



LOWER BARWON REVIEW 2020

Issues and advice paper | Final | 13 May 2020

This Issues Paper has been prepared by Alluvium Consulting Australia Pty Ltd for the Corangamite Catchment Management Authority under the contract titled 'Lower Barwon Review 2020'. The paper has been prepared in collaboration with the Expert Review Panel (John Sherwood, Paul Boon, David Crook, Richard Loyn, Guy Dutson), appointed by the Department of Environment, Land, Water and Planning.

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Summary

Reedy Lake and Hospital Swamps are part of a larger Lake Connemara wetland complex that is associated with the Lower Barwon River. The wetland complex, located on the central Victorian Coast, is part of the larger Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site and is highly valued for its environmental values. Reedy Lake and Hospital Swamps are actively managed with environmental water to improve the ecological character of the sites.

In 2012, a study was undertaken by Lloyd et al. (2012) to determine the water requirements for maintenance of ecological values of the Reedy Lake and Hospital Swamps, to set ecological objectives and to devise an optimal watering regime to achieve these objectives. In the years since the initial recommendations for Reedy Lake and Hospital Swamps were made, new information has become available and management actions have been adapted to adjust to changing circumstances. A major change over this time has been the adaptation of a recommended watering regime to attempt to better accommodate the shared benefits of the site. The adapted watering regime was implemented on a four-year trial basis (Figure 1) to conclude with a review of the effectiveness of its implementation.

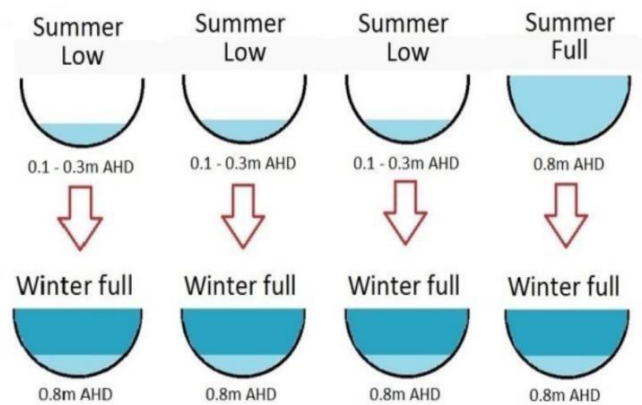


Figure 1. Adapted four year trial watering regime implemented at Reedy Lake, showing years 1 to 4 from left to right.

The purpose of this project was to improve the ability of the Corangamite Catchment Management Authority (CMA) to deliver and manage water within Reedy Lake and Hospital Swamps to achieve environmental objectives whilst accommodating the values of the community wherever possible. The focus of this project was to review the environmental watering regime of the past three years in the context of the environmental objectives for the site. Specifically, to:

- review the adapted watering actions and their impact on the ecological values of the site
- provide comment on the appropriateness of the adapted watering regime for achieving ecological outcomes and balancing shared benefits.

An independent Expert Review Panel was engaged by the Department of Environment, Land, Water and Planning (DELWP) to review the adapted watering actions and their impact on the ecological values of the site; and provide comment on the appropriateness of the adapted watering regime for achieving ecological outcomes and balancing shared benefits. Alluvium Consulting Australia (Alluvium) was engaged by the Corangamite CMA to manage the project to ensure a fully independent process.

Management context for the Lower Barwon wetlands

Management of the Lower Barwon Wetlands needs to be considered and implemented within the context of the Ramsar obligations associated with the broader Port Phillip (Western shoreline) and Bellarine Peninsula Ramsar site. This primarily focuses on maintaining the ecological character of the site within the Limits of Acceptable Change (LAC).

Environmental water management at the site must also be undertaken within the planning and policy framework for Victoria. Management of the site must occur within the rules and obligations set out in the Water Act 1989, be consistent with policy and strategic directions outlined by DELWP and adhere to the planning process and timeframes established by DELWP and the Victorian Environmental Water Holder (VEWH).

Management of the site is coordinated to achieve the overall site objective for the Lower Barwon wetlands developed by the Lower Barwon Community Advisory Committee (LBCAC) through the seasonal watering proposal process. The objective is to:

“Maintain the ecological character of the wetlands”

This goal is consistent with Ramsar obligations, State Government policy and the objective of the environmental water reserve (i.e. to preserve the environmental values and health of water ecosystems, including their biodiversity, ecological functioning and quality of water and other uses that depend on environmental condition). The ‘ecological character’ of the wetlands refers to the diversity of habitats present in 1983 when the wetlands were listed under Ramsar, and is supported by the LAC which requires that:

“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 more than 70% of the total wetland area for more than five successive years”.

Implementation of the environmental water regime during the trial period

Hospital Swamps was recognised by Lloyd et al (2012) as having a fairly stable hydrological regime. Regular winter flooding and summer drying cycles appear to have allowed a steady state to be achieved for its plant communities. Lloyd et al (2012) recommended a continuation of the existing pattern of watering and this has been achieved. The swamp has filled each winter to 0.6 - 0.8m AHD and then gradually dried to 0.2m AHD in autumn before beginning to refill.

The adapted flow regime implemented at Reedy Lake (Figure 1) in place of the 10-year watering regime was based on the long-term recommendations in Lloyd et al. (2012) with some changes to a number of elements. The changes to these recommendations that were made during implementation were:

- Not implementing a full drying scenario as proposed one year in four
- Commencing drawdown in October – November rather than in December
- Allowing water levels to draw down to between 0.1 and 0.3 mAHD, with an open outlet and tidal fluctuation
- Commencing refilling in mid-March rather than during winter – spring.

These changes were made based on the best available advice at the time and responded to a variety of different factors such as addressing the potential risk posed by acid sulphate soils, to accommodate shared benefits at the site and as a part of the annual process of compiling the available information and agreeing on actions through community engagement as a part of developing the seasonal watering proposal.

Review of current knowledge

To understand the impact of adopting a modified watering regime at Reedy Lake and Hospital Swamps, the Expert Review Panel examined the new data that had become available since 2012, along with older data (where available) to provide a longer-term perspective. It is important to note that, at the time of doing this study, the full four-year watering regime has not yet been delivered at Reedy Lake. The current water year is intended to be a full wetland summer scenario after the previous three dry summer scenarios.

On review of the evidence and existing monitoring data the Expert Review Panel identified several findings and issues for further consideration. While the Expert Review Panel reviewed all the data that was available, they particularly focused on data that related to key issues and questions about the site raised through engagement with the community-based project advisory group.

Highlight findings and issues identified by the Expert Review Panel included:



The claim that tall reeds are expanding needs further investigation

Previous watering recommendations were developed on the assumption that tall reeds were expanding. New satellite data shows no evidence of tall reed expansion. The proportion of

open water habitat has remained consistent between 20 and 30% of total wetland area since 1997. Recent survey has also indicated there has not been a significant increase in tall reed extent. Further investigation is required to conclusively determine if tall reeds are expanding and habitat composition is changing.



Carp densities may be lower than previously estimated

Observed carp densities have indicated that management for carp may be required less frequently than previously thought. Population modelling has indicated that it would take several years for carp to reach the threshold density of 200 kg/ha that indicate detrimental impacts. Less frequent management to control carp through drying will reduce the risk to native fish populations.



The status of birds and their use of the site needs further investigation

There has been a decline in the numbers of shorebirds and ducks at the site which have coincided with very dry years. The decline in bird numbers could be related to a decline in waterbirds across south-eastern Australia or site-specific management, however there is not enough information to determine this. There has also been a decline in colonial waterbird nesting, however the importance of the site for breeding is still unknown.

Throughout this project, a significant number of Australasian Bittern were recorded, indicating the site may be important to support this species. Further investigation is required to determine how this species utilise the wetlands.



The risk of acid sulphate soil generation is low

There is a low risk of generating acid sulphate soils if sediments below 0 m AHD are not disturbed. Concentrations of heavy metals are generally within the national guidelines.



Urban runoff is an emerging threat

Urban development adjacent to the site is an emerging threat particularly for Hospital Swamps. Increased runoff of reduced quality from Armstrong Creek has the potential to impact on values. Mitigation measures to manage this runoff will need to be collaboratively developed to ensure that negative impacts are reduced.

Advice

Having reviewed the available data and gained an understanding about the key issues at the site the Expert Review Panel developed advice about future environmental water management actions and monitoring activities required at the Lower Barwon Wetlands. The Expert Review Panel provide seven pieces of advice (noting that those marked with ! are of critical importance).



Commit to updating the environmental watering recommendations by 2022

The current environmental watering recommendations for the site should be updated and reviewed by 2022 as a matter of high priority. After reviewing the currently available information, the Expert Review Panel questions the validity of assumptions that the flow recommendations were based upon. Other matters raised about the suitability of the current watering regime concern the hydrological data and assumptions used to inform the recommendations. These uncertainties warrant an evidence-based review of the ecological values, management objectives and current watering recommendations for Reedy Lake and Hospital Swamps.



Develop a water and salt balance model prior to updating the environmental watering recommendations

Only with the information provided by a water-balance model can critical management decisions such as the timing of drawdown, the necessity of assisted drawdown and the appropriateness of stormwater runoff mitigation measures be made in the form of watering

recommendations. Watering recommendations should not be reviewed unless a water and salt balance model has been undertaken.

The model must include Reedy Lake, Hospital Swamps and Lake Connnewarre and will need to consider:

- Surface-water and ground-water interactions
- A range of hydrologic conditions including drought years, average years and wet years
- Future stormwater runoff from the Armstrong Creek development
- Climate change scenarios

3

Address other key knowledge gaps prior to updating environmental flow recommendations

To better understand the potential threats and drivers for management at the site it would be advantageous to undertake further investigations prior to the 2022 review to determine:

- If the encroachment of undesirable taxa of tall reeds (especially *Phragmites australis* and *Typha* spp.) is a problem that management actions should focus on.
- If carp densities are approaching levels requiring management action
- Responses of vegetation and fish to the summer-full water regime applied in the fourth and final year of the current trial.
- Monitoring of Australasian Bittern breeding to determine their use of the site and any adaptations to the watering regime that may support improved outcomes

As the previous environmental water recommendations were based on some key assumptions, it would be beneficial to re-evaluate the central assumptions that underpinned them before undertaking a review of the existing recommendations.

4

Develop an agreed environmental water management plan for the wetlands

Environmental Water Management Plans (EWMPs) are an important and detailed management document that will assist in the long-term management of the Lower Barwon wetlands. The plan will set out the goals of environmental watering, ecological objectives and the watering regime to achieve the ecological objectives at the site or waterway scale and cover a longer planning scale than the annual seasonal watering plans. Typically, an EWMP is developed after environmental watering recommendations as a way to develop these recommendations into a plan for water management at the site.

5

Implement the longer-term Lloyd et al watering regime in Reedy Lake in the short term

The Expert Review Panel supports a wetting and drying regime for Reedy Lake. In the absence of reviewed or modified environmental watering recommendations, the Expert Review Panel advises that the long-term watering recommendations from Lloyd et al. (2012) should be implemented at Reedy Lake. Long-term watering recommendations were made with the objective of balancing all the ecological values at the site. The recommendations were based on a seasonally adaptive approach.

Given the recent wetting and drying regime that has been implemented at Reedy Lake, the Expert Review Panel advises that implementing the driest 25% of years scenario should be avoided in the years leading up to a review in 2022.

6

Implement the environmental watering recommendations from Lloyd et. al. (2012) in Hospital Swamps in the short term and advocate for strong control measures on urban inflows

The available data at Hospital Swamps seems to indicate that the environmental watering recommendations are appropriate and ecological values are in good condition. The wetting and drying hydrology of Hospital Swamps has been maintained over a long period of time and there appears to be no detrimental impact of this regime. For this reason, the Expert

Review Panel advise that the water regime at Hospital Swamps should be maintained pending better future monitoring data.

The increasing urban area and increased stormwater runoff from the Armstrong Creek urban development poses a significant risk to Hospital Swamps. Mitigation measures and operating rules around stormwater runoff for the development have not yet been finalised. The Expert Review Panel strongly advises that the CMA continue engaging with the City of Greater Geelong on the Southern Diversion Channel, Sparrovale Wetland, water quality and connectivity issues, changes to watering infrastructure and the implications for operating rules and approaches.



Implement a targeted monitoring regime to address key monitoring questions

The Expert Review Panel have recommended strongly that a targeted monitoring program be undertaken to gauge the effectiveness of past and future water-level manipulations. The requirements for this program are outlined in the full report. Less focussed survey work or surveillance programs may also be undertaken to provide background information, but future monitoring efforts should address the answering of specific management or scientific questions, framed before the monitoring activities commence.

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1 Introduction

Reedy Lake and Hospital Swamps are part of a larger Lake Connewarre wetland complex that is associated with the Lower Barwon River. The wetland complex, located on the central Victorian Coast, is part of the larger Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar site and is highly valued for its environmental values. Reedy Lake and Hospital Swamps are actively managed with environmental water to improve the ecological character of the sites.



Figure 2. Reedy Lake and Hospital Swamps within the Lake Connewarre Wetland complex. The Ramsar site boundary is shown in white, and the focus of this review are shaded blue.

In 2012, a study was undertaken by Lloyd et al. (2012) to determine the water requirements for maintenance of ecological values of the Reedy Lake and Hospital Swamps, to set ecological objectives and to devise an optimal watering regime to achieve these objectives. In the years since the initial recommendations for Reedy Lake and Hospital Swamps were made, new information has become available and management actions have been adapted to adjust to changing circumstances. A major change over this time has been the adaptation of a recommended watering regime to attempt to better accommodate the shared benefits of the site. The adapted watering regime was implemented on a four-year trial basis to conclude with a review of the effectiveness of its implementation.

An independent Expert Review Panel (ERP; [Table 1Table 1](#)) has been engaged by the Department of Environment, Land, Water and Planning (DELWP) to review the adapted watering actions and their impact on the ecological values of the site; and provide comment on the appropriateness of the adapted watering regime for achieving ecological outcomes and balancing shared benefits. Alluvium Consulting Australia (Alluvium) have been engaged by the Corangamite Catchment Management Authority (CCMA) to manage the project to ensure

a fully independent process. Alluvium are responsible for coordinating all of the technical input and advice from the Expert Review Panel, facilitating the input of, and reporting back to the project Steering Committee and the Project Advisory Group.

Table 1. Independent Expert Review Panel

Panel member	Qualifications	Experience summary
Dr John Sherwood Estuarine specialist	Bachelor of Science (Honours), UNSW (1965-1968) PhD, UNSW, 1974	John has extensive experience in aquatic biogeochemistry as it relates to estuaries. A significant amount of his published work relates to the hydrodynamics and management of SW Victorian estuaries.
Prof. Paul Boon Ecologist	Bachelor of Science (Honours), University of Sydney (1976-1979) PhD, Griffith University, Qld (1981-1984)	Paul has 40 years of experience in aquatic systems, with specific expertise in aquatic biogeochemistry, the ecophysiology of aquatic vegetation, and the environmental flow requirements of vegetation in rivers, wetlands, estuaries and floodplains.
Dr David Crook Aquatic ecologist	Bachelor of Science (Honours), UTAS (1990-1993) PhD Environmental Science, CSU, 1998-2002	David has 25 years of experience conducting aquatic research and providing expert advice for environmental policy and management. Much of David's research focusses on the migration of diadromous fishes (species that migrate between freshwater and the sea), where he has applied telemetry, otolith and genetic techniques to study a range of Victorian coastal fishes, including eels, tupong, Australian grayling and Australian smelt.
Dr Richard Loyn Ecologist	Master Natural Sciences, Cambridge University (1969-1972) DSc. University of Melbourne, 2019	Richard previously worked for more than 26 years as a principal scientist at the Arthur Rylah Institute where he managed the Community Ecology section. Richard's areas of expertise and research interest include ecology and management of wetlands, forests, fire and threatened species.
Dr Guy Dutson Ornithologist	Master Natural Sciences, Cambridge University (1987-1990) VetMB. Cambridge University (1990-1994)	Guy has worked for more than 30 years on bird science and conservation projects in Australia and the wider Pacific region. He has worked mostly for BirdLife Australia and as a private consultant. Guy lives in Ocean Grove and has been personally exploring and documenting the wildlife of the Lower Barwon Wetlands for many years.

1.1 Project scope

Scope

Alluvium and the Expert Review Panel were required to review the environmental watering actions of the past three years and associated impacts at Reedy Lake and Hospital Swamps. This project focuses solely on the environmental watering, which is the responsibility of the Corangamite CMA, not other land management including pest animal control, access and visitor facilities, which are the responsibility of Parks Victoria.

The focus of this project was to review the environmental watering regime of the past three years in the context of the environmental objectives for the site. Specifically, the purpose of the project was to:

1. review the adapted watering actions and their impact on the ecological values of the site; and
2. provide comment on the appropriateness of the adapted watering regime for achieving ecological outcomes and balancing shared benefits.

The original flow/ecology report (Lloyd et al. 2012) has been through a Technical Assessment Panel review and it was not the intention of this project to review the report again. Rather, the intention is to set out the legal

and policy context, the additional technical advice, stakeholder concerns, management adaptations made to date, and any early data as to the effectiveness of the current watering program.

Objectives

The purpose of this project is to improve Corangamite CMA's ability to deliver and manage water within Reedy Lake and Hospital Swamps to achieve environmental objectives whilst accommodating the values of the community wherever possible. At the conclusion of this project, Corangamite CMA hope to have increased their ability to adaptively manage the sites and assess the effectiveness of the watering regime through targeted monitoring activities.

1.2 This report

This project had two stages:

1. Understanding the issues

This stage was about gaining an understanding of the past management actions at the sites, describing community issues and concerns and reviewing the technical evidence in the context of these issues.

2. Developing recommendations

This stage was about using the evidence gathered to make recommendations about the future management of environmental watering at the sites and recommend future monitoring activities.

This report is the final 'Issues and Advice Paper' and summarises the work completed in the first and second stage of the project. Throughout the project, the Expert Review Panel have had the opportunity to engage with the Project Advisory Group and Steering Committee (list of members of both groups provided in Attachment A) to understand the issues and concerns of the community as well as gain an understanding of the history and context of environmental water management of this site (outlined in sections 1-4).

The Expert Review Panel then developed advice for the ongoing management of environmental water at the site and future monitoring activities (provided in section 5). This report does not outline new environmental objectives and watering recommendations for the site, rather it provides advice on management actions based on the appropriateness of the adapted water regime and maximising benefit to the environmental whilst balancing the shared benefits of the site.

2 Management context

Environmental watering is guided in Victoria through a comprehensive framework of policy and legislation. Additional legislative and policy frameworks also apply to sites that are of international significance such as Ramsar listed wetlands like Reedy Lake and Hospital Swamps.

2.1 Management obligations under the Ramsar Convention

The Ramsar Convention on Wetlands of International Importance is an international treaty that aims to prevent the loss of and encourage conservation and wise use of all wetlands. Under the Convention, sites containing representative, rare or unique wetlands, or wetlands that are important for conserving biological diversity may be listed. Once designated, these sites are added to the Convention's List of Wetlands of International Importance and become known as Ramsar sites. The Lower Barwon Wetlands were listed under the Convention in 1982, as part of the Port Phillip (Western shoreline) and Bellarine Peninsula Ramsar site. The listing requires that additional planning and implementation of management actions be undertaken to ensure their protection.

The listing of a site under the Ramsar Convention requires DELWP and on-ground managers such as Parks Victoria, Melbourne Water and CMAs to meet a range of obligations relating to management of Ramsar sites to maintain or improve the site's 'ecological character'. There are three guiding documents that the managers need to prepare and keep up to date:

1. **Ramsar information sheet (RIS)**
A RIS is required for each Ramsar site and should be updated every six years or if/when the ecological character of the site changes.
2. **Ecological character description (ECD)**
An ECD provides a baseline of the ecological character of the site at the time it was listed under the Ramsar Convention. It must include the site details, a description of the important components, processes, benefits and services of the site, the limits of acceptable change for the site, potential threats to the site and knowledge gaps and monitoring needs. The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site ECD has not been endorsed by the Commonwealth Government and is in draft format.
3. **Site management plan**
Management plans outline the management, monitoring and evaluation activities that are required to ensure the maintenance of ecological character of Ramsar sites and address current and future risks to the site. The Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan was updated in 2018.

Management oversight and implementation of management actions at Victoria's Ramsar sites is set out by clear roles and responsibilities, as follows:

- **Ramsar state-wide coordinator:** DELWP
- **Ramsar site coordinators:** catchment management authorities and Melbourne Water
- **Ramsar site managers:** Parks Victoria and Melbourne Water for most sites.

DELWP, as the state-wide coordinator, oversees the implementation of Ramsar Convention obligations in Victoria. DELWP oversight supports a consistent approach to management, planning, monitoring and reporting and addresses issues that cannot be managed at a site level. DELWP is also responsible for reporting to the Australian Ramsar Administrative Authority within the Commonwealth Department of Agriculture, Water and the Environment (AWE) and working with AWE to keep Ramsar site documentation up-to-date.

Ramsar site coordinators are responsible for convening site coordinating committees, made up of agency partners under an agreed Terms of Reference. Corangamite CMA is the site coordinator for the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. The site coordinating committees oversee implementation of the site management plans and monitoring, evaluation, reporting and improvement (MERI) plans. The site coordinator is responsible for developing, with the coordinating committee, an annual action plan that targets priority actions and monitoring, according to available resources, and includes an agreement

as to which agency is responsible for each action. The site coordinator completes annual investment and implementation reporting to the state-wide coordinator, tracks ecological character and agrees to report any trends that may indicate a potential decline or change in ecological character. The site coordinator also agrees to take an active part in renewing site management plans and providing input for site documentation updates.

The **Ramsar site manager** is the agency that has land management responsibility. Parks Victoria is the land manager for most parts of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site, and Melbourne Water is the land manager for the Western Treatment Plant. Ramsar managers are responsible for taking part in site coordinating committee activities, implementing their agreed responsibilities, and notifying the site coordinator of any indication of a potential change in the ecological character of the site.

2.2 Water for Victoria

Water for Victoria is the Victorian Government's long-term direction for managing Victoria's water resources (DELWP 2016b). It guides the direction of water management across the state and sets out priority actions to be implemented throughout the life of the plan. The plan covers all facets of water resource management including the management of environmental water. Water for Victoria recognises that community expectations around water have changed and many communities value lakes, rivers and wetlands for their recreational opportunities and cultural significance.

An important focus of Water for Victoria is providing shared benefits for all users. The plan seeks to do this by targeting actions that aim to recognise and manage Aboriginal values through capacity building, incorporation of traditional values in water planning and supporting access to water for economic development of Aboriginal communities. Water for Victoria also aims to recognise recreational values by including these values in water planning, helping communities understand how to achieve their recreational objectives and support recreation at water storages.

2.3 Victoria's Water Entitlement Framework

In Victoria, environmental water is managed in accordance with the Victorian water entitlement framework, established under the *Water Act 1989*. The *Water Act 1989* (Vic) defines rights to water:

- Section 7 provides that the Crown has the right to the use, flow and control of all water in a waterway and all groundwater
- Section 8 provides for an individual's rights to water
- Section 9 sets out rights of water corporations to water

The *Water Act 1989* (Vic) also governs entitlements to water issued by the Minister for Water, including: Bulk Entitlements, Environmental Entitlements, water shares, and water licences.

In 2005, the Act was amended to formally establish the Environmental Water Reserve (EWR). This amendment helped to improve the distinction between water that is available for consumptive use and water for environmental purposes and created a new provision for allocating environmental entitlements (DELWP 2016a).

Water for the environment is provided under the EWR in three ways:

- Environmental Entitlements
- Obligations and conditions on consumptive use
- Above cap water

In the Lower Barwon Wetland system, water for the environment is provided under the *Barwon River Environmental Entitlement 2011*. Environmental Entitlements are allocated to the Victorian Environmental Water Holder (VEWH) by the Minister for Water under Section 48B of the *Water Act 1989* (Vic). The Minister may allocate an environmental entitlement for the purpose of preserving or improving the environmental values and health of water ecosystems, including their biodiversity, ecological functioning and water quality, and the other uses that depend on environmental condition.

Unlike many other Environmental Entitlements in Victoria, the *Barwon River Environmental Entitlement 2011* does not provide a specified volume of water that is set aside for the environment. The Entitlement allows the Water Holder to take water from the Barwon River downstream of the McIntyre Bridge Gauging Station for the purpose of inundating floodplain wetlands. Clause 8 and 9 of the Entitlement states:

8. The water taken under clause 7 may only be taken from the waterway at the following locations:

- (a) Reedy Lake inlet and;
- (b) Hospital Swamps inlet

9. The water taken under clause 7 may be taken from the waterway at any time when the river height is –

- (a) above 0.7 metres AHD as recorded at the Upstream of Lower Barrage Gauging Station; or
- (b) if the Upstream of Lower Barrage Gauging Station is not in operation –
 - (i) for water taken at the Reedy Lake inlet, above 0.7 metres AHD as recorded at the Reedy Lake inlet; or
 - (ii) for water taken at the Hospital Swamps inlet, above 0.7 metres AHD as recorded at the Hospital Swamps inlet.

2.4 Environmental water planning

The management of environmental water in Victoria is guided by the following principles outlined in the Victorian Waterway Management Strategy (DEPI 2013):

Integrated waterway management

- priority rivers, estuaries, wetlands and groundwater- dependent ecosystems for environmental water management will be identified through regional waterway planning processes, in consultation with the community
- environmental water management will be comprehensively integrated with complementary on ground works programs for rivers, estuaries and wetlands

Maximising efficiency and seeking multiple benefits

- management will be efficient and maximise the environmental benefit achieved from the available water resources and funding; to minimise the economic and regional impacts associated with water recovery for the environment
- adverse social, cultural and economic and environmental effects will be managed and, where possible, minimized
- social and cultural benefits will be provided if possible, where this does not adversely affect environmental outcomes
- consumptive water and/or recycled water should be used to provide environmental benefits where this does not adversely affect existing users of water for non- environmental purposes

Transparent and sound decision-making

- management will be accountable and transparent, with clear roles and responsibilities for agencies and clear communication of decisions and outcomes achieved
- key stakeholders will be engaged at appropriate stages of environmental water management
- management will be based on the best available knowledge.

Being prepared for future conditions

- planning will consider the full range of climate scenarios
- management will aim to address the risks of severe droughts, floods and the potential impacts of climate change, while avoiding unacceptable costs if these events do occur
- ongoing monitoring, evaluation and reporting will be used to facilitate adaptive management and continuous improvement.

These principles are applied in the planning and delivery of environmental water which is undertaken in accordance with the planning framework outlined in [Figure 3](#) ~~Figure 2~~.

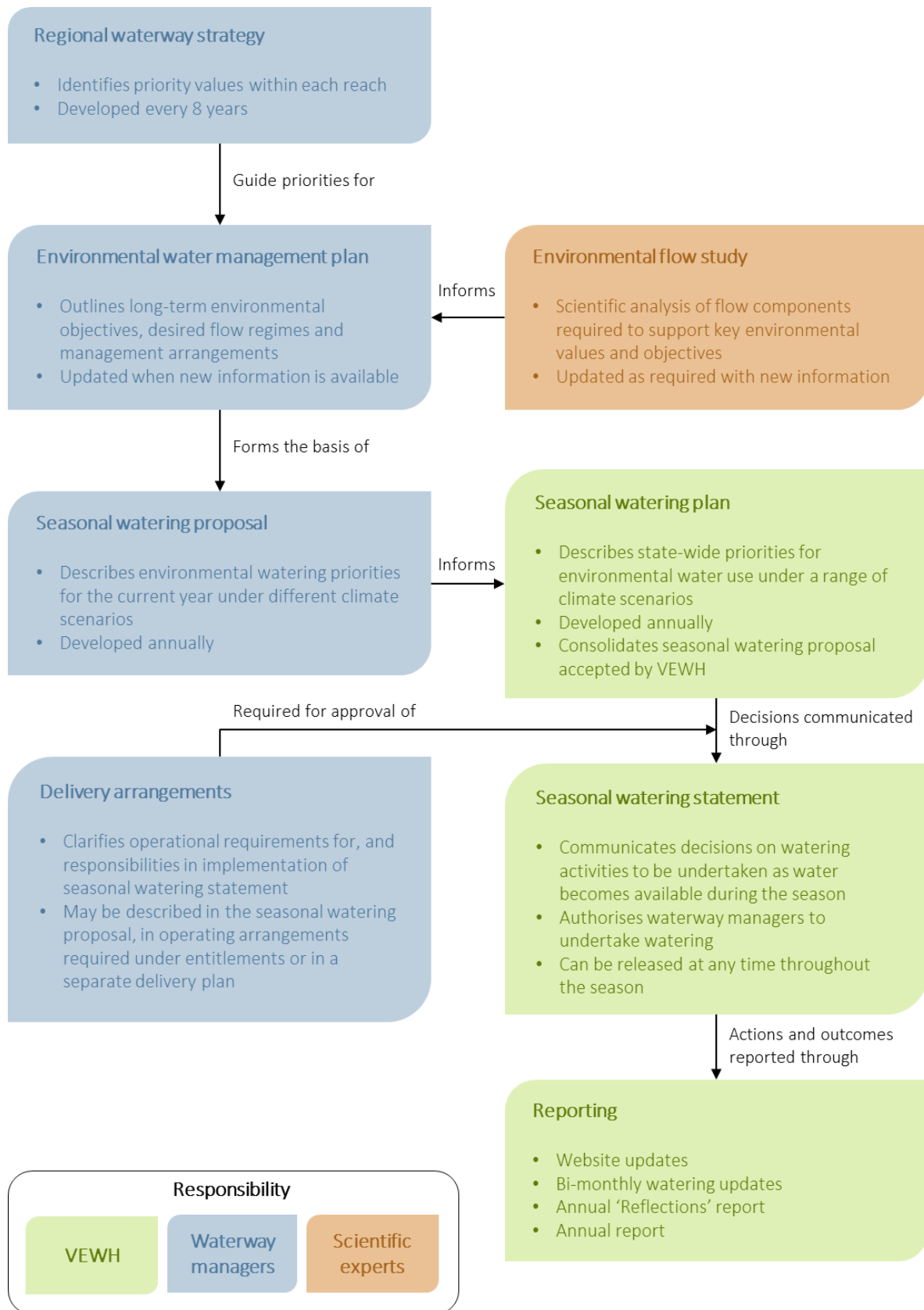


Figure 3. Environmental water planning in Victoria. Adapted from DEPI 2013.

The framework details the planning documents and strategies that help guide environmental water decision making and planning, shows how the different planning tools inform each other and highlights the agency responsible for the development of various planning documents. Environmental water planning within the Lower Barwon Wetland system largely follows the framework in [Figure 3](#)~~Figure 2~~, however, as yet the site does not have an Environmental Water Management Plan.

The annually prepared Seasonal Watering Proposals describe the Corangamite CMA's proposed priorities for the use of environmental water in the Lower Barwon Wetland system, as required under section 192A of the Water Act 1989. In developing the proposals, consideration is given to a range of environmental water management objectives, constraints, opportunities and uncertainties, and their complex interactions using the best available information. Much of this information is provided by a FLOWS study, recent monitoring observations and an environmental water management plan (where available).

The overall site objective for the Lower Barwon wetlands was developed by the Lower Barwon Community Advisory Committee (LBCAC) through the seasonal watering proposal process. The objective is to **"Maintain the ecological character of the wetlands"**. This goal is consistent with Ramsar obligations, State Government policy and the objective of the EWR (i.e. to preserve the environmental values and health of water ecosystems, including their biodiversity, ecological functioning and quality of water and other uses that depend on environmental condition). The 'ecological character' of the wetlands refers to the diversity of habitats present in 1983 when the wetlands were listed under Ramsar, and is supported by the Limit of Acceptable Change under Ramsar for Reedy Lake which requires that;

"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 more than 70% of the total wetland area for more than five successive years".

3 Managing the water regime in the Lower Barwon wetlands

3.1 Flow/ecology relationships and watering recommendations – Lloyd et al 2012

In 2012, a study was undertaken by Lloyd et al. (2012) to determine the water requirements for maintenance of ecological values of Reedy Lake and Hospital Swamps, set ecological objectives and devise a watering regime to achieve these objectives. As there is no stand-alone method for determining environmental watering recommendations for wetlands, this study utilised aspects of the FLOWS method (a method for determining environmental water requirements for rivers and stream in Victoria) that has been adapted to be applied in estuarine systems (Estuary Environmental Flows Assessment Methodology – EEFAM 2012).

The study provided two sets of watering recommendations for Reedy Lake. The first set of watering recommendations were to be implemented with the purpose of “resetting” the wetland in the face of two perceived threats: (1) excessive carp biomass and (2) the spread of tall reeds across previously open-water areas. This watering regime consisted of predominately dry summer scenarios over a 10-year period with complete drying in two of the 10 years with the dual objectives of (1) controlling carp populations and (2) halting the putative spread of tall reeds (Lloyd et al. 2012). The study stated that this proposed watering regime “has placed the highest priority on restoring vegetation types in Reedy Lake, to the composition and extent recorded in 1983” and “the water regime has placed a lower priority, in the short term, on waterbird and fish ecological objectives” (Lloyd et al. 2012, p.121). The choice of the 1983 date is significant, as the ecological condition of Ramsar sites is defined in terms of their ecological character at the time of listing, which in the case of the Port Phillip (Western shoreline) and Bellarine Peninsula Ramsar site was 1982.

A second set of watering recommendations was made for long-term management of Reedy Lake with the objective of balancing all the ecological objectives for the site. The long-term watering regime recommended high lake levels (at or around 0.8 m AHD) throughout the entire year in the wettest 25% of years, winter/spring filling to 0.8 m AHD with a drawdown to 0.3 m AHD through summer in average years and a winter/spring fill to 0.8 m AHD with a full drawdown over summer in the driest 25% of years.

An annual wetting and drying watering regime has been maintained at Hospital Swamps and was seen as “beneficial to the ecosystem values of the site” (Lloyd et al. 2012, p.123). As such, a regime that maintains this annual wetting and drying cycle was recommended for Hospital Swamps.

Following the completion of the 2012 flow/ecology relationships study, it was reviewed by a Technical Assessment Panel. The Technical Assessment Panel comprised experts Prof. Gerry Quinn, Prof. Tom McMahon and Prof. Barry Hart. The review (2012) stated the methodology used in the study was adequate and the recommended watering regimes were appropriate. However, they highlighted three key issues before the study could be fully assessed as adequate:

- Uncertainties associated with the hydrology and hydraulics of the study (particularly relating to the impact of local runoff and the adequacy of evaporation input).
- Justification of the frequencies of the hydrological components for the recommended watering regimes.
- Linking and prioritising the monitoring and knowledge gaps with key ecological assets and objectives.

3.2 Implementation of FLOWS recommendations

Reedy Lake has had a much more variable water history than Hospital Swamps. Lake levels were held at unnaturally high levels for most of the later 20th century. This is thought to have led to an expansion in both carp and tall reed populations. In response Lloyd et al (2012) argued for a re-setting of the lake ecosystem and proposed a water regime featuring annual summer drying. The intention of this ‘resetting’ was to elevate the priority of vegetation management in the short-term in order to provide a more diverse habitat mosaic to support the entire ecosystem in the long-term. After re-establishment of a more natural plant community Lloyd et al (2012) proposed a longer-term watering regime which would also benefit native fish and bird populations. Neither set of recommendations has been fully implemented at Reedy Lake. The environmental watering actions proposed for each year (2012-2020) for both Reedy Lake and Hospital Swamps are provided in Attachment B.

The initial 10-year summer dry scenario for Reedy Lake was not implemented as recommended by Lloyd et al (2012). Community concerns about these recommendations and concern about the risk of acid sulphate soils resulted in an adapted flow regime to be implemented over a 4-year trial period. The adapted water regime for Reedy Lake, consists of three consecutive years of summer drawdown and one year of summer with a high wetland water level, targeting the lake levels proposed by the initial recommendations in Lloyd et al (2012). The trial of this adapted watering regime has not yet been completed. To date, summer drawdowns have occurred over the last three years with the intention to keep Reedy Lake at a target level around 0.8 m AHD in 2019/20 (the final year of the trial). During this summer (2019/20) wetland levels were managed to give a fluctuating “full” level of between 0.8 and 0.6 m AHD.

Hospital Swamps was recognised by Lloyd et al (2012) as having a fairly stable hydrological regime. Regular winter flooding and summer drying cycles appear to have allowed a steady state to be achieved for its plant communities. Lloyd et al (2012) recommended a continuation of the existing pattern of watering and this has been achieved. The swamp has filled each winter to 0.6 - 0.8m AHD and then gradually dried to 0.2m AHD in autumn before beginning to refill.

Key features of the hydrographs shown [Figure 4](#) [Figure 3](#) are summarised in [Table 2](#) [Table 2](#) and [Table 3](#) [Table 3](#). Reedy Lake has had extended “full” periods at levels above 0.8m AHD in each of the water years 2016/17 to 2019/20 - for between 121 and 163 days in each year. Hospital Swamps has also been full (> 0.5m AHD) for periods of 102 – 126 days in each year. Maximum peaks superimposed on the winter/spring water levels of both lakes result from sharp rises in Barwon River levels. Lloyd et al (2012) suggested a draw down rate for Reedy Lake of 10mm/day. Measured average rates were above this in 2016/17 (16mm/day) but lower in each of the subsequent years (7.4 and 4.6mm/day). Lloyd et al (Table 19; 2012) did not specify a rate for Hospital Swamps but its average draw down rate has varied from 2.6 to 6.7 mm/day. Draw down in both wetlands has commenced in late winter /early spring. Minimum water levels (between 0.1 and 0.2m AHD) have been reached in both lakes by late March/early April.

The adapted flow regime implemented at Reedy Lake in place of the 10-year watering regime was based on the long-term recommendations in Lloyd et al. (2012) with some changes to a number of elements. The changes to these recommendations that were made during implementation were:

- Not implementing a full drying scenario as proposed one year in four by Lloyd et al. (2012)
- Commencing drawdown in October – November rather than in December
- Allowing water levels to draw down to between 0.1 and 0.3 m AHD, with an open outlet and tidal fluctuation
- Commencing refilling in mid-March rather than during winter – spring.

These changes were made based on the best available advice at the time and responded to a variety of different factors such as addressing the potential risk posed by acid sulphate soils, to accommodate shared benefits at the site and as a part of the annual process of compiling the available information and agreeing on actions through community engagement as a part of developing the seasonal watering proposal.

Table 2. Key features of the Reedy Lake hydrograph for the water years 2016/17 to 2019/20. Note that records cover the period 28 April 2016 to 19 January 2020.

Water Year	2016/17	2017/18	2018/19	2019/20
Maximum WL (m AHD)	1.61	1.00	0.94	1.08
Minimum WL (m AHD)	0.11	0.13	0.17	–*
Draw down rate (mm/day)	16	7.4	4.6	–*
Days above 0.8m AHD	162	124	121	163
Date WL fall begins	29 Oct	21 Sep	15 Aug	15 Aug

* 2019/20 was a “wet” year scenario and the lake was intended to be kept full

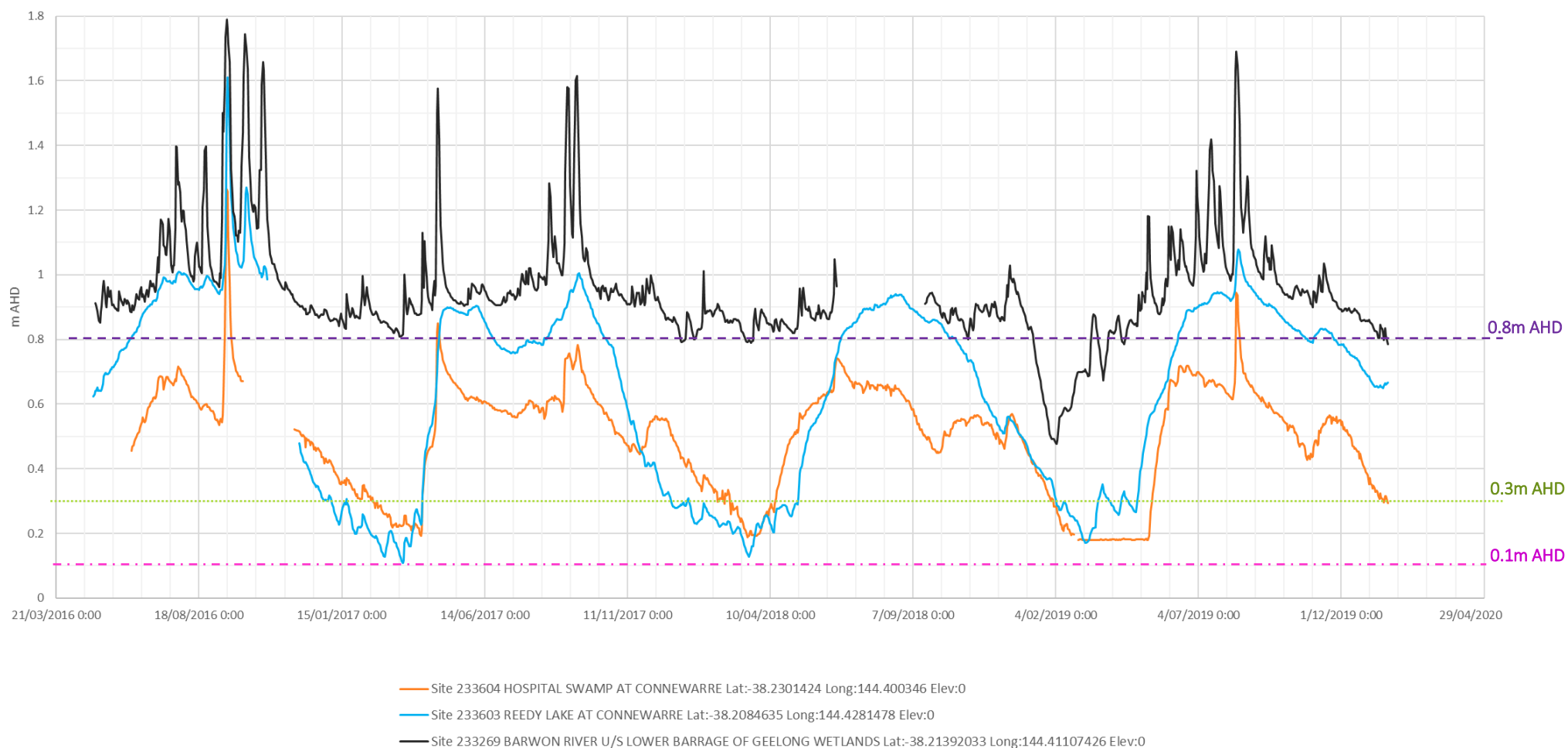


Figure 4. Water levels from gauge sites in the Lower Barwon wetlands. Barwon River at the Lower Barrage in black, Reedy Lake blue and Hospital Swamps orange.

Table 3. Key features of the Hospital Swamps hydrograph for the water years 2016/17 to 2019/20. Note that records cover the period 28 April 2016 to 19 January 2020.

Water Year	2016/17	2017/18	2018/19	2019/20
Maximum WL (m AHD)	1.26	0.85	0.74	0.94
Minimum WL (m AHD)	0.19	0.19	0.17	-
Draw down rate (mm/day)	2.6	3.9	6.7	-
Days above 0.6m AHD	102	126	108	105

3.3 Management considerations

Managing environmental water is challenging and replicating a natural watering regime through management interventions is not possible. The CCMA, in their role of environmental water managers, are required to achieve the best possible ecological outcomes for a site while working within a range of policy, legislative and infrastructure constraints (see Section 2), and also consider the community values in their management actions. Some of the management challenges for Reedy Lake and Hospital Swamps are outlined below.

Management tensions: the management of wetlands needs to consider the best available science, community values and the options that are possible. The possibilities for management interventions are many (e.g. with different target levels, rates of drawdown, gate configurations etc). It can be challenging to always arrive at the optimum option. Environmental water management needs to work within the policy framework and the Ramsar convention is a key driver for management at the wetlands. Maintaining the diversity of habitat and ecological character of the wetland is a key part of Ramsar requirements.

Monitoring: there are limits to what can be monitored with the budget and resources available. The limited nature of data for this project has been recognised but the CCMA has a strong desire to make the best use of what is available.

Trade-offs: original recommendations called for a 10-year summer dry to ‘reset’ the wetland and this wasn’t implemented. Adaptations had to be made to manage for shared benefits, community desires and values for the site, and to manage risks (e.g. exposure of acid sulphate soils) while trying to maximise ecological outcomes.

3.4 Community values and concerns

As a part of this project, the Expert Review Panel, Steering Committee and Project Advisory Group (PAG) took part in a site visit to Reedy Lake and Hospital Swamps. The purpose of the site visit was to provide an opportunity for community stakeholders to articulate what they value about the sites and the concerns they have for the future of the sites. The text below summarises the values and concerns attached to the study site as expressed by community stakeholders present at this site visit and during subsequent workshops.

Community values

Recreational and social value: Many PAG members highlighted the inherent value of the wetlands in themselves as well as their value as an open natural space in a rapidly urbanising environment. People enjoy coming to sit by the wetlands and relax and enjoy the view. It is an important place for people to bring their families and spend time together outdoors.

Recreational fishing: PAG members spoke about enjoying recreational fishing within the wetlands. Some present at the PAG meeting recalled fishing at the site since they were young children.

Commercial fishing: Commercial fishing activities have been important at the wetlands. The site is valued for its eel population which one commercial fisherman said had created “one of the best eel fisheries in the state”.

Birdwatching: The wetlands are highly valued for their birdwatching opportunities. Birdwatchers value rare species, threatened species, breeding birds, the spectacle of large numbers of birds, contributing to scientific monitoring and photography. Reedy Lake is a site of national importance for species such as Australasian Bittern

and migratory shorebirds. Birdwatchers carefully search through flocks of migratory shorebirds in search of rarities – Reedy Lake is famous for its rare birds such as Australia’s first Lesser Yellowlegs.

Hunting: The site has long been used by hunters. Duck and quail hunting have a long history at the site. Again, many PAG members recall coming to the site to hunt since they were young children. In the past hunting groups, particularly Geelong Field and Game, have dedicated a considerable amount of effort to maintenance of access, watering infrastructure and conservation at the site.

Community concerns

Declining bird numbers: a decline in bird numbers as well as the number of species and specific bird groups such as shorebirds and waders were highlighted as a concern for the community. A number of PAG members also highlighted their concern about the apparent decline in bird breeding at the site.

Water quality: poor water quality in the warmer months was raised as a concern with a particular emphasis on the implications of poor water quality and stagnant pools on birds and fish. Recent Ibis deaths at the site were highlighted as a concern linked with one or more of poor water quality, hot weather conditions, and timing of drawdown.

Pests: Concerns were raised about the impact of pest animal species at the site. Major pests of concern include carp, rabbits, foxes and deer.

Lack of boat access: Eel fishers expressed concern that low water levels over recent years have reduced boat access for commercial fishing in Hospital Swamps and Reedy Lake.

Tall reed encroachment: PAG members highlighted their concern over potential encroachment of tall reeds at the site reducing the total area of open water within the wetlands.

Appropriateness of management interventions: some PAG members raised their concern about the appropriateness of managing risks at the wetlands. These concerns centred around the use of tidal flows to assist with management of tall reeds in a freshwater system, risk that drying poses for the liberation of heavy metals and the exposure of acid sulphate soils, and the possibility of the site transitioning from a freshwater marsh environment to something else.

Lack of monitoring data: the lack of sufficient and appropriate monitoring data was raised as a concern. The lack of monitoring data raised doubts from the PAG about the ability to undertake a thorough review of the watering regime.

Loss of commercial fishing: some PAG members have expressed concern about the loss of commercial fishing at the site.

Future stormwater runoff: the development of Armstrong Creek is a concern to the community in terms of the increased volume of stormwater runoff and potential increases in contaminants and nutrients entering the wetlands from this runoff.

4 Review of current knowledge

To understand the impact of adopting a modified watering regime at Reedy Lake and Hospital Swamps, the Expert Review Panel examined the new data that had become available since 2012, along with older data (where available) to provide a longer-term perspective. It is important to note that, at the time of doing this study, the full four-year watering regime has not yet been delivered at Reedy Lake. The current water year is intended to be a full wetland summer scenario after the previous three dry summer scenarios.

The focus of this review is the impact of the current wetting and drying water regime. Monitoring data over the trial period is limited for both Reedy Lake and Hospital Swamps, making it difficult to thoroughly assess the impact that changes in the water regime may have had. The relevant data that is available for the sites has been supplemented with new satellite data covering the period from 1986 to present. This section outlines the review of evidence undertaken by the Expert Review Panel in relation to issues of most concern.

4.1 Habitat composition and changes in Reedy Lake and Hospital Swamps

The Expert Review Panel was given access to remote sensing data collected and processed by the United States Geological Survey (USGS) and Geoscience Australia and developed into Geoscience Australia's draft Wetlands Insight Tool. The Wetlands Insight Tool provides a summary of the percentage of a given map polygon area classified as water, wet, green, dry or bare for each clear satellite observation.

The draft Wetlands Insight Tool was developed using optical satellite imagery from 1987 to 2019, captured approximately fortnightly (see Attachment C for more details on the Tool) and the overall habitat composition results are shown in [Figure 5](#) [Figure 4](#) and [Figure 6](#) [Figure 5](#). The tool is still under development, is for general informational purposes only, and is not intended to provide any commercial, financial, or legal advice. It has been provided on an "as is" and "with all faults" basis without any warranty whatsoever. This dataset should be used in conjunction with other datasets to characterise wetlands. The algorithms used to create this dataset have not been validated on these specific wetlands and as such should be used as general information. Graphing and interpretation of the data has been done by the review panel, not by Geoscience Australia.

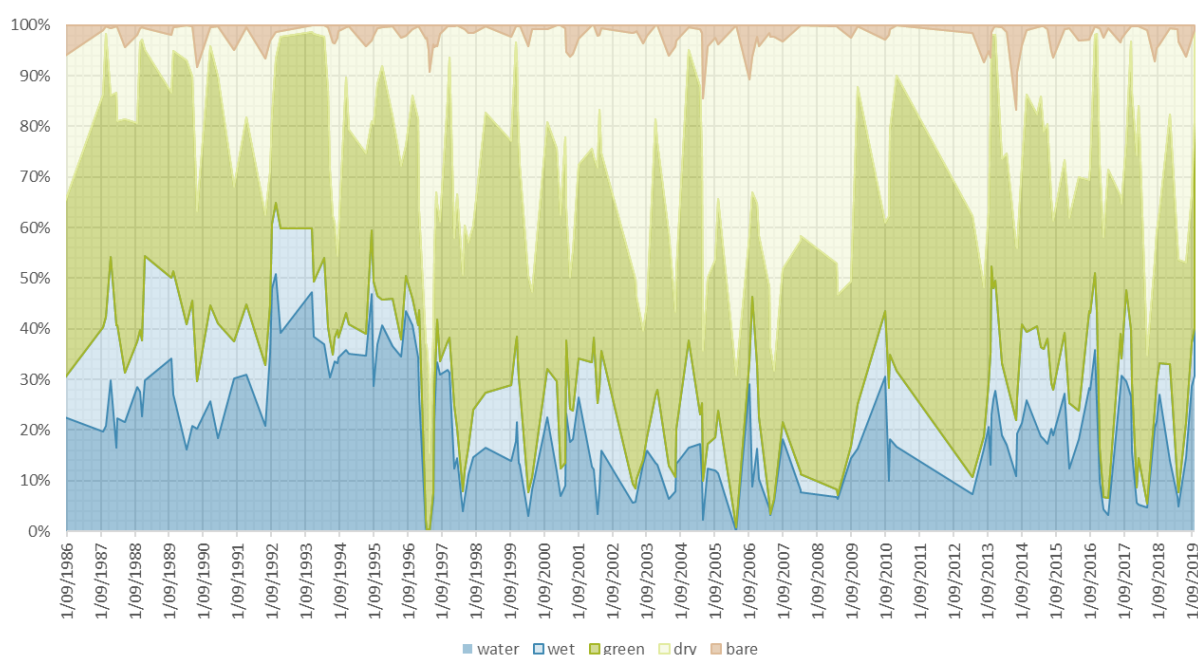


Figure 5. Graph showing percentage habitat composition over time at Reedy Lake. Habitat types include (from bottom to top of the graph) open water, wet vegetation, green vegetation, dry vegetation and bare soil. Note: there is a gap in the dataset between 01/11/2011 and 01/04/2013 where the data captured by satellite was unsuitable for use in this tool due to sensor issues with Landsat 7.

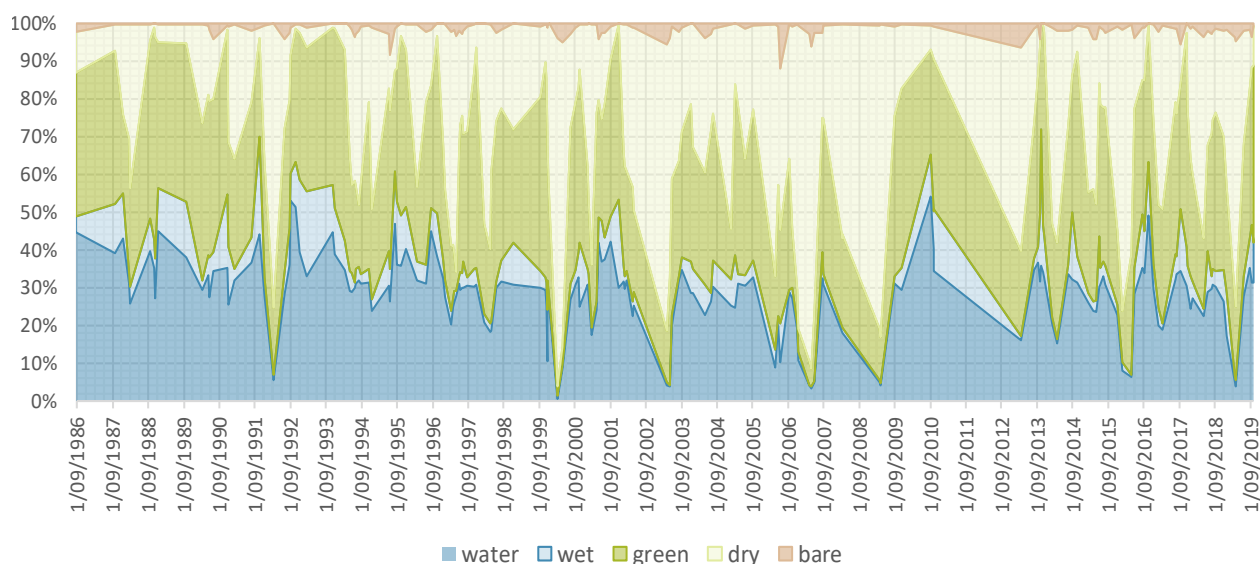


Figure 6. Graph showing percentage habitat composition over time at Hospital Swamps. Habitat types include (from bottom to top of the graph) open water, wet vegetation, dry green vegetation, dry vegetation and bare soil. Note: there is a gap in the dataset between 01/11/2011 and 01/04/2013 where the data captured by satellite was unsuitable for use in this tool due to sensor issues with Landsat 7.

Reedy Lake

The satellite imagery data shows three Reedy Lake open water states of different duration ([Figure 7](#)~~Figure 6~~):

- | | | |
|---|--|---|
| 1 | 19/8/1986 (start of data collection) to 2/7/1992 | The proportion of open water surface area varied in a narrow range (20 – 30% of the wetland area) with minimum values of 16 – 20%. |
| 2 | 19/8/1992 to 5/1/ 1997 | The proportion of water in the wetland showed a sharp increase with values commonly over 40% and minimum values of above 29%. |
| 3 | 14/6/1997 to 2/10/2019 | Following lake drying in 1997 the proportion of open water dropped significantly. The seasonal maxima in open water area were typically between 20 – 30% - similar to values between 1986 and 1992. Minima however were much lower – regularly 5% or less of the wetland area. The reductions in surface water associated with managed seasonal water levels during the three recent “dry years” of the trial are clearly shown, as is the drying of the lake for carp control in 1996/97 and 2006. |

The satellite imagery data demonstrated that open water habitat comprised approximately 15 – 35% of the wetland area from 1986 – 1992, increased substantially (30 – 50%) from 1992 – 1996, followed by a sharp decline from 1996 to 1998. These changes in the extent of open water habitat correspond with anecdotal accounts reported by Lloyd et al. (2012): *“Between 1990 and 1993 there was a rapid change in vegetation with the growth of open water and the loss of reeds. However, this trend reversed over the following seven years and reeds increased dramatically in extent”* (Ian MacLachlan pers comm. Geelong Field and Game 2006).

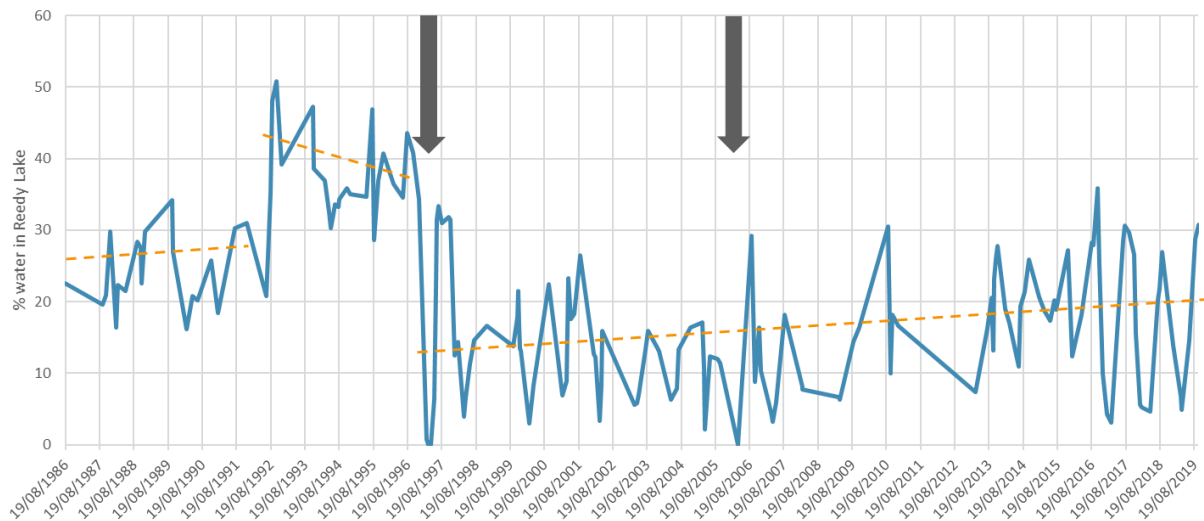


Figure 7. The percentage of open water within the Reedy Lake polygon as surveyed by satellite. Arrows show the two recent periods when the lake was deliberately drained for carp control (1996/97 and 2006). Trend lines (dotted) are derived from linear regression of the three time periods separated by apparent step changes in water area. There is a gap in the dataset between 01/11/2011 and 01/04/2013 where data captured by satellite was unsuitable for use in this tool. (Source: Geoscience Australia)

Since 1997, the satellite data shows strong temporal variation in the extent of open water habitat and vegetation cover. However, the overall trend since 1997 is a slight increase in open water habitat and a decrease in vegetation cover (Figure 5). The data also show that the difference between maximum and minimum areas of open water among successive years has increased during the three recent trial years (i.e., change in habitat cover over time has been greater during the trials). Importantly, the satellite imagery data provide no evidence of an ongoing trend of vegetation encroachment or loss of open water habitat since 1997.

Hospital Swamps

The Geoscience data does not show step changes in the proportion of open water in Hospital Swamps over the survey period (1986 to 2019) (Figure 8). There has been a small decrease in the mean proportion over this time (from 32% to 24%). The swamp shows maxima (over 50% in open water area) in the winters of 1992 and 2010. Low proportions of open water (<10%) occur in the autumns of 1992, 2000, 2003, 2006, 2007, 2009, 2016 and 2019. Apart from 2000, there has always been at least some surface water present in Hospital Swamps, suggesting that complete drying is an uncommon occurrence in this wetland. This differs somewhat from the findings of Lloyd et al. (2012) who suggested that Hospital Swamps is usually dry by the end of summer. Nonetheless, there is no evidence that recent management of Hospital Swamps has increased the frequency of complete drying and the area of open water does not appear to have changed appreciably since the late 1990's (Figure 8).

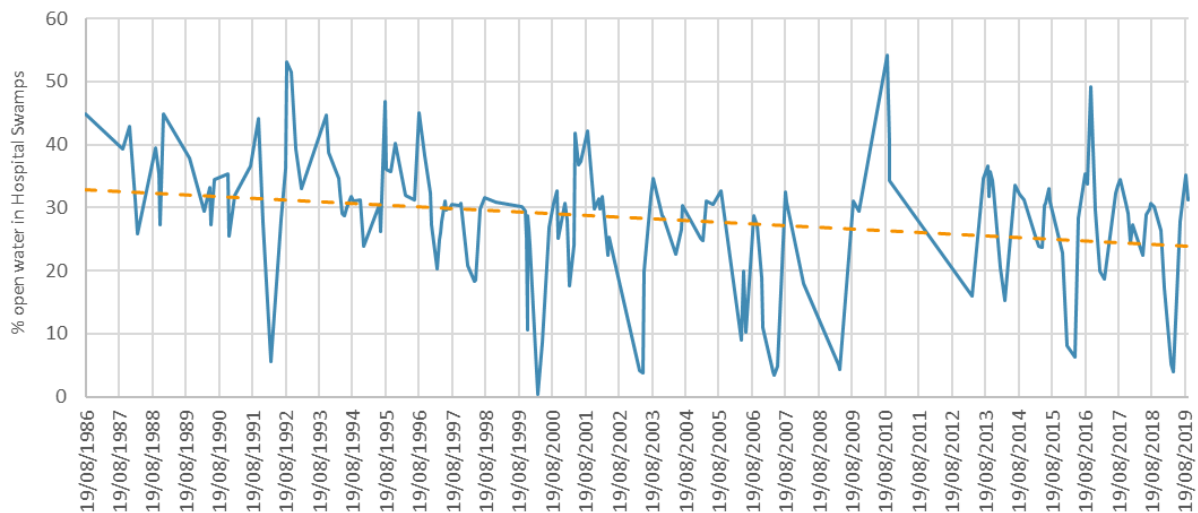


Figure 8. The percentage of open water within the Hospital Swamps polygon as surveyed by satellite. The trend line (dotted) is derived from linear regression. There is a gap in the dataset between 01/11/2011 and 01/04/2013 where the data captured by satellite was unsuitable for use in this tool due to sensor issues with Landsat 7. (Data source: Geoscience Australia).

4.2 Reed-bed dynamics and management

There have been expressions of concern from the community and site managers that tall reeds have encroached across the Lower Barwon wetlands complex, impacting on the ecological character of the sites, and reducing the total area of open water at Reedy Lake and Hospital Swamp in particular. In this Issues Paper, the Expert Review Panel assumes that the term ‘tall reeds’ refers primarily to Common Reed (*Phragmites australis*) and/or Cumbungi (*Typha* spp.). The putative expansion of tall emergent plant species such as Common Reed and Cumbungi was also a primary factor (along with carp control) driving the environmental-watering recommendations proposed by Lloyd et al. (2012) in the initial FLOWs study. Three topics require consideration when assessing the possibility of tall-reed expansion in the Connemare wetlands complex and whether, if such vegetation change has indeed taken place, that it represents a real management problem that needs to be addressed.

The first topic concerns the value of anecdotal claims about long-term environmental change in wetlands. The problem is that anecdotal claims about the expansion of particular plant species are often not supported by independent assessments that quantify vegetation changes across entire wetland systems. A good example is provided by the claim made in the early 2000s that Common Reed (*Phragmites australis*) was aggressively expanding in the brackish-water wetlands of the Gippsland Lakes, particularly in the 1,500 ha, Ramsar-listed Dowd Morass. An analysis of aerial photographs from the late 1950s until 2004 indicated that this was not the case, and that the area of reeds had, in fact, declined markedly over the four decades covered by the aerial photographs (Boon et al. 2008). This finding was consistent with the findings of Roberts (2000), that *Phragmites* had declined markedly across south-eastern Australia since European colonisation. Boon et al. (2019) have subsequently reported similar trends for coastal beds of *Phragmites* across the Gippsland region specifically over the period 1840-1960+. Many other studies elsewhere in Australia have shown that that anecdotal reports, based on local oral histories, on putative environmental change are not supported by subsequent scientific analysis (e.g. Finlayson and Brizga 1995 in Victoria; Halse and Massenbauer 2005 in Western Australia; Tibby et al. 2007 in New South Wales; Boon 2014 in Victoria).

This is not to say that the tall-reed community has not expanded in the Connemare wetlands complex, only that anecdotal claims alone are insufficient evidence on which to base a firm conclusion. Such conclusions should be based instead on firm quantitative grounds, using data obtained in independent, focused and science-based investigations. This leads to the second difficulty with an examination of the proposition that vegetation has changed so markedly in the Connemare wetlands complex that management interventions are required, via the implementation of an altered hydrological regime: the absence of such formal, independent sources of information.

The second topic concerns the availability of empirical, quantitative investigations into vegetation change across the Connewarre wetland complex. These types of independent study are needed to test anecdotal claims about environmental change and to draw firm conclusions as to the long-term dynamics of tall reeds across the site. To date, the necessary focussed, hypothesis testing, science-based studies have not been undertaken on the Connewarre wetlands complex, despite the number of consultants' reports commissioned for the area.

Yugovic (1985) provided the first quantitative description of the vegetation of Reedy Lake and Hospital Swamps. Ecological Associates (2006) provided a short history of vegetation change and mapped the vegetation of the wetlands complex, using the original maps from Yugovic (1985) as a baseline, supplemented by aerial photographs taken in 1995 and 2004. Distributions were overlaid on an aerial photograph from 2004 to show changes in different plant species: there was a marked decline in the extent of Common Reed and Cumbungi from 1984 to 1995, but a considerable expansion from 1995 to 2004. Unfortunately, vegetation communities were not mapped using the map units used in the State-endorsed framework for vegetation assessment: Ecological Vegetation Classes (EVCs). Moreover, the frequency of analysis in the Ecological Associates (2006) assessment was too coarse to enable much to be said about temporal change: only two years were assessed and changes within the 1984-1995 and 1995-2004 periods are therefore impossible to decipher. This is a critical point, because 1983, 1995 and 2004 may represent, by chance, years when the tall-reed plant community was very abundant or abnormally scarce. There is simply no way of differentiating these possibilities with the data presented in Ecological Associates (2006). However, tall marsh vegetation generally takes a number of years to grow or disappear, and the observations conform with some of the anecdotal information about increases in reed cover from 1995 to 2004.

In 2007, a Deakin University study (Billows and Gwyther 2007) examined some aspects of the ecology of the Lake Connewarre wetlands complex, but little is relevant to the current investigation. The report is useful, however, in providing information on the presence of submerged macrophytes such as *Ruppia* spp, plant types often ignored in other studies.

A later study (Ecological Associates 2014) reported on spatial changes in tall-reed communities, using among other tools satellite imagery. It found that in 2012 there were 420 ha of tall-reed vegetation, ~40% of which was Common Reed and ~60% of which was Cumbungi. Repeat analysis in 2013 returned similar results to those obtained for 2012.

In 2017, GHD released its synthesis report on the *Integrated Monitoring Program for Reedy Lake*. It provided an overview of vegetation monitoring to date, commenting decisively on the near-doubling in area of *Bolboschoenus caldwellii* (Salt Club-rush) from 1983-2012 and the 75% decline in area of coastal saltmarsh from 44 ha in 1983 to just 9 ha in 2012. The 2017 GHD report found that there were marginal, if any, change to the physicochemical conditions in the sediment, surface water and groundwater of Reedy Lake during the low-partial drying regime. Potential acid sulphate soils were not activated by the drawdown phase, nor were metals liberated. Vegetation monitoring identified "... relatively minor changes in most species and their distribution and those of plant functional groups compared to [sic] previous monitoring (2013/14)" (GHD 2017, page ii). Unfortunately, the *Phragmites* and *Typha* monitoring transects established in 2013/14 were not subject to re-analysis. Nevertheless, it was concluded that "... some of the quadrat data indicate further spread of reeds and rushes from consistently high-water levels" (page ii). With regard to native plant species, the report drew attention to "Notable declines in frequency of occurrence between 2010 to 2016 were herbs *Crassula helmsii* (Swamp Crassula, 23% to 12%), *Sarcocornia quinqueflora* (Beaded Samphire, 21% to 8%), *Senecio pinnatifolius* (Variable Groundsel, 21% to 13%) and the macro-algae *Chara* sp. (13% to 4%)..." (GHD 2017, page 64).

To conclude, the evidence provided in the reports that were available at the time of review for the preparation of this Issues Paper, either as commissioned consultants' reports or as other documents in the 'grey literature' (e.g. unpublished university investigations) do not provide firm empirical evidence for or against the proposition that the area of tall reeds has increased in recent years at the expense of open-water areas.

The third topic concerns the Panel's activities in (1) identifying a hitherto-unused source of information on long-term vegetation dynamics and (2) having started to interpret findings from the most recent State-endorsed monitoring studies on vegetation dynamics in wetlands (WetMap).

The first line of new evidence comes from the spatial information in the Wetlands Insight Tool developed by Geoscience Australia (Figures 5 and 6). These graphs show that the area of green vegetation across the Reedy Lake and Hospital Swamp has varied markedly since 1986 but that there is no evidence for tall reeds having ‘taken over’ the wetland to the detriment of the total area of open water. This information, although on a coarse spatial scale, therefore does not support a central underpinning of the Lloyd et al. (2012) flow recommendations, namely that tall reed beds have expanded so vigorously across the wetland complex and into areas of former open-water that they require control via the implementation of a radically new hydrological regime.

The second line of new evidence comes from the vegetation assessments of April 2017, February 2018, February 2019, December 2019 and February 2020 undertaken as part of the WetMAP, a program designed to determine the effectiveness of environmental watering on wetlands on a State-wide basis across Victoria. The summary reports available to date (February 2020) are short (1 page each) and throw little light on the matter of the putative expansion of tall-reed communities. More recently however (January 2020), whole-of-wetland imagery of the vegetation of parts of the Connewarre wetland complex have been obtained by the Arthur Rylah Institute (ARI), using satellite imagery and remote aerial vehicles (‘drones’). These images are yet to be fully analysed, and it is expected that the analysis will be completed soon after this draft Issues Paper has been circulated. A preliminary analysis of the data by vegetation specialists at the ARI indicates that recent hydrological manipulations have resulted in the following vegetation changes over the past ~3 years:

- A transition in some areas from bare ground to Brackish Aquatic Herbland (EVC537) during the wet phase;
- Areas of Tall Marsh dominated now by *Schoenoectus* and *Bolboschoenus* spp., rather than *Phragmites australis*, have developed in some places;
- Some areas of Tall Marsh (EVC821) have understories that are now very diverse floristically, especially with brackish aquatic herbs;
- Some areas of Brackish Lignum Swamp (EVC 947) are suffering severe water stress and may require environmental watering;
- In contrast, some other areas of halophytic vegetation, including some patches of Brackish Lignum Swamp, plus areas of Wet Saltmarsh Herbland (EVC A107) and Coastal Hypersaline Saltmarsh (EVC A111), should not receive environmental water;
- A general improvement in floristic diversity among those taxa that grow on newly emerged mudflats, such as herbs and forbs, as well as formerly absent submerged taxa such as *Ruppia*, *Potamogeton* etc. Note that these are similar responses to those reported when a drawdown phase was implemented in the 1,500 ha Ramsar-listed Dowd Morass (Gippsland Lakes) in the early 2000s (Raulings *et al.* 2010, 2011).

To conclude, until the beginnings of the WetMAP program ~3 years ago there have been no targeted, long-term studies undertaken to examine long-term vegetation dynamics with a suitably fine temporal resolution or to answer the specific proposition that the tall-reed community has expanded across the Connewarre wetlands complex to the detriment of the total area of open-water. For this reason, the claim that the tall-reed community has expanded can be neither verified nor rebutted on the basis of the existing literature. However, time series of green vegetation cover based on satellite imagery (see [Figure 5](#), [Figure 4](#) and [Figure 6](#)) provides little evidence to support the proposal that there has been a persistent encroachment of vegetation or loss of open water habitat since satellite information became available in the mid-late 1980s. Note also that the WetMAP program necessarily takes a broad, State-wide view when testing the effectiveness of environmental watering and more focused studies, testing specific hypothesis, may be required for the Connewarre wetlands complex. Some recommendations on how these more focussed studies may be structured, and why, are developed below, in Section 5.

A note about vegetation monitoring and assessment

A more general issue needs to be raised concerning the periodicity and type of vegetation monitoring undertaken over the past ~15 years at the Lower Barwon wetlands complex. The issue is that applications of environmental water aimed at rehabilitating degraded aquatic systems require focused monitoring programs, backed-up by rigorous R&D investigations, to test their effectiveness and to explain why they may have succeeded or failed.

The wetlands complex requires a focussed vegetation monitoring to test, among other hypotheses, the claim that the tall-reed community has expanded across the system. Environmental monitoring is expensive, and funding can be difficult to obtain. The problem is not unique to the Connemara wetlands complex: the woeful inadequacy of wetland monitoring has been commented on for at least two decades in the environmental - management literature (e.g. see Streever 1997; Finlayson and Mitchell 1999; Westgate et al. 2013). It is relevant that Ecological Associates (2014) recommended vegetation mapping be undertaken across the Connemara wetland complex every five years.

Monitoring alone will not explain why a particular intervention succeeded or failed. This requires a dedicated R&D program. At a state-wide level, the effectiveness of environmental watering is now being monitored through the Victorian WetMap program (Papas 2018). This program has a State-wide aegis and thus cannot explain on a site-by-site basis why a particular change to the hydrological regime had the observed effect. This requires a dedicated R&D program. An example of how a focussed R&D program can inform environmental watering activities is again provided by an example from the Gippsland Lakes. Dowd Morass had been maintained for nearly two decades at artificially high-water levels to (1) prevent intrusions of saline water from the Southern Ocean and (2) to foster duck hunting. The water regime had had serious detrimental consequences for aquatic vegetation, so a trial draining of the wetland was undertaken. Rigorous scientific analyses over many years quantified the benefits that accrues to wetland vegetation by implementing this change to the existing water regime (e.g. see Morris et al. 2008; Raulings et al. 2007, 2010, 2011; Salter et al. 2010). Without the explanatory power provided by focussed scientific investigations and the resultant peer-reviewed publications, the reasons for the success of the program would not have been understood.

Control options for *Phragmites australis*

The original FLOWS study for the Connemara wetlands system (Lloyd et al. 2012) invoked deep flooding in spring, the removal of shallow summer flooding and the expected rise in sediment salinity that would accrue as measures that could help control the spread of *Phragmites australis* (see section 4.4.1 of Lloyd et al. 2012, especially Tables 17 and 18).

Alluvium (2013) undertook an analysis of control measures for Common Reed and Cumbungi. It concluded; “The main recommendation from this report is to conduct a trial or series of trials involving a combination of implementing a 1 in 4 year drying regime, *Phragmites* cutting (boat based and/or dryland slashing/mowing), and tidal flushing. The drying regime is important for a suite of flow-ecology objectives, the tidal flush is primarily to mitigate against potential contaminant release, and as *Phragmites* is salt tolerant then cutting is deemed necessary to have any significant impact on *Phragmites* extent. Given that *Typha* prefers stable water levels, and is expected to be less salt tolerant than *Phragmites*, then it is likely that implementing the 1 in 4 year drying regime, and the tidal flushing, may have a significant impact on *Typha* extent (without the need for cutting)” (Alluvium 2013, p.i).

The fundamental problem is that *Phragmites australis* has one of the widest hydrological niches of any wetland plant in Australia (Ganf et al. 2010; Rogers and Ralph 2011). This means it can survive (and often spread or reproduce) in a wide range of wetting-and-drying settings, ranging from more-or-less dry to permanently inundated with up to 1.5 m of water. Although sexual reproduction *in situ* might be precluded by permanent inundation, existing plants can continue to spread via asexual (clonal) mechanisms (Hatton et al. 2008). *Phragmites australis* is also highly salt-tolerant, and field observations and greenhouse-trials conducted on specimens from around the Gippsland Lakes indicate it can survive in water at least one-half the salinity of seawater (Boon et al. 2019). To conclude, control of *Phragmites australis* is not likely to be easy. The species does not have a global distribution, from the tropics to high-latitude regions, across a very wide range of hydrological regimes, and sometimes in quite salty environments, for nothing.

4.3 Changes in native fish populations

The Connemara wetland complex supports a diverse native fish fauna, including five exclusively freshwater species, eight diadromous species (species that migrate between fresh and saline water) and ~20 predominantly estuarine species that spend some time in fresh water and are occasionally found in the wetlands. There are also populations of at least seven introduced species, including Common carp (*Cyprinus carpio*) which have been reported to reach high densities at times. A list of fish species recorded from the wetlands or expected to be present can be found in Tables 10 and 11 on p. 94-96 of Lloyd et al. (2012). In addition to the species listed by

Lloyd et al. (2012), there are recent records of the Australian mudfish (*Neochanna cleaveri*) in the Connnewarre wetlands complex.

Surveys of fish assemblages in Reedy Lake were conducted in November 2016 and February 2017 with the aim of establishing a baseline of fish assemblage diversity, abundance and age structure prior to implementation of the drying regime (GHD 2017). These surveys used boat electrofishing, bait trapping and seine netting, and recorded seven native and four introduced fish species. Additional visual surveys (looking for carp from the boat or shore) were carried out in March and April 2017. Results of the surveys showed that introduced Common carp was the numerically most abundant species collected, followed by the native Common galaxias and Small-mouthed hardyhead. As catch-per-unit-effort (CPUE) was not reported in the 2016/17 survey, the data cannot be used to assess changes in the relative abundance (CPUE) or density (kg/Ha) of fish over time and have limited utility as a baseline for future monitoring of fish abundance. To the knowledge of the Expert Review Panel, there have been no recent systematic surveys of fish assemblages upon which to draw conclusions about the current status of fish in the wetlands.

Four of the native fish species recorded from the Connnewarre wetland complex are listed as threatened under the Victorian FFG Act (1988) and/or the Federal EPBC Act (1988). These are the Australian grayling *Prototroctes maraena* (Vulnerable EPBC, Threatened FFG), the Yarra pygmy perch *Nannoperca obscura* (formerly *Edelia obscura*, Vulnerable EPBC, Threatened FFG), the Australian mudfish (Threatened FFG) and the Dwarf galaxias. At the time of the Lloyd et al. (2012) report, Dwarf galaxias in the Connnewarre wetlands were classified as *Galaxiella pusilla* (Vulnerable EPBC, Threatened FFG). However, a revision of the species' taxonomy by Coleman et al. (2015) found that western Victorian populations are a distinct species from populations in the Melbourne area and in eastern Victoria and Tasmania. Coleman et al. (2015) named the new species *Galaxiella toourtkoourt* (common name 'Little galaxias'). This species is currently listed as Threatened in Victoria (FFG) but has not yet been listed on the EPBC Act. The wetlands of the Connnewarre complex represent the approximate eastern limit of the distribution of the Little galaxias.

Nine of the native fish in the system are diadromous and must migrate between freshwater and the sea as part of their life cycle. These species are the Short-finned eel (*Anguilla australis*), Common galaxias (*Galaxias maculatus*), Spotted galaxias (*Galaxias truttaceus*), Broad-finned galaxias (*Galaxias brevipinnis*), Australian mudfish, Tupong (*Pseudaphritis urvillii*), Australian grayling, Short-headed lamprey (*Mordacia mordax*) and Pouched lamprey (*Geotria australis*). Given their migratory requirements, barriers to connectivity between freshwater and the sea represent an important threat to these species. A vertical slot fishway was installed at the Barwon River tidal barrage in 2013 to provide passage past this major barrier. The effectiveness of the fishway was assessed by the Arthur Rylah Institute and was found to be effectively passing large numbers of fish from 18 species (O'Connor et al. 2019). The Barwon River tidal barrage fishway is currently undergoing upgrades, with a second fishway to be installed on the opposite side of the barrage. A new fishway is also being installed at the Reedy Lake outflow.

In addition to supporting fish species of high conservation concern, Reedy Lake and Hospital Swamps support abundant populations of Short-finned eels (*Anguilla australis*). These populations have supported commercial fishing operations for many decades. The primary method used to catch eels in the fishery is fyke netting. Licencing of the commercial eel fishery is managed by the Victorian Fisheries Authority under the Victorian Eel Fishery Management Plan 2017. Three commercial eel licences have been allocated in the region (#5 Lower Barwon River between Queen's Park and Grab Hole Drain Lower Barwon River including section of Connnewarre Game reserve; # 13 Hospital Swamps, Lake Learmonth, Reedy Lake section of Lake Connnewarre; #17 Lake Connnewarre). Water management activities over the past three years have had an adverse effect on commercial fishing operations in Reedy Lake and Hospital Swamps due to access issues (shallow water) and reductions in the extent of eel habitat.

Lake Connnewarre and the Barwon River are popular locations for recreational fishing, with Black bream, Luderick, Estuary perch and Short-finned eels among the primary species targeted. Infrastructure for recreational fishing (fishing platforms) has been installed in Lake Connnewarre and the Barwon River. Reedy Lake and Hospital Swamps support some recreational fishing activity, although the value of these wetlands for anglers is considered low in comparison to other waters in the region.

Effects of water management on fish

As outlined by Lloyd et al. (2012), fish in the Reedy Lake and Hospital Swamps have specific habitat and migratory requirements. Whilst many of the species are highly tolerant to habitat disturbance – and even temporary habitat desiccation in the case of Australian mudfish and Little galaxias – all fish have a basic general requirement for aquatic habitat to sustain their physiological processes and food sources. In addition, many fish have specific structural habitat requirements: for example, Yarra pygmy perch and Little galaxias are strongly associated with dense submerged vegetation and do not occur in habitats that lack complex structure. Management actions that reduce the availability of suitable aquatic habitat are likely to have detrimental effects on fish populations.

Nonetheless, wetland drying during summer is a natural process to which wetland fish are adapted. Indeed, some degree of water level variability is beneficial for maintaining species diversity and habitat productivity. However, very low water levels or complete drying pose risks to fish populations by reducing available habitat and forcing fish to emigrate away from the wetlands into more permanent (but potentially less suitable) habitat or suffer mortality as their preferred habitats dry out. Given the risks that increasing the frequency and extent of drawdowns poses to wetland fish populations, it is essential that the benefits of managed drawdowns to the overall ecology of the system outweigh the risks. This principle was articulated by Lloyd et al (2012):

“Effective management of the wetland for birds and fish must ensure that a diversity of habitat types is maintained in proportion as a mosaic across the wetland and that carp populations are effectively controlled. The hydrological objectives required to achieve these outcomes may periodically result in a lower abundance and diversity of waterbird and fish species able to utilise the wetland. Over the long-term the benefits to the waterbird and fish community of a productive and diverse wetland outweigh this short-term loss of habitat.”

The Expert Review Panel considers this a reasonable approach but notes that the drawdown recommendations for Spring and Summer are predicated on the conclusion that the drawdowns are necessary to control the spread of tall reeds and to control carp populations (see Lloyd et al 2012). Given the risks posed to native fish and the issues of decreased access for commercial and (to a lesser extent) recreational fishers, the Expert Review Panel considers that increased frequency and extent of water level drawdowns can be justified from a fish conservation perspective as long as the broader ecosystem benefits (tall reed control and carp control) are supported by the best available evidence. Evidence relating to vegetation management and carp control is discussed in other sections of this report.

4.4 Carp populations in Reedy Lake and Hospital Swamps

The introduced common carp (*Cyprinus carpio*) has caused widespread damage to aquatic ecosystems in Australia and across the world (Koehn 2004). Carp have been present in the Lake Connemara wetland complex since at least the 1980's and are considered to present a threat to the ecological condition of Reedy Lake and Hospital Swamps (Lloyd et al. 2012). A global review of experimental studies testing the effects of carp by Villizi et al. (2009) found that carp densities in the order of ~200 kg/Ha represent an approximate critical threshold when considering the detrimental impacts of carp on wetlands.

Although carp have a wide range of potential effects on ecosystems (Koehn 2004), the primary effects of carp on wetlands like Reedy Lake and Hospital Swamps are thought to result from their benthic feeding habits. Carp feed by sucking up sediments and filtering macroinvertebrates and other food using their gill rakers – this process causes sediment resuspension and uprooting of aquatic vegetation. At high densities, carp can cause high water turbidity and extensive damage to beds of aquatic vegetation (Koehn 2004).

In the 1990's and 2000's, concern regarding the density and effects of the carp populations in the Connemara wetland complex prompted management action. Reedy Lake was drained in 1996 and 2006 in attempts to control carp numbers: these efforts resulted in mass mortality of large carp and subsequent reductions in carp biomass in the wetlands [Figure 9](#) ~~Figure 8~~).



Figure 9. *Dead carp in Reedy Lake following the 1996 draining (photo: Trevor Pescott)*

In 2011, Fisheries Victoria conducted a field-based assessment of the carp population in Reedy Lake. Boat electrofishing surveys were conducted at four sites and, despite extensive sampling effort, no common carp were captured. Fyke net surveys were also conducted and a total of eight carp were collected after 286 net-hours. Based on these findings, Brown (2013) concluded that the carp population in Reedy Lake was very low at the time (~ 8 kg/Ha). Reasons for the low carp numbers were at least partially attributed to a large fish kill event (likely associated with low dissolved oxygen levels or 'blackwater') that occurred in Reedy Lake after major flooding in 2011.

Brown (2013) undertook modelling of the carp population using a quantitative population model to predict the population trajectory in Reedy Lake. The model, which took the 2011 fish kill into account, predicted that the carp population would decline for several years after the fish kill, before rising to ~ 15 kg/Ha by 2018. Based on the prediction that carp would remain well below the threshold density for detrimental effects, Brown (2013) concluded that draining of the lake was not required for at least five years (until 2018 or later).

One of the aims of the 2016/17 fish surveys at Reedy Lake was to assess the impacts of carp to address community concern regarding the impact of carp on aquatic vegetation and native fish during the drying regime (GHD 2017). Surveys of carp were conducted in the lake in November 2016 and again in the Big Hole part of the lake in March 2017. Further visual assessments were also conducted in March and April 2017. These surveys showed that carp continue to recruit in the system and that adult carp perished at the inlet channel and aggregated at the outlet channel during the lake drawdown, providing an opportunity for carp control at this time. The 2016/17 survey did not provide quantitative information on the relative abundance or density of carp at Reedy Lake.

To our knowledge, the Fisheries Victoria study was the last assessment of carp densities in the Connewarre wetland complex. Additional catch information and observations relating to carp populations have also been provided by commercial eel fishers and the Arthur Rylah Institute to the Expert Review Panel. This information has been useful for understanding the context of the carp issue in the wetlands; however, it is noted that quantitative assessments are necessary for monitoring of carp abundance over time to inform future management actions.

Conclusions

Brown (2013) found that carp densities in 2011 were ~ 8 kg/Ha and were only likely to reach ~ 15 kg/Ha by 2018. Although recent quantitative data on carp densities are not available, the population modelling suggests that current carp densities in Reedy Lake are likely to be well below the ~ 200 kg per hectare threshold for detrimental effects on wetland ecosystems.

Given this finding, the Expert Review Panel finds no evidence that frequent draining of wetlands in the Connewarre complex for the purposes of carp control is warranted. Wetland drainage for carp control should be considered only when the carp biomass approaches threshold levels (e.g., 100 kg per hectare, see Vilizzi et al. 2009). Based on the population models of Brown (2013), the frequency of wetland draining required to control the effects of carp to this level is in the order of once per decade.

The lack of quantitative data on carp population status is a major limitation to effective management of carp in the system. An ongoing program of scientific monitoring of carp populations - for example every five years - would improve management of carp into the future. Such monitoring should use a systematic sampling design to allow for estimates of carp density (kg/Ha) and population modelling (as per Brown 2013), so that the requirement for carp control can be assessed on an ongoing basis. Whilst wetland draining appears to be an effective option for carp control in this system, active engagement by managers with pest fish specialists when considering future carp management actions is needed to ensure that the full range of available options (e.g., biological control, physical removal) is given appropriate consideration.

Finally, the Expert Review Panel suggest that there may be future opportunities for an increased focus on aligning data collection and carp management with the activities of commercial eel fishers. Carp are susceptible to capture in fyke nets and are a common bycatch for eel fishers in the region (Ben Osbourne pers. comm). Eel fishers therefore provide a potential means for removing carp on an ongoing basis without cost to managers. They also present a potential source of high-resolution data on carp population status that – if based on a well-devised and implemented protocol – could feed directly into an adaptive management framework for carp control.

4.5 Changes in bird populations / communities

Waterbirds are often considered easy to monitor as they are conspicuous and easily viewed and counted on open water. However, interpretation of waterbird numbers needs to consider that many species will utilise a range of sites, potentially across the whole continent, so numbers will be heavily influenced by off-site conditions. Moreover, there are real challenges in doing accurate counts in heavily vegetated wetlands such as Reedy Lake, and in large wetland systems with access issues. Birds that feed among dense vegetation (such as bitterns and crakes) cannot be counted accurately unless dedicated surveys are made, targeted at those species. Nevertheless, most waterbirds favour more open habitats and various surveys have been done in the Lower Barwon wetlands over many years. Four datasets have been examined in order to gain a perspective of how waterbird numbers have changed over time, namely:

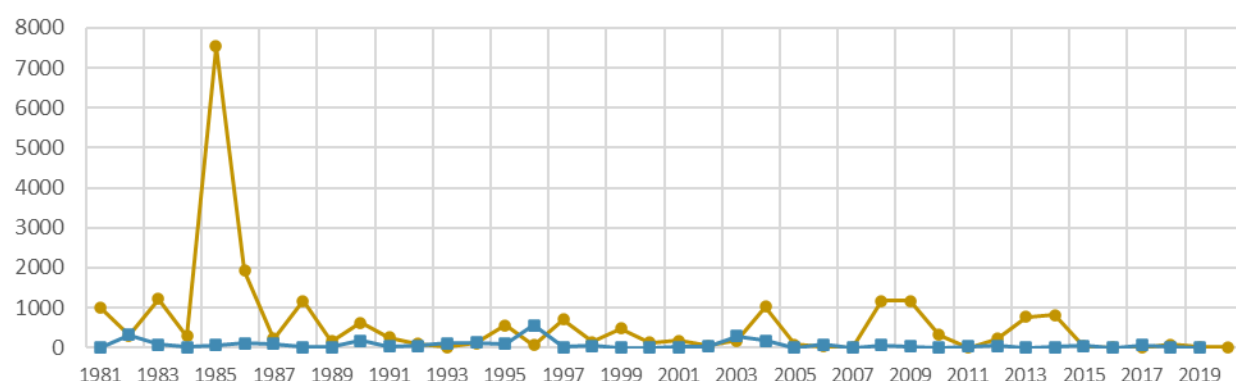
- Shorebirds 2020 project (S2020, Birdlife Australia); systematic counts of shorebirds and waterbirds in summer and winter from 2006 to 2020;
- Previous summer and winter counts of shorebirds from 1981, tabulated in the Geelong Bird Report 2005 by Mackenzie et al. (2005);
- Summer Waterbird Counts (DELWP); systematic counts of waterfowl (ducks, geese, swans and grebes) and other waterbirds in most years from 1987 to 2019; and
- Non-systematic reports from birders to the eBird database from 2016 to 2020, to provide extra data for the period of the current water regime.

The following key conclusions have been made from analysing the data and reports on Hospital Swamps' and Reedy Lake's birds:

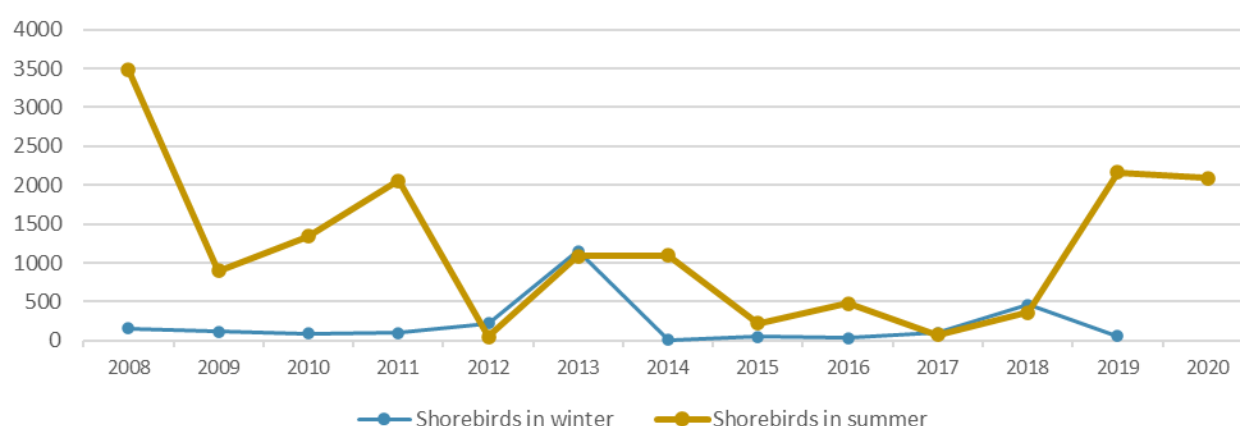
Shorebirds

The numbers of migratory shorebirds, a criterion for the Ramsar Site designation, have been extremely variable, with very high numbers at Reedy Lake in summer 1985-86 (~7000) and hundreds in subsequent years when receding waters provided wet mud and shallow water habitats. As expected, extremely few were noted in the dry wetlands in the summers of 2016/17, 2017/18 and 2018/19 (as well as in 2014/15 and 2015/16), and also in the continually high-water levels of summer 2019/20. More shorebirds (hundreds and often thousands) were recorded more frequently at Hospital Swamps which had suitable mud and shallow water in late summer most years ([Figure 10](#)~~Figure 9~~).

Shorebirds are only found at either wetland when there is plenty of exposed mud or shallow-water habitats. On some occasions (such as uncontrolled inflows from the Armstrong Creek development into Hospital Swamps) flushes of water in late summer or autumn have swamped those habitats and few if any shorebirds remain. This is unfortunate as most shorebirds are migratory and need as much habitat as possible to put on weight for their journeys to breeding sites in Siberia or Alaska. Most species depart on these migrations mainly in March or April, so the period from February to April can be a critical period for them to gain weight for these journeys.



a) Shorebird numbers at Reedy Lake



b) Shorebird numbers at Hospital Swamps

Figure 10. Shorebirds in Reedy Lake (a) and Hospital Swamps (b) in summer (orange) and winter (blue) (BirdLife Australia Shorebirds2020)

Waterbirds

Numbers of other waterbirds, notably ducks, a criterion for the Ramsar Site designation, have declined since the 1980s and 1990s (Table 4Table 4). Most of the ducks (including all the dabbling ducks and grazing ducks) are classified as game species.

Table 4. Mean numbers of waterbird guilds counted at Reedy Lake during Summer Waterfowl Counts 1987-2019. Note that coverage has varied between years, and no correction for this was possible as relevant data were not recorded consistently. Counts in recent years (2017 and 2018) were considered to have covered the entire wetland.

Guild	Mean 1987-96	Mean 1997-2015	Mean 2017-18
Australian breeding shorebirds	9.2	129.3	39
Migratory shorebirds	Not counted	39.5	81
Dabbling ducks	1318	433.2	110
Diving ducks	8.4	3.3	0
Filter-feeding ducks	74.4	39.2	0
Grazing ducks	246	42.9	0

Guild	Mean 1987-96	Mean 1997-2015	Mean 2017-18
Grazing waterbirds other than ducks	829.6	512.4	71.5
Grebes	62.8	5.8	0
Gulls	0	0.8	0
Long-legged wading birds	45	28.5	6.5
Marsh terns	23.5	0.0	0
Fishers	33.3	13.2	44
Partial fishers	106.9	17.2	12.5
Fishers and partial fishers	140.2	30.5	56.5
Waterbirds	2650	1248	352

Ibis

Numbers of nesting Straw-necked Ibis, Australian White Ibis and Royal Spoonbill have declined as they have colonised Mud Islands (Menkhorst 2010). The use of Reedy Lake as a breeding site appears to have been a temporary phenomenon, commencing in the 1970s with peak counts of 19,000 breeding Straw-necked Ibis in 1978, and 10,000 flying young in December 1996, then 1800-2700 breeding birds in 2002 (Mackenzie et al. 2005). In 2018 a breeding attempt by Straw-necked Ibis at Reedy Lake had apparently failed, with many nestlings (at least a few dozen) found dead in nests after hot weather, when water was very shallow as a result of planned drawdowns. No information seems to be available about the numbers of ibis that had attempted to nest that year and whether any young birds fledged successfully. A degree of nestling mortality is common (though sad) in ibis colonies, and mass mortality has been recorded after drawdowns elsewhere (e.g. Barmah State Forest, Chesterfield et al. 1984), perhaps as a result of over-heating. Ibis nests are also known to have been drowned by unseasonal flushes of water at wetlands along the Murray River, although not to our knowledge at Reedy Lake. However, it would be advisable to check for breeding waterbirds before refilling the lake in autumn.

Unfortunately, few counts of breeding ibis have been made since the early 2000s. (In the Advice section of this report, it is recommended that ibis nesting is monitored to inform drawdowns.)

Comparison to Ramsar criteria

Bird populations contribute to the site's listing under the Ramsar Convention and also constitute a value that is highly prized amongst the community. [Table 5](#) shows the Ramsar criteria relating to bird populations and their change over time.

Table 5. Ramsar criteria for birds

Ramsar criteria	Counts cited in the Ramsar nomination	Most recent high counts
>1% of the flyway population of Sharp-tailed Sandpiper and Curlew Sandpiper	8,424 Sharp-tailed Sandpiper 4,820 Curlew Sandpiper	4,800 Sharp-tailed Sandpiper 1,250 Curlew Sandpiper (2019 count at Hospital Swamps)
>1% of the Australian population of Marsh Sandpiper and Red-necked Stint	230 Marsh Sandpiper 4,630 Red-necked Stint	41 Marsh Sandpiper 2,000 Red-necked Stint (2019 count at Hospital Swamps)
>20,000 waterbirds		Reedy Lake contributed an average of 1248 waterbirds to the number across the entire Ramsar site
Nesting Straw-necked Ibis, Australian White Ibis and Royal Spoonbill		Numbers have declined after they colonised Mud Islands which is now the main breeding site for Ibis and Spoonbills in the region.

The 'summer low' water levels of 2016/17, 2017/18 and 2018/19 appear to have been associated with minimal numbers of waterbirds in the dry summers (just occasional influxes of a few hundred shorebirds as waters receded), reduced numbers of piscivorous (fish-eating) birds (after earlier declines in the mid-1990s); and no

detectable trend in most species, because of inadequate monitoring. The effect of the flooding regime on birds is therefore uncertain until there is a longer time-series of counts and better quality monitoring data to overcome the physical challenges of access and the possible biases in surveys focused mainly on shorebirds or waterfowl.

It is noted that the Ramsar listing omits the regular occurrence of two globally threatened species for which the Lower Barwon Lakes can be important, namely the Australasian Bittern (mainly at Reedy Lake) and Orange-bellied Parrot (mainly in saltmarsh at Lake Connewarre, and perhaps no longer occurring). The regular surveys of shorebirds and conspicuous waterbirds do not provide useful data for these species. An opportunistic count of 15 Australasian Bitterns at Reedy Lake was made by Guy Dutson on 22 February 2020 (by wading for seven hours). The previous highest count was of 12 Australasian Bitterns in 2002 (Mackenzie et. al. 2005) and small numbers occur most years (BirdLife Australia 2019, 2020; eBird 2020). Similarly, the regular surveys often fail to detect other waterbirds of conservation interest that inhabit vegetated parts of the lake, including Magpie Geese (which breed in some years, including 2020; eBird 2020) and Brolgas (which also breed; seven were observed in summer 2020; BirdLife Australia 2020; eBird 2020); both of these species are listed as threatened in Victoria.

4.6 Heavy metals and acid sulphate soils

A state-wide Victorian survey of coastal areas has identified the Lower Barwon complex as having potential acid sulphate soils/sediments (Map 3 CASS 2009). Acid sulphate soils result when areas previously inundated by a Holocene higher sea level (ca. +1.5m) about 6,000 years ago are now exposed. Acid sulphate soils contain pyrite (iron sulphide) formed by reduction in anoxic conditions of the sulphate ions originally in the seawater. If re-exposed to air the sulphide can be oxidised back to sulphate in the form of sulphuric acid. The loss of oxygen and/or production of highly acidic water can result in death of biota – visible often as a fish kill.

Any activity which lowers the soil groundwater table can lead to oxidation when oxygen comes into contact with sulphide. Examples of such activities include soil disturbance (e.g. by trenching) or lowering of lake level which causes a drop in groundwater level (CASS 2009). Reedy Lake has experienced water level fluctuations both naturally and as a result of management. In 1996/97 and 2006 the lake was deliberately dried almost completely to eradicate large populations of introduced carp (*Cyprinus carpio*).

Sediment analyses by environmental consultants GHD concluded that only sediments at greater depth than 0.0m AHD contained significant acid generating potential (GHD 2015, 2017). It is likely that the natural incidence of wetting and drying cycles of the lake over thousands of years has removed any sulphides from regularly exposed sediments at higher elevations. Based on the GHD studies and provided water levels are kept above 0m AHD the ERP believes the risk of acid sulphate sediment activation to be low.

A related issue for management is the concentration of heavy metals (e.g. copper, lead and chromium) and metalloids (e.g. arsenic and selenium) in sediment. These elements can dissolve in acidic waters (such as those produced from sulphide oxidation) or become incorporated into food chains as a result of uptake from sediments by plants, bacteria or burrowing invertebrates. At high concentrations these elements are toxic.

Corangamite CMA has engaged GHD to undertake sampling of sediment and water during 2014 (GHD 2015), 2016/17 (GHD 2018) and 2018/19 (GHD 2020) and again in 2020/21. Sampling on five occasions between December 2018 and August 2019 saw analyses for 24 elements in water and 10 elements in lake sediment. Concentrations were compared to Australian and New Zealand water and sediment guideline values where these were available (ANZG 2018). A guideline concentration for an element is a value below which there are unlikely to be unacceptable environmental or other effects.

GHD (2020) concluded:

- All sediment quality parameters were below ANZG (2018) guidelines
- Water column concentrations of antimony, cadmium, mercury, molybdenum and selenium, silver and thallium were below guidelines at all times and sites. Chromium, cobalt, copper, manganese, nickel, vanadium and zinc generally met concentration guidelines with a few instances of minor exceedance.

- Concentrations of arsenic and boron in water exceeded guideline values at a number of sites and at a number of times. Aluminium exceeded its water column guideline on one occasion at one site.

These results were similar to those found in GHD's earlier surveys. The consultant concluded the metals in sediments *"did not pose a risk to environmental and community values"* (GHD 2020). Water column metal concentrations were considered low risk noting that variable exceedances of metal concentrations *"is not uncommon in modified environment[s] with catchment inputs from urban areas"* (GHD 2020).

The Expert Review Panel support continuing the proposed sediment and water quality sampling over 2020/21 and then review the complete data set from all surveys. A decision on whether to continue monitoring of particular elements should be made following the review.

4.7 Urban run-off entering the wetlands

Urban development within the Armstrong Creek catchment has been identified as a potential threat to the Ramsar listed values of Hospital Swamps - primarily through hydrological alteration. In particular, the increased runoff resulting from subdivision may interfere with the seasonal drying and salinisation of the swamp over summer and autumn (p 165, DELWP 2018). This key part of the annual hydrological cycle is required to maintain the ecological character of the swamp (Lloyd et al. 2012).

Actions to reduce the effects of changed hydrology of Armstrong's Creek have been recommended (Ecology and Heritage Partners Pty Ltd 2018). Under this proposal a stormwater retention basin is being constructed at Sparrovale. Subject to agreement between City of Greater Geelong and CCMA, the plan is for summer and autumn runoff from Armstrong Creek to be diverted to Sparrovale, via the yet to be constructed southern diversion channel. Here the water will be allowed to evaporate or will be discharged to Lake Connemara or Hospital Swamps over winter. During the high flow period of winter and spring Armstrong Creek discharge can be undiverted and enter Hospital Swamps via Baensch's Wetland, unless there is a risk of flooding private property. It will be important to investigate whether this altered summer flow regime (which prevents inflows to Baensch's Wetland) impacts negatively on it.

In the report the volume of winter flows from Armstrong Creek are considered negligible compared to the inflows to Hospital Swamps from the Barwon River but this is unlikely to be the case. At full development of the subdivision average annual discharge from Armstrong Creek is estimated to be 6,580 ML. The consultants suggest this is small when compared to the average annual discharge of the Barwon River (395,000 ML; Table 2 in Ecology and Heritage Partners 2018). This comparison is not justified however since not all of the Barwon River flow passes through Hospital Swamps. The volume of Barwon River water which does enter Hospital Swamps is not known but will be much less than this total. The extent of dilution of storm water inflows from Armstrong Creek by Barwon River inflows to Hospital Swamps cannot be assumed but should be measured.

Water quality of the inflowing water from Armstrong Creek is not a focus of the report by Ecology and Heritage Partners. Urban development can result in poor water quality from a wide variety of sources. These include litter, fertilizers, animal faeces, cars, biocides, detergents, spillages and illegal discharges (Stormwater Committee 1999 Table 1.1). Ecology and Heritage Partners point out that water quality treatment systems are the responsibility of individual property developers and/or the City of Greater Geelong. Best practice environmental management guidelines (Storm Water Committee 1999) are required to be implemented by property developers under EPA Victoria's State Environment Protection Policy (Waters) objectives and Clause 56 of the Victoria Planning Provisions. Implementation of water quality treatment systems within Armstrong Creek catchment should result in creek discharge having superior quality to that of the untreated Barwon River but this is still to be determined.

Hospital Swamps has a surface area of 213 ha (p50; Lloyd et al 2012). To raise its water level by 0.5 m as typically happens during winter/spring will require 1065 ML of water. This volume is significantly lower than the present (3540 ML) and predicted (6580 ML) discharge from Armstrong Creek - most of which would be expected during winter and spring. Clearly Armstrong Creek inflow will have a major influence on Hospital Swamps depending on how the southern diversion channel is operated.

As urban development progresses within the Armstrong Creek catchment it is important to measure runoff volume and composition for their potential to impact on Hospital Swamps:

1. Water quality and discharge of both inflowing Armstrong Creek and Barwon River waters should be measured especially at times when water is entering Hospital Swamps. It is important to determine whether water treatment installed as part of subdivisions has altered contaminant loads as well as flow volumes in Armstrong Creek. Loads of dissolved and suspended constituents are calculated as the product of flow volume and their concentrations. It is also important to determine the relative magnitudes of Armstrong Creek and Barwon River inputs (i.e. water volume and contaminant loads) to Hospital Swamps and whether there are undesirable changes in Baensch's Wetland.
2. If mixing of Barwon River inflows and Armstrong Creek flows is inefficient localised effects associated with the latter may result. Vegetation surveys of Baensch's Wetland and in Hospital Swamps adjacent to the Wetlands would allow identification of undesirable changes.

If unacceptable changes to Hospital Swamps are detected alteration of the water management regime will be required to protect Ramsar values.

4.8 Frogs

Environmental watering recommendations from Lloyd et al. (2012) did not include specific recommendations for frogs. However, Reedy Lake supports the Growling Grass Frog which is listed nationally as threatened and is listed in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan (DELWP 2018) as a 'critical component' of the Ramsar Site. Very little frog monitoring has been undertaken at the site, but GHD (2017) undertook a baseline survey, recording five frog species:

- Common Froglet (*Crinia signifera*)
- Southern Brown Tree Frog (*Litoria ewingii*)
- Growling Grass Frog (*Litoria raniformis*)
- Southern Bull (Banjo) Frog (*Limnodynastes dumerili*)
- Spotted Marsh Frog (*Limnodynastes tasmaniensis*)

The baseline monitoring results indicated that there were suitable water levels at a suitable time of the year (September) to support the presence of large numbers of common species. GHD (2017) concluded that "Timing of the implementation of a drying regime should where possible to commence after the breeding season for eastern froglet and spotted grass frog. High lake levels and wet years will support all frog species." The breeding season of Growling Grass Frog is from about August or September to about January or February, and metamorphosis generally occurs within about three months of hatching, but occasionally takes as long as 12 months (Pyke 2002).

4.9 Other considerations

There are many other issues that also need to be considered in the management of Reedy Lake and Hospital Swamps. While these considerations are not directly related to environmental watering and are outside the scope of this project, they should be considered either to reduce the risk of not achieving intended ecological outcomes or to fulfil the direction set by state policy.

Fire risk

Tall reeds such as Phragmites and Typha pose a fire risk in dry conditions. An increase in the abundance of tall reeds, changing climate conditions and encroaching urban development may increase the fire risk at Reedy Lake and Hospital Swamps.

Cultural flows

Recognising and incorporating Aboriginal values into water management is an important policy direction set out by the State Government in Water for Victoria. Aboriginal values are already considered through engagement during the seasonal watering proposal process, however there is a need to consider these values more

thoroughly, an initiative already being implemented by Corangamite CMA and Wadawurrung Aboriginal Corporation.

Grazing

Historically, sheep and cattle grazing in Victoria's wetlands has been a common occurrence. However, the continued presence of sheep and cattle within the wetland environment can put the achievement of ecological objectives at risk. Trampling of sensitive wetland vegetation, overgrazing and introduction of excess nutrients are all threats introduced by sheep and cattle access.

Access

In an increasingly urban environment, demand for natural open space will increase. While outside of the CMA management responsibilities, planning for future community access and the associated risks should be considered along with partner agencies in planning and delivering environmental water to Reedy Lake and Hospital Swamps.

Mosquito control

The Ramsar site plan risk assessment lists chemical mosquito control (Methoprene) as a low risk to fish, invertebrates and waterbirds. The results from the literature on the use of Methoprene for mosquito control show varied results with some studies reporting no effects to birds and others indicating the possibility of waterbird decline.

5 Advice

As a part of this review, the Expert Review Panel was asked to review the implementation of existing environmental watering recommendations, management actions and new technical information. Using insights gained through the review of this information, the Panel has been asked to provide advice to the CMA on these key areas:

- The suitability of the current management approach
- Specific advice as to any recommended changes to the management approach
- Recommendations around critical monitoring needs

5.1 Advice on current management approach and any recommended changes

Advice 1. Commit to updating the current environmental watering recommendations by 2022

The environmental watering recommendations developed by Lloyd et al. (2012) were developed eight years ago, using the best available information at the time. The State Government aims to review existing environmental watering recommendations after 10 years, although shifting priorities and the necessity of a review means this updating does not occur for every aquatic system that has a previous FLOWS assessment. The Expert Review Panel advises that the current environmental watering recommendations for the site should be updated and reviewed after 10 years (i.e. 2022) as a matter of high priority.

The original 2012 recommendations were largely built around some key assumptions:

- That there was encroachment of tall reeds across the wetland, reducing the area of open water habitat
- That this encroachment of undesirable taxa of native plants could be controlled through manipulation of water levels and through the related increase in salinity concentrations in surface-expressed groundwater following water-level drawdowns.
- That frequent drying of Reedy Lake is required to control carp numbers in order to limit their environmental impacts.

After reviewing the currently available information, the Expert Review Panel questions the validity of these assumptions.

Other matters raised about the suitability of the current watering regime concern the hydrological data and assumptions used to inform the recommendations and knowledge gaps around salinity and future impacts of increased urban runoff. The Technical Assessment Panel (2012) highlighted the uncertainties around hydrology and hydraulics, particularly in relation to runoff and evaporation inputs as a potential problem. The Expert Review Panel also sees this as a knowledge gap. Effective modelling of evaporation-assisted drawdown, changes to catchment runoff and salinisation of the wetlands would be possible using a suitable water balance model and would be of great assistance to managers.

Little is known about the salinity dynamics of the wetland system (including surface water-ground water interactions) and how operations at Reedy Lake and Hospital Swamps affect each other and Lake Connewarre. Lloyd et al. (2012) identified this as a knowledge gap in their recommendations report and the Expert Review Panel believes that further work needs to be undertaken to quantify the salinity dynamics and impacts of management on salinity at the site. These uncertainties and the effects of the future Sparrovale wetland and channel warrant an evidence-based review of the ecological values, management objectives and current watering recommendations for Reedy Lake and Hospital Swamps.

Advice 2. Develop a water and salt-balance model prior to updating the environmental watering recommendations

Prior to undertaking a review of watering recommendations, the Expert Review Panel advises that there are some important investigations that need to be undertaken. The most critical of these is a water and salt balance model that includes Reedy Lake, Hospital Swamps and Lake Connnewarre. Hydrodynamic modelling for the site has previously been undertaken, however these models can only provide limited information required to inform management decisions. In 2009, a model was developed but this only covered Lake Connnewarre.

A hydrodynamic model was also developed to inform the Lloyd et al. (2012) recommendations. As highlighted by both Lloyd et al. (2012) and the Technical Assessment Panel (2012) there are concerns around this modelling especially in relation to local catchment runoff, groundwater discharges, evaporation and the fact that the scenario modelling of wet, dry and maximum variation was based off a single year, 2008/09, a low flow year not typical of average conditions. A wetland connectivity study was undertaken by Water Technology in 2014, however this investigation built on the existing model used to inform the flow recommendations and focused on identifying infrastructure modifications that could be made to improve inundation and connectivity.

A new water and salt balance model will need to consider:

- Reedy Lake, Hospital Swamps and Lake Connnewarre
- Surface-water and ground-water interactions
- A range of hydrologic conditions including drought years, average years and wet years
- Sparrovale wetland and the future stormwater runoff from the Armstrong Creek development
- Climate change scenarios

Incorporation of climate change scenarios will be particularly important, given the scale of likely change across Victoria in coming decades (Gross et al. 2015) and considering that freshwater wetlands have been lost over much of western Victoria since European colonisation in the mid-1800s. The Glenelg Hopkins CMA estimates that 50% of wetlands in its region have been drained since European settlement – and the region holds 44% of the State’s wetlands (GHCMA 2013). Given this, and climate modelling which suggests the south west of the state may experience reductions to rainfall and hence river flow, the ecological and social importance of the Lower Barwon wetlands can only increase with time (GHCMA 2016). Kingsford et al. (2016) estimated that over 40% of the area of pre-European wetlands had been lost in the past 200 years. Subject to its availability, Barwon River water may make it ecologically beneficial to fill Reedy Lake (and Hospital Swamps) during times of drought in south-eastern Australia (as for example in 2019/20; Figure 3). This wetland complex could supply an invaluable drought refuge for water birds at such times. Incorporating climate change scenarios into a water- and salt balance model may assist managers to further investigate these opportunities.

Only with the information provided by a water-balance model can critical management decisions such as the timing of drawdown, the necessity of assisted drawdown and the appropriateness of stormwater runoff mitigation measures be made in the form of watering recommendations.

Advice 3. Address other key knowledge gaps prior to updating environmental flow recommendations

In addition to developing a water and salt-balance model, it would advantageous prior to the 2022 review to undertake further investigations to determine:

- If the encroachment of undesirable taxa of tall reeds (especially *Phragmites australis* and *Typha* spp.) is a problem that management actions should focus on.
Note: a time-series analysis of remote imagery (e.g. historical aerial photographs or satellite imagery) of Hospital Swamp and Reedy Lake for the areal extent of different vegetation communities, including tall reed EVCs and of halophytic vegetation types such as coastal saltmarsh and estuarine wetland EVCs, would complement and extend the Geoscience data reported here (see also Ecology Associates; 2006 and 2014).
- If carp densities are approaching levels requiring management action (ca. 100kg/Ha; see Brown 2013).

- Responses of vegetation and fish to the summer-full water regime applied in the fourth and final year of the current trial.

The Expert Review Panel also recommends that a document be prepared by the CCMA to provide a single summary of the annual operating actions and infrastructure changes for the wetlands since the Lloyd et. al. (2012) study. This will enable the arrangements and operation of the watering infrastructure at the wetlands to be easily and quickly understood by those providing technical advice regarding the watering regimes.

The purpose of these investigations is to better understand the potential threats and drivers for management at the site. The Geoscience Australia data (shown in [Figure 5](#) ~~Figure 4~~ to [Figure 8](#) ~~Figure 7~~) are very finely resolved in the temporal sense, but lack resolution in terms of spatial scale and do not discriminate among the various types of vegetation present at the different wetlands in the Lower Barwon. The preliminary assessments recommended above would expand on the spatial scale and on the distributions of different types of vegetation. As the previous environmental water recommendations were based on some key assumptions around the points above, it would be beneficial to re-evaluate the central assumptions that underpinned them before undertaking a review of the existing recommendations.

The Expert Review Panel understands the budgetary and timeline constraints that managers must work within and suggests that these investigations are undertaken before a review of the existing watering recommendations. If this is not possible, the Panel emphasises that these investigations should not cause a delay in the timing of a watering recommendations review.

Advice 4. Develop an agreed environmental water management plan for the wetlands

Environmental Water Management Plans (EWMPs) are an important and detailed management document (see [Figure 3](#) ~~Figure 3~~, Section 2.4). The plans set out the goals of environmental watering, ecological objectives and the watering regime to achieve the ecological objectives at the site or waterway scale and cover a longer planning scale than the annual seasonal watering plans. Many managed rivers and streams in northern Victoria have an EWMP and this long-term management document would be useful for the management of Reedy Lake and Hospital Swamps. EWMPs document the frameworks within which a site must be managed (e.g. Ramsar, state and federal legislation etc.) and document the site governance arrangement and agency responsibilities. Further information on where EWMPs fit within the management context for the wetlands is provided in Section 2.4.

An EWMP could provide an overarching vision for the site, contributing to future watering recommendations and other management strategies. It would document the goals of environmental watering, document the priority ecological objectives and the rationale for selecting priorities, detail the long-term watering regime that will be required to achieve the priority objectives and document any constraints, adaptive management actions and the justification for these. It is noted that the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan and associated Ecological Character Description and Limits of Acceptable Change offers relatively high-level and/or geographically specific objectives for the whole Ramsar site and does not offer adequate detail at adequate scale to provide a vision, goals, objectives, actions or monitoring for the Lower Barwon Wetlands.

An EWMP could be incorporated into a larger management plan that includes priorities and actions for complementary, on ground management actions. This would require close co-ordination with the land manager for the site, Parks Victoria. The plan would need to clearly define the roles and responsibilities of the agencies involved in management of the site.

The current review has questioned the priority that should be given to the goals of limiting reed expansion and controlling carp populations: they are both seen as worthy goals, but arguably not deserving the priority that has been assigned to them. This provides an opportunity to look more closely at other goals that may deserve high priority for future watering recommendations or other management actions, all in the context of the Ramsar obligations (to maintain the ecological character of the wetlands). Some suggestions for consideration are provided below.

1. *Provision of habitat for marsh birds (especially Australasian Bittern and Magpie Goose) may deserve higher priority than has previously been recognised.*

Currently Reedy Lake is the main wetland in the broader Port Phillip (Western Shoreline) and Bellarine Peninsula Ramsar Site that contains an extensive growth of tall reeds and cumbungi. That vegetation provides important habitat for several waterbird species including at least three that are listed as threatened globally (Australasian Bittern) or in Victoria (Magpie Goose and Brolga), as well as a number of marsh birds whose local status is not well known (e.g. crakes and rails). Reedy Lake has had these characteristics for many years (e.g. Belcher 1914). Magpie Geese have been found to breed at Reedy Lake and Australasian Bitterns are likely to breed there. The tall marsh vegetation also supports small breeding colonies of ibis and spoonbills in some years and is known to have supported larger breeding colonies of those species in the past.

2. *One of the special features of the Lower Barwon wetlands is that they receive water from the Otway Ranges, one of the highest-rainfall catchments in the state.*

The southerly location of the Otways may make them less sensitive than most catchments to reducing rainfall with climate change (Grose et al. 2015). Additional water recovery in the Upper Barwon may provide improved flexibility for watering options at the Lower Barwon Wetlands. This increased flexibility for watering may provide the opportunity to fill Reedy Lake in dry years when most ephemeral wetlands in south-eastern Australia are dry. As Figure 3 shows the Barwon had sufficient water in the summer of 2019/20 when much of SE Australia was in severe drought. We would anticipate that in future there will be some drought years when sufficient water was available in the Barwon to allow Reedy Lake to act as a drought refuge. This would be a different approach from that suggested by Lloyd et al (2012), who advised filling the wetland mainly in wet years to accord with natural processes. It would also be a departure from the current policy to use the environmental entitlements to benefit the site over the longer term, to an approach that triggered consideration of state-wide priorities such as bird refuges, in times of drought. This would need to be dealt with within a revised FLOWS study and EWMP.

Note that elsewhere in the Ramsar site, the Western Treatment Plant (WTP) provides a remarkable drought refuge for waterbirds and duck species in every year, as it is fed by effluent from Melbourne's water system (Loyn et al. 2014). However, the WTP does not provide as much quality habitat for some marsh birds as Reedy Lake: the WTP is rarely visited by Magpie Geese and attracts only small numbers of Australasian Bitterns. Brolgas have occurred in similar numbers at both sites, and regularly breed at or near the WTP.

If the suggestion above is adopted, it would be important to reduce water levels at Reedy Lake in some wet years, as seasonal variation in water levels is important for maintaining biodiversity, as recommended by Lloyd et al (2012). Specifically, this process could provide mudflat habitat for shorebirds when most local wetlands are full. Some wetlands benefit from complete drying, and support high populations of waterbirds when they are refilled, as a result of enhanced invertebrate food production with a flush of new nutrients and little competition from fish (especially where refilling comes from local catchments or non-riverine flows) (e.g. see Bouffard & Hanson 1997; Stamation & Loyn 2009). However, Reedy Lake will always depend mainly on the river for refilling, and such management is only likely to be needed if problems with carp or reeds become more severe in future years.

3. *Areas of saltmarsh on the periphery of Reedy Lake may deserve more attention*

Although we note that these EVCs are likely to be better represented on Lake Connemara than at Reedy Lake. These EVCs have intrinsic value and have been used periodically as early-winter feeding sites by the Critically Endangered Orange-bellied Parrot (e.g. Hewish and Starks 1988). However, it is not currently clear what watering or management actions may be most useful for this vegetation.

The development of an EWMP could be undertaken in conjunction with a review of the environmental watering recommendations, however any changes to the objectives and recommendations need to inform the EWMP. Generally, an EWMP is developed after environmental watering recommendations as a way to develop these recommendations into a plan for water management at the site.

Advice 5. Implement the longer-term Lloyd et. al. (2012) watering regime in Reedy Lake in the short term

It is important to note that the Expert Review Panel supports a wetting and drying regime for Reedy Lake. This fits the agreed watering objective and the science. Both the Lloyd et al. (2012) study and other research

undertaken in coastal wetlands in Victoria (e.g. Raulings et. al. 2010, 2011; Boon 2011) show that a permanently full lake will lead to a decrease in biodiversity. Wetting and drying regimes produce a mosaic of different habitat types as the water availability fluctuates providing specialist habitat for a wide variety of different flora and fauna species to utilise. Productivity at wetlands adapted to a wetting and drying regime, such as Reedy Lake, is driven by the disturbances caused by fluctuating water levels, occasional periods of high water and occasional periods of very low water. Occasional wet years would occur intermittently during unusually high flow years but should not be seen as “normal” or desirable.

In the absence of reviewed or modified environmental watering recommendations, the Expert Review Panel advises that the long-term watering recommendations from Lloyd et al. (2012) should be implemented at Hospital Swamp and Reedy Lake. Long-term watering recommendations were made with the objective of balancing all the ecological values at the site. The recommendations were based on a seasonally adaptive approach and can be found in Table 6.

Table 6. Long-term watering recommendations developed by Lloyd et al (2012)

Scenario	Hydrological objective	Frequency*	Environmental objectives
Wettest 25% of years	Maintain high lake level (at or near 0.8 m AHD) throughout the year	1 year in 4	<i>Major waterbird breeding events</i> <i>Summer feeding by waterbirds in flooded vegetation and wetland fringe</i> <i>Major fish breeding and recruitment</i> <i>Growth of fish</i> <i>Migration and dispersal of fish between river, lake and estuary</i>
Typical years	Allow wetland to fill in winter and spring to 0.8 m AHD. Gradually reduce water levels to 0.3 m AHD (below the reed beds) at an approximate rate of 7 cm per week, starting December 1. Restart drawdown following overbank flows in summer, if any.	2 years in 4	<i>Moderate waterbird breeding events</i> <i>Wading bird habitat over summer</i> <i>Spring feeding by waterbirds in flooded vegetation and wetland fringe</i> <i>Moderate fish breeding and recruitment events</i>
Driest 25% of year	Allow wetland to fill in winter Gradually reduce water levels to 0 m AHD at an approximate rate of 7 cm per week, starting November 1 Restart drawdown following overbank flows in summer, if any.	1 year in 4	<i>Recruitment of aquatic macrophytes at wetland fringes</i> <i>Retard or reverse reed colonisation of low-lying areas</i> <i>Control carp</i> <i>Wading bird habitat over summer</i> <i>Decay of organic matter on wetland bed, which will increase lake productivity when reflooded</i>

* frequency is to be considered in terms of a longer time period than just four years, i.e. the driest years may occur in years 1 and 2 of a 10-year period, not evenly spaced every once every 4 years.

Given the recent wetting and drying regime that has been implemented at Reedy Lake, the Expert Review Panel advises that implementing the driest 25% of years scenario should be avoided in the years leading up to a review in 2022. The ERP believes the ecological effects of such a complete drying are too extreme for frequent application. Adoption of the longer-term watering recommendations of Lloyd et al (2012) should see the following changes relative to the trial watering regime:

- 1. A later start to the active drawdown (no earlier than December)** compared to the October – November starts which have characterised earlier years (see Table 2 and Attachment B for planned actions). The later drawdown will allow breeding by Australasian Bitterns and other waterbirds, and will provide muddy margins for migratory shorebirds when it is most needed between January and March. The later fall in water level will also benefit frogs and nesting water birds (see Section 4.8 for Frogs and Attachment D [Figure 14](#)~~Figure 13~~ for birds).

2. **A possible slower rate of drawdown** as discussed below. This will ensure muddy margins are available for migratory shorebirds from December/January through to mid-April or early May.
3. **A final (March) lake level close to 0.3m AHD** rather than the 0.1 - 0.2m AHD observed in years 1-3 of the trial period (see [Figure 12](#)[Figure 11](#) for indication of inundation extents at those levels). Note that if water levels in the Barwon River prevent top up from the inlet, the outlet gate should be opened if levels drop below 0.3m AHD to allow tidal inflows and prevent complete drying.
4. As outlined in the Lloyd et al (2012) long-term recommendations, **refilling occurs through winter/spring**. The ERP recognises that this is a large window of time. Most migratory shorebirds that utilise Reedy Lake depart for the Northern Hemisphere between mid-March and late-April. Therefore, the ERP advise that filling should not commence before mid-April/ early May. Commencing wetland filling in line with this advice will provide a number of benefits:
 - Exposed mudflats at the fringes of the wetland will be available to migratory shorebirds immediately prior to their departure, helping them to be well prepared for the journey.
 - With a later and slower drawdown, the later commence-to-fill date will ensure that mudflats are available for enough time to support migratory shorebird species through to late April, when most will have departed for their breeding areas in the Northern Hemisphere.
 - The proposed system will still see ducks utilising the wetland at the usual opening of the duck season (mid-March) as it will not be drawn down below 0.3m, and there will still be expanses of shallow water favoured by most duck species. Subsequent influxes of fresh water (from mid-April/early May) are expected to attract further influxes of ducks before the usual end of the duck season (June).

The Lloyd et al. recommendations suggest a drawdown rate of approximately 7 cm/ week which was achieved under management arrangements in 2017/18 and 2018/19 (see Table 2). If the lake is drawn down at 7cm/week then it will fall from 0.8m AHD to 0.3m AHD in seven weeks (i.e. from 1 Dec to 21 Jan approximately). Actively drawing down over this full time period (i.e. Dec-Mar) may be unnecessary, and not beneficial to meeting the ecological objectives.

The rainfall deficit during the drawdown period (Dec – Mar) is about 0.1m per month (see evaporation and rainfall data in [Table 7](#)[Table 7](#) below). This suggests that evaporation alone could lower the lake by 0.5m between 1 Dec and 1 May. Operationally this would mean closing inlet and outlet gates at 0.8m AHD and monitoring lake level. If experience shows evaporation alone is not sufficient, then gates could remain open until the lake reached about 0.5 m AHD and then evaporation be allowed to further drop lake level. These options are illustrated schematically in [Figure 11](#)[Figure 10](#). Note that if water levels in the Barwon River prevent top up from the inlet, the outlet gate should be opened if levels drop below 0.3m AHD to allow tidal inflows and prevent complete drying. This simple analysis ignores the effects of Barwon River freshes overtopping levees, groundwater inflows and catchment runoff in summer storms. All these factors mean that timing of drawdown interventions cannot be an exact science.

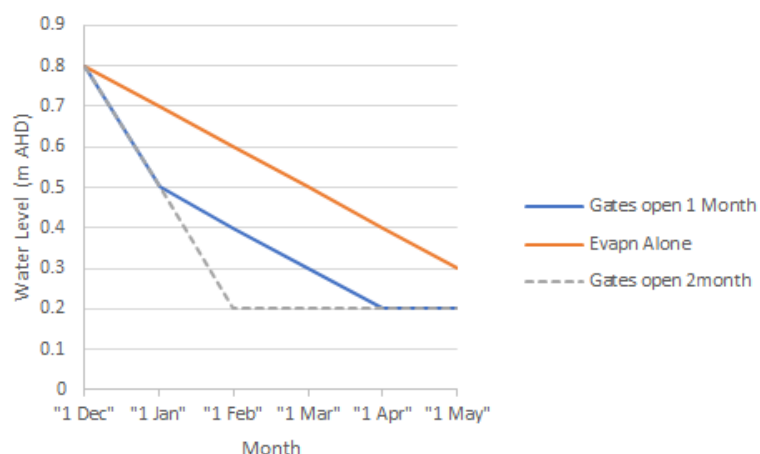


Figure 11. Schematic representation of three scenarios for lowering the level of Reedy Lake over summer/autumn. When gates are open the rate of fall is assumed to be 7cm/week. Tidal exchange with Lake Connewarre is assumed to maintain the lake at 0.2m AHD.

Table 7. Mean monthly evapotranspiration and rainfall data for Geelong Racecourse (at Breakwater) from June 2011 to February 2020. The difference (rainfall deficit) is also shown. The orange highlight identifies the summer drawdown period. (Source: Bureau of Meteorology)

Month	Evapotranspiration (mm)			Rainfall (mm)	Difference (mm)
	Average	Maximum	Minimum	Average	Average
June	29.8	33.4	26.7	58.7	30
July	40.5	48.8	34.3	44.8	4.3
Aug	55.5	62.6	46.6	42.9	-12.6
Sep	78.3	53.3	92	47	-31.3
Oct	112	123	101	31.9	-79.9
Nov	126	146	110	48.4	-77.2
Dec	157	187	123	28.3	-129
Jan	160	190	132	37.4	-123
Feb	125	139	82.6	36.8	-88.1
Mar	111	128	92.1	25	-86.3
Apr	69.5	83	48.5	113	44
May	49.4	57.7	41.1	52.3	2.9

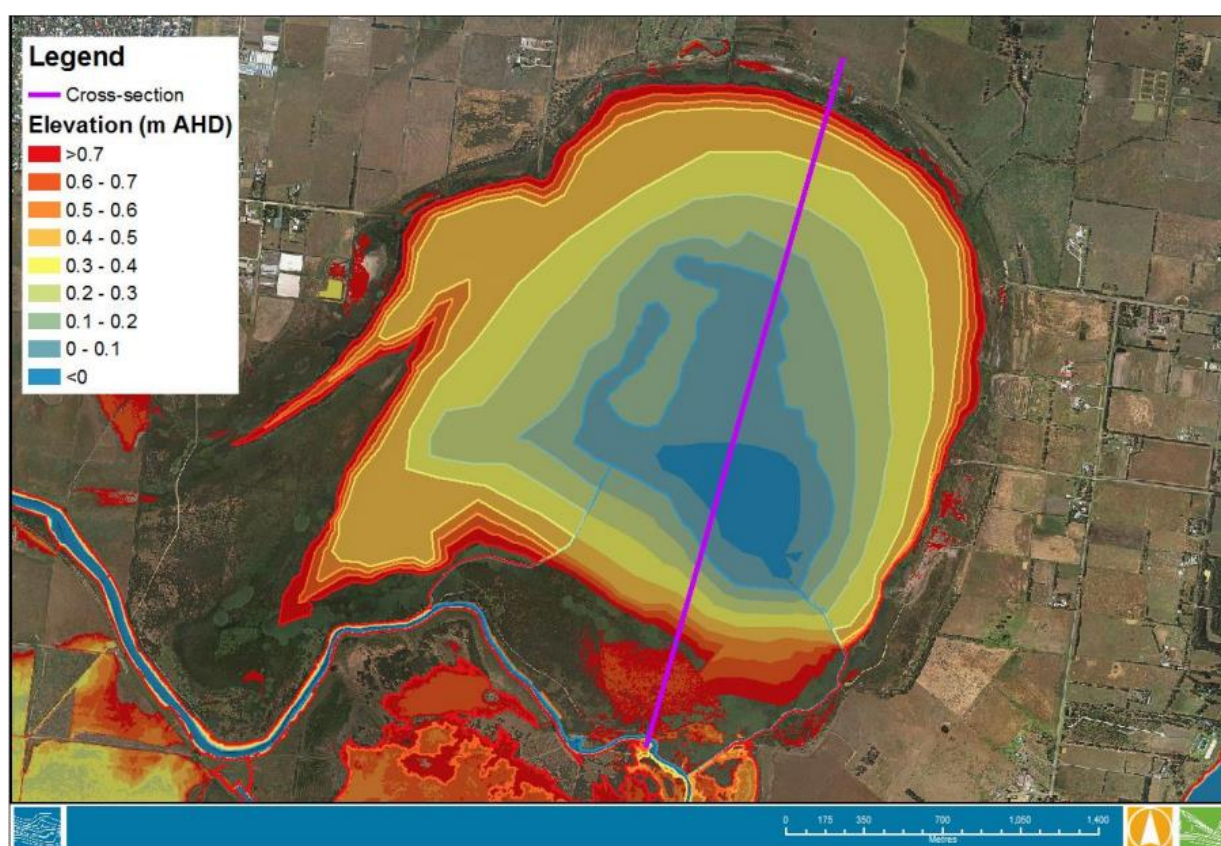


Figure 12. Elevation contours (0.1m increments) for Reedy Lake (Water Technology 2014)

Advice 6. Implement the environmental watering recommendations from Lloyd et. al. (2012) in Hospital Swamps in the short term and advocate for strong control measures on urban inflows

The available data at Hospital Swamps seems to indicate that the environmental watering recommendations are appropriate and ecological values are in good condition. The wetting and drying hydrology of Hospital Swamps has been maintained over a long period of time and there appears to be no detrimental impact of this regime. For this reason, the ERP advise that the water regime at Hospital Swamps should be maintained pending better

future monitoring data. The current watering recommendations for Hospital Swamp are outlined in [Table 8](#). While the ERP advises that the current recommendations for Hospital Swamps should be implemented in the short-term, they should be reviewed and updated along with the recommendations for Reedy Lake in 2022.

Table 8. Existing watering recommendations for Hospital Swamps developed by Lloyd et al (2012)

Scenario	Hydrological objective	Frequency
Typical years	Allow wetland to fill to 0.5 m AHD in winter/spring period Allow flow freshes (0.7 m AHD) to flush the wetland Drawdown to a level of less than 0.3 m AHD by the end of January Allow wetland bed to dry in late Summer/Autumn	9 years in 10
Dry years	Wetland bed dry Possible shallow flooding	1 year in 10

While the current watering regime at Hospital Swamps appears to be mostly appropriate, two issues have been identified. One is that flushes of water in later summer in some years (including 2020) have drowned shorebird habitat when it is most needed before northward migration. Another is that increased stormwater runoff from the Armstrong Creek urban development poses a significant risk. The increasing urban area will likely result in an increase in the volume of stormwater runoff as well as decreasing water quality associated with the impacts of nutrient, chemicals and turbidity loads. The mitigation measures and operating rules around stormwater runoff for the development have not yet been finalised and while this is not the responsibility of the CMA, there is an opportunity for the CMA to engage with Parks Victoria and the City of Greater Geelong to ensure the best outcome for the long-term health of Hospital Swamps. The CMA have engaged on these issues and the ERP strongly advises that the CMA continue engaging with the City of Greater Geelong on the Southern Diversion Channel, Sparrovale Wetland, water quality and connectivity issues, changes to watering infrastructure and the implications for operating rules and approaches.

Advice 7. Implement a targeted monitoring regime to address key monitoring questions

The provision of environmental water aimed at rehabilitating degraded aquatic systems requires focused monitoring programs, backed-up by rigorous R&D investigations, to test their effectiveness and to explain why they may have succeeded or failed. Three different sorts of activities are often combined under the moniker of ‘monitoring’ (Hellawell 1991, Kennish 2004):

- *Survey work.* Surveys are qualitative observations made without any preconceptions as to the findings. They may include, for example, collecting baseline data as part of an inventory process to describe the condition of a given water body.
- *Surveillance sampling.* Surveillance sampling uses a time series of surveys to determine the variability or range of given variables in the environment. It may include, for example, repeated sampling over time to characterise ecological responses to natural variability in the physical environment, such as seasonal changes.
- *Monitoring.* Monitoring, in the strict sense, is the systematic collection of data over time to gauge compliance with a pre-determined standard or model. The standard could be, for example, a legal compliance value for swimming or other water-contact activities, or the quantitative objectives of a management program.

Only the last is bona fide ‘monitoring’. Moreover, monitoring differs from the other two more general data-collecting activities in two other ways (Finlayson and Mitchell 1999):

- Monitoring is underpinned by a specific reason for collecting the data; and
- The results are compared with a standard or model, which is used to interpret, check or test the data, and a set of actions then arise according to whether compliance is achieved or not.

The Expert Review Panel recommends strongly that bona fide monitoring be undertaken to gauge the effectiveness of past and future water-level manipulations. Less focussed survey work or surveillance programs



may also be undertaken to provide background information, but future monitoring efforts should address the answering of specific management or scientific questions, framed before the monitoring activities commence.




The Expert Review Panel has formulated a set of monitoring questions for each of the ecological values at Reedy Lake and Hospital Swamp and developed some monitoring guidelines that will assist in answering these questions (~~Table 9~~~~Table 9~~). Not all monitoring activities are required annually, and monitoring priorities will depend on the priority of different ecological values and watering objectives. It is also important to note that the monitoring activities are not required indefinitely. Some questions may be able to be answered after only a few years of monitoring, others will need to continue for many years.






In designing ~~Table 9~~ the ERP were aware that the rationale for the monitoring proposals has been described in earlier sections of this report. They have avoided repeating individual justifications for them here. Some of the listed monitoring recommendations have been identified in earlier pieces of our Advice and these should be regarded as of highest priority. The ERP also recognises that resources for monitoring may be limited and so was conscious that the list in ~~Table 9~~~~Table 9~~ should not pose an unreasonable financial burden on managers.


Citizen science can contribute usefully to monitoring programs, and it has provided much of the data on waterbirds reported here. However, professional support is needed to provide a robust framework for such monitoring and ensure that the main questions are addressed comprehensively for all groups of organisms (e.g. waterfowl and shorebirds together) across the entire wetland. Specialist techniques including use of drones and targeted surveys of marsh birds are likely to require the services of professional providers, as are the suggested programs to monitor vegetation and fish. Combinations of citizen science and professional support can provide a cost-effective process for some of the monitoring tasks suggested here.

Table 9. Critical future monitoring needs

	Monitoring question	Monitoring data required	Collection method	When monitoring data is collected	Where the data is collected	Who collects the monitoring data	How the monitoring data could inform management decisions
Monitoring to inform short term environmental water management decisions							
 Birds	How do birds respond to short-term water management?	Breeding stage of colonially-nesting ibis (and spoonbills)	Visual surveys; drones, listening for calls (Bittern)	Before drawdown starts	Reedy Lake	Citizen science, community groups, professionals	Inform start date and rate of drawdown Inform management of an unexpected summer floods
	-Habitat for colonially-nesting species -Habitat for Australasian Bittern nesting	Numbers and breeding activity		After any unexpected flood in Oct-Jan			
	How do birds respond to water management?	Shorebird numbers	Counts	Summer, Winter, optimal timing*	Reedy Lake and Hospital Swamps	Citizen science, community groups, professionals	Inform recommended environmental watering actions annually e.g. the timing of refilling – if shorebirds need low water levels for longer than they are currently getting Identify water flow and bird events that might require special management (e.g. breeding waterbird colonies or threatened marsh birds) Assess effects of water management Inform recommended watering strategy for future years
 Vegetation	Has the area or distribution of tall reed vegetation communities changed?	Area of tall reeds (Ha)	Remote sensing with ground truthing. Aerial photograph or satellite	Once annually in Spring or Summer	Reedy Lake and Hospital Swamps	Professionals (e.g. ARI, other ecological consultants)	Inform the update to the environmental watering recommendations for the wetlands with respect to the need for tall-reed control Inform assessment of compliance with Ramsar LACs

	Monitoring question	Monitoring data required	Collection method	When monitoring data is collected	Where the data is collected	Who collects the monitoring data	How the monitoring data could inform management decisions
	Has the area or distribution of invasive species changed? e.g. water couch (<i>Paspalum distichum</i>) or Common Reed (<i>Phragmites australis</i>)	Area of target species (Ha)	imagery analysis (5 yearly)				Inform the update to the environmental watering recommendations for the wetlands with respect to possible use of water regimes for control of undesirable plant taxa other than tall reeds. Identify where complementary management activities may be required to reduce threats and achieve the environmental objectives for the site
 Processes	How does increasing runoff from Armstrong Creek impact Hospital Swamps?	Discharge Suspended solids Nutrients Metals	Gauge stations: @ Barwon inflow to Hospital Swamps @inflow from Armstrong Creek to Hospital Swamps	Event based sampling	Hospital Swamps	Professionals	Trigger for maintenance / remedial actions on upstream treatment assets To allow adaptive management of operating rules for the Sparrovale diversion channel" To identify when pollutants stemming from Armstrong's Creek require management intervention
Monitoring to inform longer term environmental water management decisions							
 Birds	How do birds respond to long-term water management? -Has there been a change in waterbird abundance?	Threatened marsh birds numbers and breeding records (Australasian Bittern, Magpie Goose, Brolga, etc) Waterfowl numbers	Listening for calls; visual surveys; drones Counts	Spring (continued into summer as necessary) Summer (Feb), Winter	Reedy Lake and Hospital Swamps Reedy Lake and Hospital Swamps	Citizen science, community groups, professionals	Inform recommended environmental watering actions annually Identify water flow and bird events that might require special management (e.g. breeding waterbird colonies or threatened marsh birds) Assess effects of water management Inform recommended watering strategy for future years
 Fish	How do listed/threatened species respond to water management?	Age population structure, CPUE	Targeted survey	Annual in Summer	Reedy Lake and Hospital Swamps	Professionals (e.g. ARI, other ecological consultants)	Inform environmental watering actions for fish objectives in environmental flows studies, EWMPs, seasonal watering plans and other flow-related management

	Monitoring question	Monitoring data required	Collection method	When monitoring data is collected	Where the data is collected	Who collects the monitoring data	How the monitoring data could inform management decisions
 Vegetation	Has there been a change in condition of vegetation?	Floristic diversity, condition of adults, extent of recruitment	Stratified random and/or transects	Once annually in Spring or Summer	Reedy Lake and Hospital Swamps	Professionals (e.g. ARI, other ecological consultants)	Inform the update to the environmental watering recommendations for the wetlands
 Frogs	What is the status of Growling grass frog populations?	Frog calls/sightings	Mapping locations and order-of-magnitude numbers of calls and sightings	Spring (warm wet nights)	Reedy Lake and Hospital Swamps	Citizen science. Professionals.	Provide evidence base to inform the development of environmental flow recommendations
 Processes	What is the salinity status at the site?	Salinity (EC)	Data logger	Continuous	Reedy Lake and Hospital Swamp	CCMA (existing monitoring)	Provide evidence base to inform the development of environmental flow recommendations, To identify changes to the salinity regime in each wetland which may have negative ecological effects
Monitoring to inform Ramsar requirements							
 Fish	Are carp a management threat?	Carp density	Fish survey (Electrofishing and fyke nets)	Once every 5 years beginning 2021	Reedy Lake	Professionals (e.g. ARI, other ecological consultants)	Inform necessity and priority of carp control actions Informs when a management intervention to control carp is required
 Vegetation	Has there been a change in the area or distribution of different EVCs?	Areas of different EVCs present at the site (Ha)	Remote sensing with ground truthing. Aerial photograph or satellite imagery analysis (5 yearly)	Once annually in Spring or Summer	Reedy Lake and Hospital Swamps	Professionals (e.g. ARI, other ecological consultants)	Inform the update to the environmental watering recommendations for the wetlands wrt optimal watering regimes for different EVCs (including EVCs that should not receive environmental water, such as coastal saltmarsh) Inform assessment of compliance with Ramsar LACs Reports on Saltmarsh and freshwater vegetation LACs

	Monitoring question	Monitoring data required	Collection method	When monitoring data is collected	Where the data is collected	Who collects the monitoring data	How the monitoring data could inform management decisions
 Processes	Is environmental water management effective?	Volume delivered Timing, extent and duration of inundation of key vegetation classes	Monitoring station data Inundation and vegetation mapping	Annually	Reedy Lake and Hospital Swamps	CMA	Required to meet Ramsar monitoring activities outlined in the site MERI plan
	Are management actions appropriate to minimise the risk of Coastal Acid Sulphate Soils (CASS)?	CASS mobility	Surface water, sediment and groundwater monitoring	Annually	Reedy Lake and Hospital Swamps	Professionals	

* "Optimal timing" surveys for shorebirds may be needed when drawdowns deliver optimal conditions.

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7 Abbreviations

AHD	Australian Height Datum
Alluvium	Alluvium Consulting Australia Pty Ltd
ARI	Arthur Rylah Institute
CMA	Catchment Management Authority
CCMA	Corangamite Catchment Management Authority
DELWP	Department of Environment, Water, Land and Planning
DEPI	Department of Primary Industries
EPBC Act	Environmental Protection and Biodiversity Conservation Act
ERP	Expert Review Panel
EVC	Ecological Vegetation Class
EWR	Environmental Water Reserve
EWMP	Environmental Water Management Plan
FFG Act	Flora and Fauna Guarantee Act
GHCMA	Glenelg Hopkins Catchment Management Authority
LBCAC	Lower Barwon Community Advisory Committee
ML	Mega litre
PAG	Project Advisory Group
PV	Parks Victoria
RMIT	Royal Melbourne Institute of Technology
S2020	Shorebirds 2020
SWP	Seasonal Watering Proposal
VEWH	Victorian Environmental Water Holder

Attachment A: Steering Committee and Project Advisory Group members

A1. Project Advisory Group

The Project Advisory Group comprises Traditional Owner Representatives and the Lower Barwon Community Advisory Committee. The Project Advisory Group will ensure there is a source of local knowledge and insight into community values and expectation regarding wetland health. The project is an opportunity for the group to have access to subject matter experts that will endeavour to answer any questions and concerns raised throughout the project.

Members

- Ash Smith (Geelong Gun & Rod Association)
- Bruce Wilson (Landholder)
- Craig Morley (Geelong Field Naturalists)
- Geoff Gayner (Geelong Environment Club)
- Graham Perkins (Landholder)
- Joan Lindros (Geelong Environmental Council)
- John Hotchin (Geelong and District Angling Clubs)
- Matthew Currel (RMIT)
- Melinda Kennedy (Wadawurrung Aboriginal Corporation)
- Peter Lawson (DELWP)
- Stephen McGain (EstuaryWatch)
- Trent Lee (Field & Game)
- Stuart Wilsher (Parks Victoria)
- Ben Obsourne (Osseels)
- Bill Allen (Eel fisher)
- Jared Scott (Barwon Water)
- Angus Ramsey (Southern Rural Water)
- Greg Bensted (Southern Rural Water)

A2. Project Steering Committee

The Steering Committee is responsible for overseeing the project and comprises representatives from a number of government agencies. The Steering Committee is not responsible for any technical input on the project. The Steering Committee may be called on to provide contextual information about past management actions however, these actions along with the most recent technical studies will be independently reviewed by the Expert Review Panel.

Members

- Jayden Woolley (CCMA)
- Lauren Johnson (DELWP)
- Janice Taylor (VEWH)
- Sharon Blum-Caon (CCMA)
- Bill Allen (PAG representative)
- Ash Smith (PAG representative)

Attachment B: Proposed environmental watering actions in Reedy Lake and Hospital Swamps 2012-2020

Table 10. Proposed environmental watering actions from annual Seasonal Watering Plans from 2012/13 to 2019/20. Rows highlighted in green indicate the 'trial' period subject of this review.

Seasonal Watering Plan year	Proposed environmental watering action	
	Reedy Lake	Hospital Swamps
2019-2020	Autumn/winter/spring fill and top-ups (all year) The inlet to Reedy Lake will be opened in autumn in response to a sustained increase in flows in the Barwon River	Autumn/winter/spring fill and top-ups (during March and April to December) Hospital Swamps will be connected to the Barwon River for at least six weeks by keeping the inlet and outlet open
		Summer/autumn drawdown (during December to March and April) The inlet to Hospital Swamps will be closed to allow water levels to drop through evaporation; during this period, the outlet will be opened for short periods of time if a summer storm increases water levels above 0.85 m AHD to reduce levels.
2018-2019	Autumn/winter/spring fill and top-ups (March/April–October) The inlet to Reedy Lake will be opened in autumn in response to a sustained increase in flows in the Barwon River.	Autumn/winter/spring fill and top-ups (March/April–December) Hospital Swamps will be connected to the Barwon River for at least 6 weeks by keeping the inlet and outlet open.
	Spring/early summer drawdown (October– January) and then variable low water levels (around 0.1–0.3m AHD) throughout summer/ autumn (January– March/April) The inlet to Reedy Lake will be closed and the outlet opened to allow water levels to drop to about 0.1–0.3 m AHD; during this period, the inlet and outlet may be manipulated if required to maximise the drawdown or to introduce saltwater to the lake	Summer/autumn drawdown (December– March/April) The inlet to Hospital Swamps will be closed to allow water levels to drop through evaporation; during this period, the outlet will be opened for short periods of time if a summer storm increases water levels above 0.85 m AHD
2017-18	Autumn/winter/spring fill and top-ups (March/April–October) The inlet to Reedy Lake will be opened in autumn in response to a sustained increase in flows in the Barwon River	Autumn/winter/spring fill and top-ups (March/April–December) Hospital Swamps will be connected to the Barwon River for at least 6 weeks by keeping the inlet and outlet open
	Spring/early summer drawdown (October–January) and continued low water levels (around 0.3 m AHD) throughout summer/autumn (January– March/April) The inlet to Reedy Lake will be closed to allow water levels to drop to about 0.3 m AHD through evaporation; during this period, the inlet and outlet may be manipulated if required to maximise the drawdown or to introduce saltwater to the lake	Summer/autumn drawdown (December–March/April) The inlet to Hospital Swamps will be closed to allow water levels to drop through evaporation; during this period, the outlet will be opened for short periods if a summer storm increases water levels above 0.85 m AHD
2016-17	Autumn/winter/spring filling flows (March/April– October) The inlet to Reedy Lake will be opened in autumn in response to a sustained increase in flows in the Barwon River	Autumn/winter filling flows (May–November) Hospital Swamps will be connected to the Barwon River for at least 6 weeks by keeping the inlet and outlet open
	Spring/early summer drawdown (October– January) and continued low water levels throughout summer/autumn (January–March/ April) The inlet to Reedy Lake will be closed to allow water levels to drop through evaporation; during	Summer/autumn drawdown (December– March/April) The inlet to Hospital Swamps will be closed to allow water levels to drop through evaporation; during this period, the outlet will be opened for short periods of time if a summer storm increases water levels above 0.85 m AHD

Seasonal Watering Plan year	Proposed environmental watering action	
	Reedy Lake	Hospital Swamps
	this period, the outlet may be manipulated if required to maximise the drawdown or to introduce saltwater to the lake	
2015-16	Autumn/winter/spring filling flows (during March/April–October) Trial spring/early summer drawdown (during October–January) and continued low water levels throughout summer/autumn (January–March/April)	Autumn/winter filling flows (during May–November) Hospital Swamps will be connected to the Barwon River as much as possible by keeping the inlet and outlet open Summer/autumn drawdown (during December–March/April) The inlet to Hospital Swamps will be closed to allow water levels to drop through evaporation. During this period, the outlet will be opened for short periods of time if a summer storm increases water levels above 0.85 m Australian height datum
2014-15	Keeping the inlet to the wetland open and the outlet from the wetland closed year-round to maintain water levels in the wetland with natural variation resulting from changes in river flows Close the inlet to the wetland and allow drawdown in levels if the Barwon River drops below 0.7m AHD1	Open the inlet to the wetland during autumn (March to May) to fill the wetland, but close the inlet if the Barwon River flows fall below those recorded in summer Maintain full water levels in the wetland over winter, spring and summer (from June to the end of December), if rainfall results in water levels above 0.6m AHD in Hospital Swamps, the inlet may be closed Close the inlet to the wetland to allow it to draw down naturally during summer (end of December to February). During this time, the inlet will be opened for short periods if lower Barwon water levels increase to 0.85m AHD Close the inlet to the wetland if the Barwon River drops below 0.7m AHD at any time
2013-14	Keeping the inlet to the wetland open and the outlet from the wetland closed year-round to maintain water levels in the wetland with natural variation resulting from changes in river flows Close the inlet to the wetland and allow minor drawdown in levels if the Barwon River drops below 0.7m AHD	Open the inlet to the wetland during autumn (March to May) to fill the wetland, but close the inlet if Barwon River flows fall below those recorded in summer Maintain water levels in the wetland over winter, spring and summer (from June to the end of December). Close the inlet to the wetland to allow it to draw down naturally during summer (December to February) Close the inlet to the wetland if the Barwon River drops below 0.7m AHD at any time
2012-13	To achieve the environmental objectives detailed in the previous section, the priority watering actions during 2012-13 for Reedy Lake and Hospital Swamps are as follows: <ul style="list-style-type: none"> • provide spring inflows until river flows decline from September to November • manage a summer drying phase from December to February (Reedy Lake) • allow a summer drying phase from December to February (Hospital Swamps) • provide filling flows in autumn from March to May • maintain depth during winter from June to August. 	

Attachment C: Habitat composition

C1. Satellite observations – Reedy Lake

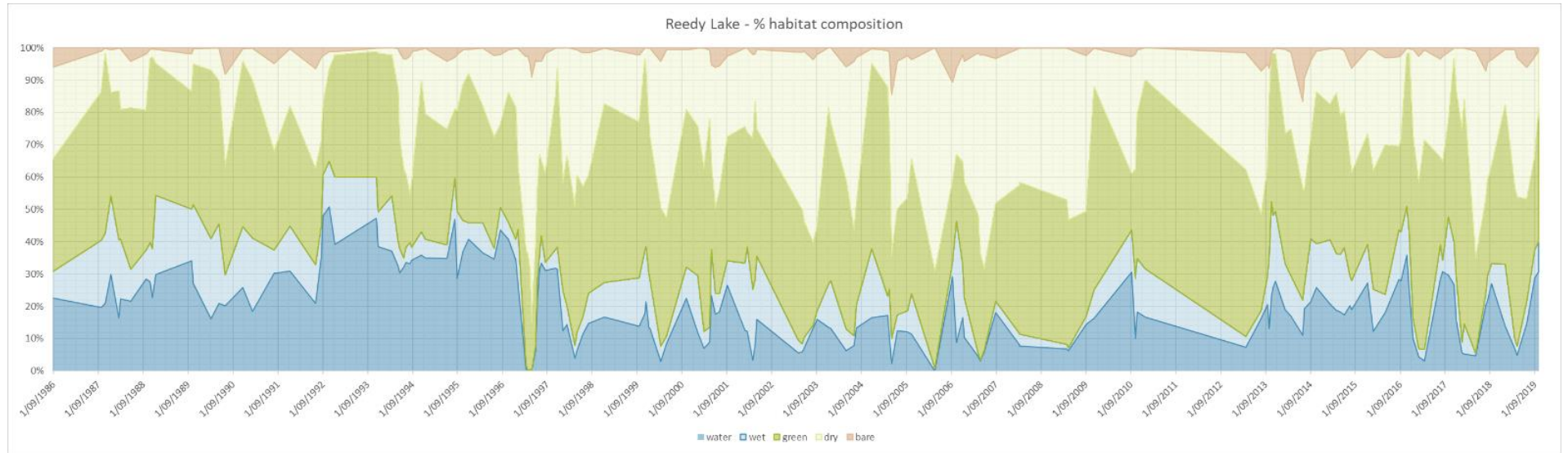


Figure 13. Graph showing percentage habitat composition over time at Reedy Lake. Habitat types include open water, wet vegetation, dry vegetation, green vegetation and bare soil

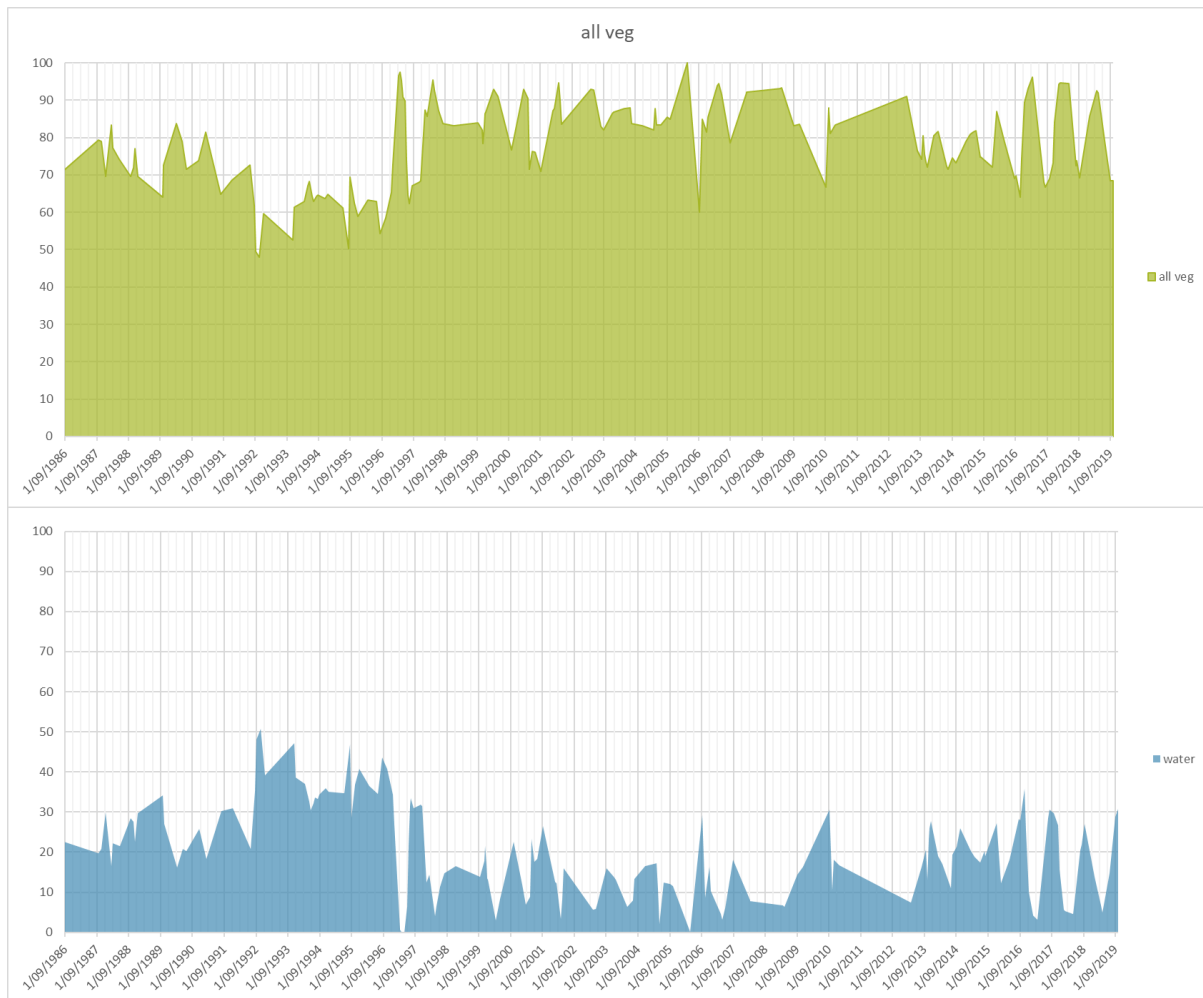


Figure 14. Graphs showing the percentage cover of all vegetation classifications including wet, green and dry (green) and open water (blue) over time at Reedy Lake.

C2. Satellite analysis methodology

The description below has been adapted from information supplied by Geoscience Australia. Observations used to build the Wetlands Insight Tool are made by Landsat satellites 5, 7, and 8 at 25m resolution. Areas smaller than 25m are subject to spectral mixing between classes so the tool should be used as a guide to system changes rather than a method of calculating absolute changes in area.

* The Water Observations from Space Algorithm (WOfS), developed by Geoscience Australia, is used to find the percentage of the area containing open water. WOfS only provides open water.

* The Wetlands Insight Tool uses the Fractional Cover Algorithm developed by the Joint Remote Sensing Research Program to find the percentage of the area containing pixels dominated by green vegetation, dry vegetation or bare soil. The dominant fraction is returned by the tool, so the tool does not reflect whether the pixel was 80% green and 20% dry, or 40% green, 30% dry and 30% bare. It will return that the pixel was green dominated. The Tasselled Cap Index is used to find the percentage of the area that is likely to represent wet vegetation. This is thresholded at -350, a conservative threshold based on work in the Macquarie Marshes, and may underestimate the extent of wetness in soil and vegetation. This class is referred to as 'wet' and has not currently been validated for how much of this represents inundated vegetation or other wet cover types (e.g. mud).

* Values are only calculated when >90% of a box enclosing the polygon area is observed (i.e. is not obscured by cloud). For small polygons this could mean that only a few pixels or a small part of the polygon is observed, if

the box enclosing the polygon is much larger than the polygon, which could be the case for a number of small polygons.

* For a given wetland vector area (polygon/shapefile), the tool calculates the proportion of that area that is classified as being either green vegetation (green), dry vegetation (beige), bare soil (brown), open water (blue) or wet vegetation (light blue) on the y-axis. The x-axis shows how the wetland changes over time.

* Times in which the satellite does not observe the data are not captured by the tool. Observations when the area is obscured by cloud are not recorded in the tool. This introduces the potential to under-represent wet periods of the year and wet seasons.]

Acknowledgment

We gratefully acknowledge Bex Dunn (Geoscience Australia) for providing access and assistance with data from the draft Wetland Insight Tool.

Attachment D: Changes in bird populations at Reedy Lake

D1. Species summaries: Bird species of conservation interest

Australasian Bittern (listed as nationally and globally Endangered)

- Numbers fluctuate; reduced numbers since 2002 might be caused by the national decline.
- No S2020 records (compared to singles in four S2020 surveys at Hospital Swamps).
- Eight incidental records between 2016-2019 (max three birds), five in 2013, and 14 records (max three birds) between 2006-2010.
- During the latest summer high water levels, 15 flushed on a survey on 22 Feb 2020, which is one of the highest counts from anywhere in Australia. Four were seen the next week on 29 Feb 2020, including one in a deeper part of the lake not visited the previous week, so total numbers are likely to be significantly higher. An exceptional total of 25 was flushed in the north west of Reedy Lake on 28 April 2020. The birds were mostly observed in sedge beds of *Bolboschoenus caldwellii*. All observations were made by Guy Dutson.
- (At Hospital Swamps, ten incidental records between 2016-2019, 5 in 2015, and 4 records between 2006-2010; all single birds)
- At least two calling (suggestive of breeding) in Sep 2013 (and in earlier years e.g. 2001) but no proof of breeding.
- Previously, most records Apr-Oct; generally single birds scattered through reedbeds, but max nine in 2001 and 12 in 2002.
- There are little data on breeding season in Australia but the graph below from New Zealand suggests that most chicks will have fledged by the end of January.

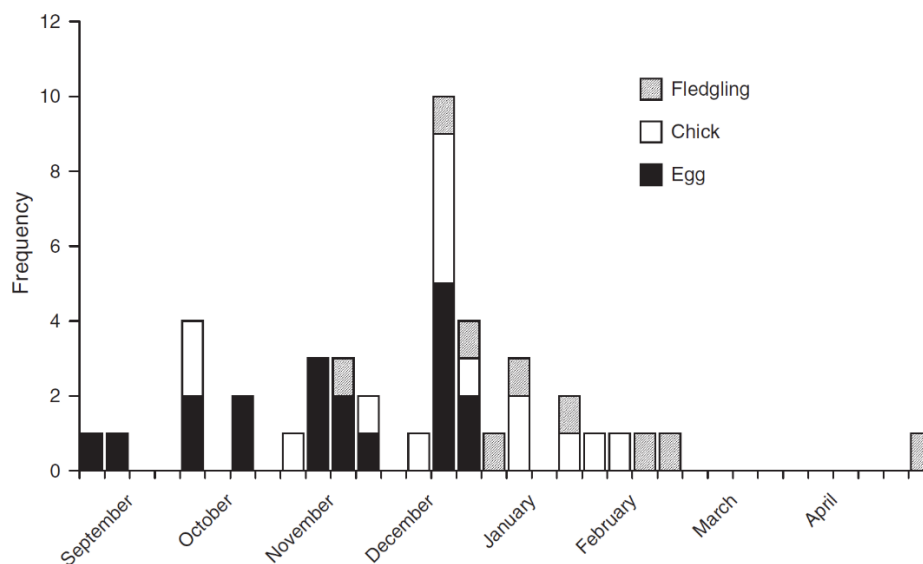


Figure 13. Frequency of Australasian Bittern nesting in New Zealand ($n = 43$ reports) per week from the first week of September (O'Donnell 2011).

Brolga (listed as Vulnerable by DELWP; listed under Victorian FFG Act)

- No trend in numbers; 3 in S2020 surveys in winter 2017, 2018 and 2019 suggest successful breeding.
- Previously, max 5 on incidental surveys in 2008 and 2009 and 2010.
- During the latest summer high water levels, 7 seen on a survey on 22 Feb 2020.

Magpie Goose (recently re-colonised from reintroduced birds at Serendip; listed under Victorian FFG Act)

- None in S2020 counts since 2016.
- Previously, 1-51 in most S2020 summer counts.
- Bred successfully in 1989, 2002 and 2005 (and probably other years).

- During the latest summer high water levels, counts of 50 and 111 in Feb 2020, including probably fledglings, and two fledglings observed on 6 Mar 2020 with adult pair (drone survey by Craig Morley & Richard Shelton).

Australian White Ibis and Straw-necked Ibis (regularly nesting in southern Victoria only at Mud Islands)

- Variable numbers bred many years 1970s-2000, including 10,000 nesting in 1977, 19,000 nesting in 1978 and 10,000 young in 1996 (stimulated by spring flooding in 1995 and maintained high water levels).
- Lower numbers bred after 2000, when most moved to Mud Islands, but >1000 nests in 2002.
- Nestling mortality noted in 2011 and 2018 (CCMA records).

Other nesting waterbirds

- Numbers of other nesting waterbirds are too small to be of conservation or hunting significance, and there are no clear trends except that most species need water to nest.

Other waterbirds

- Reedy Lake commonly supports small numbers of wetland species which are uncommon in Victoria and probably breed at Reedy Lake, including Spotless Crake and Baillon's Crake
- Significant numbers of non-breeding Glossy Ibis occurred in summer 2019/2020, including 58 on 22 Feb 2020

D2. Species summaries: Bird species of duck hunting interest

Australian Shelduck

- Small numbers at S2020 surveys since 2016, max 8.
- Previously, larger numbers in many S2020 surveys, max 112 in 2009, but often zero.
- A high incidental count of 1000 in 2009.
- (Compared to higher numbers, max 1460 in 2008, in S2020 surveys at Hospital Swamps.)

Australasian Shoveler

- Only one S2020 record since 2016.
- Previously, small numbers in many recent S2020 surveys, max 21 and 152 in 2015.
- During the latest summer high water levels, 26 counted in the centre of the lake on 29 Feb 2020, many paired but no proof of breeding.
- (Compared to four S2020 counts over 200, maximum 738, at Hospital Swamps).
- Previous incidental high counts include 1000 in 1994 and 2002.

Grey Teal

- Fluctuating numbers on S2020 surveys, with no clear trend.
- Highest S2020 counts were 8722 in 2013, then 391 in 2017.
- (Compared to similarly fluctuating numbers in S2020 surveys at Hospital Swamps, max 829.)

Chestnut Teal

- Fluctuating numbers on S2020 surveys, with no clear trend.
- Highest S2020 counts were 150 in 2017, then 75 in 2018.
- (Compared to higher numbers in S2020 surveys at Hospital Swamps, max 3040 in 2019.)
- Previous incidental high counts include 1200 in 1999 and 750 in 2001.

Pacific Black Duck

- Fluctuating numbers with no clear trend.
- Highest S2020 counts were 8722 in 2013, then 391 in 2017.
- No consistent trends in S2020 counts since 2016; maximum S2020 count since 2016 was 676 in 2017; previous highest S2020 counts were 216, then 161 birds.
- (Compared to similar fluctuating numbers in S2020 surveys at Hospital Swamps, max 594.)

D3. Species summaries: Commoner bird species that can inform population monitoring

Little Pied Cormorant (fish-eater)

- Lower S2020 counts since 2016, with three records of single birds.
- Previously, 1-36 birds recorded most years on S2020 surveys.
- (Compared to irregularly higher numbers in S2020 surveys at Hospital Swamps, max 53.)

Little Black Cormorant (fish-eater)

- Lower S2020 counts since 2016, with two records of single birds.
- Previously, 1-23 birds recorded most years on S2020 surveys.
- (Compared to similar numbers in S2020 surveys at Hospital Swamps, max 40, then 26.)

Great Egret (fish-eater)

- Much lower S2020 counts since 2016, with one single record.
- Previously, >10 recorded annually on S2020, max 86 in 2010 and 80 in 2009.
- (Compared to <10 in most S2020 surveys at Hospital Swamps, max 64, then 28.)
- (High numbers at Hospital Swamps in summers 2018 and 2019 might have been Reedy Lake individuals, but as the species doesn't breed in the region, this seems unlikely.)

Australian Pelican (fish-eater)

- Lower S2020 counts, max 31, since 2016.
- Previously, highest S2020 counts were 347 in 2014 and 88 in 2013.
- (Compared to smaller numbers in S2020 surveys at Hospital Swamps, max 36.)

White-faced Heron (eats fish, frogs, reptiles and insects)

- No significant trends: 2-16 recorded on all S2020 surveys since 2016.
- Previously, 1-52 recorded on all S2020 surveys.
- High incidental counts of 127 in 2001, 100 in 2005 and 44 in 2018.
- (Compared to similar numbers in S2020 surveys at Hospital Swamps.)

Black Swan (flooded wetlands)

- None in S2020 summer counts since 2016, but S2020 winter counts unchanged.
- (Compared to consistent numbers in S2020 surveys at Hospital Swamps since 2010.)
- 200 including a nest with eggs on 29/2/20.

Masked Lapwing (dry lake beds and very short vegetation)

- No consistent trends in S2020 counts since 2016; maximum S2020 count since 2016 was 72 in 2018; previous highest S2020 counts were 128, then 73 birds.
- (Compared to increasing numbers in S2020 surveys at Hospital Swamps, max 102.)

Purple Swamphen (wetlands)

- No consistent trends in winter S2020 counts since 2016; maximum S2020 count since 2016 was 386 in 2018; previous highest S2020 counts were 900, then 544 birds.
- Summer S2020 counts much lower since 2016.
- However, during the latest summer high water levels, 912 counted on 22 Feb 2020 (in 7.2 hours wading by GD).
- (Compared to small numbers in S2020 surveys at Hospital Swamps, max 360.)

Royal Spoonbill and Yellow-billed Spoonbill (shallow wetlands; mostly summer visitor)

- Lower S2020 counts since 2016, max 5.
- Royal: Previously ≤5 birds on five S2020 surveys, but >100 birds on three S2020 surveys.
- Yellow-billed: Previously ≤5 birds on six S2020 surveys, but >20 birds on six S2020 surveys.
- Royal Spoonbills regularly nested with ibis 1947-2004; small numbers max 150 pairs in 1995.
- (Compared to slightly increasing numbers in S2020 surveys at Hospital Swamps, max >60.)

Black-winged Stilt (shallow waters)

- Much lower S2020 counts since 2016, max 5.
- Previously >100 birds on many S2020 surveys; maximum 374 in 2014.
- (Compared to consistent numbers in S2020 surveys at Hospital Swamps, max 345.)

Sharp-tailed Sandpiper (shallow wetlands; summer visitor); representative of other migratory shorebirds with stable numbers internationally

- Much lower S2020 counts since 2016, with only one record of six birds.
- Previously 100-1000 in S2020 surveys in most years but <10 in two years.
- Max historical counts 4170 in 1985 and 3000 in 2005.
- (Compared to fluctuating numbers in S2020 surveys at Hospital Swamps, mostly 100-1000, max 3000; with an incidental count of 4800 in Dec 2019.)

Marsh Sandpiper (shallow wetlands; summer visitor); representative of other migratory shorebirds with declining numbers internationally

- None in S2020 counts since 2016.
- Previously 3-24 in most summer S2020 surveys 2008-2014.
- Significant decline compared to max historical counts e.g. 130 in 1983, 121 in 1990, 80 in 1995, 73 in 2000, 103 in 2002, 50 in 2005 and 36 in 2016.
- (Compared to declining numbers in S2020 surveys at Hospital Swamps, from 300 in 1995 to 113 in 2006 to 41 in 2019.)

D4. Total counts of shorebird species and numbers at Reedy Lake

Totals from the standardised BirdLife Australia Shorebirds2020 monitoring data, noting variable access to all of the water bodies.

Year	Summer		Winter	
	Number of shorebird species	Total number of shorebirds	Number of shorebird species	Total number of shorebirds
1981	8	1012	1	5
1982	3	312	6	327
1983	9	1226	5	75
1984	4	287	2	14
1985	12	7533	4	67
1986	4	1921	7	109

1987	6	224	3	90
1988	8	1173	2	18
1989	4	161	1	17
1990	8	621	3	180
1991	6	262	3	33
1992	4	92	7	41
1993	1	18	5	110
1994	9	105	6	134
1995	9	557	3	101
1996	4	66	7	563
1997	4	703	1	9
1998	3	144	2	51
1999	5	478	1	3
2000	3	131	2	6
2001	5	175	1	9
2002	1	52	4	37
2003	3	174	3	291
2004	8	1022	5	180
2005	1	80	2	4
2006	1	32	2	77
2007	2	6	2	7
2008	8	1172	2	68
2009	7	1166	2	36
2010	12	326	1	2
2011	-	-	2	24
2012	5	216	2	47
2013	5	772	1	5
2014	11	820	2	17
2015	4	31	2	40
2016	-	-	-	-
2017	1	4	2	65
2018	2	74	1	9
2019	2	8	1	5
2020	2	10		

Table 11. Waterbird guilds as % of total waterbirds from Summer Waterfowl Counts at Reedy Lake 1987-2019. Note that the main focus of these counts was on ducks and associated waterfowl (grebes, coot, swans and geese) so numbers of shorebirds, fish-eaters and long-legged wading birds may have been under-estimated on some counts.

Waterbird guilds as % total waterbirds at Reedy Lake	%
Australian breeding shorebirds	4.2
Migratory shorebirds	1.5
Dabbling ducks	43.4
Diving ducks	0.29
Filter-feeding ducks	2.86
Grazing ducks	6.88

Grazing waterbirds other than ducks	34.5
Grebes	1.60
Gulls	0.02
Long-legged wading birds	2.82
Marsh terns	0.54
Fishers	1.35

References

O'Donnell, C. F. J. (2011) Breeding of the Australasian Bittern (*Botaurus poiciloptilus*) in New Zealand. *Emu* **111**, 197-201.