of residential and commercial areas in the catchment and adjacent to the Ramsar site. Although an assessment of specific projects is outside the scope of this risk assessment, the general nature of development and direct habitat removal is considered. Of particular concern is that residential and commercial development in many areas is close to the site reducing buffers.
Urban development and recreation	Habitat removal	Adversely affects saltmarsh	Possible	Moderate	Medium	Historical large scale clearing of saltmarsh due to land clearing and reclamation resulted in large losses of extent of saltmarsh (Boon et al. 2011). However, the recent EPBC listing of coastal saltmarsh as a vulnerable community affords the vegetation class more protection from future developments.
Urban development and recreation	Habitat removal	Indirect effects to sea and shorebirds (loss of food and habitat)	Possible	Minor	Low	Based on assessment of saltmarsh, noting that birds are mobile and can move to other intertidal areas.
Shipping and navigation (oil spills)	Hydrocarbons					The Ports of Geelong and Melbourne in Port Phillip Bay receive the highest number of shipping visits of all the Victorian ports. The possibility of a major oil spill in the bay is slight, however, small spills are a common occurrence. Estimations of the frequency of oil spills indicate that a spill of 5 L or less occurs almost daily, while spills of more than 100 L occur less than once a month. The only major spill in Port Phillip Bay was in 1903 (1100 tonnes) and there have only been 20 spills of > 100 tonnes in Australia in the last 100 years (AMSA https://www.amsa.gov.au/environment/major-historical-incidents/). Risk management measures are in place to minimise the risk of a major spill and respond in the event to minimise impacts (Melbourne Water 2009). The risk assessment below is based on a spill of over 100 tonnes, with the likelihood assessed as "Rare" based on historic records of oil spills in Australia.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects seagrass (direct and shading)	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects saltmarsh	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects intertidal flats	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Direct oiling of wildlife: waterbird diversity and abundance	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Indirect effects to waterbirds (food webs, breeding)	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Affects threatened species	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Disturbance of Coastal Acid Sulphate Soils (CASS)	Metals liberated as a result of oxidation of CASS and acidity					Areas of CASS have been mapped around Port Phillip Bay. If disturbed due to prolonged drying of wetland areas or physical disturbance of the soil surface, then sulphuric acid is formed and can liberate metals from the sediments. The risk from altered pH was considered in by workshop participants to be too small and localised to be considered given the buffering potential of seawater. However, the release of heavy metals was considered to be a risk, albeit localised and of low likelihood due to current strategies and policies in place to minimise disturbance of CASS (Department of Sustainability and Environment 2009). Risks are from disturbance of CASS in adjacent areas.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects saltmarsh	Unlikely	Minor	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects mangroves	Unlikely	Minor	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Adversely affects invertebrates reducing condition, abundance and diversity	Unlikely	Moderate	Low	Expected localised inshore impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Affects waterbird diversity and abundance	Unlikely	Minor	Low	Through food chain impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Affects waterbird breeding	Unlikely	Minor	Low	Through food chain impacts only.
CASS	Metals liberated as a result of oxidation of CASS and acidity	Impacts threatened species	Unlikely	Minor	Low	Through food chain impacts only.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Introduced marine pests					Over 100 non-native marine species exist in Port Phillip Bay, many with a long history. There is an argument that the biota of the Bay has not been "natural" for more than 100 years (Hewitt et al. 1999). Current introduced marine species cover all taxonomic groups from algae to invertebrates and fish. Parks Victoria indicated that marine pests were a significant risk to Marine National Parks based on stakeholder perceptions (Carey et al. 2007). Impacts to biota have been assessed based on trajectories of change over the past decade.
Invasive species	Introduced marine pests	Adversely affects intertidal and sub-tidal flats	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Adversely affects seagrass	Possible	Moderate	Medium	Baywide monitoring of seagrass health in Port Phillip Bay (2008 to 2011) indicated little change in health over this time (Hirst et al. 2012); indicating a degree of stability under current conditions While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Adversely affects diversity, abundance or condition of fish	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Affects waterbird diversity and abundance	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Affects waterbird breeding	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Impacts threatened species	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Salt tolerant agricultural weeds					There are a number of salt tolerant weed species that have been recorded in Port Phillip Bay or have the potential to invade. Of most concern are tall wheat grass (*Thinopyrum ponticum*), cord-grass (*Spartina* spp.) and sea lavender *(Limonium hyblaeum*). There are examples from Western Port where tall wheat grass has severely impact saltmarsh and bird habitat, with control proving very difficult (Hirst and Boon 2016) similar impacts could be realised in Port Phillip Bay.
Invasive species	Salt tolerant agricultural weeds	Adversely affects saltmarsh	Almost certain	Moderate	High	Paul Boon (pers. comm.)
Invasive species	Salt tolerant agricultural weeds	Affects waterbird diversity and abundance	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for waterbirds in intertidal areas.
Invasive species	Salt tolerant agricultural weeds	Affects waterbird breeding	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits breeding habitat for beach nesting birds.
Invasive species	Salt tolerant agricultural weeds	Impacts threatened species	Likely	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for threatened shorebirds in intertidal areas.
Invasive species	Predators (foxes and cats)					Foxes and cats are present in the Ramsar site and currently controlled by Parks Victoria programs.
Invasive species	Predators (foxes and cats)	Adversely affects waterbird diversity and abundance	Almost certain	Minor	Medium	Based on advice from Parks Victoria
Invasive species	Predators (foxes and cats)	Affects waterbird breeding	Almost certain	Minor	Medium	Based on advice from Parks Victoria
Invasive species	Predators (foxes and cats)	Adversely affects threatened species	Likely	Minor	Medium	Based on advice from Parks Victoria
Invasive species	Grazing animals (rabbits)					Rabbits are present in the site, but damage under current management arrangements is minor.
Invasive species	Grazing animals (rabbits)	Adversely affects saltmarsh	Almost certain	Minor	Medium	Based on advice from Parks Victoria
Invasive species	Grazing animals (rabbits)	Adversely affects waterbird diversity and abundance	Possible	Minor	Low	Based on advice from Parks Victoria

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Grazing animals (rabbits)	Adversely affects threatened species	Rare	Minor	Negligible	Based on advice from Parks Victoria
Recreational activities						Increased populations in and around Melbourne will add pressure to recreational areas of the Ramsar Site, particularly of beaches and on water activities (Deloitte 2016).
Recreational activities	Vehicles in intertidal areas	Adversely affects saltmarsh	Possible	Minor	Low	Coastal saltmarsh is an EPBC listed species and is vulnerable to impacts and slow to recover from damage. Damage arising from vehicular access is widespread around Port Phillip Bay, but not common in this section of the Ramsar site
Recreational activities	Vehicles in intertidal areas	Adversely affects intertidal flats	Possible	Minor	Low	Intertidal areas are vulnerable to damage from vehicles, but access is difficult and not common in this section of the Ramsar site.
Recreational activities	Vessels	Affects waterbird diversity and abundance	Almost certain	Moderate	High	There is growing evidence that disturbance of waterbirds by human activities (walking, boating, vehicles) can have significant negative impacts on both feeding behaviour and habitat use. A database collated from a large number of scientific studies of flight initiation distances (FID, the distance between the activity and the bird talking flight) indicates that nesting birds can be disturbed by human activities at very short distances (e.g. mean FID for nesting pelicans was only 21 m and for ducks 32 m from pedestrians) (Livezey et al. 2016). FIDs for non-nesting species were typically greater (e.g. 60 metres for ducks from pedestrians). Birds are disturbed at closer distances by dogs and watercraft as opposed to pedestrians, but interestingly, non-motorised watercraft such as canoes and paddleboards had equal or smaller FIDs compared to motorised vessels (Glover et al. 2015, Livezey et al. 2016). The consequences for individuals and populations can be significant, with decreased time spent feeding, increased energy spent in flying away from disturbances, nest abandonment and ultimately population declines all cited as potential effects (Glover et al. 2011, Martín et al. 2015). An increasing population is highly likely to result in an increase in recreational users of Port Phillip Bay, which has the potential to impact on waterbird abundance and diversity. Swan Bay is a sheltered waterbody and popular with non-motorised watercraft.
Recreational activities	Vessels	Affects waterbird breeding	Almost certain	Minor	Medium	See above
Recreational activities	Vessels	Impacts threatened species	Almost certain	Moderate	High	See above

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird diversity and abundance	Almost certain	Minor	Medium	Shorebirds and nesting seabirds are vulnerable to disturbance from walkers and dogs. As the population increases, it is expected that this pressure will also increase, with some significant shorebird sites located near to Melbourne and Geelong. Advice from BirdLife Australia indicates that this stretch of shoreline is moderately popular for recreational use.
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird breeding	Almost certain	Negligible	Negligible	Not a site for waterbird breeding.
Recreational activities	Passive recreation (dogs, walkers, horses)	Impacts threatened species	Almost certain	Minor	Medium	See above
Biological resource use	Recreational fishing					Not allowed in the Marine Park of Swan Bay
Biological resource use	Commercial fishing					Not allowed in the Marine Park of Swan Bay
Biological resource use	Hunting					Not permitted at this location
Climate change						Regional climate projections have recently been released by CSIRO for sub-cluster regions in Australia. The relevant region for Port Phillip Bay is "Southern Slopes Victoria West" http://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=SSVWC&tooltip=true&popup=true. These are provided for each relevant stressor below. The risks are based on the recently completed marine vulnerability under climate change (Klemke and Arundel 2013). An expert panel reviewed the potential effects of climate change on Port Phillip Bay values in 2015 (Hale and Brooks 2015) these have been used here to assess the likely risks in the next 30 - 35 years.
Climate change	Increased carbon dioxide					Atmospheric carbon dioxide is increasing and has increased in recent decades and recently exceeded 400 ppm (http://www.esrl.noaa.gov/gmd/ccgg/trends/).
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects seagrass	Unlikely	Negligible	Negligible	Predicted that increased CO_2 may benefit seagrass (Morris 2013).

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects saltmarsh	Possible	Minor	Low	Score of 'minor' impact based on belief that selection amongst C3/C4 plants will exert little overall adverse effect on saltmarshes. Might result in shifts across plant groups (e.g. grasses neutral effect; C3 taxa, such as shrubs, herbs and mangroves, advantaged)
Climate change	Increased carbon dioxide	Adversely affects mangroves			#N/A	Mangroves likely to be advantaged - not a plausible pathway.
Climate change	Increased temperature					Surface water temperatures are predicted to increase by 0.5 degrees Celsius by 2030 with a very high degree of confidence. There will also be an increase in the frequency of extreme temperature days (Grose et al. 2015).
Climate change	Increased temperature	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	An assessment of climate change related increased temperature impacts to intertidal and subtidal flats indicated moderate vulnerability and adaptive capacity (Morris 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects seagrass	Unlikely	Minor	Low	Assessment of impacts of climate change related temperature increases on seagrass and soft sediment habitats in Victoria indicated low vulnerability, but high uncertainty in embayments. (Morris 2013).
Climate change	Increased temperature	Adversely affects saltmarsh	Unlikely	Moderate	Low	Saintilan and Rogers (2013) hypothesised that temperature has an influence in the diversity of saltmarsh communities, with increased diversity at mean minimum daily temperatures of < 8 ºC, and increased germination success of southern Australian saltmarsh species at lower temperatures. The increase in mean temperature coupled with an increased frequency in extreme temperature days could be expected to decrease the diversity of saltmarsh communities. The effects, however, may be expected in the longer term rather in the next 30 - 35 years.
Climate change	Increased temperature	Adversely affects fish abundance and diversity	Possible	Minor	Low	An assessment of climate change related increased temperature impacts to marine fish indicated high vulnerability and low adaptive capacity of larval stages (Hirst and Hamer 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects waterbirds	Unlikely	Minor	Low	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios.
Climate change	Increased temperature	Adversely affects waterbird breeding	Unlikely	Minor	Low	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios.
Climate change	Increased temperature	Adversely affects threatened species	Unlikely	Minor	Low	Temperature effects the timing of migration in many shorebirds, which may influence recruitment and survival (Robinson et al. 2009). Impacts to orange-bellied parrots through saltmarsh impacts.
Climate change	Sea level rise					Sea levels are predicted to increase by 0.08 to 0.18 m by 2030 with a very high degree of confidence (Grose et al. 2015). Recent studies indicate a potential loss of bird habitat in this sector of 63% by 2040 (Roy 2015).
Climate change	Sea level rise	Adversely affects seagrass	Likely	Major	High	Intertidal seagrass is highly vulnerable to sea level rise and has a low adaptive capacity (Morris 2013).
Climate change	Sea level rise	Adversely affects intertidal and subtidal flats	Likely	Major	High	Intertidal mudflats are highly vulnerable to sea level rise and have a low adaptive capacity (Morris 2013).
Climate change	Sea level rise	Adversely affects saltmarsh	Likely	Major	High	Saltmarsh and mangrove community composition and extent is largely determined by tidal depth (Boon et al. 2011). There is already evidence of mangroves expanding at the expense of saltmarsh communities in southern Australia (Boon in prep).
Climate change	Sea level rise	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Low vulnerabilities of fish to sea level rise (adults and larvae) (Hirst and Hamer 2013).
Climate change	Sea level rise	Adversely affects waterbirds	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Sea level rise	Adversely affects waterbird breeding	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Sea level rise	Adversely affects threatened species	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting. Impacts to orange-bellied parrots through saltmarsh impacts.
Climate change	Ocean acidification					pH is predicted to decrease by 0.07 to 0.08 pH units by 2030 with a medium degree of confidence (Grose et al. 2015).
Climate change	Ocean acidification	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Assessed as being highly vulnerable, particularly for organisms with a calcified outer shell (Morris 2013). However, possibly a longer term risk, rather than in the next two decades.
Climate change	Ocean acidification	Adversely affects fish abundance and diversity	Rare	Negligible	Negligible	Low to moderate vulnerability (Hirst and Hamer 2013).
Climate change	Ocean acidification	Adversely affects waterbirds	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects waterbird breeding	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects threatened species	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)					Time spent in drought is projected, with medium confidence, to increase over the course of the century (Grose et al. 2015). During the millennium drought, the salinity of the Bay increased to greater than that of sea water (Lee et al. 2012). Decreased nutrient inputs to the Bay occurred over this period, but not at Swan Bay.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects seagrass	Unlikely	Moderate	Low	Based on Port Phillip Bay EMP expert panel assessment and recent investigation of seagrass in the Bay (Jenkins et al. 2015). Seagrass in Swan Bay did not significantly decline during the Millennium drought.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects saltmarsh	Possible	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Evidence that the Millennium drought had a positive effect of snapper recruitment, but adverse effect on some deep water species (e.g. spiky globe fish, eagle rays) due to reduced productivity from lower nutrients in the central part of the bay (Hirst in prep.)
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects waterbird diversity and abundance	Possible	Minor	Low	Potential impacts through decreased productivity, noting that the link between productivity and shorebird abundance is more relevant to the north of the Bay.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects waterbird breeding	Possible	Minor	Low	Potential impacts through decreased productivity, noting that the link between productivity and shorebird abundance is more relevant to the north of the Bay.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects threatened species	Possible	Minor	Low	Potential impacts through decreased productivity, noting that the link between productivity and shorebird abundance is more relevant to the north of the Bay.
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines					Extreme events (storms and high rainfall events) are predicted to occur with high confidence (Grose et al. 2015). Erosion of shorelines in Port Phillip Bay is currently occurring due to both natural processes and in some instances exacerbated by artificial structures such as groynes and beach armouring (Bird 2011).

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and intensity of storms	Adversely affects intertidal and subtidal flats	Possible	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects saltmarsh	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects waterbird breeding	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects threatened species	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.

Risk assessment for the **Mud Islands** sector of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Cells highlighted in blue provide a description of the threat / stressor that is applicable to the relevant impact pathways that follow. A full explanation of the risk assessment process, including descriptors for likelihood and consequence, is provided in section 3.1. It should be noted that this risk assessment represents risk under current management arrangements. Were management of the site to change (e.g. through a reduction in funding for existing activities) some risks would be increased.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Western Treatment Plant	All stressors					Studies from the south of the Bay (including sampling sites at Swan Bay and Mud Islands) indicate that the nutrients from the Western Treatment Plant do not enter the food chain at this location. It is equally likely that chemicals of emerging concern from the Western Treatment Plant do not spread to south in concentrations above detectable limits. Not considered a plausible impact pathway for Mud Islands.
Catchment inflows (including stormwater)	Increased nutrients					There are several major rivers and over 300 stormwater drains that flow directly into Port Phillip Bay (City of Port Phillip 2010). Better Bays and Waterways (Melbourne Water 2009) contains some modelled predictions of approximately 20% increase in total nitrogen loads from the catchment by 2030. These figures are currently being reviewed. However, in terms of this risk assessment, an increase in this magnitude was used as the basis for this impact pathway. Noting that Mud Islands are in the south of the Bay away from most point source discharges and are subject to a high exchange of water and flushing with Bass Strait (Jenkins et al. 2016.)
Catchment inflows (including stormwater)	Increased nutrients	Results in increased algal growth and a decline in seagrass extent and condition	Unlikely	Minor	Low	Studies have indicated that the decline in seagrass in Mud Islands from 2000 to 2011 was due to nutrient limitation brought on by the drought. There was a subsequent recovery following higher loads of nutrients entering the system during flood years (Jenkins et al. 2016). It is considered that a 20% increase in nutrients may favour the growth of seagrass in nutrient limited locations.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affect subtidal and intertidal flats	Unlikely	Minor	Low	Greatest impact to northern areas only, not to the south
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects saltmarsh	Unlikely	Minor	Low	Given the well-flushed environment of Mud Islands this is unlikely to be a significant impact
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects mangrove communities			#N/A	There are currently no mangroves at Mud Island

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Increased nutrients	Result in a decline in seagrass and adversely affects fish abundance and diversity	Unlikely	Minor	Low	Based on low risk to seagrass at Mud Islands
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects waterbird diversity and abundance through altered habitat / food	Unlikely	Minor	Low	Some species only - food web via seagrass and fish. Expect change in community structure. Potential positive impacts on anchovy and pilchards flow through to fish eating birds.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects waterbird breeding through altered habitat / food	Unlikely	Minor	Low	Some species only - food web via seagrass and fish. Expect change in community structure. Potential positive impacts on anchovy and pilchards flow through to fish eating birds.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects threatened species	Rare	Negligible	Negligible	The threatened species that use Mud Islands are shorebird species that are not likely to be negatively impacted by nutrients
Catchment inflows (including stormwater)	Increased sediments					There are several major rivers and over 300 stormwater drains that flow directly into Port Phillip Bay (City of Port Phillip 2010). Better Bays and Waterways (Melbourne Water 2009) contains some modelled predictions of approximately 30% increase in total sediment loads from the catchment by 2030. These figures are currently being reviewed. However, in terms of this risk assessment, an increase in this magnitude was used as the basis for this impact pathway.
Catchment inflows (including stormwater)	Increased sediments	Reduced light (TSS and deposition) adversely affects seagrass	Unlikely	Minor	Low	Seagrass in the south east of the Bay is known to be light limited and may be further impacted by increased suspended sediments (Bulthuis 1983). Particularly from large flood events. The effect at Mud Islands, however, will be less than at coastal locations.
Catchment inflows (including stormwater)	Increased sediments	Reduced light (TSS and deposition) adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	Mud Islands is a highly mobile area of intertidal flats that are constantly shifting with deposition and erosion (Bird 1993, Ball 2013)
Catchment inflows (including stormwater)	Increased sediments	Reduced light and increased TSS adversely affects fish	Unlikely	Minor	Low	Direct impacts to fish gills are observed at high TSS loads, with larval fish considered the most vulnerable (Jenkins and McKinnon 2006). It is very unlikely that increased turbidity from catchment

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						inflows could be detected at levels above background at Mud Islands.
Catchment inflows (including stormwater)	Increased sediments	Adversely affects waterbird diversity and abundance	Rare	Negligible	Negligible	Unlikely to be detectable in most feeding areas above background and compared to resuspended shoreline sediments
Catchment inflows (including stormwater)	Increased sediments	Adversely affects waterbird breeding	Rare	Negligible	Negligible	Unlikely to be detectable in most feeding areas above background and compared to resuspended shoreline sediments
Catchment inflows (including stormwater)	Increased sediments	Adversely affects threatened species	Rare	Negligible	Negligible	The threatened species that use Mud Islands are shorebird species that are not likely to be negatively impacted by sediments.
Residential and commercial development (dredging)	Increased sediments					Potentially two sets of impact pathway associated: Maintenance dredging and a new capital dredging program. Maintenance dredging shown to have very localised (in space and time) impacts on suspended sediments (Hale 2006) and was considered not significant enough to consider. Risks associated with a capital dredging program are highly dependent on the characteristics of the sediments to be dredged and the values in proximity to dredging. Therefore, it's not possible to assess anything other than increased TSS (which is applicable to all dredging programs). Risks have been derived from the Channel Deepening Project (CDP). Any proposed capital dredging would have a specific assessment as part of an impact assessment.
Residential and commercial development (dredging)	Increased sediments	Reduced light (TSS and deposition) adversely affects seagrass	Possible	Moderate	Medium	Although this is a generic dredging project, information from the Channel Deepening Project (CDP) can inform the assessment. Monitoring before, during and after dredging indicated no detectable impacts to seagrass health or extent (Hirst et al. 2012). Seagrass in Port Phillip Bay started to decline in 1998 at some sites in 1998, and effects of prolonged drought coupled with exposure the longshore drift has been hypothesised as a potential cause (Ball et al. 2014) and this was confirmed by empirical studies of seagrass biomass and tissue composition (Parry et al. 2016).
Residential and commercial development (dredging)	Increased sediments	Reduced light (TSS and deposition) adversely affects subtidal and intertidal flats	Unlikely	Minor	Low	Mud Islands is a highly mobile area of intertidal flats that are constantly shifting with deposition and erosion (Bird 1993, Ball 2013). There was no detectable impact of CDP on Mudflats at Mud Islands and so future dredging programs can be expected to have similar undetectable impacts.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Residential and commercial development (dredging)	Increased sediments	Reduced light and increased TSS adversely affects fish	Unlikely	Minor	Low	Inter-annual variation for all fish species, except eastern shovelnose stingray in the west region and sand flathead in the shallow, intermediate and deep regions, were within expected variability for Port Phillip Bay during the reporting period 2008-2011 (Hirst et al. 2012). No impact to fish or fisheries was detected during CDP.
Residential and commercial development (dredging)	Increased sediments	Impacts to fish and reduced visibility adversely affects feeding waterbirds	Unlikely	Minor	Low	CDP risk assessment for seabirds was very low for most species and medium for gannets and terns (Brett Lane and Associates 2004). The effects on the species that use the shoreline in this segment would be low.
Residential and commercial development (dredging)	Increased sediments	Impacts to fish and reduced visibility adversely affects breeding waterbirds	Unlikely	Minor	Low	CDP risk assessment for seabirds was very low for most species and medium for gannets and terns (Brett Lane and Associates 2004). The effects on the species that use the shoreline in this segment would be low.
Residential and commercial development (dredging)	Increased sediments	Adversely affects threatened species	Rare	Negligible	Negligible	The threatened species that use Mud Islands are shorebird species that are not likely to be negatively impacted by sediments.
Catchment inflows (including stormwater)	Toxicants (includes metals as well as chemicals of emerging concern)					Concentrations of toxicants are occasionally elevated in the water column of the lower Yarra and Maribyrnong Rivers from urban and industrial stormwater (Melbourne Water 2009). There are over 300 stormwater drains that discharge directly to the Bay that carry road run-off and urban (and peri-urban) pollutants. Chemicals of emerging concern remain a significant knowledge gap.
Catchment inflows (including stormwater)	Toxicants	Toxicants adversely affects fish reducing condition, abundance and diversity	Unlikely	Minor	Low	Toxicants are mostly sediment bound and impact is restricted to the inshore areas. Mud Islands is well flushed and toxicants are unlikely to exceed guideline levels at this location.
Catchment inflows (including stormwater)	Toxicants	Toxicants adversely affects invertebrates reducing condition, abundance and diversity	Unlikely	Minor	Low	Toxicants are mostly sediment bound and impact is restricted to the inshore areas. Mud Islands is well flushed and toxicants are unlikely to exceed guideline levels at this location.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Toxicants	Impacts to fish and invertebrates adversely affects waterbirds through the food chain	Unlikely	Minor	Low	Pathway is likely to be species specific, with little information on the effects to shorebirds and waterbirds. Mud Islands is well flushed and toxicants are unlikely to exceed guideline levels at this location.
Catchment inflows (including stormwater)	Toxicants	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Unlikely	Minor	Low	Pathway is likely to be species specific, with little information on the effects to shorebirds and waterbirds. Mud Islands is well flushed and toxicants are unlikely to exceed guideline levels at this location.
Catchment inflows (including stormwater)	Toxicants	Adversely affects threatened species	Unlikely	Minor	Low	The threatened species that use Mud Islands are shorebird species that feed on invertebrates. Mud Islands is well flushed and toxicants are unlikely to exceed guideline levels at this location.
Urban development and recreation	Litter (including microplastics)					Recent surveys of the Lower Yarra and Maribyrnong rivers indicated a large amount of litter and micro plastics and micro-plastics on beaches of Port Phillip Bay (Blake and Charko 2014). This is consistent with an Australia wide study of micro-plastics in oceanic waters, which found levels in Australia similar to those in the Caribbean, but lower than in the Mediterranean (Reisser et al. 2013). Local knowledge indicates that litter accumulates at Mud Islands which acts as a form of trap for litter in the Bay. Although not surveyed, micro-plastics are also likely to be of concern.
Urban development and recreation	Litter (including microplastics)	Adversely affects fish reducing condition, abundance and diversity	Possible	Moderate	Medium	Impact pathways for fish include entanglement and ingestion of plastics (Hammer et al. 2012). Studies from the northern hemisphere indicate that fish species, regardless of feeding habit, ingest micro-plastics (Lusher et al. 2013). Although the long-term effects are not fully understood, there is evidence of transfers of toxic chemicals, liver disease (Rochman et al. 2013) and blocking of the digestive tract leading to starvation (Gregory 2009).
Urban development and recreation	Litter (including microplastics)	Adversely affects invertebrates reducing condition, abundance and diversity	Likely	Moderate	Medium	There is evidence of ingestion and digestion of micro-plastics by marine invertebrates. Accumulation of microplastic particles in marine invertebrates could potentially cause blockages throughout the digestive system, suppressing feeding due to satiation (Wright et al. 2013)

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Urban development and recreation	Litter (including microplastics)	Direct impacts to waterbird diversity and abundance	Likely	Major	High	There are regular reported entanglements of seabirds in marine debris. Seabirds and shorebirds are also susceptible to ingestion of micro-plastics with effects on nutrition and toxicity reported (Sutherland et al. 2012). At Mud Islands the effects may be more pronounced as adults are feeding chicks.
Urban development and recreation	Litter (including microplastics)	Direct impacts to waterbird breeding	Likely	Major	High	There are regular reported entanglements of seabirds in marine debris. Seabirds and shorebirds are also susceptible to ingestion of micro-plastics with effects on nutrition and toxicity reported (Sutherland et al. 2012). At Mud Islands the effects may be more pronounced as adults are feeding chicks.
Urban development and recreation	Litter (including microplastics)	Adversely affects threatened species	Likely	Major	High	The threatened species that use Mud Islands are shorebird species that feed on invertebrates. It is likely that they will be ingesting plastics from shorelines and this could impact survival rates for threatened species.
Shipping and navigation (oil spills)	Hydrocarbons					The Ports of Geelong and Melbourne in Port Phillip Bay receive the highest number of shipping visits of all the Victorian ports. The possibility of a major oil spill in the bay is slight, however, small spills are a common occurrence. Estimations of the frequency of oil spills indicate that a spill of 5 L or less occurs almost daily, while spills of more than 100 L occur less than once a month. The only major spill in Port Phillip Bay was in 1903 (1100 tonnes) and there have only been 20 spills of > 100 tonnes in Australia in the last 100 years (AMSA https://www.amsa.gov.au/environment/major-historical-incidents/). Risk management measures are in place to minimise the risk of a major spill and respond in the event to minimise impacts (Melbourne Water 2009). The risk assessment below is based on a spill of over 100 tonnes, with the likelihood assessed as "Rare" based on historic records 100of oil spills in Australia.
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects saltmarsh	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003). Boon et al. (2011) provides a literature review of the impacts of hydrocarbon pollution on Victorian coastal wetlands: few cases of pollution recorded, but impacts can be prolonged.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects intertidal flats	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Adversely affects seagrass (direct and shading)	Rare	Major	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Direct oiling of wildlife: waterbird diversity and abundance	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Indirect effects to waterbirds (food webs, breeding)	Rare	Extreme	Low	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Shipping and navigation (oil spills)	Hydrocarbons	Affects threatened species	Rare	Extreme	Medium	Impacts of oil spills on marine biota and shorelines are well documented (e.g. Gundlach and Hayes 1978, Swan et al. 1994, Islam and Tanaka 2004) and effects are both acute and chronic, with recovery in many instances taking decades (e.g. Peterson et al. 2003).
Invasive species	Introduced marine pests					Over 100 non-native marine species exist in Port Phillip Bay, many with a long history. There is an argument that the biota of the Bay has not been "natural" for more than 100 years (Hewitt et al. 1999). Current introduced marine species cover all taxonomic groups from algae to invertebrates and fish. Parks Victoria indicated that marine pests were a significant risk to Marine National Parks based on stakeholder perceptions (Carey et al. 2007). Impacts to biota have been assessed based on trajectories of change over the past decade. The impacts at local scales have been identified as a knowledge gap.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Introduced marine pests	Adversely affects intertidal and sub-tidal seagrass condition and extent	Possible	Moderate	Medium	Baywide monitoring of seagrass health in Port Phillip Bay (2008 to 2011) indicated little change in health over this time (Hirst et al. 2012); indicating a degree of stability under current conditions While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Adversely affects intertidal and sub-tidal flats	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Adversely affects diversity, abundance or condition of fish	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Affects waterbird diversity and abundance	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Affects waterbird breeding	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests	Impacts threatened species	Possible	Moderate	Medium	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Predators (foxes and cats)					Mud Islands is predator free - not a plausible impact pathway.
Invasive species	Grazing animals (rabbits)					Mud Islands is rabbit free - not a plausible impact pathway.
Invasive species	Silver gulls and straw-necked ibis					There is an increasing trend in numbers of silver gulls and straw-necked ibis breeding on Mud Islands. This both reduces habitat available for other species, causes damage to saltmarsh (ibis) and increases predation on eggs by silver gulls on other species.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Silver gulls and straw-necked ibis	Adversely affects saltmarsh	Likely	Moderate	Medium	Damage to saltmarsh at Mud Islands as a result of straw-necked ibis has already been documented (Hale et al. 2009).
Invasive species	Silver gulls and straw-necked ibis	Adversely affects waterbird breeding	Almost certain	Moderate	High	Loss of breeding habitat would be a major impact, given the important of Mud Islands for nesting birds and the already crowded conditions.
Invasive species	Salt tolerant weeds					There are a number of salt tolerant weed species that have been recorded in Port Phillip Bay or have the potential to invade. Of most concern are tall wheat grass (*Thinopyrum ponticum*), cord-grass (*Spartina* spp.) and sea lavender *(Limonium hyblaeum*). There are examples from Western Port where tall wheat grass has severely impact saltmarsh and bird habitat, with control proving very difficult (Hirst and Boon 2016) similar impacts could be realised in Port Phillip Bay.
Invasive species	Salt tolerant weeds	Adversely affects saltmarsh	Likely	Major	High	Although not yet present on Mud Islands, there is concern that salt tolerant weeds have the potential to invade saltmarsh, with the large bird population that travels from the mainland to the islands carrying seeds and propagules. Weed control is only by NGOs and groups such as Friends of Mud Islands only have the resources to implement on ground management a few times a year, which provides ample opportunity for establishment of weeds species.
Invasive species	Salt tolerant weeds	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for waterbirds in intertidal areas.
Invasive species	Salt tolerant weeds	Adversely affects waterbird breeding	Likely	Major	High	Loss of breeding habitat would be a major impact, given the important of Mud Islands for nesting birds and the already crowded conditions.
Invasive species	Salt tolerant weeds	Adversely affects threatened species	Possible	Major	High	The threatened species that use Mud Islands are shorebird species that feed on invertebrates. Loss of feeding habitat could impact survival rates for threatened species.
Recreational activities						Increased populations in and around Melbourne will add pressure to recreational areas of the Ramsar Site, particularly of beaches and on water activities (Deloitte 2016).
Recreational activities	Vessels	Disturbance of shorebirds	Almost certain	Moderate	High	There is growing evidence that disturbance of waterbirds by human activities (walking, boating, vehicles) can have significant negative impacts on both feeding behaviour and habitat use. A database collated from a large number of scientific studies of flight initiation

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						distances (FID, the distance between the activity and the bird talking flight) indicates that nesting birds can be disturbed by human activities at very short distances (e.g. mean FID for nesting pelicans was only 21 m and for ducks 32 m from pedestrians) (Livezey et al. 2016). FIDs for non-nesting species were typically greater (e.g. 60 metres for ducks from pedestrians). Birds are disturbed at closer distances by dogs and watercraft as opposed to pedestrians, but interestingly, non-motorised watercraft such as canoes and paddleboards had equal or smaller FIDs compared to motorised vessels (Glover et al. 2015, Livezey et al. 2016). The consequences for individuals and populations can be significant, with decreased time spent feeding, increased energy spent in flying away from disturbances, nest abandonment and ultimately population declines all cited as potential effects (Glover et al. 2011, Martín et al. 2015). An increasing population is highly likely to result in an increase in recreational users of Port Phiilip Bay, which has the potential to impact on waterbird abundance and diversity.
Recreational activities	Vessels	Disturbance of nesting birds	Almost certain	Major	Extreme	Major breeding colonies of birds are at Mud Islands (terns, gulls, ibis), and although Mud Islands are not a hotspot of recreational boating activity, there is recent evidence of major disturbance to nesting birds and deaths of chicks from boating activity on and near the islands (M. Rodrigue, Parks Victoria, Pers. comm.). With predicted population increases, recreational boating is likely to increase.
Recreational activities	Vessels	Disturbance of threatened species	Almost certain	Moderate	High	The threatened species that use Mud Islands are shorebird species that are easily disturbed by human activity and the loss of time spent feeding can have significant impacts on survival rates (P. Dann, pers. comm).
Recreational activities	Passive recreation (dogs, walkers)	Affects waterbird diversity and abundance	Almost certain	Moderate	High	Shorebirds and nesting seabirds are vulnerable to disturbance from walkers and dogs. As the population increases, it is expected that this pressure will also increase.
Recreational activities	Passive recreation (dogs, walkers)	Affects waterbird breeding	Almost certain	Moderate	High	Shorebirds and nesting seabirds are vulnerable to disturbance from walkers and dogs. As the population increases, it is expected that this pressure will also increase.
Recreational activities	Passive recreation (dogs, walkers)	Impacts threatened species	Almost certain	Moderate	High	Shorebirds and nesting seabirds are vulnerable to disturbance from walkers and dogs. As the population increases, it is expected that this pressure will also increase.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Biological resource use	Recreational fishing					Although recreational fishing is not permitted in the marine park at Mud Islands, this is poorly understood by some sectors of the community and recreational fishing is a common occurrence.
Biological resource use	Recreational fishing	Adversely affects fish abundance and diversity	Almost certain	Minor	Medium	Assessments of the stocks of target species have indicated a sustained population for King George Whiting and snapper; but a continuing decline in sand flathead populations (Bruce et al. 2012). Population projections over the next 40 years, would suggest that increasing recreational fishing effort in the Bay is likely.
Climate change						Regional climate projections have recently been released by CSIRO for sub-cluster regions in Australia. The relevant region for Port Phillip Bay is "Southern Slopes Victoria West" http://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=SSVWC&tooltip=true&popup=true. These are provided for each relevant stressor below. The risks are based on the recently completed marine vulnerability under climate change (Klemke and Arundel 2013). An expert panel reviewed the potential effects of climate change on Port Phillip Bay values in 2015 (Hale and Brooks 2015) these have been used here to assess the likely risks in the next 30 - 35 years.
Climate change	Increased carbon dioxide					Atmospheric carbon dioxide is increasing and has increased in recent decades and recently exceeded 400 ppm (http://www.esrl.noaa.gov/gmd/ccgg/trends/).
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects seagrass	Unlikely	Negligible	Negligible	Predicted that increased CO_2 may benefit seagrass (Morris 2013).
Climate change	Increased carbon dioxide	Increased photosynthesis adversely affects saltmarsh	Possible	Minor	Low	Score of 'minor' impact based on belief that selection amongst C3/C4 plants will exert little overall adverse effect on saltmarshes. Might result in shifts across plant groups (e.g. grasses neutral effect; C3 taxa, such as shrubs, herbs and mangroves, advantaged)
Climate change	Increased temperature					Surface water temperatures are predicted to increase by 0.5 degrees Celsius by 2030 with a very high degree of confidence. There will also be an increase in the frequency of extreme temperature days (Grose et al. 2015).

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased temperature	Adversely affects seagrass	Unlikely	Minor	Low	Assessment of impacts of climate change related temperature increases on seagrass and soft sediment habitats in Victoria indicated low vulnerability, but high uncertainty in embayments. (Morris 2013).
Climate change	Increased temperature	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	An assessment of climate change related increased temperature impacts to intertidal and subtidal flats indicated moderate vulnerability and adaptive capacity (Morris 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects saltmarsh	Unlikely	Moderate	Low	Saintilan and Rogers (2013) hypothesised that temperature has an influence in the diversity of saltmarsh communities, with increased diversity at mean minimum daily temperatures of < 8 ºC, and increased germination success of southern Australian saltmarsh species at lower temperatures. The increase in mean temperature coupled with an increased frequency in extreme temperature days could be expected to decrease the diversity of saltmarsh communities. The effects, however, may be expected in the longer term rather in the next 30 - 35 years.
Climate change	Increased temperature	Adversely affects fish abundance and diversity	Possible	Minor	Low	An assessment of climate change related increased temperature impacts to marine fish indicated high vulnerability and low adaptive capacity of larval stages (Hirst and Hamer 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects waterbirds	Likely	Moderate	Medium	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios. Temperature effects the timing of migration in many shorebirds, which may influence recruitment and survival (Robinson et al. 2009) in the long term. There is however a risk of increased incidence of disease such as avian botulism and avian cholera under hotter conditions (Traill et al. 2009). Incidents of botulism in the site have anecdotally increased in recent years in parts of the Ramsar site.
Climate change	Increased temperature	Adversely affects waterbird breeding	Likely	Moderate	Medium	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios. There is however a risk of increased incidence of disease such as avian botulism and avian cholera under hotter conditions (Traill et al. 2009). Incidents of botulism in the site have anecdotally increased in recent years in parts of the Ramsar site.
Climate change	Increased temperature	Adversely affects threatened species	Likely	Moderate	Medium	Temperature effects the timing of migration in many shorebirds, which may influence recruitment and survival (Robinson et al. 2009) in the long term. There is however a risk of increased incidence of disease such as avian botulism and avian cholera under hotter conditions (Traill et al. 2009). Incidents of botulism in the site have anecdotally increased in recent years in parts of the Ramsar site. Both avian botulism and cholera are known to also affect shorebirds resulting in death.
Climate change	Sea level rise					Sea levels are predicted to increase by 0.08 to 0.18 m by 2030 with a very high degree of confidence (Grose et al. 2015). Mud Islands are very low profile and sea level rise even in the medium term could result in a dramatic loss of habitat.
Climate change	Sea level rise	Adversely affects seagrass	Likely	Moderate	High	Intertidal seagrass is highly vulnerable to sea level rise and has a low adaptive capacity (Morris 2013).
Climate change	Sea level rise	Adversely affects intertidal and subtidal flats	Likely	Moderate	High	Intertidal mudflats are highly vulnerable to sea level rise and have a low adaptive capacity (Morris 2013).
Climate change	Sea level rise	Adversely affects saltmarsh	Likely	Major	High	Saltmarsh and mangrove community composition and extent is largely determined by tidal depth (Boon et al. 2011). There is already evidence of mangroves expanding at the expense of saltmarsh communities in southern Australia (Boon in prep).
Climate change	Sea level rise	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Low vulnerabilities of fish to sea level rise (adults and larvae) (Hirst and Hamer 2013).
Climate change	Sea level rise	Adversely affects waterbirds	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Sea level rise	Adversely affects waterbird breeding	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Sea level rise	Adversely affects threatened species	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting.
Climate change	Ocean acidification					pH is predicted to decrease by 0.07 to 0.08 pH units by 2030 with a medium degree of confidence (Grose et al. 2015).
Climate change	Ocean acidification	Adversely affects seagrass	Rare	Negligible	Negligible	Seagrass in Victoria is not considered vulnerable to predicted changes in ocean acidification (Morris 2013).
Climate change	Ocean acidification	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Assessed as being highly vulnerable, particularly for organisms with a calcified outer shell (Morris 2013). However, possibly a longer term risk, rather than in the next two decades.
Climate change	Ocean acidification	Adversely affects fish abundance and diversity	Rare	Negligible	Negligible	Low to moderate vulnerability (Hirst and Hamer 2013).
Climate change	Ocean acidification	Adversely affects waterbirds	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects waterbird breeding	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects threatened species	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)					Time spent in drought is projected, with medium confidence, to increase over the course of the century (Grose et al. 2015). During the millennium drought, the salinity of the Bay increased to greater than that of sea water (Lee et al. 2012). Decreased nutrient inputs to the Bay occurred over this period.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects seagrass	Possible	Moderate	Medium	Baywide monitoring of seagrass heath in Port Phillip Bay (2008 to 2011) indicated little change in health over this time, and nutrient limitation a more important factor in seagrass decline than nutrient enrichment (Hirst et al. 2012). There was a major decline in seagrass in a number of areas of the bay including Mud Islands from the late 1990s attributable to the onset of the drought and consequent decline in nutrients (Jenkins et al. 2016)
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects saltmarsh	Possible	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Evidence that the Millennium drought had a positive effect of snapper recruitment, but adverse effect on some deep water species (e.g. spiky globe fish, eagle rays) due to reduced productivity from lower nutrients in the central part of the bay (Hirst in prep.)
Climate change	Increased frequency and duration of droughts (increased salinity,	Adversely affects waterbird diversity and abundance	Possible	Minor	Low	Potential impacts through decreased productivity, noting that the link between productivity and shorebird abundance is more relevant to the north of the Bay.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
	decreased nutrients)					
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects waterbird breeding	Possible	Minor	Low	Potential impacts through decreased productivity, noting that the link between productivity and shorebird abundance is more relevant to the north of the Bay.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects threatened species	Possible	Minor	Low	Potential impacts through decreased productivity, noting that the link between productivity and shorebird abundance is more relevant to the north of the Bay.
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines					Extreme events (storms and high rainfall events) are predicted to occur with high confidence (Grose et al. 2015). Erosion of shorelines in Port Phillip Bay is currently occurring due to both natural processes and in some instances exacerbated by artificial structures such as groynes and beach armouring (Bird 2011).
Climate change	Increased frequency and intensity of storms	Adversely affects seagrass	Possible	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects intertidal and subtidal flats	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects saltmarsh	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and intensity of storms	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects waterbird breeding	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.
Climate change	Increased frequency and intensity of storms	Adversely affects threatened species	Possible	Moderate	Medium	Based on Port Phillip Bay EMP expert panel assessment.

Risk assessment for the **Lake Connewarre** complex sector of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Cells highlighted in blue provide a description of the threat / stressor that is applicable to the relevant impact pathways that follow. A full explanation of the risk assessment process, including descriptors for likelihood and consequence, is provided in section 3.1. It should be noted that this risk assessment represents risk under current management arrangements. Were management of the site to change (e.g. through a reduction in funding for existing activities) some risks would be increased.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)						The major issue is from stormwater entering the system from the current (and future) development in the Armstrong Creek Urban Growth Area. The plan is for 22,000 homes on 2500 ha of previous farm land in an area immediately adjacent to the Ramsar Site. A storm water management strategy for the Armstrong Creek Urban Growth Zone include construction of retention wetlands at Sparrovale. The diversion of storm water from the Armstrong Creek system into the Sparrovale Regional Wetlands is expected to reduce the volumes of storm water being discharged into the Connewarre complex portion of the Ramsar site mitigating potential environmental impacts to ecological character. The channel construction has not commenced and freshwater is entering from the urban estates into Hospital Swamp. As this risk assessment is considering current management, the risks are considered under current conditions.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity					Freshwater is entering Hospital Swamp making the system more permanent and fresh (Corangamite CMA, pers. comm.).
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity	Increased duration of inundation affects intertidal flats	Unlikely	Moderate	Low	Intertidal habitat is largely at Lake Connewarre and below, mostly out of the zone of influence of the stormwater.
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity	Adversely affects saltmarsh	Almost certain	Moderate	High	Hospital Swamp has diverse and important saltmarsh habitat. There is already evidence of a shift from saline communities to freshwater permanent communities.
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity	Adversely affects mangroves	Rare	Negligible	Negligible	Mangroves in this sector are restricted to the Barwon Estuary and unlikely to be impacted by changes as far upstream as Hospital Swamp
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity	Adversely affects freshwater vegetation communities	Almost certain	Moderate	High	An expansion of typha and phagmites has already been observed.
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	The permanent saline system of Hospital Swamp supports some birds, but the bulk of bird abundance and diversity is in other temporary parts of the system.
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity	Adversely affects waterbird breeding	Possible	Moderate	Medium	Hospital Swamp is not an important breeding area
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity	Adversely effects fish abundance and diversity	Unlikely	Minor	Low	A move to more fresh conditions could favour freshwater fish, but also carp and gambusia
Catchment inflows (including stormwater)	Altered water regimes leading to decreased salinity	Adversely effects threatened species	Rare	Negligible	Negligible	The threatened species at the site (orange-bellied parrot, Australian grayling, growling grass frog) are not associated strongly with Hospital Swamp.
Catchment inflows (including stormwater)	Increased nutrients					Stormwater can carry nutrient loads, particularly from garden fertilisers and septic leakage.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects saltmarsh	Possible	Moderate	Medium	Surface runoff from nearby residential areas. There is considerable information to show the adverse effect of catchment-derived nutrients on coastal saltmarsh (see Boon et al. 2011).

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects mangroves	Rare	Negligible	Negligible	Mangroves in this sector are restricted to the Barwon Estuary and unlikely to be impacted by changes as far upstream as Hospital Swamp
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects freshwater vegetation communities	Likely	Moderate	Medium	Increased nutrients can result in decreased submerged vegetation and increased phytoplankton. The consequences will be related to the magnitude of nutrients entering the system and this is not known.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects waterbird diversity and abundance	Rare	Minor	Negligible	Waterbirds are most often advantaged by increases in productivity.
Catchment inflows (including stormwater)	Increased nutrients	Adversely affects waterbird breeding	Rare	Minor	Negligible	Hospital Swamp is not an important breeding area
Catchment inflows (including stormwater)	Increased nutrients	Adversely effects fish abundance and diversity	Unlikely	Minor	Low	The impact of increased nutrients may be localised to Hospital Swamp, which is not currently an important habitat for fish.
Catchment inflows (including stormwater)	Increased nutrients	Adversely effects threatened species	Rare	Negligible	Negligible	The threatened species at the site (orange-bellied parrot, Australian grayling, growling grass frog) are not associated strongly with Hospital Swamp.
Catchment inflows (including stormwater)	Increased sediments					Sediments inflowing into the Connewarre system from catchment inflows remain a knowledge gap. It is possible that Hospital Swamp may be acting as a sediment retention basin with deposition of sediments when the fresh stormwater enters the saline system. This could have long term implications, but is a knowledge gap.
Catchment inflows (including stormwater)	Increased sediments	Impacts productivity and vegetation	Unlikely	Minor	Low	
Catchment inflows (including stormwater)	Increased sediments	Reduced light and increased TSS adversely affects fish	Rare	Minor	Negligible	Direct impacts to fish gills are observed at high TSS loads, with larval fish considered the most vulnerable (Jenkins and McKinnon 2006). Sediments from catchment inflows are not expected to reach these levels.
Catchment inflows (including stormwater)	Increased sediments	Affects waterbird diversity and abundance	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Catchment inflows (including stormwater)	Increased sediments	Affects waterbird breeding	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Catchment inflows (including stormwater)	Increased sediments	Impacts threatened species	Rare	Negligible	Negligible	Impact pathway is only through food chain and not considered a threat at this location.
Catchment inflows (including stormwater)	Toxicants (includes metals, herbicides, pesticides as well as chemicals of emerging concern such as pharmaceuticals and personal care products)					The toxicants in the urban inflows to the Lake Connewarre Complex are also largely unknown. There are high levels of toxicants in the sediments of Reedy Lake, from historical activities. The effects will be most likely from pesticides and herbicides applied to urban gardens and metals and hydrocarbons in road run-off.
Catchment inflows (including stormwater)	Toxicants	Toxicants adversely affects fish reducing condition, abundance and diversity	Likely	Minor	Medium	Toxicants are mostly sediment bound and impact is likely to be low.
Catchment inflows (including stormwater)	Toxicants	Adversely affects waterbird diversity and abundance	Likely	Minor	Medium	Toxicants are mostly sediment bound and impact is likely to be low.
Catchment inflows (including stormwater)	Toxicants	Adversely affects waterbird breeding	Almost certain	Minor	Medium	Toxicants are mostly sediment bound and impact is likely to be low.
Catchment inflows (including stormwater)	Toxicants	Adversely effects threatened species	Likely	Moderate	Medium	Toxicants are mostly sediment bound and impact is likely to be low. May be more of an influence on frog species such as growling grass frog.
Urban development	Habitat removal					Increasing populations lead to an expansion of residential and commercial areas in the catchment and adjacent to the Ramsar site. Although an assessment of specific projects is outside the scope of this risk assessment, the general nature of development and direct habitat removal is considered. Of particular concern is that residential and commercial development in many areas is close to the site reducing buffers.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Urban development	Habitat removal	Adversely affects saltmarsh	Possible	Moderate	Medium	Historical large scale clearing of saltmarsh due to land clearing and reclamation resulted in large losses of extent of saltmarsh (Boon et al. 2011). However, the recent EPBC listing of coastal saltmarsh as a vulnerable community affords the vegetation class more protection from future developments.
Urban development	Habitat removal	Adversely affects mangroves	Possible	Moderate	Medium	Proximity of site to large urban development and loss of adequate buffer.
Urban development	Habitat removal	Adversely affects freshwater vegetation communities	Possible	Moderate	Medium	Proximity of site to large urban development and loss of adequate buffer.
Urban development	Habitat removal	Indirect effects to waterbirds (loss of food and habitat)	Possible	Moderate	Medium	Based on assessment of habitat and proximity of large urban development.
Mosquito control	Toxicants (s-methoprene and *Bacillus thuringiensis israelensis*)					The City of Greater Geelong undertakes aerial mosquito control in known mosquito breeding locations, which includes Limeburners Bay, Swan Bay and the Lake Connewarre complex. The two agents used are natural products that are targeting specific insect groups. This includes both mosquito and midge larvae (chironomids) the latter of which are significant prey items for many waterbirds in general and migratory shorebirds specifically. An EPBC referral was assessed in 2005 and the practice permitted, with some restrictions. Since that time, however, research has suggested that the risk to shorebird prey items may be higher than initially thought.
Mosquito control	Toxicants (s-methoprene and *Bti*)	Toxicants adversely affects invertebrates reducing condition, abundance and diversity	Almost certain	Minor	Medium	These insecticides are designed to impact on invertebrate populations and affect a wider number of species than the two target species (Antunes-Kenyon et al. 2001). The effects, however, for most taxonomic groups are short lived (Lagadic et al. 2014).
Mosquito control	Toxicants (s-methoprene and *Bti*)	Toxicants adversely affects fish reducing condition, abundance and diversity	Unlikely	Minor	Low	Studies in Australia and overseas have indicated that the two substances at the concentrations recommended for field applications are not toxic to fish (Hurst et al. 2007).
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts to fish and invertebrates adversely affects	Possible	Minor	Low	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). This remains a knowledge gap.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
		waterbirds through the food chain				
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts to fish and invertebrates adversely affects waterbird breeding through the food chain	Possible	Minor	Low	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). This remains a knowledge gap.
Mosquito control	Toxicants (s-methoprene and *Bti*)	Impacts threatened species	Possible	Moderate	Medium	There are varied results from the literature. Some studies report no effects to birds through the food chain (Lagadic et al. 2014) others indicate that there can be declines in some waterbird species (Poulin and Lefebvre 2016). The effects on frogs such as the threatened growling grass frog, may be higher. This remains a knowledge gap.
Urban development and recreation	Litter (including microplastics)					It is possible that the encroaching urban development may result in increased litter in the system. There is no evidence of this as yet.
Urban development and recreation	Litter (including microplastics)	Adversely affects fish reducing condition, abundance and diversity	Possible	Minor	Low	Impact pathways for fish include entanglement and ingestion of plastics (Hammer et al. 2012). Studies from the northern hemisphere indicate that fish species, regardless of feeding habit, ingest micro-plastics (Lusher et al. 2013). Although the long-term effects are not fully understood, there is evidence of transfers of toxic chemicals, liver disease (Rochman et al. 2013) and blocking of the digestive tract leading to starvation (Gregory 2009).
Urban development and recreation	Litter (including microplastics)	Adversely affects invertebrates reducing condition, abundance and diversity	Possible	Minor	Low	There is evidence of ingestion and digestion of micro-plastics by marine invertebrates. Accumulation of microplastic particles in marine invertebrates could potentially cause blockages throughout the digestive system, suppressing feeding due to satiation (Wright et al. 2013)
Urban development and recreation	Litter (including microplastics)	Adversely affects waterbird diversity and abundance	Possible	Minor	Low	Greatest risk to waterbirds in from entanglement in fishing line, which is less likely in these inland systems.
Urban development and recreation	Litter (including microplastics)	Adversely affects waterbird breeding	Possible	Minor	Low	Greatest risk to waterbirds in from entanglement in fishing line, which is less likely in these inland systems.
Urban development and recreation	Litter (including microplastics)	Adversely affects threatened species	Possible	Minor	Low	Greatest risk to waterbirds in from entanglement in fishing line, which is less likely in these inland systems.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Disturbance of Coastal Acid Sulphate Soils (CASS)	Decreased pH and release of metals as a result of oxidation of CASS					Areas of CASS have been mapped around Port Phillip Bay. If disturbed due to prolonged drying of wetland areas or physical disturbance of the soil surface, then sulphuric acid is formed and can liberate metals from the sediments. There is CASS in the Lake Connewarre system, but of most concern is the drawing down of permanent wetlands such as Reedy Lake. There is a management process in place to ensure that the high risk areas in Reedy Lake are not exposed. Therefore the likelihood of exposure was considered low.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Decreased pH and release of metals	Adversely affects fish reducing condition, abundance and diversity	Unlikely	Minor	Low	Expected localised impacts only.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Decreased pH and release of metals	Adversely affects invertebrates reducing condition, abundance and diversity	Unlikely	Moderate	Low	Expected localised impacts only.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Decreased pH and release of metals	Adversely affects waterbird diversity and abundance	Unlikely	Moderate	Low	Expected localised impacts only.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Decreased pH and release of metals	Adversely affects waterbird breeding	Unlikely	Minor	Low	Expected localised impacts only.
Disturbance of Coastal Acid Sulphate Soils (CASS)	Decreased pH and release of metals	Adversely affects threatened species	Unlikely	Moderate	Low	Expected localised impacts only.
Invasive species	Introduced marine pests (current species)					Over 100 non-native marine species exist in Port Phillip Bay, many with a long history. There is an argument that the biota of the Bay has not been "natural" for more than 100 years (Hewitt et al. 1999). Current introduced marine species cover all taxonomic groups from algae to invertebrates and fish. Parks Victoria indicated that marine pests were a significant risk to Marine National Parks based on stakeholder perceptions (Carey et al. 2007). Impacts to biota have

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						been assessed based on trajectories of change over the past decade. At Lake Connewarre, this is likely to be restricted to the tidal parts of the site. The impacts of marine pests on ecological character have been identified as a knowledge gap.
Invasive species	Introduced marine pests (current species)	Adversely affects diversity, abundance or condition of fish	Unlikely	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests (current species)	Affects waterbird diversity and abundance	Unlikely	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests (current species)	Affects waterbird breeding	Unlikely	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Introduced marine pests (current species)	Impacts threatened species	Unlikely	Minor	Low	While marine pests almost certainly would have changed the ecology of the Bay from natural (pre-invasion) states, the benchmark for this assessment is current condition and there is no evidence of a trajectory of change.
Invasive species	Salt tolerant agricultural weeds					There are a number of salt tolerant weed species that have been recorded in Port Phillip Bay or have the potential to invade. Of most concern are tall wheat grass (*Thinopyrum ponticum*), cord-grass (*Spartina* spp.) and sea lavender *(Limonium hyblaeum*). There are examples from Western Port where tall wheat grass has severely impact saltmarsh and bird habitat, with control proving very difficult (Hirst and Boon 2016) similar impacts could be realised in Port Phillip Bay. Weeds in saltmarsh at the Lake Connewarre Complex are very localised and not considered a significant threat (Corangamite CMA, pers. comm.).
Invasive species	Salt tolerant agricultural weeds	Adversely affects saltmarsh	Possible	Moderate	Medium	Paul Boon (pers. comm.)

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Salt tolerant agricultural weeds	Affects waterbird diversity and abundance	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for waterbirds in intertidal areas.
Invasive species	Salt tolerant agricultural weeds	Affects waterbird breeding	Possible	Moderate	Medium	These weeds species are known to grow in dense mats which limits breeding habitat for beach nesting birds.
Invasive species	Salt tolerant agricultural weeds	Impacts threatened species	Likely	Moderate	Medium	These weeds species are known to grow in dense mats which limits feeding habitat for threatened shorebirds in intertidal areas. Impacts to saltmarsh would influence habitat for orange-bellied parrot.
Invasive species	Predators (foxes and cats)					Foxes and cats are present in the Ramsar site and currently controlled by Parks Victoria and Corangamite CMA programs. Control options are limited and there is likely to be an increase in cats with urban encroachment.
Invasive species	Predators (foxes and cats)	Adversely affects waterbird diversity and abundance	Almost certain	Moderate	High	Based on advice from Corangamite CMA
Invasive species	Predators (foxes and cats)	Affects waterbird breeding	Almost certain	Moderate	High	Based on advice from Corangamite CMA
Invasive species	Predators (foxes and cats)	Adversely affects threatened species	Likely	Moderate	Medium	Based on advice from Corangamite CMA
Invasive species	Grazing animals (rabbits and deer)					Rabbits are present in the site, but damage under current management arrangements is minor. Deer within the site, however were identified at the stakeholder workshop as a high threat.
Invasive species	Grazing animals (rabbits and deer)	Adversely affects freshwater vegetation communities	Almost certain	Moderate	High	Based on advice from Corangamite CMA and stakeholder workshop
Invasive species	Grazing animals (rabbits and deer)	Adversely affects saltmarsh	Almost certain	Moderate	High	Based on advice from Corangamite CMA and stakeholder workshop
Invasive species	Grazing animals (rabbits and deer)	Adversely affects waterbird diversity and abundance	Possible	Moderate	Medium	Based on advice from Corangamite CMA and stakeholder workshop
Invasive species	Grazing animals (rabbits and deer)	Adversely affects threatened species	Possible	Moderate	Medium	Based on advice from Corangamite CMA and stakeholder workshop

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Invasive species	Carp and gambusia					Introduced fish species are present in the system, but only in Reedy Lake (Corangamite CMA, pers. comm.).
Invasive species	Carp and gambusia	Adversely affects native fish	Almost certain	Minor	Medium	Based on advice from Corangamite CMA
Invasive species	Carp and gambusia	Adversely affects waterbird diversity and abundance	Unlikely	Minor	Low	Some fish predate on these introduced species, possibly off-setting the effects of lower native fish abundance to fish eating birds in the system.
Invasive species	Carp and gambusia	Adversely affects threatened species	Possible	Moderate	Medium	Based on impacts to frogs (growling grass frog) with carp a known predator of tadpoles.
Recreational activities	Vehicles and vessels					Four-wheel drive damage to vegetation has been reported in Port Phillip Bay reserves in general and at the Lake Connewarre complex specifically. Population of Greater Melbourne is predicted to increase from 4.3 million in 2013 to 7.8 million in 2051 (DTPLI 2014). This is likely to increase recreational pressure on wetlands and coastal areas.
Recreational activities	Vehicles in intertidal areas	Adversely affects saltmarsh	Almost certain	Moderate	High	Coastal saltmarsh is an EPBC listed species and is vulnerable to impacts and slow to recover from damage. Damage arising from vehicular access is widespread around Port Phillip Bay and considered a problem at this sector of the Ramsar site, which is not adequately protected by fencing (Corangamite CMA).
Recreational activities	Vehicles in intertidal areas	Adversely affects intertidal flats	Almost certain	Minor	Medium	
Recreational activities	Vehicles in intertidal areas	Adversely affects waterbird diversity and abundance	Almost certain	Minor	Medium	Two impact pathways: habitat destruction and disturbance of nesting seabirds and roosting / foraging shorebirds. Human presence impacts on shorebirds is well documented (e.g. Martin et al. 2014) with reduced feeding and unnecessary energy use feared to impact birds abilities to successfully make return journey to the northern hemisphere to breed.
Recreational activities	Vessels	Adversely affects waterbird diversity and abundance	Almost certain	Minor	Medium	Localised to the Barwon Estuary - little boating occurs in the rest of this sector.
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird diversity and abundance	Almost certain	Minor	Medium	Shorebirds and nesting waterbirds are vulnerable to disturbance from walkers and dogs. As the population increases, it is expected that this pressure will also increase, with some significant shorebird sites located near to Melbourne and Geelong. The increase in urban

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						encroachment will increase this threat (e.g. The City of Geelong's Great Walk project crosses the Ramsar site).
Recreational activities	Passive recreation (dogs, walkers, horses)	Affects waterbird breeding	Almost certain	Minor	Medium	See above
Recreational activities	Passive recreation (dogs, walkers, horses)	Impacts threatened species	Almost certain	Minor	Medium	See above
Biological resource use	Recreational fishing					A survey of recreational fishers in Victoria indicates that for some species, the recreational catch is many times higher than the commercial catch (Ford and Gilmour 2013). There are policies and rules in place (size and bag limits) to limit the impact of recreational fishing on fish stocks. Risk assessment is on the basis of an increasing population resulting in an increase in recreational fishing. Although rules such as bag limits may change to ensure sustainable stocks. The Barwon estuary portion of the site is popular for recreational fishing
Biological resource use	Recreational fishing	Adversely affects fish abundance and diversity	Almost certain	Minor	Medium	Limited mostly to the Barwon estuary.
Biological resource use	Recreational fishing	Indirect effects to waterbirds through the food chain (loss of food)	Possible	Minor	Low	Based on assessment of fish, noting that not all waterbirds that use the site are fish eaters.
Biological resource use	Commercial fishing					There are two commercial licences for netting in the Lake Connewarre portion of the Ramsar site that have the potential to impact native species through by-catch.
Biological resource use	Commercial fishing	Adversely affects fish abundance and diversity	Almost certain	Moderate	High	
Biological resource use	Commercial fishing	Indirect effects to waterbirds through the food chain (loss of food)	Possible	Minor	Low	Based on assessment of fish, noting that not all waterbirds that use the site are fish eaters.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Biological resource use	Hunting					Parts of the Lake Connewarre Complex are designated as a Game Reserve with duck hunting permitted during the season (March to June). The numbers of game species declined during the Millennium drought, but increased in subsequent years. Impacts to target species are controlled through the Game Management Authority, but of greater concern is the disturbance to shorebirds and the threatened orange-bellied parrot.
Biological resource use	Hunting	Affects waterbird diversity and abundance	Almost certain	Moderate	High	It is certain that shooting birds results in a decrease in bird abundance. Impacts to target species are controlled by bag limits. This risk is based on effects to non-target species through mis-identification and disturbance of shorebirds, with an overlap between the start of duck hunting season and presence of shorebirds in the site.
Biological resource use	Hunting	Affects waterbird breeding	Possible	Moderate	Medium	Effect on breeding birds is not known.
Biological resource use	Hunting	Impacts threatened species	Almost certain	Moderate	High	As per effects on abundance, with threatened species in this segment being shorebirds. Effects on orange-bellied parrots at the site remain unknown.
Climate change						Regional climate projections have recently been released by CSIRO for sub-cluster regions in Australia. The relevant region for Port Phillip Bay is "Southern Slopes Victoria West" http://www.climatechangeinaustralia.gov.au/en/climate-projections/future-climate/regional-climate-change-explorer/sub-clusters/?current=SSVWC&tooltip=true&popup=true. These are provided for each relevant stressor below. The risks are based on the recently completed marine vulnerability under climate change (Klemke and Arundel 2013). Workshop participants were asked to review the risk rankings and make any adjustments with a justification / lines of evidence to support their decisions.
Climate change	Increased carbon dioxide					Atmospheric carbon dioxide is increasing and has increased in recent decades and recently exceeded 400 ppm (http://www.esrl.noaa.gov/gmd/ccgg/trends/).
Climate change	Increased carbon dioxide	Adversely affects freshwater vegetation	Unlikely	Minor	Low	May competitively advantage some weed species.
Climate change	Increased carbon dioxide	Increased photosynthesis	Possible	Minor	Low	Score of 'minor' impact based on belief that selection amongst C3/C4 plants will exert little overall adverse effect on saltmarshes. Might

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
		adversely affects saltmarsh				result in shifts across plant groups (e.g. grasses neutral effect; C3 taxa, such as shrubs, herbs and mangroves, advantaged).
Climate change	Increased carbon dioxide	Adversely affects mangroves			#N/A	Mangroves likely to be advantaged - not a plausible pathway.
Climate change	Increased temperature					Surface water temperatures are predicted to increase by 0.5 degrees Celsius by 2030 with a very high degree of confidence. There will also be an increase in the frequency of extreme temperature days (Grose et al. 2015).
Climate change	Increased temperature	Adversely affects freshwater vegetation	Unlikely	Minor	Low	Australian woody wetland vegetation is characterised by a few widely distributed species that have broad temperature tolerances (James et al. 2016). The non-woody species may be more vulnerable to temperature extremes and it is possible that invasive native species such as Typha and Phragmites will out compete other sedge communities.
Climate change	Increased temperature	Adversely affects saltmarsh	Unlikely	Moderate	Low	Saintilan and Rogers (2013) hypothesised that temperature has an influence in the diversity of saltmarsh communities, with increased diversity at mean minimum daily temperatures of < 8 ºC, and increased germination success of southern Australian saltmarsh species at lower temperatures. The increase in mean temperature coupled with an increased frequency in extreme temperature days could be expected to decrease the diversity of saltmarsh communities. The effects, however, may be expected in the longer term rather in the next 30 - 35 years.
Climate change	Increased temperature	Adversely affects mangroves			#N/A	Mangroves likely to be advantaged - not a plausible pathway.
Climate change	Increased temperature	Adversely affects fish abundance and diversity	Possible	Minor	Low	An assessment of climate change related increased temperature impacts to marine fish indicated high vulnerability and low adaptive capacity of larval stages (Hirst and Hamer 2013). However, the greatest risks are for longer term projections and the likelihood and magnitude of change in the next two decades is lower.
Climate change	Increased temperature	Adversely affects waterbirds	Unlikely	Minor	Low	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased temperature	Adversely affects waterbird breeding	Unlikely	Minor	Low	Temperature increases are not likely to directly affect most of the waterbird species that use the Ramsar Site. The vast majority of species have large distributions and are found in the north of Australia (Higgins and Marchant 1990, 1993, Higgins and Davies 1996), where current temperatures are higher than those predicted for south eastern Australia under climate change scenarios.
Climate change	Increased temperature	Adversely affects threatened species	Unlikely	Minor	Low	Temperature effects the timing of migration in many shorebirds, which may influence recruitment and survival (Robinson et al. 2009). Impacts to orange-bellied parrots through saltmarsh impacts.
Climate change	Sea level rise					Sea levels are predicted to increase by 0.08 to 0.18 m by 2030 with a very high degree of confidence (Grose et al. 2015). Recent studies indicate a potential loss of bird habitat in this sector of 64% by 2040 (Roy 2015).
Climate change	Sea level rise	Adversely affects freshwater vegetation	Unlikely	Moderate	Low	There are barriers between the fresh and saline wetland vegetation that may protect these communities at Reedy Lake.
Climate change	Sea level rise	Adversely affects intertidal and subtidal flats	Likely	Moderate	Medium	Intertidal mudflats are highly vulnerable to sea level rise and have a low adaptive capacity (Morris 2013).
Climate change	Sea level rise	Adversely affects saltmarsh	Likely	Major	High	Saltmarsh and mangrove community composition and extent is largely determined by tidal depth (Boon et al. 2011). There is already evidence of mangroves expanding at the expense of saltmarsh communities in southern Australia (Boon in prep).
Climate change	Sea level rise	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Low vulnerabilities of fish to sea level rise (adults and larvae) (Hirst and Hamer 2013). Freshwater fish would only be impacted if barriers were breached.
Climate change	Sea level rise	Adversely affects waterbirds	Likely	Major	High	Shorebirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting.
Climate change	Sea level rise	Adversely affects waterbird breeding	Possible	Moderate	Medium	Beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et al. 2009). These species are not the common breeders in this sector of the Ramsar site.
Climate change	Sea level rise	Adversely affects threatened species	Likely	Major	High	Shorebirds and beach nesting seabirds are highly vulnerable to sea level rise, with loss of habitat predicted to be extensive (Robinson et

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
						al. 2009). This may include loss of intertidal feeding habitat and supratidal habitat needed for roosting and nesting. Impacts to orange-bellied parrots through saltmarsh impacts.
Climate change	Ocean acidification					pH is predicted to decrease by 0.07 to 0.08 pH units by 2030 with a medium degree of confidence (Grose et al. 2015).
Climate change	Ocean acidification	Adversely affects intertidal and subtidal flats	Unlikely	Minor	Low	Assessed as being highly vulnerable, particularly for organisms with a calcified outer shell (Morris 2013). However, possibly a longer term risk, rather than in the next two decades.
Climate change	Ocean acidification	Adversely affects fish abundance and diversity	Rare	Negligible	Negligible	Low to moderate vulnerability (Hirst and Hamer 2013).
Climate change	Ocean acidification	Adversely affects waterbirds	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects waterbird breeding	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Ocean acidification	Adversely affects threatened species	Rare	Negligible	Negligible	Only plausible pathway is through food chain effects, but considered to be very low risk.
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines					Extreme events (storms and high rainfall events) are predicted to occur with high confidence (Grose et al. 2015). Erosion of shorelines in Port Phillip Bay is currently occurring due to both natural processes and in some instances exacerbated by artificial structures such as groynes and beach armouring (Bird 2011). In this sector, this may be most relevant at the Barwon Estuary
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects intertidal and subtidal flats	Possible	Minor	Low	Localised effects, possibly limited to the Barwon Estuary
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects saltmarsh	Possible	Minor	Low	Localised effects, possibly limited to the Barwon Estuary

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects fish abundance and diversity	Unlikely	Minor	Low	Localised effects, possibly limited to the Barwon Estuary
Climate change	Increased frequency and intensity of storms leads to increased erosion of shorelines	Adversely affects waterbirds	Possible	Minor	Low	Localised effects, possibly limited to the Barwon Estuary
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)					Time spent in drought is projected, with medium confidence, to increase over the course of the century (Grose et al. 2015). This could lead to a decrease in freshwater inflows at the site and an increase in salinity. Possibly only relevant to Reedy Lake, which is maintained with e-water.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects freshwater vegetation	Possible	Moderate	Medium	Currently maintained by e-water and expected to remain so into the medium term future.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects freshwater vegetation	Possible	Minor	Low	Currently maintained by e-water and expected to remain so into the medium term future.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects waterbirds	Unlikely	Minor	Low	Currently maintained by e-water and expected to remain so into the medium term future.
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects waterbird breeding	Unlikely	Minor	Low	Currently maintained by e-water and expected to remain so into the medium term future.

Threat	Stressors	Effect	Likelihood	Consequence	Risk	Evidence / comments
Climate change	Increased frequency and duration of droughts (increased salinity, decreased nutrients)	Adversely affects threatened species	Possible	Minor	Low	Currently maintained by e-water and expected to remain so into the medium term future.

Appendix C: Review of 2003 management plan objectives and strategies

A review of the 91 management strategies within the 2003 Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Strategic Management Plan was conducted and is summarised here. The shading in the tables below indicates the current status:

- Blue-green – current or past actions have addressed the management action (in full or part, noting that this does not necessarily mean that the action is no longer required as most require ongoing activity).
- Red – the management action remains a priority, but no evidence of previous actions to address the issue could be found. Cross-references to relevant management strategies from this 2016 plan are provided.
- Unshaded – not related to priority values and threats identified in 2015.

Lead agency key:

BoQ	Borough of Queenscliffe	MPC	Melbourne Port Corporation
BCCM	Barwon Coast Committee of Management	MW	Melbourne Water
BW	Barwon Water	PPWCMA	Port Phillip and Westernport Catchment Management Authority
CCB	Central Coastal Board	PV	Parks Victoria
CCMA	Corangamite Catchment Management Authority	SCS	Surf Coast Shire
CoGG	City of Greater Geelong	SRW	Southern Rural Water
DPI	Department of Primary Industries (now (DEDJTR)	TFN	Trust for Nature
DSE	Department of Sustainability and Environment (now DELWP)	VCA	Victorian Channels Authority
ECC	Environment Conservation Council	VWSG	Victorian Wader Study Group
EPA	Environment Protection Authority	WCC	Wyndham City Council
MSV	Marine Safety Victoria		

Management Objective 1: Increase the scientific understanding of wetland ecosystems and their management requirements

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
1.1	Support and promote environmental research in the Ramsar site by accredited research and education organisations (including community groups and tertiary education institutions) and encourage research directly relevant to management priorities taking account of the priorities in Appendix 3.	EPA, MW, DSE, PV, SRW, Councils	Higher	Numerous research activities by various agencies including MW, Parks Victoria (PV Research Panel), EPA Victoria, Corangamite CMA and DELWP
1.2	Investigate the causes of dieback amongst mangroves in Limeburners Bay.	DSE	Medium	

Management Objective 2: Maintain or seek to restore appropriate water regimes

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
2.1	Implement the Barwon River Bulk Entitlement and negotiate for flows to be provided in Stream Flow Management Plans for the Barwon and Moorabool Rivers to protect Reedy Lake and the other lower Barwon River wetlands.	DSE, BW, CCMA, SRW	Higher	CCMA: Seasonal Watering Proposals for the Lower Barwon Wetlands
2.2	Ensure that new water developments consider and provide for protection of Ramsar values, in particular projects involving water recycling and changes to sewage treatment at the Western Treatment Plant.	DSE, MW, BW, CCMA	Higher	Melbourne Water EPBC Strategic Compliance Plan and associated monitoring and reporting
2.3	Implement the adaptive management strategy described in the Western Treatment Plant and Spit Wildlife Reserve Conservation Management and Action Plan (July 2000) for monitoring and managing the impact of changes in sewerage lagoon operations on waterbirds.	MW	Higher	Melbourne Water EPBC Strategic Compliance Plan and associated monitoring and reporting
2.4	Document and continue to implement a hydrological management plan for the Cheetham Wetlands that includes all waterbirds' habitat requirements.	PV	Higher	PV: Cheetham Wetlands Hydrology Manual
2.5	Implement the water level management plan for Reedy Lake developed by Parks Victoria.	PV	Higher	CCMA: Seasonal Watering Proposals for the Lower Barwon Wetlands
2.6	Seek to restore an appropriate water regime for Ryans Swamp in the Western Treatment Plant.	MW	Higher	Works at outlet undertaken during February 2005, following a review of information. Fluker Post installed 2011 to record wetting and drying.
2.7	Ensure future coastal development has minimal impact on coastal hydrodynamic characteristics and associated features and habitats.	DSE, PV, MPC, VCA, MW, Defence, Councils, CCB	Higher	Input through planning scheme referrals to Parks Victoria where development may have impact on park values including for Lake Connewarre, Swan Bay, Western Shoreline, Cheetham

2.8	Implement actions in the Corangamite Regional Catchment Strategy to protect water quality and flows in the Barwon River.	CCMA, BW	Higher	Addressed as core business for CCMA
2.9	Support the development of stormwater management plans for urban areas adjacent to or near the Ramsar site incorporating the principles of water-sensitive urban design and flow retention.	MW, EPA, CoGG, BoQ, WCC	Medium	EPA and MW: Better Bays and Waterways
2.10	Ensure regular monitoring of the effects of the drainage scheme of the Point Cook Estate on Skeleton Creek and the Cheetham Wetlands within the Ramsar site.	PV, WCC	Medium	Addressed as core business for Parks Victoria
2.11	Develop a hydrological management plan for Lake Connewarre that takes into account natural water flows and the health of the whole river-wetland ecosystem.	PV, BW, CCMA	Medium	Established under the Lower Barwon Environmental Water Entitlement
2.12	Liaise with Cheetham Salt to investigate possibilities to improve water flows for shorebirds in the north and south parts of the Avalon Saltworks to complement the Ramsar site.	DSE	Lower	Underway at present with Ridley Corp land transfer

Management Objective 3: Address adverse processes and activities

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
3.1	Develop and implement plans to eradicate or limit the spread of pest plants and pest animals (primarily foxes and rabbits) in key areas.	DPI, PV, MW, Councils, Defence	Higher	CCMA: OBP / saltmarsh protection project and CoastalTender. PPWCMA Ramsar Protection Program
3.2	Continue to monitor the extent of Spartina invasion within the Ramsar site and maintain programs to reduce the extent of invasions.	DSE, PV	Higher	OBP / saltmarsh protection project and CoastalTender project delivery.
3.3	Ensure that the provisions of the EPA's 'Draft Best Practice Management Guidelines for Dredging' are strictly adhered to during the planning and execution of all dredging operations in Port Phillip Bay.	PV, Toll Geelong, VCA, EPA	Higher	Parks Victoria Managed Dredging Programs comply with EPA best practice guidelines
3.4	Take all precautions to avoid accidental and deliberate oil and other chemical spills into the bay - including enforcing legislation.	EPA, MSV, Toll Geelong, MPC, PV, VCA	Higher	Safety and Environmental Management Plans (SEMPs) developed for all local ports
3.5	Ensure proponents are aware that development proposals that may impact on Ramsar values should be referred to Environment Australia or an approved State authority as directed by the EPBC Act 1999.	DSE, PV, CMAs, CGCoM, Councils	Higher	Addressed as part of DELWP core business
3.6	Extend coverage of oil spill response plans to all parts of the Port Phillip Bay Ramsar site.	DSE, PV, Toll Geelong & MPC, VCA, MSV	Higher	Safety and Environmental Management Plans (SEMPs) developed for all local ports

3.7	Maintain current or higher levels of fox and rabbit control around all Port Phillip Bay Ramsar site areas in cooperation with private landowners.	DPI, PV, MW	Higher	Considerable investment on rabbit and fox programs across all Parks Victoria sites. CoastalTender and Saltmarsh Protection Project. Bellarine Catchment Network (BCN) have also coordinated in the past with PV, the Bellarine Ark project, which targeted fox control
3.8	Upgrade and ensure the safe operation of sewerage in Queenscliff and Point Lonsdale to prevent further spills into southern Swan Bay and develop a protocol for rapid response to leakages.	BW, EPA, DSE	Higher	
3.9	Seek to prevent and control the introduction of marine pest plant and animal species and implement the Victorian Protocol for Managing Marine Organism Incursions.	DSE, VCA, MSV, EPA, MPC	Higher	Current management strategies 1.3 and 4.1
3.10	Manage and control human access to minimise disturbance at waterbird and seabird breeding colonies in the Port Phillip Bay Ramsar site during the breeding season.	PV, MW	Higher	Current management strategies 1.1, 1.2 and 5.1
3.11	Examine options to regulate boating activities in or adjoining sensitive habitats.	DSE, PV, MSV	Higher	Current management strategy 1.2
3.12	Educate the general public of the risks to Ramsar bird species associated with disturbance (e.g. walking, horse riding, exercising dogs).	DSE, PV, Councils	Higher	PPWCMA Ramsar Protection Program Partnership programs with Birds Australia, COGG, Barwon Coast Hobsons Bay delivered
3.13	Develop and implement planning controls for Ramsar wetlands and adjacent wetland areas to ensure that land use and development does not significantly impact on Ramsar values.	DSE, Councils	Higher	Addressed as part of core business for DELWP.
3.14	Minimise disturbance to roosting and feeding shorebirds during the duck hunting season at the Lake Connewarre system.	PV, DSE	Higher	Current management strategy 4.4
3.15	Continue the ban on water-skiing and jet skis in the Lake Connewarre State Game Reserve and extend the ban to the south-east and east sides of the lake adjacent to important shorebird feeding sites.	PV	Higher	Current management strategy 1.2
3.16	Minimise pollution of Swan Bay from town wastewater discharge and agricultural runoff, for example using planning controls, EPA licences or stormwater management/nutrient management plans.	DSE, CoGG, BoQ, CCMA	Higher	Current management strategy 3.1
3.17	Discourage dog and vehicle access to Edwards Point to reduce disturbance to shorebird roosts and feeding habitat.	DSE, PV	Higher	Dogs on leads permitted in reserve. Vehicles prevented from entry
3.18	Enforce speed restrictions and ban use of jet skis in Swan Bay and Mud Islands to minimise disturbance to feeding and roosting shorebirds.	PV, DSE	Medium	Current management strategy 1.2

3.19	Fence areas where grazing is damaging wetland vegetation and habitat.	DSE, PV	Medium	Some priority areas fenced near Lake Connewarre, Reedy Lake and along Western Shoreline.
3.20	Minimise disturbance by boating, fishing, walking and vehicle use to shorebird roosts and feeding areas in the Barwon estuary through signposting at access points and boat ramps and education aimed at user groups.	PV, BW, CoGG, BCCM	Medium	Some works completed by Parks Victoria
3.21	Develop and implement measures to control carp within the Barwon River, Reedy Swamp and Hospital Swamp.	DSE, PV	Medium	Drying program to control carp implemented in 2016
3.22	Discourage landing on Mud Islands and boating in the lagoon.	PV	Lower	

Management Objective 4: Manage within an integrated catchment management framework

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
4.1	Implement strategies and initiatives in the State Environmental Protection Policy (EPA 1997) and Corangamite Regional Catchment Strategy to reduce nutrient and sediment loads entering the Port Phillip Bay along watercourses.	CCMA, PPWCMA, EPA, MW, CCB, DPI, DSE, SRW	Higher	Better Bays and Waterways, Healthy Waterways Strategy
4.2	Implement Wyndham and Hobsons Bay stormwater management plans to better manage delivery of pollutants to stormwater, and retention and removal of pollutants from stormwater entering Ramsar sites.	MW, EPA, CoGG, BoQ	Medium	Better Bays and Waterways, Healthy Waterways Strategy
4.3	Support continued refinement and implementation of catchment protection measures in the Swan Bay catchment.	DPI, DSE, CCMA, CoGG, BoQ	Medium	Bellarine Catchment Network.
4.4	Encourage the minimal use of fertilisers and other chemicals on private land adjoining the Point Cook Coastal Park/Cheetham Wetlands and on agriculturally managed parts of the park and provide buffers to minimise pollution of the wetlands.	PV, DPI, WCC	Lower	
4.5	Investigate the impacts of salinity and levels of flow on the Lake Connewarre system from the Corangamite and Lough Calvert drainage schemes.	BW, SRW, CCMA, DSE	Lower	
4.6	Monitor the extent and health of mangroves and seagrass in the Barwon estuary in relation to alterations in sediment flows, catchment water inputs and damage from boating.	BW, PV, EPA, DSE, BCCM, SCS	Lower	
4.7	Ensure regional catchment strategies and subsidiary documents recognise and protect the Ramsar wetlands and other important wetlands that contribute to supporting species for which the Ramsar site is recognised, particularly threatened species and shorebird habitat.	DSE, CCMA, CoGG, BoQ	Lower	Corangamite Waterway Strategy

Management Objective 5: Manage resource utilisation on a sustainable basis

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
5.1	Participate in appropriate consents for use of adjacent land including, mineral extraction and intensive animal husbandry under the *Planning and Environment Act 1987* and during the Environmental Effects Statement process.	PV, DSE	Higher	Addressed as part of DELWP and EPA Victoria core business
5.2	Continue current monitoring, research and assessment programs on the impacts of recreational fishing and adjust regulations to ensure utilisation of fishery resources in line with ESD principles.	DPI	Higher	Baywide fish monitoring 2005 - 2012
5.3	Manage marine national parks and marine sanctuaries in accordance with the National Parks Act 1975 and Werribee River Estuary Special Management Area in accordance with the ECC recommendations accepted by Government.	DSE, PV	Higher	Addressed as part of DELWP and Parks Victoria core business
5.4	Ensure that future aquaculture developments in and near the Ramsar site only occur if they do not impact on Ramsar site values and also meet other legislative and administrative requirements.	DPI, PV	Higher	New aquaculture developments near Avalon, in Pinnace Channel are required to meet WQ standards set by EPA and permits under Fisheries.
5.5	Finalise and implement the Draft Ramsar and Conservation Management Plan - Western Treatment Plant, The Spit Nature Conservation Reserve and Adjacent Habitats (Lane et al.1999), relating to the protection of Ramsar values at the Western Treatment Plant.	MW	Higher	
5.6	Ensure that no further clearing of native coastal vegetation occurs in or adjacent to the Ramsar site for agriculture or urban development.	Councils, DSE	Medium	Addressed as part of DELWP core business
5.7	Continue current controls on hunting to ensure a sustainable harvest.	DSE, PV	Medium	Addressed as part of DELWP core business

Management Objective 6: Protect, and where appropriate enhance, ecosystem processes, habitats and species

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
6.1	Protect all existing saltmarsh and mangrove habitats and, where practicable, rehabilitate areas subject to degradation.	DSE, PV, MW, Councils, Defence	Higher	Parks Victoria: Ongoing management programs across the site aim to protect saltmarsh / mangroves PPWCMA Ramsar Protection Program
6.2	Protect important habitats for internationally important migratory waders, particularly FFG, JAMBA, CAMBA and Bonn-listed species, and ensure important high tide roosting sites are not regularly disturbed by people.	DSE, PV, MW	Higher	PPWCMA Ramsar Protection Program Addressed as part of DELWP core business

6.3	Protect values of adjacent and nearby wetlands (Appendix 9) that contribute significantly to the ecological character of the Ramsar site.	PV, Defence	Higher	Current management strategy 6.1
6.4	Finalise and/or implement the Cheetham Wetlands (PV 1996), Draft Ramsar and Conservation Management Plan - Western Treatment Plant, The Spit Nature Conservation Reserve and Adjacent Habitats (Lane et al.1999), Limeburners Bay (CoGG 2000), Swan Bay Marine & Wildlife Reserves (DCE 1991) and Lake Connewarre State Game Reserve (DCNR 1993) management plans.	PV, DSE, MW	Higher	Plans for the Point Cook Marine Sanctuary and Port Phillip Heads Marine National Park (include Swan Bay and Mud islands) have been completed. Current management strategy 6.4
6.5	Monitor the impact on ecosystems and waterbirds of water recycling and changes in sewage treatment processes and reduced nutrient inputs to the nearshore environment at the Western Treatment Plant. Where impacts are found to be adverse, ensure compensatory measures are implemented which may include: provision of additional, artificial habitat; local changes in the nature of discharges; and/or changes in sewage treatment processes.	MW, DSE	Higher	Melbourne water extensive monitoring and research programs.
6.6	Ensure implementation of the provisions of Action Statements under the *Flora and Fauna Guarantee Act 1988* for species in the Ramsar site that are covered by Action Statements.	DSE, PV	Higher	Addressed as part of DELWP core business
6.7	Implement and continually review activities and outcomes of elements of the Orange-bellied Parrot Recovery Plan that apply to the Port Phillip Bay Ramsar site.	OBP Recovery Team, DSE, PV,	Higher	Addressed as part of DELWP core business through the orange-bellied parrot recovery team
6.8	Site any buildings, tracks and other structures to minimise disturbance to shorebirds habitat and disturbance to feeding and roosting birds.	All land managers	Higher	Addressed as part of DELWP and Parks Victoria core business
6.9	Investigate the effects of proposed aquaculture at Avalon on the ecological character of the Ramsar site.	DPI	Higher	Current management strategy 6.2
6.10	Ensure municipal strategic statements and local planning schemes recognise and protect important wetlands and migratory shorebird values in the Ramsar site and also take account of the complementary values of wetlands outside the Ramsar site.	Councils	Medium	Current management strategy 1.7
6.11	Assist Councils in evaluating any applications for clearing native vegetation in wetland areas under the State Planning Policy Framework of planning schemes.	DSE	Medium	Addressed as part of DELWP core business
6.12	Ensure that grazing regimes and mowing in the Laverton-Point Cook area do not reduce grass and sedge vegetation in shallow swamps, drainage lines or fringes of larger wetlands.	DPI, PV, MW	Medium	Addressed as part of Parks Victoria core business
6.13	Continue breeding habitat restoration and maintenance at The Spit Nature Conservation Reserve.	VWSG, PV	Medium	PPWCMA Ramsar Protection Program Addressed as part of Parks Victoria core business

6.14	Ensure that the significance of shallow freshwater or slightly brackish wetlands between Laverton and Point Cook for shorebirds is recognised in management planning.	PV, DSE, MW	Lower	Addressed as part of Parks Victoria core business
6.15	Protect woody and semi-woody wetland vegetation from fire.	All land managers	Lower	Addressed as part of DELWP core business

Management Objective 7: Encourage strong partnerships between relevant agencies

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
7.1	Provide support to Councils engaged in activities that protect and enhance Ramsar values around Port Phillip Bay.	PV, DSE, Councils	Higher	PPWCMA Ramsar Protection Program Addressed as part of DELWP core business
7.2	Develop a coordinated coastal planning framework incorporating Ramsar wetlands in Port Phillip Bay under the *Coastal Management Act 1995* that ensures wise use of the areas, consistent with the protection of the site's Ramsar values.	CCB	Higher	
7.3	Ensure a coordinated approach to the management of the Port Phillip Bay Ramsar site, including integration with the Port Phillip and Western Port Regional Catchment Strategy, the Corangamite Regional Catchment Strategy, the Port Phillip Bay SEPP and the Victorian Coastal Strategy.	CCMA, PPWCMA, MW, EPA, DSE, PV, CCB, Councils	Higher	Ramsar Coordinating Committee to be formed as part of implementation. Current management strategy 6.5

Management Objective 8: Promote community awareness and understanding and provide opportunities for involvement in management

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
8.1	Develop and implement a Port Phillip Bay Ramsar site wetland information and interpretation program.	PV, DSE, Councils	Higher	Current management strategy 5.1
8.2	Encourage involvement of local Aboriginal people in all facets of Ramsar site management, consistent with the commitment of the Indigenous Partnership Strategy to recognise the fundamental role Aboriginal indigenous communities have in natural resource management.	All land managers	Higher	Current management strategy 5.1
8.3	Consult with local Aboriginal people to ensure that other site management strategies in this plan do not adversely impact on Aboriginal cultural heritage values.	All land managers	Higher	Current management strategy 5.1
8.4	Wherever appropriate, encourage and support the involvement of community groups and landholders in environmental research and management in the Port Phillip Bay Ramsar site.	All land managers	Higher	PPWCMA Ramsar Protection Program Coastal Tender and Ramsar Protection Program
8.5	Encourage community groups, local schools and educational institutions to visit the Ramsar wetlands, and become involved in monitoring and rehabilitation.	PV, DSE, Councils	Medium	PPWCMA Ramsar Protection Program Coastal Tender and Ramsar Protection Program

8.6	Establish a regular forum for community groups, landholders and management agencies to come together and discuss Ramsar site management and monitoring activities and outcomes.	DSE, PV	Medium	PPWCMA Ramsar Protection Program Coastal Tender and Ramsar Protection Program
8.7	Retain the consultative committee for Cheetham Wetlands and extend its area of concern to other shorebird habitat in the Point Cook Coastal Park.	PV	Medium	
8.8	Encourage private landowners adjacent to the Ramsar site to enter into conservation covenants, to protect sensitive areas and to actively manage the land for conservation purposes.	All land managers	Medium	

Management Objective 9: Ensure recreational use is consistent with the protection of natural and cultural values

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
9.1	Educate local communities and visitors of the risks that recreational activities pose to Ramsar values, particularly to coastal vegetation and waterbird populations.	PV, DSE	Higher	Current management strategies 1.1, 1.2 and 5.1
9.2	Ensure that recreational development in and near wetlands of the Port Phillip Bay Ramsar site does not prejudice specific wetland values.	PV, DSE, Councils	Higher	Current management strategies 1.1, 1.2 and 5.1
9.3	Support local ecotourism initiatives that are compatible with the maintenance of Ramsar values.	DSE, PV, Councils	Medium	Current management strategies 1.1, 1.2 and 5.1
9.4	Apply an ecotourism accreditation scheme to ensure tour operators adopt clear strategies and procedures to reduce disturbance in the wetlands of the Port Phillip Bay Ramsar site.	Tourism Victoria, PV, DSE	Medium	Current management strategies 1.1, 1.2 and 5.1
9.5	Discourage or prohibit the approach of jet skis within 150 metres of the mean high water mark on Mud Islands, Swan Bay and The Spit Nature Conservation Reserve, except in an emergency or for authorised research or management.	PV	Medium	Current management strategy 1.2

Management Objective 10: Develop ongoing consistent programs to monitor ecological character

	Site Management Strategy	Lead agency	Priority	Example actions / programs implemented
10.1	Prepare a coordinated program to monitor the ecological character of the Ramsar site identifying key indicators for recognised Ramsar values, monitoring regimes and reporting programs.	DSE	Higher	DELWP Ramsar MERI Framework
10.2	Implement a monitoring program at Cheetham Wetlands to ensure ongoing optimisation of water pumping, water level management and waterbird habitat enhancement.	PV	Higher	Cheetham Wetlands Operations Manual

10.3	Implement a monitoring program to determine the impact of water recycling and changes in sewage treatment processes at the Western Treatment Plant.	MW	Higher	Melbourne Water extensive research and monitoring program
10.4	Closely monitor the status and management requirements of the critically endangered Orange-bellied Parrot in the Port Phillip Bay Ramsar site.	OBP Recovery Team, DSE, PV	Higher	Orange-bellied parrot recovery program
10.5	Support continued monitoring of the status of water birds by community groups.	DSE, PV	Higher	Shorebirds 2020; Geelong Field Naturalists
10.6	Establish a regular seagrass monitoring program for Swan Bay and Limeburners Lagoon as a basis for determining the effectiveness of water quality management and as an indicator of environmental quality.	PV	Higher	Parks Victoria Swan Bay monitoring. DELWP Reef and Seagrass Program.
10.7	Continue monitoring the status of Cord Grass / Spartina infestations in the Lake Connewarre and lower Barwon River wetlands as a basis for prioritising control works.	DSE, PV	Higher	Parks Victoria annual program
10.8	Encourage submission of all flora and fauna observations in the Port Phillip Bay Ramsar site to update relevant Victorian databases.	DSE, PV	Medium	Addressed as part of DELWP core business
10.9	Monitor coastal erosion and sediment movement and the extent and health of sea grass beds.	DSE, PV, Councils	Medium	Parks Victoria Monthly monitoring at Point Cook completed
10.10	Prepare regular vegetation condition reports for the coastal vegetation (wetland and terrestrial) of the Port Phillip Bay Ramsar site.	PV, DSE	Lower	PPWCMA Ramsar Protection Program CCMA habitat hectare assessments, DELWP Ramsar Rolling review and Index of Wetland Condition

Appendix D: Derivation of Resource Condition Targets

Resource Condition Targets (RCTs) were derived by a process of expert opinion and local knowledge taking into consideration Limits of Acceptable Change and current condition for each value. They are designed to be feasible and achievable within the life of the plan (next seven years).

Value and baseline at the time of listing	Limit of Acceptable Change	Current condition	Resource Condition Target
Hydrology	Barwon River Estuary remains open to upstream river environments and the Bay from March to November each year.	**Insufficient data to assess LAC.**	Maintain connectivity between the Barwon River and the Southern Ocean.
Hydrology	Reedy Lake to be wet for no longer than 10 continuous years, or dry for more than five. 75% of aerobic treatment lagoons with permanent water at the Western Treatment Plant 75% of lagoons at Cheetham with permanent water.	Reedy Lake dried during the Millennium drought, filled in 2007 and dried again in 2015 (Corangamite CMA 2015). **LAC is met.**	Maintain Cheetham Wetlands according to the hydrological management manual. That is, in spring: 3% of ponds in a dry state, 67% shallow and suitable for migratory shorebird foraging and 30% deep for longer legged shorebirds.
Seagrass – in 1981 was around 2500 hectares within the Ramsar site boundary. Seagrass in Swan Bay seems stable, but at Mud Islands can vary considerably over time.	Seagrass extent will not decline below 1500 hectares for a period of greater than 20 continuous years.	GIS maps from 2000 indicate a total of 2900 hectares of seagrass within the Ramsar site boundary in 2000. A recent assessment indicated that seagrass cover in Swan Bay and Pt Wilson / Limeburners Bay had changed little from 2000 to 2012 (Ball et al. 2014). **LAC is met.**	Maintain condition and extent of seagrass within the Ramsar site (i.e. >2900 hectares)
Saltmarsh – 1225 hectares of saltmarsh within the site boundary.	Total saltmarsh extent will not decline below 900 hectares.	The most recent assessment of saltmarsh extent in the Ramsar site (Boon et al. 2011) indicates 1225 hectares. There is no evidence of a significant decline in saltmarsh extent. **LAC is met.**	Maintain condition and extent of saltmarsh within the Ramsar site (i.e. >1200 hectares)
Mangrove – 52 hectares within the site boundary	Total mangrove extent will not decline below 40 hectares.	The most recent assessment of mangrove extent in the Ramsar site indicates 52 hectares. **LAC is met.**	Maintain condition and extent of mangroves within the Ramsar site (i.e. >50 hectares)

Value and baseline at the time of listing	Limit of Acceptable Change	Current condition	Resource Condition Target
Freshwater vegetation - Management of Reedy Lake is designed to maintain a habitat mosaic of open water, emergent freshwater vegetation (reed and sedge beds), submerged vegetation (e.g. *Myriophyllum* spp.) and lignum shrubland (Ecological Assocaites 2014, Corangamite CMA 2015).	A habitat mosaic will be maintained at Reedy Lake that comprises open water, emergent native vegetation (sedges, rushes and reeds) and lignum shrubland with no habitat comprising more than 70 percent of the total wetland area for more than five successive years.	Assessments of vegetation in 2014, indicated 50% emergent vegetation (sedges and reeds); 30% open water; 10% lignum shrubland and 10% other communities (Ecological Associates 2014 **LAC is met.**	Maintain condition and extent of Freshwater emergent vegetation at Reedy Lake.
Waterbird abundance Annual maximum counts from 1981 to 1994, a 13 year period that should reflect conditions at the time of listing (% of population): Total shorebirds – 37,000 Curlew sandpiper – 9400 (6.5%) Double-banded plover – 900 (1.8%) Red-necked stint – 13,500 (4%) Sharp-tailed sandpiper – 6500 (4%) Data for non-shorebird species are more recent (from 2000) and so all data (2000 to 2015) have been used to cover during and post drought conditions. Average annual maximum counts for non-shorebirds are as follows (% of population): Total non-shorebirds – 90,000 Australasian shoveler – 7000 (7%) Australian shelduck – 16,000 (1.6%) Blue-billed duck – 5400 (54%) Chestnut teal – 8200 (8%) Hoary-headed grebe – 17,000 (1.7%) Musk duck – 1300 – (5%) Pink-eared duck – 23,000 (2%)	Abundance of waterbirds will not decline below the following (calculated as a rolling five year average of maximum annual count; percentages calculated based on the latest Wetlands International Waterbird Population Estimates): Total shorebirds - 17,000 Total non-shorebirds – 45,000 Curlew sandpiper – 3% Double-banded plover – 1% Red-necked stint – 2% Sharp-tailed sandpiper – 2% Australasian shoveler – 3% Australian shelduck – 1% Blue-billed duck – 25% Chestnut teal – 4% Hoary-headed grebe – 1% Musk duck – 2% Pink-eared duck – 1%	Data from Birdlife Australia (shorebirds) and DELWP (non-shorebirds) indicates the following annual maximum counts (2011 – 2015): Total shorebirds - 22,900 Total non-shorebirds – 110,000 **Curlew sandpiper – <1% (1400)** Double-banded plover – 1.5% (900) Red-necked stint – 2% (6500) **Sharp-tailed sandpiper – 1.7% (2600)** Australasian shoveler – 3% (3200) Australian shelduck – 1.9% (19,000) Blue-billed duck – 25% (2500) Chestnut teal – 9% (8900) Hoary-headed grebe – 1.7% (17,000) Musk duck – 3% (700) Pink-eared duck – 2% (20,000) **LAC is met for most species and total shorebirds and non-shorebirds.** **LAC is exceeded for total shorebirds, curlew sandpiper and sharp-tailed sandpiper (due to factors outside the Ramsar site).**	Maintain abundance of waterfowl (i.e. maximum total annual abundance is > 80,000). Maintain abundance of shorebirds (i.e. maximum total annual abundance is > 20,000).

Value and baseline at the time of listing	Limit of Acceptable Change	Current condition	Resource Condition Target
Waterbird breeding – good data from the Western Treatment Plant, limited quantitative data from elsewhere, but the importance of Mud Islands as a nesting site is well documented.	Annual breeding at Mud Islands of: Pied Cormorant > 40 pairs Straw-necked Ibis > 10,000 pairs Australian White Ibis > 5, 000 pairs White-faced Storm-Petrels > 1000 pairs Crested Terns > 1000 pairs Silver Gulls > 30,000 pairs Annual breeding at Western Treatment Plant of: Pied Cormorant > 300 pairs	The only comprehensive recent count of nesting waterbirds at Mud Island was in 2009 (Menkhorst 2010): Pied Cormorant - 50 pairs Straw-necked Ibis 56,000 nests Australian White Ibis 7500 nests White-faced Storm-Petrels 1000 nests Crested Terns 1300 nests Silver Gulls > 30,000 nests Nesting pied cormorants increased at the Western Treatment Plant to approximately 1000 nests in 2010-2012 (Loyn et al. 2014). **LAC is met**	Maintain abundance of nesting Birds at the Western Treatment Plant (> 500 pairs of pied cormorant). Mud Islands: Maintain breeding colonies of White-faced storm petrels, and crested terns (noting that abundance is a knowledge gap).
Threatened species: birds Counts of bar-tailed godwit, eastern curlew, great knot, hooded plover, lesser sand plover and red knot indicate moderate to low, but persistent numbers within the site. At the time of listing there were larger numbers of orange-bellied parrot in the site, with an average of 70 individuals at Point Wilson and over 30 in the Lake Connewarre complex. Numbers of orange-bellied parrots on mainland Australia have decline in recent years, although the Werribee section of the Ramsar site is one of the few mainland areas that continues to support the species.	Bar-tailed godwit, eastern curlew, great knot, hooded plover, lesser sand plover and red knot recorded within the site in three out of five seasons.	Data from 2011 – 2015 indicate presence of the four species (BirdLife Australia): Bar-tailed godwit – four years Eastern curlew – five years Great knot – three years Hooded plover – three years **Lesser sand plover – zero years** Red knot – four years **LAC is met for all species except lesser sand plover.**	Re-establish Orange-bellied parrots within the Ramsar site. Maintain Australian fairy tern, bar-tailed godwit, eastern curlew, great knot, hooded plover, lesser sand plover and red knot within the site.
Threatened species: Growling grass frog. Large population at the Western Treatment Plant	At Western Treatment Plant > 200 Growling Grass Frogs in 3 out of 5 years.	Growling grass frog recorded in three of the five years from 2012 to 2016 (Melbourne Water unpublished). **LAC is met.**	Maintain population of growling grass frog in the Western Treatment Plant.

Appendix E: Cross reference of management strategies with priority values, threats and knowledge gaps

Values	Threats	Knowledge gaps
V1. Hydrology V2. Fish • Abundance and diversity • Threatened species (Australian grayling) V3. Waterbirds • Abundance and diversity • Breeding • Threatened species (shorebirds, Australasian bittern, OBP) V4. Growling grass frog V5. Coastal saltmarsh V6. Intertidal sand and mud flats V7. Freshwater aquatic vegetation V8. Mangroves	T1. Climate change: sea level rise T2. Climate change: increased frequency and intensity of storms leading to shoreline erosion T3. Recreation: boats, jets skis, kit surfers disturbing waterbird feeding, breeding and roosting T4. Recreation: walkers, horse-riding) disturbing waterbird feeding, breeding and roosting T5. Recreation: vehicles damaging saltmarsh T6. Recreation: duck hunting impacts to non-target species T7. Invasive species: salt-tolerant weeds T8. Invasive species: foxes and cats predating on waterbirds T9. Invasive species: introduced marine pests (current and potential new invasions) T10. Grazing animals (rabbits, deer) in wetlands and saltmarsh T11. Changed operations at the Western Treatment Plant decreasing nutrients and carbon T12. Stormwater altering salinity and hydrological regimes T13. Toxicants from stormwater T14. Urban, commercial and industrial development (direct habitat removal and associated impacts)	K1. Chemicals of emerging concern: sources, concentrations and risk to Port Phillip Bay K2. Micro-plastics: risk to ecological character K3. Effect of mosquito control chemicals on waterbirds through the food chain K4. Water quality of stormwater discharges in key locations. K5. Potential impacts of stormwater discharge on Hospital Swamp K6. Impacts of duck hunting on shorebirds. K7. Freshwater inflows to Swan Bay - magnitude and effects on ecology K8. The benefits of surrounding wetland systems on the ecological character of the Ramsar site (Swan Bay in particular) K9. Causes and effects of pathogens and disease on waterbirds (e.g. botulism, avian cholera) K10. The impacts of introduced marine pests on ecological character

Management Strategies	Responsibility	Linkages to existing programs / activities	Relevant Priority values	Relevant knowledge gaps	Relevant threats	Relevant segments
1.1 Manage human access to minimise disturbance at waterbird and seabird breeding colonies in the Port Phillip Bay Ramsar site during the breeding season.	Parks Victoria		V3		T3, T4, T5, T6	Mud Islands, Lake Connewarre complex
1.2 Work with the community, tour operators and other stakeholders to minimise impacts to shorebirds and nesting birds from recreational boating activities.	Parks Victoria DELWP	Port Phillip Bay Environmental Management Plan (EMP)	V3		T3	Mud Islands Swan Bay
1.3 Monitor priority locations for marine pests and respond rapidly to new introductions.	Parks Victoria DELWP EPA Victoria	Port Phillip Bay Parks Victorian Marine Invasive Species Guide	V2, V5, V7	K10	T9	Mud Islands Swan Bay Limeburners Bay
1.4 Develop and implement measures to control carp within the Barwon River, Reedy Swamp and Hospital Swamp.	CCMA Parks Victoria	Corangamite Waterway Strategy	V2			Lake Connewarre complex
1.5 Continue to implement pest plant and animal control in priority locations for species identified as a significant threat to ecological character (i.e. salt tolerant weeds in saltmarsh; cats and foxes in orange-bellied parrot, shorebird and nesting bird habitats).	Parks Victoria Melbourne Water CMAs	Coastal Tender and Saltmarsh Protection Project PPWCMA Ramsar Protection Program	V3, V4, V5, V6, V7, V8		T7, T8, T10	All
1.6 Identify and prioritise litter hotspots within the Ramsar site and undertake prevention and remediation activities.	EPA Victoria Parks Victoria	Port Phillip Bay EMP	V2, V3	K2	T15	Mud Islands
1.7 Investigate options for addressing cumulative impacts of land use change and development on ecological character.	DELWP Councils	DELWP Wetland Buffer Guidelines Planning schemes	All	K4, K5, K7	T14	All
1.8 Develop advice to assist local government and other agencies to manage development within the Ramsar site buffers to protect the ecological character of the Ramsar site.	DELWP	DELWP Wetland Buffer Guidelines Planning schemes	All	K8	T1, T2, T14	All
2.1 Identify and assess options for managing risk to coastal habitats (saltmarsh, seagrass and intertidal flats) from sea level rise and implement as appropriate.	DELWP Councils CMAs	Priority Zone Plan for Bellarine Peninsula DELWP Climate change vulnerability assessment and adaptive capacity of coastal wetlands	V3, V5, V6, V7, V9		T1, T2	All

2.2 Identify opportunities for artificial habitat creation within and adjacent to the Ramsar site to compensate for potential habitat loss due to sea level rise and implement as appropriate.	DELWP CMAs	DELWP Climate change vulnerability assessment and adaptive capacity of coastal wetlands	V3, V5, V6, V7		T1, T2	All
2.3 Identify sites at most risk from extensive shoreline erosion and implement appropriate interventions.	DELWP	Bellarine Peninsula - Corio Bay Local Coastal Hazard Assessment	V3, V5, V6, V7, V9		T1, T2	Cheetham Mud Islands
3.1 Continue to implement the actions in the Stormwater and Corangamite Waterways strategies aimed at reducing nutrient, sediment and toxicant discharges to the Ramsar site.	Melbourne Water CCMA	Healthy Waterways Strategy 2018 Corangamite Waterways Strategy Integrated Water Management Framework	V2, V4, V5		T12, T13	
3.1 Maintain appropriate concentrations and loads of nutrients (nitrogen and total organic carbon) in Western Treatment Plant discharges to adjacent intertidal mudflats to support ~12,000 shorebirds over summer.	Melbourne Water	Monitoring for a specific management objective: protection of shorebird foraging habitat adjacent to a waste water treatment plant (Morris et al. 2017)	V3		T11	Werribee
3.3 Continue to implement water regime management in artificial habitats within the Ramsar site.	Melbourne Water Parks Victoria	Cheetham Wetlands Hydrology Manual Environmental Flow Recommendations of Recycled Water to Support Significant Biodiversity Values at the Western Treatment Plant	V1, V2, V3, V4, V6, V8		T12, T13	Cheetham Werribee Pt Wilson (Snake Island)
3.4 Continue to develop and implement environmental watering at Reedy Lake.	CCMA	Barwon Wetlands Seasonal Watering Proposals	V1, V2, V3, V4, V8		T12	Lake Connewarre complex
3.5 Assess the risk to water quality in Swan Bay from inflowing streams.	EPA Victoria City of Greater Geelong	Monitoring for a specific management objective: protection of shorebird foraging habitat adjacent to a waste water treatment plant (Morris et al. 2017)	V2, V3, V5, V6	K4, K7	T12, T13, T14	Swan Bay

4.1 Investigate the risks to ecological character from microplastics	EPA Victoria	PPB EMP	V2, V3	K2	T15	All shoreline locations
4.2 Investigate the risks to waterbirds and fish associated with aerial spraying for mosquitoes in intertidal habitats	City of Greater Geelong EPA Victoria		V2, V3	K3	T14	Swan Bay, Pt Wilson, Lake Connewarre Complex
4.3 Improve our understanding of the effects of chemicals of emerging concern on ecological character	EPA Victoria Melbourne Water	PPB EMP	V2, V3, V4	K1	T13	Werribee
4.4 Assess the impact of duck hunting on disturbance of non-target species, particularly shorebirds and OBP.	DELWP		V3	K6	T6	Lake Connewarre Complex, Werribee, Pt Wilson
4.5 Investigate the causes and potential mitigation strategies for avian diseases in the Ramsar site	DELWP EPA Victoria	PPB EMP	V3	K9		Werribee Mud Islands
5.1 Develop and implement a Port Phillip Bay Ramsar site wetland information and interpretation program.	PV DELWP Councils	PPB EMP	All		T3, T4, T5, T6, T14	All
5.2 Work with Aboriginal groups to improve understanding of Aboriginal values associated with the Ramsar site and develop opportunities for Aboriginal involvement in Ramsar site management	CMAs DELWP PV	Wetland Wardens PPB EMP	All			All
5.3 Build capacity and collaboration with community and industry groups by supporting citizen science and on-ground community action in Ramsar site management	CMAs DELWP PV NGOs	PPWCMA Ramsar Protection Program PPB EMP	All		T3, T4, T5, T6, T14	All
6.1 Review the Ramsar sit boundary to reflect: • potential adjacent habitat that could be added to the site • excising of areas that do not contribute habitat or buffer capacities • to allow for future migration of habitats under future climates.	DELWP DoEE Ramsar Coordinating Committee		All	K8	T1, T2	All
6.2 Apply the appropriate State and Commonwealth environmental impact assessment and approval processes for	DELWP DoEE		All	K5	T11, T14	All

activities that have the potential to impact on the Ramsar site and Matters of National Environmental Significance (MNES).				
6.3 Undertake a regular review of the status of the ecological character of the Ramsar site. This review should include new and emerging issues as well as the current listed values and threats.	DELWP	All	All	All
6.4 Update management plans for the Lake Connewarre State Game Reserve and The Spit Nature Conservation Reserve	DELWP, CCMA, PV	All	All	Lake Connewarre Complex
6.5 Develop action plans for this strategy.	Ramsar Coordinating Committee	All		All

Appendix F: Public consultation feedback

The draft Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan was open for public comment from 6 December 2017 to 1 March 2018. Two versions of the plan were made available on the Corangamite CMA website:

- The full draft plan; and
- The summary draft plan.

The broader community along with agencies, councils and non-government organisations were invited to provide feedback, either by providing a formal submission via a feedback form available on the Corangamite CMA website, or in person at two community forums:

- **Werribee** – 12th February 4 pm Wyndham Park Community Centre
- **Geelong** – 13th February 4 pm Geelong West Town Hall

A diverse group of interested community members and organisations attended the community forums and provided verbal feedback. Written submissions were received from 18 individuals and organisations. Issues raised in the consultation process have been grouped into a series of themes with responses to common questions provided below.

Feedback received – Ramsar site boundary review

The issue of reviewing the boundary for the Ramsar sites was the most common comment received on the draft plan. It was raised at the community forums and in the majority of written submissions. For example:

"*We note that the existing extent of the Ramsar site does not include some key wetlands which are recognised as forming part of the same wetland and coastal complex for the waterbirds using these sites, and form part of the Important Bird Area (IBA) designated as 'Bellarine Wetlands' by Birdlife Australia. In particular, the Cheetham Saltworks at Moolap and the wetlands system at Point Lonsdale are integral sites which should be encompassed within this Ramsar site*."

Response:

There is an action in the management plan to undertake a boundary review. This will be undertaken in line with policy set out in the Victorian Waterway Management Strategy and in collaboration with all interested parties and stakeholders.

Feedback received – Objective of the management plan

Several submissions provided feedback on the purpose and / or form of the management plan. For example:

"*It needs to include the words "using ecosystem approaches", as used by the Convention*."

"*What is needed here is a goal (not objective) that references the Ramsar agreement. Australia has signed up to conserving the biodiversity, preventing unsustainable and unwise use, protecting threatened species and adopting an ecosystem approach*."

Response:
The development of Ramsar site management plans are guided by the rules of the Ramsar Convention and the Australian Ramsar Management Principles, the latter of which is embedded in the EPBC Act. These management plans provide the strategic direction for management of the Ramsar sites to maintain and restore ecological character. The concept of "wise use" is central to the Ramsar Convention and the management of Ramsar sites. The Convention specifically recognises that wetlands support multiple and often conflicting values and uses and seeks to promote the protection of ecological character through sustainable use. The objective of this management plan reflects this principle.

Feedback received – Scope of the management plan

A small number of submissions made suggestions for including management of values that are located outside the Ramsar site boundary. For example: the inclusion of growling grass frog in the freshwater streams of the Swan Bay Catchment.

Response:
The objective of this Ramsar Site Management Plan is to maintain the ecological character of the site (as dictated by the Ramsar Convention and the Ramsar Management Principles). While this includes addressing

threats outside the boundary that may be impacting on the ecological character of the site, it does not include managing all the values in the region or catchment. This would dilute the effectiveness of the plan to maintain character of the core wetland habitats within the site boundary. Protected species, such as growling grass frog, are subject to a range of additional management and policy initiatives.

Feedback received – Priority threats

Threats to the ecological character of the Ramsar site were a commonly raised issue. The most frequently raised threats were:

- the impacts of catchment inflows on the water quality in Swan Bay.
- pressures from urban expansion and land development adjacent to the Ramsar site.
- climate change and sea level rise.

Response:
The development of the Ramsar Site Management Plan included a rigorous risk assessment which assed the potential risks from all plausible threats to the values of the Ramsar site. The issues raised have been captured in this risk assessment using an evidence based approach. In instances where additional evidence was provided in public submissions, the risk assessment has been updated and additional information included. In some instances, such as water quality impacts to Swan Bay, there is little evidence on the effects of altered water quality on ecological character and this has been identified as a priority knowledge gap. Several additional management strategies were added to address priority threats raised in the public consultation including:

- *1.8 Develop advice to assist local government and other agencies to manage development within the Ramsar site buffers to protect the ecological character of the Ramsar site.*
- *3.5 Assess the risk to water quality in Swan Bay from inflowing streams.*

Feedback received – Consultation and stakeholder involvement

Several submissions raised the issue of stakeholder involvement in the implementation of the plan. For example:

"*Opportunities on an annual or bi-annual basis for community members and groups to comment on the management of Ramsar sites and highlight problems or areas of concern is requested*."

Response:

The steering committee governing the development of the management plan agreed that there should be an opportunity for regular input to site management by interested stakeholders and community members. This will form a component of the "Communication, Education, Participation and Awareness (CEPA)" activities associated with the management of this Ramsar Site. This is covered by the three management strategies under theme 5, which specifically targets CEPA activities.

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