Healthy Waterways Strategy 2018-2028
Port Phillip & Westernport, Victoria

Wetlands

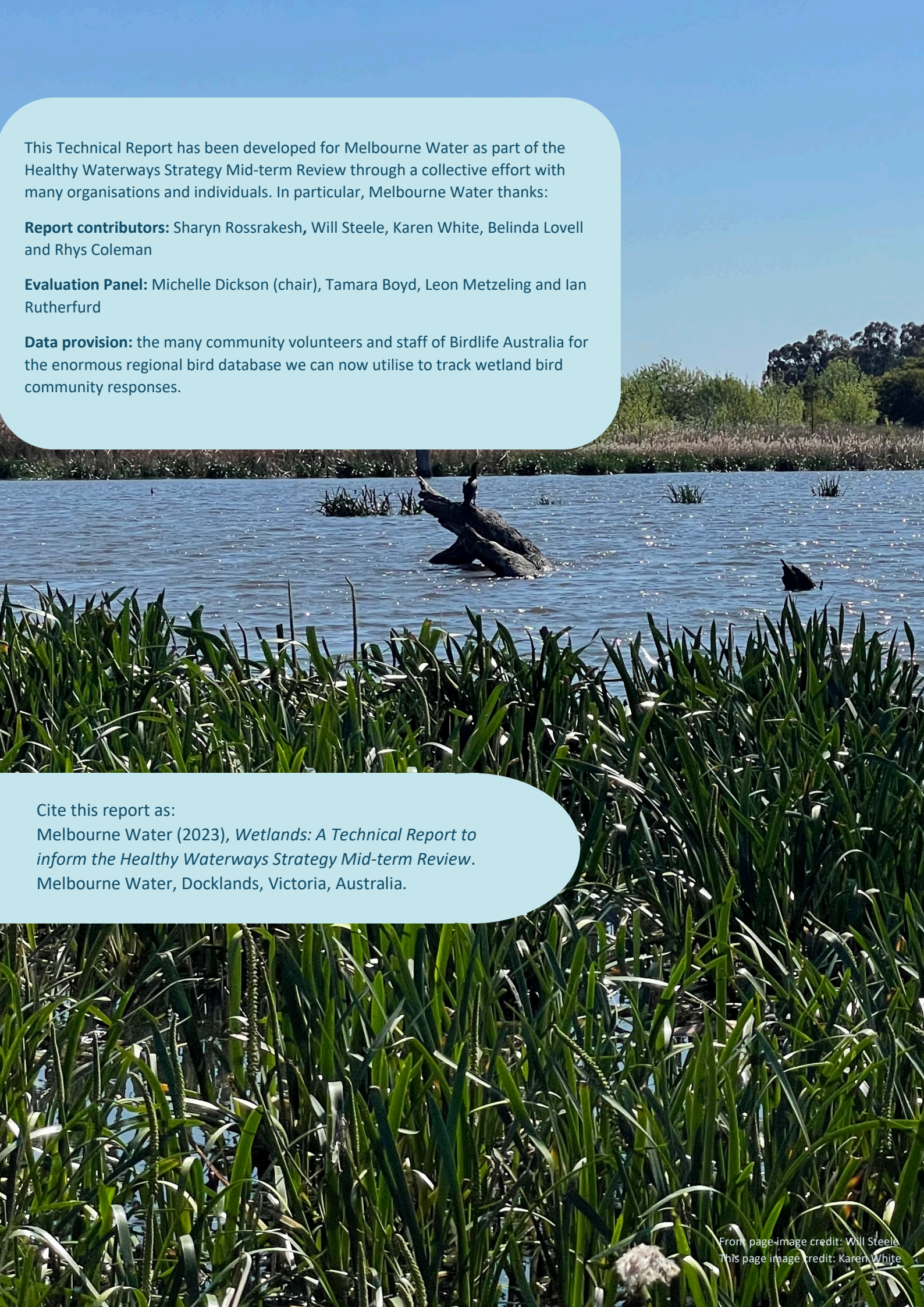
A Technical Report to inform the Healthy Waterways Strategy Mid-term Review

This Technical Report has been developed for Melbourne Water as part of the Healthy Waterways Strategy Mid-term Review through a collective effort with many organisations and individuals. In particular, Melbourne Water thanks:

Report contributors: Sharyn Rossrakesh**,** Will Steele, Karen White, Belinda Lovell and Rhys Coleman

Evaluation Panel: Michelle Dickson (chair), Tamara Boyd, Leon Metzeling and Ian Rutherfurd

Data provision: the many community volunteers and staff of Birdlife Australia for the enormous regional bird database we can now utilise to track wetland bird community responses.



Cite this report as:
Melbourne Water (2023), *Wetlands: A Technical Report to inform the Healthy Waterways Strategy Mid-term Review*. Melbourne Water, Docklands, Victoria, Australia.

Front page image credit: Will Steele
This page image credit: Karen White

Table of Contents

Glossary of terms and abbreviations

AVIRA	Aquatic Values Identification and Risk Assessment
All other waterbodies	All waterbodies other than the regionally significant wetlands.
Constructed wetlands	Wetlands which have been constructed, often for stormwater treatment purposes. Sometimes referred to as artificial or modified wetlands.
DSS	Developer Service Schemes
IWC	Index of Wetland Condition
HWS	Healthy Waterways Strategy
HWS priority wetland groups	The 82 wetland groupings (or 123 individual wetlands) identified in the 2018 HWS strategy which include targets and performance objectives.
KBA	Key Biodiversity Area
KEQ	Key evaluation questions
MERI	Monitoring Evaluation Reporting Improvement
MEP	Monitoring Evaluation Plan
Natural wetlands	Naturally occurring wetlands, including billabongs and swamps.
PSP	Precinct Structure Plans
SoBS	Sites of Biodiversity Significance
RAP	Registered Aboriginal Party
Regionally significant wetlands	The 249 wetlands identified in the 2020 Wetlands Monitoring and Evaluation Plan (MEP; Melbourne Water 2020b) as being regionally significant. These are identified in the MEP and have monitoring programs suggested.
RLG	Region-wide Leadership Group
RPO	Regional Performance Objective
Waterbodies	All natural and constructed wetlands in the region, including quarry pits and rural storages such as farm dams. These have been mapped as part of a joint Melbourne Water/ University of Melbourne research project.
Wetlands	As a class of waterway asset are defined in the 2018 HWS as: "*areas, whether natural, modified or artificial, subject to permanent or temporary inundation, that hold static or very slow-moving water and develop, or have the potential to develop, biota adapted to inundation and the aquatic environment. They may be fresh or saline.*"

Acknowledgement of Traditional Owners

The rivers, wetlands and estuaries of the Port Phillip and Westernport region are part of Country belonging to the Bunurong, Gunaikurnai, Taungurung, Wadawurrung and Wurundjeri Woi-wurrung peoples. These Traditional Owners have lived in and been connected to the land, water, plants and animals of this area for many thousands of years, and we offer our respect to their Elders past and present.

1. Summary

The *Healthy Waterways Strategy* (HWS) (Melbourne Water 2018) included wetlands as a separate waterway, or asset class, to be managed. This was the first time wetlands had been included in a Healthy Waterways Strategy in any detail, with targets described for key values and supporting conditions.

This report is one of several background reports informing the HWS mid-term review Science Inquiry Melbourne Water, 2023a. It presents an evaluation of values and conditions associated with wetlands. A separate report will be produced for estuaries.

The evaluation has focused on two key evaluation questions (KEQs) and their sub-KEQs:

- KEQ – What is the state of waterway values?
    - 3a. To what extent are key values on the target trajectory?
    - 3b. What other spatial and temporal trends and patterns for key values are of significance for implementation?
- KEQ – To what extent has progress been made towards the longer-term environmental condition targets for rivers, wetlands and estuaries?
    - 2a. What environmental conditions (e.g. water quality) and external conditions (e.g. policy) help explain current key value trends?

For the benefit of the reader, some background and contextual information is presented in Table 1.1 relating to the HWS development and implementation to date, along with an overview of how each of the KEQs will be evaluated with respect to wetland values and conditions.

Establishing new benchmarks for wetlands values and conditions

This report has collated a broad selection of information and data relating to wetlands in the HWS region. Wetlands were a new asset class to be explicitly included in the Healthy Waterways Strategy 2018, with condition and value targets. The information originally used to set the baseline status for values and conditions was based on the best available information at the time but had significant data gaps. This was recognised in the HWS Resource Document (Melbourne Water 2020a), and it was reported that adaptive management through the Monitoring Evaluation Reporting Improvement (MERI) framework would seek to improve the information and data relating to wetlands as part of a monitoring program.

The Wetlands Monitoring and Evaluation Program (MEP) (Melbourne Water 2020b) provided the first detailed monitoring program for selected wetlands in the region. It reviewed the indices used to determine the current status of wetland values and conditions, and recognised shortcomings in terms of being able to monitor change in future years. Through consultation with organisations that have a responsibility to manage wetlands in the region, it was decided that the wetlands monitoring program would use different methods and indices to track progress (compared to those in the HWS) and that a new baseline using these indices would need to be established.

The past few years have been about setting that new baseline, doing foundational work about the extent of wetlands in the region, and understanding key threats. Delays in setting up the monitoring program due to a number of factors, has meant that the new benchmark (as it is referred to in the report to distinguish from the 2018 HWS baseline) is still being determined for some wetland values (i.e. frogs, vegetation, fish) and all wetland conditions.

Table 1.1. *Summary of the mid-term evaluation KEQs and the extent to which they are represented in this report*

KEQ	Sub-KEQ	Relevance to this report
1 – To what extent have the performance objectives of the Strategy been achieved?	1a. To what extent has collaboration and co-delivery contributed to achieving the Performance Objective targets so far?	Frog and bird data are collected by an extensive network of community volunteers. Wetland management requires collaboration of different government agencies. An evaluation of collaboration and co-delivery related will be part of the Implementation Inquiry (Melbourne Water (*in prep*)).
	1b. To what extent is strategy delivery on track to achieve the Performance Objective targets by 2028?	An overview of progress wetland performance objectives is provided in Section 3.
3 – What is the state of waterway values?	3a. To what extent are key values on the target trajectory?	Section 5 provides an evaluation of wetland birds. Other key values do not have sufficient data for evaluation as yet but a preliminary assessment is provided for Frogs (Section 4).
	3b. What other spatial and temporal trends and patterns for key values are of significance for implementation?	Section 5 provides an evaluation of wetland birds. While the main focus of this report is birds, there is evaluation of some threatened frog species (Section 4) and environmental conditions (Section 7).
2 – To what extent has progress been made towards the longer-term environmental condition targets for rivers, wetlands and estuaries?	2a. What environmental conditions (e.g. Water quality) and external conditions (e.g. policy) help explain current key value trends?	Section 6 provides an analysis of recent Index of Wetland Condition data which is used to set a new benchmark to monitor future changes against.
	2b. To what extent have projected known and emerging future threats changed from 2018? Have any assumptions about impacts to key values changed?	A list of threats to wetlands are provided in Section 9.
4 -To what extent have the delivery methods of the Strategy been appropriate, effective, and efficient?	4a. To what extent are interventions appropriate and effective for achieving outcomes?	Section 10 provides an overview of interventions relevant to wetland management including where intervention monitoring is underway.
	4b. What are the key remaining knowledge gaps that need to be addressed in the next 5 years to improve strategy delivery or prepare for the next HWS?	Section 8 provides a summary of recent research relating to wetlands. Identification of remaining knowledge gaps is outlined in Part F of the Science Inquiry report (Melbourne Water, 2023a)
	4c. How can collaborative governance enable effective and efficient delivery of the Strategy?	This will be answered through the implementation Inquiry (Melbourne Water (*in prep*)).

Therefore, this report can present only a limited evaluation of progress towards HWS targets. Instead, a large portion of this report provides updated assessments of baseline condition, highlights a number of issues with future monitoring, and makes recommendations for management and further work to enable assessment and tracking of all wetland values and conditions.

Tracking of wetland loss

Despite the lack of data for evaluation purposes, HWS Annual Reports since 2019 have identified ongoing wetland loss in the region. The first HWS Annual Report Card (2018/19) reported the loss, through previously approved urban development, of some natural wetlands considered regionally significant, e.g. Wyndham Swamp. Other natural wetlands in urban growth areas remain at risk from urbanisation. In total, there have been four natural wetlands considered to have regional significance with a combined area of 114 ha effectively lost since the HWS was launched in late 2018. The 2020/21 Annual Report lists a further 14 regional priority wetlands under imminent risk of degradation (total of 663 ha) through PSPs or Developer Services Schemes (DSS).

In response to the first Annual Report, the HWS Region-wide Leadership Group (RLG) requested a paper on the problem; the policy and planning context; and options for improved management. Since then, protection mechanisms have been considered. Foundational work has been undertaken to understand the potential options available to Melbourne Water and HWS Partners for natural wetland protections. This has included the formation of a special HWS partner working group, chaired by the Department of Environment, Energy and Climate Action (DEECA) RLG representative. Members of the Wetland Working Group to the RLG include representatives from Melbourne Water, DEECA, Parks Victoria, Victorian Planning Authority, EPA, a Council in the growth area and, most recently, a representative of the Wurundjeri woi-wurrung Cultural Heritage Aboriginal Corporation.

In consultation with scientists and planners, the group developed a decision/risk framework tool to support priority setting and action planning for natural wetlands, particularly those on private land (Jacobs 2022). This is important because there is a current policy gap around protecting wetlands from being physically lost. For example, if there are no listed species or communities present in a wetland, then current planning controls do not protect a wetland from potentially being built over. Further work and recommendations regarding this issue are outlined in this report and highlight the importance of having a solid knowledge base and data to help influence and inform decision-making.

Summary of the evaluation results

Birds

KEQ3a - To what extent are key values on the target trajectory?

A new 2018 benchmark has been calculated for wetland birds in 50 of 108 HWS priority wetlands (i.e. those for which waterbirds are relevant as a value). Current assessments can be calculated for 25 wetlands (as at mid-2022). Of these, 18 are 'on track' according to the Wetland MEP rubric. There are 5 wetlands ranked as 'slightly off-track' and 2 where there is considered to be a high chance that long-term targets will not be met.

KEQ3b - What other spatial and temporal trends and patterns for key values are of significance for implementation?

Wetland Bird Indices show that the wetland bird communities are generally stable and tracking well at Ramsar Sites (Edithvale-Seaford Wetlands, Western Port and the Western Treatment Plant), Key Biodiversity Area (KBA) sites (Eastern Treatment Plant, ETP South - Banyan Waterhole and Braeside

Park Wetlands), a 'Migratory Shorebird Site' (Swan Lake), and one of two 'Regional Wetlands' (Paisley Challis wetland/Jawbone Reserve).

Another 'Regional Wetland', Devilbend Reservoir, has shown declines in the Wetland Bird Index since 2003-2008, which may relate to the refuge capacity of the site during the Millennium Drought and many birds leaving once the drought broke.

Wetland bird communities at three of the four Dandenong Valley stormwater wetlands are stable and tracking well (Heatherton Road North and South Wetlands and Frog Hollow Wetland). Generally, bird communities appear to decline at stormwater constructed wetlands as the fringing vegetation becomes too dense for many waterbirds and the water quality deteriorates.

Two 'Social value' urban lakes are experiencing declines in most indices which require further investigation, although possibly related to human disturbance and the predominance of common, abundant and tolerant species.

Climatic variability during the four time periods considered (2003/04 – 2018/19) has undoubtedly affected the bird abundances at individual wetlands (and the calculated wetland bird indices) through its influence on wetland hydrology both at a wetland and in the surrounding area.

Frogs

KEQ3b -What other spatial and temporal trends and patterns for key values are of significance for implementation?

An assessment of observed/expected species by sub-catchment, over three time periods, suggests a declining trend in frog community health in six sub-catchments (with many others not assessable, or suggesting possible declines but with low confidence in the conclusion). The sub-catchments showing declines are: Plenty River Lower, Darebin Creek, Gardiners Creek, Dalmore Outfalls, Jacksons Creek and Lollypop Creek.

Results from long term studies of Growling Grass Frog (*Litoria raniformis*) populations in the northern Growth corridor show that site occupancies have significantly declined over the last 20 years. Given that site populations are relatively stable, it appears that urbanisation is having a deleterious effect.

Whilst it's not possible to determine a statistical significance, Southern Toadlet (*Pseudophryne semimarmorata*) populations in the southeast are declining. Likely drivers are deer impacts, climate change and human movement e.g. bike paths, silting and changes to flow paths.

Fish

KEQ3b - What other spatial and temporal trends and patterns for key values are of significance for implementation?

There are very little historical data on fish within wetlands across the region. To begin to address this significant knowledge gap, the HWS MERI eDNA monitoring program is collecting data during both spring and autumn across all regionally significant wetlands. Results from the initial survey run in spring 2021 are presented in Wetlands Frogs and Fish section of this report and show that up to nine native fish species and six exotic fish species were detected in our surveyed wetlands.

In response to substantial declines across the region, threatened fish management programs are currently underway for Dwarf Galaxias (*Galaxiella pusilla*) along the Dandenong Creek corridor and

being developed for Yarra Pygmy Perch (*Nannoperca obscura*) along the Deep Creek corridor in the Maribyrnong catchment (stream, not wetland sites).

Contaminants

Research project A3P Project B1.1: Identifying and managing emerging contaminants of concern has found concerning levels of contaminants for aquatic life in most urban wetlands including Melbourne Water Sites of Biodiversity Significance (SoBs) and Ramsar sites (Long et al. *in prep a*) Long et al. *in prep b*). A framework for prioritising chemicals for screening, impact assessment and determining major sources to target management is proposed. Contaminants have been found in all wetlands, including such important ones as the Ramsar-listed Edithvale-Seaford Wetlands and Carrum Key Biodiversity Area wetlands.

2. Overview of wetlands and wetland values

2.1 Healthy Waterway Strategy wetlands

Wetlands, as a class of waterway asset, are defined in the 2018 HWS as: "*areas, whether natural, modified or artificial, subject to permanent or temporary inundation, that hold static or very slow-moving water and develop, or have the potential to develop, biota adapted to inundation and the aquatic environment. They may be fresh or saline. Examples of wetlands include swamps and billabongs.*" (Melbourne Water 2018, p. 173).

There are tens of thousands of wetlands (including natural, artificial/constructed and modified natural) across the ~13,000 km^2 Port Phillip and Westernport region (**Figure 2.1**).

At the time of the development of the HWS 2018, comprehensive mapping and characterisation of wetlands and waterbodies throughout the region had not been done, and it was recognised that the knowledge base was patchy and incomplete (see Appendix A). Nonetheless, for a subset of waterbodies, the available knowledge base for wetland environmental, cultural, social and economic values was drawn upon to identify an initial set of "priority", or high-value, wetlands on the following grounds (Melbourne Water 2020a):

i) international significance (e.g. Ramsar-, Important Bird Areas-listed wetlands)
ii) national significance (e.g. Directory of Important Wetlands in Australia, contains EPBC-listed species or communities such as Growling Grass Frog, Dwarf Galaxias, seasonal herbaceous wetlands)
iii) regional significance (e.g. Sites of Biodiversity Significance, FFG Act-listed species, DNRE 2000 biosites, Yarra billabongs)
iv) local significance (e.g. constructed wetlands with environmental values such as populations/communities defined in a past report as being 'of significance', such as Swamp Harrier [*Circus approximans*] concentrations, and wetlands with high amenity and/or cultural values).

This initial regional prioritisation process by Melbourne Water identified 132 wetlands of potential significance for natural values and conservation of biodiversity and/or for their social values. We recognise the lack of knowledge on cultural significance to Traditional Owners, and economic significance. This desk-top exercise was tenure-blind, and considered all wetlands in the region not only those on public land.

Following assessment, in a process outlined in Appendix B, priority (or high value) wetlands were grouped, purely for mapping purposes, into 82 "wetland groups" (comprising 123 named wetlands) in the HWS (see Figure 2.2).

These priority wetlands reflect a notion of "high value" where value could be solely ecological (e.g. biodiversity-based), amenity/recreational, cultural or some combination of the three. This also implies priority for management (e.g. monitoring, threat assessment and mitigation, etc.) and hence these 82 wetland groups have performance objectives to maintain or improve their condition to support the key environmental values.

Following the release of the 2018 HWS, with the Wetlands Monitoring and Evaluation Plan (Melbourne Water 2020a), the wetland priority list was expanded to 249 wetlands (see Appendix C

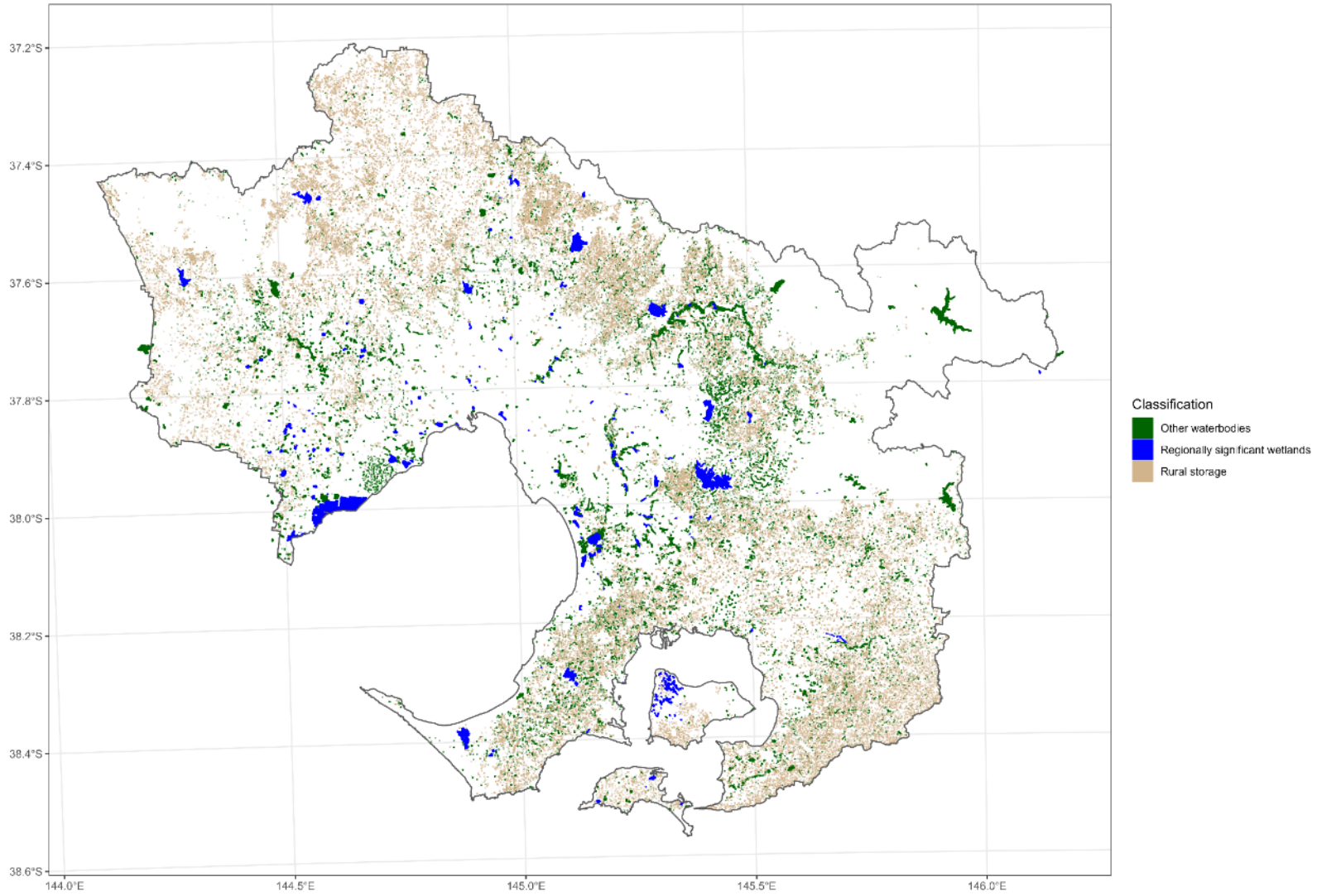


Figure 2.1 *Map showing all waterbodies in the region categorised by regionally significant wetlands and rural storages (e.g. farm dams)*

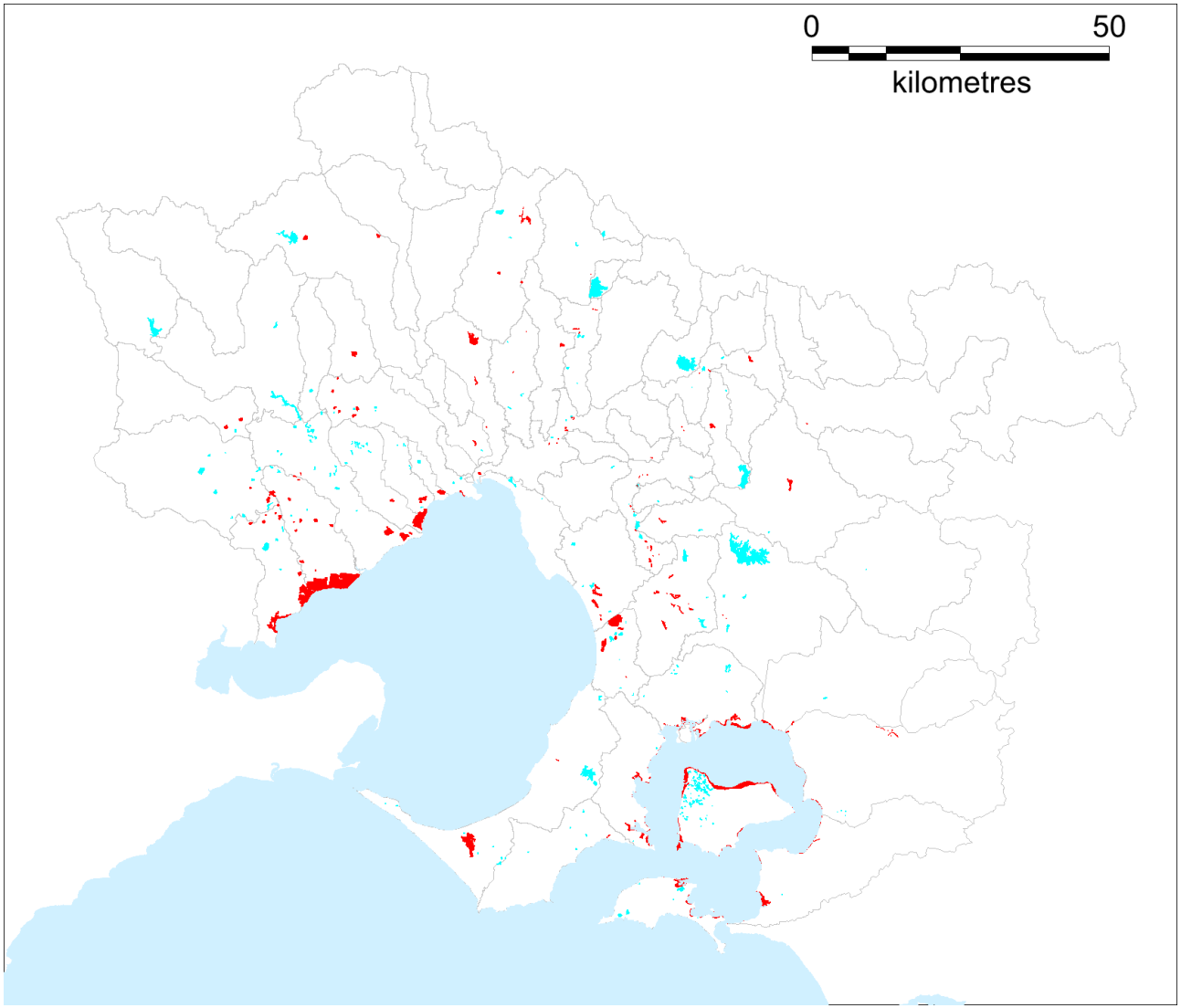


Figure 2.2 *Map showing the HWS priority wetlands that have performance objectives (in red) and the other regionally significant wetlands identified since 2018 (in blue).*

and **Figure 2.2**.2) based on a more thorough prioritisation process. The intent was for this list of designated regional priority wetlands to evolve as data availability and knowledge progressively improved. See Appendix B for further details of the second wetland prioritisation process. Note that these additional wetlands do not have performance objectives, but they have been included in the wetland monitoring program (see Appendix C) and, wherever possible, we will act to protect and/or improve the values of these wetlands.

Since the 2020 Wetland MEP yet more wetlands have been identified by expert opinion as being of regional significance. For example, a Birdlife Australia report identified previously overlooked wetlands providing important Latham's Snipe (*Gallinago hardwickii*) habitat (Birdlife Australia 2020). Since constantly updating the list of priority wetlands was confusing to all, the Wetland MEP list of regional priority wetlands was temporarily fixed at the 249 identified in the 2020 MEP. Another comprehensive regional prioritisation exercise will be undertaken during 2023/24.

2.2 Values and conditions

The four key biological values for wetlands in the HWS are:

- Birds
- Frogs
- Fish
- Vegetation

It should be noted that aquatic macroinvertebrates were considered a key wetland value by conceptual models prepared for the HWS (Alluvium 2017) but were not included as a key wetland value in the HWS due to a lack of available data and the absence of an agreed metric for aquatic macroinvertebrate status in wetlands. We consider the state of the aquatic macroinvertebrate community in a waterbody to be more appropriately represented as a measure of ecosystem condition for strategic planning purposes rather than being included in the suite of Key Values for wetlands.

Social values were identified as important for wetlands, but the lack of data and metrics prevented the values from being included in the HWS. Instead, a Regional Performance Objective (RPO) was created to address this by developing an understanding of the amenity, community connection and recreation values of wetlands and develop performance objectives to enhance these values.

The cultural values of wetlands, that is the physical and spiritual connection of people to land, water, plant and animal species and their stories are very important to Aboriginal Traditional Owners. Their connection to wetlands in this region has been damaged by colonisation and urbanisation and as such, shared knowledge of the traditional cultural values is limited. There are some exceptions to this, such as Edithvale and Seaford Wetlands, Bolin Bolin Billabong and Hannah's Swamp, which have been identified by Bunurong or Wurundjeri people as being highly culturally significant. Where this shared knowledge is available, it has been included in the selection of regionally significant wetlands.

The HWS defines waterway (and hence) wetland **condition** as the overall state of the waterway and the key processes that underpin a well-functioning ecosystem (Melbourne Water 2018). It is assumed that – generally – improvement in wetland conditions will improve all wetland key values. This is not always true, since drawing down natural wetlands to promote environmental values can

be to the detriment of social values. There will need to be trade-offs between environmental and social requirements for some conditions.

Five environmental conditions are seen as key influencers of wetland values (Figure 2.3). Understanding of the critical environmental conditions of wetlands that influence the key environmental values was developed from the HWS Conceptual Models (Figure 2.4) and largely follow the Index of Wetland Condition (IWC) approach.

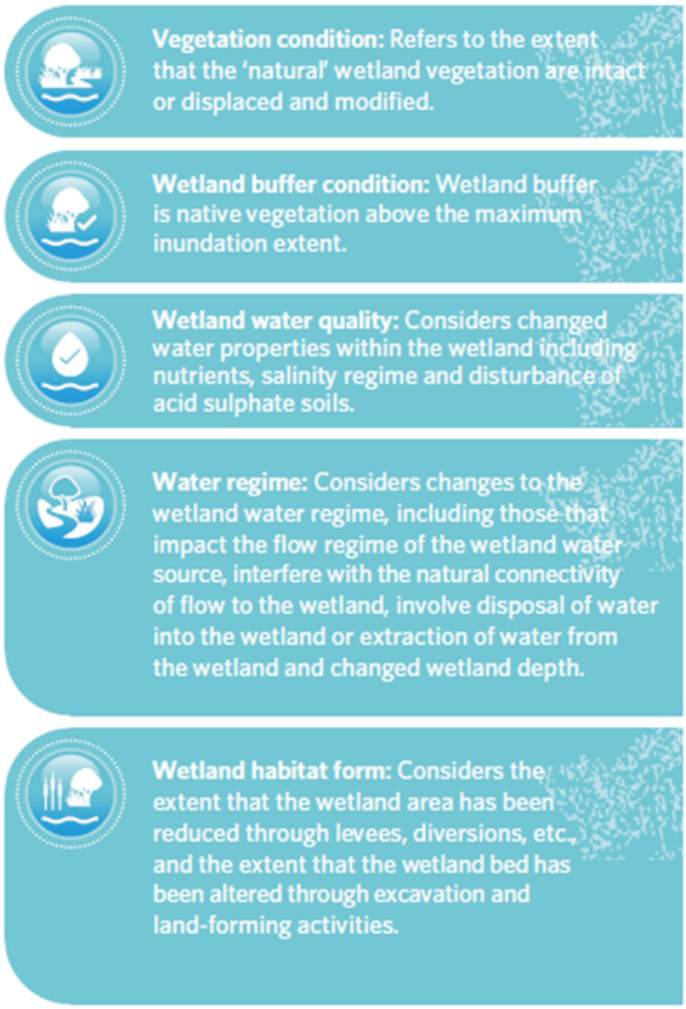


Figure 2.3 *The critical environmental conditions of wetlands which determine key value status (Melbourne Water 2018)*

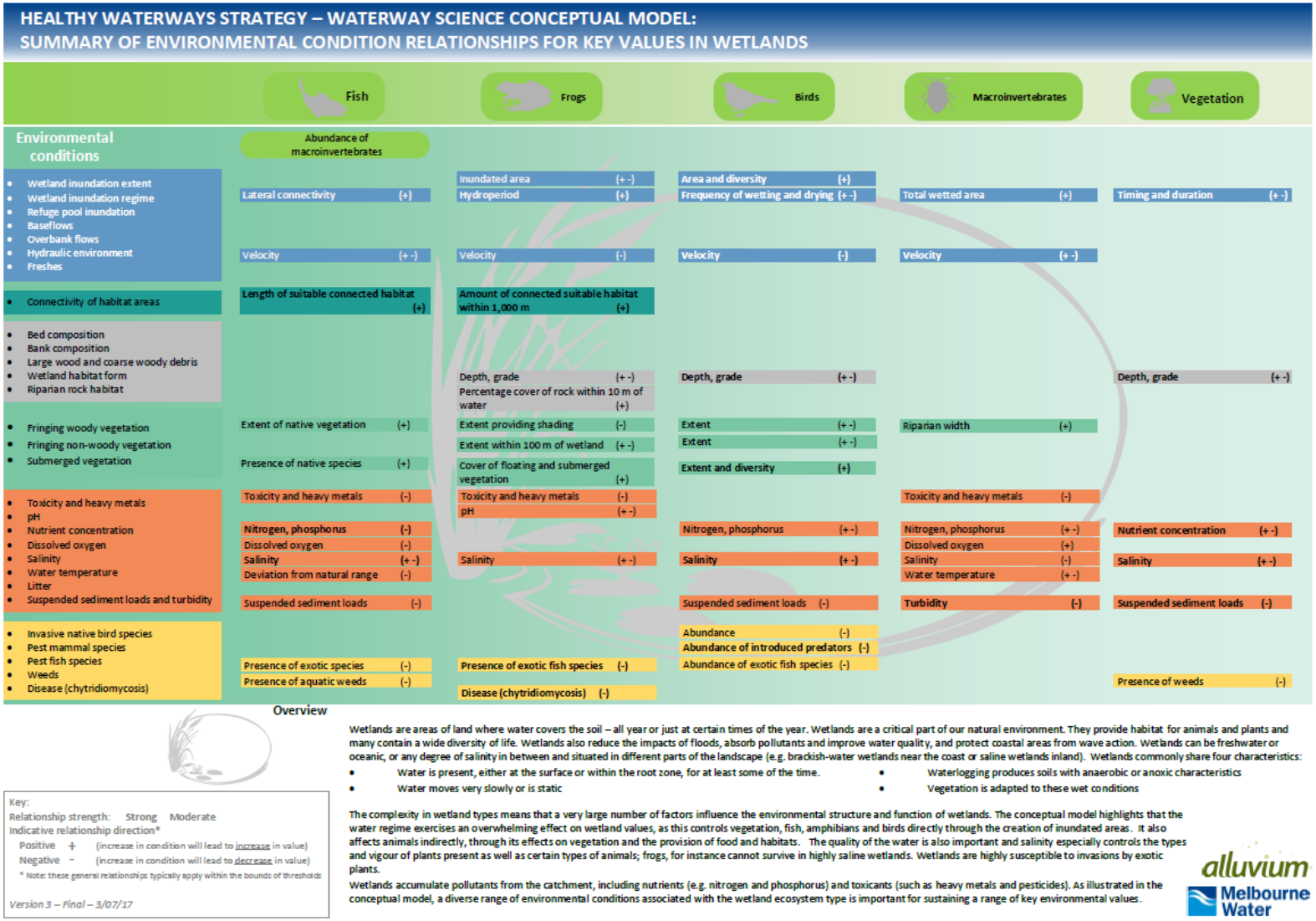


Figure 2.4 Summary of environmental values and condition relationships for wetlands (Alluvium 2017)

HWS Target setting

Healthy Waterway Strategy baseline - 2018 state

The state of key wetland values and conditions (as at 2017/18) at priority wetlands was set as a baseline against which progress was to be measured over the life of the HWS. However, the metrics used to assess this baseline were based on AVIRA (Aquatic Values Identification and Risk Assessment, DELWP 2015) using sparse data sources as described in the HWS Resource Document (Melbourne Water 2020b). Therefore, the 2020 Wetland MEP describes new ways to determine the 2018 baseline state for several values.

Box 2.1 The need for a revised baseline

Potential shortcomings of the data and methods used to establish the HWS baseline became apparent during the development of the Wetland Monitoring and Evaluation Plan (MEP) (Melbourne Water 2020a). One of the biggest shortcomings was the limited extent of data input into AVIRA, which meant that the assessment downgraded the condition and values of many of the wetlands. This issue was raised during the consultation of the draft MEP with stakeholders and the HWS Science Panel and a decision was made by Melbourne Water to invest in improving the data extent and quality for wetlands that would allow a benchmark with greater certainty to be established which would provide a strong foundation for monitoring change. An alternative set of data and indices were proposed and approved by the HWS Science Panel for wetland values and conditions and these are outlined on the Wetland MEP. Therefore, the focus for the mid-term review is on the progress in setting a new baseline, or benchmark, for wetland values and conditions with limited opportunities to evaluate trajectories for many of the values.

Forecast trajectory under a 'business as usual' scenario

Although there will be a new baseline (or 'benchmark') set for wetland values and conditions, it is still important to understand how the HWS forecast the trajectory under a business as usual scenario since this links to how the long-term Strategy targets were derived.

A long-term Business as Usual trajectory (2017/18 'current' trajectory) was based on rules and assumptions around the likely impacts of significant future threats, particularly climate change and urbanisation. This was determined through the following steps:

1) Hosting a workshop with experts in aquatic ecology, environmental flows, wetland and estuary ecology and management to assess which threats are most likely to impact wetland key values and conditions and how this is likely to vary across the region and wetland typology (see Box 2.2). In particular, which threats would be particularly exacerbated by climate change and urbanisation.

2) Using outputs from this workshop and expert opinion to combine AVIRA metrics to develop rules-based metrics to determine current state and current trajectory for each wetland asset. Metrics were refined to ensure that they were appropriate to the region and asset types and

based on the available data. Threats scores that had been rated as increasing under climate change and urbanisation were moderated up to a high.

Box 2.2 Wetland Typology

A typology for wetlands in the Melbourne Water region was developed based on findings from expert workshops regarding the key characteristics of wetlands in the region. This was used to guide 'rules-based' decisions determining the trajectory of key values and waterway conditions. The three main typologies are based on both wetland geology/geomorphology and position in the landscape. The typologies are Basalt plains (Maribyrnong and Werribee rivers), Alluvial Plains (Yarra, Westernport and Dandenong) and coastal wetlands (see Figure 2.5). A further three subsets sit under these typologies, based on land use. These are: existing urban, urban growth area, forest and/or remaining rural.

It must be noted that a range of wetland typologies have been developed and are used for the classification and management of wetlands both at the state and federal level, and our HWS typology does not override these. This coarse typology was developed solely for HWS planning and is not intended to be utilised for other purposes.

The typology was applied to take into account, at a strategic level, likely different trajectories. Wetlands located in the alluvial plains were considered to have better future prospects than those located in the coastal and basalt plains regions – which were identified as more at risk from intractable threats, including climate change and sea level rise. Alluvial plains wetlands were considered to have practical management options to address some threats (such as environmental flow releases and pumping of water to priority billabongs, particularly in the Yarra). Reductions in rainfall are projected to be less in the Yarra, Dandenong and Westernport catchments than in the western catchments (Maribyrnong and Werribee).

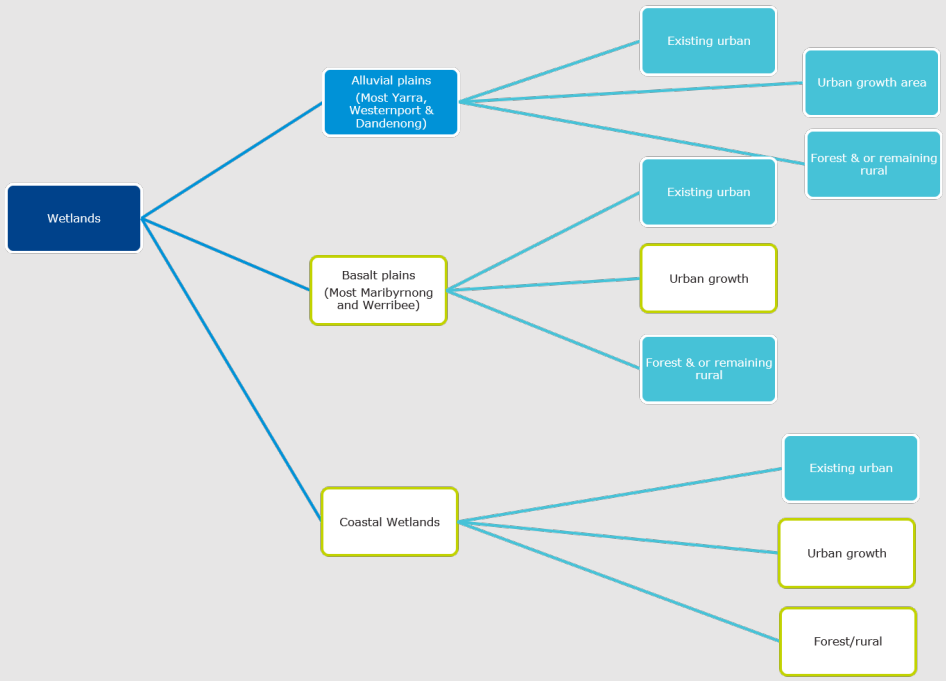


Figure 2.1. *Typology adopted for trajectory planning for wetlands in the HWS.*

3) Reviewing preliminary scores against local knowledge of the assets. These reviews could alter the rating in either direction if additional knowledge showed the site to have a different current state or trajectory than indicated by the AVIRA score. Comments received from subject matter or local experts were used to refine the value status and trajectory ratings.

Long-term target setting

Ideally, in setting long-term targets, we would compare current and future wetland 'state' to some understanding of pre-1836; to gauge the true extent of wetland loss and degradation. However, we do not have adequate mapping of the landscape before European settlement to use for this.

DEECA's (previous) mapping of 'Wetlands 1788' did not show major natural wetlands, such as the former Koo Wee Rup Swamp, the true historic extent of Hernes Swamp, the Carrum Carrum Swamp and the Yarra River mouth wetlands, to name only a few major omissions. It was decided to track changes in extent, condition and values since ~2017/18 – rather than trying to go back to assess what was there decades ago.

Although there will be a new 2018 "benchmark" set for most wetland values and conditions (compared to the baseline presented in the HWS), the long-term targets will remain as stated in the HWS, until the next iteration of a regional waterways strategy; likely to be prepared in 2028. The reason for this is that long-term targets described in the HWS still represent the ambition of the strategy to maintain and improve wetlands recognising that threats such as urban development and climate change will make this challenging.

To set long-term targets in the HWS, a set of assumptions were made about the potential for change into the future. These assumptions are listed in Table 2.1 for values and Table 2.2 for wetland conditions. Targets were set for individual wetlands for values and conditions and these targets were then averaged (similar to rivers) to provide targets at the catchment scale.

2.3 Performance objectives

The short term (one to ten-year quantitative steps) by which long-term targets can be achieved are described in the HWS by Performance Objectives. These objectives provide short-term, tangible outcomes which indicate progress towards longer-term outcomes (i.e. change in condition or in key value).

Each of the wetlands in the HWS were assigned performance objectives for the particular values or conditions to manage. Most wetlands have several performance objectives assigned to them which when applied in combination, are intended to maintain or improve the wetland. These include regional performance objectives as well as wetland-group specific performance objectives, which are described in more detail in Section 3 and Appendices D and E.

Table 2.1 *Summary of assumptions for setting long-term targets for wetland values*

Value	Long-term trajectory assumptions
Vegetation	Basalt plains: vegetation value could improve (from current BAU trajectory) once programs to improve wetland buffers, vegetation condition and habitat form are implemented. This also assumes that forward planning for adaptation and migration of coastal wetland vegetation is undertaken. Alluvial plains: vegetation value could improve (from current BAU trajectory) once actions to reduce threats of changed water regime and invasive plants and animals are implemented. The Western Port coastal wetlands are assumed to improve significantly from BAU current trajectory due to the opportunity to allow landward migration of key vegetation communities in the long term.
Birds	Basalt plains: bird values could improve (from current BAU trajectory) once programs to improve wetland buffers, vegetation condition and habitat form are implemented. Alluvial plains: bird values would remain the same or improve (from current BAU trajectory) once actions to reduce threats of changed water regime and invasive plants and animals are implemented. The Western Port coastal wetlands bird values are assumed to improve significantly from BAU current trajectory due to the opportunity to allow landward migration of key vegetation communities in the long term thereby providing habitat.
Frogs	Basalt plains: Frog values could improve (from current BAU trajectory) once programs to improve wetland buffers, vegetation condition and habitat form are implemented. Additionally frog values could improve further in the Werribee wetlands if threats such as decline in water regime and water quality are effectively mitigated. Alluvial plains: frog values could improve (from current BAU trajectory) once actions to reduce threats of changed water regime and altered wetland form are implemented in addition to programs to improve wetland buffers and vegetation condition. The Yarra catchment wetlands frog values are assumed to improve significantly from BAU current trajectory due to environmental watering of key billabongs.
Fish	No target trajectory was developed for fish in wetlands on the basalt plains due to limited data available. The target trajectory of fish values in wetlands on the alluvial plains could be maintained or improved (from current BAU trajectory) once actions to improve the water regime are implemented on the basis of the presence of a significant species (e.g. Yarra Pygmy Perch or Dwarf Galaxiids).

2.4 Monitoring wetland values and condition

As discussed previously, the Wetlands MEP (Melbourne Water 2020a) describes different ways to measure many wetland values and conditions relative to that used to derive baseline descriptions in the HWS. The Wetlands MEP provides detailed descriptions of why a different approach is more appropriate for each value and condition and as the MEP was approved by the MEP working group – the reader is directed to the Wetlands MEP for further information. In essence, AVIRA threat data was used as the basis for reporting on the condition of wetlands in the HWS. The reason for this is that there was no condition data for wetlands and AVIRA allowed a baseline dataset to be developed rapidly for values and conditions. However, assessments made using this method were frequently

hampered by a lack of available data from on-ground assessments of particular wetlands, particularly IWC assessments (Jacobs 2018). As AVIRA is a prioritisation method, not a monitoring one, it was deemed during the development of the Wetlands MEP as not suitable to be used as the basis of monitoring over the life of the Strategy. Instead, the Victorian IWC (Papas & Frood 2016) has been adopted as the basis of wetland waterway condition monitoring over the life of the Strategy. A new condition baseline is currently being established, and this is discussed further in Section 7.

Table 2.2 *Summary of assumptions for setting long-term targets for wetland conditions*

Condition	Long-term trajectory assumptions
Water regime	Alluvial plains: water regime could be maintained or improved (from current BAU trajectory) once actions to improve the water regime are implemented on the basis of the presence of a significant species (e.g. Yarra Pygmy Perch, Dwarf Galaxiids, frog species). Basalt plains: water regime could be maintained or slightly improved (from current BAU trajectory) however, the condition is anticipated to still be low due to pressures of climate change and urban development
Wetland habitat form	Alluvial plains: wetland habitat could be maintained or improved to moderate (from current BAU trajectory) once actions to improve the water regime, and increase wetland buffers is implemented. Basalt plains: wetland habitat could be maintained or slightly improved (from current BAU trajectory) however, the condition is anticipated to still be low/moderate due to pressures of climate change and urban development
Wetland buffer condition	Alluvial plains: wetland buffer condition could be improved to moderate/high (from current BAU trajectory) once actions to improve the water regime, and increase wetland buffers is implemented. Basalt plains: wetland buffer condition could be maintained or improved (from current BAU trajectory) depending on whether the sites could receive environmental water (e.g. Werribee catchment) and the extent of wetland buffer improvement planned.
Wetland vegetation	Alluvial plains: wetland vegetation condition could be improved to moderate/high (from current BAU trajectory) once actions to improve the water regime, reduce threat of invasive plants and increase wetland buffers is implemented. The target trajectory of the vegetation condition on the basalt plains could be improved to moderate (from current BAU trajectory) depending on whether the sites could receive environmental water (e.g. Werribee catchment) and the extent of vegetation condition improvement is planned.
Wetland water quality	Alluvial plains: water quality could be improved to moderate (from current BAU trajectory) once actions to improve the water regime for some wetlands (i.e Yarra billabongs) is implemented. Basalt plains: water quality could be maintained or slightly improved (from current BAU trajectory) however, the condition is anticipated to still be low due to pressures of climate change and urban development

The Wetland MEP switches to the Index of Wetland Condition (for environmental conditions) and eDNA (for many fauna groups) as a step-change to fit-for-purpose methods, despite the costs these incur. The Wetlands MEP outlines that robust data needs to be collected using fit-for-purpose methods rather than repeating the methods in the HWS.

The revised metrics for monitoring the four key *values* are summarised in Table 2.3**Table** and more detailed information is available in the Wetland MEP (Melbourne Water 2020a). The use of eDNA is a new approach for setting baseline and monitoring progress for wetlands compared to what was used for the HWS. It was expected that eDNA sampling could be completed quickly to describe new, current, benchmarks by the time for the mid-term review . But COVID restrictions and wet weather, unfortunately, have meant this data was not available for mid-term review.

The metrics for monitoring wetland *condition* are summarised in Table 2.4 and more detailed information is available in the Wetland MEP (Melbourne Water 2020a). The main method proposed for monitoring these conditions is the Victorian Index of Wetland Condition (IWC), a method different to AVIRA (Aquatic Values Identification and Risk Assessment, DELWP 2015) – which should draw on IWC scores, and which was used to assess wetland waterway condition in 2018.

Box 2.3 Environmental DNA

Environmental DNA (eDNA) involves sampling DNA that organisms have shed into the environment. It provides a new, relatively cheap, quick and non-invasive method for detecting species in aquatic environmental. Environmental DNA sampling is also safer than many traditional survey techniques because it does not require operators to enter the water and also avoids stress to animals that would otherwise be trapped and/or handled. It is intended to have eDNA sampling at suitable priority wetlands during both autumn and spring every 2-3 years to ascertain the presence native and pest species of fish, frogs, and selected waterbirds. It is anticipated that three sub-samples will be taken at each wetland. However this may need to be adjusted to suit wetland size and form. Initial testing of eDNA sampling requirements for wetlands according to size and complexity was conducted during the spring of 2021. These trials were delayed because of COVID restrictions.

Table 2.3 *Summary of proposed wetland key value metrics and monitoring methods (Melbourne Water 2020a)*

Key Value	Monitoring method (any change from HWS 2018)	Indicators	Other information to support evaluation	Monitoring frequency	Monitoring locations	Baseline data
 Birds	Field surveys of wetlands through Birdlife Australia volunteers (Data-based metrics)	Native waterbird species richness and reporting rate, weighted by threatened species and observations of breeding	Abundance/ density of wetland birds Habitat use by birds (e.g. foraging vs roosting) eDNA may be trialled, using vertebrate primers to screen for waterbirds and provide complementary data to the primary Birdlife Australia program.	Monthly at key wetlands (e.g. Edithvale-Seaford Ramsar wetlands) Ideally at least quarterly at other wetlands.	Selected priority wetlands (locations dependent on Birdlife Australia citizen science volunteer teams)	September 2017 – to be recalculated using the new indicators
 Fish	eDNA (This is a new survey technique not available when the HWS was prepared.)	Species' presence (observed/ expected ratios may be calculable following habitat suitability modelling)	Safety considerations are likely to limit broad-scale surveillance to eDNA method. But traditional field surveys will be required to validate eDNA results and obtain information not available through DNA analysis.	Two sampling sessions per year (autumn and spring), with each of the priority wetland sampled during at least once autumn and once spring prior to the mid-review, and the same effort repeated between the mid and final review.	Subset of priority wetlands (locations to be confirmed following trials) Refer Appendix B	To be established from autumn 2021
 Frogs	eDNA (New survey technique)	Species' presence/ absence (observed/ expected)	Frog Census records. Targeted field surveys for threatened species, e.g. call-playback, acoustic monitoring, dip-netting and spotlighting	Two sampling sessions per year (autumn and spring)	Subset of priority wetlands (locations to be confirmed following trials)	Expected species to be derived from MW's current frog records database

Key Value	Monitoring method (any change from HWS 2018)	Indicators	Other information to support evaluation	Monitoring frequency	Monitoring locations	Baseline data
Vegetation 	IWC, plus field surveys to include a more detailed vegetation assessment (e.g. IWC-GDEOf [1] and IWC with added veg quadrats[2]) (Improved field data rather than desk top assessment of the HWS)	Vegetation condition and extent	Presence of rare species/ communities Wetland vegetation uniqueness	Every five years (Note, every three years at SoBS and some WTP wetlands)	Selected priority wetlands with notable native vegetation values, e.g. Seasonal Herbaceous wetlands	To be established from 2020 onwards

[1] Papas, P. & Frood, D. (2016a) Index of Wetland Condition for Groundwater Dependent Wetlands – assessment methods and data entry sheets V1.1. Unpublished report prepared for Melbourne Water by the Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

[2] Ecology Australia (2020e) Index of Wetland Condition and Monitoring Round 2 Report. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Table 2.4 *Summary of wetland condition metrics and monitoring. (Melbourne Water, 2020a)*

Condition	Monitoring method (Change from HWS 2018)	Indicators	Monitoring frequency	Monitoring locations	Baseline data
Water regime	IWC: Hydrology (water regime) sub-index (new)	• Severity of change to the water regime expected from activities identified as altering the water regime	Rolling assessments	Sub set of priority wetlands	From 2018 onwards (as wetlands assessed)
Vegetation condition	IWC: Biota sub-index (new)	• Native/ weed cover ratio • Floristic diversity (overall and against functional groups) • flora abundance • EVC structure, extent, critical lifeforms			
Wetland buffer condition	IWC: Wetland Catchment (buffer) sub-index (expanding)	• Width of native buffer • % of wetland perimeter with a buffer			
Wetland water quality	IWC: Water Properties (modified) (nutrients, salinity, ASS- new) sub-index (expanding)	• Severity of nutrient enrichment • Severity of change in salinity • Activation of acid sulphate soils (additional metric for HWS)			
Wetland habitat form	IWC: Physical Form (wetland area, wetland form) sub-index (expanding)	• Percentage reduction in wetland area • Percentage of wetland where activities have resulted in a change in bathymetry • Severity and extent of wetland soil disturbance			

2.5 Limitations

There are data limitations for all wetland values, conditions and threats. Even wetland birds – for which we have collected good data for Ramsar wetlands over decades – reveal a lack of data or analysis to adequately account for the natural variation in weather and wetland condition. Recent work on new approaches, such Habitat Suitability Models and eDNA, as well as an increased effort on field data collection have not yet generated the data needed to adequately monitor, track and evaluate or wetlands.

An even more basic data limitation is that our waterbodies mapping has not been widely accepted, and the DEECA wetland mapping in common use has known weaknesses, including missing wetlands.

The 2018 HWS attempted to describe wetland values' health and environmental conditions using limited data, in many cases, we are only now collecting sufficient data to establish true 'benchmark' condition.

3. Summary of current management actions and progess

3.1 Progress towards performance objectives

Wetlands have been a focus in the last three *Healthy Waterways Strategy* annual summary reports in recognition of the challenges faced in retaining wetlands in a landscape that is rapidly urbanising. Figure 3.1 is an excerpt from the 2020/21 annual summary. There are many Regional Performance Objectives which relate to wetlands. These are outlined in Appendix E. Of these, there are a few which specifically refer to wetlands and the 2020/21 progress reports on these objectives are provided in Appendix F.

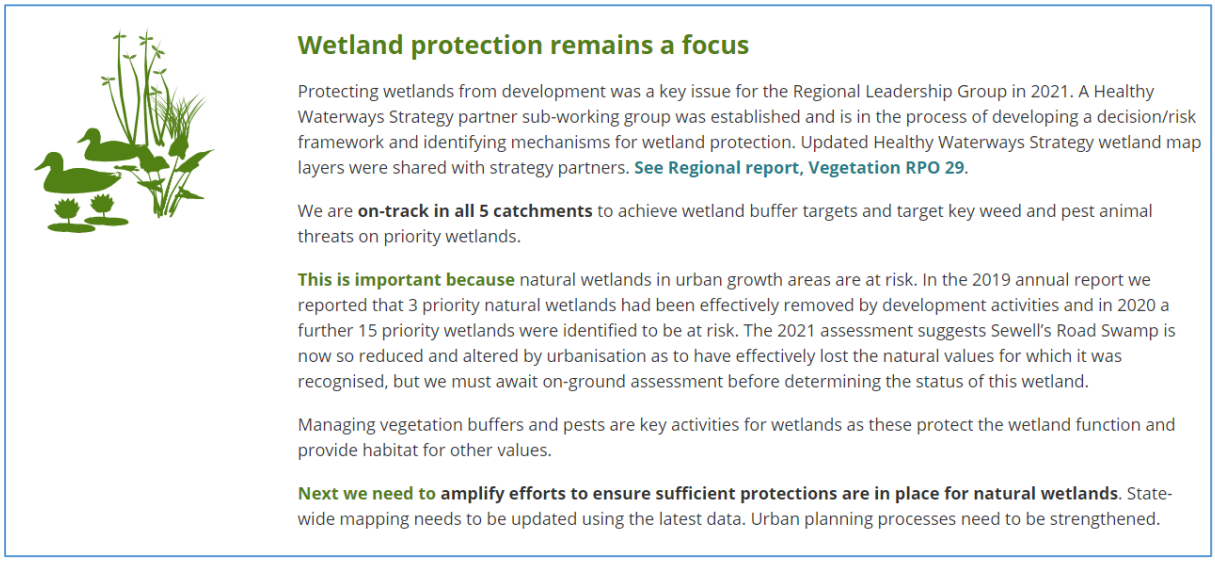


Figure 3.1 *Annual summary report for wetlands (20/21 annual report* Annual Summary 2021 | Healthy Waterways Strategy for Port Phillip and Westernport, Victoria*)*

There are also performance objectives for each of the HWS priority wetland groups. Progress towards managing pests and vegetation including the creation of buffers around wetlands is on-track as of the 2020/21 (Table 3.1**Table**). Data for the 2021/22 annual report is currently being collated and will be reviewed through the Implementation Inquiry. Since the HWS began, buffers around wetlands have been mapped to capture relevant works, set measureable output targets and track progress. We have mapped 200 m buffers (for pest animal control) and 50 m buffers (for vegetation management) around each regionally significant wetland. While we have mapped buffers for all 249 regionally significant wetlands identified in the Wetland MEP, and can track work at these wetlands, we report only on the 123 HWS priority wetlands (i.e. those with targets in the HWS). Areas of work are extracted from internal databases and rules have been developed around what proportion of area the works affect.

Cattle are not included in the 'pest animal control' works or targets. The 200 m buffer for pest animal control was based on discussion with Parks Victoria and how they report works to DELWP (now DEECA) through 'standard outputs'. Any pest animal program – baiting, trapping, shooting, warren ripping, den fumigation - is assumed to have a radius of influence within which animals are removed. From this, and using Parks Victoria figures, our thinking is that any pest animal control program within 200 m of a waterbody – if properly planned and executed – is going to significantly reduce the pest animal threat to that wetland. In contrast, weed control affects a much more direct area. Therefore, weed programs need to have occurred within 50 m of a wetland to be "counted" towards meeting wetland targets.

Table 3.1 *Summary of progress towards wetland specific performance objectives as of 2021/22 i.e. number of the 123 HWS priority wetlands with relevant objectives, where work has commenced or not (green = on-track, orange = slightly off-track, red = significantly off-track). Note, some wetland performance objectives are 'under review' because further study suggests they are impractical or unnecessary.*

Performance Objective	Werribee	Maribyrnong	Yarra	Dandenong	Westernport
Reduce threats from invasive flora and fauna	20 not started 11 in progress 2 under review (as considered impractical, irrelevant or cost-prohibitive)	2 in progress	11 in progress 1 under review	2 not started 9 in progress 1 under review	1 not started 7 in progress
Protect, maintain, or improve wetland vegetation to support habitat values.	1 in progress	No POs	Report end of strategy	1 not started 4 in-progress 1 under review	1 not started
Improve wetland buffer along wetland perimeters.	10 not started 10 in progress	1 in progress	3 not started 9 in progress 1 under review	1 not started 10 in progress	3 not started 3 in progress
Maintain or improve flow regimes	Will be reported in 2022				

There are a few wetland specific performance objectives that are reported regionally via Regional Performance Objectives. These include:

- Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls. Regional Performance Objective 29.
- Conserve priority species and communities through habitat protection, research and monitoring. Reported through Regional Performance Objective 32.
- Ensure appropriate stormwater planning controls are in place upstream, or above, key wetlands with stormwater or water quality targets. Reported through Regional Performance Objectives 15 and 29.
- Implement urban stormwater treatment systems to improve water quality in HWS priority wetlands. Reported through Regional Performance Objective 32.

3.2 Influencing decision making

Tracking and reporting wetland loss

The *Healthy Waterways Strategy* featured natural wetlands in detail for the first time in 2018. Prior to this, little was known about the location, extent and ecological characteristics of wetlands in the region and, culturally, Melbourne Water historically considered only constructed stormwater treatment systems as "wetland assets". The *Healthy Waterways Strategy* has brought to light the issue of threats to natural wetlands, particularly on private land and has become a topic of discussion by decision-makers and practitioners.

The first HWS Annual Report Card reported the loss of some natural wetlands considered significant due to previously approved urban development. Other natural wetlands in urban growth areas remain at risk from urbanisation. The 2020/21 assessment of regionally significant wetlands suggests Sewell's Road Swamp is now so reduced and altered by urbanisation as to have effectively lost the natural values for which it was recognised in the 1990s. On-ground observations when walking on Country with the Werribee River Keeper, Melbourne Water and Wyndham City Councillor confirm its status to be effectively lost. In total there are now four natural wetlands effectively lost since the HWS was launched in late 2018.

The 2020/21 HWS Annual Report also listed a further 14 regional priority wetlands under imminent risk of degradation through Precinct Structure Plans (PSPs) or Developer Services Schemes (DSS). On the positive side, 104 of 249 regional priority wetlands, as articulated in the Wetlands Monitoring and Evaluation Plan, are protected, and the number under threat has not increased since 2018. In terms of area, there is a total of 6,253 ha of natural wetlands mapped in the region. Of this 2,137 ha are managed within a protected area network of public land (within Parks Victoria parks and reserves, Melbourne Water sites of biodiversity significance, botanic gardens, etc.). Since 2018, 114 ha have been effectively lost; 663 ha are judged to be under imminent threat, and 163 ha at future risk of urbanisation.

This reporting approach has been streamlined through the development of an ESRI tool (Figure 3.2) that overlays the status of development services schemes and Precinct Structure Plans to assess the risk and socialise the forward threat. This affords teams within Melbourne Water to visually assess the threat to prioritise efforts for protection.

Responding to the problem

In response to the first Annual Report, the HWS Region-wide Leadership Group (RLG) requested a discussion paper on the problem, the policy and planning context, and options for improved management. This paper found that the basic machinery of managing wetlands in urban and peri-urban environment is not developed (Melbourne Water 2020c). The paper was issued to the RLG on 28 July 2020, and has also been circulated more broadly to senior staff at DEECA and the Victorian Planning Authority.

Over the past two years protection mechanisms have been considered and were discussed among the RLG on 23 April 2021. Foundational work was approved to understand the potential options available to Melbourne Water and HWS Partners for natural wetland protections. This has included the formation of a special HWS partner working group, chaired by DEECA's RLG representative. Members of the Wetland Working Group to the RLG include representatives from Melbourne Water, DEECA, Parks Victoria, Victorian Planning Authority, EPA, a Council in the growth area and, most recently, a representative of the Wurundjeri woi-wurrung Cultural Heritage Aboriginal Corporation.

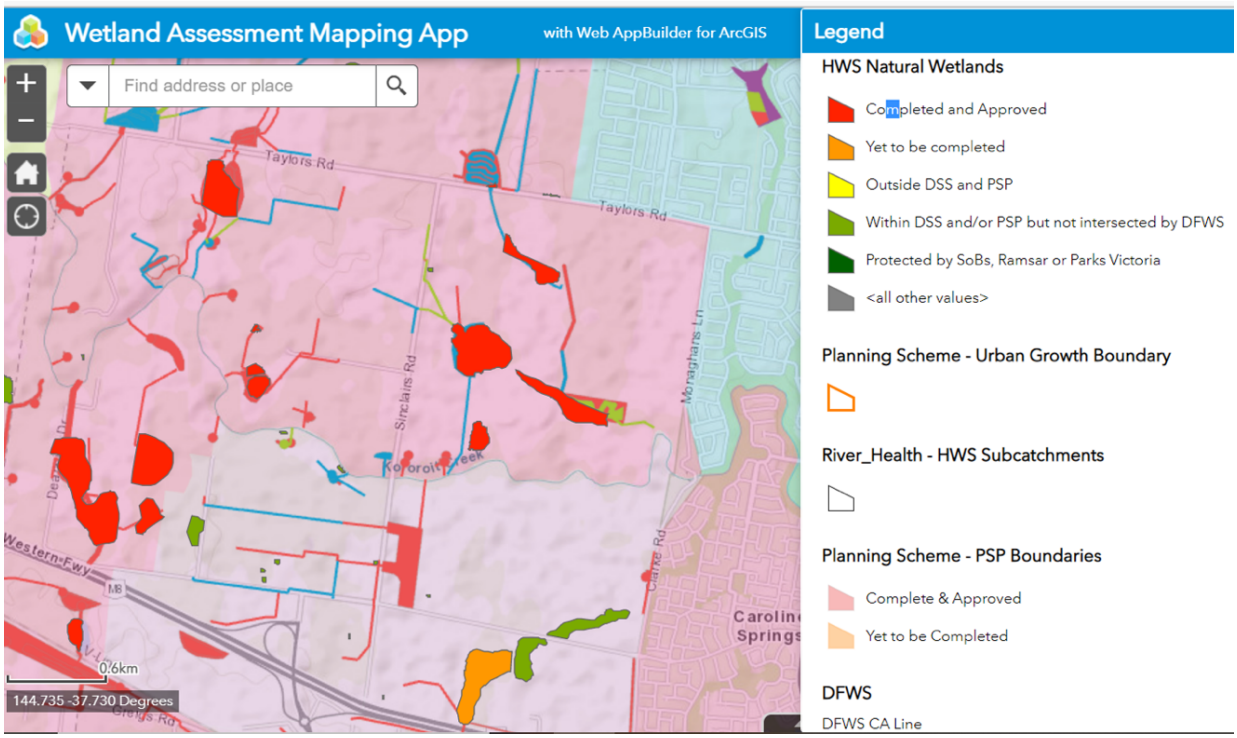


Figure 3.2 *Wetland status assessment mapping tool.*

In consultation with scientists and planners, the group developed a decision/risk framework tool to support priority setting and action planning for natural wetlands, particularly those on private land. This is important because there is a current policy gap around protecting wetlands from being physically lost. For example, if there are no listed flora or fauna species present in a wetland, then current planning controls do not protect a wetland from potentially being built over.

While the tool has potential, it is hampered by a lack of data. Despite this, the tool can be used to help inform a forward plan and prioritise investigations into wetland function, value and subsequent response. Adopting a precautionary principle, that assumes their value and worth for protection, and is ahead of the pace of development, given the stakes are high, will be needed in absence of this information. This place-based approach to planning will need to be utilised in the interim.

Other initiatives

There have been a number of other initiatives of relevance to wetland protection in the last couple of years. These are summarised below:

- DEECAs are updating the wetland inventory to improve urban development planning decision-making.
- DEECA multi-agency natural wetlands protection working group investigated options for protection included powers under existing legislation and a final report is being written for the RLG.
- Through Melbourne Water's price submission, the willingness to pay of the community to protect natural wetlands was tested and they ranked this as very high.
- As an alternative pathway towards protection, Melbourne Water worked with the (formerly) Port Phillip and Westernport Catchment Management Authority (CMA) to ensure all natural wetlands were mapped and publicly available on the Regional Catchment Strategy website. There is the opportunity to explore avenues for protection under existing legal instruments now that Melbourne Water and the Port Phillip and Western Port CMA are integrated.
- The Victorian Planning Authority's Precinct Structure Plan Guidelines now includes guidance around wetlands i.e. "Opportunities to retain and protect natural wetlands and open waterway channels should be explored with relevant councils and servicing agencies during place-shaping."
- The State Government's Victorian Waterway Management Strategy review is explicitly considering the impacts of urbanisation and wetland habitat loss because of the *Healthy Waterways Strategy* annual reporting recording these losses. The timing of the policy will be released in time for end of HWS evaluation and will inform the development of any future strategy.
- Protection measures for Cunningham's Swamp and Hannah Swamp, are being considered via PSP planning. It is hoped that this collaborative planning activity will demonstrate how to protect wetlands in urbanised settings. The Wurundjeri woi wurrung Cultural Heritage Aboriginal Corporation and the Nature Glenelg Trust have strongly advocated for the protection of Hannah Swamp and as a result, VCAT has required a softer approach than the originally proposed hard flood engineering response. What this looks like and how much of the wetland extent is protected is still unclear.

3.3 Recommendations for consideration in Science Inquiry

- Ensure new regional priority wetlands identified since 2018 (that do not have performance objectives) are managed to maintain existing values, for example risk-based predator control.
- Strengthen the protection of natural wetlands from the specific threat of urban development by instituting a new RPO or rewording, RPO 29, such as "Programs, standards, tools and guidelines are in place to protect natural wetlands (values and function) are protected from urban development".

- Complete updating state wetlands mapping to reflect the best available information for the Port Phillip and Westernport region, alignment with mapping on the Healthy Waterways Strategy and Regional Catchment Strategy web sites. This is important because it functions as the key reference document for all planning decisions for natural wetlands as related to in Victorian Planning Provisions 12.01-1S Biodiversity where the Regional Catchment Strategy is referred. This may need to be more strongly referred to and integrated by embedding into State Planning Scheme.
- Further explore opportunities from the integration of Melbourne Water with Port Phillip and Westernport CMA, to improve wetland protection, particularly for those of most significance such as seasonal herbaceous wetlands.
- Victorian Planning Provisions 12.03-1S River corridors, waterways, lakes and wetland to be updated by government to refer to the Healthy Waterways Strategy 2018 (as it still refers to HWS 2013).
- Advocate to improve natural wetland protections through the next iteration of the Victorian Waterway Management Strategy through a planning and policy framework that recognises the need for protection of function and form not just for managing condition.
- Continue to improve data and give further consideration of available spatial data, quantum/costs of management action, expert opinion, and economic analysis to increase the power of the prioritisation decision tool. Work to embed this tool into policy, decision making and planning processes (e.g. getting ahead of PSP processes).
- PSPs and Development Services Schemes to ensure that they understand when a natural wetland is a Designated Waterway and design responses that support their protection in accordance with this (i.e. minimum 20 m buffer). Embedding the General Environmental Duty into decision making, “manage your activities to avoid the risk of environmental damage” is a principle also for further exploration. Ensure environmental and cultural values are considered in planning stages (e.g. Minta Farm is a good example).
- Support alternative water supplies and integrated water management to reduce private landholders reliance on natural wetlands for use as farm dams and open the door to consideration of policy change through review of the Victorian Water Management Strategy. This will be of upmost importance when we face another drought.
- Proactively review natural wetland values and establishing planning protections in collaboration with local governments and DEECA near and around the growth boundary to ensure their consideration for better protection with future growth boundary reviews.
- Collaboratively explore with the Natural Wetlands Protection Working Group mechanisms such as the application of Urban Flood Zones for natural wetland protection when associated with floodplains.
- More deeply walk with traditional owners on this issue and provide accessible information and data to support Caring for Country beyond the archaeological perspective.
- Continue to have collaborative catchment forums to foster community awareness in recognition of the community’s enduring value of natural wetlands.

4. Wetland frogs and fish evaluation

The 2018 HWS reported the condition of frog communities at two different scales.

- At the wetland scale (regional priority wetlands only) the frog condition score was derived through the AVIRA process, which considered presence of listed species of frog. The AVIRA process was severely limited by data availability and the wetland frog condition scores were known to be no more than a poor, first guess at condition.
- At the sub-catchment scale we used field data and considered the observed / expected species present ratio as our metric. Field data were obtained through the Victorian Biodiversity Atlas (VBA) and the Melbourne Water Frog Census program. At that stage we used data modelling that weighted more recent records to generate the expected species scores (Ecology & Heritage Partners 2017).

The 2020 HWS Monitoring and Evaluation Plans stated our intent to focus on frog (and wetland fish) communities at the wetland scale, and to use eDNA sampling to determine presence/ absence of species. Field data from the Victorian Biodiversity Atlas (VBA) and Frog Census would be used to determine the 'expected' species for sub-catchments – which would then be applied to all wetlands within a sub-catchment.

However, financial approvals, covid restrictions and, to some extent, the weather has delayed and limited eDNA sampling. The first sampling run only took place in Spring 2021, and results are available for only one further run to date: autumn 2022. In addition, the initial sampling runs have produced puzzlingly low frog detections, and only seven species have been detected.

While we still believe eDNA is the preferred method for determining species' presence/ absence at priority wetlands we have little eDNA data now to inform the mid-strategy review.

Given the limited monitoring data for frogs and fish across the region and the limitations of using AVIRA in the HWS to estimate the status and trajectory of these wetlands values and threats, this section begins by presenting progress towards setting a new, eDNA-based benchmark. Then, for a select number of threatened species, KEQ3b (What other spatial and temporal trends and patterns for key values are of significance for implementation?) is considered through case studies.

Given the problems with eDNA not yet being a robust detection method for frogs in wetlands it might be some time before we have much robust data from wetlands. Therefore, a sub-catchment scale approach – as presented in the HWS – considering the frog species recorded across an entire sub-catchment and comparing this with the total number of species that might be expected, is one wat we can report on changes in frog community condition. This interim approach is reported in Section 4.2 below.

4.1 eDNA sampling program for wetland frogs and fish

Melbourne Water's eDNA program was principally designed to detect change in the status of fish, frog and Platypus (*Ornithorhynchus anatinus*) key values in waterways, wetlands and estuaries. Water samples are taken, DNA extracted and analysed with metabarcoding (multiple species) and qPCR (single species) to detect the presence of species in those habitats. Samples are taken when target animals are most active (spring and autumn) to give the best chance that species have shed

DNA material into the environment and therefore, increase detection probability. Approximately 1500 waterway sites will ultimately be sampled (including estuaries) with an additional ~200 wetland sites targeted.

Importantly, barcodes exist for all fish and frog species known to occur across Melbourne, so there is high confidence in positive species identifications. During a trial, we selected wetlands where we had Frog Census data showing seven or eight species of frog had been recorded. We could then compare the Frog Census records for each wetland against the subsequent eDNA detections. This showed quite close agreement, although the Eastern Dwarf Tree Frog (*Litoria fallax*) was not detected through eDNA as we did not have the species' bar code and Lesueur's Frog (*Litoria lesueurii*) eDNA was detected at sites when Frog Census did not detect this species (Weeks et al. 2021; Table 4.1)

Table 4.1 *Comparison of eDNA and Frog Census records at selected wetlands. (Source: Weeks et al. 2021,)*

Species	Total number of eDNA detections	Number of sites with eDNA detections	Number of sites with historic detections
Growling Grass Frog (*Litoria raniformis*)	0	0	2
Southern Toadlet (*Pseudophryne dendyi*)	0	0	2
Victorian Smooth Froglet (*Geocrinia victoriana*)	0	0	2
Eastern dwarf tree frog (*Litoria fallax*)*	0	0	6
Lesueur's frog (Litoria *lesueurii*)	16	4	0
Peron's Tree Frog (*Litoria peronii*)	26	7	10
Southern Brown Tree Frog (*Litoria ewingii*) OR Whistling Tree Frog (*Litoria verreauxii*)	105	21	20
Striped Marsh Frog (*Limnodynastes peronii*)	61	19	14
Spotted Marsh Frog (*Limnodynastes tasmaniensis*)	62	15	20
Eastern Banjo Frog (*Limnodynastes dumerili*)	95	22	19
Eastern Common Froglet (*Crinia signifera*)	125	24	25

*No reference sequence was available for this species.

The program is designed to confidently detect condition change over two different five-year periods; i.e. Block I, 2018-2023, and Block II, 2023 to 2028, with sampling campaigns occurring twice (in spring and autumn) during each period. Delays to program initiation meant that sampling in Block I did not begin until spring of 2021. This does not put the program 'off track', but creates an element of risk in collecting and interpreting early data. The main issue created by a late start to the program was a reduced inability to adaptively manage the program with reliable evidence. For example, wetland sampling and sample processing times has not been ideal and has resulted in lower than expected detection of frogs in spring 2021. There is now little scope to adjust methods and perform additional sampling to compensate. While teething issues are to be expected in a new and substantial program, the delayed start has compromised the ability for meaningful analysis and reporting in the HWS mid-term review.

Frogs map

Figure 4.1 shows wetland frog species diversity detected through eDNA sampling during spring 2021. Open circles indicate samples were taken but no frog species were detected. A majority of sites with positive detections contain a single species of frog and four sites contain >4 frog species (of that suit

of species we can currently test for). Wetlands sampled in spring 2021 represent approximately 40% of wetlands targeted in the overall program presented in the Wetland MEP.

Native fish map

Figure 4.2 shows wetland native fish species diversity detected in spring 2021. Open circles indicate samples were taken but no native fish were detected. Most wetlands contained >1 fish species and four wetlands contained >6 species of native fish.

Exotic fish map

Figure 4.3 shows wetland exotic fish species diversity detected in spring 2021. Open circles indicate samples were taken but no exotic fish were detected. Most wetlands contained >1 exotic fish species and five wetlands contained >4 exotic fish species.

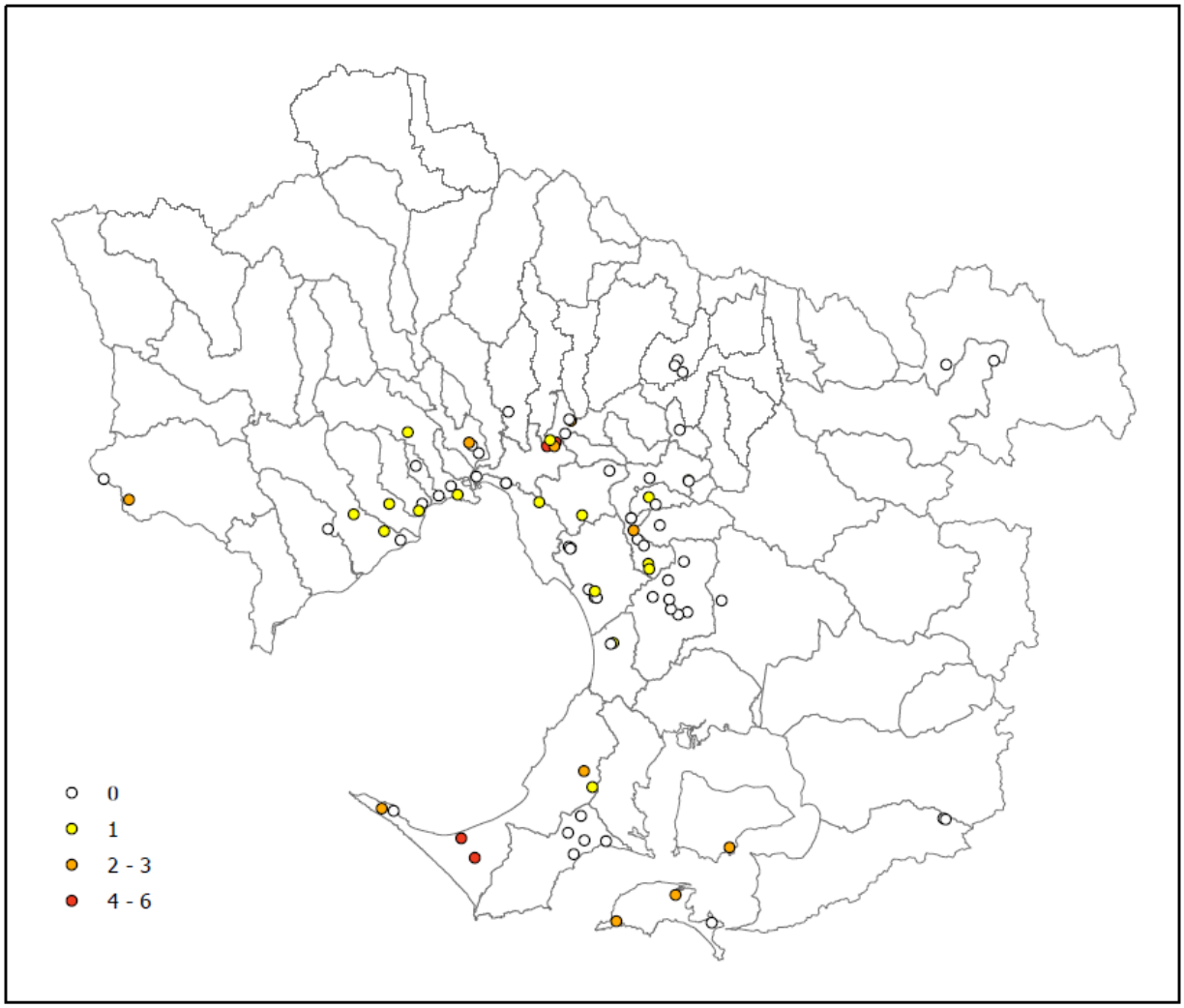


Figure 4.1 *Frog species richness in a sub-set of regionally significant wetlands derived from spring 2021 eDNA data. (Source: Weeks et al. 2021.)*

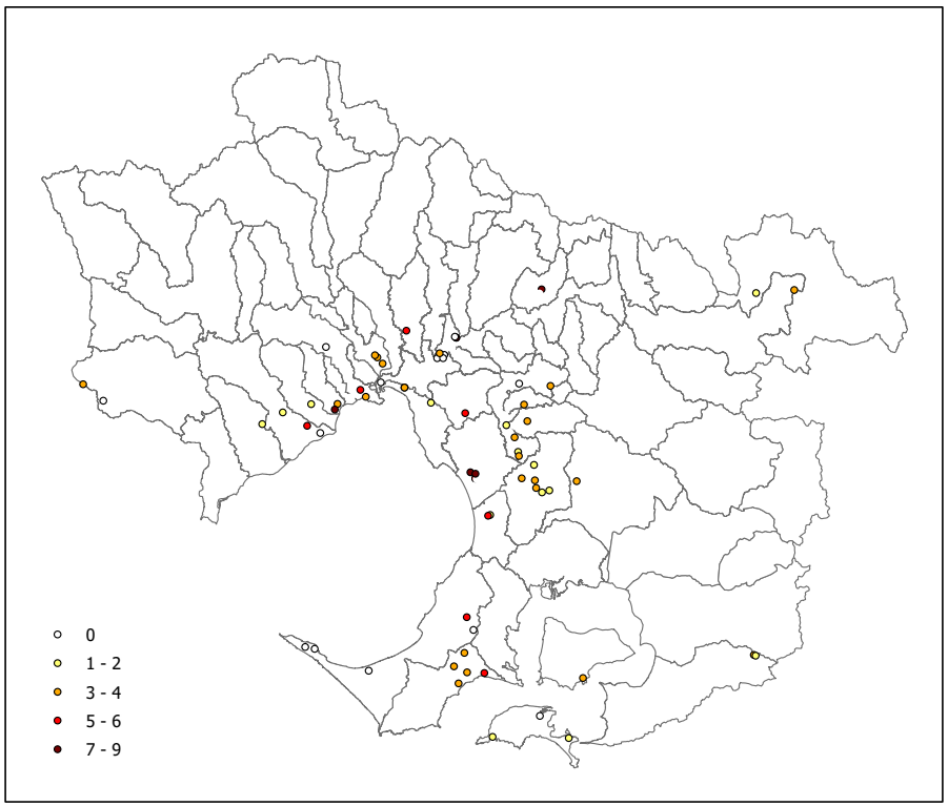


Figure 4.2 *Native fish species richness in a sub-set of regionally significant wetlands derived from 2021 spring eDNA data.*

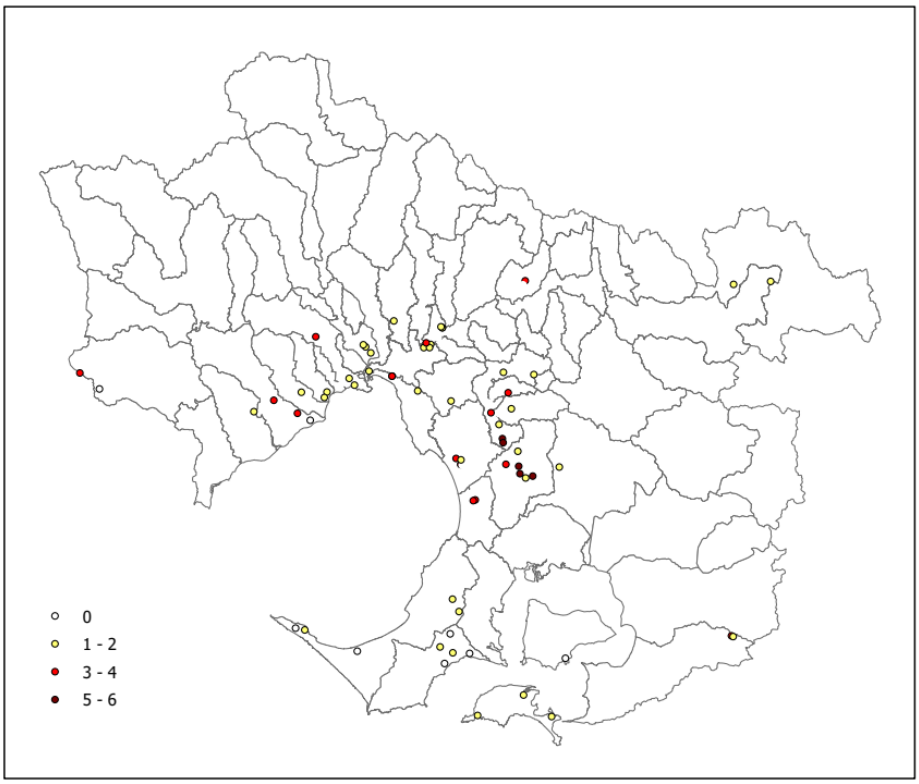


Figure 4.3 *Exotic fish species richness in a subset of regionally significant wetlands derived from spring 21 eDNA data.*

4.2 Sub-catchment scale frog assessment

Given the lack of eDNA available to assess the current condition and trajectory of frog communities at this mid-term review we used available field observations to investigate these. We used all available frog data, from the VBA, a survey of consultants in 2010 and Frog Census records (39,578 records in total, between January 1960 and June 2022) to determine the 'expected' species in each sub-catchment; taking the data between 1960 and 2017 (i.e. the last year before the HWS) as the data source.

We do not know how many frog records are required before we have sufficient data to calculate a meaningful observed list of species. A quick species accumulation curve assessment suggested around 200 records is the minimum required to get to an asymptote. However, this limitation would severely restrict the number of sub-catchments for which we could report. Therefore, for this mid-term review, we have arbitrarily set the cut-off for determining observed species lists at 100 records.

We looked for changes in score (obs/exp spp richness) by sub-catchment using data-derived expected species lists over three time periods: <2001, 2001 to 2010 inclusive, and >2010 (Table 4.2). Note that the obs/exp ratios for all three periods were calculated using all available records, and not the Symbolix modelled number (Ecology & Heritage Partners 2017).

Twenty of the 69 sub-catchments could not be assessed because of a lack of records (Table 4.2). Six sub-catchments were classified as 'declining' because there was an observed drop of at least one category over time. These were: Plenty River Lower, Darebin Creek, Gardiners Creek, Dalmore Outfalls, Jacksons Creek and Lollypop Creek. Several other sub-catchments showed potential declines over time, or variable changes over the three time periods, but data limitations mean we are not confident there is a real decline.

Of those six sub-catchments classified as 'declining', some are understandable, such as the urban streams Plenty Lower, Darebin and Gardiners. Lollypop Creek has seen extensive urbanisation. But it is difficult to explain why Dalmore Outfalls and Jacksons Creek should have declining frog health. Jacksons Creek has seen major revegetation, and there has been a detectable response from riparian birds (Melbourne Water 2023b).

Table 4.2 *Results of an interim assessment of frog community 'trajectory', comparing simple community scores over three time periods.*

Catchment	Sub-catchment	TRAJECTORY	Exp spp	Obs spp <2001	No. records <2001	O/E <2001	<2001	Obs spp 2001-2010	No. records 2001-2010	O/E 2001-2010	2001-2010	Obs spp >2010	No. records >2010	O/E >2010	>2010
Dandenong	Bayside	Stable	9	5	8	0.56	Insufficient data	6	72	0.67	Insufficient data	7	258	0.78	2 High
Dandenong	Blind Creek	Stable	10	9	14	0.90	Insufficient data	7	50	0.70	Insufficient data	8	165	0.80	2 High
Dandenong	Corhanwarrabul, Monbulk & Ferny Creeks	Stable	11	5	37	0.45	Insufficient data	8	80	0.73	Insufficient data	11	484	1.00	1 Very high
Dandenong	Dandenong Creek Lower	Stable	13	9	222	0.69	3 Moderate	9	316	0.69	3 Moderate	10	522	0.77	2 High
Dandenong	Dandenong Creek Middle	Stable	12	9	89	0.75	Insufficient data	10	396	0.83	2 High	11	1654	0.92	1 Very high
Dandenong	Dandenong Creek Upper	Gap	6	3	6	0.50	Insufficient data	2	8	0.33	Insufficient data	5	47	0.83	Insufficient data
Dandenong	Eumemmerring Creek	Stable	14	11	133	0.79	2 High	10	459	0.71	2 High	10	1101	0.71	2 High
Dandenong	Kananook Creek	Stable	13	10	75	0.77	Insufficient data	10	127	0.77	2 High	10	285	0.77	2 High
Maribyrnong	Boyd Creek	Gap	13	13	57	1.00	Insufficient data				Insufficient data				Insufficient data
Maribyrnong	Deep Creek Lower	Declining?	13	12	101	0.92	1 Very high	8	19	0.62	Insufficient data	9	89	0.69	Insufficient data
Maribyrnong	Deep Creek Upper	Gap	11	10	60	0.91	Insufficient data	5	7	0.45	Insufficient data	7	224	0.64	Insufficient data
Maribyrnong	Emu Creek	Gap	11	10	70	0.91	Insufficient data	5	12	0.45	Insufficient data	8	52	0.73	Insufficient data
Maribyrnong	Jacksons Creek	Declining	13	10	228	0.77	2 High	10	232	0.77	2 High	8	396	0.62	3 Moderate
Maribyrnong	Maribyrnong River	Stable	9	6	56	0.67	Insufficient data	6	55	0.67	Insufficient data	8	179	0.89	2 High
Maribyrnong	Moonee Ponds Creek	Stable	14	10	90	0.71	Insufficient data	8	228	0.57	3 Moderate	10	423	0.71	2 High
Maribyrnong	Steele Creek	Stable	7	5	12	0.71	Insufficient data	4	25	0.57	Insufficient data	6	114	0.86	2 High
Maribyrnong	Stony Creek	Gap	5	2	8	0.40	Insufficient data	2	3	0.40	Insufficient data	5	86	1.00	Insufficient data
Maribyrnong	Taylors Creek	Gap	9	9	32	1.00	Insufficient data	5	14	0.56	Insufficient data	5	21	0.56	Insufficient data
Werribee	Cherry Creek	Gap	7	6	38	0.86	Insufficient data	6	26	0.86	Insufficient data	1	3	0.14	Insufficient data
Werribee	Kororoit Creek Lower	Stable	11	7	164	0.64	3 Moderate	9	417	0.82	2 High	7	247	0.64	3 Moderate
Werribee	Kororoit Creek Upper	Gap	8	7	29	0.88	Insufficient data	4	33	0.50	Insufficient data	4	7	0.50	Insufficient data
Werribee	Laverton Creek	Gap	8	6	84	0.75	Insufficient data	5	23	0.63	Insufficient data	5	58	0.63	Insufficient data
Werribee	Lerderderg River	Declining?	13	12	158	0.92	1 Very high	3	6	0.23	Insufficient data	8	57	0.62	Insufficient data
Werribee	Little River Lower	Stable	10	9	133	0.90	2 High	6	210	0.60	3 Moderate	6	349	0.60	3 Moderate
Werribee	Little River Upper	Declining?	10	10	202	1.00	1 Very high	4	4	0.40	Insufficient data	7	31	0.70	Insufficient data
Werribee	Lollypop Creek	Declining	8	8	84	1.00	Insufficient data	7	206	0.88	2 High	5	181	0.63	3 Moderate
Werribee	Parwan Creek	Gap	7	7	43	1.00	Insufficient data				Insufficient data	6	56	0.86	Insufficient data
Werribee	Skeleton Creek	Stable	8	5	45	0.63	Insufficient data	6	96	0.75	Insufficient data	7	112	0.88	2 High
Werribee	Toolern Creek	Gap	10	8	52	0.80	Insufficient data	5	39	0.50	Insufficient data	8	96	0.80	Insufficient data
Werribee	Werribee River Lower	Stable	11	9	176	0.82	2 High	5	50	0.45	Insufficient data	8	185	0.73	2 High
Werribee	Werribee River Middle	Stable	13	11	170	0.85	2 High	7	59	0.54	Insufficient data	12	594	0.92	1 Very high
Werribee	Werribee River Upper	Gap	7	5	18	0.71	Insufficient data	4	13	0.57	Insufficient data	6	75	0.86	Insufficient data

Catchment	Sub-catchment	TRAJECTORY	Exp spp	Obs spp <2001	No. records <2001	O/E <2001	<2001	Obs spp 2001-2010	No. records 2001-2010	O/E 2001-2010	2001-2010	Obs spp >2010	No. records >2010	O/E >2010	>2010
Westernport	Bass River	Declining?	10	10	204	1.00	1 Very high	6	38	0.60	Insufficient data	5	11	0.50	Insufficient data
Westernport	Bunyip Lower	Stable	11	8	97	0.73	Insufficient data	8	352	0.73	2 High	9	105	0.82	2 High
Westernport	Bunyip River Middle & Upper	Stable	9	8	255	0.89	2 High	8	191	0.89	2 High	8	109	0.89	2 High
Westernport	Cardinia, Toomuc, Deep & Ararat Creeks	Stable	11	8	467	0.73	2 High	9	937	0.82	2 High	9	343	0.82	2 High
Westernport	Dalmore Outfalls	Declining	12	11	90	0.92	Insufficient data	9	273	0.75	2 High	8	112	0.67	3 Moderate
Westernport	French and Phillip Islands	Declining?	8	7	126	0.88	2 High	4	27	0.50	Insufficient data	6	41	0.75	Insufficient data
Westernport	King Parrot and Musk Creeks	Gap	7	4	7	0.57	Insufficient data	4	16	0.57	Insufficient data	5	6	0.71	Insufficient data
Westernport	Lang Lang River	Gap	10	9	60	0.90	Insufficient data	10	61	1.00	Insufficient data	7	28	0.70	Insufficient data
Westernport	Mornington Peninsula NE Creeks	Stable	10	8	110	0.80	2 High	9	563	0.90	2 High	9	236	0.90	2 High
Westernport	Mornington Peninsula SE Creeks	Stable	12	9	137	0.75	2 High	11	707	0.92	1 Very high	11	204	0.92	1 Very high
Westernport	Mornington Peninsula W Creeks	Stable	13	8	369	0.62	3 Moderate	11	1226	0.85	2 High	11	442	0.85	2 High
Westernport	Tarago River	Gap	9	8	48	0.89	Insufficient data	3	7	0.33	Insufficient data	8	56	0.89	Insufficient data
Yarra	Brushy Creek	Stable	11	9	66	0.82	Insufficient data	5	56	0.45	Insufficient data	11	112	1.00	1 Very high
Yarra	Darebin Creek	Declining	12	10	156	0.83	2 High	10	390	0.83	2 High	8	285	0.67	3 Moderate
Yarra	Diamond Creek (Rural)	Declining?	12	12	530	1.00	1 Very high	8	429	0.67	3 Moderate	9	847	0.75	2 High
Yarra	Diamond Creek (Source)	Declining?	11	10	111	0.91	1 Very high	4	17	0.36	Insufficient data	7	39	0.64	Insufficient data
Yarra	Gardiners Creek	Declining	10	7	33	0.70	Insufficient data	8	133	0.80	2 High	7	263	0.70	3 Moderate
Yarra	Koonung Creek	Declining?	12	10	100	0.83	2 High	8	54	0.67	Insufficient data	7	45	0.58	Insufficient data
Yarra	Little Yarra River & Hoddles Creek	Gap	9	8	97	0.89	Insufficient data	4	8	0.44	Insufficient data	8	95	0.89	Insufficient data
Yarra	Merri Creek Lower	Declining?	13	12	112	0.92	1 Very high	8	611	0.62	3 Moderate	10	445	0.77	2 High
Yarra	Merri Creek Upper	Declining?	13	13	565	1.00	1 Very high	9	1070	0.69	3 Moderate	10	224	0.77	2 High
Yarra	Mullum Mullum Creek	Gap	12	11	75	0.92	Insufficient data	9	82	0.75	Insufficient data	7	164	0.58	Insufficient data
Yarra	Olinda Creek	Stable	12	9	56	0.75	Insufficient data	6	40	0.50	Insufficient data	10	139	0.83	2 High
Yarra	Plenty River (Source)	Declining?	14	14	332	1.00	1 Very high	5	5	0.36	Insufficient data	6	11	0.43	Insufficient data
Yarra	Plenty River Lower	Declining	14	12	298	0.86	2 High	9	98	0.64	Insufficient data	8	507	0.57	3 Moderate
Yarra	Plenty River Upper	Declining?	14	13	858	0.93	1 Very high	9	58	0.64	Insufficient data	11	477	0.79	2 High
Yarra	Steels and Pauls Creek (Rural)	Declining?	10	9	136	0.90	2 High	7	104	0.70	3 Moderate	7	23	0.70	Insufficient data
Yarra	Steels and Pauls Creek (Source)	Gap	9	9	97	1.00	Insufficient data	6	13	0.67	Insufficient data	6	10	0.67	Insufficient data
Yarra	Stringybark Creek	Gap	10	6	29	0.60	Insufficient data	6	36	0.60	Insufficient data	8	24	0.80	Insufficient data
Yarra	Watsons Creek	Stable	13	11	148	0.85	2 High	7	53	0.54	Insufficient data	10	131	0.77	2 High
Yarra	Watts River (Rural)	Declining?	10	10	147	1.00	1 Very high	5	14	0.50	Insufficient data	8	44	0.80	Insufficient data
Yarra	Watts River (Source)	Gap	7	5	17	0.71	Insufficient data	6	12	0.86	Insufficient data	2	4	0.29	Insufficient data
Yarra	Woori Yallock Creek	Stable	11	9	248	0.82	2 High	9	76	0.82	Insufficient data	9	347	0.82	2 High
Yarra	Yarra River Lower	Stable	15	13	709	0.87	2 High				Insufficient data	11	839	0.73	2 High
Yarra	Yarra River Middle	Stable	12	10	154	0.83	2 High	12	721	1.00	1 Very high	9	241	0.75	2 High
Yarra	Yarra River Upper (Rural)	Declining?	10	10	106	1.00	1 Very high	6	61	0.60	Insufficient data	8	294	0.80	2 High
Yarra	Yarra River Upper (Source)	Declining?	8	8	179	1.00	1 Very high	6	40	0.75	Insufficient data	1	1	0.13	Insufficient data

4.3 Threatened species case studies

Three threatened species of frog occur in the Port Phillip and Westernport region:

- Brown Toadlet, also known as Bibron's Toadlet, (*Pseudophryne bibroni*) – Endangered (FFG Act)
- Southern Toadlet (*Pseudophryne semimarmorata*) – Endangered (FFG Act)
- Growling Grass Frog (*Litoria raniformis*) – Vulnerable (EPBC Act, FFG Act)

The HWS includes specific performance objectives for the toadlet species:

PO ID	Catchment	Sub-catchment	Performance objective
73	Dandenong	Dandenong Creek Middle	Target three riparian areas for habitat improvement works to support *Pseudophryne semimarmorata* (Southern Toadlet).
86	Dandenong	Eumemmerring Creek	Target three riparian areas for habitat improvement works to support *Pseudophryne semimarmorata* (Southern Toadlet).
267	Werribee	Kororoit Creek Lower	Target three areas (min. 2 ha) for habitat improvement for Brown Toadlet.
274	Werribee	Kororoit Creek Upper	Target three areas (min. 2 ha) for habitat improvement for Brown Toadlet.
317	Werribee	Toolern Creek	Target three areas (min. 2 ha) for habitat improvement for Brown Toadlet.

It should be noted that there are no suitable areas in Kororoit Lower to create habitat for Brown Toadlet, and Kororoit Upper has only a small suitable area which is privately owned. These performance objectives are to be reviewed during the implementation enquiry.

There are also general performance objectives for certain sub-catchments such as Merri Creek and the Little River Lower sub-catchment that seek to protect the significant Growling Grass Frog population there:

- Undertake monitoring to ensure that site stays within the limits of acceptable change as identified in the Ramsar Management Plan and in accordance with new requirements for monitoring, evaluation and reporting at Ramsar sites.
- Identify and assess management options for addressing risk to coastal habitat from sea level rise and increasing coastal storm surge.
- Continue to implement water regime management to meet ecological objectives in artificial habitats within the Ramsar site.

Case studies on these threatened species of frog are summarised below.

Case Study - Growling Grass Frog populations in Melbourne's Northern Growth Area

Dr Geoff Heard was commissioned to survey Growling Grass Frog populations in and around conservation areas (118 sites) established by the Melbourne Strategic Assessment (MSA) to protect the species.

Long-term monitoring sites beyond the Growling Grass Frog conservation areas (encompassing parts of the mid catchments of Darebin and Merri Creek and upper and mid catchments of Moonee Ponds Creek) established by him in 2001/02 were also surveyed (185 sites), providing a wider regional view of the status of *L. raniformis*, including contemporary occupancy rates and changes in occupancy since monitoring commenced in this region 20 years ago.

A total of 385 surveys for *L. raniformis* were undertaken across the 185 sites accessed during the 2021/2022 season. The species was detected at 37 sites for a naïve occupancy estimate of 20%.

Among the 118 MSA sites, *L. raniformis* was detected at 26 sites, giving a naïve estimate of occupancy rate of 22%. Fitting single-season occupancy models to these data provided an estimated occupancy rate for the full set of sites of 23% (95% CI: 20–31%) and 25% (95% CI: 22–33%) for MSA sites only (equating to median estimates of the number of occupied sites of 43 and 30 respectively).

Comparing estimates of occupancy rates of *L. raniformis* across the study area during the 2001/2002 season and the 2021/2022 season show a significant decline in occupancy in the intervening 20 years among these sites (Figure 4.4) Of the 118 sites surveyed in both seasons, *L. raniformis* was detected at 43 of these sites in 2001/2002 (naïve occupancy rate of 36%) and only 16 in 2021/2022 (naïve occupancy rate of 19%) — a decline of 63%. Corresponding estimates of site occupancy accounting for imperfect detection are 65 (95% CI: 50, 92) and 26 (95% CI: 20, 35) — a decline of 60%. Observed declines are even steeper when considering only sites within the MSA set that were surveyed in both season (n = 76). Among these sites, *L. raniformis* was detected at 35 in 2001/2002 but only 10 in 2021/2022 — a decline of 71%. Corresponding estimates of site occupancy accounting for imperfect detection are 53 (95% CI: 39, 76) and 13 (95% CI: 10, 19), equating to a decline of 75%.

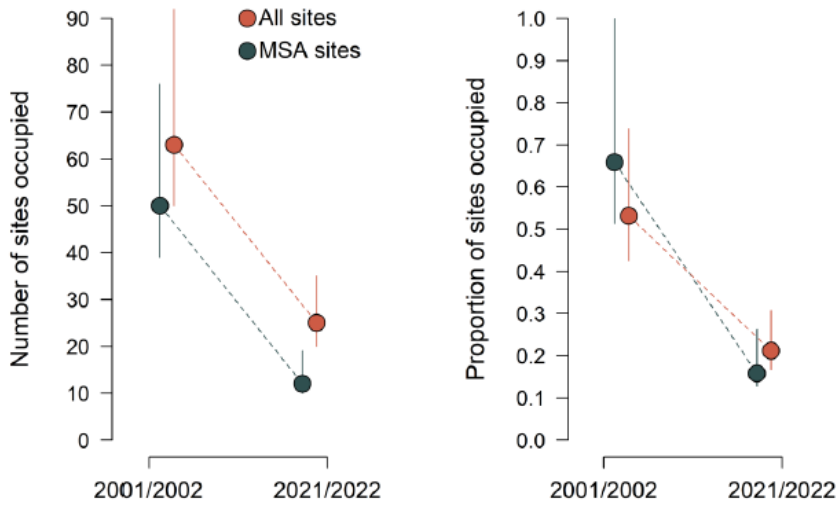


Figure 4.4 *2 A comparison of occupancy rates over 20 years between 2001/02 and 2021/22 of growling grass frog species in the northern growth corridor.*

These results indicate that Growling Grass Frogs occupancy rates have declined in the conservation sites (MSA) and Melbourne's Northern Growth area more broadly in the past 20 years and this has implications for the future management of this species in this urban area.

The MSA outlined the need to construct 90 Growling Grass Frog ponds to offset urban development in the northern growth corridor. To date (mid-2022), only one pond has been constructed, with another nine in the design phase.

Case Study - Growling Grass Frogs Management and Monitoring, Western Treatment Plant

Melbourne Water continues to manage dedicated Growling Grass Frog habitat ponds at the WTP. This management has been in place since 2002 and has been adaptive, with annual monitoring of populations every summer since 2002. Specific triggers for additional management investment were established in response to an EPBC controlled action (Melbourne Water 2003) and have been reported to the Commonwealth Department every year since. Triggers for additional management are:

- A decline of 10% in population recorded during standardised summer monitoring program over three successive years.
- An overall decline of >25% in average annual numbers recorded during standardised summer monitoring

The standardised monitoring program uses fixed transects at 24 sites.

A Ramsar management plan LAC (Limit of Acceptable Change) is less conservative, and is "More than 200 Growling Grass Frogs recorded during at least three out of every five years".

This monitoring program has revealed very high inter-annual variability in frog numbers; in response to both rainfall and management. Additional management initiated in past years has included more ponds being allocated to the species, additional research (including radio-tracking and chytrid studies) and increased hydroperiod of conservation ponds in response to research findings.

Since the 2018 HWS, annual monitoring has continued (Ecology Australia 2019, 2020; Ecology & Heritage Partners 2021, 2022). The most recent results in 2022 show 57% site occupancy (21 of 37 sites) and a total of 224 Growling Grass Frogs detected on 24 standard transects and 221 detected at other sites. This is the seventh highest number recorded in the last 12 years (so above average), but a decline of 59% over numbers counted on transects last year. However, 2020/21 saw an exceptionally high number of frogs recorded and no management triggers were passed.

This provides an interesting contrast to the previous case study of Growling Grass Frogs in the Melbourne Northern Growth area where occupancy rates have significantly declined.

Case Study - Southern Toadlet investigations

The Southern Toadlet is an autumn-breeding frog that utilises neither wetlands nor streams for breeding, but prefers small seasonally flooded depressions. Consequently this is a difficult species to study and little was known for certain about its habitat preferences and constraints, or populations trends.

A review of data concludes:

"To the north and northeast of Melbourne all historical populations of Southern Toadlet appear to now be extinct. Extensive surveys of the area over the past 15 years (Cleeland, unpubl. data.) have failed to confirm the presence of the species. Once widespread and locally common around Wallan and extending eastwards to Sugarloaf Reservoir, the Southern Toadlet habitat is now highly modified with few suitable breeding sites remaining. The last confirmed southern toadlet recorded at the Yan Yean north reference area was from 2010 (Cleeland, unpubl. data). In 2020, Ecology Australia on behalf of Melbourne Water placed 11 audio recorders within this area including last known occupied site (Marr & Cleeland 2021). This was followed up by nocturnal surveys in 2021 (Greenfield et al. 2021). The failure of these surveys to locate calling males would indicate that this historically significant population is now extinct.

"East of Melbourne, Southern Toadlet persists in isolated populations along ridgeline gullies to the extreme east of the Shire of Nillumbik and around Yering Gorge, but no longer persists in the valleys immediately east of there. Foothill populations around Yellingbo and Healesville are presumed extinct, with recent surveys failing to detect calling males (Cleeland, unpubl. data.). It is plausible that these foothill populations became extinct towards the end of the Millennium drought (Cleeland, pers. obs.).

"To the south and southeast of Melbourne, populations at Churchill National Park, Lysterfield State Park, Langwarrin Flora and Fauna Reserve, Mornington Peninsula National Park and Devilbend Reservoir are all persisting, although it should be noted both Lysterfield and Langwarrin populations have contracted significantly and persist in very small numbers (<11 calling males)" (Cleeland 2022).

In addressing the HWS performance objectives to target areas of suitable habitat for improvement and protection we had first to undertake surveys to try to establish the species' occupied range, and the nature of occupied habitat. We have now completed four seasons of surveys, from 2019 to 2022, across Sugarloaf Reservoir, Churchill National Park and Lysterfield State Park, despite covid restrictions and other difficulties (Ecology Australia 2019a, 2019b, 2020a, 2020b, 2021; Cleeland 2022).

The results from the surveys are highlighting a decline:

"The number of toadlets heard calling at the three areas has remained consistent with those recorded in the 2019 surveys, both 2020 and 2021 indicated slight decreases, particularly at Churchill National Park. More concerning is the decrease in occupancy of sites across all three properties. Historical records demonstrate this contraction in distribution is most pronounced at Lysterfield but even recent surveys from 2019 onwards have shown the loss is continuing, with a reduction of sites along Lambert's track while remaining sites at Quarry Dam and Donelan Track both have extremely low probabilities of recruitment due to their inability to hold water for tadpole development.

Churchill National Park has similarly shown a reduction in occupancy with toadlets no longer found in the channel to the far west of the park and recent surveys have failed to find calling males north of the intersection of Channel and Bayview tracks. The other two populations away from the main channel are showing a drop in numbers of calling males in particular Stonemason site, which has had an 86% reduction in calling males in the last two years.

Very little historical data exists for Sugarloaf Reservoir and hence trends in occupancy are more difficult to define. Sugarloaf Creek Gully and Stevenson Creek Gully no longer contain

calling males, although number of calling males were low when surveys began in 2019. However, recruitment was noted for all sites.

"Furthermore, weather during the 2020 breeding season and into the subsequent tadpole development period was more favourable than for the previous year and subsequent years. However, anecdotal evidence suggests males mature and commence calling at two years and older, which indicates recruitment from this event is unlikely to be detected until 2023." (Cleeland 2022)

During 2022, we initiated a Southern Toadlet survey program using eDNA techniques to compare with the efficacy of field surveys, and try to better determine where sites are truly unoccupied (and not merely missing a calling male). Results of ~100 water samples from known habitat were disappointing, with only two detections (from a single site) despite the fact we sampled at several sites where Southern Toadlet were known to be at that time (Hale et al. 2023). Further work is required to develop eDNA as an effective and reliable means of detecting *Pseudophryne* species.

More recently, a review of *Pseudophryne* records and information across the region has sombre conclusions:

"As you move from southeast to northwest across the Melbourne Water region the abundance and occupancy of sites by toadlets decreases dramatically. Brown Toadlets, P. bibronii, may no longer be present within the region and Southern Toadlets, P. semimarmorata, appear to be contracting in distribution with the coastal plain containing the greatest abundance and distribution." (Cleeland 2023, p. 2).

Advice is being sought on what on-ground works are possible to enhance/protect *Pseudophryne* habitat. It appears that deer are a major threat, through trampling and wallowing in sites and fencing is being considered. Another significant threat is altered hydrology, with sites not holding water for long enough to ensure tadpole development. A number of factors may affect the hydrology of these shallow depressions: climate change and reduced rainfall, or human traffic on nearby cycle paths contributing to change in water flow and increased silt loads.

Case Study – Yarra Pygmy Perch and Dwarf Galaxias

Dwarf Galaxias (*Galaxiella pusilla*) and Yarra Pygmy Perch (*Nannoperca obscura*) are two threatened native freshwater fish under the federal *Environment Protection and Biodiversity Conservation Act 199*9. They are small species found in freshwater streams and swamps in coastal catchments of south-eastern Australia, and have undergone a dramatic decline in range and abundance. In particular, they have significantly declined around greater Melbourne, and are now both considered extinct from the Yarra River system and Yarra Pygmy Perch extinct from the Dandenong Creek system.

The local demise of these two species is believed to be largely due to a loss of inter-connected floodplain habitats across the landscape. Loss of suitable habitat is due to direct filling, piping, channel concrete lining, vegetation clearing and changes in hydrology. Invasion by exotic fish (e.g. *Gambusia*, Redfin) also places greater pressure on these small fish.

For Deep Creek and Boyd Creek in the Maribyrnong River catchment, there are performance objectives to 'investigate opportunities to translocate Yarra Pygmy Perch into suitable habitat along the creek corridor', while in the Dandenong Catchment there are performance objectives for habitat

improvement at 20 sites as part of the “Enhancing Our Dandenong Creek” project i.e. to ‘maintain critical water regime components in wetlands along Dandenong Creek to protect wetland environmental values, Yarra Pygmy Perch and Dwarf Galaxias’ and ‘monitor threat levels from invasive fish species on Dwarf Galaxias and mitigate risks if required’.

To underpin an assessment of opportunities to translocate Yarra Pygmy Perch in the Deep Creek catchment, both eDNA and traditional survey techniques targeted creek and floodplain habitats. Sites where perch were detected have the potential to be source fish for translocations and sites with suitable habitat without perch could be candidate translocation sites. Results from these surveys indicated Yarra Pygmy Perch at multiple sites along the creek. In addition to translocating fish within the Deep Creek catchment, Melbourne Water has been attempting to breed Yarra Pygmy Perch alongside Dwarf Galaxias in a purpose built habitat at Narre Warren, and has also investigated a commercial arrangement with a specialist breeder in Gippsland.

Surveys and translocations of Dwarf Galaxias in the Dandenong Creek catchment habitats constructed as part of the “Enhancing Our Dandenong Creek” project have been constrained over the past 2 years due to covid restrictions. Annual surveys in the Narre Warren habitat wetland where fish are being sourced for translocations, however, have indicated ongoing breeding success and stable numbers of fish. This is encouraging given, earlier water level issues associated with a water pump failure and its replacement. To fast-track translocations, Melbourne Water is also investigating a commercial arrangement to obtain additional Dwarf Galaxias stock from a specialist breeder in Gippsland. In addition to the Narre Warren wetland, there have been observations of juvenile dwarf galaxias in Tirhatuan Wetland (the first and only translocation site to date) over multiple years.

4.4 Recommendations for consideration in Science Inquiry

- Urgent attention to protect threatened species is required – develop a strategic management plan for Growling Grass Frog, Southern Toadlet, Brown Toadlet and Yarra Pygmy Perch. There is the potential to use the Platypus strategic management plan as an example (Griffiths & Weeks, 2018).
- Work to improve eDNA sampling methods in wetlands of varying area, depth, retention time and turbidity to increase confidence in eDNA results.

5. Wetland birds

5.1 Background

The 2018 *Healthy Waterways Strategy "*bird value" is treated as riparian or wetland bird values separately (Melbourne Water 2018, 2020a, 2020b). Each of these bird communities requires data collection for two distinct purposes:

- region-wide monitoring (to inform high-level indices for reporting and tracking) and
- targeted works evaluation studies (to improve conceptual models and guide management investment) (Figure 5.1).

The wetland bird community has seen more work in both areas, but particularly the latter. The Ramsar sites at the Western Treatment Plant and Edithvale-Seaford Wetlands have hosted numerous works evaluation and other studies, including:

- Nutrient and salinity modelling (Loyn et al. 2014a, 2014b, 2023), ongoing.
- Water depth management for shorebirds (Rogers & Hulzebosch 2014; Rogers et al. 2015, 2021).
- Common Reed control measures to restore shorebird foraging habitat (Greet & Rees 2015)
- Movements of waterbirds in response to inland rainfall (Clark et al. 2015).
- Water requirements of Straw-necked Ibis (a Ramsar value at the WTP) (Macak & Menkhorst 2014; Macak et al. 2015), ongoing.
- Development of a Wetland Bird Index (Birdlife Australia 2020, 2022a)
- Bird responses to billabong watering (Birdlife Australia 2022b)
- A review of the drivers (and prior indicators) of avian botulism (Jacobs 2021).

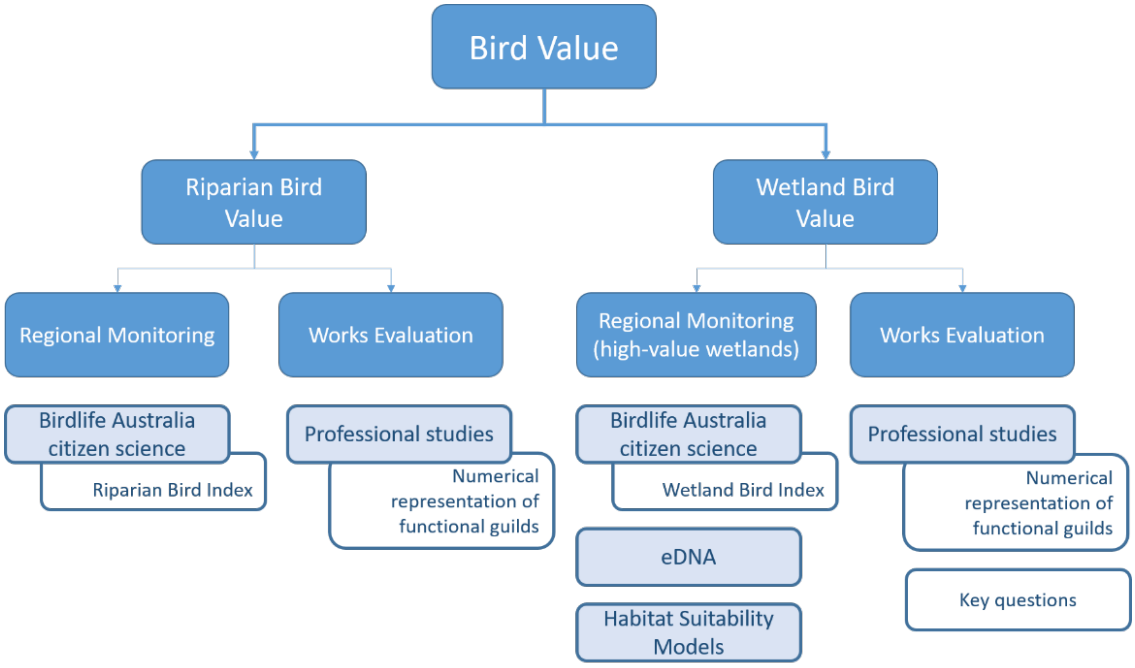


Figure 5.1 *Schematic representation of the Bird value approach.*

Wetlands have also seen trials of eDNA to improve bird detection, and Habitat Suitability Models for wetland species are being developed by the University of Melbourne's Waterways Ecosystem Research Group (WERG).

Melbourne Water commissioned monitoring of birds at wetlands long before riparian birds were considered a HWS key value (Tzaros et al. 2004, 2005; Silcocks et al. 2007; Silcocks & O'Connor 2007, 2008, 2009, 2010, 2011; Lau 2008, 2009, 2011a, 2011b; Silcocks 2013a, 2013b; Purnell 2013, 2014, 2015; Loyn et al. 2014a, 2014b; Menkhorst et al. 2014, 2015, 2017, 2018, 2019, 2020, 2021; Herman & Purnell 2016; Herman 2017, 2018; Birdlife Australia 2020a, 2020b, 2022), and it has proved easier to recruit community volunteers to survey wetlands than it has directing volunteers to consistent and standardized bird surveys of riparian areas. However, we still were not able to cover all of the regional priority wetlands (see below).

Region-wide monitoring

Development of a high-level Wetland Bird Index for regional reporting began prior to the 2013 *Healthy Waterways Strategy* (Melbourne Water 2013). Initially, the index was calculated as the summed reporting rate of a list of expected wetland species for the Port Phillip and Westernport region (Steele 2011). During the period of the 2013 Healthy Waterways Strategy, this index was tested and refined (Herman & Purnell 2016; Herman 2017, 2018), and different approaches considered (e.g. Herman 2015). Despite acknowledged simplicity, a modified Wetland Bird Index was considered a useful high-level measure of relative bird community 'health' over time. Subsequent testing and refinement in response to Birdlife Australia suggestions around the need to include more measures (such as threatened species and breeding) led to modifications (described in the Wetland MEP, Melbourne water 2020a).

The HWS scores and target setting were not based on bird data and have proved to be inadequate (see Appendix A). Later, with the Wetland MEP, the revised Wetland Bird Index was used to

describe 'current' condition of the wetland bird communities in 2018, as a new 'benchmark' for the *2018 Healthy Waterways Strategy* (Melbourne Water 2018).

It must be emphasized that the Wetland Bird Index is intended, and designed, to be a high-level and simple reporting tool. One which presents a simplistic summary of wetland bird condition over a defined period and area, and which can be used to infer changes in condition ("health") of wetland bird communities. It is not a detailed or analytical tool.

Wetland Bird Index

Timeframes during strategy development (2017-18) prevented a thorough assessment of bird communities, and little of the available bird data were referenced. Instead, results of a simple AVIRA process were used to estimate the status of wetland bird communities at the, then, listed priority wetlands. This meant that AVIRA measures such as formally recognized significance (i.e. Ramsar wetlands, East Asian-Australasian Flyway Sites, or Directory of Important Wetlands in Australia); VBA records of rare or threatened species; and the desktop assessment of wetland vegetation condition, were used to infer the status of wetland birds[3].

The HWS Resource Document states that: "*to ensure our investment in activities to protect bird values is directed towards the most beneficial actions at the most important locations, it is important that we undertake a more thorough analysis of the bird data to test our original assumptions*." (Melbourne Water 2020a).

There are several possible indices, or indictors, for wetland bird community health. The best condition metric would be based upon quantitative count data communities. But, for high level reporting we decided initially to use summed reporting rate of expected wetland species of bird as the metric (see Steele 2011, 2019; Melbourne Water 2020a, 2020b).

Since the HWS, an index of wetland bird community status based on the comprehensive datasets held by Birdlife Australia has been developed and tested (see Birdlife Australia 2020, 2022b). The indicators selected are presented in Table 5.1.

Importantly, utilising only the species presence/absence information from surveys avoids problems of observer skills and bias; and detectability issues related to wind and weather at the time of a survey. Volunteer birdwatchers are generally competent at identifying species. But their accuracy when estimating numbers of birds actually present will vary with their skill and experience. Therefore, the wetland bird index is based on species' presence/absence information, with 'modifiers' to the score through the number of listed (migratory and/or threatened) species, and breeding species. (Please refer to the Wetland MEP for details of the Wetland Bird index). Birdlife Australia continues testing quantitative data, using metrics such as bird density, but we can see no clear benefit to these approaches at this time (Birdlife Australia 2020, 2022b.)

[3] For further detail, please refer to the HWS Technical Resource Document (Melbourne Water 2020b).

Table 5.1 *Indicators for the wetland bird community value at regional surveillance scale used in the mid-term evaluation.*

Indicator	What it's useful for
Summed reporting rates of specified wetland bird species over the time period in question (minimum of 20 standardised surveys required). Note: we recommend returning to a minimum requirement of 40 robust counts per reporting period for future evaluations.	A simple aggregate score that includes elements of both appropriate species richness and frequency of occurrence, thus measuring changes in overall species richness and increased (or decreased) frequency of use.
No. of wetland bird species recorded breeding over period	Wetlands are critical waterbird breeding habitat and breeding is essential for the persistence of these species.
No. of listed species of wetland bird (both threatened and migratory) recorded over the period	Threatened or migratory species have particular importance for conservation management. This is used as a modifier to weight wetland bird communities by the number of these important species found at a site, to ensure that wetlands with otherwise low numbers and variety of waterbirds but which support listed or migratory species are not under scored.

From 2002/03 onwards Melbourne Water has worked with Birdlife Australia to develop a comprehensive regional, community-based bird monitoring program. This sees teams of volunteers recruited to conduct standardised surveys at a large number of selected sites. For regional surveillance monitoring we will continue to use community-based 'citizen scientist' surveys, combined with professional bird counts where available, to collect field data. The advantages obtained through community engagement and participation (e.g. see community engagement performance objectives in the HWS) outweigh limitations, such as not recording nocturnal or cryptic species of bird.

However, quantitative count data collected by community volunteers will vary with observer skills (in addition to other sources of variation in detectability: weather conditions, time of day, etc.). Therefore, while count data will be useful when explaining results, for regional surveillance we have developed indicators of wetland bird community that do not require accurate count data.

Regional surveillance monitoring of wetland birds will be conducted at suitable wetlands among the 123 HWS priority wetlands, and others. Some priority wetlands, where birds are not considered to be a community value, will not be targeted for surveys (see Appendix C). Also, it is recognised that some priority wetlands are small, ephemeral or on private land and unlikely to be accessible to bird survey teams.

Table 5.2 *Summary of regional wetland bird monitoring proposed in the 2020 Wetland MEP.*

Method	Where monitoring is required	Monitoring frequency (when)	Monitoring responsibility	Baseline data
BirdLife Australia bird surveys Types 2 (<500 m active search) and 5 (fixed route)	~120 of the 249 significant wetlands listed in the Wetland MEP Note: Following this mid-term evaluation we recommend a reduction in target wetlands to obtain more frequent counts at fewer priority wetlands.	Quarterly surveys. Note following this mid-term review we recommend monthly counts at all monitored wetlands Monthly surveys at important wetlands (e.g. Ramsar listed wetlands)	MW catchment Asset Management team (to commission BirdLife Australia)	Birdlife Australia database at September 2018; using only selected survey types and centred within 50 m of a priority wetland polygon (see Birdlife Australia 2020, 2022b)

Table 5.3 *Wetland Bird Community Index scoring.*

Indicator	Score	Description
Basic score Sum of reporting rate of wetland species	<5	Very low condition
	5 to 10	Low condition
	10 to 15	Moderate condition
	15 to 20	High
	>20	Very high condition
Modifier 1 No. spp. Breeding	<5	No change to basic score
	5 to 10	If basic score is less than Moderate, increase score to this category
	11 to 15	If basic score is less than High, increase score to this category
	>15	If basic score is less than Very High, increase score to this category
Modifier 2 No. listed spp. Recorded	<10	No change to basic score
	10 to 15	If basic score is less than Moderate, increase score to this category
	16 to 20	If basic score is less than High, increase score to this category
	>20	If basic score is less than Very High, increase score to this category

Monthly surveys will continue at 13 Ramsar wetland ponds and other wetlands with reporting requirements (under a Council permit to build the ETP Solar Farm). The goal was to have standard bird surveys at a further *c*. 120 of the 249 regionally significant wetlands listed in the 2020 Wetland MEP, every quarter (Table 5.2). However, following a review of the data for this mid-term evaluation, we recommend focussing on fewer priority wetlands (which are representative of overall priority wetlands). In addition to the 13 wetlands with Ramsar or other reporting obligations, target

around 40 representative priority wetlands for monthly quantitative counts (thus ensuring we have more than 40 counts per five-year reporting period and can calculate a Wetland Bird Index with some confidence.

There are three wetland bird community indicators: (1) the sum of the reporting rate of all wetland species; (2) the number of wetland species recorded breeding; and (3) the number of listed species of wetland bird recorded (Table 5.3)**Table** . The two modifiers are considered separately, and the higher of the scores used. Wetland species of bird are defined in Appendix G.

We considered basing the Wetland Bird Index on a 'reference' or expected bird community structure. However, it was found that regional wetlands are so varied in their character no one expected wetland bird community could be estimated. Furthermore, once annual variability in landscape wetness and continental rainfall were taken into account, it proved impossible to set any useful 'expected' bird community for overall wetlands. Given this variability, we looked into using 'indicator species' or landscape species, or flagship species' – all different concepts. But these would have negated our desire to have an index that could not be 'played' by simply attracting one or two species (perhaps to the detriment of others). We wanted an index that pushed managers to provide habitat for the best range of native species they could, whenever they could. So, rewarding them with an increase in index score if they got more native birds, more often. This led to the preference for a reporting rate approach.

5.2 KEQ 3a To what extent are key values on the target trajectory?

Evaluation methodology

Birdlife Australia was commissioned to calculate Wetland Bird Index scores over four 5-year periods and also to critically evaluate the index (Birdlife Australia 2022b). The following results and evaluation are taken from this report.

Birdlife Australia calculated, and considered, a range of wetland bird statistics in their evaluation of wetlands by 5-year time periods:

- Wetland significance according to Melbourne Water's wetland significance rating (see Melbourne Water 2020a and 2020b);
- Site Area (ha);
- Number of surveys;
- Average Maximum Annual Abundance of Wetland Birds;
- Density of Wetland Birds;
- Average Annual Total Wetland Bird Species Richness;
- Summed Reporting Rate (Basic Score);
- Number of Breeding Wetland Bird Species (Modifier 1);
- Number of Listed Wetland Bird Species (Modifier 2); and
- Final Wetland Bird Index Category, including changes to the Basic Score associated with Modifier 1 and/or Modifier 2.

Only the Melbourne Water Wetland Bird Index results are discussed below, in Appendix H. For further details of the Birdlife Australia assessment, and testing of other metrics, please refer to Appendix H or the Birdlife Australia assessment report (Birdlife Australia 2022b).

To assess whether we are 'on track' to meet HWS targets, the Wetland Bird Index was re-calculated, for all priority wetlands for which we have at least 20 robust surveys for the 5-year period preceding the 2018 HWS (our new 2018 benchmark) and the period July 2018 to mid-2022.

Table 5.4 *Rubric for value for assessing performance against long term HWS targets at each priority wetland at the mid-term evaluation.*

Performance rating	Performance criteria / evidence
On-track to achieving long term target	Bird value score is maintained at, or above, the 2018 benchmark.
Slightly off-track to achieving long term target	Bird value score has decreased by one category relative to the 2018 benchmark.
High chance that long-term targets will not be met	Bird value score has decreased by two categories or more relative to the 2018 benchmark.

The 2022 ("current") scores are then compared with the new 2018 ("benchmark") to assess if we are on-track to meet HWS objectives. This assessment follows the rubric presented in the HWS *Wetlands Monitoring and Evaluation Plan v1.0* (Melbourne Water 2020a).

Analysis of data

Site Identification

Melbourne Water's High Value Wetlands were identified in Melbourne Water's Priority Wetland GIS spatial layer. A total of 249 High Value Wetlands were mapped across the Port Phillip and Western Port Catchment area by the Wetland MEP (Melbourne Water 2020b).

Survey Data

GIS was used to apply a 50 m buffer to the wetlands in the High Value Wetlands GIS layer. Survey data extracted from the 50 m buffer were filtered by survey type and data collected from surveys coded as 'limited' were removed. Limited surveys include, for example, surveys which do not count all species of bird, but only select groups/guilds of birds. Survey data for surveys starting or continued after 19:00 were removed from the analysis.

Survey Data Limitations

Limitations to the survey data were identified in Birdlife's 2018/19 report (BirdLife Australia 2020a). Limitations include the difficulty in determining whether the total number species present at a site is detected since the detection of cryptic species requires special techniques for survey (e.g. call playback, night-time listening and remote camera surveys). It was concluded that the methods used

in this project represent a standardised replicable approach, and are the best methods currently known to provide a comprehensive inventory of species presence.

Minimum Survey Number

Species Accumulation Curves to determine the minimum number of surveys required at wetlands to detect most species of wetland birds were presented in the 2018/2019 Annual Report (BirdLife Australia 2020a). Although up to 90% of species are generally detected in the first 20 surveys, it is estimated that between 10-20% of species are only detected between 20 and 40 surveys. Thus, in the Melbourne Water Regional Bird Monitoring (MWRBM) study area, 40 surveys are generally required for the species accumulation curves to reach an asymptote.

The results suggested that where available, data should be selected from sites which have been surveyed at least 40 times. However, to avoid eliminating useful data resulting in a much smaller dataset to work with, the data collected during a minimum of 20 surveys from sites during each time block were assumed to be representative of the site during that period and were used in the analyses for the 2018/2019 report (BirdLife Australia 2020).

Since government-imposed restrictions on movement were in place for much of this period, related to Covid-19, for the purposes of this Mid-term Review, survey data were selected if at least 20 surveys have been undertaken. However, a revision of our wetland bird monitoring approach is recommended to focus attention on fewer, representative, wetlands to aim for at least 40 robust surveys per period (see below).

Minimum Data Type

Data were used where observers had recorded all species seen and heard within the site boundaries.

Temporal Grouping of Site Data

For this Mid-term Review, the bird count data collected from 2003/2004 and held in BirdLife Australia's Birdata Portal were divided into four time periods based on the reporting of progress following the investment outlined in the Healthy Waterways Strategy (Table 5.5):

- BLOCK 4 represents the post-*2018 Healthy Waterways Strategy* – 2018/19 to 2021/22;
- BLOCK 3 represents the period of the *2013 Healthy Waterways Strategy* – 2013/14 to 2017/18;
- BLOCK 2 represents the pre-Healthy Waterways Strategy – 2008/09 to 2012/13; and
- BLOCK 1 represents the earlier period for wetlands which have sufficient data – 2003/04 to 2007/08 (coinciding with the latter stages of the Millennium Drought).

Table 5.5 *Temporal grouping of time blocks and reporting requirements.*

	Block 1	Block 2	Block 3	Block 4
1998/99 to 2002/03	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2022/23
Drought	Late Drought	Post-Drought	Recovery?	
Plans	Melbourne 2030 (October 2002)	"Melbourne at 5 Million" (December 2008)	"Plan Melbourne 2014" (May 2014)	"Plan Melbourne 2017 – 2050"
HWS Strategy			HWS 2013	HWS 2018
Second Bird Atlas starts			Regional Bird Monitoring starts	

Species Selection

For this assessment, the wetland bird species are defined following DELWP (2019) as all waterbird species, comprising species from the following families: Podicipidae (grebes); Pelicanidae (Australian Pelican); Phalacrocoridae (cormorants); Anhingidae (Australasian Darter *Anhinga novaehollandiae*); Ardeidae (herons, egrets and bitterns); Threskiornithidae (spoonbills and ibis); Rallidae (crakes and rails); Anatidae (ducks, geese and Black Swan *Cygnus atratus*); Gruidae (Brolga *Antigone rubicunda*); several families of shorebirds, including Recurvirostridae (Banded Stilt *Cladorhynchus leucocephalus* and Red-necked Avocet *Recurvirostra novaehollandiae*), Charadriidae (plovers), Scolopacidae (sandpipers and snipes) and Rostratulidae (Australian Painted Snipe *Rostratula australis*); and Laridae (gulls and terns).

In addition to waterbird species, the following species are also included as wetland species because of their use of wetland habitats:

- Azure Kingfisher (*Ceyx azureus*);
- Orange-bellied Parrot (*Neophema chrysogaster*);
- Little Grassbird (*Poodytes gramineus*);
- Australian Reed-warbler (*Acrocephalus australis*);
- Golden-headed Cisticola (*Cisticola exilis*);
- White-fronted Chat (*Epthianura albifrons*);
- Swamp Harrier (*Circus approximans*);
- White-bellied Sea-Eagle (*Haliaeetus leucogaster*); and
- Eastern Osprey (*Pandion cristatus*).

A total of 125 wetland species were defined for this assessment (see Appendix G).

5.3 Results and discussion

Table 5.6 presents the HWS assessment of wetland bird value (i.e. 2017) and the target assigned for 123 HWS priority wetlands. These scores are compared to values determined through our data-derived Wetland Bird Index. First, our re-assessment of condition at the adoption of the 2018 HWS. This is our proposed new 'benchmark' condition. Second, our assessment at the 'current' state of wetland birds (i.e. 2018/19 to 2021/22 data).

Of 44 wetlands for which we can calculate a new benchmark index (i.e. 2018) only five are scored below the HWS assessment:

- Austen Road Pond 1 (Summer Pond 1), WTP
- Q4 Wetland, WTP
- RAAF Lake, Point Cook
- The Doughnut, ETP
- Chelsea Heights Wetland, Wannarkladdin Wetlands

We consider the Wetland Bird Index conclusion to be more accurate than the HWS assessment in these cases. It is notable that four of the five sites – which we know are not exceptional bird habitat – are scored high in the HWS simply because they occur in a wider Ramsar or KBA site. The fifth is located in a SoBS but is seriously degraded over many years prior to the HWS - to the point that serious consideration was given to filling it in to address odour and mosquito issues for neighbours. The index derived scoring is more accurate at the wetland scale than the HWS scoring, which is weighted by more general factors, such as protected status of an area.

Disappointingly, by mid-2022 we can only calculate 'current' (2022) status for 25 of the HWS priority wetlands. While we will get more wetlands to the required 20 surveys by 30 June 2023, it is concerning that we can only assess 25 of 108 wetlands with valid Bird targets.[4] Despite community interest and strong support from Birdlife Australia it would appear that land tenure and access make it difficult to have some priority wetlands surveyed regularly for birds.

Of the 25 priority wetlands for which we can calculate a 2022 index, 18 are 'on track' according to the Wetland MEP rubric.

Five wetlands are 'slightly off-track' (i.e. one category below the 2018 benchmark): Western Lagoon at the WTP, Tootgarook Swamp, Edithvale North, Serpentine Lagoon at the ETP, and Banyan waterhole at the ETP. The Serpentine Lagoon is not managed as bird habitat and the decline in bird value is certainly a valid statement of what has occurred there. The other four wetlands are all recognised and managed for their bird values and the apparent decline is worrying and we will need to investigate further. All are particularly valued because of migratory shorebird use, and the occasional appearance of vagrant migratory or threatened species is the reason they score highly in the 2018 assessment. The 2022 assessment uses data between mid-2018 and early 2022, or not

[4] Of the 123 priority wetlands listed in the 2018 HWS: 3 have since been effectively lost to urbanisation; and 12 are not of importance to wetland birds (e.g. constructed Dwarf Galaxias or Growling Grass Frog habitat ponds). Thus, only 108 HWS priority wetlands are suitable for wetland bird monitoring and assessment. As discussed further, we now intend to target around 53 representative wetlands from this wetland set for more intense bird monitoring.

quite four years. It is possible that survey results from another summer season will record increased migratory/threatened species – and so increase the index.

Two wetlands are 'off-track' (i.e. two or more categories below the 2018 benchmark) – i.e. 'High chance that long-term targets will not be met': Paradise Road Ponds at the WTP, and Truganina Swamp. Paradise Road Ponds and Truganina are cause for concern as they are large and provide important bird habitat. Both are particularly important for migratory shorebirds and so would suffer the same problem as Western Lagoon, Banyan Waterhole and Edithvale North, discussed above. By having only four summer counts, rather than five, we have had less opportunity to detect occasional vagrant migratory species (many of which are threatened), and which positively affect the Wetland Bird Index.

But, given their importance, further investigation is required into this decline in index. Recent work by our research-practice partnership has revealed high levels of contaminants in several WTP habitat ponds and also Edithvale Wetlands and Banyan Waterhole (Long et al. 2022; Chinathamby et al. 2022; Long et al (in prep a&b.) and we need to understand far better this risk to waterbirds in our Ramsar sites. Banyan Waterhole is downstream of a drain that was found to be polluted with lead shot from an adjacent shooting club (Long et al. 2021).

Recommendations for consideration in Science Inquiry

- Investigate the two wetlands where the bird index score has dropped (i.e. Truganina and Paradise Road Ponds at the WTP).
- Communicate the new benchmark results and explore options for updating the long term targets in light of the new benchmark

5.4 KEQ 3b What other spatial and temporal trends and patterns for key values are of significance for implementation?

Evaluation methodology

In evaluating trajectories of wetland birds we include all wetlands listed in the 2020 Wetland MEP (and not only those in the 2018 HWS with status and targets described). Birdlife Australia was commissioned to analyse the bird data and describe, where possible, the trajectories of wetland bird communities at our wetlands. The following is taken from their report (Birdlife Australia 2022b).

This section investigates the basis of the trajectory of the indices obtained at each wetland which has adequate survey data (i.e., at least 20 surveys undertaken) during three or more time blocks. The investigation includes an assessment of the Summed Reporting Rates/Basic Scores and Number of Breeding Species and Number of Listed Species (Modifiers) used to develop the Wetland Bird Index.

The investigation also attempts to determine the causes driving the trajectories observed, especially where declines are detected in the indices, but also where increases in indices are obtained and where they remain stable. The investigation provides bar graphs for each wetland with the Summed Reporting Rate/Basic Score over the time blocks for which more than 20 surveys have been undertaken. For each wetland, separate bar graphs are provided giving the numbers of Breeding and Listed Species for each time block.

Table 5.7 provides an indication of the trajectories of the wetland bird indices at 19 wetlands across at least three time-blocks and an indication of whether the bird communities are stable, improving or declining at each wetland.

In summary, the Wetland Bird Indices indicate that the wetland bird communities are stable and tracking well at Ramsar Sites (Edithvale-Seaford Wetlands, Western Port Bay and the Western Treatment Plant), KBA sites (Eastern Treatment Plant, ETP South - Banyan Waterhole and Braeside Park Wetlands), a 'Migratory Shorebird Site' (Swan Lake), and one of the two 'Regional Wetlands' (Paisley Challis wetland/Jawbone Reserve).

The other 'Regional Wetland', Devilbend has shown declines in Indices since Block 1 which may relate to the refuge capacity of the site during the Millennium Drought and birds leaving once the drought broke. The Wetland Bird Indices also indicate that the wetland bird communities at three of the four Dandenong Valley s/w Wetlands' are stable and tracking well (Heatherton Road North and South Wetlands and Frog Hollow Wetland).

The indices for the fourth s/w treatment wetland', Kilberry Boulevard/ Rivergum Creek Wetlands, indicate a decline in the wetland bird community which is thought to be related to the age of constructed stormwater treatment wetlands and vegetation succession. Immediately after construction, there is little emergent or surrounding aquatic vegetation. However, as vegetation expands and increases in density over time, a reduction in bird diversity and abundance occurs (W.K. Steele, pers obs.). The other three constructed wetlands could follow a similar course.

The two 'Social value Lakes' are experiencing declines in most indices which could be related to human disturbance and the predominance of common, abundant and tolerant species at Karkarook Park. The declines at Westgate Park Wetlands are less clear and we are currently investigating this with the Friends of Westgate Park.

Table 5.6 *Wetland Bird scores for HWS priority wetlands, comparing HWS assessment and target with our Wetland Bird Index scoring.*

2018 HWS wetland grouping	Wetland name	Catchment	HWS score	HWS target	2013/14 to 2017/18 (new benchmark)	2018/19 to 2021/22 (Current)	Tracking
Banyan Waterhole, ETP	Banyan Waterhole	Dandenong	5 Very low	5 Very low	1 Very high	2 High	Slightly off-track
Barnbam Swamp	Barnbam Swamp	Dandenong	5 Very low	5 Very low			Not assessable
Braeside Park Wetlands	Braeside Park wetlands	Dandenong	4 Low	4 Low	3 Moderate	2 High	On track
Dandenong Catchment s/w treatment wetlands	Eumemmerring Creek wetland (Frog Hollow Wetland)	Dandenong	5 Very low	5 Very low	3 Moderate	3 Moderate	On track
Dandenong Catchment s/w treatment wetlands	Golf Links Road Wetland	Dandenong	5 Very low	5 Very low	3 Moderate		Not assessable
Dandenong Catchment s/w treatment wetlands	Hallam Valley RB Wetland	Dandenong	5 Very low	5 Very low	3 Moderate		Not assessable
Dandenong Catchment s/w treatment wetlands	Hampton Park RB East Wetland (Kilberry Boulevard wetlands?)	Dandenong	5 Very low	5 Very low			Not assessable
Dandenong Catchment s/w treatment wetlands	Heatherton Road North Wetland	Dandenong	5 Very low	5 Very low	4 Low	4 Low	On track
Dandenong Catchment s/w treatment wetlands	Heatherton Road South Wetland	Dandenong	5 Very low	5 Very low	4 Low	4 Low	On track
Dandenong Catchment s/w treatment wetlands	Mordialloc Creek Wetland (Waterways Estate)	Dandenong	5 Very low	5 Very low			Not assessable
Dandenong Catchment s/w treatment wetlands	Rivergum Creek Wetlands	Dandenong	5 Very low	5 Very low	3 Moderate	3 Moderate	On track
Dandenong Catchment s/w treatment wetlands	Troups Creek Wetland	Dandenong	5 Very low	5 Very low	3 Moderate		Not assessable

2018 HWS wetland grouping	Wetland name	Catchment	HWS score	HWS target	2013/14 to 2017/18 (new benchmark)	2018/19 to 2021/22 (Current)	Tracking
Dandenong Catchment s/w treatment wetlands	Waterford Valley Wetland (Karoo Rd Wetland)	Dandenong	5 Very low	5 Very low	4 Low		Not assessable
Dwarf Galaxias Conservation Wetland	Dwarf Galaxias Conservation Pond	Dandenong	5 Very low	5 Very low	5 Very low	5 Very low	On track
Dwarf Galaxias habitat ponds, Dandenong Creek (place holder)	Dwarf Galaxias wetlands along Dandenong Creek	Dandenong	4 Low	4 Low			Not required
Eastern Treatment Plant wetlands	Eastern Treatment Plant wetlands	Dandenong	3 Moderate	3 Moderate	1 Very high	1 Very high	On track
Eastern Treatment Plant wetlands	Serpentine Lagoon, ETP	Dandenong	3 Moderate	3 Moderate	2 High	3 Moderate	Slightly off-track
Eastern Treatment Plant wetlands	The Doughnut, ETP	Dandenong	3 Moderate	3 Moderate	4 Low		Not assessable
Edithvale Wetlands	Edithvale North Wetland	Dandenong	2 High	2 High	1 Very high	2 High	Slightly off-track
Edithvale Wetlands	Edithvale South Wetland	Dandenong	2 High	2 High	1 Very high	1 Very high	On track
Hallam Valley floodplain wetland	Hallam Valley floodplain	Dandenong	4 Low	4 Low	3 Moderate		Not required
Hallam Valley floodplain wetland	Hallam Valley floodplain wetland (O'Gradys Road)	Dandenong	4 Low	4 Low			Not required
Seaford Wetland	Seaford Wetland	Dandenong	2 High	2 High	1 Very high	1 Very high	On track
Tamarisk Waterway Reserve wetland	Tamarisk Waterway Reserve wetland	Dandenong	5 Very low	5 Very low			Not assessable
Tirhatuan Wetlands	Tirhatuan Wetlands	Dandenong	5 Very low	5 Very low	3 Moderate	3 Moderate	On track
Wannarkladdin Wetlands	Chelsea Heights Wetland	Dandenong	4 Low	4 Low	5 Very low		Not assessable
Wannarkladdin Wetlands	Wannarkladdin wetlands	Dandenong	4 Low	4 Low	4 Low	2 High	On track

2018 HWS wetland grouping	Wetland name	Catchment	HWS score	HWS target	2013/14 to 2017/18 (new benchmark)	2018/19 to 2021/22 (Current)	Tracking
Winton Wetlands	Winton Wetlands	Dandenong	5 Very low	5 Very low	5 Very low	5 Very low	On track
Gisborne marshlands	Gisborne Racecourse Swamp	Maribyrnong	5 Very low	3 Moderate			Not assessable
Greenvale Reservoir	Greenvale Reservoir	Maribyrnong	5 Very low	5 Very low	3 Moderate		Not assessable
Jacana Wetlands	Jacana Wetlands	Maribyrnong	5 Very low	3 Moderate	4 Low		Not assessable
Pipemakers Park Wetland	Pipemakers Park Wetland	Maribyrnong	5 Very low	5 Very low			Not assessable
Queens Park wetlands	Queen's Park wetland	Maribyrnong	5 Very low	5 Very low			Not assessable
Altona Treatment Plant	Altona Treatment Plant	Werribee	5 Very low	5 Very low			Not assessable
Balls Wetland Complex	Balls Swamp/ Wetland complex	Werribee	4 Low	4 Low			Not assessable
Baths Swamp	Baths Swamp	Werribee	4 Low	4 Low			Not assessable
Black Forest Rd Wetland	Black Forest Rd Wetland	Werribee	5 Very low	5 Very low			Not assessable
Black Swamp	Black Swamp	Werribee	5 Very low	5 Very low			Not assessable
Cheetham Wetlands	Cheetham Saltworks	Werribee	2 High	2 High	1 Very high		Not assessable
Cherry Lake	Cherry Lake	Werribee	5 Very low	5 Very low		4 Low	Not assessable
Cobbledicks Ford cluster	Cobbledicks Ford Wetland	Werribee	5 Very low	4 Low			Not assessable
Cobbledicks Ford cluster	Windmill Wetland	Werribee	5 Very low	4 Low			Not assessable
Cunninghams Swamp (historic extent)	Cunninghams Swamp	Werribee	5 Very low	5 Very low			Not assessable
Deanside Marsh	Deans Marsh	Werribee	4 Low	4 Low			Not assessable
Greens Road East No. 2	Greens Road Swamp East No. 2	Werribee	5 Very low	5 Very low			Not assessable

2018 HWS wetland grouping	Wetland name	Catchment	HWS score	HWS target	2013/14 to 2017/18 (new benchmark)	2018/19 to 2021/22 (Current)	Tracking
Holden Road Wetland	Holden Road Wetland	Werribee	5 Very low	5 Very low			Not assessable
Jawbone Reserve	Paisley-Challis Wetland	Werribee	5 Very low	5 Very low	1 Very high	1 Very high	On track
Jenz Swamp	Jensz Swamp	Werribee	5 Very low	5 Very low			Not assessable
Kirks Bridge Rd West Wetland	Kirks Bridge Rd West Wetland	Werribee	5 Very low	5 Very low			Not assessable
Kororoit Creek No. 3	Kororoit Creek No. 3	Werribee	5 Very low	5 Very low			Not assessable
Laverton RAAF Swamp	Laverton RAAF Swamp	Werribee	5 Very low	5 Very low			Not assessable
Live Bomb Wetland	Live Bomb Wetland	Werribee	5 Very low	5 Very low			Not assessable
Paynes Road North Swamp	Paynes Road North Swamp (North Swamp)	Werribee	4 Low	4 Low			Not assessable
Point Cook Wetlands - RAAF Lake	RAAF Lake	Werribee	2 High	2 High	5 Very low		Not assessable
Point Cook Wetlands - Spectacle Lake	Spectacle Lake	Werribee	1 Very high	1 Very high			Not assessable
Rabbiters Lake and Swamp	Rabbiters Lake	Werribee	4 Low	4 Low			Not assessable
Rabbiters Lake and Swamp	Rabbiters Swamp	Werribee	4 Low	4 Low			Not assessable
Richmond's Grass Swamp	Richmond's Grass Swamp	Werribee	5 Very low	5 Very low			Not assessable
Rockbank No. 1 wetland	Rockbank No. 1	Werribee	5 Very low	5 Very low			Not assessable
Rockbank railway Swamp	Rockbank Railway Swamp	Werribee	5 Very low	5 Very low			Not assessable
Rolling Thunder Wetland	Binghams Swamp	Werribee	5 Very low	5 Very low			Not assessable
Target Range Swamp	Target Range Swamp	Werribee	5 Very low	5 Very low			Not assessable

2018 HWS wetland grouping	Wetland name	Catchment	HWS score	HWS target	2013/14 to 2017/18 (new benchmark)	2018/19 to 2021/22 (Current)	Tracking
The Spit NCR	The Spit Lagoon	Werribee	2 High	2 High			Not assessable
Troups Road Swamp	Troups Road Swamp	Werribee	5 Very low	5 Very low	Wetland effectively lost		
Truganina Swamp	Truganina Swamp	Werribee	4 Low	4 Low	1 Very high	3 Moderate	Off-track
West Quandong Swamp	West Quandong Swamp	Werribee	4 Low	4 Low			Not assessable
WTP - Paul & Belfrages Wetland	Paul and Belfrages Wetland	Werribee	1 Very high	1 Very high			Not assessable
WTP – ponds	Austen Road Pond 1 (Summer Pond 1)	Werribee	2 High	2 High	3 Moderate		Not assessable
WTP – ponds	Austen Road Pond 2 (Summer Pond 2)	Werribee	2 High	2 High	1 Very high		Not assessable
WTP – ponds	Cherry Tree Creek pool	Werribee	2 High	2 High			Not assessable
WTP – ponds	Lake Borrie	Werribee	2 High	2 High			Not assessable
WTP – ponds	Lake Borrie Ponds 28 & 29	Werribee	2 High	2 High			Not assessable
WTP – ponds	Paradise Road Ponds	Werribee	2 High	2 High	1 Very high	3 Moderate	Off-track
WTP – ponds	Q4 Wetland	Werribee	2 High	2 High	3 Moderate		Not assessable
WTP – ponds	The Triangle, WTP	Werribee	2 High	2 High			Not assessable
WTP – ponds	T-Section Lagoon	Werribee	2 High	2 High	1 Very high	1 Very high	On track
WTP – ponds	Walshs Lagoon Ponds 1 & 6	Werribee	2 High	2 High	1 Very high		Not assessable
WTP – ponds	Western Lagoon	Werribee	2 High	2 High	1 Very high	2 High	Slightly off-track
WTP – ponds	WTP habitat ponds	Werribee	2 High	2 High			Not assessable

2018 HWS wetland grouping	Wetland name	Catchment	HWS score	HWS target	2013/14 to 2017/18 (new benchmark)	2018/19 to 2021/22 (Current)	Tracking
WTP – ponds	WTP operational ponds - 115E Lagoon	Werribee	2 High	2 High			Not assessable
WTP – ponds	WTP operational ponds - 25W Lagoon	Werribee	2 High	2 High			Not assessable
WTP – ponds	WTP operational ponds - 55E Lagoon	Werribee	2 High	2 High			Not assessable
WTP – ponds	WTP operational ponds - 85W Lagoons	Werribee	2 High	2 High			Not assessable
WTP – ponds	WTP operational ponds - Walshes	Werribee	2 High	2 High			Not assessable
WTP - Ryans Swamp	Ryans Swamp	Werribee	1 Very high	1 Very high			Not assessable
Wyndham Vale Swamp	Wyndham Vale Swamp	Werribee	5 Very low	5 Very low	Wetland effectively lost		
Cardinia Creek RB wetlands	Cardinia Creek RB wetlands	Westernport	5 Very low	5 Very low			Not assessable
Coolart Wetlands	Coolart Lagoon	Westernport	5 Very low	5 Very low	5 Very low	3 Moderate	On track
Lang Lang floodpain wetlands	Lang Lang River old course	Westernport	5 Very low	3 Moderate			Not assessable
The Briars wetlands	The Briars Park wetlands	Westernport	5 Very low	5 Very low			Not assessable
Tootgarook Swamp	Tootgarook Swamp (Boneo Swamp)	Westernport	5 Very low	5 Very low	3 Moderate	4 Low	Slightly off-track
Tootgarook Swamp	Truemans Road Reserve	Westernport	5 Very low	5 Very low			Not assessable
Western Port coastal wetlands	Westernport	Westernport	2 High	2 High	1 Very high	1 Very high	On track
Yallock Creek floodplain wetlands	Yallock Creek billabongs and palaeochannel	Westernport	5 Very low	3 Moderate			Not assessable
Andersons Creek East RB	Andersons Creek East RB	Yarra	5 Very low	5 Very low	N/a – since identified as not a wetland		

2018 HWS wetland grouping	Wetland name	Catchment	HWS score	HWS target	2013/14 to 2017/18 (new benchmark)	2018/19 to 2021/22 (Current)	Tracking
Annulus Billabong	Annulus Billabong	Yarra	5 Very low	3 Moderate			Not assessable
Banyule Flats Billabong	Banyule Flats Billabong	Yarra	4 Low	4 Low	4 Low		Not assessable
Bolin Bolin Billabong	Bolin Bolin Billabong	Yarra	4 Low	3 Moderate			Not assessable
Burke Road Bilabong	Burke Road Billabong	Yarra	5 Very low	3 Moderate			Not assessable
Cardigan Road RB	Cardigan Road RB	Yarra	5 Very low	5 Very low	N/a – since identified as not a wetland		
Cockatoo Creek floodplain	Cockatoo Creek floodplain wetland	Yarra	2 High	2 High			Not assessable
Domain Chandon billabongs	Domain Chandon Billabongs	Yarra	4 Low	3 Moderate			Not assessable
Donnybrook Road Lake	Donnybrook Road Lake	Yarra	5 Very low	5 Very low	Wetland effectively lost		
Growling Grass Frog reserve ponds (placeholder)	Growling Grass Frog reserve wetlands	Yarra	5 Very low	5 Very low	3 Moderate	5 Very low	Not required
Hays Paddock Wetland	Hays Paddock Wetland	Yarra	5 Very low	3 Moderate			Not assessable
Hearnes Swamp	Herne Swamp (remnant)	Yarra	5 Very low	5 Very low			Not assessable
Kalkallo Common	Kalkallo Common	Yarra	5 Very low	5 Very low			Not assessable
Kalkallo Common	Kalkallo Creek Wetland	Yarra	5 Very low	5 Very low			Not assessable
Lillydale Lake	Lillydale Lake	Yarra	5 Very low	5 Very low	2 High	2 High	On track
Ringwood Lake	Ringwood Lake	Yarra	5 Very low	5 Very low	5 Very low	5 Very low	On track
Spadonis Reserve	Spadonis Billabong	Yarra	4 Low	3 Moderate			Not assessable
Westgate Park wetlands	Westgate Park lakes	Yarra	4 Low	4 Low	4 Low		Not assessable
Willsmere Billabong	Willsmere Billabong (Kew Billabong)	Yarra	5 Very low	3 Moderate			Not assessable

2018 HWS wetland grouping	Wetland name	Catchment	HWS score	HWS target	2013/14 to 2017/18 (new benchmark)	2018/19 to 2021/22 (Current)	Tracking
Yarra Bridge Steamside Reserve	Yarra Bridge Steamside Reserve	Yarra	5 Very low	4 Low			Not assessable
Yarra Catchment s/w treatment wetlands	Brushy Creek sed ponds	Yarra	N/A	N/A			Not required
Yarra Catchment s/w treatment wetlands	Hawkstowe Wetlands	Yarra	N/A	N/A			Not required
Yarra Catchment s/w treatment wetlands	Laurimar Park Estate Wetland	Yarra	N/A	N/A			Not required
Yarra Catchment s/w treatment wetlands	Mill Park Lakes	Yarra	N/A	N/A	3 Moderate		Not required
Yarra Catchment s/w treatment wetlands	Simons Creek Wetland	Yarra	N/A	N/A			Not required
Yarra catchment s/w treatment wetlands (WRONG)	Dunnetts Road Swamp	Yarra	5 Very low	5 Very low			Not assessable
Yarra catchment s/w treatment wetlands (WRONG)	Galada Tamboore wetlands	Yarra	5 Very low	5 Very low			Not assessable
Yering Backswamp	Yering Backswamp	Yarra	4 Low	4 Low			Not assessable

Table 5.7 *Summary of Index Categories for 19 of Melbourne Water's Priority Wetlands with at least 20 surveys for at least three time blocks. The wetlands are listed according to Melbourne Water's wetland significance rating (see Melbourne Water 2020a and 2020b).*

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22	Conclusion of Trajectory Investigation
Ramsar					
Edithvale North Wetlands	Very High	High	Very High	High	The wetland bird community at Edithvale North Wetlands is tracking well.
Edithvale South Wetlands	Very High	Very High	Very High	Very High	The wetland bird community at Edithvale South Wetlands is tracking well.
Seaford Wetlands	Very High	Very High	Very High	Very High	The wetland bird community at Seaford Wetlands is tracking well.
Western Port	Very High	Very High	Very High	Very High	The bird community at Western Port Bay is tracking well.
WTP - T Section Lagoon		Very High	Very High	Very High	The bird community at the WTP – T-Section Lagoon is tracking well.
WTP - Western Lagoon		Very High	Very High	High	The wetland bird community at the Western Lagoon is tracking well.
WTP - Habitat Ponds		Very High	Very High	Moderate	Summed Reporting Rates are stable. However, a decline in the Wetland Index from the 'Very High' category obtained during Blocks 2 and 3 to the 'Moderate' calculated during Block 4 is associated with a decline in Numbers of Listed Species recorded during these three blocks (i.e. 27 and 23 to 14). A decline in the Average Annual Species Richness was also recorded during these blocks (i.e. 44.0 and 42.8 to 37.5), indicating a decline in species richness over the three blocks. The decline in species

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22	Conclusion of Trajectory Investigation
					richness and Numbers of Listed Species could simply reflect the much lower number of surveys undertaken during Block 4 due to Covid restrictions. But there has been some concern expressed about a decline in the quality of shorebird habitat in a number of ponds associated with vegetation encroachment and consistently high water levels in most ponds which do not provide expanses of mudflat for shorebirds. A decline in quality of shorebird habitat could result in a decline in numbers of shorebirds in turn manifested in overall species richness and the Numbers of Listed Species. Further survey data are required to determine if there is a decrease in either the statistic or index or the decrease is a result of the lower number of surveys.
Key Biodiversity Area					
Eastern Treatment Plant	Very High	Very High	Very High	Very High	The wetland bird community at the Eastern Treatment Plant is tracking very well.
ETP South - Banyan Waterhole	High	Very High	Very High	High	The wetland bird community at the ETP South – Banyan Waterhole is relatively stable and appears to be tracking well. The increase in indices from Block 1 to Block 2 could relate to active management and hydrological improvements undertaken by Melbourne Water and/or a bounce back in waterbird populations following breaking of the Millennium Drought.
Braeside Park	Moderate	High	Moderate	High	For Blocks 2, 3 and 4, the Summed Reporting Rate has been stable and the

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22	Conclusion of Trajectory Investigation
					Numbers of Listed and Breeding Species have been tracking well. The increase in indices from Block 1 to Block 2 possibly resulted from a bounce back in waterbird populations following breaking of the Millennium Drought.
Migratory Shorebird Site					
Swan Lake	Very Poor	High	High		All indices and statistics were much lower during Block 1 compared to those calculated for Blocks 2 and 3, which could be a result of the Millennium Drought impacting waterbird numbers, or a reflection of the low number of surveys undertaken during Block 1. The number of surveys were insufficient to evaluate the indices and statistics for Block 4, but the results for Blocks 2 and 3 suggest that the wetland bird communities at Swan Lake were tracking well during those two blocks.
Regional significance					
Paisley Challis/Jawbone Reserve		Very High	Very High	Very High	For Blocks 2 to 4, a consistency in the index category has been obtained from the Summed Reporting Rate and Numbers of Listed Species. However, all statistics and indices have been much lower during Block 4 compared to Block 3, which may reflect the far smaller number of surveys (i.e. 30 compared to 174) undertaken during Block 4. An

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22	Conclusion of Trajectory Investigation
					improvement in these statistics and indices is expected with more data.
Devilbend Reservoir	High	High	Moderate		Most wetland bird indices (except for Number of Listed Species) and statistics for Blocks 2 and 3 were much lower than those for Block 1. Devilbend Reservoir possibly provided a refuge during the Millennium Drought for waterbirds, which then departed once the Drought broke.
Dandenong Valley s/w Wetlands					
Heatherton Rd North Wetland	Moderate	Moderate	Poor	Poor	The indices and statistics suggest that after showing an initial increase from Block 1 to Block 2, the wetland bird community has been stable since Block 2. In the future, there could be a decline associated with the age of the constructed wetland and increase in cover and density of aquatic vegetation (see below for Kilberry Boulevard/Rivergum Creek Wetlands).
Heatherton Rd South Wetland		Moderate	Poor	Poor	The indices and statistics suggest that the wetland bird community has been stable since Block 2. In the future, there could be a decline associated with the age of the constructed wetland and increase in cover and density of aquatic vegetation (see below for Kilberry Boulevard/Rivergum Creek Wetlands).

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22	Conclusion of Trajectory Investigation
Frog Hollow Wetland		Moderate	Moderate	Moderate	The indices and statistics suggest that the wetland bird community has been stable since Block 2. In the future, there could be a decline associated with the age of the constructed wetland and increase in cover and density of aquatic vegetation (see below for Kilberry Boulevard/Rivergum Creek Wetlands).
Kilberry Boulevard/Rivergum Creek Wetlands		High	Moderate	Moderate	Most indices and statistics have declined by more than 10% during at least one block since Block 2. The decline in indices and statistics is thought to be associated with the age of constructed stormwater treatment wetlands. Following construction, initially, there is little emergent or surrounding aquatic vegetation. However, as vegetation expands and increases in density over time, a reduction in bird diversity and abundance occurs.
Social value wetlands					
Karkarook Park		Moderate	High	Moderate	Some indices and statistics displayed an increase from Blocks 2 to 3 (e.g. Average Maximum Annual Abundance, Density, Numbers of Breeding Species and Numbers of Listed Species), while others (Summed Reporting Rate and Average Annual Waterbird Richness) declined from Blocks 2 to 3. However, all indices and statistics have experienced substantial declines from Block 3 to Block 4. This reduction may relate to human disturbance and the dominance of common and abundant bird species.

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22	Conclusion of Trajectory Investigation
Westgate Park Lakes	High	Moderate	Poor		Summed Reporting Rates are stable. However, except for this Index and the Average Annual Waterbird Richness, all other indices and statistics have shown substantial decreases from Block 1 (i.e. Millennium Drought) to Block 2 and Block 2 to Block 3. The reasons for these declines are unclear and are currently being investigated with the Friends of Westgate Park.

5.5 Factors affecting Wetland Bird Index scores

The factors generally affecting the Wetland Bird Indices were addressed in the Melbourne Water Regional Bird Monitoring Annual Report (Birdlife Australia 2020a).

Climatic variability during the four time blocks would have undoubtedly affected the bird abundances at individual wetlands and the wetland bird indices calculated through its influence on water supply to wetlands. This has been addressed in DEPI (2014b and 2014c), Clarke et al. (2015), Melbourne Water (2017), DELWP (2015, 2018b and 2019b) and BirdLife Australia (2020c, 2021a and 2021b). Block 1 (2003/2004 to 2007/2008) occurred within the period of the Millennium Drought. Block 2 (2008/2009 to 2012/2013) covered the period coinciding with pre-breaking of the Millennium Drought in 2010 and early wetter times. Block 3 (2013/2014 to 2017/2018) covered periods of both wet and dry and the commencement of Block 4 (2018/2019) covered a period of record low rainfalls followed by improvement during 2020 and 2021.

The variation in rainfall in Eastern Australia is shown graphically in Figure 5.2, which shows the Annual Rainfall Anomaly for the Murray-Darling Basin from 1900 to 2021 based on the 1961-1990 (30-year) average of 492.6 mm. Chronologically, Figure 5.2 shows:

- the deficit in annual rainfall (i.e. below the 30-year average) from 2001 to 2009 during the Millennium Drought, sometimes by as much as 200 mm or more;
- breaking of the Millennium Drought during 2010 and higher rainfalls in 2011 and 2012;
- three years of below-average rainfall from 2013 to 2015;
- a wet year in 2016 with rainfall >100 mm above average;
- a return to very dry conditions from 2017 to 2019, with 2018 and 2019 experiencing rainfall deficits of 200 mm or more; and
- improvement during 2020 and 2021 with 2021 receiving more than 100 mm above the 30-year average.

The first six months of 2022 show that the Murray-Darling Basin was receiving rainfall close to average (Figure 5.3).

The Annual Mean Temperature Anomaly for the Murray-Darling Basin from 1910 to 2021 based on the 1961-1990 (30-year) average of 17.7°C is shown in Figure 5.4. The temperature has been above the 30-year average since 1994, which would result in increased evaporation rates. The first six months of 2022 show that the Murray-Darling Basin experienced variable temperatures with smaller decreases during February and June (i.e. less than 0.5°C) and larger increases (i.e. 0.8 to 1.8°C) during January, March, April and May (Figure 5.5).

The assessment of Melbourne Water (2017), DELWP (2018b and 2019b) and BirdLife Australia (2020c, 2021a and 2021b) found that different wetlands in the Port Phillip and Western Port Region responded differently to drought (also see Kingsford & Norman 2002; Wen et al. 2016). Some coastal wetlands provide drought refuge. During the first decade of this century, the Millennium Drought affected much of southern Australia, and this ultimately influenced the number of waterbirds using the WTP. Over this period, numbers of waterfowl at the WTP rose to the highest numbers ever recorded during the early or middle years of the decade, and then declined gradually. More sudden and large declines were associated with widespread rains and flooding in inland Australia in 2009/10 and in 2015/16, which attracted birds from coastal areas. A major recovery in numbers of waterbirds at the WTP followed both declines which was attributed to birds returning with new cohorts of young.

Therefore, the WTP provided important drought refuge, especially for species whose main breeding habitats are ephemeral swamps of inland Australia (Kingsford & Norman 2002). As a wastewater treatment plant, it provides an extensive supply of permanent water and consequently attracts waterbirds even during severe drought. Numbers of most waterfowl guilds increased during 2018 and 2019 associated with low rainfall for several years across Eastern Australia (Birdlife Australia 2022b). Drought conditions in inland Australia also provided a reason for the increase in numbers of shorebirds at the WTP over 2017/18 and 2018/19 (DELWP 2018b and 2019b).

The general increase in bird numbers at the WTP during drought contrasted with the severe declines in waterbird numbers observed during the Millennium Drought at Edithvale-Seaford Wetlands Ramsar Site between 2000 and 2009, and the three-year decline between 2016/17 to 2018/19. The shallow wetlands of Edithvale-Seaford are more prone to the effects of drought than the WTP, because of the latter site's extensive supply of permanent water. This was clearly exhibited during the Millennium Drought, when Edithvale and Seaford became very shallow, stagnant and had poor water quality over the last years of the Drought, while the WTP ponds were still full and supporting record numbers of waterbirds.[5]

It is likely that most of the wetlands of the Port Phillip and Western Port Region that are mostly dependent on rainfall to fill were affected by the Millennium Drought and more recent periods of low rainfall in a similar way to the effects on the Edithvale-Seaford Ramsar Site. The indices suggest that the ETP, not surprisingly, may operate in a similar manner to the WTP by attracting large numbers of waterbirds during dry times, which then depart when extensive flooding occurs in Eastern Australia.

A factor affecting migratory shorebirds which will undoubtedly affect the Wetland Bird Indices is that, throughout the world, many populations of shorebirds are declining (Wilson 2000; IWSG 2003; Olsen et al. 2003; CHSM 2004; van de Kam et al. 2004; Murray et al. 2013, 2015; Clemens et al. 2016; BirdLife Australia 2017b). In 2003, trend estimates were available for 41 per cent of the 499 populations of shorebirds around the world. Of these, 44 per cent appeared to be declining, 13 per cent were increasing, 39 per cent were stable and 4 per cent had become extinct (Delany 2003; IWSG 2003).

The population declines that were detected coincide with accelerating loss and degradation of shorebird habitat (Murray et al. 2013, 2015). In the East Asian–Australasian Flyway (EAAF), a disproportionately high number of shorebird species have been classified as threatened, and many are under increasing threat from habitat destruction (IWSG 2003; Murray et al. 2013, 2015). The Red List Index, which uses information from the IUCN Red List (IUCN 2019) to track trends in the projected overall extinction risk of sets of species, is among the indicators adopted by the world's governments to assess performance under the Convention on Biological Diversity and the United Nations Millennium Development Goals.

Of the 49 Australian species which had deteriorated in status in the last 20 years, over half were migratory shorebirds or seabirds (Szabo et al. 2012). Population-trend analysis of the BirdLife Australia Shorebird 2020 database shows strong evidence of declines in the Australian populations

[5] The known vulnerability of Edithvale-Seaford Wetlands to climate change through drought and sea level rise has triggered ongoing, detailed, studies of the hydrology of this wetland and how water supply might be supplemented without compromising water quality and the Ramsar values of the site (Hydrotechnology 1994; GHD 2006; SKM 2011; Melbourne Water 2012; Jacobs 2015, in prep.; Ecology Australia 2016; Chinathamby et al. 2022; Long et al. 2023).

of 12 species of migratory shorebirds, and evidence of declines evident in another eight species of shorebirds (BirdLife Australia 2016c).

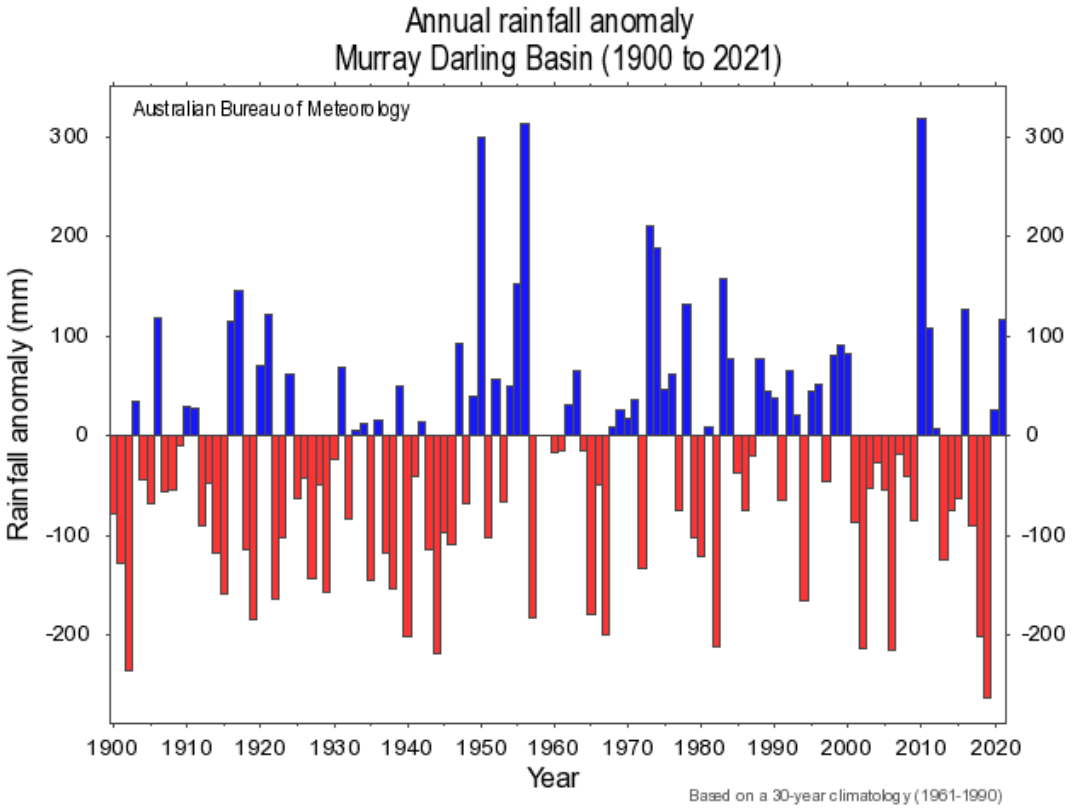


Figure 5.2 *Annual rainfall anomaly for the Murray Darling Basin from 1900 to 2021 based on the 1961-1990 average of 492.6 mm. Graph and data sourced from the Australian Bureau of Meteorology.*

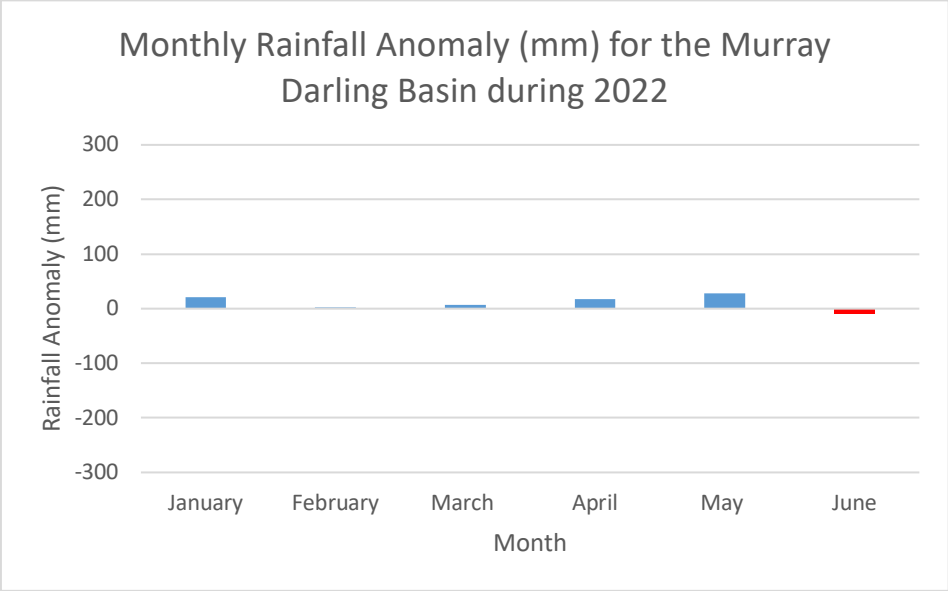


Figure 5.3 *Monthly rainfall anomaly for the Murray Darling Basin for the first six months of 2022 (scale is for Figure 39). Data sourced from the Australian Bureau of Meteorology.*

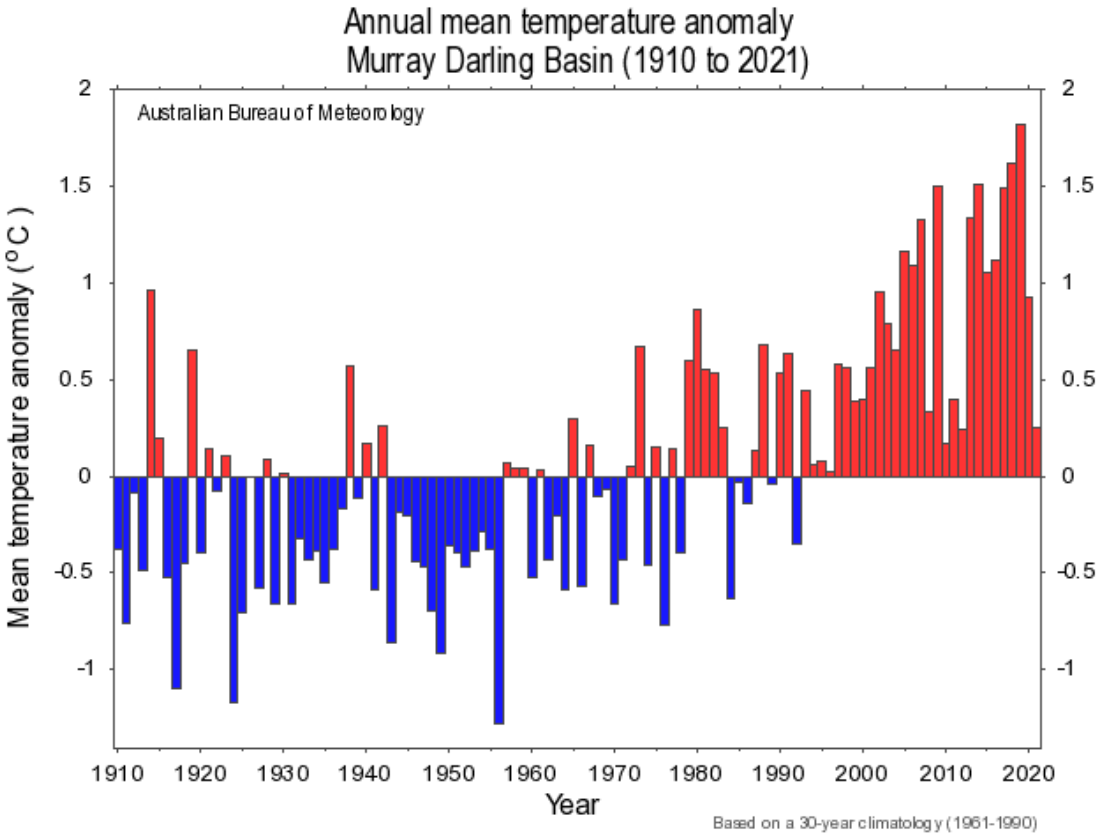


Figure 5.4 *Annual Mean Temperature Anomaly for the Murray Darling Basin from 1910 to 2021 based on the 1961-1990 average of 17.7°C. Graph and data sourced from the Australian Bureau of Meteorology.*

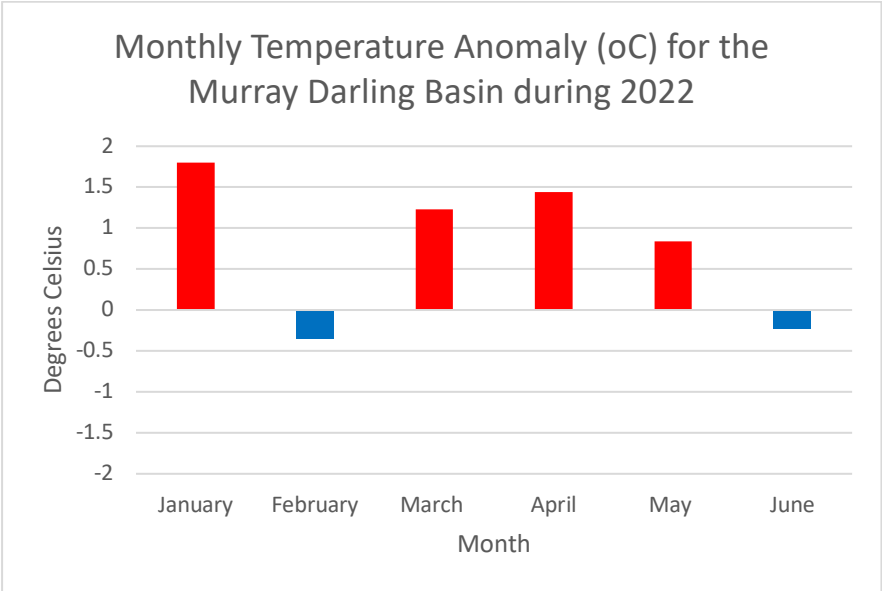


Figure 5.5 *Monthly temperature anomaly for the Murray Darling Basin for the first six months of 2022 (scale is for Figure 5.4). Data sourced from the Australian Bureau of Meteorology.*

Other potential sources of variation in the site-based indices of wetlands both between sites and within sites and between time blocks potentially include climatic and/or management factors, including timing/season, extent and duration of inundation and wetland depth and the effects of these factors on (see DELWP 2019a and 2019c, but also DEPI 2014b):

- Landscape modifiers, such as the availability of alternative habitat locally or regionally;
- Site modifiers, such as salinity and water temperature of wetlands, nutrient levels, growth of aquatic plants, vegetation structure and water quality; and
- Species modifiers, such as foraging habitats available and their influence on the different species foraging preferences and breeding habitats available and the effects of these on the different species breeding habitat preferences.

We have identified some of the sources of variation in the site-based indices and found that climatic variability across south-eastern Australia, regional and local scales, together with wetland size, influences the site-based indices in the Port Phillip and Western Port Region. The mobility of birds makes site-based and even region-based assessments problematic. The Wetland Bird Index, as a site-based index, cannot address many sources of uncertainty. Detailed studies, using quantitative counts by species or guild, will be more useful in examining the relationships between site characteristics and bird community structure (and change to this).

5.6 Wetland Bird Index assessment

At the time of preparing this report, the 2018/19 to 2022/23 period (Block E) for wetland bird index assessment was only just into its fourth year of a proposed five. Despite government-imposed restrictions during Covid-19 (2020 and 2021) significantly affecting data collection, it is encouraging to see that many wetlands meet the 20 survey minimum for only a portion of during Block 4 (which we have used for index calculation in this assessment). Although, note, we intend to limit future analyses to sites with a minimum of 40 robust surveys per period. With another year of data collection to go, many of the wetland sites should reach the 40-survey target by the June 2023.

A discussion of the value of Melbourne Water's Wetland Bird Index is provided in the 2018/19 Annual Report (BirdLife Australia 2020a). Birdlife Australia has not changed their conclusions in this regard (Birdlife Australia 2022a). The Wetland Bird Index is a useful measure for providing wetland bird community trend estimates at the wetland spatial scale and over temporal scales and can provide an early indication of a declining wetland bird community and important information for wetland managers.

The Wetland Bird Index provides Melbourne Water with a toolkit to track the condition of wetland bird communities over time using bird data (BirdLife Australia 2020a). The Summed Reporting Rate calculated for the wetland bird species is the Basic Score that reflects species richness and implies a measure of abundance and frequency of occurrence or habitat use. The Summed Reporting Rate is further informed by the categorical 'weightings' provided for the numbers of breeding and listed species recorded at a site during each time block. Therefore, the index values and categories calculated for wetlands over four 5-year time blocks provide an indication of whether bird communities are increasing, stable, or declining from one block to the next.

The different index components can also provide an indication of any change in the wetland bird community at each site which occur because of any changes in the availability of wetland bird resources (BirdLife Australia 2020a). The Summed Reporting Rate provides on-ground managers

with the goal for improving habitat to attract more wetland bird species to a site. For example, a change in Summed Reporting Rate (and therefore, a change in species richness and abundance) of wetland bird communities at a wetland may reflect a change in volume of water and/or number or area of aquatic habitats. This may have 'flow-on' effects to the numbers of breeding and threatened species present at the site. The indices enable Melbourne Water to investigate the cause of change to indices, especially if the indices indicate a detrimental change.

The index can also potentially be used to evaluate the effectiveness of Melbourne Water's works at sites. For example, during Block 3, Dandenong Valley Wetland (Rigby's Wetland Cells) supported a wetland bird community categorised as Poor based on the Summed Reporting Rate, but the high number of Listed Species recorded there elevated the community into a 'Very High' category. The site currently (during Block 4), supports a community categorised as Moderate based on a Summed Reporting Rate, but again the high number of Listed Species recorded there has elevated the community into a 'Very High' category. Therefore, these indices can reflect the successful construction of this wetland and the time at which the revegetation of this wetland became favourable to supporting high diversities/richness and abundances of wetland birds and high numbers of breeding and threatened waterbird species.

In contrast, the indices can also potentially be used to gauge when wetlands constructed for other important purposes (e.g. water filtration) become less favourable to wetland birds through continued planting of aquatic plants (e.g. Common Reed *Phragmites australis*) which form monocultures to aid in water filtration, through a decline in the wetland bird index values and categories.

The indices can be used to assess the presence of some species at wetlands which can indicate the effectiveness of planting aquatic plant species. For example, the presence of crake and rail species are good indicators of marshy habitats. The continued presence of high abundances of Sharp-tailed Sandpipers at Edithvale-Seaford Wetlands reflects the management of habitats at the Ramsar Site, including the grooming of sections of invasive Common Reed reedbeds which helps to provide open areas for shorebird foraging and Australasian Bittern foraging. The supply of water over winter and spring (when the Australian Bittern occurs at Edithvale Wetlands) which draws down over summer months when the sandpipers are in Southern Australia also provides foraging habitat (SKM 2011; Greet & Rees 2015; Ecology Australia 2016; BirdLife Australia 2020a,c). Similar management of water regimes is undertaken at the WTP to provide abundant water for waterfowl and extensive areas of mudflat with shallow water which draws down over summer months to provide shorebirds with foraging habitat (Melbourne Water 2017; DELWP 2018b and 2019b).

The Wetland Bird Index also discriminates between the higher and lower value sites for supporting wetland bird communities. The three internationally-significant Ramsar Sites, Edithvale-Seaford Wetlands and Western Port Bay Ramsar Sites, and various systems of the Western Treatment Plant, which are components of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site, consistently support wetland bird communities categorised as Very High. Another very significant site, the Eastern Treatment Plant, as a component of the Carrum KBA, also supports wetland bird communities categorised as Very High with its extensive areas of water, high abundances and diversities of wetland bird species and high numbers of breeding and listed species. These wetlands supported Summed Reporting Rates and numbers of Listed species categorised as Very High. Furthermore, the ETP South - Banyan Waterhole is another important component of the Carrum KBA, and also supports wetland bird communities categorised as High (Blocks 1 and 4) and Very High (Blocks 2 and 3). From the Cheetham- Altona KBA, Truganina Swamp supported a bird community categorised as Very High during Block 3.

Birdlife Australia recommend that a measure of wetland bird abundance should not be used in place of Summed Reporting Rate for developing the Basic Score and consider that the Summed Reporting Rate is an excellent measure. The Summed Reporting Rate is the Basic Score that reflects species richness and an indicator of abundance. Furthermore, in the 2018/19 Annual Report (BirdLife Australia 2020a), we found highly significant correlations between Summed Reporting Rate and Total Species Richness (56% of variation) and Average Maximum Annual Abundance (46%) for Block 3 (the Block for which we had most data) indicating that Reporting Rate can account for both measures. We also found that Species Richness and Average Maximum Annual Abundance also produced highly significant correlations (77%) reflecting the relationship between these two measures. Instead, while we found that one is related to the other, species richness and abundance are important variables *per se* as indicated by, for example, Ramsar criteria, which identify internationally important wetlands or wetland systems which support high species diversity and greater than 20,000 waterbirds. They are both important values/measures, but have been captured by the Reporting Rate developed by Melbourne Water and don't necessarily need to be considered in isolation for the index.

Recommendations for consideration in Science Inquiry (from Birdlife Australia 2022b)

- Melbourne Water continues to develop the Wetland Bird Index using Summed Reporting Rate for the Basic Score as a useful means of tracking the condition of wetland bird communities over time using bird data.
- Where possible/available, the data used in analyses for the Wetland Bird Index should include sites surveyed at least 40 times.
- For the Wetland Bird Index, Melbourne Water considers a weighting system for identifying 'listed' species, such that species listed as threatened under the Commonwealth EPBC Act 1999 and the Victorian FFG Act 1988, are provided more weight than species listed only under the Migratory Schedules (i.e. not threatened) under EPBC Act.
- For the Listed Species sub-index, Melbourne Water considers, for completeness and because it is a dynamic document and often a precursor to a threatened species being listed under the EPBC Act 1999, incorporating the Conservation Statuses of threatened wetland bird species provided in the *National Action Plan for Australian Birds* (Garnett et al. 2020).
- To rigorously comment on the drivers behind wetland bird community change at the site level (and subsequent wetland bird index score changes), it is important to incorporate site-based management data (e.g. water levels, salinity, vegetation works, nutrient levels) as covariates.

In addition, Melbourne Water recommends that, in all future analyses, a minimum of 40 robust bird counts at a wetland are required for each reporting period before a Wetland Bird Index can be calculated. To achieve this, monthly counts are required (rather than the quarterly counts previously suggested). Therefore, a focus on fewer, representative, priority wetlands to ensure adequate accurate bird data are obtained is strongly recommended.

5.7 Review of Healthy Waterways Strategy wetland bird monitoring and evaluation approach

This section is taken, with only minor modifications, from Birdlife Australia's 2022 review of our wetland bird monitoring.

This critical review of the entire *Healthy Waterways Strategy* (Melbourne Water 2018) monitoring and evaluation approach for wetland birds as covered in the Wetlands Monitoring and Evaluation Plan (Melbourne Water 2020b), includes an evaluation of the following questions/issues:

- Should the measures be restricted to quantitative bird counts?
- Would focussed data collection at a few, selected wetlands be a better approach?
- How reliable are volunteer bird counts for detecting cryptic marsh birds?
- Are quarterly to bi-monthly surveys an adequate frequency of data collection?
- Can data collection be restricted to the spring/summer months when resident species are breeding, migratory species are present, and birds may congregate at wetlands in a dry landscape?

There will be overlap in the discussion of a number of these questions.

Should the measures be restricted to quantitative bird counts?

BirdLife Australia volunteer and professional counters are encouraged to undertake counts of all species to collect abundance data for all species at each site, including wetland bird species and terrestrial bird species. As such, abundance data are collected during each survey and at all sites by both volunteer and professional bird counters. While the presence/absence of species, and therefore, species richness is useful for assessing wetland bird community health, abundance data can be used for additional purposes, including estimating density (see BirdLife Australia 2020a), and potentially for detecting population declines sooner than would be realised if only species presence was recorded and used to derive a species richness variable to be used in analyses (Melbourne Water 2020b). Furthermore, abundance data can potentially be used for examining the 'evenness' of wetland bird populations. For example, an even spread of foraging guilds at a wetland may indicate a healthy wetland bird community (see Melbourne Water 2020b). Abundance data collected from wetland bird counts have also been used to develop Limits of Acceptable Change criteria for Ramsar sites, with species counts allocated to a number of foraging guilds and criteria used to determine if annual abundances are contributing to the sites meeting acceptable thresholds (e.g. Edithvale-Seaford Wetlands Ramsar Site; BirdLife Australia 2020c, 2021a and 2021b).

When a series of linear regression analyses were undertaken to assess collinearity between Wetland Bird Indices and other statistics as part of the Melbourne Water Regional Bird Monitoring Program Annual Report (BirdLife Australia 2020a), a high degree of collinearity between the indices and statistics was found. The relationship between the species richness and abundance variables (during Block 3) was highly significant with 77% of the variation explained. Therefore, there was a high degree of relationship between these two variables with the relationship indicating that wetland bird species richness is higher when wetland bird abundance is higher. We do not propose to use one in place of the other, but suggest that abundance data should always be collected to be used to calculate species richness variables and abundance variables as, although related to one another, both can be generated from the one dataset and may be indicators of wetland bird community health *per se*.

Relationships between the indices/statistics and wetland area also indicated that between 20 and 32% of the variation in the indices/statistics was related to wetland size which has also been found

previously in international studies (see BirdLife Australia 2020a). Although a high proportion of the variation remains unexplained (i.e. 68%), the statistically significant relationship between wetland area and wetland bird abundance was interpreted as indicating that the abundance data collected by volunteer and professional bird counters are quite accurate (BirdLife Australia 2020a).

The MWRBM program adopts methods which represent a standardised and repeatable approach at the same wetlands, and are the best methods currently known to provide a comprehensive inventory of species presence and abundance. The use of standardised and replicable methods at the same wetlands which are used to collect abundance data are appropriate for obtaining 'signals' in the data which can indicate management issues that either require addressing or are indicative of its success. As counters tend to visit their 'favourite' wetlands time after time, we consider that excellent knowledge of the wetlands facilitates accurate counts of each site. Furthermore, at most wetlands, volunteer counters are not counting wetland bird populations in their thousands but are counting wetland birds in their hundreds at the most, which would simplify and provide a more accurate count.

We have also found that co-ordination of counters to cover targeted wetlands in a standardized manner, including the collection of quantitative data, is contingent on agreement of site selection prior to the targeted survey period. It is important to note that retrospective selection of sites for analysis may introduce the risk of incorporating less structured, less detailed datasets. In almost every case where wetlands have been pre-identified for surveying since project induction in 2013, regular quantitative surveys have been submitted for those sites. Repeat surveys at these sites is also likely to be undertaken by an identified observer or team of observers and is thus less prone to observer bias.

In summary, and is current practice, bird counters should always undertake abundance counts of all species at all wetlands and not species presence/absence only counts.

Melbourne Water response: We continue with quantitative wetland bird counts at monitored wetlands.

Would focussed data collection at a few, selected wetlands be a better approach?

Melbourne Water response: Despite Birdlife Australia's suggestion that we continue to target ~120 regional priority wetlands for monitoring of wetland bird value, and consider only 20 counts per period as adequate (Birdlife Australia 2022), we recommend a narrowing of focus – to only around 50 selected, representative, wetlands – aiming to have a minimum of 40 robust bird surveys per wetland per period. This will provide more confidence when analysing naturally variable data.

How reliable are volunteer bird counts for detecting cryptic marsh birds?

Cryptic wetland bird species (such as bitterns, crakes and rails) often require special or different techniques to detect their presence and for some of these techniques, it is usually very difficult to determine the abundance of these species when they are recorded. Melbourne Water has funded a number of studies. Call-playback during the breeding season and preferably around dawn or dusk has been used successfully to detect the presence of crake and rail species (e.g. see Ecology Australia 2005, 2006, 2007a, 2007b, 2008 and 2012; Schmidt et al. 2018). Remote-sensing cameras have also been used successfully to detect cryptic bittern, crake and rail species (Melbourne Water and Ecology Australia, unpublished data). Acoustic monitoring (i.e. recording the calls of species using song meters or AudioMoths) and listening to the recorded calls on a computer program (e.g. Arbimon) has also been employed successfully to detect the Australasian Bittern and some species

of crake and rail, such as the Glenelg-Hopkins Catchment Management Authority's Australasian Bittern Recovery Project (Bradley Clarke-Wood, unpublished data).

There are two other techniques for detecting the Australasian Bittern. The first involves walking (or canoeing or kayaking) through reed-beds and 'flushing' and counting bitterns as they are flushed and take to the air. Unfortunately, for OH&S reasons we cannot permit staff or volunteers to enter a wetland to undertake a 'flushing' survey.

The second technique involves undertaking fortnightly visits to a wetland between late-October and late-March (especially if the water level is declining late in the season) and 'listening' at night for the bittern 'boom' calls for a minimum of 30 minutes, but preferably for a period of 1.5-2.0 hours (see BirdLife Australia, undated). If more than one bittern is calling, the compass direction and distance from the observation point to the birds is recorded. Where more than one person is participating in a survey, standing some distance apart can help determine the number of birds calling. If the exact time of the call, the compass bearing, the estimated distance to the bird, and the call sequence are recorded by each person, the information can be compared and triangulation used to determine approximate location of each bittern.

All special or different techniques are more labour intensive and additional to the standardised survey. Furthermore, unless cryptic species are detected as part of the standardised bird count undertaken at a wetland, the record of the species cannot be used in index calculations (i.e. they are detected using a different technique to the standardised count). Incidental observations obtained outside of the standardised survey can also be recorded and contribute to a site list, but cannot be used in wetland Bird Index analyses and reporting. Cryptic species are by nature difficult to detect for both professionals and volunteers and the most reliable way of consistently recording the species at a site would be to employ one or more of these additional techniques.

Melbourne Water response: We consider volunteer bird counts as adequate for determining our high-level Wetland Bird Index (providing >40 robust counts per wetland per period). Cryptic and nocturnal species require targeted surveys by professional ecologists. These fall under a 'works effectiveness' study, rather than our coarse Index.

Are quarterly to bi-monthly surveys an adequate frequency of data collection?

Species Accumulation Curves to determine the minimum number of surveys required at wetlands to detect most species of wetland birds were prepared for the 2018/19 Annual Report (BirdLife Australia 2020a). It was found that: 40 surveys are generally required for the species accumulation curves to reach an asymptote; up to 90% of species are detected in the first 20 surveys; and 10-20% of species are only detected between 20 and 40 surveys. Birdlife Australia conclude that, ideally, each wetland should be surveyed monthly to cover all four seasons (see next section) and bird data collected from each wetland in their various seasonal states throughout each year while accumulating about 60 monthly surveys per five-year block. But they go on to suggest that data collected during a minimum of 20 surveys could be assumed to be representative of the wetland during that period, and included wetlands with only 20 counts per period in their analyses (Birdlife Australia 2022a).

Melbourne Water response: We recommend wetland bird surveys focus on getting a minimum of 40 surveys per 5-year period to allow confident calculation of a Wetland Bird Index. This would mean monthly counts at around 50 wetlands (to obtain reasonable representation of the region's wetland types) rather than aiming to cover 120 wetlands – which results to date show to be unlikely to be achieved.

Can data collection be restricted to the spring/summer months when resident species are breeding, migratory species are present, and birds may congregate at wetlands in a dry landscape?

The advantage of restricting data collection to spring/summer months is that data collection can focus on the spring/summer breeding season to obtain wetland bird breeding records which are used as a Modifier to elevate the Basic Score in the Wetland Bird Index calculation. The spring/summer season also coincides with the period when a majority of international and national migratory bird species are present in Victoria, and therefore, records of these species are contributing to both the Basic Score and Listed Species modifier. The third advantage is that waterbirds may congregate at some wetlands, such as the WTP, in a dry landscape (e.g. during the Millennium Drought), which also has the advantage of focussing on the period when species richness and abundance are greatest. Therefore, to obtain the most data to be used in the Wetland Bird Index, it might be suggested that survey effort be restricted to spring/summer.

To restrict data collection to the spring/summer period to coincide with the breeding seasons of most bird species is a good argument. However, we are aware that some species, such as the Black Swan and Pacific Black Duck breed outside the spring/summer period. At the ETP, the Black Swan appears now to breed all year round (Mike Carter, pers. comm.). However, species that breed outside the usual spring/summer period may be still detected breeding during the breeding season, especially if they breed all year round.

The spring/summer period also coincides with the period when a majority of international and national migratory bird species are present in Victoria. However, it does not coincide with the presence in Victoria of two key wetland bird species, reducing the likelihood of recording these species. The Critically Endangered Orange-bellied Parrot moves from its breeding grounds in southwest Tasmania to overwinter on the south-eastern Australian mainland from autumn to spring. The Double-banded Plover also migrates from its breeding grounds on the braided riverbeds of the northeast of the Southern Island of New Zealand to Australia, where it is also present from autumn to spring. As data collection aims to record all species, including terrestrial species within a buffer surrounding each wetland, another species which may be missed is the Swift Parrot (*Lathamus discolor*) which also moves from its breeding grounds in Tasmania to overwinter on the south-eastern Australian mainland from autumn to spring. Being a terrestrial species, the Swift Parrot will not contribute to the Wetland Bird Index, but it does utilise riparian vegetation. The other group of terrestrial birds which would potentially be missed are the altitudinal migrants which move from higher altitudes to more open habitats at lower altitudes during winter, such as the Flame Robin (*Petroica phoenicea*).

The third advantage which might be considered applicable is that waterbirds congregate at some wetlands during spring/summer, which would focus data collection on the period when species richness and abundance are greatest. One such wetland complex is the WTP, which is a well-known drought refuge, and provided a significant refuge during the Millennium Drought. However, not all wetlands behave in this fashion. The assessments of Melbourne Water (2017), DELWP (2018b and 2019b) and BirdLife Australia (2020c, 2021a and 2021b) found that different wetlands in the Port Phillip and Western Port Region responded differently to drought (also see Kingsford & Norman 2002; Wen et al. 2016; see 'Factors Affecting Wetland Bird Indices' above). The increase in waterbird numbers at the WTP during drought contrasted with the severe declines in waterbird numbers observed during the Millennium Drought at Edithvale-Seaford Wetlands Ramsar Site between 2000 and 2009, and the three-year decline between 2016/17 to 2018/19 (BirdLife Australia 2020c, 2021a and 2021b). The shallow wetlands of Edithvale-Seaford were prone to the effects of drought unlike the WTP with its extensive supply of permanent water. Therefore, most of the

wetlands of the Port Phillip region that are mostly dependent on rainfall to be filled were likely to have been affected by the Millennium Drought and more recent periods of low rainfall in a similar way to Edithvale-Seaford Wetlands. The indices suggest that the ETP may operate in a similar manner to the WTP by attracting large numbers of waterbirds during dry times, which then depart when extensive flooding occurs in Eastern Australia. If data collection was restricted to spring/summer, only some of the wetlands (e.g. WTP and ETP) would have the advantage that during drought, waterbirds congregate at them, while the reverse would be the case for rainfall-dependent wetlands, bearing in mind long droughts may affect a wetland during all seasons.

Another disadvantage with restricting data collection at wetlands to spring/summer is that the period of data collection would not cover all of the successional stages of the wetlands which go through a 'succession' with respect to water levels in southern Australia. For example, some zones of the Edithvale-Seaford Wetlands Ramsar Site fill with deeper water during winter and attract diving ducks which include a number of listed species, but then drawdown over spring/summer attracting large waders (shallow water) and ultimately shorebirds (mudflats). Data collection would miss the winter period when zones are holding deeper water which is attractive to diving ducks.

A final disadvantage of restricting data collection to spring/summer is restricting the feedback provided by birdwatchers to Melbourne Water regarding emerging threats at wetlands to a narrow period of time, potentially resulting in the threat requiring a bigger management effort than if the threat was detected and reported earlier to site managers.

In summary, we consider that restricting data collection at wetlands to the spring/summer period runs the risk of missing important information, including the following:

- Information on wetland bird species which breed outside of spring/summer;
- Key wetland bird species which overwinter in the Port Phillip and Westernport region and some terrestrial bird species which are known to occur in vegetation surrounding wetlands during late-autumn, winter and early-spring;
- Critical information relating to species occurrences at wetlands during better conditions, including while they are holding deeper water (e.g. during winter); and
- Earlier detection of emerging threats (i.e. during autumn/winter) at wetlands which can be reported to Melbourne Water site managers.

Melbourne Water response: We recommend monthly counts at targeted, representative, priority wetlands.

6. Wetland vegetation value

6.1 Monitoring outline

The HWS describes vegetation – as a wetland value – through three criteria:

 Vegetation	Incorporates condition and rarity data Significant flora = 5 Significant EVC = 5 Vegetation condition	Very High	If all 3 metrics meet criteria (Score 5)
		High	If condition = 5 and one other metric meets criteria
		Moderate	If condition = 3 and one other metric meets criteria or condition is 5
		Low	If condition = 3 (moderate) and meets one significance metric
		Very Low	If condition = 1 (very poor or poor)

The Wetland MEP elaborated on this and set out a more detailed method of assessment and scoring as follows (Melbourne Water 2020b).

> For the purposes of the Wetland MEP, monitoring of wetland vegetation will be limited to vascular plants, and will not include groups such as cyanobacteria, forms of eukaryotic unicellular algae, multicellular algae such as charophytes, or bryophytes (mosses). Only inundation-dependent species and communities are considered in this wetland vegetation value.
>
> The primary objectives are to assess and report vegetation condition at appropriate regional priority wetlands (i.e. those where wetland vegetation is considered a value, such as seasonal herbaceous wetlands, coastal saltmarsh wetlands, etc.).

Indicators

For the 2018 HWS, a very rough assessment was carried out for a proportion of the priority wetlands using the AVIRA method. Due to data and time constraints, this was based on desk-top measures of wetland vegetation condition, formal significance (such as listed/threatened species under Victorian and/or Commonwealth legislation) and the presence of significant wetland vegetation classes (EVCs).

In developing the Wetland MEP the need for more robust wetland vegetation assessment and scoring became apparent. Work to develop riparian vegetation scoring (Dell 2021); trialing of an IWC assessment with enhanced vegetation assessments at wetlands, "IWC+", (Ecology Australia 2019d, 2020, 2022) similar to the modified IWC for groundwater-dependent wetlands (Papas 2014); and four years of vegetation assessments at Melbourne Water SoBS (Ecology Australia 2017, 2018a, b, 2019e, 2020e) informed our thinking. Improved indicators have been identified (Table 6.1) and the need for regular field assessments confirmed.

Vegetation condition ("health")

The Index of Wetland Condition (IWC) Biota sub-index score (assessed in the field as part of vegetation condition monitoring – see below) will be used as the measure of vegetation condition. The Biota sub-index provides a score based on the condition of the vegetation expected in each EVC, and is comprised of assessments of critical lifeforms; presence of weeds; indicators of altered processes; and vegetation structure and health. Biota scores and condition categories are provided in **Table** 6.2 below.

Table 6.1 *Summary of various indicators for vegetation and how they can be used.*

Indicator	What it's useful for
Wetland vegetation condition (or 'health')	An assessment of vegetation that integrates the condition of key vegetation attributes including structure and health, life forms group, weediness, etc. This signals if vegetation attributes are able to support values expected of that vegetation community.
Wetland vegetation extent	Extent of vegetation is important for resilience and is one characteristic we can influence through on-ground management. This inform habitat availability for some biota and extent can also signal changes in abiotic conditions.
Presence of rare vegetation communities	A measure of importance for rarity and representativeness.
Presence of rare species of flora	
Wetland type rarity	

Table 6.2 *IWC Biota sub-index score range and condition category.*

Biota sub-index score range	Condition category
0–8	Very poor
>8–13	Poor
>13–16	Moderate
>16–18	Good
>18–20	Excellent

Presence of rare vegetation communities

National The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a mechanism for identifying and listing species and ecological communities as threatened, and for protecting these species and communities through legislative controls and the development of conservation advice and recovery plans. Two vegetation communities listed under the EPBC Act are present at priority wetlands in the region:

- Seasonal Herbaceous Wetlands of the Temperate Lowland Plains (SHW) – listed as Critically Endangered; and
- Subtropical and Temperate Coastal Saltmarsh – (Coastal Saltmarsh) – listed as Vulnerable.

There are 58 (of 249) priority wetlands with areas of SHW (modelled); and a smaller number with Coastal Saltmarsh (Cherry Lake, Truganina, Western Lagoon WTP, The Spit NCR, Seaford Swamp and Cheetham Saltworks).

Regional The Bioregional Conservation Status (Endangered, Vulnerable, Depleted, or Rare) of the EVCs at the priority wetlands will be used to indicate rarity of vegetation type. Wetland EVCs are

listed in Table A1.1 of DEPI 2013c. The DEECA modelled EVC layer[6] will be used except where more accurate information is available (e.g. on ground mapping by botanists) or updated information from DEECA.

Presence of rare species of flora

Wetland flora can be listed under several conservation programs/legislation:

- *Flora and Fauna Guarantee Act 1988* (Vic.) – the FFG Act.
- *Environment Protection and Biodiversity Conservation Act 1999* (Cth) – the EPBC Act

A full list of wetland waterway dependent significant flora is provided in Appendix H (Table 12) of the Aquatic Value Identification and Risk Assessment (AVIRA) Manual (DELWP 2015).

Flora records will be obtained from:

- Melbourne Water's long-term monitoring program at Sites of Biodiversity Significance (SoBS) sites (of 44 SoBS, of which at least 27 include priority wetlands; some SoBS with multiple wetlands, such as the Western Treatment Plant (WTP) with 19 priority wetlands).
- Records from the Victorian Biodiversity Atlas.
- Records from IWC+ assessments.
- Records from additional sources (e.g. requests for data from the Arthur Rylah Institute, PV, Councils or consultants).

Flora data records are unevenly distributed across the region, generally due to sparse and varying survey effort exacerbated by the problems of flora responses to weather patterns and wet/dry phases. IWC assessments undertaken for the Wetland MEP will partially remedy this by collecting on-ground data from many additional wetlands.

Table 6.3 *Native wetland vegetation cover scores.*

Area of native wetland vegetation cover	Condition category
<0.5 ha	Very poor
0.5 – 1 ha	Poor
1 – 5 ha	Moderate
5 – 10 ha	Good
>10 ha	Excellent

Wetland type rarity

Wetland type has been mapped[7] and classified (DELWP 2014) for wetlands in Victoria. The rarity of wetland type has not yet been established by bioregion or hydrological basin. Once this has been

[6] Native Vegetation - Modelled 2005 Ecological Vegetation Classes (with Bioregional Conservation Status) (NV2005_EVCBCS). http://services.land.vic.gov.au/catalogue/metadata?anzlicId=ANZVI0803003495&publicId=guest&extractionProviderId=1

[7] As per Wetland_Current (2018 DELWP spatial layer and classification).

determined by DEECA, rare and threatened wetland types will be included in scoring. Should there be no updated wetland rarity determined we use the Corrick wetland classification system (Corrick & Norman, 1976) and measures of relative rarity determined using that system.

Wetland vegetation extent

The spatial extent of native wetland vegetation affects value as larger patches may be more resistant to weeds and other edge effects, and are likely to be more resilient to impacts such as fires and floods.

Metric for assessment

The following metric will be used to determine overall wetland vegetation value (Table 6.4).

***Table 6.4**. Vegetation value metric.*

Indicator	Score	Description
Basic score (Condition)	0--8	Very low
	>8--13	Low
	>13--16	Moderate
	>16--18	High
	>18--20	Very high
Modifier 1 (Rarity)	No listed species or vegetation communities	No change to basic score
	Presence of state listed flora (VROT/FFG) OR EVC BCS	If basic score is less than Moderate, increase score to this category
	Presence of state listed flora AND EVC BCS	If basic score is less than High, increase score to this category
	Federally listed vegetation community AND/OR Federally listed flora records	If basic score is less than Very High, increase score to this category
Modifier 2 (Wetland vegetation Extent)	Native vegetation extent score = very poor, poor or moderate	No change to basic score
	Native vegetation extent score = good or excellent	Increase score by one category

Data will be collected in a rolling program targeting priority wetlands. Appendix F sets out a *possible* rotational scheme for priority wetlands. In addition, wetlands at SoBS will be assessed every three years as part of the SoBS monitoring program (Ecology Australia 2017, 2018a, b, 2019e, 2020).

Table 6.5 *Summary of vegetation monitoring methods.*

Indicator	Monitoring method	Monitoring frequency (when)	Where monitoring is required	Monitoring responsibility	Baseline data
Biota sub-index Listed species Physical Form	Index of wetland condition – biota sub-index	2018 - 2022	All priority wetlands being assessed as per IWC monitoring program	Waterways and Biodiversity team, Melbourne Water	For most wetlands this will be from 2020 onwards as we will only then have IWC assessments at most priority wetlands
Rare communities	DEECA EVC mapping	Data extraction as required	All priority wetlands being assessed	DEECA	
Listed species	SoBS monitoring method (threatened species and EVC records)	Data extraction as required	SoBS sites with listed wetland flora (data collected from existing programs)	CLaW team, Melbourne Water	
	Victorian Biodiversity Atlas species records	Data extraction as required	All priority wetlands being assessed	DEECA	
Extent – area of wetland vegetation	Aerial photography interpretation following ground inspection.	2018 - 2022	Selected priority wetlands being assessed		

Assessments will be timed appropriately, for example spring is when most wetlands should hold some water and vegetation is best assessed. Although the IWC vegetation assessments are best timed for the drawdown phase (D. Frood, pers. comm.) and it must be remembered that any flora survey is unlikely to record all possible or potential values at any wetland.

6.2 What has been achieved

The wetland vegetation monitoring which has occurred was undertaken in conjunction with other programs (e.g. our Sites of Biodiversity Significance Program and our IWC assessments, see below). This included the addition of a more detailed vegetation assessment to the IWC method, as “IWC+” (Ecology Australia 2019, 2020, 2022). These programs include a focus on threatened flora and threatened communities, and their continuation was seen as providing data for a later wetland vegetation value assessment.

To gain a more detailed view of wetland vegetation changes over time (in response to threats or management) we include a level of vegetation assessment above the standard IWC. This is the "+" component of our "IWC+" method (Ecology Australia 2019, 2020b, 2022).

The intent of this added component to the standard IWC method is to capture the diversity and cover of native and exotic flora within wetlands, with the idea that changes at this scale, in response to management interventions and other factors, will become evident in shorter time frames than is likely through the standard IWC scoring. This added vegetation component to the standard IWC has been tested and developed by Ecology Australia during 2018/19 and 2019/20. This component was developed to be a repeatable and cost-effective technique to assess the state and health of wetlands.

Permanent transects and quadrats are established and positioned subjectively to measure species presence and cover. Transects and quadrats must extend outside the wetland and into the margins of the wetland. The number of transects and plots established per wetland is dependent upon the level of complexity and variability of the vegetation.

Following the procedure described in the Index of Wetland Condition – Assessment of Wetland Vegetation (Frood 2019), ecological vegetation classes (EVCs) are identified at individual wetlands using the defining characteristics, indicator species and notes on distributions for individual EVCs outlined in Frood (2016).

An outline of the added vegetation assessment method is as follows:

- Wetlands were inspected visually and an appropriate number of 'survey lines' were assigned.
- Survey lines were marked within each wetland, extending from the margins to the centre, and the ends were permanently marked with stakes and geospatially recorded. The zero reading of each line marked the edge of the wetland vegetation (unless specified) while the end point was situated in the wettest representation of the wetland vegetation.
- The survey lines were each allocated a survey method, with at least one quadrat survey at each wetland. Depending on the size of the wetland, the remaining survey lines were allocated to a quadrat or transect survey method.
    - Survey lines allocated a quadrat survey method received two to three regularly spaced monitoring quadrats. Quadrats were marked with a central stake and were 6 m^2 (at billabongs, due to their small area) or 10 m^2 (at all other wetlands) . At each central stake, a location co-ordinate was recorded, as well as the distance along the line that it was positioned.
    - Those allocated a transect survey method were modified no further.
- All species within quadrats were recorded and covers estimated using a modified version of the Domin-Krajina scale (Table 6.6**Table 6.6**).
- Transect data were collected at 0.5 m intervals between the start and end mark of the quadrat line, ± 6 m or 10 m for billabongs and wetlands respectively (Figure 6.1**Figure**). We refer to the rectangular area comprising the quadrat lines ± survey width as the 'transect'.
- During the 2021/22 round 5 m × 5 m quadrats were established along transects running from the margins of the wetlands to the centre of the wetlands. The number of transects

and plots established per wetland were dependent upon the level of complexity and variability of the vegetation.

Table 6.6 *Cover-abundance ratings (modified Domin-Krajina scale) for vegetation functional groups.*

Score	Cover (%)
1	<1
2	1- 5
3	5 - 10
4	10 - 25
5	25 - 33
6	33- 50
7	50 - 75
8	> 75
9	~ 100

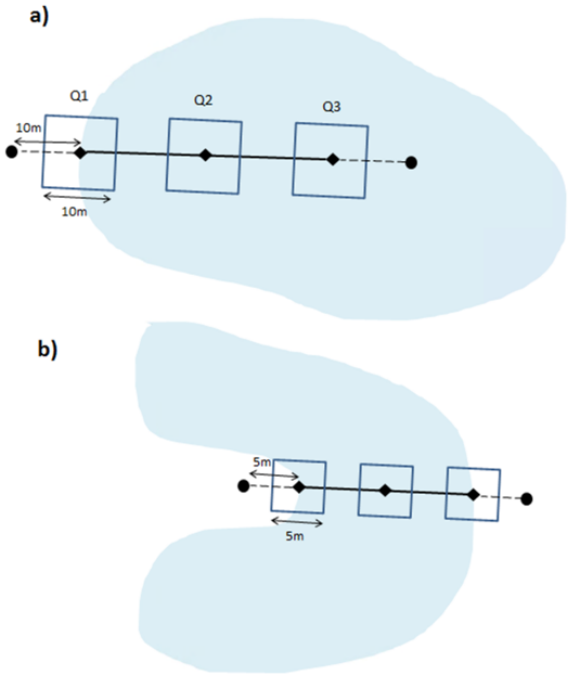


Figure 6.1 *Schematic showing the method used to monitor a) standard wetlands and b) billabongs*

Flora species lists were recorded at each of wetlands assessed. The purpose of documenting wetland species was to expand upon the IWC biota scoring. Species lists are generally comprehensive for smaller sites. A selective sampling approach was undertaken for larger wetlands, with particular focus on vegetation types and locations with higher species richness. Species inventories include terrestrial – particularly fringing species of billabongs – amphibious and aquatic taxa. Species were assigned to a hydro-ecological category (Cassanova et al. 2011).

During 2022/23, taking advantage of a wet spring, a major study was commissioned to complete IWC assessments at as many regional priority wetlands as possible during the preferred drawdown

stage. The final result, and detailed vegetation data, were not available at the time of writing this report.

One targetted assessment is ongoing at the WTP, where Coastal Saltmarsh extent is measured every four years (Birdlife Australia 2013; Ecology Australia 2017; Jacobs 2021), and Coastal Saltmarsh colonisation tracked at the restored Western Lagoon. This monitoring program shows changes in saltmarsh extent, with gains and losses across the WTP, but a slight recent increase in overall extent (Jacobs 2021). The Western Lagoon restoration project has been key to maintaining Coastal Saltmarsh extent at the site (as Orange-bellied Parrot habitat) (Ecology Australia 2009, 2010, 2012, 2017, 2018, 2020).

ARI has been undertaking assessments of seasonal herbaceous wetlands in the Western Grassland Reserve (Steve Sinclair, pers. comm.).

The resources to collate and evaluate vegetation condition data has been constrained and represents a large gap in our mid-term evaluation. It was hoped that remote sensing of extent of wetland habitat might be possible in time for this mid-term review, but this has not been the case. Similarly, ARI has been improving models of seasonal herbaceous wetland occurrence which can be used in future reporting.

In terms of wetland management, in 2021/22 a new pricing period began and we were able to start further developing the program directly. This has included:

- Updated vegetation and wetland buffer mapping, to ensure we are accurately capturing works which will impact on the wetlands.
- In 2024/25, we are planning to roll out on-ground works using the information above to help prioritise these work locations.

6.3 Recommendations for consideration in Science Inquiry

- Develop remote sensing to collect data for the wetland extent metric and ensure data for other metrics (e.g. IWC vegetation condition) and threatened species is ready for final strategy evaluation.

7. Wetland conditions

7.1 Monitoring outline

The 2020 Wetland Monitoring and Evaluation Plan (Melbourne Water 2020a) identified a number of issues relating to wetland prioritisation, mapping and the allocation of 2017 'benchmark' condition and Strategy targets (see Appendix A). This necessitated the establishment of new, data-based, 'benchmarks' for conditions of high value wetlands through the state tool, the Index of Wetland Condition (IWC). Very few IWC assessments had been completed – and added to the state database – prior to the Wetland Monitoring and Evaluation Plan.

The Wetland Monitoring and Evaluation Plan identified 249 high value wetlands (or regional priority wetlands). Of these, IWC assessments were required for 189 wetlands – 61 others being constructed wetlands or similar, not ideally suitable for IWC assessment. While sewage ponds, such as those at the WTP are Ramsar-listed and support significant waterbird populations, they would consistently score very poorly in IWC, which is intended to judge natural wetlands. The exclusions included regional priority wetlands already lost to development since the 2018 HWS was prepared: Wyndham Vale Swamp and Donnybrook Road Lake.

It was initially thought that Mornington Peninsula National Park wetlands would be too small and/or scattered to suit IWC assessments. But, in fact, three representative wetlands in the national park were successfully assessed during 2019/20 (Ecology Australia 2020b).

Recognizing that not all of the targeted wetlands would be accessible, we aimed to have around 160 regional wetlands assessed. With two 4-year periods under the HWS, we sought to have around 40 wetlands assessed each year, over a four year cycle. This would allow the initial 'benchmarking' of 160 wetlands, with a follow up assessment to investigate trajectories. Although disappointing to have to start benchmarking during the HWS this was seen as "setting ourselves up for the next strategy".

Because of delays in starting IWC assessments (covid, weather, or other causes) the planned monitoring was later changed to take advantage of the wet spring of 2022 and aim to get as many wetlands done during the 2023 drawdown.

7.2 What has been achieved

In the four years since the HWS was published 2018, there have been several issues limiting our monitoring and evaluation of wetland conditions including resourcing, funding, business process and health and safety constraints). The capital project to collect wetland condition data through IWC assessments is now up and running, and field work commenced spring 2022.

Despite these limitations, we were able to commission three rounds of IWC assessments covering 60 wetlands or wetland cells (one wetland twice: Laverton RAAF Swamp).

- 2018/19 – 24 wetlands (Ecology Australia 2019)
- 2019/20 – 28 wetlands (Ecology Australia 2020)

- 2021/22 – 9 wetlands, including one assessed in 2019/20 (Ecology Australia 2022).[8]

However, three wetlands could not be assessed as the consultants found no evidence of a wetland on the ground: Tarneit (modelled) Seasonal Herbaceous Wetland, Deanside West and Paynes Road South Swamp (Ecology Australia 2020b). This is in addition to the three HWS [9]priority wetlands identified as having been lost to urban development: Wyndham Vale Swamp, Donnybrook Road Lake and Troups Road Swamp.

While only 60 wetland cells were assessed (since some assessments consider only one cell, or pond, of a regional priority wetland) between 2019 and 2021, consultants completed IWC assessments of 104 wetlands during 2022/23, (85 regional priority wetlands and 19 others on the consultants' initiative because they considered these wetlands to be significant) (Alluvium 2023).

In addition to the HWS monitoring program, several other wetlands have been assessed since 2018 through other programs. HWS priority wetlands in the growth area which would, in the past, have been lost or modified to treat urban stormwater are now highlighted and trigger further assessment and investigation before development occurs. Wetlands assessed include:

- Cunningham's Swamp (Ecology & Heritage Partners 2019, 2020; Engeny 2020; GHD and Streamology 2020; GHD 2021; Kerr et al. 2021; Alluvium in prep. b)
- Laverton RAAF Swamp (Jacobs 2020)
- Hernes Swamp (remnant) (Alluvium 2020, in prep. c; Ecology & Heritage Partners 2021)
- The Spit Nature Conservation Reserve (Taylor et al 2020).
- Tootgarook Swamp (Biosis 2019).
- Minta Farm wetlands (Alluvium 2021c)
- Troups Road North (Rakali 2020b)
- Paynes Road Wetland (Rakali 2020a) – Note: this wetland is different to both Paynes Road North and Paynes Road South wetland, but is threatened by urbanization and was the focus of a targeted investigation.
- Hanna's Swamp (Burrung Biluk) – although not listed in the HWS as a regionally significant wetland has since been identified by Traditional Owners as having cultural significance, in light of general HWS performance objectives, and this has triggered further wetland assessments (Alluvium 2021a, 2021b).

Unfortunately, these assessments do not include IWC data collection or, if they do, we are unable to access these data until they are released on DEECA's IWC database. But we are increasing our current knowledge of the state and values of natural wetlands in the urban growth area.

[8] A further 104 wetland assessments were undertaken in early 2023 (Alluvium 2023), but results were received too late to be incorporated into this report.

[9] Note that a fourth priority wetland has been effectively lost (Sewells Road Swamp) but this was not on the original 2018 HWS list of priority wetlands

7.3 KEQ 3a To what extent are wetland conditions on the target trajectory?

It is not possible to answer this question at this stage, when assessment criteria have been modified and data collection has been limited. As a result of setting a new benchmark for reasons described in section above, it will not be possible to evaluate the condition of wetlands until the end of Strategy when another round of IWC assessments are done.

As noted above, during the three years of IWC assessments to date a total of 60 wetland ponds were assessed (Ecology Australia 2019, 2020, 2021). . Table 7.1 **Table** shows the HWS 'baseline score' (i.e. 2017) for wetland condition elements, the proposed HWS target, and – where possible – our 'new 2018 benchmark' using actual IWC sub-indices results for 38 cells, representing 32 HWS priority wetlands.[10] Some wetlands comprise a number of cells and IWC assessments can be undertaken at more than one cell per wetland. For example, Black Forest Road Wetland has had IWC assessments at two cells: East and West. Where the IWC scores differ between wetland cells we include both in the following table.

The HWS lists 82 "wetland groups" and assigns condition scores for these. These 'wetland groups' comprise 123 priority wetlands, since some wetland groups include numerous separate wetlands. However, of these 123 wetlands:

- One wetland 'group', of two wetlands, was erroneously included in the HWS since neither site has a significant wetland – Anderson Road East RB and Cardigan Road RB. These are consequently not counted as one of the 123 HWS priority wetlands.
- Three have been lost (or have been so impacted by urbanization that they no longer retain the natural wetland values for which they were recognized) – Wyndham Vale Swamp, Donnybrook Road Lake and Troups Road Swamp. Another three wetlands could not be found: Tarneit, Deanside West and Paynes Road South Swamp (Ecology Australia 2020b).
- Two wetland 'groups' were assigned wetland condition and value scores and targets, despite the fact they were not yet built – Dwarf Galaxias habitat Ponds on Dandenong Creek and Growling Grass Reserve wetlands.

From Table 7.1 it is apparent that the new IWC benchmark indicates wetland conditions are typically better than originally presented in the HWS. This is highlighted in Figure 7.1**Figure** which shows how water regime, wetland habitat form, wetland buffer condition and wetland water quality typically have increased by 2 categories as a result of the using the new IWC data.

[10] Please note, 60 ponds assessed but only 32 HWS priority wetlands covered because some assessments targeted wetlands prioritised in the 2020 Wetland MEP – and which consequently do not have HWS baseline descriptors.

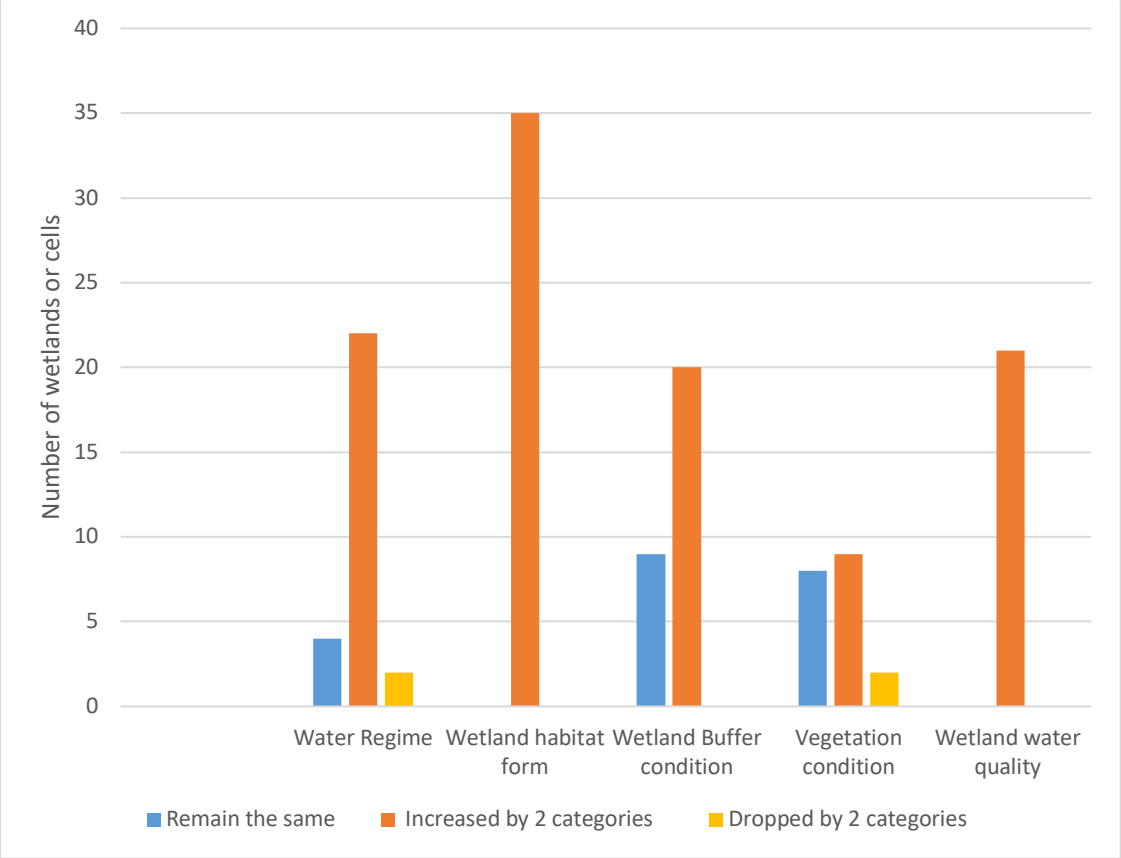


Figure 7.1 *Change in wetland condition status from HWS baseline (2017) by using data from recent (2019 – 2022) IWC assessments as the new benchmark*

Table 7.1 shows our current IWC scores (proposed to be the new benchmark) is sometimes above the 50-year target set in the HWS. This could, in part, be caused by the La Nina conditions in recent years, and the consequent better than average condition of many wetlands when assessed. This was commented upon by consultants undertaking IWC assessments. However, this improvement is also exaggerated by the HWS reliance on AVIRA, which uses IWC inputs and – where no inputs are available, as was so often the case in 2017/18 when the HWs was being written – AVIRA scores wetland elements as poor.

This change in benchmark does not mean the HWS target has been "met", since the Strategy targets are for 50 years hence when climate change effects are expected to have dramatically affected some wetland conditions. However the resetting of the wetland benchmark does raise the question of the need to reconsider the long-term targets. There are a number of aspects to consider in resetting the long-term target, including the need to go back to the Water Minister to approve new targets if there is a change to the overall targets at a catchment scale in the *Healthy Waterways Strategy*. However if the long term targets are not changed, there is a risk of perverse outcomes in terms of funding, resources and policy not being perceived as being needed due to the targets being several categories lower than the new benchmark condition.

Table 7.2 lists those HWS priority wetlands for which we do not plan to undertake IWC assessments (n = 42). These wetlands are stormwater or sewage treatment ponds, or similar constructed wetlands for which the IWC is not suitable. Melbourne Water's asset management team undertakes

regular monitoring of these constructed assets completely separate to the HWS Wetlands MEP. Tracking against HWS targets will have to be done in a similar fashion to that when 2017 condition scores and targets were described. This assessment has not been done for the mid-term review and there is an option that these wetlands will not be part of the end of strategy HWS condition assessments as they are monitored via Melbourne Water's asset management framework which focuses on system performance.

Table 7.3 lists those priority wetlands (n = 49) for which we still have to commission benchmarking IWC assessments and this will occur over the next 2 years. In addition to the wetlands listed in Tables 7.1, 7.2 and 7.3 we plan IWC assessments of many of the regionally significant wetlands identified in the 2020 Wetland MEP (see Appendix C). These assessments should be completed within the next two years (see discussion above).

Table 7.1 *Wetland Condition scores for HWS priority wetlands.*
HWS score is the 'current condition' scores assigned in the HWS. Target scores are defined in the HWS. New benchmark scores are the available recent IWC assessments.
Blue shading indicates new benchmark is two or more categories above the HWS assessment; green shading indicates our IWC assessment is one category above the HWS assessment; orange shading indicates IWC assessment is one category lower than the HWS assessment; pink shading indicates the new IWC assessments is two or more categories below the HWS assessment.

2018 HWS wetland grouping	Wetland name (cell)	Catchment	Water regime			Wetland habitat form			Wetland buffer condition			Vegetation condition			Wetland water quality		
			HWS score	New Benchmark	HWS target	HWS score	New Benchmark	HWS target	HWS score	New benchmark	HWS target	HWS score	New benchmark	HWS target	HWS score	New benchmark	HWS target
Barnbam Swamp, Lynbrook	Barnbam Swamp	Dandenong	very low	Moderate	moderate	moderate	Very high	high	very low	Very Low	very high	very low	Moderate	moderate	very low	High	low
Dandenong Catchment s/w treatment wetlands	Mordialloc Creek Wetland (Waterways Estate)	Dandenong	very low	Very high	low	moderate	Low	moderate	very low	High	low	low	High	low	very low	High	low
Seaford Wetland *	Seaford Wetland (1)	Dandenong	very low	High	low	low	High	moderate	very low	Very high	very high	moderate	High	moderate	very low	High	low
Seaford Wetland *	Seaford Wetland (2)	Dandenong	very low	High	low	low	High	moderate	very low	High	very high	moderate	High	moderate	very low	High	low
Tirhatuan Wetlands	Tirhatuan Wetlands	Dandenong	moderate	Low	moderate	moderate	High	high	very low	Low	very high	moderate	Moderate	moderate	very low	High	low
Gisborne marshlands	Gisborne Racecourse Swamp	Maribyrnong	very low	Moderate	moderate	low	High	low	very low	Very Low	moderate	moderate	High	high	moderate	High	moderate
Pipemakers Park Wetland	Pipemakers Park Wetland	Maribyrnong	very low	High	low	moderate	Very high	moderate	very low	Low	low	very low	Moderate	low	very low	Moderate	low
Black Forest Rd Wetland	Black Forest Rd Wetland (east)	Werribee	very low	Very high	low	very low	Very high	moderate	very low	Low	very high	very low	Very high	moderate	moderate	High	low

2018 HWS wetland grouping	Wetland name (cell)	Catchment	Water regime			Wetland habitat form			Wetland buffer condition			Vegetation condition			Wetland water quality		
			HWS score	New Benchmark	HWS target	HWS score	New Benchmark	HWS target	HWS score	New benchmark	HWS target	HWS score	New benchmark	HWS target	HWS score	New benchmark	HWS target
Black Forest Rd Wetland	Black Forest Rd Wetland (west)	Werribee	very low	Moderate	low	very low	Very high	moderate	very low	Moderate	very high	very low	Low	moderate	moderate	High	low
Black Swamp	Black Swamp	Werribee	very low	High	low	very low	High	moderate	very low	Low	very high	very low	Moderate	moderate	very low	High	low
Cobbledicks Ford cluster	Cobbledicks Ford Wetland (Wilsons 3)	Werribee	very high	Very high	moderate	very low	Very high	moderate	very low	Very high	very high	very low	Low	moderate	moderate	High	low
Cobbledicks Ford cluster	Cobbledicks Ford Wetland (Wilsons 4)	Werribee	very high	Very high	moderate	very low	Very high	moderate	very low	Very high	very high	very low	Low	moderate	moderate	High	low
Deanside Marsh	Deans Marsh	Werribee	very high	High	moderate	very low	Very high	moderate	very low	Low	very high	moderate	High	moderate	moderate	High	low
Greens Road East No. 2	Greens Road Swamp East No. 2	Werribee	very low	Very high	low	very low	Very high	moderate	very low	Very Low	very high	very low	Very Low	moderate	moderate	Very high	low
Laverton RAAF Swamp	Laverton RAAF Swamp	Werribee	very low	Very Low	moderate	very low	Very high	moderate	very low	Very Low	very high	low	Low	moderate	very low	Moderate	low
Jawbone Reserve	Paisley-Challis Wetland	Werribee	moderate	Very high	low	moderate	Very high	moderate	very low	Low	moderate	moderate	High	moderate	very low	High	low
WTP - Paul & Belfrages Wetland	Paul and Belfrages Wetland	Werribee	moderate	Moderate	moderate	very low	Very high	low	low	Low	moderate	high	High	high	moderate	High	low
Point Cook Wetlands - RAAF Lake	RAAF Lake	Werribee	very high	Very high	moderate	very low	Very high	moderate	very low	Very high	very high	moderate	High	moderate	moderate	High	low

2018 HWS wetland grouping	Wetland name (cell)	Catchment	Water regime			Wetland habitat form			Wetland buffer condition			Vegetation condition			Wetland water quality		
			HWS score	New Benchmark	HWS target	HWS score	New Benchmark	HWS target	HWS score	New benchmark	HWS target	HWS score	New benchmark	HWS target	HWS score	New benchmark	HWS target
Point Cook Wetlands - Spectacle Lake	Spectacle Lake	Werribee	very high	High	moderate	very low	Very high	moderate	very low	Very high	very high	very high	Moderate	high	moderate	High	low
Target Range Swamp	Target Range Swamp	Werribee	very low	Very high	low	very low	Very high	moderate	very low	Low	very high	very low	Moderate	moderate	moderate	High	low
Truganina Swamp	Truganina Swamp (east)	Werribee	very low	Moderate	low	low	High	low	very low	Very Low	moderate	moderate	High	low	very low	Moderate	low
Cobbledicks Ford cluster	Windmill Wetland (Wilsons 1)	Werribee	very high	Low	moderate	very low	High	moderate	very low	Very high	very high	very low	Low	moderate	moderate	Very high	low
Cobbledicks Ford cluster	Windmill Wetland (Wilsons 2)	Werribee	very high	Low	moderate	very low	High	moderate	very low	Very high	very high	very low	Low	moderate	moderate	Very high	low
The Briars wetlands	The Briars Park wetlands	Westernport	very low	Very high	low	very low	Very high	very low	very low	Low	low	very low	Moderate	moderate	moderate	Very high	moderate
Tootgarook Swamp	Tootgarook Swamp	Westernport	very low	High	low	low	High	moderate	very low	High	very high	very low	Moderate	moderate	very low	High	moderate
Tootgarook Swamp	Truemans Road Reserve	Westernport	very low	High	low	low	Very high	moderate	very low	Moderate	very high	very low	High	moderate	very low	High	moderate
Annulus Billabong	Annulus Billabong	Yarra	very low	Moderate	very high	low	Very high	low	moderate	Moderate	very high	moderate	Low	moderate	very low	High	moderate
Banyule Flats Billabong	Banyule Flats Billabong	Yarra	very low	Moderate	very high	very low	Very high	moderate	very low	Moderate	very high	moderate	Low	very high	very low	High	moderate
Bolin Bolin Billabong	Bolin Bolin Billabong	Yarra	very low	Moderate	very high	very low	Very high	moderate	very low	High	very high	moderate	Low	very high	moderate	High	moderate

2018 HWS wetland grouping	Wetland name (cell)	Catchment	Water regime			Wetland habitat form			Wetland buffer condition			Vegetation condition			Wetland water quality		
			HWS score	New Benchmark	HWS target	HWS score	New Benchmark	HWS target	HWS score	New benchmark	HWS target	HWS score	New benchmark	HWS target	HWS score	New benchmark	HWS target
Burke Road Bilabong	Burke Road Billabong	Yarra	very low	Moderate	very high	very low	Very high	moderate	low	High	very high	moderate	Moderate	very high	very low	High	moderate
Domain Chandon billabongs	Domain Chandon Billabongs (1)	Yarra	very low	Low	very high	moderate	Very high	high	very low	Low	very high	moderate	Moderate	very high	moderate	High	moderate
Domain Chandon billabongs	Domain Chandon Billabongs (2)	Yarra	very low	Low	very high	moderate	Very high	high	very low	Very Low	very high	moderate	Very Low	very high	moderate	High	moderate
Hearnes Swamp	Herne Swamp (remnant)	Yarra	very low	Low	moderate	moderate	Low	high	very low	Very Low	moderate	very low	Low	moderate	moderate	Low	moderate
Spadonis Reserve	Spadonis Billabong (1)	Yarra	very low	Low	very high	low	Very high	moderate	very low	Moderate	moderate	moderate	Moderate	very high	moderate	High	moderate
Spadonis Reserve	Spadonis Billabong (2)	Yarra	very low	Low	very high	low	Very high	moderate	very low	Moderate	moderate	moderate	Moderate	very high	moderate	High	moderate
Willsmere Billabong	Willsmere Billabong (Kew Billabong)	Yarra	very low	Moderate	very high	very low	Very high	low	very low	Moderate	very high	moderate	High	very high	very low	High	moderate
Yarra Bridge Steamside Reserve	Yarra Bridge Steamside Reserve	Yarra	very low	Very high	very high	very low	Very high	very low	low	Very high	very high	moderate	High	very high	moderate	High	moderate
Yering Backswamp	Yering Backswamp	Yarra	moderate	Low	very high	very low	Very high	moderate	low	Very high	very high	moderate	High	very high	very low	High	moderate

* The high scores assigned to Seaford Wetland for water regime and water quality by the IWC assessors are being questioned since we know this wetland suffers from very poor conditions in both these elements.

Table 7.2 *HWS condition scores and targets for priority wetlands for which IWC assessments are not planned (i.e. constructed wetlands considered unsuitable for this method, or no wetland, n = 42).*

2018 HWS wetland grouping	Wetland name	Catchment	Water regime		Wetland habitat form		Wetland buffer condition		Vegetation condition		Wetland water quality	
			HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target
Wannarkladdin Wetlands	Chelsea Heights Wetland	Dandenong	very low	low	high	high	very low	low	moderate	moderate	very low	low
Dwarf Galaxias Conservation Wetland	Dwarf Galaxias Conservation Pond	Dandenong	very low	low	very low	very low	very low	low	low	low	very low	low
Dwarf Galaxias habitat ponds, Dandenong Creek (place holder)	Dwarf Galaxias wetlands along Dandenong Creek	Dandenong	very low	low	very low	very low	low	low	low	low	moderate	low
Eastern Treatment Plant wetlands	Eastern Treatment Plant wetlands	Dandenong	very low	low	very low	moderate	very low	low	low	moderate	very low	low
Dandenong Catchment s/w treatment wetlands	Eumemmerring Creek wetland (Frog Hollow Wetland)	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Dandenong Catchment s/w treatment wetlands	Golf Links Road Wetland	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Dandenong Catchment s/w treatment wetlands	Hallam Valley RB Wetland	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Dandenong Catchment s/w treatment wetlands	Hampton Park RB East Wetland (Kilberry Boulevard wetlands)	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Dandenong Catchment s/w treatment wetlands	Heatherton Road North Wetland	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Dandenong Catchment s/w treatment wetlands	Heatherton Road South Wetland	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Dandenong Catchment s/w treatment wetlands	Rivergum Creek Wetlands	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Eastern Treatment Plant wetlands	Serpentine Lagoon, ETP	Dandenong	very low	low	very low	moderate	very low	low	low	moderate	very low	low

2018 HWS wetland grouping	Wetland name	Catchment	Water regime		Wetland habitat form		Wetland buffer condition		Vegetation condition		Wetland water quality	
			HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target
Dandenong Catchment s/w treatment wetlands	Troups Creek Wetland	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Dandenong Catchment s/w treatment wetlands	Waterford Valley Wetland (Karoo Rd Wetland)	Dandenong	very low	low	moderate	moderate	very low	low	low	low	very low	low
Greenvale Reservoir	Greenvale Reservoir	Maribyrnong	very low	low	very low	very low	very low	low	very low	low	very low	low
Queens Park wetlands	Queen's Park wetland	Maribyrnong	very low	low	very low	very low	very low	low	very low	low	very low	low
Altona Treatment Plant	Altona Treatment Plant	Werribee	very low	low	very low	very low	very low	very high	very low	moderate	very low	low
WTP - ponds	Lake Borrie	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	Lake Borrie Ponds 28 & 29	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	Q4 Wetland	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	The Triangle, WTP	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
Troups Road Swamp	Troups Road Swamp	Werribee	very low	low	low	low	very low	very high	very low	moderate	very low	low
WTP - ponds	T-Section Lagoon	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	Walshs Lagoon Ponds 1 & 6	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	Western Lagoon	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	WTP habitat ponds	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	WTP operational ponds - 115E Lagoon	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	WTP operational ponds - 25W Lagoon	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	WTP operational ponds - 55E Lagoon	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	WTP operational ponds - 85W Lagoons	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low

2018 HWS wetland grouping	Wetland name	Catchment	Water regime		Wetland habitat form		Wetland buffer condition		Vegetation condition		Wetland water quality	
			HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target
WTP - ponds	WTP operational ponds - Walshes	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
Wyndham Vale Swamp	Wyndham Vale Swamp	Werribee	very low	low	very low	very low	very low	very high	very low	moderate	very low	low
Yarra Catchment s/w treatment wetlands	Brushy Creek sed ponds	Yarra	very low	low	moderate	moderate	very low	low	low	low	very low	moderate
Donnybrook Road Lake	Donnybrook Road Lake	Yarra	very high	very high	low	low	very low	low	low	low	moderate	low
Yarra Catchment s/w treatment wetlands	Hawkstowe Wetlands	Yarra	very low	low	moderate	moderate	very low	low	low	low	very low	moderate
Yarra Catchment s/w treatment wetlands	Laurimar Park Estate Wetland	Yarra	very low	low	moderate	moderate	very low	low	low	low	very low	moderate
Lillydale Lake	Lillydale Lake	Yarra	very low	low	very low	very low	very low	low	very low	low	very low	low
Yarra Catchment s/w treatment wetlands	Mill Park Lakes	Yarra	very low	low	moderate	moderate	very low	low	low	low	very low	moderate
Growling Grass Frog reserve ponds (placeholder)	Growling Grass Frog conservation pond (DWL473A)	Yarra	very high	very high	very low	very low	very low	very high	very low	moderate	moderate	moderate
Growling Grass Frog reserve ponds	Growling Grass Frog MSA Pond No. 1 (Lyle Lane, Aintree)		very high	very high	very low	very low	very low	very high	very low	moderate	moderate	moderate
Ringwood Lake	Ringwood Lake	Yarra	very low	low	very low	very low	very low	low	very low	low	very low	low
Yarra Catchment s/w treatment wetlands	Simons Creek Wetland	Yarra	very low	low	moderate	moderate	very low	low	low	low	very low	moderate

Table 7.3 *HWS condition scores and targets for priority wetlands for which IWC assessments are still to be done (n = 49).*

2018 HWS wetland grouping	Wetland name	Catchment	Water regime		Wetland habitat form		Wetland buffer condition		Vegetation condition		Wetland water quality	
			HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target
Banyan Waterhole, ETP	Banyan Waterhole, ETP	Dandenong	moderate	moderate	very low	moderate	very low	very high	very low	moderate	moderate	low
Braeside Park Wetlands	Braeside Park wetlands	Dandenong	very high	very high	low	low	very low	low	moderate	moderate	moderate	low
Edithvale Wetlands	Edithvale North Wetland	Dandenong	moderate	moderate	moderate	moderate	very low	moderate	moderate	moderate	very low	low
Edithvale Wetlands	Edithvale South Wetland	Dandenong	moderate	moderate	moderate	moderate	very low	moderate	moderate	moderate	very low	low
Hallam Valley floodplain wetland	Hallam Valley floodplain	Dandenong	very low	low	high	very high	very low	very high	very low	moderate	very low	low
Hallam Valley floodplain wetland	Hallam Valley floodplain wetland (O'Gradys Road)	Dandenong	very low	low	high	very high	very low	very high	very low	moderate	very low	low
Tamarisk Waterway Reserve wetland	Tamarisk Waterway Reserve wetland	Dandenong	very low	very high	very low	very low	low	low	moderate	moderate	very low	low
Eastern Treatment Plant wetlands	The Doughnut, ETP	Dandenong	very low	low	very low	moderate	very low	low	low	moderate	very low	low
Wannarkladdin Wetlands	Wannarkladdin Wetlands	Dandenong	very low	low	high	high	very low	low	moderate	moderate	very low	low
Winton Wetlands	Winton Wetlands	Dandenong	very low	very high	moderate	high	very low	very high	very low	very high	moderate	moderate
Jacana Wetlands	Jacana Wetlands	Maribyrnong	very low	moderate	low	low	very low	moderate	very low	moderate	very low	moderate
WTP - ponds	Austen Road Pond 1 (Summer Pond 1)	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
WTP - ponds	Austen Road Pond 2 (Summer Pond 2)	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
Balls Wetland Complex	Balls Swamp/ Wetland complex	Werribee	very low	low	very low	moderate	very low	very high	moderate	moderate	moderate	low
Baths Swamp	Baths Swamp	Werribee	very high	moderate	very low	moderate	very low	very high	very low	moderate	moderate	low
Rolling Thunder Wetland	Binghams Swamp	Werribee	very high	moderate	very low	moderate	very low	very high	very low	moderate	moderate	low

2018 HWS wetland grouping	Wetland name	Catchment	Water regime		Wetland habitat form		Wetland buffer condition		Vegetation condition		Wetland water quality	
			HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target
Cheetham Wetlands	Cheetham Saltworks	Werribee	very low	low	very low	very low	very low	very high	moderate	moderate	very low	low
Cherry Lake	Cherry Lake	Werribee	very low	low	very low	very low	very low	moderate	very low	low	very low	low
WTP - ponds	Cherry Tree Creek pool, WTP	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low
Cobbledicks Ford cluster	Cobbledicks Rise Wetland	Werribee	very high	moderate	very low	moderate	very low	very high	very low	moderate	moderate	low
Cunninghams Swamp (historic extent)	Cunninghams Swamp	Werribee	very low	low	low	low	very low	very high	very low	moderate	moderate	low
Holden Road Wetland	Holden Road Wetland	Werribee	very high	moderate	very low	low	very low	very high	very low	moderate	moderate	low
Jenz Swamp	Jensz Swamp	Werribee	very high	moderate	very low	moderate	very low	very high	very low	moderate	moderate	low
Kirks Bridge Rd West Wetland	Kirks Bridge Rd West Wetland	Werribee	very low	low	very low	moderate	very low	very high	very low	moderate	moderate	low
Kororoit Creek No. 3	Kororoit Creek No. 3	Werribee	very high	moderate	very low	moderate	very low	very high	very low	moderate	moderate	low
Live Bomb Wetland	Live Bomb Wetland	Werribee	very high	moderate	very low	moderate	very low	very high	very low	moderate	moderate	low
Paynes Road North Swamp	Paynes Road North Swamp (North Swamp)	Werribee	very low	low	very low	moderate	very low	very high	very low	moderate	moderate	low
Jawbone Reserve	Jawbone Reserve wetland	Werribee	moderate	low	moderate	moderate	very low	moderate	moderate	moderate	very low	low
Rabbiters Lake and Swamp	Rabbiters Lake	Werribee	very low	low	very low	moderate	very low	very high	very low	moderate	moderate	low
Rabbiters Lake and Swamp	Rabbiters Swamp	Werribee	very low	low	very low	moderate	very low	very high	very low	moderate	moderate	low
Richmond's Grass Swamp	Richmond's Grass Swamp	Werribee	very low	low	very low	moderate	very low	very high	very low	moderate	moderate	low
Rockbank No. 1 wetland	Rockbank No. 1	Werribee	very high	moderate	very low	moderate	very low	very high	very low	moderate	moderate	low
Rockbank railway Swamp	Rockbank Railway Swamp	Werribee	very low	low	very low	moderate	very low	very high	very low	moderate	moderate	low
WTP - Ryans Swamp	Ryans Swamp	Werribee	moderate	moderate	very low	low	very low	moderate	high	high	moderate	low

2018 HWS wetland grouping	Wetland name	Catchment	Water regime		Wetland habitat form		Wetland buffer condition		Vegetation condition		Wetland water quality	
			HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target	HWS score	HWS target
The Spit NCR	The Spit Lagoon	Werribee	very high	low	very low	moderate	very low	very high	high	high	very high	low
West Quandong Swamp	West Quandong Swamp	Werribee	very low	low	low	moderate	very low	very high	very low	moderate	moderate	low
Cardinia Creek Retarding Basin wetlands	Cardinia Creek RB wetlands	Westernport	very low	low	moderate	moderate	low	low	moderate	moderate	very low	low
Coolart Wetlands	Coolart Lagoon	Westernport	moderate	moderate	high	high	low	low	very high	high	moderate	moderate
Lang Lang floodpain wetlands	Lang Lang River old course	Westernport	very low	moderate	moderate	moderate	moderate	very high	moderate	high	very low	moderate
Western Port coastal wetlands	Westernport coastal wetlands	Westernport	very high	moderate	very high	very high	very low	very high	moderate	high	moderate	moderate
Yallock Creek floodplain wetlands	Yallock Creek billabongs and palaeochannel	Westernport	very low	moderate	moderate	moderate	moderate	very high	very low	high	very low	moderate
Cockatoo Creek floodplain	Cockatoo Creek floodplain wetland	Yarra	very low	high	high	very high	high	very high	high	very high	very low	moderate
Yarra catchment s/w treatment wetlands (WRONG)	Dunnetts Road Swamp	Yarra	very low	low	moderate	moderate	very low	low	low	low	very low	moderate
Yarra catchment s/w treatment wetlands (WRONG)	Galada Tamboore wetlands	Yarra	very low	low	moderate	moderate	very low	low	low	low	very low	moderate
Hays Paddock Wetland	Hays Paddock Wetland	Yarra	very low	very high	very low	moderate	very low	very high	very low	very high	very low	moderate
Kalkallo Common	Kalkallo Common	Yarra	moderate	moderate	very low	moderate	very low	moderate	high	moderate	moderate	moderate
Kalkallo Common	Kalkallo Creek Wetland	Yarra	moderate	moderate	very low	moderate	very low	moderate	high	moderate	moderate	moderate
Westgate Park wetlands	Westgate Park lakes	Yarra	moderate	moderate	very low	very low	very low	low	very low	low	very low	low
WTP - ponds	Paradise Road Ponds	Werribee	very low	low	very low	moderate	very low	moderate	very low	low	moderate	low

7.4 KEQ 3b What other spatial and temporal trends and patterns for key values are of significance for implementation?

Seven IWC assessments were in the state database prior to our monitoring, including three HWS groundwater dependent ecosystems covered by Melbourne Water's environmental flows team. These prior assessments allow us to compare IWC assessments over time for three wetlands: Laverton RAAF Swamp, Seaford Wetland and Truganina Wetland.

We have a recent (2023) IWC assessment of Truganina and Seaford Wetlands (Alluvium 2023). While this report arrived too late to be fully incorporated into this mid-term review we can present this recent assessment to compare with previous scores.

Comparison of Wetland Condition scores at Laverton RAAF Swamp

Date	Wetland Buffer (Catchment sub-index)	Habitat (Physical Form sub-index)	Water Regime (Hydrology sub-index)	Water Quality sub-index	Vegetation (Biota sub-index)
2019/20	Very poor	Excellent	Moderate	Good	Moderate
2021/22	Very poor	Excellent	Very poor	Moderate	Poor

Laverton RAAF Swamp deteriorated from an overall 'Moderate' condition to 'Poor' (Ecology Australia 2020b, 2022). This change has been driven by altered hydrology and water quality (nutrients) scores and also the wetland vegetation score (see above). We know that this wetland has been impacted by urbanization, despite our efforts to divert increased low flows and protect the wetland vegetation and bird habitat. The wetland still receives excessive flows from the urbanized catchment and is in poor condition. Water quality is also poor, not least from legacy PFAS contamination from the former Air Force base. The owner undertakes some vegetation management. Discussions are underway between the owner and Melbourne Water to allow a major vegetation improvement.

Comparison of Wetland Condition scores at Truganina Swamp

Date	Wetland Buffer (Catchment sub-index)	Habitat (Physical Form sub-index)	Water Regime (Hydrology sub-index)	Water Quality sub-index	Vegetation (Biota sub-index)
2011	Good	Excellent	Very poor	Poor	Good
2016	Very poor	Good	Moderate	Moderate	Good
2023	Poor	Excellent	Very poor	Moderate	Moderate

Truganina Swamp saw mixed changes between 2011 and 2016 (i.e. prior to the 2018 HWS). Wetland Buffer and Physical Form both deteriorated whereas Hydrology and Water Quality were assessed as having improved.

The initial assessment reported increasing salinity and altered hydrology as major contributors to its poor scoring. The second assessment reported improved water quality, with less obvious salinity effects. By 2023, we had observed a decline in wetland vegetation due to the poor hydrological conditions, with the wetland holding too much water for too long.

Surprisingly, Seaford Swamp was assessed as having improved across all condition scores between 2016 and 2019. Different consultants undertook the two assessments, and one focused on Seaford as a groundwater dependent ecosystem. So, we probably need to interpret these results with caution. The 2019 assessment is unexpectedly optimistic and seems to ignore the significant water quality and water supply problems facing this wetland. A repeat assessment in 2023 (by different consultants again) perhaps more accurately scored some sub-indices lower than the 2019 assessors.

Comparison of Wetland Condition scores at Seaford Swamp

Date	Wetland Buffer (Catchment sub-index)	Habitat (Physical Form sub-index)	Water Regime (Hydrology sub-index)	Water Quality sub-index	Vegetation (Biota sub-index)
2016	Very poor	Poor	Very poor	Very poor	Poor
2019/20	Excellent/ Good	Good	Good	Good	Good
2023	Good/ Poor	Excellent	Good/ Moderate	Moderate	Moderate

7.5 Lessons learned and proposed changes

We considered grouping wetlands and then selecting 'representative' examples of each group to reduce the number of IWC assessments required. However, the first IWC round targeted our most urgent knowledge gap – seasonal herbaceous wetlands in the growth area – and it quickly became apparent that individual wetlands within this grouping varied too much for any to be taken as 'representative' of all (Andrew McMahon, Ecology Australia, pers. comm.).

There is ongoing work at DEECA to develop a system for wetland 'grouping'. Currently DEECA is considering:

- Ramsar wetlands to be considered individually. We have three Ramsar wetlands in our region.
- Other natural wetlands to be grouped by Wetland Landscape and Commonwealth IBRA sub-regions. This would give our region 30 broad groupings.
- Fine scale grouping is still under discussion, but wetland type and/or water source are considered good candidate characteristics.

Once DEECA confirms a wetland grouping system we can consider focusing on a sub-set of wetlands that could be taken to be representative of each group. But this would not cover our complex needs for a range of wetlands that includes social value, cultural value and ecological values; constructed/modified wetlands and natural wetlands.

The capital monitoring project is now underway and can increase the rate at which wetlands are assessed. Alluvium has proposed two options to cover the remaining wetlands:

- Option 1. If rainfall is sufficient across the landscape and we receive average or near average rainfall we will schedule 45 to 50 IWC assessments per field season, this strategy will result in all being assessed in late spring/early summer of 2022, 2023 and 2024.
- Option 2. If above average rainfall occurs later in 2022 or in 2023, we will deploy additional field staff to assess a minimum of 100 sites in either field season.

Thus we hope to have at least 'benchmark' condition assessments for all of our (appropriate) regionally significant wetlands by June 2024. Second-round assessments for the end of Strategy evaluation will take a further two to three field seasons.

7.5 Recommendations for consideration in Science Inquiry

- Review the wetlands to focus monitoring on –high value, "priority" or regionally significant wetlands. At the very least, certain wetlands need to be removed since we now know they have been altered and/or lost the values for which they were noted.
- Remove constructed wetlands and waterbodies, e.g. urban lakes from the IWC assessments as these are monitored via Melbourne Water's asset management framework which focuses on system performance. These wetlands should not be part of the end of strategy HWS condition assessments.
- All wetland assessments undertaken for other reasons, e.g. planning for growth, should include a standard IWC assessment, and these data should be made available to the monitoring team as early as possible.
- Communicate the new benchmark results and explore options for updating the long-term targets in light of the new benchmark.

8. Research

This section presents research from the Melbourne Waterway Research-Practice Partnership and the Aquatic Pollution Prevention Partnership (A3P). In particular, it focuses on findings from one of the key research projects (A1 - 'Spatial prioritisation of management actions for biodiversity outcomes in streams and wetlands'). Other related research projects are also listed below.

8.1 New wetlands/ waterbodies map layer

From December 2018, a major focus of the research has been the development of spatial data infrastructure—from the ground-up— for fine-scale mapping of wetlands (waterbodies) and their catchments, and a wetland-relevant companion environmental data library ('environmental predictors' that help characterise habitat e.g. vegetation cover, inundation) for enabling the development of HSMs for wetland-dependent frogs, fish and birds. This waterbodies spatial layer also has fundamental applications for Melbourne Water and our stakeholders e.g. tracking wetland wetland loss/gain, identifying wetlands at risk from land development.

Recommendation for consideration in Science Inquiry:

- Regularly update, maintain and evaluate the waterbodies spatial inventory to ensure ongoing utility and reliability for management and research applications and identify wetlands at risk.

8.2 Habitat Suitability Models for frogs and wetland birds

The A1 project also takes the new waterbodies layer and ecologically-meaningful environmental data as a starting point for developing tools such as habitat suitability models (HSMs) and prioritisation approaches for action planning.

Similar to the HSMs that were used for instream values (aquatic macroinvertebrates, fish, platypus) during the development of the HWS, the ultimate goal is for HSMs for wetland biota to be used to: a) illustrate where wetland taxa of interest could? occur in the landscape; b) assess and illustrate the effects of broad-scale impacts such as climate change and land use change on wetland taxa habitat suitability; and c) develop a quantitative action prioritisation (analysis using Zonation) to cost-effectively maximise biodiversity outcomes in wetlands at the whole-of-region scale.

Whilst the project is not at the stage of being able to provide all of the desired applications above, it can contribute preliminary analyses to inform the HWS mid-term review process. To date a first-cut habitat suitability models (HSMs) for frog species for which there is sufficient occurrence data has been developed. The research has also been able to show where existing HWS 2018 priority waterbodies sit in relation to abiotic environmental gradients across the landscape as a whole, how wetland extent varies across wet and dry periods and information on threats and management opportunities.

Of the 18 frog species recorded in survey data across the region's wetlands, ten were deemed to have enough data for model building, including frogs with a mixture of traits and habitat preference

including tree frogs, cocoon building frogs, frogs that inhabit densely vegetated areas and those that inhabit relatively cleared areas (Table 8.1).

The HSMs were developed by using a range of ecologically-meaningful physical and climatic variables. Of the 26 variables considered in the model building process, 17 variables were included in the models. These were a mixture of physical and climatic variables. Their importance varied among models and not all variables were present in every model. It is important to note that due to time constraints additional variables considered to be relevant have not yet been included in the models, e.g. impervious surface areas and habitat heterogeneity.

Table 8.1 *List of frog species for which models were built.*

Species name	
Common Spadefoot Toad	Southern Brown Tree Frog
Eastern Banjo Frog	Spotted Marsh Frog
Eastern Common Froglet	Striped Marsh Frog
Growling Grass Frog	Victorian Smooth Froglet
Peron's Tree Frog	Whistling Tree Frog

A comparison of the HWS conceptual model for frogs (Figure 8.1**Figure**) and the predictor variables used in the HSMs shows good alignment. However, the HSM development process has identified a number of variables not captured in the HWS conceptual model which would be worth adding. These include:

- Temperature and climate metrics, such as Standardized Precipitation Evapotranspiration Index (SPEI). These variables will be particularly useful in the HSMs for assessing climate change impacts.
- Proportion and variability of dry features and emergent or terrestrial vegetation within the wetland. These are similar to the inundation extent and submerged vegetation conditions in the HWS conceptual models.

The conceptual models and the HSMs are a combination of variables which can be considered conditions or threats. For example, pest fish are more of a threat than an environmental condition. As has been done for the riparian vegetation conceptual model, a separate layer of threats and how they influence conditions would improve the frog conceptual model.

Preliminary model results

Broadly the models appear to reflect the recorded distributions of species. Figure 8.2 shows some examples of predictions for several frog species alongside species records. Predictions for widespread species are widely spread across the landscape and predictions for more restricted species, e.g. Growling Grass Frogs correspond to regions where these species have been recorded.

The habitat suitability models presented here are preliminary and require further validating. Additionally, the models do not yet contain some important variables, such as the extent of imperviousness in catchments.

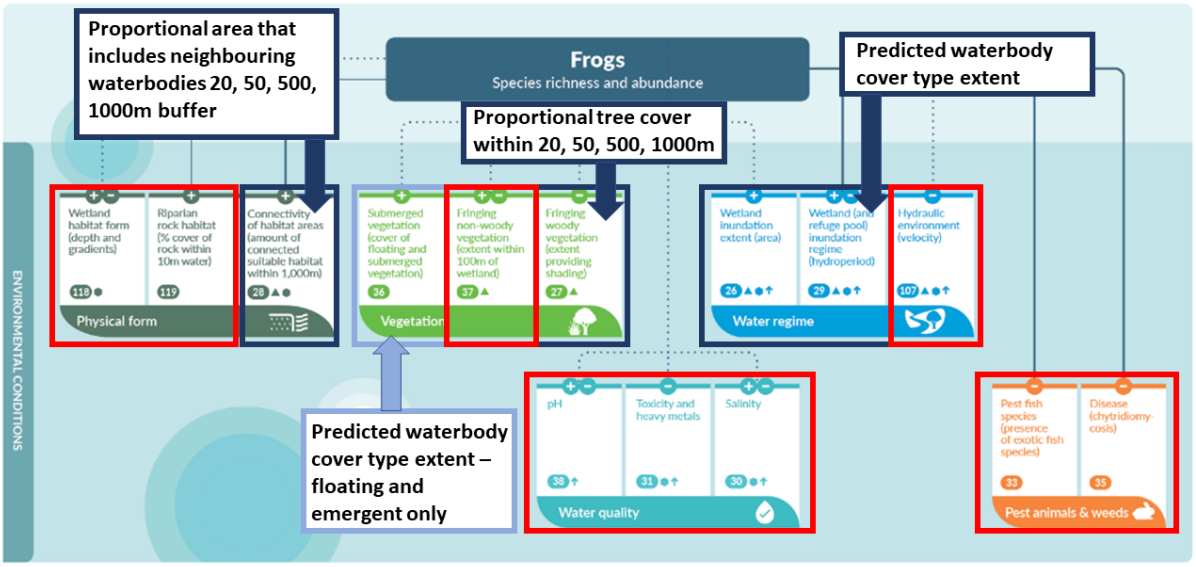


Figure 8.1 *Conceptual model of the links between environmental conditions and frogs as displayed in the HWS but with additional information showing where the predictor variables collated in the data library of the current project help inform the conceptual understanding. Bold text boxes provide descriptions of the HSM variables that directly relate to the HWS model. Variables boxed in dark blue represent those for which the SDM variables have been derived, in light blue those that are partially derived and in red, those that are not represented by the HSM variables.*

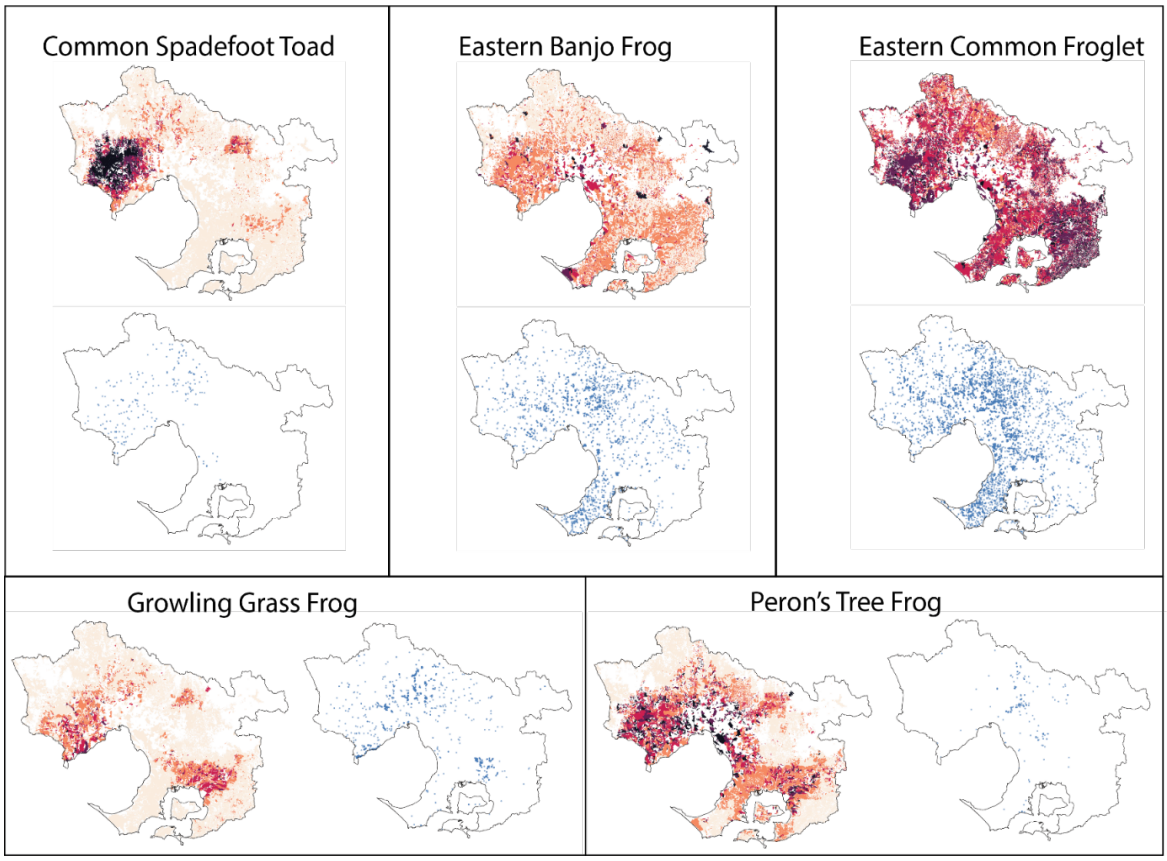


Figure 8.2 *Example of model outputs for some of the modelled species. Red shading show areas of higher habitat suitability and adjacent maps with blue shading show historical records or each species.*

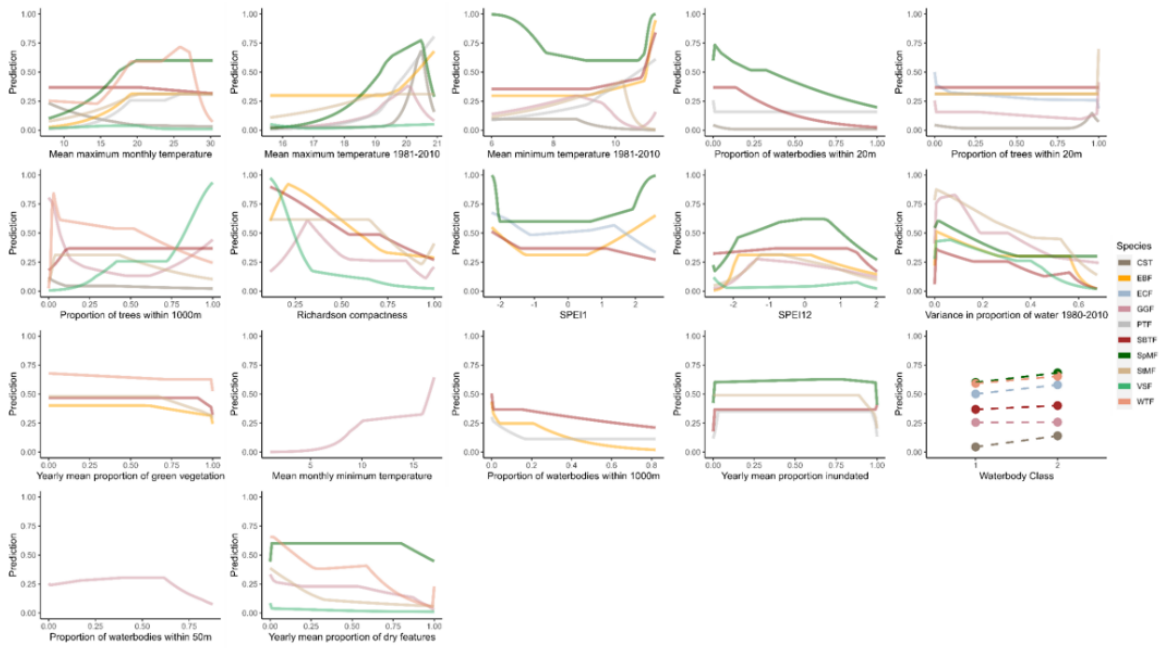


Figure 2 Partial response curves for each predictor variable. Frog species are indicated by colour. Partial response curves for a given predictor is produced by holding the values of other predictors in the fitted species model at their median value.

Figure 8.3 *Partial response curves for each predictor variable in our models.*

The responses of habitat suitability across the predictor variables show that many species respond to environmental conditions in similar ways but not in all cases. These findings suggest that a nuanced approach to wetland management will be required if healthy populations and communities of frogs are to be maximised. This may entail trade-offs in managing for specific species at the expense of other species where species co-occur.

Recommendations for consideration in Science Inquiry:

- Refine the HWS frog conceptual model based on new knowledge developed through the frog HSM development
- Regularly update and maintain the waterbodies spatial inventory to ensure ongoing utility and reliability for management and research applications.
- Finalise HSM for frogs, birds and fish, and develop decision support tools like zonation to aid in management scenarios for wetlands
- Undertake additional surveys in the south-east area of the Port Phillip and Western Port region where a number of the frog HSMs suggest high habitat suitability but where there are relatively few surveys
- Further develop the environmental data library to include predictors we expect to be influential, such as measures of impervious cover within the catchment areas of waterbodies. As well as predictors we would like to use to explore future scenarios of interest such as those associated with aspects of climate change impact

- Validate the models using averaged model predictions from specific time periods, rather than averages of the predictor variables over a time
- Consider other approaches to assessing climate change impacts as the HSMs will only provide partial ability to explore potential climate change impacts and mitigating actions. For example, they will not provide the capability to model the impacts of extreme events such as fire, heatwaves, 'rain bombs', floods, and storm surges.

8.3 How well do regionally significant wetlands relate to abiotic environmental gradients?

The rich HSM development datasets of environmental variables across the landscape have enabled an analysis of how the HWS priority wetlands reflect wetlands in the region as a whole.

The intent of the exercise is not to identify waterbodies to add to the regionally significant wetland list (many more considerations needed to inform such an action) but to highlight where gaps in environmental gradient space occur and flag these areas for further investigation.

Two approaches were taken: a Principal Components Analysis (PCA) was conducted using a set of least correlated variables, and variables were individually investigated by comparing the density of each variable across priority and non-priority waterbodies.

In both analyses the spread of regionally significant wetlands over the PCA space largely overlapped that of the remaining waterbodies (Figure 8.4). The analysis demonstrates that the regionally significant wetlands currently represent most of the variation in environmental gradients of waterbodies in the Melbourne region. Exceptions are those waterbodies with greater variance in inundation and vegetation extent and those with less perimeter complexity. Future allocation of regionally significant wetlands may take this into consideration.

While the analysis provides an inference on how representative regionally significant wetlands are across all of the considered environmental variables, how this representativeness relates to the suitability of conditions across environmental variable space for species is unexplored.

Recommendation for consideration in the Science inquiry:

- Maintain the current list of regionally significant wetlands as they appear to represent most of the variation in environmental gradients of waterbodies in the Melbourne region. Exceptions are those waterbodies with greater variance in inundation and vegetation extent and those with less perimeter complexity. Future allocation of regionally significant wetlands may take this into consideration.
- Once the HSMs are finalised, further analysis of representativeness across the region with respect to species should be carried out, ensuring timing that allows informing of the next Strategy, and wetland policy discussions.

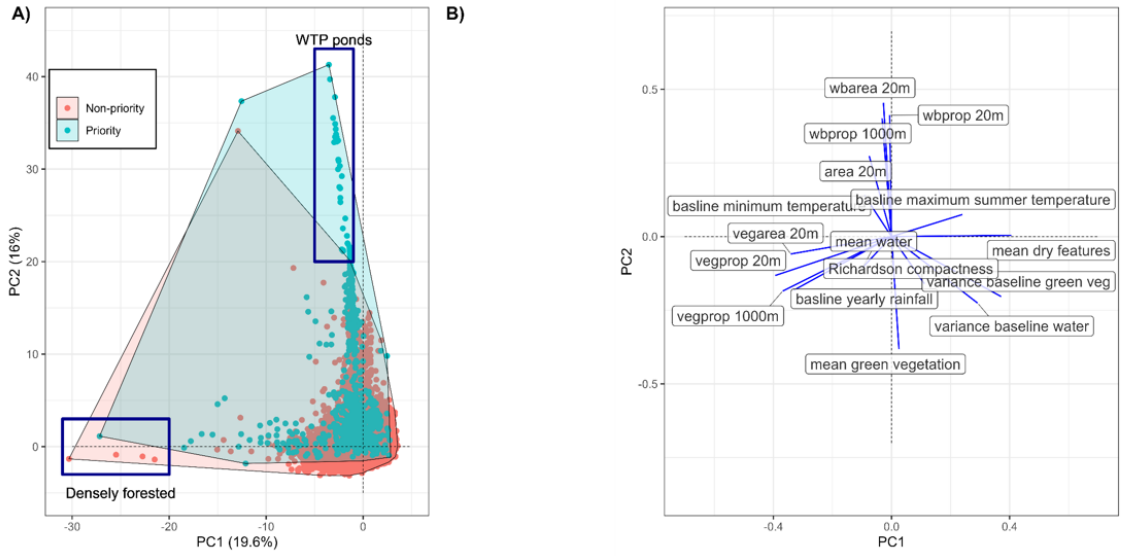


Figure 7 Results of the Principal Components Analysis on all waterbodies showing A) plot comparing the parameter space of regionally significant wetlands (blue) and all other (red) waterbodies, and B) attributes that are significantly correlated across the PCA space. Direction of trajectories indicate direction of increasing parameter value and length of trajectories indicate the cos2 (quality of representation of the variable across the PC space). Polygons around points are hulls.

Figure 8.4 *Partial response curves for each predictor variable in our models.*

8.4 Variability in wetland extent across wet and dry periods

Understanding how waterbodies in the Melbourne region may respond to drying climates is important. Predictions of cover type extent within wetland footprints were used to assess changes in cover type extent when annual climatic conditions in wetlands are much dryer than average. To determine drier years from those of average climatic conditions, measurements of 12 month lagged Standardized Precipitation Evapotranspiration Index (SPEI) were averaged for each year across all waterbodies. The analysis does not reflect the conditions in any given year but provides an indication of which waterbodies/regions undergo the greatest change at times when they experience dry climates.

Figure 8.5 provides maps of the proportional difference in feature extent within waterbodies in each of the 38,284 waterbody catchments within which waterbodies are situated. Overall, the data show that changes in cover type proportions are generally within 20%, but that the landscape predominantly becomes drier, with a smaller proportion of green features and water. Areas to the north-west and south-east tend to experience greater proportional change than elsewhere.

While refuge habitats appear to persist in the central Melbourne areas the ability for habitat to become refugia is highly dependent on species' distributions and their ability to reach refuge areas. Future analyses, incorporating the results of HSMs, could investigate the potential for waterbodies or regions to be refuge areas for particular species during dry conditions.

8.5 Change detection

Another useful analysis of the environmental attribute data is an assessment of wetland vegetation cover changes over time from 1987 – 2018. Preliminary analysis of this approach has been carried out (Figure 8.5).

Average yearly predictions of open water were calculated and a change point analysis provided a probability that a significant change in the extent of open water has occurred in each year. Google earth and Nearmap historical imagery was then used to view wetlands and assess how likely the change point analysis detected a true change in waterbody cover type extents.

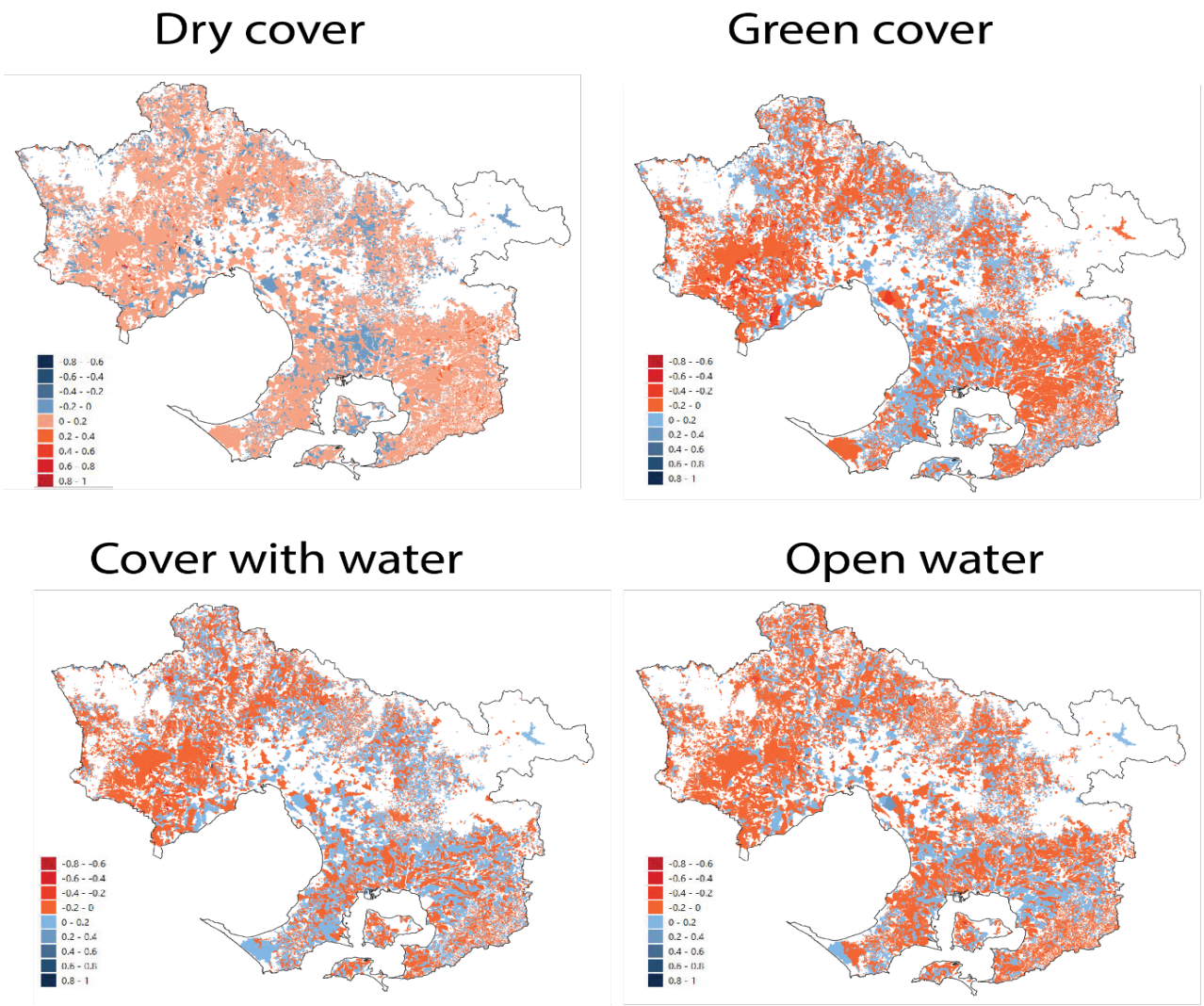


Figure 8.5 *Differences in the proportion of cover types within waterbodies from years where SPEI is between -0.5 and 0.5 to those where SPEI is < -1.5 (i.e. extra dry years). Colour scales vary such that redder values represent dryer conditions.*

Of the 678 priority waterbodies assessed, 568 had no detected change occur over the 31-year period. Forty-eight waterbodies recorded at least one detected change, primarily where waterbodies were constructed, and 37 had two changes detected. The maximum number of detected changes was 10, which occurred in one billabong situated on a floodplain. For this waterbody, detections were paired and reflected inundation in one year followed by drying in the next. The analysis was also able to detect the breaking point of the millennium drought in 2011.

This analysis needs further development to determine its applicability and accuracy of results.

Recommendation for consideration in Science Inquiry:

- Further develop the change detection methodology to determine its accuracy and applicability to flag wetlands where substantial changes in open water may have occurred and could be subject to follow up investigations.

8.6 Other relevant research and remaining knowledge gaps

KEQ 4b. What are the key remaining knowledge gaps that need to be addressed in the next five years to improve strategy delivery or prepare for the next HWS?

This question is addressed in Section F of the Science Inquiry report (Melbourne Water, 2023a) Table 8.2 .2 below is a list of current research projects that relate to wetlands that are also considered in related HWS technical reports.

Table 8.2 *Current Melbourne Waterway Research-Practice Partnership, Aquatic Pollution Prevention Partnership (A3P) and other Melbourne Water Waterways and Wetlands Program projects.*

Research Project name	Where research findings considered
A3P Project B2.6: Understanding contaminant risk to environmentally sensitive areas	Threats Technical report (Melbourne Water, 2023c)
A3P Project B1.1: Identifying and managing emerging contaminants of concern	
D4 - Yellingbo hydrology works MERI program	Interventions Technical report (Melbourne Water, 2023d)
Birrarung's billabongs - vegetation response to environmental watering	
MWRPP Project B3: Optimizing constructed wetland design, management and performance prediction	
A3P Project A1.2: Indicators and approaches to monitor the performance of stormwater wetlands	
A3P Project C3.3: Developing methods to increase the efficiency and effectiveness of waterway health assessment within streams, wetlands and estuaries	Threats Technical report (Melbourne Water, 2023c)
MWRPP Project E4: The impacts of 'next generation' citizen science programs.[11]	Values

[11] The eDNA research project with EnviroDNA is looking at the ability of eDNA to detect wetland plant species, as well as wetland bird species.

Recommendations for consideration in Science Inquiry:

- Leverage current research into constructed wetland performance to articulate the risk to key environmental values (e.g. from chemicals of concern) of using natural wetlands in the landscape as an alternative to traditional stormwater management. Develop guidance to protect and enhance natural wetlands in an urban development context.
- Undertake research to better understand the impacts of urbanisation and to define appropriate buffer distances and the measures required to maintain and improve values of differing sensitivity to human and vehicle movement, noise, lighting, introduced predators etc. In absence of this information, design responses in urban developments may miss the mark.

9. Threats

9.1 Background

This section relates to KEQ 2b. To what extent have projected known and emerging future threats changed from 2018? Have any assumptions about impacts to key values changed?

This section is provided for information purposes only as it is covered in more detail in the Threats Technical Paper (Melbourne Water 2023c).

A project has been initiated to look at 'what's changed' since the HWS was released. It considers both changes in the operating / external environment e.g. CMA merger with Melbourne Water and the new General Environmental Duty (GED) along with an evaluation of how each of the bio-physical threats (e.g. pest animals) have changed since 2018 (e.g. the threat from deer is increasing). The results of this project will feed into KEQ2b and be presented in the Science Inquiry.

The project will focus on:

1. What has changed in the external environment in the past few years to now, that may impact our effectiveness?
2. What is happening in our waterways and drainage operating environment and strategy implementation, that may impact our effectiveness, now and to the final strategy review?
3. How have our assumptions around threats to waterways changed since the strategy was developed? E.g. has the threat increased, remained the same or decreased?

The project will consider the impacts and implications of these changes. Table 9.1,**Table** below, presents a preliminary list of bio-physical threats to environmental values in wetlands. Threats to social values are outlined in the Threats Technical paper (Melbourne Water 2023c). It should be noted that climate change is considered both a threat in its own right and something that influences individual threats to varying degrees.

During the development of the HWS climate was considered to be a key threat to wetlands. The HWS resource document (Melbourne Water 2020a) summarises predicted changes to wetlands (permanent and temporary) and their biotic communities in response to forecasts of changes in climate change drivers (Nielsen & Brock 2009, cited in DELWP 2013). Wetlands considered at most risk from urbanisation and climate change were:

- Coastal wetlands within both rural and urban areas, due to sea level rise and storm surge projections and associated changes to water quality (increased salinity), inundation frequency and vegetation community change.
- Wetlands of the basalt plains within new urban growth areas due to both the physical loss of wetlands under development and changed hydrological regimes.

A series of discussions and workshops with subject matter experts are underway along with some quantitative and qualitative data analysis where feasible to help answer this KEQ. An example of the lines of enquiry being considered for the bio-physical threat evaluation is provided below.

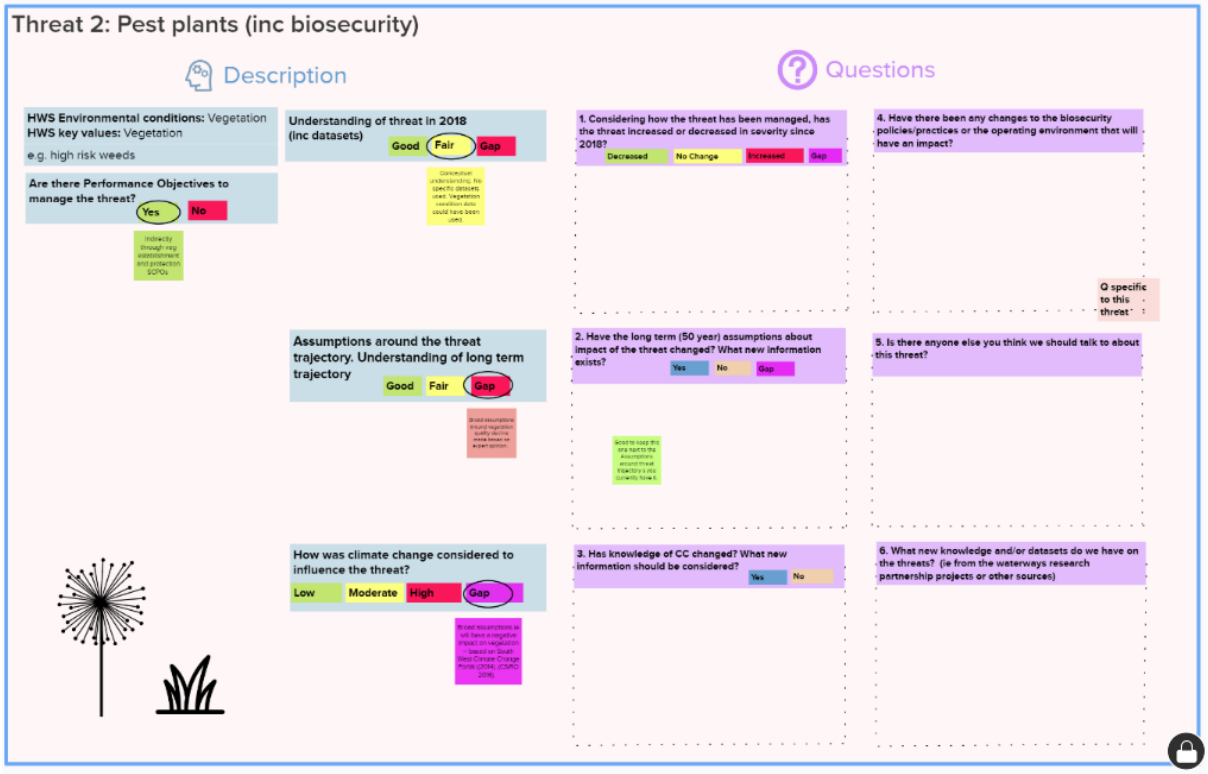


Figure 9.1 *Example of information being gathered to support evaluation KEQ2b.*

Table 9.1 *Draft list of threats to wetlands and links to related Melbourne Water research*

Threat	Examples	Environmental conditions	key values
urbanisation (quantity) changes to flow regime	Increased directly connected impervious surfaces change flow regime	Water Regime, Stormwater, Physical Form	all values
urbanisation (quality) toxicants/contaminants/microplastics/pathogens	Urban landuses e.g. industry, untreated sewerage ingress, construction phase of development.	Water quality	all values
Physical modifications	piping of headwater streams, channelisation of waterways, drains and levees, deepening for flood storage, building over wetlands, LWD removal, illegal alteration of waterway	Physical Form, Vegetation, Water regime	all values
STPs and ERSs and septic tanks	STPs discharges, ERS spills, poor septic performance/maintenance	Water quality	Macroinvertebrates, platypus
Litter	commercial areas, fishing equipment	Litter	Platypus, birds
Recreational access	Motor bikes/cars, noise, light, litter, excrement, dogs, tracks, veg clearance	Water quality, Vegetation	Birds, Vegetation

Threat	Examples	Environmental conditions	key values
instream barriers	gauging station weirs, dam walls, erosion control structures	Instream connectivity	Fish, platypus
pest plants (inc over abundant native species)	high risk weeds, Common Reed, Typha	Vegetation	Vegetation, birds
pest animals (inc over abundant native species)	deer, rabbits, cats, over abundant wildlife, exotic fish, Kangaroos, Noisy Miner	Vegetation, birds	Vegetation, birds
stock access	unfenced grazing land, trampling, pugging, introduction of weeds, bank erosion	Vegetation, Physical Form	Vegetation
vegetation clearing	illegal tree removal, forestry, recreation eg mtn bike tracks, 4WD tracks	Vegetation	Vegetation
farm dams	on-line and off-line dams, licensed and unlicensed	Water Regime	all values
water extraction	water supply dams, surface water diversions, groundwater extractions	Water Regime	all values
Agriculture	Agriculture, intensification of agriculture, pesticide drift	Water Quality, Water Regime	all values
'natural' disturbances	Bushfires, floods, storms, wind	Water Quality, Water Regime, Physical Form, Vegetation	all values
climate change (can also influence above threats)	water temperature increases, reduction in flow, increased storm intensity, increased urban heat, sea level rise	Water Quality, Water Regime, Physical Form, Vegetation	all values

10. Interventions

10.1 KEQ 4a. To what extent are interventions appropriate and effective for achieving outcomes?

There are several wetland intervention monitoring projects being run by Melbourne Water or DEECA which will lead to improved understanding of various components of our conceptual models (see HWS Technical Resource Document, Melbourne Water 2020). These are presented in Table 10.1**Table** and the ones which are suitable for evaluation are presented in Table 10.2. Note that the State run programs have very few sites in the HWS region but the findings from the programs will be used as a broader reference for comparison with results from the HWS intervention monitoring programs.

Table 10.1 *Summary of intervention monitoring projects for wetlands related to the HWS wetland conditions and key values.*

Project name	Research Questions	Objectives	Study sites	Data collection
Melbourne Water programs				
Ecological monitoring program for Yarra billabongs	(1) Does environmental water delivery enable successful frog reproduction? (2) Are predatory fish species present and potentially impacting frog breeding? (3) How should we monitor frog reproduction?	To improve knowledge about the relationship between environmental water delivery and frog reproduction to support effective delivery of environmental flows.	Eight Yarra billabongs (Willsmere, Wilson Reserve, Burke Road, Bolin Bolin, Annulus, Banyule, Birrarrung, and Montpelier). Initial (2020/21) focus is Annulus Billabong, with control sites: Birrarung and Bolin Bolin. Baseline data are being collected at six other sites.	Frog species presence (songmeter) Frog life stage (field surveys) Presence of predatory fish species Water quality Habitat assessment Time-lapse camera monitoring of water depth
A2 sub MERI: Birrarung billabong's vegetation response to environmental watering	What is the response of floodplain vegetation (including mature and culturally significant River Red Gums, Floodplain Wetland Aggregate and Floodplain Riparian Woodland) to environmental watering? Secondary Q: What is the relationship between vegetation outcomes and key fauna species?	To improve knowledge about the relationship between environmental water delivery and vegetation response (including for mature trees) to support effective delivery of environmental flows working with the Wurundjeri people.	Montpellier, Burke Rd, Bolin Bolin, Willsmere and a third site TBC (Banksia St, Annulus, Baileys' Billabongs)	Water levels Flora species River Red Gum health

Project name	Research Questions	Objectives	Study sites	Data collection
Rehabilitation of former sewage treatment ponds at the WTP – salt marsh restoration	Rehabilitation of former sewage treatment ponds at the WTP – can we restore coastal saltmarsh, and its ecological functions, in a cost effective manner?	To determine vegetation (salt marsh) response to rehabilitation works.	Former Western Lagoon, WTP.	Permanent quadrats, ~ 3 yearly surveys floristics and cover
WTP shorebird pond management	How do we best manage water levels to support maximum numbers of migratory shorebirds (foraging or roosting) at key periods on their migration cycle?	To improve water management (and achieve potential water savings) at shorebird ponds at the WTP	WTP shorebird ponds	Water levels Some water chemistry parameters Shorebird numbers and activities
Sites of Biodiversity Significance Monitoring Quadrats (relating to wetlands)	Are MW's Sites of Biodiversity Significance being effectively protected?	Monitor changes in values and threats. Determine whether investment in these sites is providing the necessary biodiversity outcomes.	43 Sites of Biodiversity Significance (assessed every 3 years)	Vegetation Community Vegetation Extent and Condition Recruitment Pest / Weeds Human Disturbance
Enhancing Our Dandenong Creek (EODC) native fish project	Can we successfully translocate threatened species of fish into 'constructed' habitat?	To assess the success of translocations of threatened native fish – dwarf galaxias and Yarra pygmy perch	Dandenong Creek	
Cockatoo Creek floodplain	What water regime is required to support Mountain Swamp Gum habitat for the Helmeted Honeyeater and Leadbeater's Possum	Improve condition of vegetation in floodplain which is habitat for threatened species of animal.	Cockatoo Creek floodplain in Yellingbo Nature Conservation Reserve	Water levels (including groundwater) Vegetation condition
Controlling over-abundant reeds at a Ramsar Wetland	How do we best limit reed bed extent and retain shorebird foraging areas?	To maintain Ramsar LACS for key listed species at Edithvale Wetlands	Edithvale Wetlands	Red bed extent Shorebird numbers and distribution Australasian Bittern numbers
State programs				
WIMP	Vegetation response to wetland grazing (weeds, native vegetation, community assemblage relative to EVC, vegetation structure, vegetation extent, habitat for significant flora)	(i) Provide rigorous evidence of the responses of wetland attributes to management, (ii) assess if and why responses to management vary among wetlands and (iii) improve	A selection of sites across Victoria in the Wimmera, Glenelg Hopkins, Corangamite and West Gippsland CMA regions.	Vegetation

Project name	Research Questions	Objectives	Study sites	Data collection
		conceptual models of expected outcomes of wetland management		
WetMAP	Identify short term responses of frogs, birds, vegetation and fish to watering events Identify the water regimes (timing, duration, frequency) needed to support populations of biota Determine if current water regimes and environmental water practice are meeting these needs. Specific KEQs for fish, vegetation, birds and frogs.	To identify the relationship between the delivery of environmental water and ecological responses in Victorian wetlands, and to understand the mechanisms that govern the movement of species across the landscape.	A selection of sites across Victoria	Birds Fish Frogs Vegetation

Table 10.2 *Summary of wetland intervention research projects to be included in mid-term evaluation*

Intervention Group	Intervention type	Specifics	Current extent of use in region	Relevant program or research project
Establish	Revegetation	Saltmarsh restoration	Low	Rehabilitation of former sewage treatment ponds at the WTP – salt marsh restoration
Maintain/protect	Vegetation	Reeds	Low	Controlling over-abundant reeds at a Ramsar Wetland
Maintain/protect	Water licensing and flow release	Flow releases Physical modification	High Low	A2-sub Birrarung's billabongs: vegetation response to environmental watering D4 Yellingbo hydrology works MERI program WTP shorebird pond management Cockatoo Creek floodplain

12. Summary of recommendations for consideration

The recommendations presented in individual sections of the report are repeated here for ease of reference and will be considered during the drafting of the Science Inquiry.

Section 3 summary of current management

- Ensure new regional priority wetlands identified since 2018 (that do not have performance objectives) are managed to maintain existing values, for example risk-based predator control.
- Strengthen the protection of natural wetlands from the specific threat of urban development by instituting a new RPO or rewording, RPO 29, such as “Programs, standards, tools and guidelines are in place to protect natural wetlands (values and function) are protected from urban development”.
- Complete updating state wetlands mapping to reflect the best available information for the Port Phillip and Westernport region, alignment with mapping on the Healthy Waterways Strategy and Regional Catchment Strategy web sites. This is important because it functions as the key reference document for all planning decisions for natural wetlands as related to in Victorian Planning Provisions 12.01-1S Biodiversity where the Regional Catchment Strategy is referred. This may need to be more strongly referred to and integrated by embedding into State Planning Scheme.
- Further explore opportunities from the integration of Melbourne Water with Port Phillip and Westernport CMA, to improve wetland protection, particularly for those of most significance such as seasonal herbaceous wetlands.
- The Victorian Planning Provisions 12.03-1S River corridors, waterways, lakes and wetland to be updated by government to refer to the Healthy Waterways Strategy 2018 (as it still refers to HWS 2013).
- Advocate to improve natural wetland protections through the next iteration of the Victorian Waterway Management Strategy through a planning and policy framework that recognises the need for the protection of function and form, not just for managing conditions.
- Continue to improve data and give further consideration of available spatial data, quantum/costs of management action (and inaction), expert opinion, and economic analysis to increase the power of the prioritisation decision tool. Work to embed this tool into policy, decision making and planning processes (e.g. getting ahead of PSP processes).
- PSPs and Development Services Schemes to ensure that they understand when a natural wetland is a Designated Waterway and design responses that support their protection in accordance with this (i.e. minimum 20 m buffer). Embedding the General Environmental Duty into decision making, “manage your activities to avoid the risk of environmental damage” is a principle also for further exploration. Ensure environmental and cultural values are considered in planning stages (e.g. Minta farm is a good example)
- Support alternative water supplies and integrated water management to reduce private landholders reliance on natural wetlands for use as farm dams and open the door to consideration of policy change through review of the Victorian Water Management Strategy. This will be of upmost importance when we face another drought.

- Proactively review natural wetland values and establish planning protections in collaboration with local governments and DEECA near and around the growth boundary to ensure their consideration for better protection with future growth boundary reviews.
- Collaboratively explore with the Natural Wetlands Protection Working Group mechanisms such as the application of Urban Flood Zones for natural wetland protection when associated with floodplains.
- More deeply walk with traditional owners on this issue and provide accessible information and data to support Caring for Country beyond the archaeological perspective.
- Continue to have collaborative catchment forums to both foster, but also highlight the existing, community appreciation and love of our wetlands and their values

Section 4 wetland frogs and fish

- Urgent attention to protect threatened species is required – develop a strategic management plan for growling grass frog, southern toadlet and pygmy perch. Use the platypus strategic management plan as an example.

Section 5 wetland birds

From KEQ 3a:

- Investigate the two wetlands where the bird index score has dropped (i.e. Truganina Swamp and Paradise Road Ponds at the WTP).
- Communicate the new benchmark results and explore options for updating the long term targets in light of the new benchmark.

(from Birdlife Australia report)

- Melbourne Water continues to develop the Wetland Bird Index using Summed Reporting Rate for the Basic Score as a useful means of tracking the condition of wetland bird communities over time using bird data.
- Ensure a minimum of 40 robust counts per 5-year reporting period to give some confidence to the calculated Wetland Bird Indices. To do this we require monthly counts (not quarterly or bi-monthly, as previously suggested). Therefore, we focus wetland bird monitoring at a number of selected, representative, regional priority wetlands rather than attempt to cover all regional wetlands with potential bird value.
- For the Wetland Bird Index, Melbourne Water considers a weighting system for identifying 'listed' species, such that species listed as threatened under the Commonwealth EPBC Act 1999 and the Victorian FFG Act 1988, are provided more weight than species listed only under the Migratory Schedules (i.e. not threatened) under EPBC Act.
- For the Listed Species sub-index, Melbourne Water considers, for completeness and because it is a dynamic document and often a precursor to a threatened species being listed under the EPBC Act 1999, incorporating the Conservation Statuses of threatened wetland bird species provided in the *National Action Plan for Australian Birds* (Garnett et al. 2020).
- To rigorously comment on the drivers behind wetland bird community change at the site level (and subsequent wetland bird index score changes), it is important to incorporate site-based management data (e.g. water levels, salinity, vegetation works, nutrient levels) as

covariates. Evidence of variation in wetland bird communities within a sub-catchment may suggest site scale influences, including management interventions, may be driving change. Given one of the goals of this project is to provide operational scale feedback to Melbourne Water site managers it is important that management influences on wetlands are being captured and related back to avian responses.

Section 6 wetland vegetation

- Develop remote sensing to collect data for the wetland extent metric and ensure data for other metrics (e.g. IWC vegetation condition) and threatened species is ready for final strategy evaluation.

Section 7 Wetland conditions

- Review/ update our priority wetland list to focus monitoring on current high value and regionally significant wetlands. At the very least, certain wetlands currently on our list need to be removed since we now know they have been altered and/or lost the values for which they were noted.
- Remove constructed wetlands and waterbodies e.g. urban lakes from the IWC assessments as these are monitored via Melbourne Water's asset management framework which focuses on system performance. These wetlands should not be part of the end of strategy HWS condition assessments.
- All wetland assessments undertaken for other reasons e.g. planning for growth should include a standard IWC assessment, and these data should be made available to the monitoring team as early as possible.
- Communicate the new benchmark results and explore options for updating the long term targets in light of the new benchmark.
- Wetland area is a basic but essential measure of wetland condition. While we record wetland extent in IWC assessments, and include an assessment of wetland area for every annual report, this is not made explicit in the 2020 Wetland Monitoring and Evaluation Plan. Ensure the next iteration of the Wetland Monitoring and Evaluation Plan includes this requirement.

Section 8 Research

New wetlands map layer

- Regularly update, maintain and evaluate the waterbodies spatial inventory to ensure ongoing utility and reliability for management and research applications and identify wetlands at risk.

Frog HSMs

- Refine the HWS frog conceptual model based on new knowledge developed through the frog HSM development
- Regularly update and maintain the waterbodies spatial inventory to ensure ongoing utility and reliability for management and research applications.

- Finalise HSM for frogs, birds and fish, and develop decision support tools like zonation to aid in management scenarios for wetlands
- Undertake additional surveys in the south-east area of the Port Phillip and Western Port region where a number of the frog HSMs suggest high habitat suitability but where there are relatively few surveys
- Further develop the environmental data library to include predictors we expect to be influential, such as measures of impervious cover within the catchment areas of waterbodies. As well as predictors we would like to use to explore future scenarios of interest such as those associated with aspects of climate change impact
- Validate the models using averaged model predictions from specific time periods, rather than averages of the predictor variables over a time
- Consider other approaches to assessing climate change impacts as the HSMs will only provide partial ability to explore potential climate change impacts and mitigating actions. Eg they will not provide the capability to model the impacts of extreme events such as fire, heatwaves, 'rain bombs', floods, and storm surges

Regionally significant wetlands

- Once the HSMs are finalised further analysis of representativeness across the region with respect to species should be carried out.

Change detection

- Further develop the change detection methodology to determine its accuracy and applicability

Knowledge gaps

- Leverage current research into constructed wetland performance to articulate the risk to key environmental values (e.g. from chemicals of concern) of using natural wetlands in the landscape as an alternative to traditional stormwater management. Develop guidance to protect and enhance natural wetlands in an urban development context. (refer section 3)
- Undertake research to better understand the impacts of urbanisation and to define appropriate buffer distances and the measures required to maintain and improve values of differing sensitivity to human and vehicle movement, noise, lighting, introduced predators etc. In absence of this information, design responses in urban developments may miss the mark. (refer section 3).

13. References

AECOM (2012a). Bird Diversity Sub-indices for Waterway Quality Assessment: Melbourne Water Region. Report prepared for Melbourne Water by AECOM Australia Pty Ltd, Melbourne.

AECOM (2012b). Evaluation of Riparian Works - Bird Communities Projects A and C (Phase 1) - Conceptual Model and Site Selection for Bird Monitoring. Report prepared for Melbourne Water by AECOM Australia Pty Ltd, Melbourne.

Alluvium (2017). Healthy Waterways Strategy Waterway Science Conceptual Models. Report developed for Melbourne Water by Alluvium Consulting, Melbourne.

Alluvium (2020). Wallan–Beveridge Pre-planning Waterways Assessment 2020 (Stage 1 to 3 – Desktop, field and modelling assessments). Report prepared for Melbourne Water by Alluvium Consulting Australia Pty Ltd, Melbourne.

Alluvium (2021a). Burrung buluk (Misty Swamp) formerly Hanna Swamp Protection and Enhancement Assessment. Report prepared for Melbourne Water by Alluvium Consulting Australia Pty Ltd, Melbourne.

Alluvium (2021b). Hanna Swamp Investigation Report. Report (no. 0120263) prepared for the Victorian Planning Authority by Alluvium Consulting Australia Pty Ltd, Melbourne.

Alluvium (2021c). Minta Farm Embankment Investigation and Assessment. Report prepared for Melbourne Water by Alluvium Consulting Pty Ltd, Melbourne.

Alluvium (2023). HWS Priority Wetlands Condition Assessments: First Summary Field Report, Spring 2022. Report prepared for Melbourne Water by Alluvium Consulting Australia Pty Ltd and EcoFutures Consulting Pty Ltd, Melbourne.

Alluvium (in prep. a). Cunningham's Swamp values and eco-hydrology investigation. Draft report to Melbourne Water by Alluvium Consulting Australia Pty Ltd, Melbourne.

Alluvium (in prep. c). Addition to Wallan-Beveridge investigation and planning for Hernes Swamp /Merri Floodplains. Draft report to Melbourne Water by Alluvium Consulting Australia Pty Ltd, Melbourne

Argent, R.M., Finlayson, B.L. & McMahon, T.A. (1991). The Hydrology of Selected Sites in the Western Wetlands Region of Melbourne. Western Wetlands Project: Report No. 2, Centre for Environmental Applied Hydrology, University of Melbourne for the Department of Conservation & Environment, Victoria.

Beardsell, C. (1991). Sites of Faunal Significance in the Western Region of Melbourne (inland of the Princes Freeway). Department of Conservation and Environment, Victoria.

Beardsell, C. (1997). Sites of Faunal and Habitat Significance in North East Melbourne, volumes 1 to 6. Nillumbik Shire Council.

Biosis (2019). Extent of Tootgarook Wetland, Mornington Peninsula, Victoria. Report prepared for Mornington Peninsula Shire Council by Biosis Pty Ltd, Melbourne.

BirdLife Australia (2013). Change in Saltmarsh Orange-bellied Parrot habitat at the Western Treatment Plant and The Spit Nature Conservation Reserve between 2005 and 2013. Unpublished report prepared for Melbourne Water by G Ehmke and K Herman. BirdLife Australia, Carlton.

BirdLife Australia (2016a). Tootgarook Swamp Bird Monitoring Program – Year 2 Annual Report. Unpublished report prepared by C. Purnell and K. Herman for the Mornington Peninsula Shire Council. BirdLife Australia, Carlton, Victoria.

BirdLife Australia (2016b). 'Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species'. Unpublished report prepared for the Australian Government Department of Environment by B.D. Hansen, R.A. Fuller, D. Watkins, D.I. Rogers, R.S. Clemens, M. Newman, E.J. Woehler & D.R. Weller. Birdlife Australia, Carlton, Victoria. https://www.environment.gov.au/system/files/resources/da31ad38-f874-4746-a971-5510527694a4/files/revision-east-asian-australasian-flyway-population-sept-2016.pdf

BirdLife Australia (2017). 'Migratory Shorebird Conservation Action Plan'. Unpublished report prepared by K. Herman for Melbourne Water. BirdLife Australia, Carlton, Victoria.

BirdLife Australia (2019). Key Biodiversity Areas (KBAs) - Nature's Hotspots. Available at: http://birdlife.org.au/projects/KBA

Birdlife Australia (2020a). Melbourne Water Regional Bird Monitoring Project: Annual report 2018–19. Unpublished report prepared for Melbourne Water by BirdLife Australia, Carlton, Victoria.

BirdLife Australia (2020b). Melbourne Water Regional Bird Monitoring Project: Annual Report 2019–20. Unpublished report prepared for Melbourne Water by BirdLife Australia, Carlton, Victoria.

BirdLife Australia (2020c). Edithvale Seaford Wetland Ramsar Site Limits of Acceptable Change reporting: July 2014 to July 2019. Unpublished report prepared for Melbourne Water. BirdLife Australia, Carlton, Victoria.

Birdlife Australia (2020d). Australian National Directory of Important Migratory Shorebird Habitat. Chapter 7: Victoria. Birdlife Australia, Carlton.

BirdLife Australia (2021a). Edithvale Seaford Wetlands Ramsar Site Limits of Acceptable Change reporting: July 2015 to July 2020. Unpublished report prepared for Melbourne Water. BirdLife Australia, Carlton, Victoria.

BirdLife Australia (2021b). Edithvale Seaford Wetlands Ramsar Site Limits of Acceptable Change Reporting: July 2016 to June 2021. Unpublished report prepared by D.G. Quin, B. Clarke-Wood, C. Purnell and A. Silcocks for Melbourne Water. BirdLife Australia, Carlton, Victoria.

BirdLife Australia (2022a). Bird Monitoring at Selected Yarra River Billabongs, 2021 to 2022. Unpublished report prepared by for Melbourne Water by BirdLife Australia, Carlton.

BirdLife Australia (2022b). Melbourne Water Mid-Term Review. Unpublished report prepared for Melbourne Water by BirdLife Australia, Carlton.

BirdLife Australia (undated). BirdLife Australia's Bittern Survey Guide. https://direct.birdlife.org.au/documents/AB-Bitternsurveyguide.pdf

Bishop, J.A. & Myers, W.L. (2005). Associations between avian functional guild response and regional landscape properties for conservation planning. *Ecological Indicators* 5: 33–48.

Casanova, M.T. (2011). Using water plant functional groups to investigate environmental water requirements. *Freshwater Biology* 56: 2637–2652.

Champness, V. & Taylor, J. (2015). 'How effective are constructed wetlands in enhancing biodiversity values? An assessment of the relationship between wetland vegetation structure and avian guild diversity in stormwater treatment wetlands'. Unpublished intern project, Birdlife Australia, Carlton, Victoria.

Chinathamby, K., Vu, H., Reid, R. & Long, S. (2022). Assessing the Toxicity of Water from Seaford Wetlands on Macroinvertebrates and Plants. Progress Report. Aquatic Environmental Stress Research Group, Technical Report No. 62, RMIT University, Victoria, Australia.

CHSM (Committee for Holarctic Shorebird Monitoring) (2004). Monitoring Arctic-nesting shorebirds: an international vision for the future. *Wader Study Group Bulletin* 103: 2–5.

Clarke, R.H., Herrod, A., Loyn, R.H., Carter, M.J., Silcocks, A., Menkhorst, P. & Johnstone, C. (2015). Waterbird Fluctuations at Coastal Wetland Refugia in Response to Murray-Darling Basin Streamflow and Rainfall. Report prepared for Melbourne Water by the School of Biological Sciences, Monash University, Melbourne.

Cleeland, C. (2022). Southern Toadlet, *Pseudophryne semimarmorata*, monitoring in Sugarloaf Reservoir, Churchill NP and Lysterfield Park - 2022. Report to Melbourne Water, Ecology Australia Pty. Ltd., Fairfield, Victoria.

Cleeland, C. (2023). Targeted Survey of Potential Toadlet, *Pseudophryne* spp. sites and analysis of historical records in the Melbourne Water catchments. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Thomastown, Victoria.

Clemens, R.S., Rogers, D.I., Hansen, B.D., Gosbell, K., Minton, C.D.T., Straw, P., Bamford, M., Woehler, E.J., Milton, D.A., Weston, M.A., Venables, B., Weller, D.R., Hassell, C., Rutherford, B., Onton, K., Herrod, A., Studds, C.E., Choi, C.Y., Dhanjal-Adams, K.L., Murray, N.J., Skilleter, G. & Fuller, R.A. (2016). Continental-scale decreases in shorebird populations in Australia. *Emu* 116: 119-135.

Cook, D., Just, K. & Jolly, K. (2013). Rockbank Area Wetland Survey. Unpublished report prepared for Melbourne Water by Rakali Consulting Pty Ltd and Holocene Environmental Science, Victoria.

Corrick, A.H. & Norman, F.I. (1976) A report on a survey of the coastal wetlands of south-eastern Victoria. Fisheries and Wildlife Division, Ministry for Conservation. Unpublished.

Corrick, A.H. & Norman, F.I. (1980). Wetlands of Victoria I. Wetlands and waterbirds of the Snowy River and Gippsland Lakes Catchment. *Proceedings of the Royal Society of Victoria* 91: 1–15.

Corrick, A.H. (1982). Wetlands of Victoria II. Wetlands and waterbirds between Port Phillip Bay and Mount Emu Creek. *Proceedings of the Royal Society of Victoria* 94: 69–87.

Cowling, S. (undated) .*Explore Melbourne's Wetlands*. National Trust Victoria with the Department of Conservation and Environment and Board of Works, Melbourne.

DEE (2017). 'EPBC Act Policy Statement 3.21 Industry Guidelines for Avoiding, Assessing and Mitigating Impacts on EPBC Act Listed migratory shorebird species'. Department of the Environment and Energy, Canberra.

Delany, S. (2003). How many of the world's wader species are declining, and where are the globally threatened species? *Wader Study Group Bulletin* 101/102: 13.

Dell, M. (2021). A Review of Sites of Biodiversity Significance Condition Monitoring Objectives and Methods. Report prepared for Melbourne Water by Dell Botany, Coldstream, Victoria.

DELWP (2015). Aquatic Value Identification and Risk Assessment (AVIRA) Manual. Department of Environment, Land, water and Planning, Victoria.

DELWP (2015). Monitoring of Waterbird Populations at the Western Treatment Plant: 2014–2015 Annual Report'. Unpublished report prepared by P.W. Menkhorst, P. Macak, D.I. Rogers, K. Stamation and R. Swindley for Melbourne Water (Arthur Rylah Institute for Environmental Research and Department of Environment, Land, Water and Planning, Heidelberg, Victoria)

DELWP (2017). Western Port Ramsar Site Management Plan. Department of Environment, Land, Water and Planning, Melbourne.

DELWP (2018). Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site Management Plan. Department of Environment, Land, Water and Planning, Victoria.

DELWP (2019a). 'WetMAP Bird Theme Annual Report 2018/19'. Unpublished report prepared by D. Rogers, D. Purdey, K. Stamation, D. Quin and R. Upton for Water and Catchments Group, Department of Environment, Land, Water and Planning. Arthur Rylah Institute for Environmental Research and Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

DELWP (2019c).. 'Project plan: 2019-20 WetMAP Bird Theme. 2019–20 Monitoring Bird Response to Environmental Water Delivery in Victoria'. Unpublished report prepared by D. Rogers, K. Stamation, D. Purdey, R. Hale and A. Sparrow for Water and Catchments, DELWP, Victoria. Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

DEPI (2013). The Impact of Melbourne's Growth on 'Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains': Melbourne Strategic Assessment, Victorian Government Department of Environment and Primary Industries, Melbourne.

DNRE (2002). Biosites: Sites of Biodiversity Significance in Port Phillip and Westernport Region, Victoria. Department of Natural Resources & Environment, Melbourne.

Doeg, T. (2011). Levels of Service for Environmental Values in the Melbourne Water Area. Discussion paper prepared for Melbourne Water, Melbourne.

DSE (2005). 'Biosites Update, State of Victoria'. Department of Sustainability and Environment, East Melbourne.

DSE (2006). 'Powerful Owl Monitoring Blackburn Creek, Blackburn'. Unpublished report prepared by E. McNabb for Melbourne Water. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria.

DSE (2007). Relationships between Shorebird and Benthos Distribution at the Western Treatment Plant. Unpublished report prepared by D.I. Rogers, R. Loyn, S. McKay, D. Bryant, R. Swindley and P. Papas. Arthur Rylah Institute for Environmental Research Technical Report Series No.169. Department of Sustainability and Environment, Heidelberg, Victoria.

DSE (2013). Advisory List of Threatened Vertebrate Fauna in Victoria - 2013. Department of Sustainability and Environment, East Melbourne.

EAAFP (2017). http://www.eaaflyway.net/revision-of-the-eaaf-population-estimates-for-37-listed-migratory-shorebird-species/

Ecoaerial (2022). Melbourne Water Yering Backswamp Bat Activity Survey. Report prepared for Melbourne Water by Ecoaerial, Melbourne.

Ecology & Heritage Partners (2017). Review of Data and Condition Metric for Healthy Waterway Strategy Frog Value Review and Data Collation. Report prepared for Melbourne Water by Ecology & Heritage Partners Pty Ltd, Melbourne.

Ecology & Heritage Partners (2018). Flora and Fauna Assessment: Hallam Valley Floodplain. Unpublished report prepared for Melbourne Water by Ecology & Heritage Partners, Melbourne.

Ecology & Heritage Partners (2019). Existing Conditions Report for Aviators Field Precinct Structure Plan: 756 Aviation Road, Point Cook, Victoria. Report prepared for the Dahua Group Melbourne Investment Pty Ltd by Ecology and Heritage Partners Pty Ltd, Melbourne.

Ecology & Heritage Partners (2020). Targeted Fauna Survey and Ground-truthing Native Vegetation Extent: Aviators Field Precinct Structure Plan, Point Cook, Victoria. Report prepared for the Dahua Group Melbourne Investment Pty Ltd by Ecology and Heritage Partners Pty Ltd, Melbourne.

Ecology & Heritage Partners (2021a). Growling Grass Frog Monitoring 2020/21, Western Treatment Plant, Victoria. Report prepared for Melbourne Water by Ecology and Heritage Partners Pty Ltd, Melbourne.

Ecology & Heritage Partners (2021b). Environment Report for the Proposed Beveridge Intermodal Logistics Park: Beveridge Road, Beveridge, Victoria. Report prepared for Beveridge Property Management Services Pty Ltd by Ecology and Heritage Partners Pty Ltd, Melbourne.

Ecology & Heritage Partners (2022). Growling Grass Frog Monitoring 2021/22, Western Treatment Plant, Victoria. Report prepared for Melbourne Water by Ecology and Heritage Partners Pty Ltd, Melbourne.

Ecology Australia (2007a). 'Skeleton Creek – Hoppers Crossing Crake and Rail Survey'. Unpublished report prepared by D.G. Quin, C. Renowden, E.D. Moysey and L.V. Crowfoot for Melbourne Water. Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2007b). 'Big Flower Farm and Fishers Wetland, Phillip Island – Flora and Fauna Review'. Unpublished report prepared by L.V.C. Crowfoot and D.G. Quin for Melbourne Water (Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2009). Western Treatment Plant: Saltmarsh Mapping for the Western Lagoon Restoration Project. (Ecology Australia: Fairfield)

Ecology Australia (2010). Western Treatment Plant: Western Lagoon and The Spit Nature Conservation Reserve Coastal Saltmarsh Assessment. (Ecology Australia: Fairfield)

Ecology Australia (2012a). Habitat Use by Latham's Snipe. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Melbourne.

Ecology Australia (2012b). Western Treatment Plant: Results of monitoring of saltmarsh colonisation of the Western Lagoon to May 2012. (Ecology Australia: Fairfield)

Ecology Australia (2012c). 'Thomson and Latrobe River Floodplains - Fauna Surveys'. Unpublished report prepared by J. Urlus and J. Ricciardello for the West Gippsland Catchment Management Authority. Ecology Australia Pty Ltd, Fairfield, Victoria)

Ecology Australia (2013a). Sites of Biodiversity Significance Management Strategy - 2013. Unpublished report prepared by C. Renowden, A.R.G. McMahon and D.G. Quin for Melbourne Water. Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2013b). Sites of Biodiversity Significance Management Strategy - Background Document 2013. Unpublished report prepared by C. Renowden, A.R.G. McMahon and D.G. Quin for Melbourne Water. Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2016). Edithvale-Seaford Wetlands Ramsar Site Management Plan. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2016). Edithvale-Seaford Wetlands Ramsar Site Management Plan. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2017a). Saltmarsh recolonisation at the Western Lagoon 'Restored Saltmarsh 2016' pond, Western Treatment Plant, December 2016 to May 2017. (Ecology Australia: Fairfield)

Ecology Australia (2017b). Coastal vegetation representing Orange-bellied Parrot food plants - Western Treatment Plant and The Spit Nature Conservation Reserve. Ecology Australia Pty Ltd, Fairfield.

Ecology Australia (2018). Saltmarsh recolonisation at the Western Lagoon 'Restored Saltmarsh 2016' pond, Western Treatment Plant, November 2017 and March 2018. (Ecology Australia: Fairfield)

Ecology Australia (2019). Growling Grass Frog Monitoring, Western Treatment Plant 2018/19. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2019a). Investigations into Southern Toadlet *Pseudophryne semimarmorata* populations in the Nillumbik and Lysterfield areas Part A: Survey results. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Melbourne.

Ecology Australia (2019b). Investigations into Southern Toadlet *Pseudophryne semimarmorata* in the Nillumbik and Lysterfield areas Part B: Survey method. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Melbourne.

Ecology Australia (2019c). Index of Wetland Condition and Monitoring Report. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2020a). Investigations into Southern Toadlet *Pseudophryne semimarmorata* populations 2020 Part A: Survey results. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2020b). Southern Toadlet *Pseudophryne semimarmorata* 2020 investigations: Part B - Literature Review and Action Plan. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2020c). Index of Wetland Condition for Groundwater-dependent Ecosystems 2020 Monitoring - Round 2. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Melbourne.

Ecology Australia (2020d). Growling Grass Frog Monitoring, Western Treatment Plant 2019/20. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2020e). Index of Wetland Condition and Monitoring Round 2 Report. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2020f). Vegetation monitoring of the 2010 and 2016 restored saltmarsh, Western Lagoons, Western Treatment Plant, 2019. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2021). Lower Yarra Billabongs Surveys 2019–2021. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Melbourne.

Ecology Australia (2021b). Investigations into Southern Toadlet *Pseudophryne semimarmorata*: Survey Results 2021. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

Ecology Australia (2022). Index of Wetland Condition assessments along Melbourne's fringe 2022. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Melbourne.

Elliott, L.H., Lawrence D., Igl, L.D. & Johnson, D.H. (2020). The relative importance of wetland area versus habitat heterogeneity for promoting species richness and abundance of wetland birds in the Prairie Pothole Region, USA. *The Condor* 122: 1-21. https://doi.org/10.1093/condor/duz060

Engeny (2020). Aviators Field PSP – Hydrological Impact Assessment. Unpublished report prepared for Melbourne Water by Engeny Water Management, Melbourne.

Environment Australia (2001). *A Directory of Important Wetlands in Australia*, third edition. Environment Australia, Canberra.

Fairbairn, S.E. & Dinsmore, J.J. (2001). Local and landscape-level influences on wetland bird communities of the Prairie Pothole Region of Iowa, USA. Wetlands 21:41–47.

Frood, D. (2016). Benchmarks for Wetland Ecological Vegetation Classes in Victoria. Report prepared for DELWP. Pathways Bushland and Environment, Greensborough, Victoria.

Garnett, S.T. & Crowley, G. (2000). *The Action Plan for Australian Birds 2000*. Environment Australia, Canberra.

Garnett, S.T., Szabo, J.K. & Dutson, G. (2011). *The Action Plan for Australian Birds 2010.* CSIRO Publishing, Clayton, Victoria.

GHD (2006). Edithvale-Seaford Wetlands: Review of Wetlands Operations. Unpublished report prepared for Melbourne Water by Aquatic System Management Pty Ltd and GHD Pty Ltd, Melbourne.

GHD (2019a). Ecological Monitoring Program for Yarra Billabongs: Monitoring Program. Report prepared for Melbourne Water by GHD Pty Ltd, Melbourne.

GHD (2019b). Ecological Monitoring Program for Yarra Billabongs: Songmeter Results. Report prepared for Melbourne Water by GHD Pty Ltd, Melbourne.

GHD (2021a). Eastern Treatment Plant Frogs: Frog survey - November 2020. Draft report prepared for Melbourne Water by GHD Pty Ltd, Melbourne.

GHD (2021b). Groundwater Dependent Ecosystems: Monitoring Data Review. Draft report prepared for Melbourne Water by GHD Pty Ltd, Melbourne.

GHD (2021c). Fauna Surveys at Aviators Field: Targeted Fauna Survey. Report prepared for Melbourne Water by GHD Pty Ltd, Melbourne.

GHD and Streamology (2020). Aviators Field PSP Environmental Impact Assessment. Report prepared for Melbourne Water by GHD Pty Ltd and Streamology, Melbourne.

Gonzalez-Gajardo, A., Sepulveda, P.V. & Schlatter, R. (2009). Waterbird assemblages and habitat characteristics: influence of temporal variability on species-habitat relationships. *Waterbirds* 32: 225-233.

Greet, J. & Rees, P. (2015). Slashing may have potential for controlling *Phragmites australis* in long-inundated parts of a Ramsar-listed wetland. *Ecological Management and Restoration* 16: 233–236.

Greet, J. (2020). Billabongs of the Lower Birrarung: Native Wetland Vegetation Responses to Watering. Melbourne Waterway Research-Practice Partnership Technical Report 20.2, University of Melbourne, Melbourne.

Greet, J. and Narrap Unit Rangers (2021). Billabongs of the lower Birrarung: native wetland vegetation responses to watering 2020/21. Technical report 21.4. Melbourne Waterway Research Practice Partnership. The University of Melbourne.

Greet, J., Fischer, S. & Fedrigo, M. (2020). Cockatoo Swamp Monitoring Program 2015–2020: Vegetation Response to Hydrology Works. Technical report 20.8. Melbourne Waterway Research Practice Partnership. The University of Melbourne.

Griffiths, J, and A Weeks. (2018). *Platypus Strategic Management Plan for Melbourne's Catchments.* Report for Melbourne Water, Cesar.

Hale, J. & Butcher, R. (2017). Addendum to Ecological Character Description for the Edithvale-Seaford Wetlands Ramsar Site. Department of Environment, Land, Water and Planning, East Melbourne, Victoria.

Hale, S., Walker, E., van Rooyen, A., Impey, R., Roberts, H., Licul, S. & Weeks, A. (2023). Investigating the presence of Southern Toadlet (*Pseudophryne semimarmorata*) in Melbourne Water catchments using Environmental DNA. Report prepared for Melbourne Water by Enviro DNA Pty Ltd, Melbourne.

Hansen, B., Menkhorst, P. & Loyn, R. (2011). Western Port Welcomes Waterbirds: Waterbird Usage of Western Port. Arthur Rylah Institute Technical Report Series No. 222, Arthur Rylah Institute for environmental research, Heidelberg, Melbourne.

Heard, G. & Robertson, P. (2022). Growling Grass Frog surveys across Melbourne's Northern Growth Corridor: 2021/2022 Season. A report to the Victorian Department of Environment, Land, Water and Planning, Melbourne Water and the City of Whittlesea by Wildlife Profiles, Melbourne.

Herman, K. & Purnell, C. (2016). Melbourne Water Regional Bird Monitoring Project. Annual Report July 2015–June 2016. Unpublished report prepared for Melbourne Water by Birdlife Australia, Melbourne.

Herman, K. (2015). Exploration of Guild Use as Indicators of Biodiversity at Wetlands and Waterways across the Port Phillip and Western Port Catchments. Report prepared for Melbourne Water by Birdlife Australia, Melbourne.

Herman, K. (2017). Melbourne Water Regional Bird Monitoring Project: Annual Report 2016/17. Unpublished report prepared for Melbourne Water by Birdlife Australia, Melbourne.

Herman, K. (2018). Melbourne Water Regional Bird Monitoring Project: Annual report 2017-18. Unpublished report prepared for Melbourne Water by BirdLife Australia, Melbourne.

HydroTechnology (1994). Groundwater Interaction with the Edithvale, Chelsea Heights and Seaford Swamp Wetlands. Unpublished consultant report (CC/32510/A/1) prepared for Melbourne Water by HydroTechnology, Melbourne.

IUCN (2019). International Union for the Conservation of Nature Red List. Available at: https://www.iucnredlist.org / Accessed 13 December 2019

IWSG (International Wader Study Group) (2003). Are waders world-wide in decline? Reviewing the evidence. *Wader Study Group Bulletin* 101/102: 8–12.

Jacobs (2015). DELWP Coastal Wetland Management Decision Support Framework Seaford Wetland. Report prepared for Melbourne Water by Jacobs Group (Australia) Pty Ltd, Melbourne.

Jacobs (2017). Wetlands and Estuaries in the Melbourne Water Catchment, Melbourne Water: Value and Threat Assessment. Report prepared for Melbourne Water by Jacobs Australia Pty Ltd, Melbourne.

Jacobs (2018). Lower Werribee River Billabongs: Determining Water Regime Management Objectives. Report prepared for Melbourne Water by Jacobs Australia Pty Ltd, Melbourne.

Jacobs (2020). RAAF Laverton Swamp Soil Contamination Review. Report prepared for Melbourne Water by Jacobs Group (Australia) Pty Ltd, Melbourne.

Jacobs (2021a). Morang Wetlands Water Regime Assessment: Final report. Report prepared for Melbourne Water by Jacobs Australia Pty Ltd, Melbourne.

Jacobs (2021b). Understanding the Drivers of Avian Botulism Outbreaks at the Western Treatment Plant. Report prepared for Melbourne Water by Jacobs Group (Australia) Pty Ltd, Melbourne.

Jacobs (2021c). Landscape approach to floodplain wetland watering: Lower Yarra floodplain wetlands objectives and watering guidance. Report prepared for Melbourne Water by Jacobs Australia Pty Ltd, Melbourne.

Jacobs (2021d). Saltmarsh and Orange-bellied Parrot food plant monitoring - Western Treatment Plant and The Spit Nature Conservation Reserve. Report prepared for Melbourne Water by Jacobs Australia Pty Ltd, Melbourne.

Jacobs (2022a). Birrarung Park Billabongs. Report prepared for Melbourne Water by Jacobs Group (Australia) Pty Ltd, Melbourne.

Jacobs (2022b). Montpelier Billabong. Report prepared for Melbourne Water by Jacobs Group (Australia) Pty Ltd, Melbourne.

Jacobs (2022c) Development of the Natural Wetlands Protection Framework and Tool. Report prepared for Melbourne Water by Jacobs Group (Australia) Pty Ltd, Melbourne.

Kerr, G.D., Farrington, L., Tuck, J. & Bachmann, M. (2021). Survey of Point Cook Wetlands: Assessing the Restoration Potential of Cunningham Swamp. Nature Glenelg Trust, Warrnambool, Victoria.

Kingsford, R.T. & Norman, F.I. (2002). Australian waterbirds – products of the continent's ecology. *Emu* 102: 47-69.

Larwill, S. & Costello, C. (1992). Inventory of Wetlands in the South East Region of Melbourne Water. Report prepared for Melbourne Water by Biosis Research Pty Ltd, Melbourne.

Lau, J. (2008). Community Monitoring of Bird Utilisation of Constructed Wetlands in the Dandenong Catchment. Report prepared for Melbourne Water by Bird Observation & Conservation Australia, Melbourne.

Lau, J. (2009). Community Monitoring of Constructed Wetlands in the Dandenong Creek Catchment: Annual Report July 2008—June 2009. Report prepared for Melbourne Water by Bird Observation & Conservation Australia, Melbourne.

Lau, J. (2011a). Community Monitoring of Constructed Wetlands in the Dandenong Creek Catchment: Annual Report July 2009—June 2010. Unpublished report prepared for Melbourne Water by Bird Observation & Conservation Australia, Melbourne.

Lau, J. (2011b). Community Monitoring of Constructed Wetlands in the Dandenong Creek Catchment: Annual Report July 2010—June 2011. Unpublished report prepared for Melbourne Water by Bird Observation & Conservation Australia, Melbourne.

Long, S., MacMahon, D. & Pettigrove, V. (2021). Identifying the Sources of Lead in Eel Race Drain: Summary Report. Aquatic Environmental Stress Research Group, Technical Report No. 51, RMIT University, Victoria.

Long, S., Myers, J., Tewman, M. & Pettigrove, V. (2022). Assessing contaminant risks to environmentally sensitive areas. Year 2 Report. Aquatic Environmental Stress Research Group, Technical Report No. 52, RMIT University, Victoria, Australia.

Long, S., Odell, E., Mondschei,n G., Kellar, C., Vu, H. & Pettigrove, V. (2023). Seaford Wetlands Monitoring Program, Stage 3 Final Report. Aquatic Environmental Stress Research Group, Technical Report No. 74, RMIT University, Victoria, Australia.

Long, S., Myers, J., Hung Vu, Tewman, M. & Pettigrove, V. (in prep. a) Assessing Aquatic Contaminant Risks to Environmentally Sensitive Areas in Greater Melbourne – Western Treatment Plant: Summary Report. Aquatic Pollution Prevention Partnership, Technical Report No. 102, RMIT University, Victoria, Australia.

Long S, Myers J, Vu H, Tewman M and Pettigrove V (in prep. b) Assessing Aquatic Contaminant Risks to Environmentally Sensitive Areas in Greater Melbourne. Years 4 & 5 Summary Report. Aquatic Pollution Prevention Partnership, Technical Report No. 111, RMIT University, Victoria, Australia.

Loyn, R.H., Potts, J., Duncan, D., Stamation, K. & Menkhorst, P. (2014b). Relationships Between Waterfowl Numbers and Water Chemistry of Ponds at the Western Treatment Plant, Victoria. Arthur Rylah Institute for Environmental Research Technical Report Series No. 260, Department of Environment and Primary Industries, Victoria.

Loyn, R.H., Rogers, D.I., Swindley, R.J., Menkhorst, P.W., Stamation, K., Haynes, S., Graham, H., Hepworth, G. & Steele, W.K. (2023). Waterfowl and sewage: benefits of a 20-year adaptive management program at the Ramsar-listed Western Treatment Plant in south-east Australia. *Hydrobiologia*; doi.org/10.1007/s10750-023-05265-9

Loyn, R.H., Rogers, D.I., Swindley, R.J., Stamation, K., Macak, P. & Menkhorst, P. (2014a). Waterbird Monitoring at the Western Treatment Plant, 2000–12: The Effects of Climate and Sewage Treatment Processes on Waterbird Populations. Arthur Rylah Institute for Environmental Research Technical Report Series No. 256, Department of Environment and Primary Industries, Victoria.

McDougall, K. (1987). Sites of Botanical Significance on the Western Region of Melbourne. Report prepared for the Department of Conservation, Forests & Lands by the Department of Geography, University of Melbourne, Melbourne.

McGuckin, J. (2021). Dwarf Galaxias (*Galaxiella pusilla*) and the Hallam Valley: 2020 study. Report prepared for Melbourne Water by Streamline Research Pty Ltd, Melbourne.

Melbourne Water (2011). Understanding the Western Port Environment. Melbourne Water Corporation, Melbourne.

Melbourne Water (2012a). EPBC Referral 2012/ 6678: Seaford Wetlands Hydrology Works. Report submitted to the Department of Sustainability, Environment, Water, Population and Communities by Melbourne Water, Melbourne.

Melbourne Water (2013). Healthy Waterways Strategy: A Melbourne Water Strategy for Managing Rivers, Estuaries and Wetlands. Melbourne.

Melbourne Water (2017). 'Western Treatment Plant 2016/17 Compliance Report for EPBC 2002/688'. Melbourne Water, Docklands, Victoria.

Melbourne Water (2018a). *Understanding the Western Port Environment 2018*. Melbourne Water Corporation, Melbourne.

Melbourne Water (2018b). *Healthy Waterways Strategy 2018*. Melbourne Water, Melbourne; https://mwrcstorage.blob.core.windows.net/files/2021-03/healthy-waterways-strategy-2018.pdf

Melbourne Water (2020a). *Healthy Waterways Strategy Resource Document*. Melbourne Water, Melbourne; https://mwrcstorage.blob.core.windows.net/files/2021-03/HWS-2018-Resource-Document.pdf

Melbourne Water (2020b). *Wetland Monitoring and Evaluation Plan: Healthy Waterways Strategy*. Melbourne Water, Melbourne. Available at: https://mwrcstorage.blob.core.windows.net/files/2021-03/HWS-Wetlands-Monitoring-and-Evaluation-Plan-v1.0-2020.pdf

Melbourne Water (2020c). "Protection of natural wetlands from urban encroachment and stormwater management". Unpublished paper prepared by Melbourne Water for the Healthy Waterways Strategy Region-wide Leadership Team.

Melbourne Water (2022). Draft Checklist for Wetlands and Waterways. Internal memo, Legal Team, Melbourne Water.

Melbourne Water (2023a) Draft Science Inquiry Report: A report to inform the mid-term review of the Healthy Waterways Strategy, Melbourne Water, Docklands, Victoria, Australia.

Melbourne Water (2023b). Riparian Birds: A Technical Report to Inform the Healthy Waterways Strategy Mid-term Evaluation. Internal report, Waterways and Biodiversity Team, Water Services Planning Group, Integrated Planning, Melbourne Water.

Melbourne Water (2023c) Threats: A Technical Report to inform the Healthy Waterway Strategy Mid-term Review, Melbourne Water, Melbourne.

Melbourne Water (2023d) Interventions: A Technical Report to inform the Mid-term Review of the Healthy Waterway Strategy, Melbourne Water, Melbourne.

Menkhorst, P., Macak, P., Rogers, D. & Stamation, K. (2017). Monitoring of Waterbird Populations at the Western Treatment Plant – 2016/2017 Annual Report. Arthur Rylah Institute for Environmental Research unpublished client report for Melbourne Water, Department of Environment. Land, Water and Planning, Heidelberg, Victoria.

Menkhorst, P., Macak, P., Rogers, D. & Stamation, K. (2018). Monitoring of Waterbird Populations at the Western Treatment Plant – 2018 Annual Report. Unpublished report to Melbourne Water, Arthur Rylah Institute for Environmental Research, Heidelberg

Menkhorst, P., Macak, P., Rogers, D. & Stamation, K. (2019). Monitoring of Waterbird Populations at the Western Treatment Plant – 2019 Annual Report. Unpublished report to Melbourne Water, Arthur Rylah Institute for Environmental Research, Heidelberg.

Menkhorst, P., Macak, P., Rogers, D. & Stamation, K. (2020). Monitoring Waterbird Populations at the Western Treatment Plant – 2020 Annual Report. Report prepared for Melbourne Water by the Arthur Rylah Institute for Environmental Research, Department of Environment, Land, water and Planning, Melbourne.

Menkhorst, P., Macak, P., Rogers, D., Stamation, K. & Fansen, B. (2021). Monitoring Waterbird Populations at the Western Treatment Plant, Victoria – 2021 Annual Report. Unpublished Client Report for Melbourne Water. Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Menkhorst, P., Rogers, D., Macak, P., Stamation, K. & Swindley, R. (2014). Monitoring of Waterbird Populations at the Western Treatment Plant, 2013 Annual Report. Report prepared for Melbourne Water by the Arthur Rylah Institute for Environmental Research, Department of Environment and Primary Industries, Melbourne.

Menkhorst, P.W., Loyn, R.H., Liu, C., Hansen, B., Mackay, M. & Dann, P. (2015a). Trends in Numbers of Piscivorous Birds in Western Port and West Corner Inlet, Victoria, 1987–2012. Arthur Rylah Institute for Environmental Research unpublished client report for Melbourne Water, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Menkhorst, P.W., Macak, P., Rogers, D.I., Stamation, K. & Swindley, R. (2015b). Monitoring of Waterbird Populations at the Western Treatment Plant: 2014–2015 Annual Report. Unpublished Client Report for Melbourne Water, Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Victoria.

Moore, S. (1994). Inventory of Wetlands, Rivers and Streams in the Carrum Lowlands. Report prepared for Melbourne Water by the Carrum-Lowlands Wetland Management Group.

Murray, N.J., Clemens, R.S., Phinn, S.R., Possingham, H.P. & Fuller, R.A. (2013). Tracking the rapid loss of tidal wetlands in the Yellow Sea. *Frontiers in Ecology and the Environment* 12: 267–272.

Murray, N.J., Ma, Z. & Fuller, R.A. (2015). Tidal flats of the Yellow Sea: A review of ecosystem status and anthropogenic threats. *Austral Ecology* 40: 472–481.

Nielsen, D. L. and Brock M. A. (2009). Modified water regime and salinity as a consequence of climate change: prospects for wetlands of Southern Australia. Climatic Change 95, 523– 533.

Olsen, P., Weston, M., Cunningham, R. & Silcocks, A. (2003). The State of Australia's Birds 2003. *Wingspan* 13 (Supplement), 1–21.

Papas, P. & Frood, D. (2016a). Index of Wetland Condition for Groundwater Dependent Wetlands – assessment methods and data entry sheets V1.1. Unpublished report prepared for Melbourne Water by the Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Papas, P. & Moloney, P. (2012). Victoria's Wetlands 2009–2011: Statewide Assessments and Condition Modelling. Arthur Rylah Institute for Environmental Research Technical Report Series No. 229. Department of Sustainability and Environment, Heidelberg, Victoria.

Papas, P., Frood, D. & Crowther, D. (2016). Index of Wetland Condition for Groundwater Dependent Wetlands – priority wetland assessments. Arthur Rylah Institute for Environmental Research Unpublished Client Report for Melbourne Water. Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Papas, P., White, M., Cant, B., Griffioen, P., Crowther, D. & Cook, D. (2016). Predicting the Occurrence of Seasonal Herbaceous Wetlands in South-east Australia. Arthur Rylah Institute for Environmental Research Technical Report Series No.271. Department of Environment, Land, Water and Planning, Victoria.

Purnell, C. (2013). Melbourne Water Regional Bird Monitoring, Annual Report: September 2012–July 2013. Unpublished report prepared for Melbourne Water by Birdlife Australia, Melbourne.

Purnell, C. (2014). Melbourne Water Regional Bird Monitoring July 2013–June 2014 Project Report. Report prepared for Melbourne Water by Birdlife Australia, Melbourne.

Purnell, C. (2015). Melbourne Water Regional Bird Monitoring Project. Annual Report July 2014–June 2015. Report prepared for Melbourne Water by Birdlife Australia, Melbourne.

Rakali (2018). Mapping the Distribution of Seasonal Herbaceous Wetlands South-east of Melbourne. Report prepared for Melbourne Water by Rakali Consulting Pty Ltd, Chewton, Victoria.

Rakali (2020a). Flora and Fauna Survey and Condition Assessment of the Paynes Road Wetland, Grangefields, Victoria. Report prepared for Melbourne Water by Rakali Ecological Consulting Pty Ltd, Chewton, Victoria.

Rakali (2020b). Flora and Fauna Survey and Condition Assessment of the Troups Road North Wetland, Rockbank, Victoria. Report prepared for Melbourne Water by Rakali Ecological Consulting Pty Ltd, Chewton, Victoria.

Reaney, L.T. & Maurer, G. (2019). 'State of Australia's Key Biodiversity Areas 2018 - 2019'. BirdLife Australia, Melbourne. Available at: http://birdlife.org.au/documents/KBA-State_of_Aus_KBAs-2018.pdf

Rogers, D. & Hulzebosch, M. (2014). Use of Non-tidal Ponds by Shorebirds at the Western Treatment Plant. Unpublished Client Report for Melbourne Water, Arthur Rylah Institute for Environmental Research, Department of Environment and Primary Industries, Heidelberg, Victoria.

Rogers, D., Stamation, K. & Menkhorst, P. (2021). Potential impacts of sea-level rise on habitat for waterbirds at the Western Treatment Plant, Victoria Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning, Heidelberg, Victoria.

Rogers, D.I., Hassell, C.J., Oldland, J., Clemens, R., Boyle, A. & Rogers, K.G. (2009). Monitoring Yellow Sea migrants in Australia (MYSMA): North-western Australian shorebird surveys and workshops, December 2008. Report to the Department of Environment, Water, Heritage and the Arts, and the Western Australian Department of Environment and Conservation. Melbourne, Australia: Australasian Wader Studies Group.

Rogers, D.I., Stamation, K., Loyn, R.H. & Menkhorst, P. (2015). Literature Review: Management of Non-tidal Ponds for Shorebirds. Arthur Rylah Institute for Environmental Research Technical Report Series No. 264, Department of Environment, Land, Water and Planning, Victoria.

Rosengren, N.J. (1987). Sites of Geological and Geomorphological Significance in the Western Region of Melbourne. Department of Conservation, Forest & Lands, Melbourne.

Schulz, M., Beardsell, C. & Sandiford, K. (1991). Sites of Faunal Significance in the Western Wetlands of Melbourne. Wildlife Branch, Department of Conservation & Environment, Melbourne.

Servat, G.P., Alcocer, R., Larico, M.V., Olarte, M.E., Linares-Palomino, R., Alonso, A. & Ledesma, K. (2017). The effects of area and habitat heterogeneity on bird richness and composition in high elevation wetlands ("Bofedales") of the Central Andes of Peru. *Wetlands* 38: 1133–1145

Silcocks, A. & O'Connor, J. (2007). Edithvale and Seaford Wetlands Bird Survey Project 2006–09: Report No. 1, May 2006 to April 2007. Report prepared for Melbourne Water by Birds Australia, Carlton, Victoria.

Silcocks, A. & O'Connor, J. (2008). Edithvale and Seaford Wetlands Bird Census Project 2006–09: Report No. 2 May 2007 to April 2008. Report prepared for Melbourne Water by Birds Australia, Carlton, Victoria.

Silcocks, A. & O'Connor, J. (2009). Edithvale and Seaford Wetlands Bird Census Project 2006-09: Report No. 3 May 2008 to April 2009. Report prepared for Melbourne Water by Birds Australia, Carlton, Victoria.

Silcocks, A. & O'Connor, J. (2010). Edithvale and Seaford Wetlands Bird Census Project 2009–10: May 2009 to June 2010. Report prepared for Melbourne Water by Birds Australia, Carlton, Victoria.

Silcocks, A. & O'Connor, J. (2011). Edithvale and Seaford Wetlands Bird Survey Project 2010/11: July 2010 to June 2011. Unpublished report prepared for Melbourne Water by Birds Australia, Carlton, Victoria.

Silcocks, A. (2013a). Edithvale and Seaford Wetlands Bird Survey Project 2011–12: July 2011 to June 2012. Report prepared for Melbourne Water by Birdlife Australia, Melbourne.

Silcocks, A. (2013b). Edithvale and Seaford Wetlands Bird Survey Project 2012–13: July 2012 to June 2013. Report prepared for Melbourne Water by Birdlife Australia, Melbourne.

Silcocks, A., Ehmke, G., Tzaros, C. & Weston, M. (2006). Edithvale and Seaford Wetlands Bird Survey Project 2003–06: Final Report 2003–2006. Report prepared for Melbourne Water by Birds Australia, Carlton, Victoria.

SKM (2011). Environmental water requirements and associated capital works for the Edithvale-Seaford Wetlands. Unpublished report prepared by B. Bonneville, P. Boon, D. Quin, S. Treadwell, R. Middleton and R. Morden for Melbourne Water. Sinclair Knight Merz, Melbourne, Victoria.

SKM (2011a). Environmental Water Requirements and Associated Capital Works for the Edithvale-Seaford Wetlands. Unpublished report prepared for Melbourne Water by Sinclair Knight Merz Pty Ltd Pty Ltd, Melbourne.

SKM (2012). Billabong Conceptualisation and Prioritisation for Environmental Watering. Unpublished report prepared for Melbourne Water by Sinclair Knight Merz, Hobart.

Steele, W.K. (2011). Calculation of an Avian Sub-index for Aquatic and Riparian Ecosystems, 2011. Internal discussion paper, Catchments Team, Melbourne Water, Melbourne.

Steele, W.K. (2017). Developing our Understanding and Treatment of the Frog and Bird Values – Science Panel Paper 8 February 2017. Internal document, Melbourne Water, Melbourne.

Steele, W.K. (in prep.). Bird Community Indices for Streams and Wetlands. Internal working document, Water Services Planning, Melbourne Water, Melbourne.

Steven, R., Pickering, C.M. & Castley, G. (2011). A review of the impacts of nature based recreation on birds. *Journal of Environmental Management* 92: 2287-2294.

Stevens, D. (ed.) (1996). *Melbourne's Great Outdoors: Parks, Waterways And Trails – Where To Go And What To Do*. David Syme & Co., Melbourne.

Szabo, J.K., Khwaja, N., Garnett, S.T. & Butchart, S.H.M. (2012). Global patterns and drivers of avian extinctions at the species and subspecies level. *PLoS ONE* 7(10): e47080. https://doi.org/10.1371/journal.pone.0047080

Taylor, B., Bachmann, M., Farrington, L. & Roberts, T. (2020). Eco-hydrological Investigation and Restoration Planning for Big Marsh. The Spit Nature Conservation Reserve, Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site. Report to the Port Phillip and Westernport Catchment Management Authority by NGT Consulting, Nature Glenelg Trust, Mumbannar, Victoria.

Tzaros, C., Silcocks, A. & Weston, M. (2004). Edithvale and Seaford Wetlands Bird Survey Project 2003–06. Report No. 1, May 2003–April 2004. Report prepared for Melbourne Water by Birds Australia, Hawthorn East, Victoria.

Tzaros, C., Silcocks, A. & Weston, M. (2005). Edithvale and Seaford Wetlands Bird Survey Project 2003–06. Report No. 2, May 2004–April 2005. Report prepared for Melbourne Water by Birds Australia, Hawthorn East, Victoria.

University of Melbourne (2020). Birrarung's billabongs: vegetation responses to environmental watering. Report prepared for Melbourne Water by WERG.

van Asten, T. (2022). Shorebird Habitat Review and Management Advice for Nine Sites Managed by Melbourne Water. Report prepared for Melbourne Water by Ecology Australia Pty Ltd, Fairfield, Victoria.

van de Kam, J., Ens B., Piersma T., and Zwarts L. (2004). *Shorebirds. An Illustrated Behavioural Ecology*. KNNV Publishers: Utrecht, Netherlands.

Weeks, A., Berran, M. & Tingley, R. (2021). Detecting Frogs in Wetlands: Optimising eDNA Sampling and Detection Strategies for Melbourne's Wetlands. Report prepared for Melbourne Water by EnviroDNA Pty Ltd, Melbourne.

Wegleb, G. & Dahms, H.-U. (2017). To what extent can constructed wetlands enhance biodiversity? *International Journal of Environmental Science and Development* 8: 561-569; doi: 10.18178/ijesd.2017.8.8.1016

Wen, L., Santilan, N., Reid, J.R.W. & Collof, M.J. (2016). Changes in distribution of waterbirds following prolonged drought reflect habitat availability in coastal and inland regions. *Ecology and Evolution* 6: 6672-6689.

Wetlands International (2019). "Waterbird Population Estimates". Retrieved from wpe.wetlands.org on Thursday 12 Dec 2019. Available at: http://wpe.wetlands.org/search?form%5Bspecies%5D=Sharp-tailed+Sandpiper&form%5Bpopulation%5D=&form%5Bpublication%5D=5&form%5Bflyway%5D%5B8%5D=8

Wilson, J. (2000). The northward movement of immature Eastern Curlews in the austral winter as demonstrated by the Population Monitoring Project. *Stilt* 36: 16–19.

Appendix A. Summary of issues with wetland mapping and target setting for wetland birds during the development of the HWS

At the time of the development of the HWS 2018, comprehensive mapping and characterisation of wetlands and waterbodies throughout the region had not been done, and it was recognised that the knowledge base was patchy and incomplete. This reflected the lack of focus on these waterway types in previous regional strategies and the very limited number of IWC assessments undertaken in our region.

Wetland "prioritisation", or the selection of wetlands upon which to focus, for the HWS was constrained by time and data availability (see Appendix B). This led to challenges with the original HWS mapping of wetlands as outlined below which has since been addressed as outlined in this report.

1. Jacobs (consultants) was provided with a preliminary list of 132 potential waterbodies Melbourne Water had identified as being of some significance/value from a biodiversity aspect.

2. Jacobs added a few wetlands they considered of some regional significance (e.g. Yarra Streamside Reserve) and Melbourne Water also added around 20 'social value' wetlands. Jacobs undertook AVIRA assessments for 133 waterbodies, and provided a spreadsheet of scores. Some wetlands were dropped from the list provided in Step 1 as some suggestions were found not to be wetlands at all, or access was not possible (Jacobs 2017). Many of the AVIRA data fields could not be completed due to a lack of information.

3. The HWS writing team added "stormwater treatment wetlands in the Yarra Catchment" after these were raised as being important during community workshops for the co-design process.

4. The HWS writing team decided to 'lump' some of the priority wetlands, for mapping purposes. For example the constructed stormwater treatment wetlands in the Hallam Valley were grouped together but, in other cases, wetlands were grouped incorrectly. For example, Dunnett's Road Swamp and Galada Tamboore wetlands were grouped when they should have been mapped separately.

5. In addition, Galada Tamboore and Dunnett's Road Swamp were mapped to a third (natural) wetland, and the AVIRA scores for these wetlands to applied to 'Yarra s/w wetlands' – which was incorrect.

6. In the initial list, sent to Jacobs, all Sites of Biodiversity Significance were included – with a note that most had wetlands within the boundary and that these wetlands could be considered to be of regional significance. Jacobs included Andersons Creek East RB and Cardigan Creek RB, as wetland sites, but they do not have wetlands. They were lumped together by the HWS writing team and included – with performance objectives – although they are not wetlands.

7. WTP ponds – which are Ramsar-listed – were not listed in the HWS published mapping.

8. "Jawbone Reserve" was included as a wetland of some regional significance. However, the constructed Paisley-Challis wetlands in the reserve were mapped as the priority wetland – and subsequent confusion has arisen with bird and IWC monitoring focussing on (potentially) the wrong wetland. There is still general confusion around the naming of wetlands in this area with Hobsons

Bay Wetland Centre, Council, Friends and Melbourne Water all using different names (Kevin Wood, Hobsons Bay Wetland Centre, *pers comm*.).

9. 'Growling Grass Frog Reserve wetlands' were included in the HWS since several of these wetlands would be constructed under the urban growth MMSA. As these wetlands would support Growling Grass Frogs they would, by definition, be of significance. A 'placeholder' was mapped for these future wetlands using a small (~0.04 ha) existing frog pond in the Yarra catchment (DWL437A). Consequently, condition and value scores were assigned to this wetland with the intention that these values and conditions will be extrapolated to future Growling Grass Frog ponds. However, the one constructed MSA Growling Grass Frog pond, and many future ones, are located in the Werribee Catchment.

Bird Target setting

In preparing the 2018 HWS the decision was made not to use the available bird data for many regional wetlands, but rather to use the (incomplete) AVIRA assessments to derive bird value scores and likely targets. In the 2018 HWS Catchment Programs, the wetland bird scores are defined as:

Score	Description
Very high	If 5 metrics meet criteria
High	If 4 metrics meet criteria
Moderate	If 2 or 3 metrics meet criteria
Low	If 1 metric meet criterion
Very low	If no metrics meet criteria and/or vegetation condition is very poor

The five metrics and their criteria, and what is meant by "vegetation condition" are outlined in the HWS resource document (Melbourne Water 2020a). This describes the wetland bird scoring as:

AVIRA value category	AVIRA metric	Measure(s) used to determine current state	Data source / notes
Formally re-cognised significance	Ramsar sites	International significance - listed as a key feature of a Ramsar site	Ramsar Wetland Areas in Victoria dataset (www.data.vic.gov.au)
	East Asian-Australasian Flyway Sites	International Significance – listed as a key feature of an East Asian-Australasian Flyway Site	East Asian-Australasian Flyway Sites in Victoria (www.data.vic.gov.au)
	Nationally Important Wetlands	Listed in the Directory of Important Wetlands in Australia (DIWA)	Victorian Wetlands listed in – A Directory of Important Wetlands in Australia – DIWA (www.data.vic.gov.au)
Naturalness	Wetland vegetation condition	Condition of wetland Ecological Vegetation Class	IWC biota sub-index Melbourne Water SoBS database Other literature Aerial photography

			DEPI 2013: Seasonal Herbaceous Wetlands assessment - rule set development
Rare or threatened species / communities	Significant fauna*	Listed on the IUCN Red List Listed under the EPBC Act 1999 Listed on the Advisory List of Rare or Threatened Plants in Victoria (VROT)	Victorian Biodiversity Atlas (VBA) records post-1980 – records within 100m of a waterway. Classified as water dependent significant fauna as listed in AVIRA manual (Riverness 2015).
	Significant Wetland EVC	Ecological Vegetation Class Bioregional Conservation Status	Native Vegetation - Modelled 2005 Ecological Vegetation Classes: Bioregional Conservation Status of EVCs (www.data.vic.gov.au) Classified as water dependent EVC as listed in AVIRA manual (Riverness 2015). DELWP - water dependent EVC list and refined wetland EVC list - Paul Boon/Jacobs (https://www.water.vic.gov.au/__data/assets/pdf_file/0025/68434/Climate-Change-and-Coastal-Wetlands_DSF_Volume-1.pdf)
Landscape features	Important bird habitats	Listed as an Important Bird Area (IBA) in AVIRA.	Meets at least one of four global criteria used by BirdLife International for IBAs, as listed in AVIRA manual (Riverness 2015).
		Listed as an Important habitat for migratory shorebirds in AVIRA	As classified by Birds Australia and listed in AVIRA manual (Riverness 2015).

There are seven 'metrics' listed and while it is unclear which five metrics the HWS used for bird scoring, it is probable the criteria used were:

- Ramsar site
- East Asian-Australian Flyway site
- DIWA site
- Rare or threatened species presence, and
- Important bird habitats (KBA or Migrator Shorebird site)

Plus Wetland vegetation condition.

Of the five criteria used to determine wetland bird condition, four are difficult to influence through management. The assessment of the fourth listed criterion, *rare and threatened species' presence*, was flawed because Jacobs (2017) did not use the Birdlife Australia database – and so missed, among other values, Australasian Bittern at Tootgarook Swamp and Cunningham's Swamp, and threatened species of bird at Laverton RAAF Swamp.

In addition, 'wetland vegetation condition' score in AVIRA could not be based, as intended, on IWC sub-index scoring. So, assumptions about only one element – wetland vegetation, for which there

was limited detailed data through IWC assessments – dominated wetland bird condition scoring. The buffer scoring in AVIRA was used as a surrogate for vegetation condition (or bird habitat) – and that this drove the wetland bird value scoring. These vegetation assumptions limit the wetland bird value being scored as anything but low or very low.

The Jacobs' report on the AVIRA data collection for wetlands (Jacobs 2017) openly states limitations (page 5):

> "*The AVIRA framework is made up of many metrics and measures, many of which could not be populated because of the lack of available data. Some metrics and measures could be populated from existing Melbourne Water and publicly available spatial datasets; others were populated using local knowledge and desktop assessment of relevant investigations and reports. But in many cases, especially for wetlands, studies had not been undertaken in the recent past from which relevant information could be extracted. A number of gaps exist within the AVIRA assessment for Melbourne Water wetlands and estuaries which can be populated over time by Melbourne Water and via future wetland estuary projects. The critical data gaps included:*
>
> - *Index of Wetland Condition assessment:*
> - *Wetland vegetation condition"*

So, wetland vegetation condition is a critical data gap in the AVIRA report, but assumptions were used to derive wetland bird condition scoring. This means the HWS reports wetland bird scores as the 'current' state which is misleading. One example of this is Tootgarook Swamp – a well-known wetland supporting bird values and which the local community are arguing should be Ramsar-listed because of its values. However, it was scored as 'Very low' bird value in the HWS. The Eastern Treatment Plant – which supports significant numbers of waterbirds, including threatened and migratory species, and which has been shown to meet the Ramsar criteria for wetland birds – is considered as only 'Moderate' in the HWS. Of the only three wetlands to be rated as supporting 'very high' wetland bird values, neither Spectacle Lake at Point Cook or Paul & Belfrages Wetland at the WTP actually support significant bird values. Spectacle Lake has been dry for some years and is generally recognised as no longer being of great value to birds. Paul & Belfrages Wetland is significant for its vegetation but does not support many waterbirds.

The HWS Resource document goes on to state:

> *"The current trajectory of bird values in wetlands was assessed by incorporating the predicted wetland vegetation condition over the next 50 years. As wetland vegetation condition is projected to decline to very low in all wetlands in the basalt plains under current trajectory, all current bird scores in the west were moderated down 2 ranks (unless already at 'very low')."*
>
> *"On the alluvial plains, at wetlands where vegetation and bird habitat is predicted to be stable or improve due to environmental water delivery or intensive management (such as the Yarra Billabongs and Cockatoo Swamp), bird values are predicted to improve by one to two ranks. Bird values at other wetlands in the east are predicted to stay at low or very low."*

Thus wetland bird trajectories were assigned according to assumptions of overall wetland trajectory at a very high level – the three wetland groupings: basalt plains, alluvial plains and coastal wetlands.

The scores for wetland bird targets are highly conservative and generally suggest a decline is acceptable as a target. Based on these findings, it is recommended that the bird targets are reviewed and, where appropriate, increased above those presented in the HWS.

Appendix B. Regional Wetland Prioritisation

With several thousand wetlands in the region and a variety of constructed and natural wetland, and a mix of social, cultural and ecological values, the HWS sought to identify a sub-set of the most important wetlands to focus upon. In the HWS these are called regional priority wetlands. In some cases these wetlands were referred to as 'representative wetlands', which they were never intended to be (although recent work by WERG show the priority wetland to be reasonably representative of all waterbodies). Wetland identification, prioritisation and mapping for the HWS were fraught with challenges and confusion.

The term 'priority wetlands' has also caused confusion and we now refer to this sub-set of wetlands as our region's 'high value' wetlands. These are wetlands with known values of some regional significance.

Initial prioritisation, 2017

A preliminary prioritisation exercise identified 155 wetlands of potential value, either for natural values and conservation of biodiversity or for their social values.

'Social value' wetlands were initially identified from publically available material – such as published books:

> Stevens, D. (ed.) (1996) *Melbourne's Great Outdoors: Parks, Waterways and Trails – Where to Go and What to Do.* David Syme & Co., Melbourne.
>
> Cowling, S. (undated) *Explore Melbourne's Wetlands*. National Trust Victoria with the Department of Conservation and Environment and Board of Works, Melbourne.

Additional 'social value' wetlands were then added during the HWS co-design process through community engagement. "Yarra catchment stormwater treatment wetlands" was also added as a public health value through community engagement.

These priority wetlands were then grouped, purely for mapping purposes, into only 82 "wetlands" in the HWS. Unfortunately, this includes one 'grouping' of two sites that do not have wetlands: Andersons Creek East RB and Cardigan Creek RB.

The preparation of the 2018 HWS highlighted the large gaps in our information on wetlands (and estuaries). This reflected the lack of focus on these waterway types in previous regional strategies and the very limited number of IWC assessments undertaken in our region. In addition, it was expected that habitat suitability models (HSM) would be available for wetlands, similar to those used to describe the distribution of our Values in rivers and to model the responses of Values to management interventions. Because these models were not available, we recognise our wetland planning in the HWS was limited. HSMs are being developed for several wetland key values and will be available to inform the next regional strategy.

Moreover, time constraints meant that a rapid data collation and prioritisation process was required for the region's wetlands. The 2018 HWS acknowledges the lack of data and limited number of wetlands assessed and does not preclude consideration of other wetlands through the implementation period.

Second prioritisation, 2019/20

Following the release of the 2018 HWS, the wetland priority list was expanded to 249 wetlands for the Wetland MEP (see Appendix C) based on a more comprehensive prioritisation process, including formally recognised significance (Melbourne Water 2020b).

In this process, wetlands of our region were prioritised, initially, on the basis of their ecological values. The conservation status of wetlands was the first consideration and wetlands selected were those lying within Ramsar sites, SSN (Shorebird Site Network) sites, IBBA (Important Bird and Biodiversity Area, now known as Key Biodiversity Areas), DIWA (Directory of Important Wetlands in Australia), Melbourne Water's SoBS (Sites of Biodiversity Significance), etc. Next, reports were reviewed and all wetlands noted for significant ecological values were added (e.g. Schulz et al. 1991; Beardsell 1991, 1997; Larwill & Costello 1992; Moore 1994; Environment Australia 2001; DNRE 2002; SKM 2012; DEPI 2013a). Parks Victoria staff and several local botanists were also asked for their recommendations for priority wetlands.

Cultural values of wetlands remained a significant knowledge gap. Other than limited information on the importance to Traditional Owners of Bolin Bolin billabong, the Edithvale-Seaford Wetlands, Burrung buluk and a small number of other wetlands we have little understanding of the relative importance, culturally, of our region's wetlands. This knowledge gap must be addressed as a priority over the life of the strategy through:

- Partnership projects with traditional owners,
- Cultural heritage surveys,
- Naming of wetlands in consultation with traditional owners, and
- Knowledge sharing.

Subsequent changes

After the Wetland MEP was written new information has imposed further changes to our list of wetlands of some regional significance.

- Growling Grass Frog MSA conservation pond no. 1 (Lyle Lane, Aintree) – a new conservation pond for Growling Grass Frogs – has been constructed (and further conservation wetlands are under construction).
- Hannah Swamp (Burrung Buluk) was identified by the Wurundjeri woi-wurung Traditional Owners as having cultural significance and added as a wetland of cultural heritage significance (Alluvium 2021). This wetland lies in an active development area and its importance needed to be highlighted immediately.
- In late 2020, three urban wetlands identified as 'nationally significant' for Latham's Snipe by Birdlife Australia (2020) were added.
- Cobbledicks Ford Reserve cluster has been divided into three wetlands following assessments by ARI (Steve Sinclair, pers comm.), adding two priority wetlands.
- The Muddy Gates complex (potential Seasonal Herbaceous Wetland vegetation) was added.
- The Serpentine Lagoon at the ETP was separated from the main ETP as a distinct wetland and bird count area.

- Cherry Swamp and Tooronga Plateau Wetlands were dropped since it was found these lie outside the Port Phillip and Westernport region.

Assessments of some 'priority wetlands' in the western urban growth areas have revealed that many no longer support the values for which they were listed as being of significance in reports dating back to the 1990s. Whether this is the result of intensified land use preventing their recovery from the Millennium Drought, or other factors we cannot tell. But a review of the priority – or regionally significant – wetlands is needed.

In summary, we have:

HWS Priority Wetland 'Groups' – These are the 82 wetland groups listed in the 2018 Strategy and given values and condition scores, targets and performance objectives. But note that one 'group' that has no significant wetlands is included (Anderson Creek East RB) and that another 'group' wrongly assigns two wetlands as stormwater treatment systems (Galada Tamboore and Dunnett's Road Swamp).

HWS priority wetlands – The 123 wetlands included within the 82 groups described above. But note that two 'wetlands' listed are not actually wetlands at all (Andersons Creek East RB and Cardigan Road RB); three priority wetlands have already been effectively lost (Wyndham Vale Swamp, Troups Road Swamp and Donnybrook Road Lake); and that six Yarra stormwater treatment wetlands are included to cover the Yarra stormwater treatment wetlands group wrongly assigned to Galada Tamboore and Dunnett's Road Swamp.

To complicate matters, Growling Grass Frog reserve ponds to be constructed under the terms of the MSA will clearly be 'regionally significant' wetlands. One small existing pond was mapped under the title Growling Grass Frog conservator ponds as a placeholder. We have now our first MSA reserve pond – at Lyle Lane, Aintree – with a second under construction. This means our list of regionally significant, or high value, wetlands will be constantly changing as new ponds are brought into operation.

Regionally significant wetlands – The output of wetland prioritisation processes after the HWS was published. At the time the Wetland Monitoring and Evaluation Plan was prepared (2019/20) there were 249 wetlands with identified significance at least at the regional level (Appendix C). We are finding that some of these wetlands – many described in reports dating back to the 1990s – no longer support the values for which they were considered to be of significance. The Millennium Drought and ever increasing intensity of land use and urbanisation since the 1990s has had adverse impacts on several of the wetlands.

The list of regionally significant wetlands should be flexible. As we learn more about wetlands we should add or remove wetlands judged on their regional significance. For example, Hanna's Swamp was recently noted as holding cultural heritage significance to Traditional Owners.

Appendix C. List of Regionally Significant Wetlands (2020)

Regional wetlands were prioritised as described above. High level prioritisation follows the categories described in Table C1.

***Table C1**. Wetland significance code.*

Code	Category	Significance
A	Ramsar wetlands	International
AA	Cultural Heritage values	
B	IBBA (Important Bird and Biodiversity Area) - not included in Ramsar sites	International
C	SSN (Shorebird Site Network) wetlands	International
D	DIWA (Directory of Important Wetlands in Australia) - not included in Ramsar sites	National
E	Seasonal Herbaceous Wetlands (Freshwater)	National
F	Growling Grass Frog reserve wetlands	National
G	Dwarf Galaxias habitat ponds	National
H	Significant wetlands listed in previous assessments	State
I	Significant wetlands listed in previous assessments	Regional
J	Priority billabongs	Regional?
K	Melbourne Water's Sites of Biodiversity Significance (SoBS)	Regional
L	Significant wetlands listed in previous assessments	Other/ local
M	"Potential SoBS" - sites raised as potentially significant for natural values	Local
N	Southeast cluster of constructed wetlands (NHT-funded construction)	Local
O	Social value wetlands added by 2018 HWS writing team	Social
P	Other wetlands identified through co-design	Social

The 2019/20 prioritisation identifies 249 wetlands across the Port Phillip and Westernport Region as being of some significance (Melbourne Water 2020b). These are listed below (Table C2), with suggested values and condition monitoring requirements:

- Values: Birds – those wetlands where we would like at least quarterly bird surveys are marked as 'yes'.
- Values: Frogs/Fish – those wetlands requiring targeted surveys for threatened species are marked 'targeted'; other priority wetlands where we would like to see eDNA sampling and analysis are marked 'yes' or 'if practicable'.

- Condition and Values: Vegetation – those wetlands requiring IWC+ assessments are marked 'yes'; those requiring targeted vegetation surveys are so indicated.

The level of monitoring shown in Table C2 is optimistic but this sets out our desired monitoring effort to get some data across the relevant subsets of our regional priority wetlands. Any data collection above the 2017 levels will be a useful improvement in our monitoring program.

Table C.2 *List of 249 regional priority wetlands identified in the 2020 HWS Wetland Monitoring and Evaluation Plan, with suggested key values monitoring requirements (Melbourne Water 2020). Note: Wetlands listed in the 2018 HWS, and given performance objectives, are indicated.*

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
1	Ryans Swamp, WTP	A	Yes	Yes	Targeted	Yes
2	Paul & Belfrages Wetland, WTP	A	Yes	Yes	Targeted	Yes (targeted)
3	Austen Road Pond 1 (Summer Pond 1)	A		Yes	Targeted	Yes
4	Austen Road Pond 2 (Summer Pond 2)	A		Yes	Targeted	Yes
5	Paradise Road Pond	A		Yes	Targeted	Yes
6	T-Section Lagoon (seven ponds)	A		Yes	Targeted	Yes
7	Western Lagoon (nine ponds)	A		Yes	Targeted	Yes (targeted)
8	Lake Borrie Ponds 28 and 29	A		Yes	Targeted	Yes
9	Walsh's Lagoon Ponds 1 and 6	A		Yes	Targeted	Yes
10	WTP habitat ponds (13 ponds)	A	Yes	Yes	Yes	No
11	WTP Q4 Wetland	A		Yes	Yes	Yes
12	WTP Cherry Tree Creek pool	A		Yes	Targeted	Yes
13	WTP The Triangle	A		Yes	No	No
14	Lake Borrie	A		Yes	No	No
15	WTP operational ponds - Walshes Lagoon	A		Yes	No	No
16	WTP operational ponds - 85W Lagoons	A		Yes	No	No
17	WTP operational ponds - 25W Lagoon	A		Yes	No	No
18	WTP operational ponds - 55E Lagoon	A		Yes	No	No

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
19	WTP operational ponds - 115E Lagoon	A		Yes	No	No
20	The Spit Nature Conservation Reserve	A	Yes	Yes	No	Yes
21	RAAF Lake, Point Cook	A	Yes	Yes	Yes	Yes
22	Spectacle Lake, Point Cook	A	Yes	Yes	Yes	Yes
23	Edithvale North Wetland	A	Yes	Yes	Yes	Yes (targeted)
24	Edithvale South Wetland	A	Yes	Yes	Yes	Yes (targeted)
25	Seaford Wetland	A	Yes	Yes	Yes	Yes (targeted)
26	Westernport (incl. coastal wetlands)	A	Yes	Yes	Yes	Yes (targeted)
27	ETP (incl. Golden Triangle, Serpentine Lagoon, Western Holding Basin, Southern Holding Basin and Effluent Holdings Basins 1 to 6, also Forebays 9A and 9B)	B	Yes	Yes	No	No
28	'The Doughnut', ETP	B	Yes	Yes	Yes	Yes
29	Banyan Waterhole (Boundary Road Wetland)	B	Yes	Yes	Yes	Yes
30	PARCS Wetland	B		Yes	Yes	Yes
31	Boggy Creek stormwater treatment wetland	B	Yes	Yes	Yes	No
32	Braeside Park wetlands	B	Yes	Yes	Yes	Yes
33	Cheetham Wetlands	D	Yes	Yes	Yes	Yes
34	Balls Wetland Complex (no. 28 in DEPI 2013a)/ incl. Balls Swamp	E	Yes	Yes	If practicable	Yes (targeted)
35	Barnbam Swamp	E	Yes	Yes	If practicable	Yes (targeted)
36	Baths Swamp (no. 31 in DEPI 2013)	E	Yes	Yes	If practicable	Yes (targeted)
37	Black Forest Road Wetland (no. 44 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
38	Bulban Road Wetland (no. 38 in DEPI 2013a) not currently mapped as a waterbody	E		Yes	If practicable	Yes (targeted)
39	Chartwell No. 1 Wetland (no. 7 in DEPI 2013a; between and east of waterbody 44,930 and 44,620) not currently mapped as a waterbody	E		Yes	If practicable	Yes (targeted)

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
40	Chartwell No. 2 Wetland (no. 15 in DEPI 2013a) not currently mapped as a waterbody	E		Yes	If practicable	Yes (targeted)
41	Chartwell No. 3 Wetland (no. 16 in DEPI 2013a) not currently mapped as a waterbody	E		Yes	If practicable	Yes (targeted)
42	Chirnside Swamp (Chirnside-Primes Swamp [DELWP wetland 70,056])	E		Yes	If practicable	Yes (targeted)
43	Cobbledick Road Ford cluster (no. 46 in DEPI 2013a)	E		Yes	If practicable	Yes (targeted)
44	Deanside West Wetland (no. 2 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
45	Donnybrook Road Lake (Donnybrook Road No. 1 Wetland, in Biosite of regional) (no. 25 in DEPI 2013a)	E	Yes	No	(lost 2018/19)	(lost 2018/19)
46	ETP north of Boggy Creek wetland	E		Yes	If practicable	Yes (targeted)
47	Former Epsom Racecourse	E		Yes	If practicable	Yes (targeted)
48	Gisborne Racecourse Swamp	E	Yes	Yes	If practicable	Yes (targeted)
49	Golf Links Road, Hallam	E		Yes	If practicable	Yes (targeted)
50	Greens Road East Wetland No. 2 (no. 43 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
51	Greens Road Rail Reserve	E		Yes	If practicable	Yes (targeted)
52	Greens Road, Manor Lakes	E		Yes	If practicable	Yes (targeted)
53	Hallam Valley	E	Yes	Yes	If practicable	Yes (targeted)
54	Hearnes Swamp (Hernes Swamp), southern remnant (no. 20 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
55	Kalkallo Common	E	Yes	Yes	If practicable	Yes (targeted)
56	Kalkallo Creek Wetland (no. 22 in DEPI 2013a, waterbody ID 70,700 in waterbodies integrated)	E	Yes	Yes	If practicable	Yes (targeted)
57	Kirks Bridge Road West Wetland (no. 45 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
58	Koala Conservation Reserve	E		Yes	If practicable	Yes (targeted)
59	Kororoit Creek No. 2 Wetland (no. 12 in DEPI 2013a)	E		Yes	If practicable	Yes (targeted)

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
60	Kororoit Creek No. 3 Wetland (no. 14 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
61	Little River Wetland (DELWP wetland 70,073 or no. 47 in DEPI 2013a)	E		Yes	If practicable	Yes (targeted)
62	Live Bomb Wetland (no. 41 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
63	Mambourin Wetland (no. 42 in DEPI 2013a); not currently mapped as a waterbody	E		Yes	If practicable	Yes (targeted)
64	Mt Derrimut Grassland Reserve	E		Yes	If practicable	Yes (targeted)
65	Muddy Gates Lane Complex (no. 49 in DEPI 2013a)	E		Yes	If practicable	Yes (targeted)
66	Old Melbourne Road	E		Yes	If practicable	Yes (targeted)
67	One Tree Hill Swamp (no. 35 in DEPI 2013a; DELWP wetland 70,080)	E		Yes	If practicable	Yes (targeted)
68	Paynes Road (South) Swamp (no. 5 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
69	Peninsula Link Interchange	E		Yes	If practicable	Yes (targeted)
70	Rabbitters Lake (no. 29 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
71	Rabitters Swamp (no. 40 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
72	Richmonds Grass Swamp (no. 32 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
73	Rockbank No. 1 Wetland (no. 11 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
74	Rockbank Railway Swamp (no. 4 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
75	Scenic Estate Conservation Reserve	E		Yes	If practicable	Yes (targeted)
76	Target Range Swamp (no. 34 in DEPI 2013a)	E		Yes	If practicable	Yes (targeted)
77	Troups Road Swamp (no. 3 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
78	West Quandong Swamp (no. 37 in DEPI 2013a)	E	Yes	Yes	If practicable	Yes (targeted)
79	William Angliss Native Grassland Reserve	E		Yes	If practicable	Yes (targeted)

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
80	Woodlot Lane	E		Yes	If practicable	Yes (targeted)
81	Wyndham Vale Swamp (no. 6 in DEPI 2013a)	E	Yes	No	No (lost 2018/19)	No (lost 2018/19)
82	Edgars Road Swamp	E		Yes	If practicable	Yes (targeted)
83	Tarneit SHW	E		Yes	If practicable	Yes (targeted)
84	Jacana Wetlands	F	Yes	Yes	Yes	Yes (targeted)
85	Growling Grass Frog habitat ponds (DWL473A) placeholder	F	Yes	No	Targeted	Targeted
86	Dwarf Galaxias Conservation pond (SoBS)	G	Yes	No	Targeted	Targeted
87	Dwarf Galaxias habitat ponds, Dandenong Creek (EODC)	G	Yes	No	Targeted	Targeted
88	Hallam Valley Floodplain, O'Grady Road	G		No	Targeted	Yes (targeted)
89	Yarra Flats billabongs (Yarra Glen Billabong)	H		Yes	Yes	Yes
90	Morang (Yarrambat-Morang) Wetlands, including Wilton Vale Marsh, Mother-in-Laws Leap, Tortoise Pond, NE Wetland and Carex Pond	H		Yes	Yes	Yes
91	Cockatoo Creek floodplain	H	Yes	Yes	Yes	Yes
92	Rhyll Swamp (DELWP wetland 70,870)	H		Yes	Yes	Yes
93	Altona Treatment Plant	I	Yes	Yes	Yes	No
94	Andersons Swamp	I	Yes	Yes	Yes	Yes
95	Bailie's Billabong	I		Yes	Yes	Yes
96	Baillieu Wetlands (waterbodies 13,622, 13,713, 13,711, 14,945, 16,184, etc.)	I		Yes	Yes	Yes
97	Bayles Fauna Reserve (DELWP wetland 71,973 - wb 15,375)	I		Yes	Yes	Yes
98	Beaconsfield Reservoir	I		Yes	Yes	No
99	Bevnol Road wetland (waterbodies 2885, 2887, 31,408, 31,436, 31,484, 31,485 and 70168)	I		Yes	Yes	Yes
100	Bingham's Swamp (DELWP wetlands 70,068 and 70,071, mistakenly referred to as Rolling	I	Yes	Yes	Yes	Yes

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
	Thunder Wetland, or 'Unnamed wetland 1')					
101	Blackburn Lake	I		Yes	Yes	Yes
102	Bombing Range Dam	I		Yes	Yes	Yes
103	Browns Road Wetland (waterbody 469)	I		Yes	Yes	Yes
104	Chelsea Heights Wetland (Carrum North Wetland or Center Swamp Drain wetland)	I		Yes	Yes	No
105	Coldstream West Billabong (waterbody 14,002)	I		Yes	Yes	Yes
106	Coolart Wetlands, Somers	I	Yes	Yes	Yes	Yes
107	Cranbourne Botanic Gardens (incl. waterbody 3209?)	I		Yes	Yes	No
108	Cunningham's Swamp	I	Yes	Yes	Yes	Yes
109	Deans Marsh, Rockbank	I		Yes	Yes	Yes
110	Devilbend Reservoir	I		Yes	Yes	Yes
111	Djerriwarrh Reservoir	I		Yes	Yes	No
112	Frankston Reservoir	I		Yes	Yes	No
113	Grasmere Creek Wetland (DELWP wetland 71,118)	I		Yes	Yes	Yes
114	Greens Road West swamps (DELWP wetland 70,419 and 70,416?)	I		Yes	Yes	Yes
115	Hann's Creek Wetland (waterbodies 20,872 and 21,004)	I		Yes	Yes	Yes
116	Jensz Swamp (DELWP wetland 70,062)	I	Yes	Yes	Yes	Yes
117	Laverton RAAF Swamp (Reserve 'C')	I	Yes	Yes	Yes	Yes
118	Melba's Dam (DELWP wetland 71,754, Biosite 1587)	I		Yes	Yes	Yes
119	Melton Reservoir	I		Yes	Yes	No
120	Melton Sewage Treatment Plant	I		Yes	Yes	No
121	Mornington Peninsula National Park (DELWP wetlands 70,254, 70,255, 70,256, 70,258, 70,259, 70,260, 70,260, 70,261)	I		Yes	No (too scattered)	No (too scattered)

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
122	Mount Rothwell Homestead Dam (waterbody 12,746 now called urban lake DUL434)	I		Yes	Yes	Yes (to determine if values lost)
123	Newell's Paddock Wetlands, Footscray	I		Yes	Yes	Yes
124	Paisley Challis Wetland, Jawbone Reserve	I	Yes	Yes	Yes	Yes
125	Paynes Road North Swamp (North Swamp)	I		Yes	Yes	Yes
126	Pobblebonk Wetland Reserve (waterbodies 31,893 and 31,899)	I		Yes	Yes	Yes
127	Portsea Swamp (Portsea Lagoon Wildlife Sanctuary) (DELWP wetland 70,267)	I		Yes	Yes	Yes
128	Riverend Park Training Facility (DELWP wetland 71,167)	I		Yes	Yes	Yes
129	SERO Wetland (waterbody 70,205)	I		Yes	Yes	Yes
130	Sewells Road Dams (DELWP wetlands 70,452, 70,532, 70,446, 70,445 and 70,456)	I		Yes	Yes	Yes
131	Shepherds Bush Billabong (waterbody 14,977)	I		Yes	Yes	Yes
132	Sorrento Golf Club (DELWP wetland 70,257)	I		Yes	Yes	No
133	Toorourrong Reservoir	I		Yes	Yes	Yes
134	Tootgarook Swamp (Boneo Swamp)	I		Yes	Yes	Yes
135	Towt's Swamp, Glenvale (DELWP wetland 71,900)	I		Yes	Yes	Yes
136	Trib of Coolart Creek Wetland (waterbody 21,701)	I		Yes	Yes	Yes
137	Truemans Road Recreational Reserve (Tootgarook Wetlands) (DELWP wetland 70,272)	I	Yes	Yes	Yes	Yes
138	Unnamed wetland Larwill & Costello 1016 (Could be waterbody 19,637?)	I		Yes	Yes	Yes
139	Unnamed wetland Larwill & Costello 795A (waterbodies 23,063, 23,130, 23,131, 23,208 and 23,248)	I		Yes	Yes	Yes

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
140	Unnamed wetland, Boneo (DELWP wetland 70,251)	I		Yes	Yes	Yes
141	Unnamed wetland, Larwill & Costello 1028, Sommers (waterbody 20,376?)	I		Yes	Yes	Yes
142	Unnamed wetland, Main Ridge (DELWP wetland 70,286)	I		Yes	Yes	Yes
143	Warringal Swamp	I		Yes	Yes	Yes
144	Waterways Estate (Mordialloc Creek Wetlands)	I		Yes	Yes	Yes
145	Woodlands Estate Wetlands	I		Yes	Yes	Yes
146	Tanunda Wetlands, Whittlesea, Plenty Gorge Park (waterbodies 49,764 to 49,692)	I		Yes	Yes	Yes
147	The Briars	I	Yes	Yes	Yes	Yes
148	Bittern Reservoir	I?		Yes	Yes	Yes
149	Banyule Billabong	J		Yes	Yes	Yes
150	Banyule Swamp	J		Yes	Yes	Yes
151	Bolin Bolin Billabong	J	Yes	Yes	Yes	Yes
152	Burke Road Billabong	J	Yes	Yes	Yes	Yes
153	Domain Chandon billabongs	J	Yes	Yes	Yes	Yes
154	Spadonis Billabong	J	Yes	Yes	Yes	Yes
155	Willsmere Billabong (The Kew Billabong)	J	Yes	Yes	Yes	Yes
156	Annulus Billabong	J	Yes	Yes	Yes	Yes
157	Yallock Creek Floodplain Wetlands	J	Yes	Yes	Yes	Yes
158	Yarra Bridge Streamside reserve	J	Yes	Yes	Yes	Yes
159	Cardinia Creek Retarding Basin	K	Yes	Yes	Yes	Yes
160	Cardinia Reservoir	K		Yes	Yes	No
161	Cherry Lake	K	Yes	Yes	Yes	Yes
162	Galada Tamboore	K		Yes	Yes	Yes
163	Dunnetts Road Swamp	K		Yes	Yes	Yes
164	Liverpool Road Retarding Basin	K		Yes	Yes	Yes
165	Monbulk Creek Retarding Basin	K		Yes	Yes	Yes

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
166	Police Road Retarding Basin	K		Yes	Yes	Yes
167	Riddell Road Retarding Basin (Lakewood Reserve Lake)	K		Yes	Yes	Yes
168	Silvan Reservoir	K		Yes	Yes	No
169	Sugarloaf Reservoir	K		Yes	Yes	No
170	Tamarisk Waterway Reserve	K	Yes	No	Yes	Yes
171	Tirhatuan Wetlands	K	Yes	Yes	Yes	Yes
172	Truganina Swamp	K	Yes	Yes	Yes	Yes (targeted)
173	Wannarkladdin Wetlands	K	Yes	Yes	Yes	Yes
174	Winton Wetlands, Dandenong Creek	K	Yes	Yes	Yes	Yes
175	Yan Yean Reservoir	K		Yes	Yes	No
176	Yering Backswamp	K	Yes	Yes	Yes	Yes
177	Abey Road Wetland, Melton South (DELWP wetland 70,437?)	L		Yes	Yes	Yes
178	Altona Lakes Golf Course	L		Yes	Yes	No
179	Altona Tip Swamp (Altona Tip Wetland)	L		Yes	Yes	Yes
180	Balliang East Dam (DELWP wetland 70,109?)	L		Yes	Yes	Yes
181	Bambra Park Swamp (DELWP wetland 70,438)	L		Yes	Yes	Yes
182	Black Swamp	L	Yes	Yes	Yes	Yes
183	Cherry Swamp	L		Yes	Yes	Yes
184	Davis Swamp, Balliang East	L		Yes	Yes	Yes
185	Dry Creeks Dam, Chartwell (same as Chartwell SHW wetlands?) (DELWP wetland 70,537 multiple polygons)	L		Yes	Yes	Yes (targeted)
186	Eynesbury Road Swamp, Exford (DELWP wetland 70,431)	L		Yes	Yes	Yes
187	Green Hills Swamps (DELWP wetlands 70,579 and 70,578?)	L		Yes	Yes	Yes
188	Holden Road Wetland (previously 'Unnamed wetland 2')	L	Yes	Yes	Yes	Yes

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
189	Mt Cottrell Road Swamp (DELWP wetland 70,575)	L		Yes	Yes	Yes
190	Newport Lakes (North Lake, South Lake and smaller ponds)	L		Yes	Yes	Yes
191	O'Herns Road Swamp, Craigieburn (DELWP wetland 70,406?)	L		Yes	Yes	Yes
192	Ripley Road Swamp (DELWP wetland 70,078)	L		Yes	Yes	Yes
193	Robinson Road Swamp (waterbody 44,608?)	L		Yes	Yes	Yes
194	Ross Swamp (DELWP wetland 70,066)	L		Yes	Yes	Yes
195	Sewells Road Swamp (DELWP wetland 70,455)	L		Yes	Yes	Yes
196	Sharkeys Swamp (waterbody 12,837 now called urban lake DUL436)	L		Yes	Yes	Yes (to determine if values lost)
197	Spring Street Swamp, Beveridge (waterbodies 63,750 and 63,762 and one other)	L		Yes	Yes	Yes
198	Toorourrung Reservoir/ Plenty Creek	L		Yes	Yes	Yes
199	Werribee CSIRO Swamp (now Heathdale Glen Orden Wetland)	L		Yes	Yes	Yes (to determine if values lost)
200	Cox's Property Billabongs (wb 14188, 14192, 14197, 14836, 14840, 14907 and 14908)	M		Yes	Yes	Yes
201	Dandenong Valley Wetland (Rigby's Wetland)	M		Yes	Yes	Yes
202	Leisure Land (Langwarrin South RB)	M		Yes	Yes	Yes
203	Gordon Rolfe Reserve	M		Yes	Yes	Yes (targeted)
204	The Pines Flora and Fauna Reserve wetlands	M		Yes	Yes	No
205	French Island coastal and freshwater wetlands	M		Yes	Yes	Yes
206	Eumemmerring Creek Wetland (Frog Hollow Wetland)	N		Yes	Yes	No
207	Golf Links Road Wetland	N		Yes	Yes	No
208	Hallam Valley RB Wetland	N		Yes	Yes	No

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
209	Hampton Park East (Kilberry Boulevard)	N		Yes	Yes	No
210	North Heatherton Road Wetland	N		Yes	Yes	No
211	Hampton Park RB East (Rivergum Creek Wetland)	N		Yes	Yes	No
212	South Heatherton Road Wetland	N		Yes	Yes	No
213	Troups Creek Wetland	N		Yes	Yes	No
214	Waterford Valley Wetland (Karoo Road Wetland)	N		Yes	Yes	No
215	Albert Park Lake	O		Yes	Yes	No
216	Aura Vale Lake	O		Yes	Yes	No
217	Caulfield Park Lake	O		Yes	Yes	No
218	Coburg Lake	O		Yes	Yes	No
219	Edwardes Lake	O		Yes	Yes	No
220	Emerald Lake	O		Yes	Yes	No
221	Greenvale Reservoir	O	Yes	Yes	Yes	No
222	Hays Paddock Billabong	O	Yes	Yes	Yes	Yes
223	Jells Park	O		Yes	Yes	No
224	Kalparrin Gardens	O		Yes	Yes	No
225	Karkarook Park Lake	O		Yes	Yes	No
226	Koomba Park	O		Yes	Yes	No
227	Lillydale Lake	O	Yes	Yes	Yes	No
228	Lysterfield Lake	O		Yes	Yes	No
229	Pipemakers Park	O	Yes	Yes	Yes	No
230	Pykes Creek Reservoir	O		Yes	Yes	No
231	Queens Park	O	Yes	Yes	Yes	No
232	Ringwood Lake	O	Yes	Yes	Yes	No
233	Rossalynne Reservoir	O		Yes	Yes	No
234	Westgate Park	O	Yes	Yes	Yes	Yes
235	Wilson Botanic Park, Berwick	O		Yes	Yes	Yes
236	Lang Lang Floodplain Wetlands	P	Yes	Yes	Yes	Yes
237	Brushy Creek Sed Ponds	P		No	No	No

#	Name (alternate name)	Code	PO in HWS	Value/ Condition to be monitored		
				Birds	eDNA (Frogs/ Fish)	Wetland condition & Vegetation
238	Hawkstowe Wetlands	P		No	No	No
239	Laurimar Park Estate Wetlands	P		No	No	No
240	Mill Park Lakes	P		No	No	No
241	Simons Creek Wetland	P		No	No	No
242	Button-grass Wetland, Bunyip	I		No	If practicable	Yes (targeted)
243	Bass Recreation Reserve Billabong	J		Yes	Yes	Yes
244	Swan Lake	I		Yes	Yes	Yes
245	Kitty Miller Wetlands	I		Yes	Yes	No
246	Tooronga Plateau wetlands	H		No	If practicable	Yes (targeted)
247	Holden Proving Ground Wetlands	L		No	If practicable	Yes
248	Wetland 72,248	E		No	No	Yes (targeted)
249	Wetland 70,662	E		No	No	Yes (targeted)

Appendix D. Types of performance objectives for wetlands

(documented more fully in the wetland MEP, Melbourne Water 2020b)

WPO theme	No. of WPOs	PO wording	Possible management actions
Build and maintain stormwater treatment systems	7	Implement urban stormwater treatment measures in the catchment/upstream to reduce water quality threat.	• Investigations • WSUD • Management of directly connected imperviousness in the catchment • Street and end-of-pipe systems (e.g. street trees and stormwater treatment wetlands) • Stormwater harvesting schemes • Distributed on-lot systems (e.g. raingardens, rainwater tanks, green roofs and living walls) • Community engagement and education
Maintain stormwater treatment systems	10	Maintain the flood retention/stormwater treatment design capacity and function of constructed wetlands, with consideration/management of the biodiversity values	• Ongoing maintenance of existing stormwater assets, such as desilting and infrastructure maintenance • Engaging with asset manager to elevate environmental priorities where appropriate • Aquatic revegetation where needed
Stormwater management foundational actions	4	Ensure appropriate planning controls are in place (e.g. Environmental Significance Overlay) to protect EPBC-listed Seasonally Herbaceous Wetland vegetation (identified in the HWS)	• Legislative controls/ improvements e.g. planning overlays • Engaging in non-regulatory controls e.g. working with developers and Councils
	1	Ensure that use of Cunningham's Swamp as a stormwater retarding basin is not at the expense of the natural wetland form.	• Planning controls • Management of stormwater through a wetland protection plan

WPO theme	No. of POs	Example PO wording	Possible management actions
Improve water quality from agricultural land practices	2	Implement urban stormwater and rural land management improvements upstream to reduce water quality threat to wetland.	• Stormwater quality wetlands • Installing and maintaining water sensitive urban design (WSUD) infrastructure. • Stock-exclusion fencing

			• Reducing fertiliser and other chemical run-off • Protecting or revegetating wetland buffers • Education and community engagement • Grants to landowners (e.g. for alternative water points, such as troughs, away from wetlands)
	3	Implement rural land management program to reduce nutrient and sediment inflow to the wetlands	• Stock exclusion fencing • Reducing fertiliser and other chemical run-off • Protecting or revegetating wetland buffers • Education and community engagement • Grants to landowners (e.g. for alternative water points, such as troughs, away from wetlands)

WPO theme	Po No	Example PO wording	Possible management actions
Maintain or improve flow regimes in regulated or unregulated systems	29	Investigate opportunities to further re-engage the natural wetlands in this area and to improve wetland water regime to meet ecological watering objectives, improve ecosystem services, cultural and social value.	• Investigate hydrological requirements of wetland values. • Deliver required hydrology through an appropriate method • Consider Scada technology and passive retrofit options for less labour-intensive data collection
	8	Maintain/implement water regime to meet ecological watering objectives (where an environmental entitlement exists)	• Deliver environmental water • Modify hydrology through works
	15	Maintain/implement water regime to meet ecological watering objectives (where no environmental entitlement exists)	• Modify hydrology through works • Manage catchment stormwater
	1	Prepare adaption pathway for climate change impacts, including opportunities to maintain water regime in light of climate change and stormwater impacts.	• Investigations • Preparation of suitable management plan • Implementation and reporting against management plan
	3	Continue to implement water regime management to meet ecological objectives in artificial habitats within the Ramsar site.	Deliver appropriate environmental, or other, flows

WPO theme	Number of POs	Example PO wording	Possible management actions
Mitigate threat of soil disturbance	5	Confirm threat to wetland from livestock access and reduce threat to low, Or Reduce soil disturbance threat to low.	• Control of stock and human traffic (both pedestrian and vehicle) through exclusion fencing, or installing gates, pathways and signs. • Controlling works near wetlands to prevent erosion and transport of sediments into the wetland. • Preparation and implementation of appropriate site management plans.
	4	Minimise threat of acidification through appropriate works practices in acid sulphate soils.	• Assess and document potential acid sulphate soils (PASS) risk. • Avoid exposure of PASS. • Control of stock and human traffic (both pedestrian and vehicle) through exclusion fencing, or installing gates, pathways and signs. • Preparation and implementation of appropriate site management plans.
Protect specific values and habitat	5	Undertake IWC assessment at wetlands identified in the HWS, and prepare wetland specific performance objectives after assessment.	• Field assessment • Planning
	9	Incorporate wetland into the Western Grassland Reserve with management.	• Land acquisition • Management plan • Management implementation
	9	Implement the WGR adaptive management regime.	• Management plan preparation and implementation
	1	Investigate feasibility of incorporating Downs Estate property into the adjacent Ramsar site.	• Review by regulating authority • Advocacy
	11	Identify opportunities for habitat creation and migration to mitigate habitat loss resulting from climate change. Identify options for addressing risk to coastal habitat.	• Assessment and planning
	8	Undertake monitoring to ensure that site stays within the limits of acceptable change as identified in the Ramsar Management Plan and in accordance with new requirements for monitoring, evaluation and reporting at Ramsar sites. This is done through DELWP's Ramsar Management System, which	• Monitoring • Reporting

WPO theme	Number of POs	Example PO wording	Possible management actions
		is effectively an online, real time MERI plan.	
	2	Implement priority actions from the Edithvale-Seaford Ramsar Wetlands Site Management Plan 2016	• On-ground works • Investigations • Monitoring
Pest management	25	Reduce/ ensure invasive wetland flora threat is low/moderate	• Weed control • Monitoring
	43	Monitor/ reduce threat of invasive fauna to moderate/low.	• Monitoring – for Smooth Newt, Red-necked Slider and other potential invasive species (e.g. detected through eDNA surveillance as part of this MEP) • Fox/cat control • Rabbit control • Deer control • Education and restrictions regarding domestic animal access
	7	Maintain threat from carp at low following watering events.	• Monitoring of pest fish following environmental flow delivery • Installing carp exclusion screens to incoming flows. • Drying wetlands, removal of pest fish.
	6	Monitor threat levels from invasive fish species on Dwarf Galaxias and Yarra Pygmy Perch, and mitigate risks if required.	• Monitoring for presence and impact of pest species of fish • Management of water levels and aquatic habitat to mitigate impacts

WPO theme	Number of POs	Example PO wording	Possible management actions
Maintain or improve vegetation quality	7	Ensure appropriate aquatic macrophyte habitat is protected in the habitat ponds.	Revegetation Weed control Water management
Increase Vegetation Extent	51	Improve/increase wetland buffer to 25/50 per cent of the wetland perimeter. Improve wetland buffer width and fill gaps in wetland buffer length.	Revegetation of sites with fencing Maintenance works – weed management, maintenance of supporting infrastructure (e.g. fencing, off-stream watering) Monitoring and investigations
	14	Investigate opportunities to improve wetland/floodplain area and habitat and create habitat as appropriate.	• Investigations and preparation of action plans • Revegetation of sites – fencing, planting, direct seeding

WPO theme	Number of POs	Example PO wording	Possible management actions
			• Maintenance works – weed management, maintenance of supporting infrastructure (e.g. fencing, off-stream watering) • Monitoring

Appendix E. RPOs that relate to wetlands

Table E.1 *List of RPOs which relate to wetlands.*

PO #	Performance Objective
RPO-10	An adaptive pathways approach is adopted to understand and manage the risks of climate change on waterways.
RPO-11	Understanding of groundwater dependent ecosystems is improved and opportunities to maintain or improve these continue to be investigated.
RPO-12	Water for the Environment continues to be managed and delivered to the region's rivers and wetlands and recovery options continue to be investigated.
RPO-13	Industry capacity for whole of water cycle and stormwater management is increased to enable collaboration, improved access to information and knowledge, and a skilful and capable industry with strong established networks.
RPO-14	Standards, tools and guidelines are in place and implemented to enable re-use and infiltration of excess stormwater, and protect and/or restore urban waterways.
RPO-15	Victoria's planning system is used effectively to protect and enhance waterway values.
RPO-17	Water quality in waterways and bays is improved by reducing inputs of sediment and other pollutants from urban construction and development.
RPO-18	Critical waterway health assets including stormwater treatment systems, fishways and erosion control structures, are maintained for their designed purpose or the same outcomes are delivered by alternative means.
RPO-20	The amenity, community connection and recreation values of wetlands are better understood and performance objectives are developed to enhance these values.
RPO-28	Seasonal Herbaceous Wetland vegetation communities are identified and a management program is in place to protect them on public and private land.
RPO-29	Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls.
RPO-32	Programs are in place to protect and enhance sites of biodiversity significance associated with the regions waterways, such as through Melbourne Water's Sites of Biodiversity Significance Plan)
RPO-34	Waterway Labs are established as needed to tackle complex or region-wide priorities.
RPO-37	Participation rates in education, capacity building, incentive programs and citizen science activities have increased and enable greater levels of environmental stewardship for our waterways.
RPO-42	Wetland condition information and prioritisation with a focus on vulnerable wetlands is understood and informs collaborative planning.

Appendix F. 2021/22 progress reports for selected RPOs

The following progress reports from the HWS website relate to several key wetland related RPOs. For further information on the remainder of the RPOs which also relate to wetlands refer to the HWS website.

RPO 20 - The amenity, community connection and recreation values of wetlands are better understood and performance objectives are developed to enhance these values.

Wetlands social value conceptual models were developed during 2020/21 by Melbourne Water in consultation with Jacobs Engineering Group. A key focus of the conceptual models was to consider the balance, conflicts and interlinks between wetland ecosystem values and the associated impacts from community access. Three wetland typologies were categorised against the conceptual models to assess this interrelationship; natural wetlands with high ecological values, constructed wetlands with flow management and treatment functions and constructed wetlands with drainage functions. Further engagement with stakeholders is required on these conceptual models.

RPO 28 Seasonal Herbaceous Wetland vegetation communities are identified and a management program is in place to protect them on public and private land.

Key Partners: Department of Environment, Energy and Climate Action (DEECA), Melbourne Water

The Western Grassland Reserve (WGR) has protected three relatively large areas of SHW (totalling 12.5 ha), and numerous smaller areas (totalling <5 ha). These areas are managed in concert with the grasslands which surround them. To date, management actions have included the removal of African Boxthorn, Artichoke Thistle, Serrated Tussock and Cane Needle Grass, along with the removal of livestock from all sites. Annual monitoring of WGR wetlands was not conducted in 2020, however results from 2014-2019 show that SHW condition is steady.

Given the wet season of 2019/20, Healthy Waterways Strategy wetlands have been easier to identify and assess this year. Melbourne Water has commissioned mapping and assessment of SHW in the northern urban growth area, which has revealed some previously unknown sites. Refer to Regional Performance Objective 29 for protection mechanisms for wetland on public and private land.

RPO 29 Programs, standards, tools and guidelines are in place to protect wetland vegetation communities from urban and rural threats, including adequate planning controls.

Key Partners: Department of Environment, Energy and Climate Action (DEECA), Melbourne Water, Parks Victoria, Local Government, Victorian Planning Authority

The Wetland Monitoring and Evaluation Plan articulates guidance and standards for management, monitoring and evaluating progress for natural wetlands. In the first year of the Healthy Waterways Strategy three natural priority natural wetlands were severely impacted and effectively lost because of urban development. There has been significant effort to reduce this threat through more sensitive planning, triggered by the first Healthy Waterways Strategy Annual Report highlighted this overlooked problem.

Over the past year protection mechanisms have been analysed and reported to the Healthy Waterways Strategy Regional Leadership Group for consideration. A special Healthy Waterways Strategy partner sub-working group has been established to further address this issue and report to the Regional Leadership Group. Work was initiated, but is not completed, to develop a decision/risk

framework for providing guidance for determining when natural wetland protection is necessary and evaluating options for such protection.

The Victorian Planning Authority has been updating the Guidelines for Precinct Structure Planning, which guide the planning of greenfield growth area suburbs. The guidelines review process has considered inclusion of planning for new greenfield suburbs to protect and enhance significant environmental and biodiversity values, including natural wetlands. These natural features are critical for the preservation of the significant cultural and biodiversity conservation values and contribute to the liveability and amenity of these new suburbs. In addition, the State Government's Victorian Waterway Management Strategy review was initiated, and the issue of the impacts of urbanisation and wetland habitat loss identified for consideration in the review.

To further support the need for urgent action, the Melbourne Waterway Research-Practice Partnership (MWRPP) is conducting research on natural wetlands. This valuable research has had significant positive impact. There have been improvements to natural wetland information data sets including location, hydro-periods, extent, and estimation of vegetation cover-types. Improved mapping information has been shared with Healthy Waterways Strategy partners including the Port Phillip and Western Port CMA for priority inclusion in the Regional Catchment Strategy and DEWLP for inclusion in their state-wide wetland mapping and will become a consistent information set for wetland planning and decisions making across the Port Phillip and Western Port region. This information is provided in the new Healthy Waterways Strategy webmap tool that includes a map of all natural wetlands across the region.

This is important because natural wetlands in urban growth areas remain at risk from urbanisation. Our 2020/21 assessment of the status of regional priority wetlands suggests Sewell's Road Swamp is now so reduced and altered by urbanisation as to have effectively lost the natural values for which it was recognised. But we must await on-ground assessment before deciding the actual status of this wetland.

If Sewell's Road Swamp is judged to be effectively lost as a natural wetland this would mean four of our natural regional priority wetlands have been effectively lost since the Healthy Waterways Strategy was launched. This year's assessment lists another 14 priority wetlands as being under imminent risk of degradation. However, on the positive side, 104 of 254 regional priority wetlands are protected, and the number under threat has not increased.

Overall, of an estimated total of 6,253 ha of natural wetlands in the region, 2,137 ha are considered protected (within Parks Victoria reserves, Melbourne Water sites of biodiversity significance, botanic gardens, etc.). But 114 ha has been effectively lost since 2018; 663 ha is judged to be under imminent threat and 163 ha at future risk of urbanisation.

Next we need to hasten progress in developing guidance for natural wetland protection, and options for such protection, to reduce the further loss and fragmentation of natural wetlands in the region. In the meantime, we need to ensure that comprehensive wetland information is updated for Melbourne's region and used, including state-wide wetland mapping, to inform all planning decisions to protect natural wetlands, into Land Use Planning Frameworks for the region, Integrated Water Management Planning, Regional Catchment Strategy implementation and Precinct Structure Planning processes.

RPO 32 - Programs are in place to protect and enhance sites of biodiversity significance associated with the regions waterways, such as through Melbourne Water's Sites of Biodiversity Significance Plan)

Key Partners: Department of Environment, Energy and Climate Action (DEECA), Melbourne Water, Parks Victoria, Councils, Birdlife Australia, (formerly) Port Phillip and Westernport Catchment Management Authority (PPWPCMA), RMIT University

DEECA oversee Ramsar wetland management across the region, working with CMAs, Parks Victoria, Melbourne Water and others to deliver dedicated Ramsar Site management plans, site MERI plans, agency co-ordination and reporting procedures. During 2020-21, we continued to implement the region's Ramsar site management and MERI plans.

PPWCMA was the site co-ordinator for the Western Port Ramsar site. The key emphasis of this role is to work collaboratively to implement the recommendations identified within the Ramsar Site Strategic Management Plan. During 2020/21 PPWCMA co-ordinated the delivery of services to protect and improve the ecological character of Western Port. At Edithvale-Seaford Ramsar site works during 2020/21 included commissioning a feasibility study into the use of recycled water from the Eastern Treatment Plant to mitigate impacts of climate change at Seaford Wetlands.

Melbourne Water also engaged RMIT to undertake a research study on the water and sediment quality at Edithvale-Seaford wetlands. This research is leading us to a better understanding of the macroinvertebrates (important bird food) living in the sediment and their tolerance to pollution. Under DEECA's $5M Suburban Parks Program at Seaford Wetlands a number of ecological based projects are being scoped ready to be delivered by June 2022. Projects include replacing old nest boxes, installing live cameras, installing natural habitat such as logs and stags, and carrying out planting to enhance habitat within the wetlands.

During 2020/21, in addition to ongoing management and habitat improvement work through Melbourne Water's SoBS program, Melbourne Water has undertaken surveys for threatened species of flora at six of these sites, prepared new management plans for five sites, and assessed five other properties for their eligibility for listing as SoBS.

In addition, a project looking at habitat improvement for the threatened Southern Toadlet continued. This project aims to retain, protect, and create habitat for the Southern Toadlet, by reducing damage from deer incursion, controlling weeds, and rehabilitating deer wallows in waterways. The project included population surveys across three publicly managed reserves over multiple years prior to the commencement of works. These investigations have been valuable for understanding Southern Toadlet populations and guiding required habitat works. On ground works are commencing in the Sugarloaf Reservoir with a larger program of works planned in South East region to follow via future projects once investigations are complete.

Appendix G. Species of bird selected for inclusion in Wetland Bird Index

Table G.1 *Species of bird selected for inclusion in the Wetland Bird Index (Birdlife Australia 2022b).*

Common name	Scientific name	EPBC Act	FFG
Magpie Goose	*Anseranas semipalmata*		NT
Plumed Whistling-Duck	*Dendrocygna eytoni*		
Blue-billed Duck	*Oxyura australis*	Migratory	EN
Pink-eared Duck	*Malacorhynchus membranaceus*		
Cape Barren Goose	*Cereopsis novaehollandiae*		
Black Swan	*Cygnus atratus*		
Australian Shelduck	*Tadorna tadornoides*		
Hardhead	*Aythya australis*		VU
Australasian Shoveler	*Spatula rhynchotis*		VU
Northern Shoveler	*Spatula clypeata*	Migratory	
Pacific Black Duck	*Anas superciliosa*		
Grey Teal	*Anas gracilis*		
Chestnut Teal	*Anas castanea*		
Freckled Duck	*Stictonetta naevosa*	Migratory	EN
Musk Duck	*Biziura lobata*		VU
Australian Wood Duck	*Chenonetta jubata*		
Australasian Grebe	*Tachybaptus novaehollandiae*		
Hoary-headed Grebe	*Poliocephalus poliocephalus*		
Great Crested Grebe	*Podiceps cristatus*		
Lewin's Rail	*Lewinia pectoralis*		VU
Buff-banded Rail	*Hypotaenidia philippensis*		
Australian Spotted Crake	*Porzana fluminea*		
Baillon's Crake	*Zapornia pusilla*		
Spotless Crake	*Zapornia tabuensis*		
Australasian Swamphen	*Porphyrio porphyrio*		
Dusky Moorhen	*Gallinula tenebrosa*		
Black-tailed Native-hen	*Tribonyx ventralis*		
Eurasian Coot	*Fulica atra*		
Brolga	*Antigone rubicunda*		VU
South Island Pied Oystercatcher	*Haematopus finschi*		
Australian Pied Oystercatcher	*Haematopus longirostris*		
Sooty Oystercatcher	*Haematopus fuliginosus*		NT

Common name	Scientific name	EPBC Act	FFG
Banded Stilt	*Cladorhynchus leucocephalus*		
Red-necked Avocet	*Recurvirostra novaehollandiae*		
Pied Stilt	*Himantopus leucocephalus*		
Grey Plover	*Pluvialis squatarola*	Migratory	EN
Pacific Golden Plover	*Pluvialis fulva*	Migratory	VU
American Golden Plover	*Pluvialis dominica*		
Red-capped Plover	*Charadrius ruficapillus*		
Double-banded Plover	*Charadrius bicinctus*	Migratory	
Lesser Sand Plover	*Charadrius mongolus*	EN/Migratory	CR
Greater Sand Plover	*Charadrius leschenaultii*	VU/Migratory	CR
Oriental Plover	*Charadrius veredus*	Migratory	
Hooded Plover	*Thinornis cucullatus*		VU
Black-fronted Dotterel	*Elseyornis melanops*		
Banded Lapwing	*Vanellus tricolor*		
Masked Lapwing	*Vanellus miles*		
Red-kneed Dotterel	*Erythrogonys cinctus*		
Australian Painted Snipe	*Rostratula australis*	EN	CR
Whimbrel	*Numenius phaeopus*	Migratory	VU
Little Curlew	*Numenius minutus*	Migratory	
Eastern Curlew	*Numenius madagascariensis*	CR/Migratory	VU
Bar-tailed Godwit	*Limosa lapponica*	VU/Migratory	
Hudsonian Godwit	*Limosa haemastica*		
Black-tailed Godwit	*Limosa limosa*	Migratory	VU
Ruddy Turnstone	*Arenaria interpres*	Migratory	VU
Great Knot	*Calidris tenuirostris*	CR/Migratory	EN
Red Knot	*Calidris canutus*	EN/Migratory	EN
Ruff	*Calidris pugnax*	Migratory	
Broad-billed Sandpiper	*Calidris falcinellus*	Migratory	
Sharp-tailed Sandpiper	*Calidris acuminata*	Migratory	
Stilt Sandpiper	*Calidris himantopus*		
Curlew Sandpiper	*Calidris ferruginea*	CR/Migratory	EN
Long-toed Stint	*Calidris subminuta*	Migratory	NT
Red-necked Stint	*Calidris ruficollis*	Migratory	
Sanderling	*Calidris alba*	Migratory	NT
Little Stint	*Calidris minuta*		
Pectoral Sandpiper	*Calidris melanotos*	Migratory	NT
Latham's Snipe	*Gallinago hardwickii*	Migratory	NT

Common name	Scientific name	EPBC Act	FFG
Terek Sandpiper	*Xenus cinereus*	Migratory	EN
Common Sandpiper	*Actitis hypoleucos*	Migratory	VU
Grey-tailed Tattler	*Tringa brevipes*	Migratory	CR
Common Greenshank	*Tringa nebularia*	Migratory	VU
Wood Sandpiper	*Tringa glareola*	Migratory	VU
Marsh Sandpiper	*Tringa stagnatilis*	Migratory	VU
Wilson's Phalarope	*Steganopus tricolor*		
Red-necked Phalarope	*Phalaropus lobatus*	Migratory	
Australian Pratincole	*Stiltia isabella*		NT
Oriental Pratincole	*Glareola maldivarum*	Migratory	
Black Noddy	*Anous minutus*		
Silver Gull	*Chroicocephalus novaehollandiae*		
Pacific Gull	*Larus pacificus*		
Kelp Gull	*Larus dominicanus*		
Bridled Tern	*Onychoprion anaethetus*	Migratory	
Little Tern	*Sternula albifrons*	Migratory	VU
Fairy Tern	*Sternula nereis*	VU	EN
Australian Gull-billed Tern	*Gelochelidon macrotarsa*		EN
Caspian Tern	*Hydroprogne caspia*	Migratory	NT
Whiskered Tern	*Chlidonias hybrida*		NT
White-winged Black Tern	*Chlidonias leucopterus*	Migratory	NT
White-fronted Tern	*Sterna striata*		NT
Common Tern	*Sterna hirundo*	Migratory	
Arctic Tern	*Sterna paradisaea*		
Crested Tern	*Thalasseus bergii*		
Australian Pelican	*Pelecanus conspicillatus*		
Australasian Bittern	*Botaurus poiciloptilus*	EN	EN
Australian Little Bittern	*Ixobrychus dubius*		EN
Nankeen Night-Heron	*Nycticorax caledonicus*		
Cattle Egret	*Bubulcus ibis*	Migratory	
White-necked Heron	*Ardea pacifica*		
Eastern Great Egret	*Ardea alba*	Migratory	VU
Intermediate Egret	*Ardea intermedia*		EN
White-faced Heron	*Egretta novaehollandiae*		
Little Egret	*Egretta garzetta*		
Eastern Reef Egret	*Egretta sacra*		
Australian White Ibis	*Threskiornis moluccus*		

Common name	Scientific name	EPBC Act	FFG
Straw-necked Ibis	*Threskiornis spinicollis*		
Yellow-billed Spoonbill	*Platalea flavipes*		
Royal Spoonbill	*Platalea regia*		
Glossy Ibis	*Plegadis falcinellus*	Migratory	
Little Pied Cormorant	*Microcarbo melanoleucos*		
Great Cormorant	*Phalacrocorax carbo*		
Little Black Cormorant	*Phalacrocorax sulcirostris*		
Black-faced Cormorant	*Phalacrocorax fuscescens*		
Pied Cormorant	*Phalacrocorax varius*		
Australasian Darter	*Anhinga novaehollandiae*		
Eastern Osprey	*Pandion cristatus*		
Swamp Harrier	*Circus approximans*		
White-bellied Sea-Eagle	*Haliaeetus leucogaster*		VU
Orange-bellied Parrot	*Neophema chrysogaster*	CE	CE
Azure Kingfisher	*Ceyx azureus*		
White-fronted Chat	*Epthianura albifrons*		
Golden-headed Cisticola	*Cisticola exilis*		
Little Grassbird	*Poodytes gramineus*		
Australian Reed-Warbler	*Acrocephalus australis*	Migratory	

Appendix H. Evaluation of Wetland Bird Species Index trends over time

The following description of wetland bird index changes and trends over time at some regionally significant wetlands is taken from Birdlife Australia's detailed 2022 report (Birdife Australia 2022b). While Birdlife Australia used several measures to assess wetland bird communities we, here, report only those three metrics included in our Wetland Bird Index: summed reporting rate for wetland species, number of listed species and number of species recorded breeding.

Ramsar Sites

Edithvale North Wetlands

The Summed Reporting Rates or Basic Scores and the Numbers of Listed Species for Edithvale North Wetlands have been close to 20 during all four time blocks (see Figures 1 and 2), indicating that the wetlands support a wetland bird community categorised as Moderate. Twenty is the threshold value for the Number of Listed Species between a 'High' and a 'Very High' Index category, and therefore, the Index Category is stable at 'Very High' or 'High'. A large increase in the Number of Breeding Species to 11 has been recorded during the current block. All Limits of Acceptable Change (LAC) criteria for the Edithvale-Seaford Wetlands Ramsar Site investigated during annual reporting have been met (except for Piscivores) despite significant annual fluctuations in guild abundances associated with annual fluctuations in water levels at the Ramsar site and significant variations in annual rainfall in eastern Australia (BirdLife Australia 2020c, 2021a and 2021b; see section below on 'Factors Affecting Wetland Bird Indices'). The bird community at Edithvale North Wetlands is tracking well.

Edithvale South Wetlands

The Summed Reporting Rates calculated for time blocks 1, 2, 3 and 4 at Edithvale South wetlands were 19.0, 18.7, 15.4 and 15.9, respectively, indicating that the wetlands support a wetland bird community categorised as Moderate (Figures 3 and 4). The high numbers of Listed Species (21-30) recorded there during all four time blocks has elevated the wetland bird communities to a 'Very High' category. All Limits of Acceptable Change (LAC) criteria for the Edithvale-Seaford Wetlands Ramsar Site investigated during annual reporting have been met (except for Piscivores) despite significant annual fluctuations in guild abundances associated with annual fluctuations in water levels at the Ramsar Site and significant variations in annual rainfall in eastern Australia (BirdLife Australia 2020c, 2021a and 2021b; see 'Factors Affecting Wetland Bird Indices'). The bird community at Edithvale South Wetlands is tracking well.

Seaford Wetlands

The Summed Reporting Rate recorded at Seaford Wetlands declined from Blocks 1 and 2 (21.5 and 22.3) to Blocks 3 and 4 (14.5 and 16.0) indicating that the basic wetland bird score there has declined from a 'Moderate' to a 'Poor' Category overtime (Figures 5 and 6). However, the high numbers of Listed Species (21-26) recorded during each block has resulted in the Index Category being stable at 'Very High'. All Limits of Acceptable Change (LAC) criteria for the Edithvale-Seaford Wetlands Ramsar Site investigated during annual reporting have been met (except for Piscivores) despite significant annual fluctuations in guild abundances associated with annual fluctuations in

water levels at the Ramsar Site and significant variations in annual rainfall in eastern Australia (BirdLife Australia 2020c, 2021a and 2021b; see 'Factors Affecting Wetland Bird Indices'). At Seaford Wetlands, there are significant management issues, including increasing salinity associated with groundwater and tidal intrusion and difficulties associated with grooming invasive Common Reed (Ecology Australia 2016). Despite these management issues, the wetland bird community is tracking well at Seaford Wetlands.

Western Port

Wetland bird communities at Western Port Bay have Summed Reporting Rates of 6.1 (Index Category of 'Very Poor') during Block 1, 10 ('Poor') during Bock 2, 17.8 ('Moderate') during Block 3 and 14.4 ('Poor') during Block 4 (Figures 7 and 8). During each block, the wetland bird communities have been elevated to the 'Very High' category by the high Numbers of Listed Species recorded during all four blocks (≥20) and by the high numbers of Breeding Species (16) recorded during Block 3. The high increases in Summed Reporting Rates, Numbers of Breeding Species and Numbers of Listed species recorded during Blocks 3 and 4 compared to Blocks 1 and 2 indicate that the wetland bird community is currently tracking well. Although during each block, the minimum of 20 surveys were undertaken, there were considerable increases in the number of surveys undertaken from Block 1 (57 surveys) to Block 2 (241 surveys) to Blocks 3 (727 surveys) and 4 (676 surveys). This could account for the increases in Summed Reporting Rate and Numbers of Breeding and Listed Species (Figures 7 and 8), during the first three blocks.

Western Treatment Plant – T-Section Lagoon (WTP – T-Section Lagoon)

A substantial increase in the Summed Reporting Rate was recorded at the WTP – T-Section Lagoon from the 13.1 and 14.7 calculated during Blocks 2 and 3, to 20.1 recorded during Block 4 (Figures 9 and 10). The high Number of Listed Species recorded during each block elevated the wetland bird community to the 'Very High' category. Most statistics and indices have been higher during Blocks 3 and 4, which may relate to the much higher number of surveys undertaken during those blocks compared to Block 2. (Although, once survey numbers exceed 40 we should not expect this to influence the index.) The wetland bird community at T-Section Lagoon is tracking well.

Western Treatment Plant – Western Lagoon (WTP – Western Lagoon)

The Summed Reporting Rates for Blocks 2 (12.7), 3 (12.9) and 4 (13.7) at the WTP – Western Lagoon are consistent over time and indicate that the site supports a wetland bird community categorised as Poor (Figures 11 and 12). The Numbers of Listed Species for those blocks (i.e. 22, 23 and 20) are also consistent considering the number of surveys undertaken during the current block (27) is currently less than half of Blocks 2 (54) and 3 (63). The Numbers of Listed Species has elevated the wetland bird communities at the site from the 'Poor' to a 'Very High' Category (i.e. >20 Listed Species) during Blocks 2 and 3 and a 'High' Category (i.e. = 20 Listed Species) during Block 4. Melbourne Water undertook decommissioning of Ponds 4 and 5 in about 2005, and rehabilitation which commenced in 2010. The wetland bird community at Western Lagoon is tracking well.

Western Treatment Plant – Habitat Ponds

The Summed Reporting Rates are low, but relatively constant at 6.3, 6.5 and 6.3 calculated for Blocks 2, 3 and 4, respectively (Figures 13 and 14). The drop in Index Category from 'Very High' recorded during Blocks 2 and 3 to 'Moderate' recorded during Block 4 is driven by the lower Number of Listed Species (14) detected during Block 4 compared to 27 and 23 observed during Blocks 2 and 3, respectively. The Average Annual Waterbird Richness has also dropped overtime from Block 2

(44.0), to Block 3 (42.8) to Block 4 (37.5). The declines in Numbers of Listed Species may reflect the much lower number of surveys undertaken during Block 4 to date (i.e. 81 surveys compared to 268 during Block 2 and 321 during Block 3), despite the threshold of 20 surveys being met.

Alternatively, there has been some concern that consistently higher water levels in most Habitat Ponds except for 85WC Pond 9, which continues to provide expanses of mud and good foraging habitat for shorebirds, have resulted in declining numbers of shorebirds. A decline in numbers of shorebirds could be manifested in a decline in the Numbers of Listed Species used to calculate the Wetland Bird Index. Habitat Pond 85WC Pond 9 is managed for shorebirds. Some Habitat Ponds are managed for the Growling Grass Frog (*Litoria raniformis*) which is listed as a Vulnerable species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. 5W Pond 9 is always managed with higher water levels for the Growling Grass Frog, while 5W Pond 10 was managed for the Growling Grass Frog during the 2021/2022 season. 5W Pond 11 has on occasions provided good habitat for shorebirds and Melbourne Water planned to manage this pond for shorebirds with provision of lower water levels during 2021/2022. However, 5W Ponds 10 and 11 are connected by an open pipe and significant rainfall combined with a relatively small and high outlet on 5W Pond 11 resulted in higher water levels than was planned for shorebirds. Management also needs to consider potential outbreaks of Avian Botulism which also hinders management for shorebirds with lower water levels during summer potentially promoting outbreaks.

Another concern for Melbourne Water associated with the Habitat Ponds is a decline in quality of shorebird habitat associated with vegetation encroachment which has occurred at Austin Road (Summer) Pond 2, 35E Ponds 8 and 9 and 270S Borrow Pit (Heather Graham, Melbourne Water, pers. comm.). The 270S Borrow Pit now supports a high cover of Coastal Saltmarsh, which would provide potential habitat for the Critically Endangered Orange-bellied Parrot (*Neophema chrysogaster*), but would not be beneficial to shorebirds. Melbourne Water has undertaken a number of studies and is investigating a number of options, including monitoring water depth to address these water levels and vegetation encroachment issues.

Further bird monitoring survey data will be beneficial to determine if the decline in Numbers of Listed Species (and Average Annual Species Richness) detected during Block 4 compared to Blocks 2 and 3 is an artefact of the lower number of surveys undertaken or whether some of the factors, namely higher water levels or vegetation encroachment are resulting in a decline in the quality of shorebird habitat.

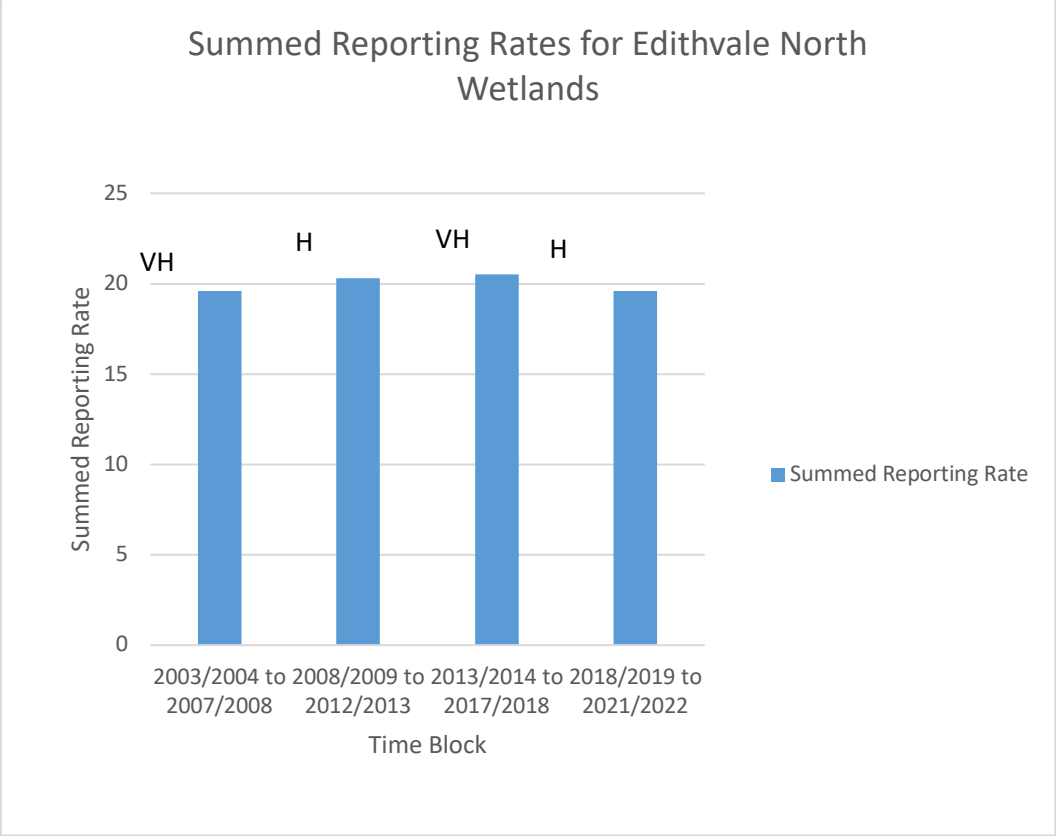


Figure H.1 *The wetland bird communities at Edithvale North Wetlands are categorised as Moderate based on the Summed Reporting Rates for the four time blocks. The numbers of Listed Species recorded there elevated the wetland bird community to a 'High' (H) (Blocks 2 and 4) or 'Very High' (VH) (Blocks 1 and 3) Category (see Figure H.2).*

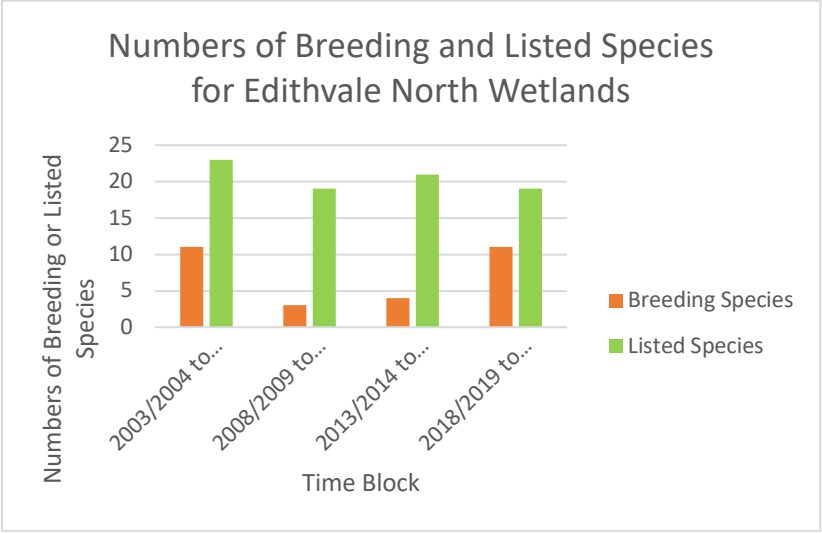


Figure H.2 *The numbers of Breeding and Listed Species recorded at Edithvale North Wetlands during the four time blocks. The numbers of Listed Species recorded there elevated the wetland bird communities from a 'Moderate' Category to a 'High' (i.e. less than 20 for Blocks 2 and 4) or a 'Very High' (i.e. more than 20 for Blocks 1 and 3) Category (see Figure H.1).*

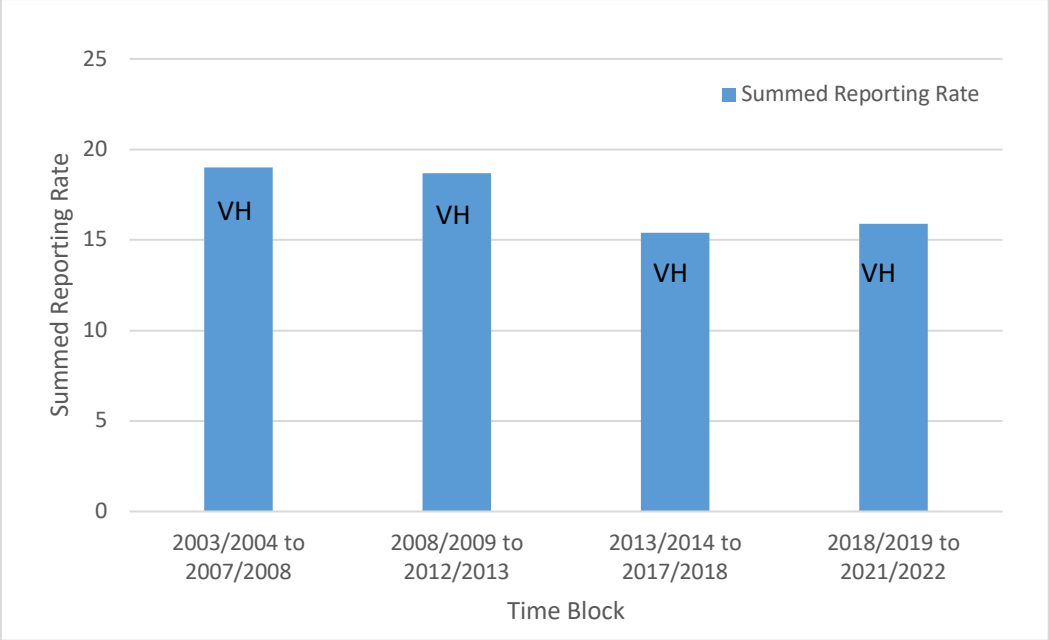


Figure H.3 *The wetland bird communities at Edithvale South Wetlands are categorised as either Moderate (Blocks 1 and 2) or Poor (Blocks 3 and 4) based on the Summed Reporting Rates for the four time blocks. The numbers of Listed Species (>20) recorded there has elevated the wetland bird community to a 'Very High' (VH) category for all four blocks (see Figure H.4).*

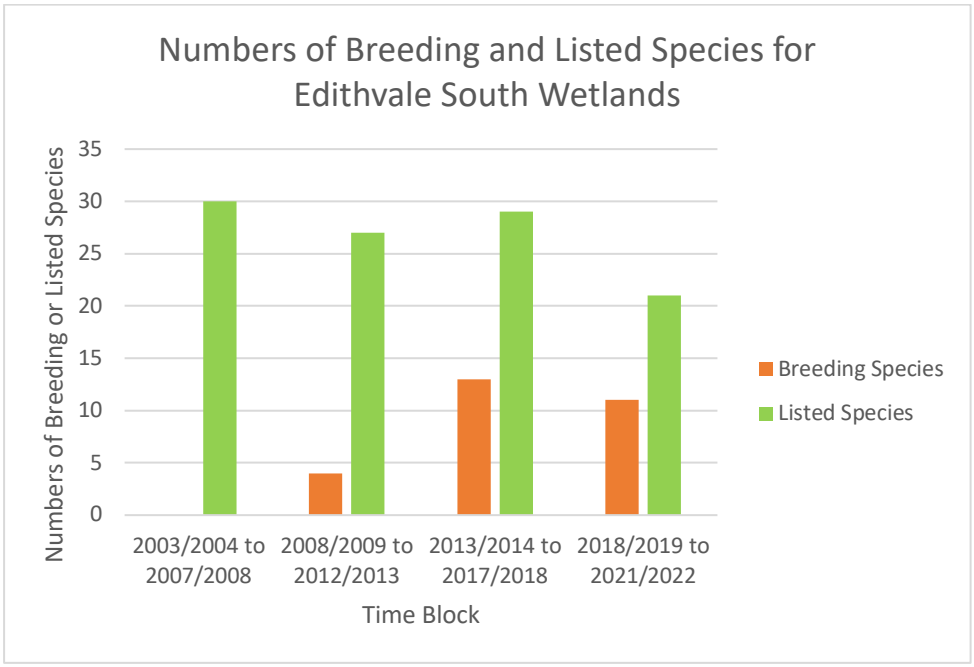


Figure H.4 *The numbers of Breeding and Listed Species recorded at Edithvale South Wetlands during the four time blocks. The numbers of Listed Species recorded there was greater than 20 during each block, and therefore, elevated the wetland bird communities from a 'Moderate' or 'Poor' Category to a 'Very High' Category during all four blocks (see Figure H.3).*

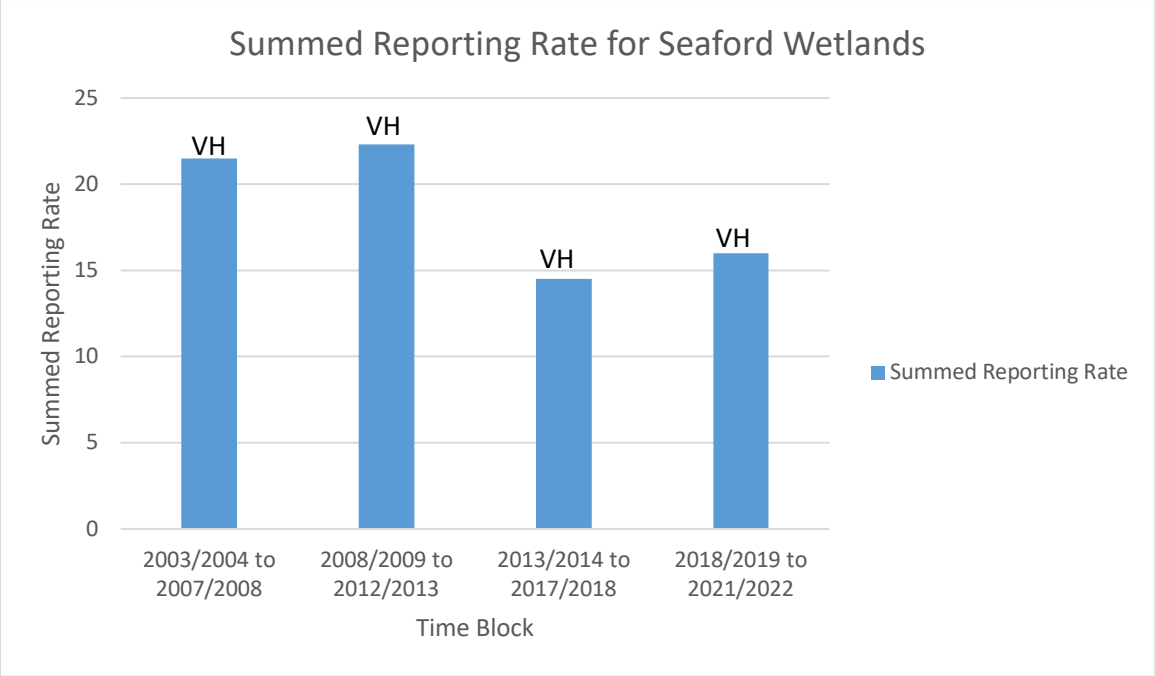


Figure H.5 *The wetland bird communities at Seaford Wetlands are categorised as either Moderate (Blocks 1 and 2) or Poor (Blocks 3 and 4) based on the Summed Reporting Rates for the four time blocks. The numbers of Listed Species (>20) recorded there has elevated the wetland bird community to a 'Very High' (VH) category for all four blocks (see Figure H.6).*

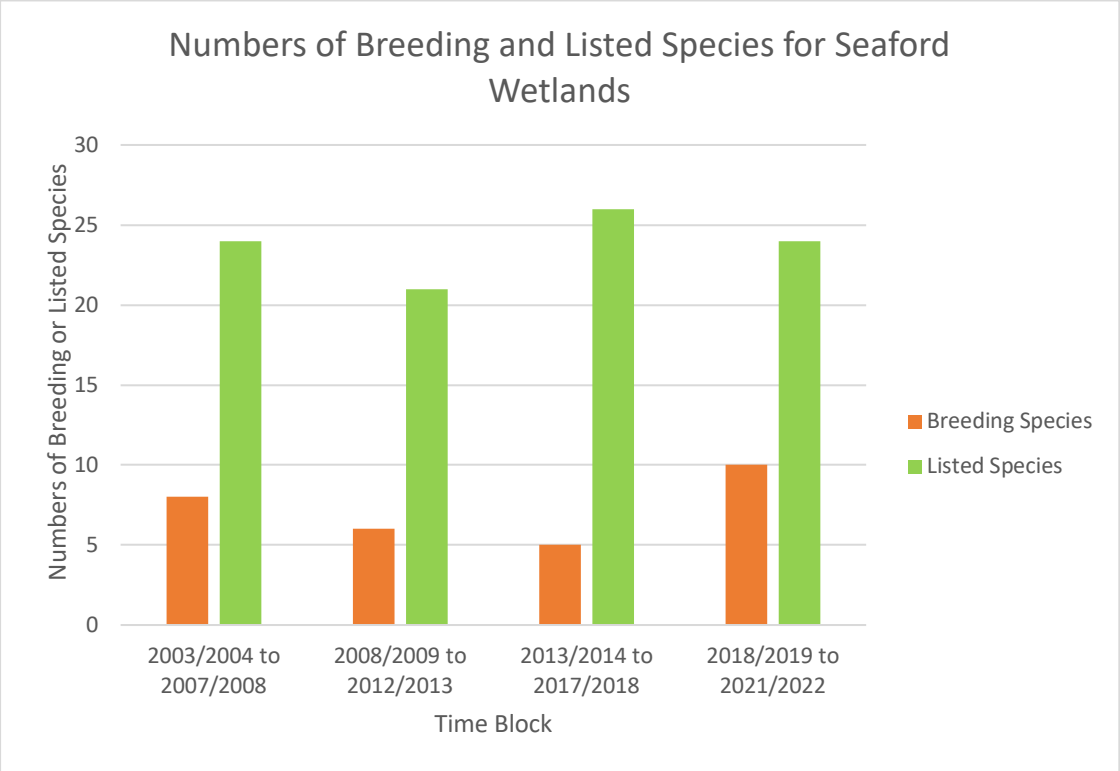


Figure H.6 *The numbers of Breeding and Listed Species recorded at Seaford Wetlands during the four time blocks. The numbers of Listed Species recorded there was greater than 20 during each block, and therefore, has elevated the wetland bird communities from a 'Moderate' or 'Poor' Category to a 'Very High' Category during all four blocks (see Figure H.5).*

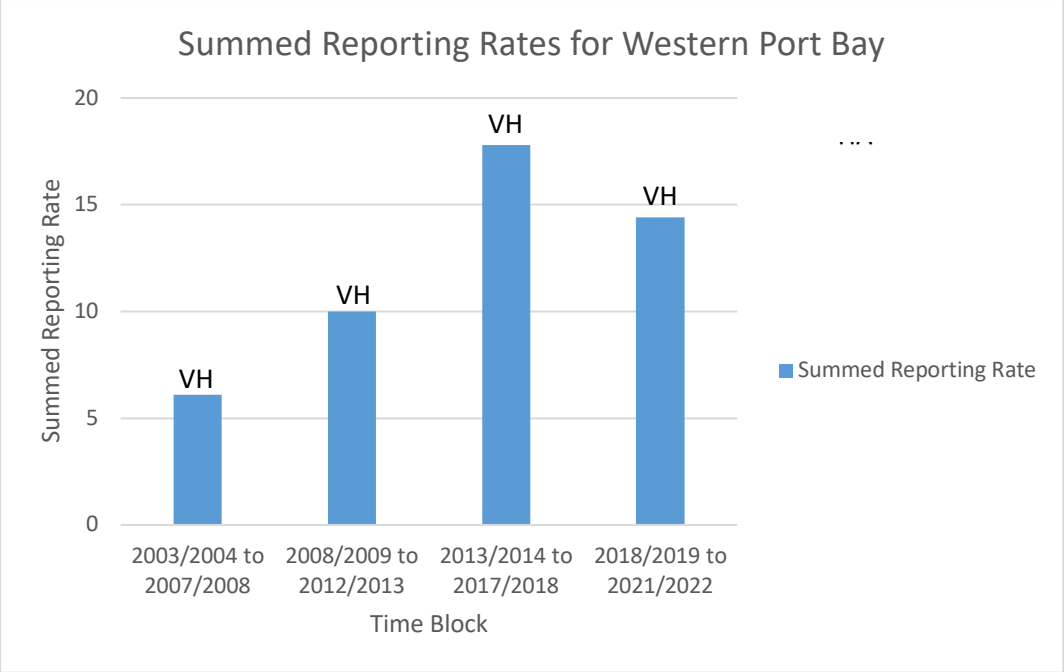


Figure H.7 *The wetland bird communities at Western Port Bay are categorised as Very Poor (Block 1), Poor (Block 2), Moderate (Block 3) and Poor (Block 4) based on the Summed Reporting Rates for the four time blocks. The numbers of Listed Species (>20) recorded there has elevated the wetland bird community to a 'Very High' (VH) category for all four blocks (see Figure H.8). The increases in Summed Reporting Rate and Numbers of Breeding and Listed Species (Figure 8) could simply relate to the number of surveys undertaken which increased from Block 1 (57 surveys) to Block 2 (241 surveys) to Blocks 3 (727 surveys) and 4 (676 surveys) (see text).*

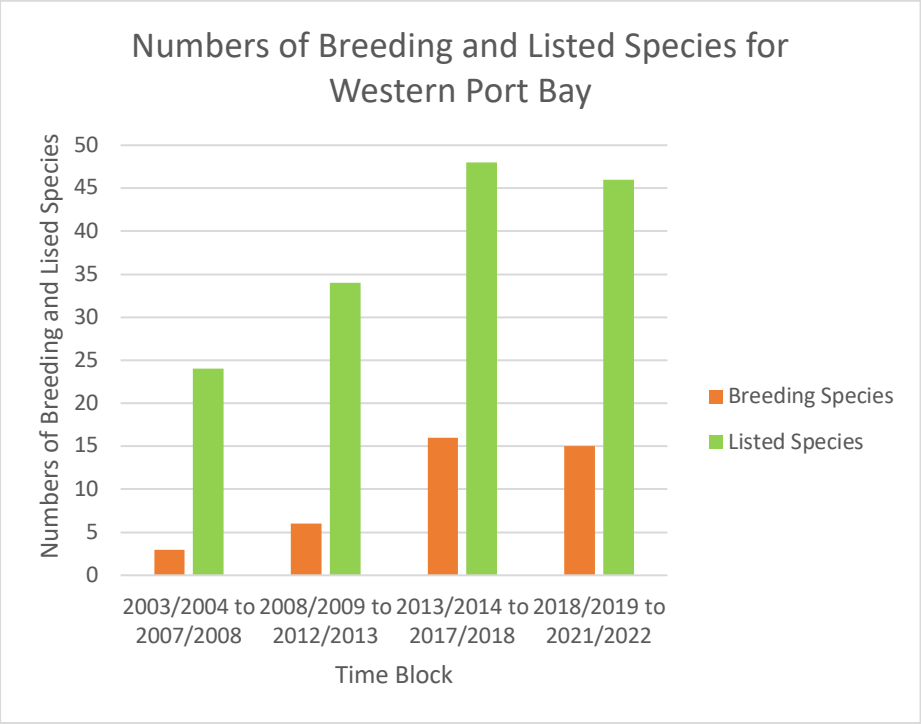


Figure H.8 *The numbers of Breeding and Listed Species recorded at Western Port Bay during the four time blocks. The numbers of Listed Species recorded there was greater than 20 during each block, and therefore, has elevated the wetland bird communities from a 'Very Poor', 'Poor' or 'Moderate' Category to a 'Very High' Category during all four blocks (see Figure H.7).*

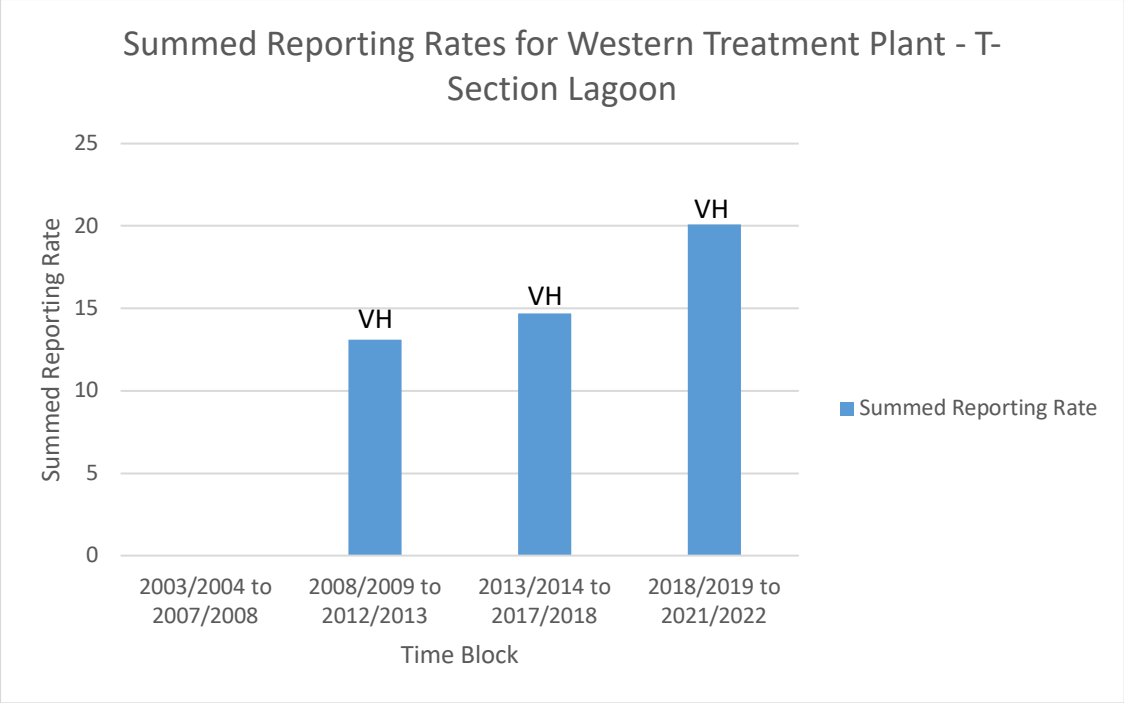


Figure H.9 *The wetland bird communities at the WTP T-Section Lagoon are categorised as Poor for Blocks 2 and 3 and Moderate for Block 4 based on the Summed Reporting Rates. The numbers of Listed Species (>20) recorded there during the three blocks has elevated the wetland bird community to a 'Very High' (VH) category (see Figure H.10).*

Figure H.10 *The numbers of Breeding and Listed Species recorded at the Western Treatment Plant's T-Section Lagoon during Blocks 2, 3 and 4. The numbers of Listed Species recorded there was greater than 20 during each block, and therefore, has elevated the wetland bird communities from a 'Poor' or 'Moderate' Category to a 'Very High' Category during all three blocks (see Figure H.9).*

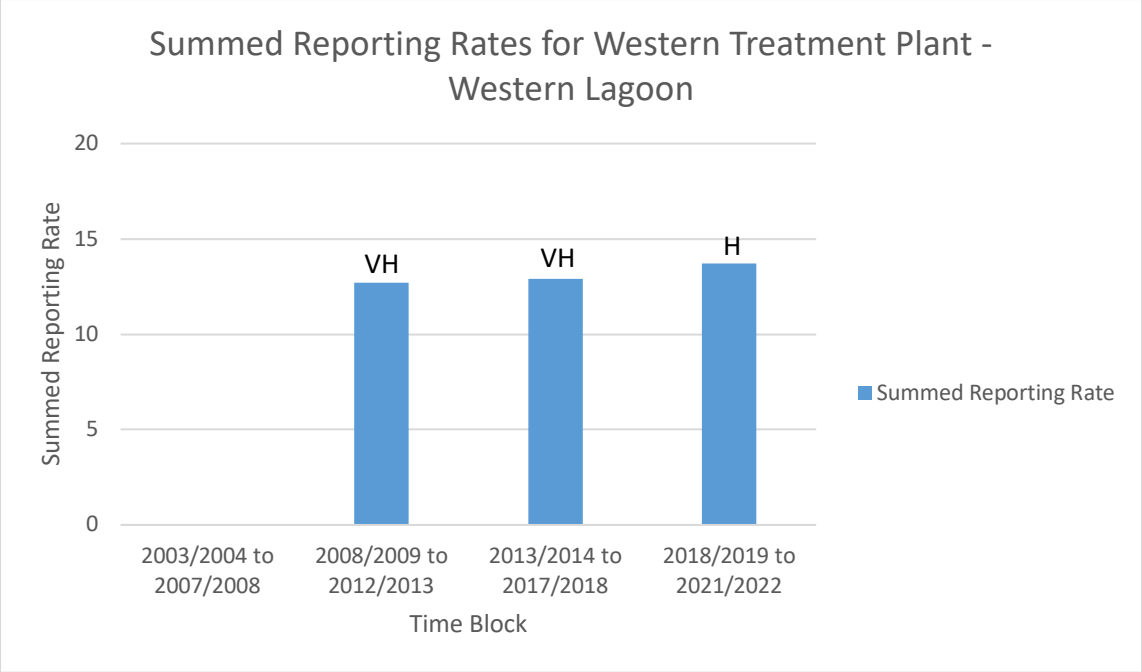


Figure H.11 *The wetland bird communities at the WTP Western Lagoon are categorised as Poor for Blocks 2, 3 and 4 based on the Summed Reporting Rates. The numbers of Listed Species (>20) recorded there during Blocks 2 and 3 elevated the wetland bird community to a 'Very High' (VH) category, while the number of Listed Species recorded during the current block (20) has elevated the community to a 'High' (H) category (see Figure H.12).*

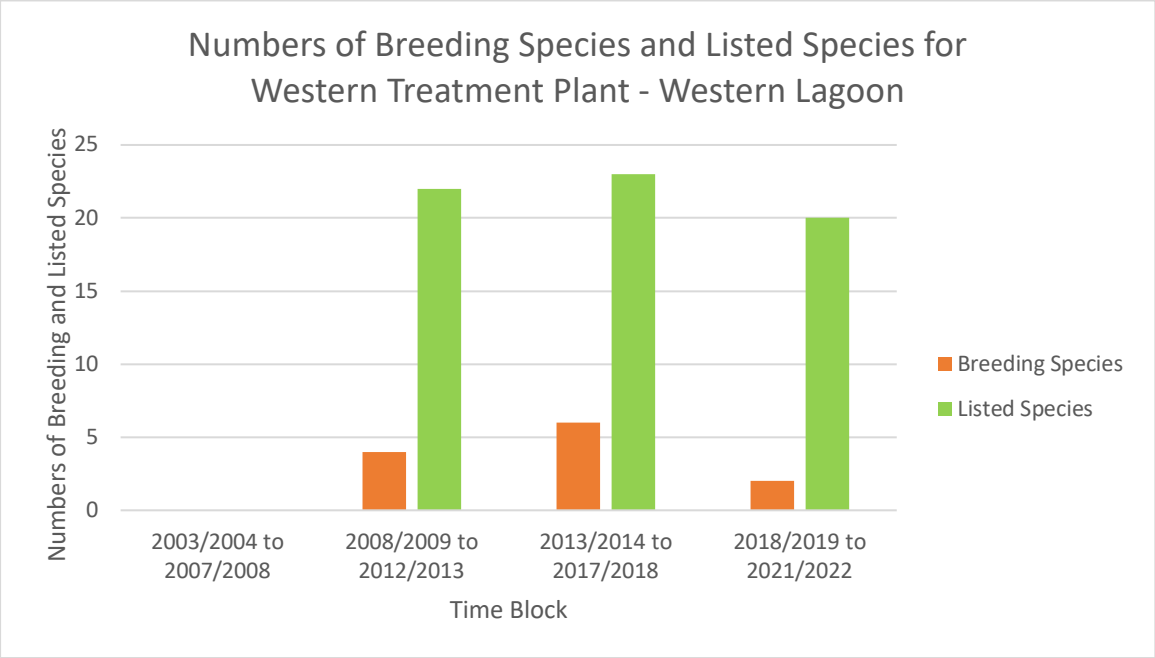


Figure H.12 *The numbers of Breeding and Listed Species recorded at the Western Treatment Plant's Western Lagoon during Blocks 2, 3 and 4. The numbers of Listed Species recorded at Western Lagoon was greater than 20 during Blocks 2 and 3, and therefore, elevated the wetland bird communities from a 'Poor' Category to a 'Very High' Category during these blocks. During Block 4, the 20 Listed Species recorded there has elevated the wetland bird community to a 'High' category (see Figure H.11).*

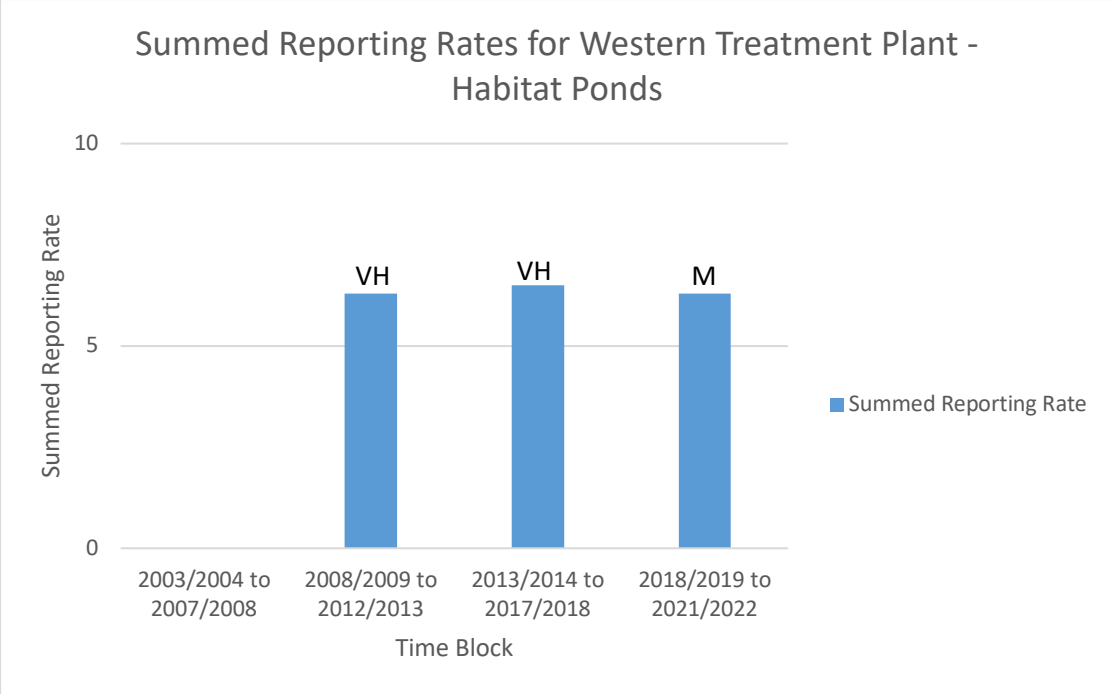


Figure H.13 *The wetland bird communities at the Western Treatment Plant's Habitat Ponds are categorised as Very Poor for Blocks 2, 3 and 4 based on the Summed Reporting Rates. The numbers of Listed Species (>20) recorded there during Blocks 2 and 3 elevated the wetland bird community to a 'Very High' (VH) category, while the number of Listed Species (14) recorded during the current block has elevated the community to a 'Moderate' (M) category (see Figure H.14).*

Figure H.14 *The numbers of Breeding and Listed Species recorded at the Western Treatment Plant's Habitat Ponds during Blocks 2, 3 and 4. The numbers of Listed Species recorded at the Habitat Ponds was greater than 20 during Blocks 2 and 3, and therefore, elevated the wetland bird communities from a 'Very Poor' Category to a 'Very High' Category during these blocks. During Block 4, the 14 Listed Species recorded there has elevated the wetland bird community to a 'Moderate' category (see Figure H.13).*

Key Biodiversity Areas - KBAs

Eastern Treatment Plant (ETP)

The Eastern Treatment Plant (ETP) supports a wetland bird community categorised as Very High during all four blocks based on the very high Summed Reporting Rates of 35.8 to 40.3 (Figure H.15). The ETP also supported a very high number of Listed species during all four blocks (32-36) and high number of Breeding Species (11-17) (Figure H.16). However, the 'Very High' category is based on the very high Basic Scores, as the wetland bird community is already at the maximum category. The wetland bird community at the ETP is tracking very well.

Eastern Treatment Plant (ETP) South – Boundary Road Wetland/Banyan Waterhole

Based on the Summed Reporting Rates, the Eastern Treatment Plant (ETP) South – Banyan Waterhole supported wetland bird communities categorised as Poor (11.7), Moderate (19.9), Moderate (16.3) and Poor (15.7) during Blocks 1, 2, 3 and 4, respectively (Figure H.17). During Blocks 1 and 4, the Numbers of Listed Species recorded there (18 and 19 respectively) elevated the wetland bird communities from a 'Poor' to a 'High' category. During Blocks 2 and 3, the Numbers of Listed Species recorded there (21 and 22 respectively) elevated the wetland bird communities from a 'Moderate' to a 'Very High' category. The increase in Summed Reporting Rate and Numbers of Listed Species from Block 1 to Block 2 at Banyan Waterhole could relate to Melbourne Water implementing active management of the wetland and making hydrological improvements or an increase in waterbird populations following the breaking of the Millennium Drought (see 'Factors Affecting Wetland Bird Indices'), or a combination Melbourne Water management and the breaking of the drought. The wetland bird community at the ETP South – Banyan Waterhole is relatively stable and appears to be tracking well.

Braeside Park Wetlands

During the Millennium Drought (i.e. Block 1), the site supported a wetland bird community categorised as Very Poor based on the very low Summed Reporting Rate (7.7), but the number of Listed Species recorded there (11) elevated the community to a 'Moderate' category (Figures H.19 and H.20). During Blocks 2 to 4, the site supported a wetland bird community categorised as Poor according to a stable Summed Reporting Rate (11.6-11.8). The number of Listed Species (20) recorded there during Block 2 elevated the wetland bird community to a 'High' category, while for Block 3, the number of Listed Species (14) recorded there elevated the community to a 'Moderate' category. For Block 4, the number of Listed Species (17) and Breeding Species (12) recorded there has elevated the community to a 'High' category. The increase in Summed Reporting Rate and Numbers of Listed and Breeding Species from Block 1 to Block 2 at Braeside Park possibly relates to a bounce back in waterbird populations following the breaking of the Millennium Drought (see' Factors Affecting Wetland Bird Indices'). For the last three time blocks, the Summed Reporting Rate has been stable and the Numbers of Listed and Breeding Species are tracking well.

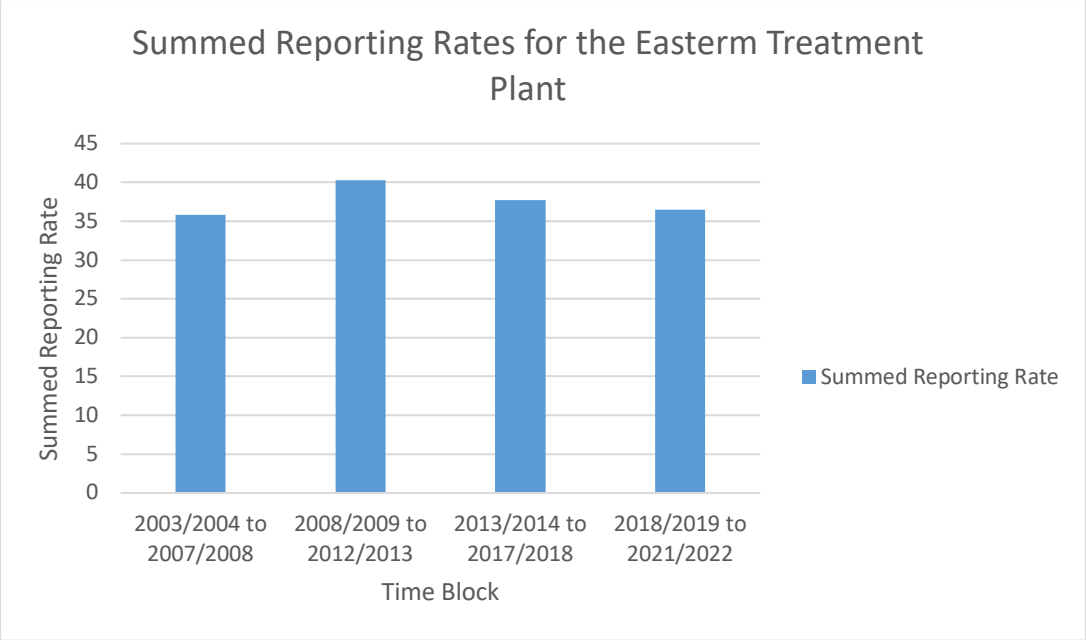


Figure H.15 *The wetland bird communities at the Eastern Treatment Plant are categorised as Very High for all four blocks based on the Summed Reporting Rates. The numbers of Listed Species (>20) recorded there during all blocks is also at the 'Very High' category (see Figure H.16).*

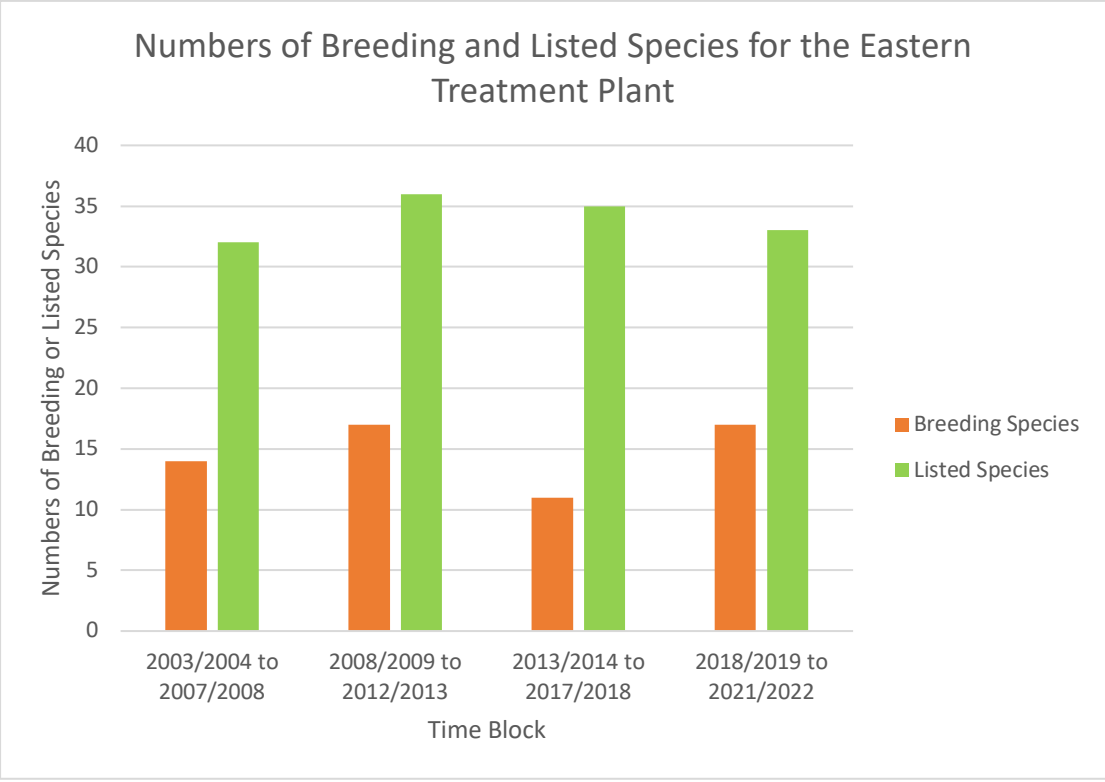


Figure H.16 *The numbers of Breeding and Listed Species recorded at the Eastern Treatment Plant during all four blocks. The numbers of Listed Species recorded there was greater than 20 during, and therefore, equal to the "Very High' category for all blocks, but unable to elevate the wetland bird communities any further (see Figure H.15).*

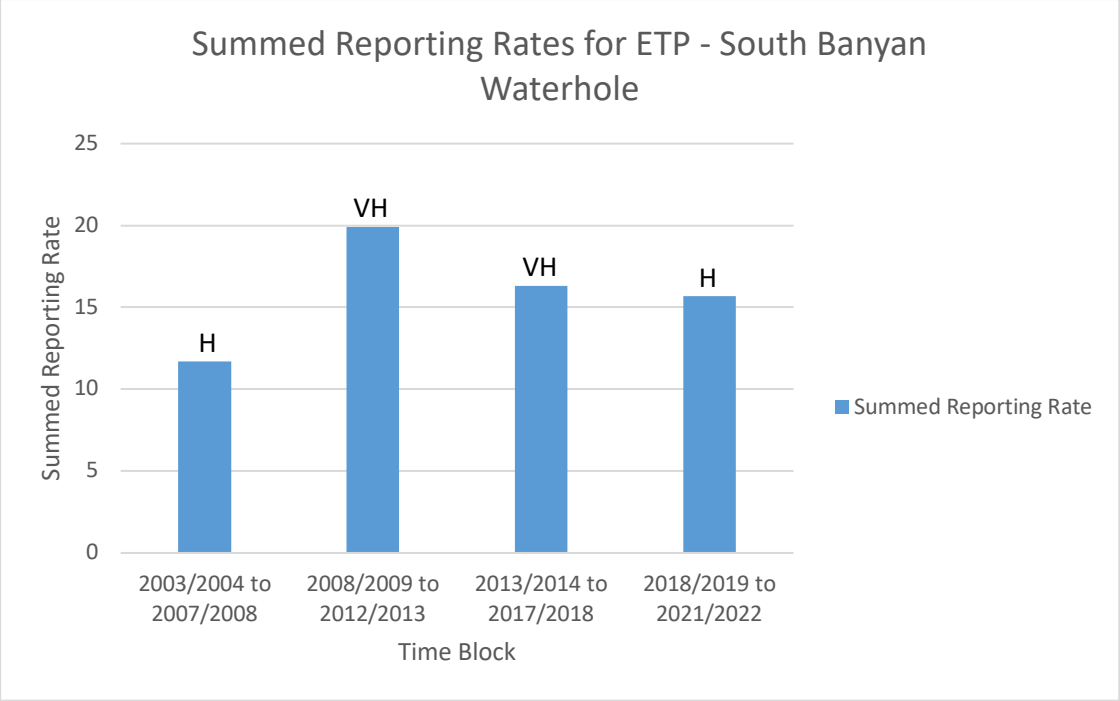


Figure H.17 *The wetland bird communities at the Eastern Treatment Plant (ETP) South – Banyan Waterhole are categorised as Poor (Blocks 1 and 4) or Moderate (Blocks 2 and 3) based on the Summed Reporting Rates. The Numbers of Listed Species recorded there during Blocks 1 and 4 (<20) elevated the wetland bird community to a 'High' (H) category and during Blocks 2 and 3 (>20) elevated the community to a 'Very High' (VH) category (see Figure H.18).*

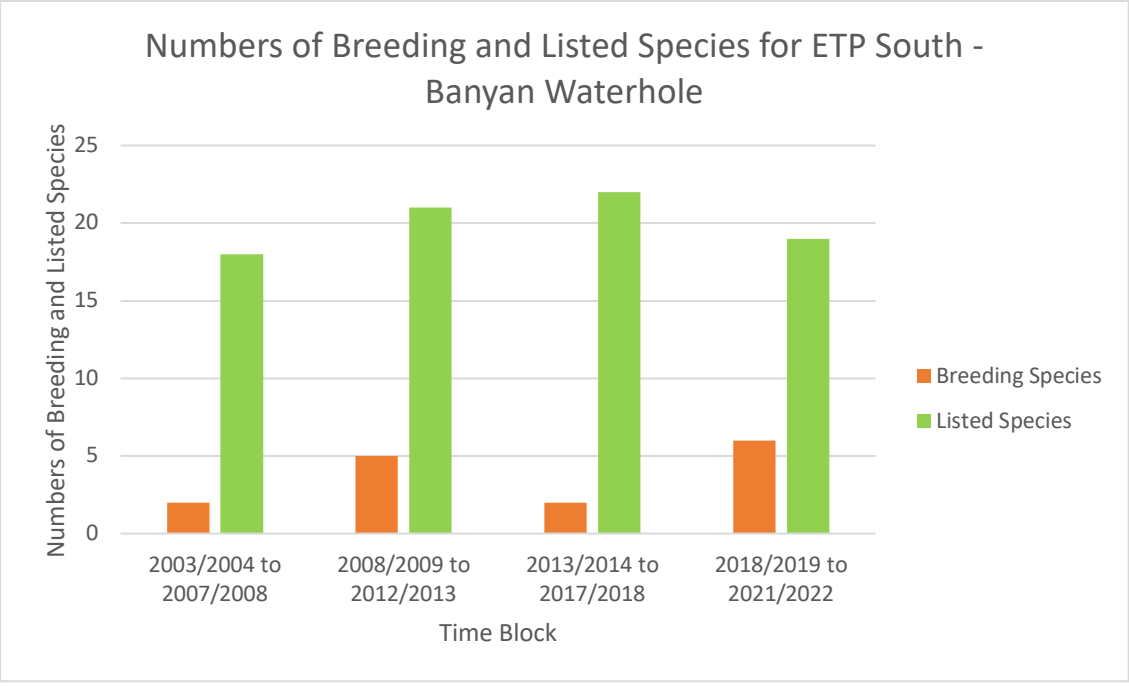


Figure H.18 *The numbers of Breeding and Listed Species recorded at the Eastern Treatment Plant (ETP) South – Banyan Waterhole during all four blocks. The numbers of Listed Species recorded there was either less than or greater than 20 during, and therefore, elevated the wetland bird community to a 'High' or 'Very High' category, respectively (see Figure H.17).*

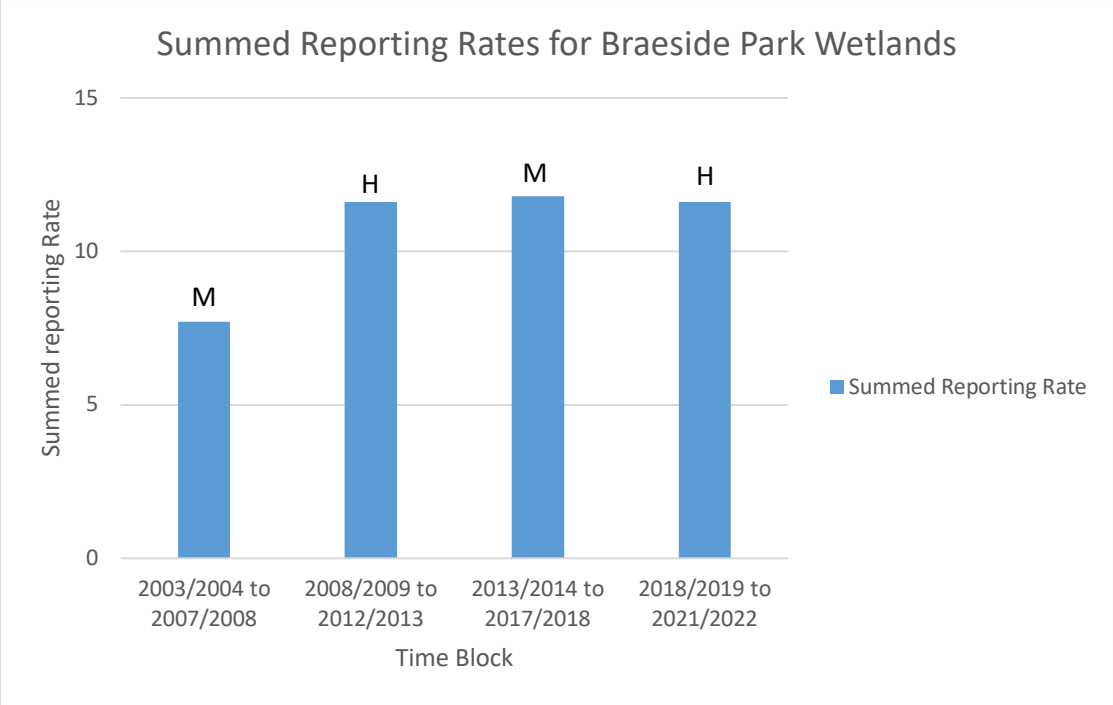


Figure H.19 *The wetland bird communities at Braeside Park Wetlands are categorised as Very Poor (Block 1) or Poor (Blocks 2, 3 and 4) based on the Summed Reporting Rates. The Numbers of Listed Species recorded there during Blocks 1 and 3 elevated the wetland bird community to a 'Moderate' (M) category and during Blocks 2 and 4 elevated the community to a 'High' (H) category. During Block 3, the Number of Breeding Species recorded there also elevated the community to a 'High' category (see Figure H.20).*

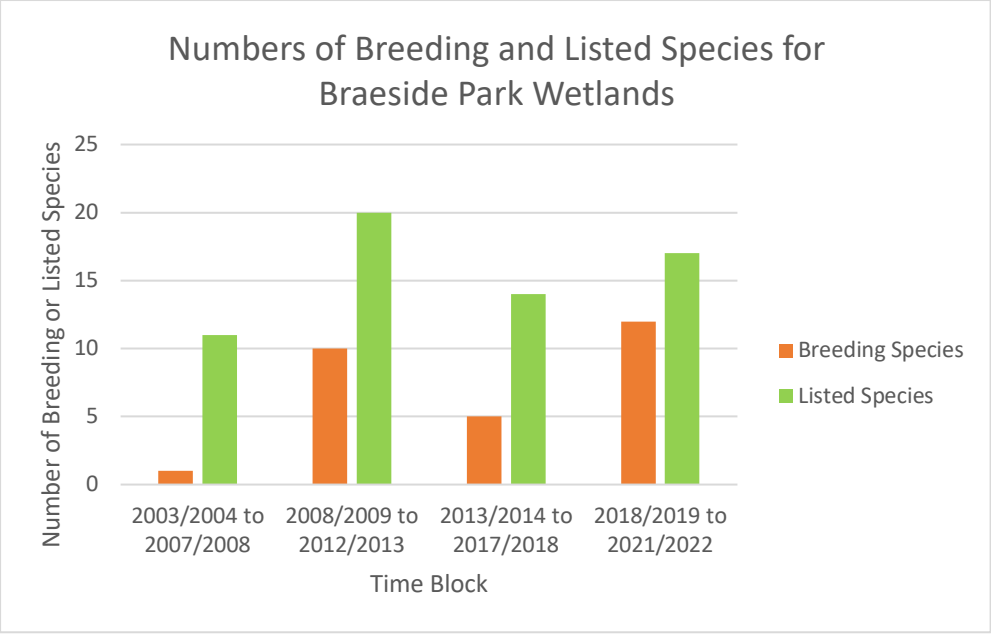


Figure H.20 *The numbers of Breeding and Listed Species recorded at Braeside Park Wetlands during all four blocks. The numbers of Listed Species recorded there was either between 11-15 or 16-20, and therefore, elevated the wetland bird community to a 'Moderate' or 'High' category, respectively (see Figure H.19). The Number of Breeding Species recorded during Block 3 (12) also elevated the community to a 'High' category.*

Migratory Shorebird Site

Swan Lake

During Block 1 (i.e. the Millennium Drought), Swan Lake supported a wetland bird community categorised as Very Poor based on the Summed Reporting Rate (7.2) which was retained after consideration of the number of Listed Species (9) and Breeding Species (3) recorded there. During Blocks 2 and 3, the site supported wetland bird communities categorised as Poor (15.7 and 16.0, respectively) based on the Summed Reporting Rates. However, this 'Poor' category was elevated to the 'High' category during Block 2 by the number of Breeding Species (15) and Listed Species (17) recorded there and during Block 3 by the number of Listed Species (18) (Figures H.21 and H.22). Based on a far smaller number of surveys undertaken during Block 1, all indices and statistics were much lower than those calculated during Blocks 2 and 3, which could be a result of the Millennium Drought (see 'Factors Affecting Wetland Bird Indices', above) or may reflect the low number of surveys. The number of surveys were insufficient to evaluate the indices and statistics for Block 4, but the results for Blocks 2 and 3 suggest that the wetland bird communities at Swan Lake were tracking well during these two blocks.

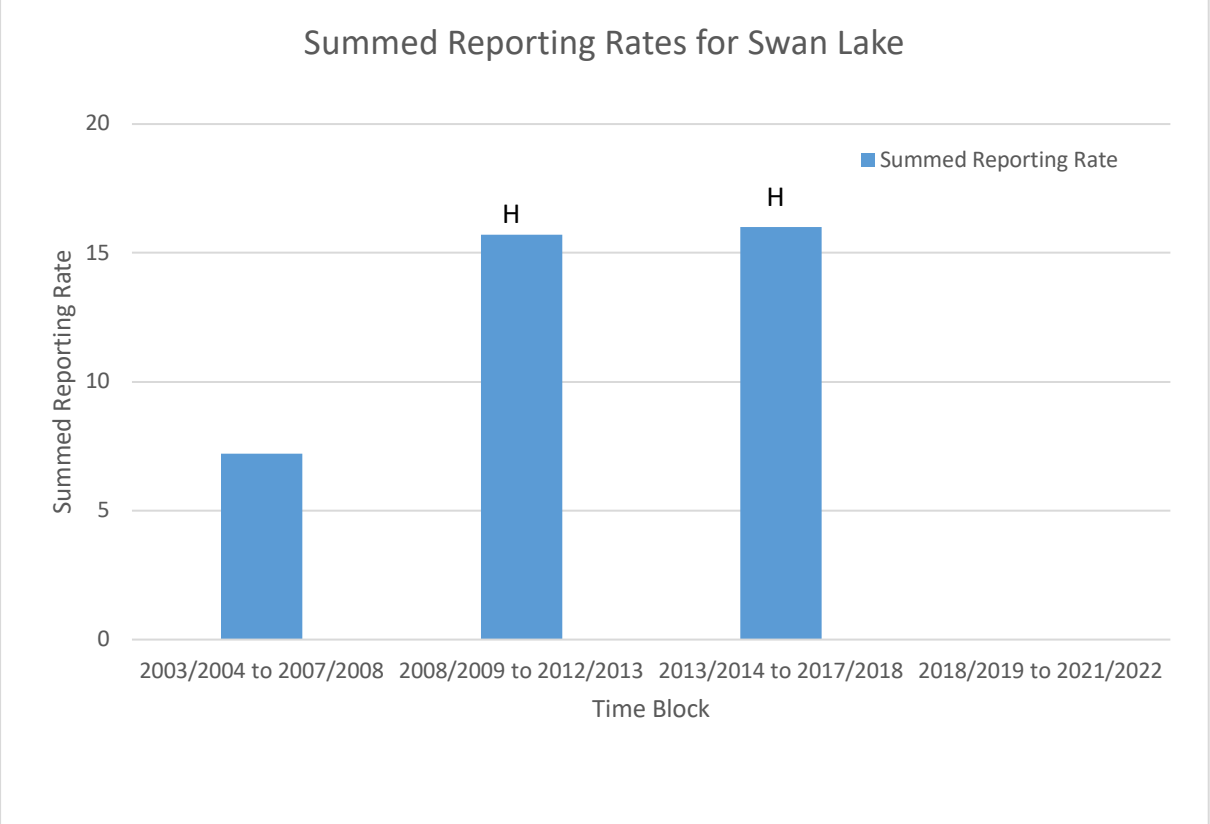


Figure H.21 *The wetland bird communities at Swan Lake are categorised as Very Poor (Block 1) or Poor (Blocks 2 and 3) based on the Summed Reporting Rates. The Numbers of Listed Species recorded there during Blocks 2 and 3 elevated the wetland bird community to a 'High' (H) category and during Block 3 by the Number of Breeding Species recorded there (see Figure H.22).*

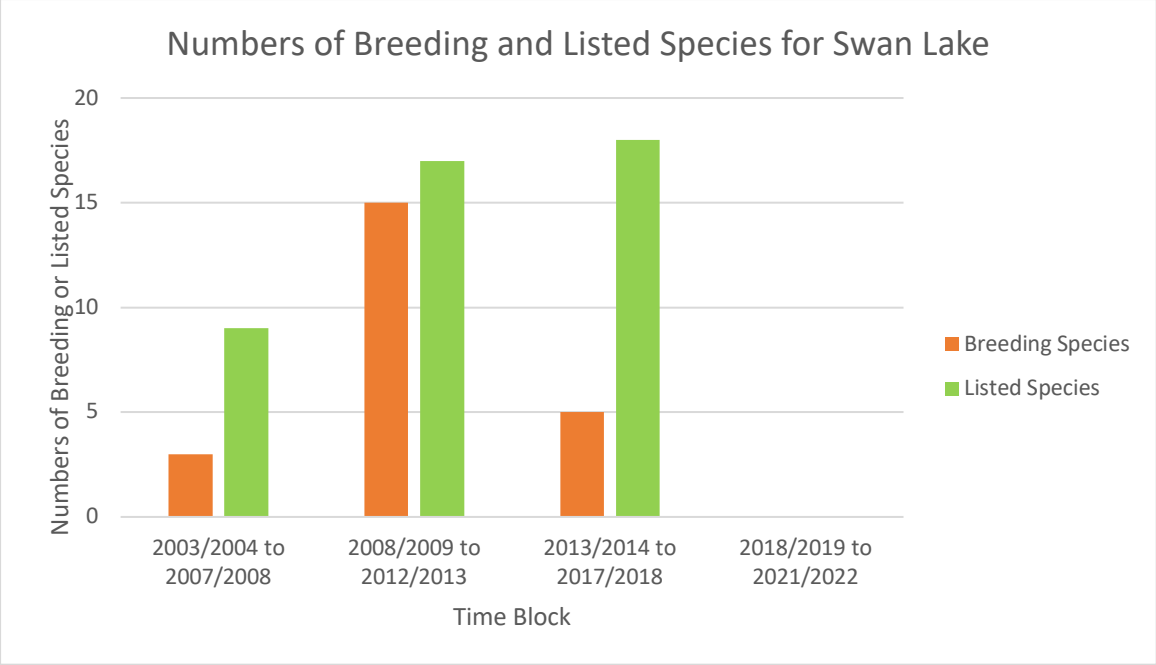


Figure H.22 *The numbers of Breeding and Listed Species recorded at Swan Lake. The numbers of Listed Species recorded there during Blocks 2 and 3 were sufficient to elevate the wetland bird community to a 'High' category. The Number of Breeding Species recorded during Block 2 (15) also elevated the community to a 'High' category (see Figure H.21).*

Regional Wetlands

Paisley Challis Wetland/Jawbone Reserve

During Blocks 2, 3 and 4, the wetland bird communities were categorised as Moderate based on the Summed Reporting Rates of 21.1, 22.1 and 17.6, respectively (Figures H.23 and H.24). The Numbers of Listed Species recorded there during each block were sufficient (i.e. >20) to elevate the wetland bird communities to a 'Very High' category. It should be noted that conditions across eastern Australia were very dry from the second half of 2017 to early-2020, then monsoonal rains broke and many waterbirds left southern Victoria which could explain the low indices and statistics during the current block (see 'Factors Affecting Wetland Bird Indices').

Devilbend Reservoir

During Blocks 1, 2 and 3, the wetland bird communities at Devilbend Reservoir were categorized as High, Moderate and Moderate based on the Summed Reporting Rates of 24.1, 18.6 and 17.9, respectively (Figures H.25 and H.26). The index categories were retained for Blocks 1 and 3, after consideration of the numbers of breeding and listed species, but during Block 2, the Number of Listed Species was sufficient to elevate the wetland bird community to a 'High' category. The number of surveys were insufficient to evaluate indices and statistics for Block 4. Most wetland bird indices (except for Number of Listed Species) and statistics for Blocks 2 and 3 were much lower than those for Block 1. It is possible that Devilbend Reservoir provided a refuge during the Millennium Drought for waterbirds, and those waterbirds then departed once the Millennium Drought broke (see 'Factors Affecting Wetland Bird Indices').

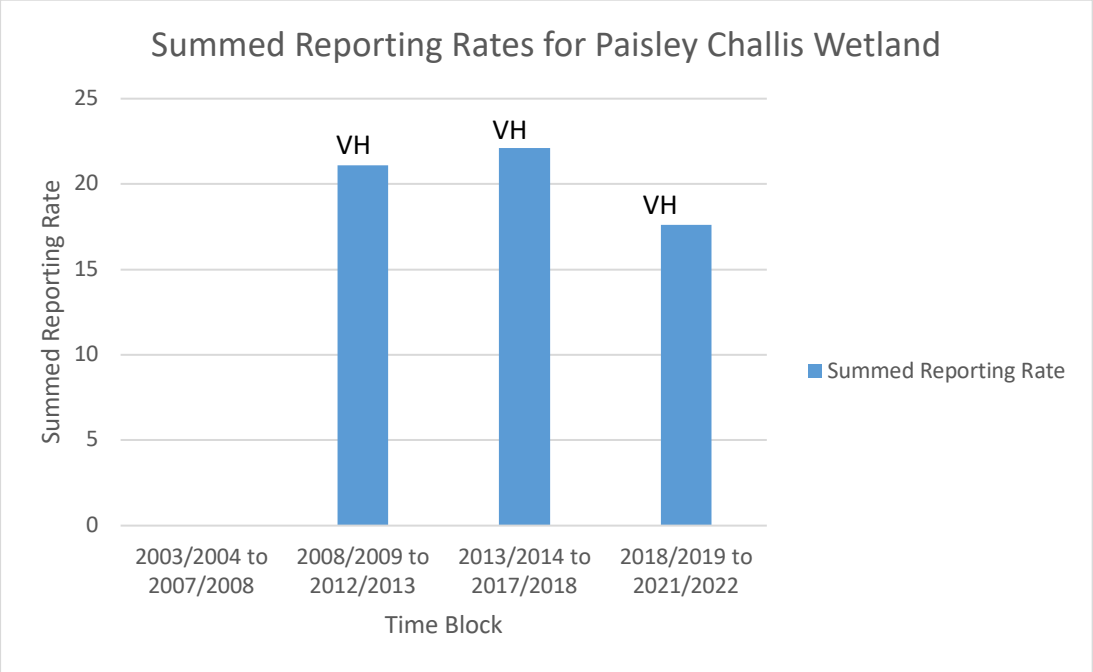


Figure H.23 *The wetland bird communities at Paisley Challis Wetland/Jawbone Reserve are categorised as Moderate for Blocks 2, 3 and 4 based on the Summed Reporting Rates. The Numbers of Listed Species recorded there during each block elevated the wetland bird community to a 'Very High' (VH) category (see Figure H.24).*

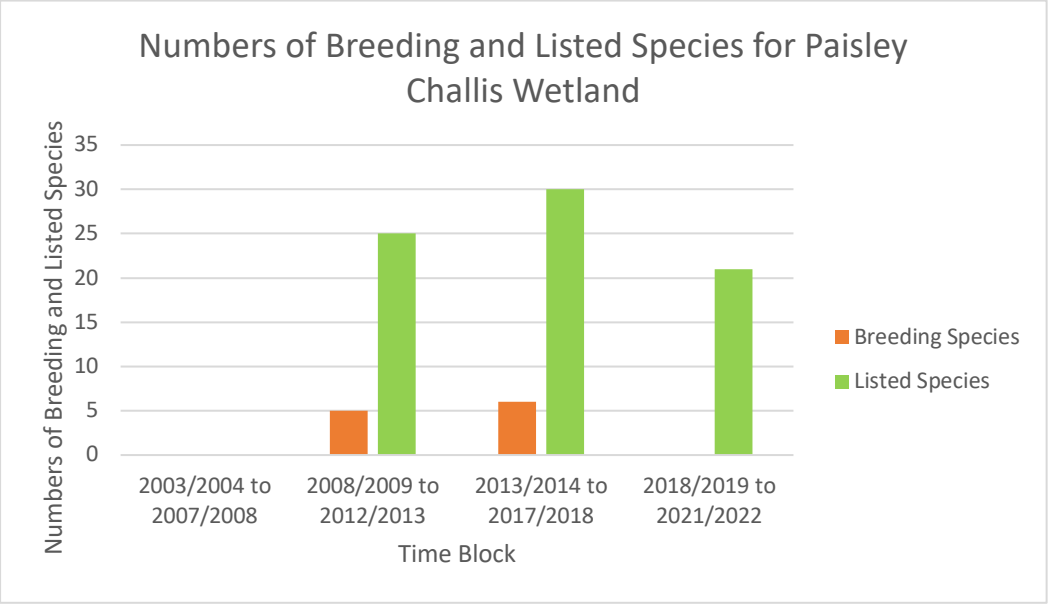


Figure H.24 *The numbers of Breeding and Listed Species recorded at Paisley Challis Wetland/Jawbone Reserve. The numbers of Listed Species recorded there during Blocks 1, 2 and 3 were sufficient (i.e. >20) to elevate the wetland bird communities to a 'Very High' category during each block (see Figure H.23).*

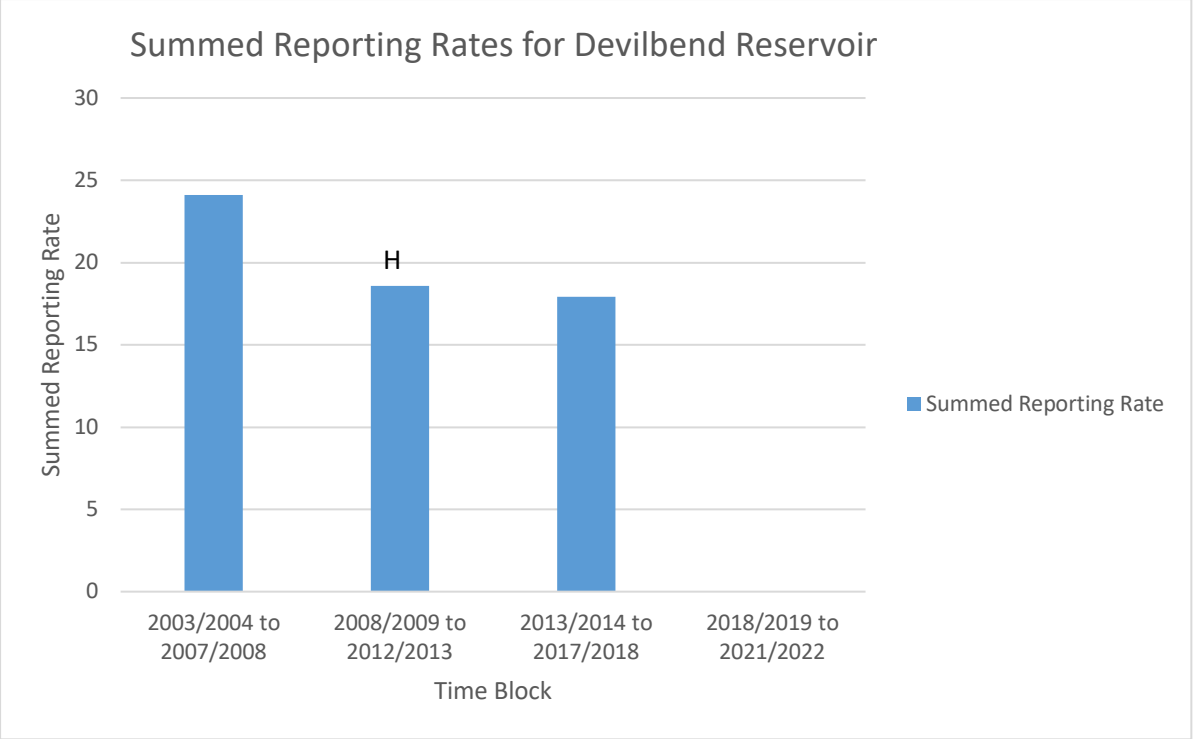


Figure H.25 *The wetland bird communities at Devilbend Reservoir are categorised as High for Block 1 and Moderate for Blocks 2 and 3 based on the Summed Reporting Rates. The Number of Listed Species recorded there during Block 2 elevated the wetland bird community to a 'High' (H) category (see Figure H.26).*

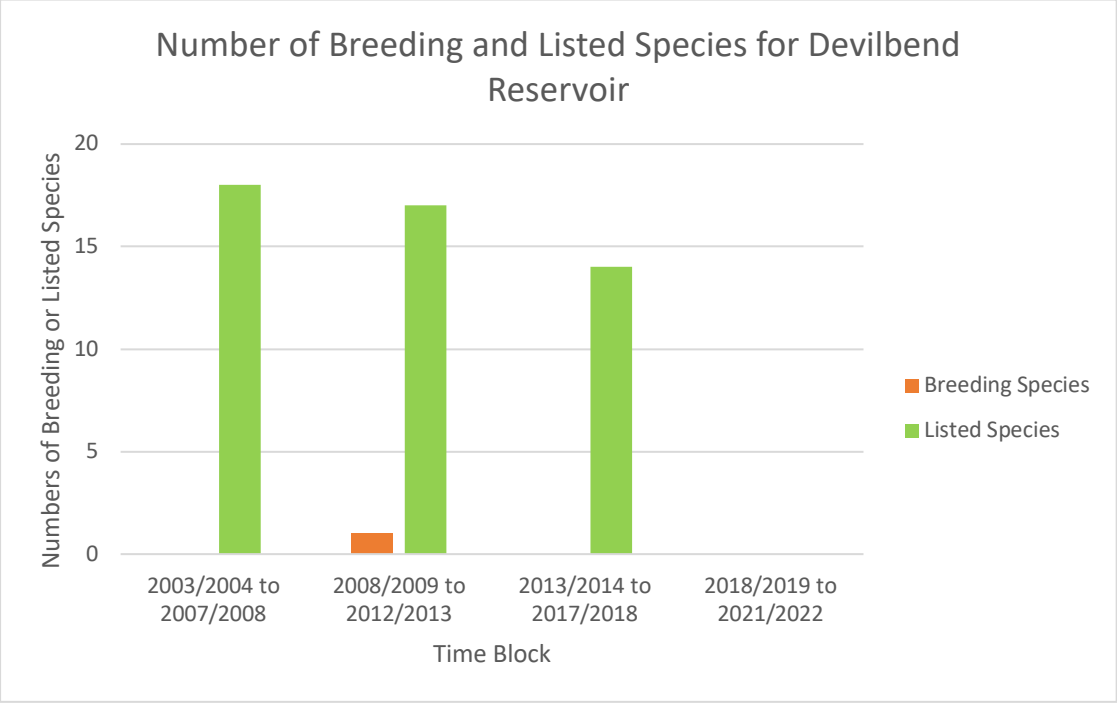


Figure H.26 *The numbers of Breeding and Listed Species recorded at Devilbend Reservoir. The numbers of Listed Species recorded there during Block 2 was sufficient (i.e. >20) to elevate the wetland bird community to a 'High' category (see Figure H.25).*

Dandenong Valley stormwater treatment wetlands

Heatherton Road North Wetland

The Summed Reporting Rate for Heatherton Road North Wetland has been stable overtime fluctuating between 14.0 and 15.1 from Blocks 1 to 4 and indicative of a wetland bird community in a 'Poor' Category (Figures H.27 and H.28). For Block 1, the Number of Breeding Species (9) recorded there was sufficient to elevate the wetland bird community to the 'Moderate' category. For Block 2, the Number of Breeding Species (6) and the Number of Listed Species (11) recorded there were sufficient to elevate the wetland bird community to a 'Moderate' category. For Blocks 3 and 4, neither the Number of Breeding nor Listed Species recorded there were sufficient to elevate the wetland bird community beyond the 'Poor' category. Wetland bird Average Annual Maximum Abundance and Density increased significantly from Blocks 1 to 2, before declining through Block3 and returning to Block2 levels in Block 4. Average Annual Waterbird Richness has declined slightly from Block 2 levels. The indices and statistics suggest that after showing an initial increase from Block 1 to Block 2, the wetland bird community has been stable since Block 2.

Heatherton Road South Wetland

The Summed Reporting Rate for Heatherton Road South Wetland has been stable fluctuating between 11.6 and 12.3 during Blocks 2, 3 and 4 and indicative of a wetland bird community categorized as 'Poor' (Figures H.29 and H.30). Only the 12 Listed Species recorded there during Block 2 were sufficient to elevate the wetland bird community to a higher category of Moderate. Wetland bird Average Annual Maximum Abundance and Density has increased since Block 2, but the Average Annual Waterbird Richness has declined slightly. The indices and statistics suggest that the wetland bird community has been stable since Block 2.

Frog Hollow Wetland

The Summed Reporting Rate for Frog Hollow Wetland has been stable, fluctuating between 11.9 and 14.2 during Blocks 2, 3 and 4 and indicative of a wetland bird community categorized as Poor (Figures H.31 and H.32). Only the 12 Listed Species recorded there during Block 2 were sufficient to elevate the wetland bird community to a higher category of Moderate. The indices and statistics suggest that the wetland bird community has been stable since Block 2.

Kilberry Boulevard/ Rivergum Creek Wetlands

The Summed Reporting Rates for Kilberry Boulevard / Rivergum Creek Wetlands have declined from 19.8 and 19.0 recorded during Blocks 2 and 3, respectively, to 14.3 calculated for the current block (Figures H.33 and H.34). These Summed Reporting Rates suggest that the wetlands support a wetland bird community categorised as Moderate. During Block 2, the Number of Breeding Species recorded there (12) elevates the wetland bird community to a 'High' category. For Blocks 3 and 4, the Numbers of Breeding and Listed Species were insufficient to elevate the wetland bird community beyond the 'Moderate' category. Most indices and statistics have declined by more than 10% during at least one block since Block 2. Wetland bird Average Annual Maximum Abundance, Density and Average Annual Waterbird Richness have each declined by more than 10% from Blocks 2 to 3 and from Blocks 3 to 4. Summed Reporting Rate declined by more than 10% from Blocks 3 to 4. The Numbers of Breeding Species and Listed Species both declined from Blocks 2 to 3, but either remained the same or increased from Blocks 3 to 4. The decline in indices and statistics is thought to be associated with the age of constructed stormwater treatment wetlands. After construction, initially, there is little emergent or surrounding aquatic vegetation. However, as vegetation expands

and increases in density over time, a reduction in bird numbers/diversity occurs (e.g. see Wiegleb & Dahms 2017).

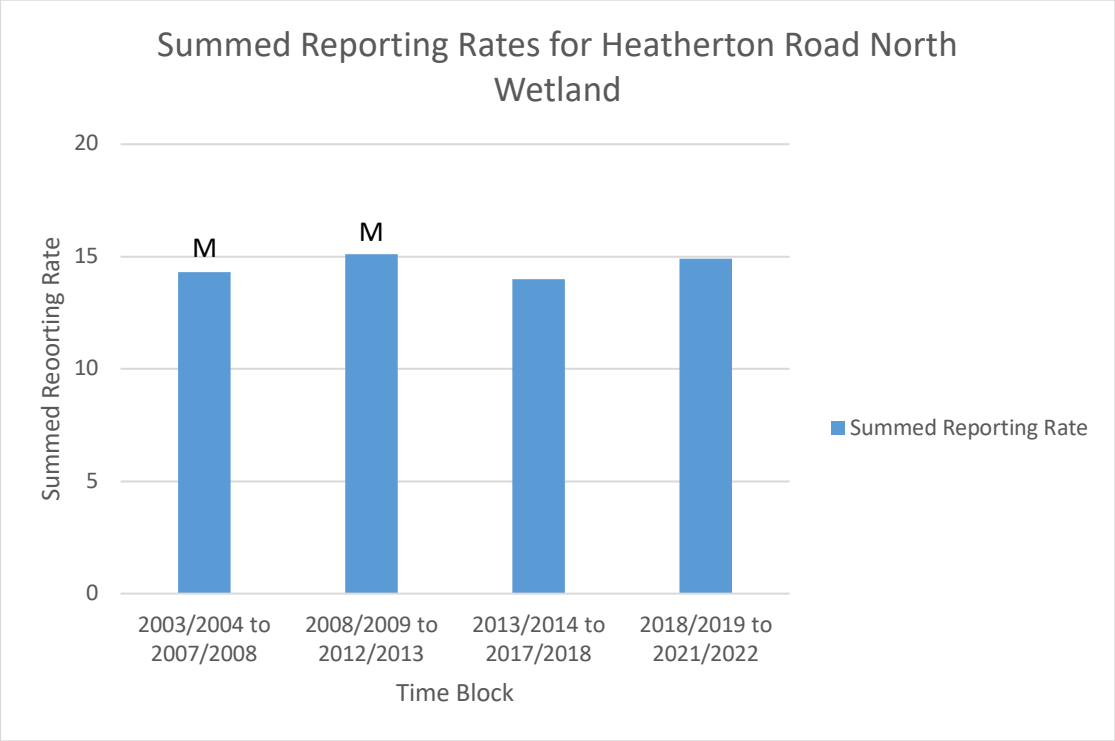


Figure H.27 *The wetland bird communities at Heatherton Road North Wetland are categorised as Poor for Blocks 1, 2, 3 and 4 based on the Summed Reporting Rates. The Number of Breeding Species recorded there during Block 1 elevated the wetland bird community to a 'Moderate' (M) category, while the Number of Breeding Species and Listed Species recorded there were sufficient to elevate the wetland bird community to a 'Moderate' category during Block 2 (see Figure H.28).*

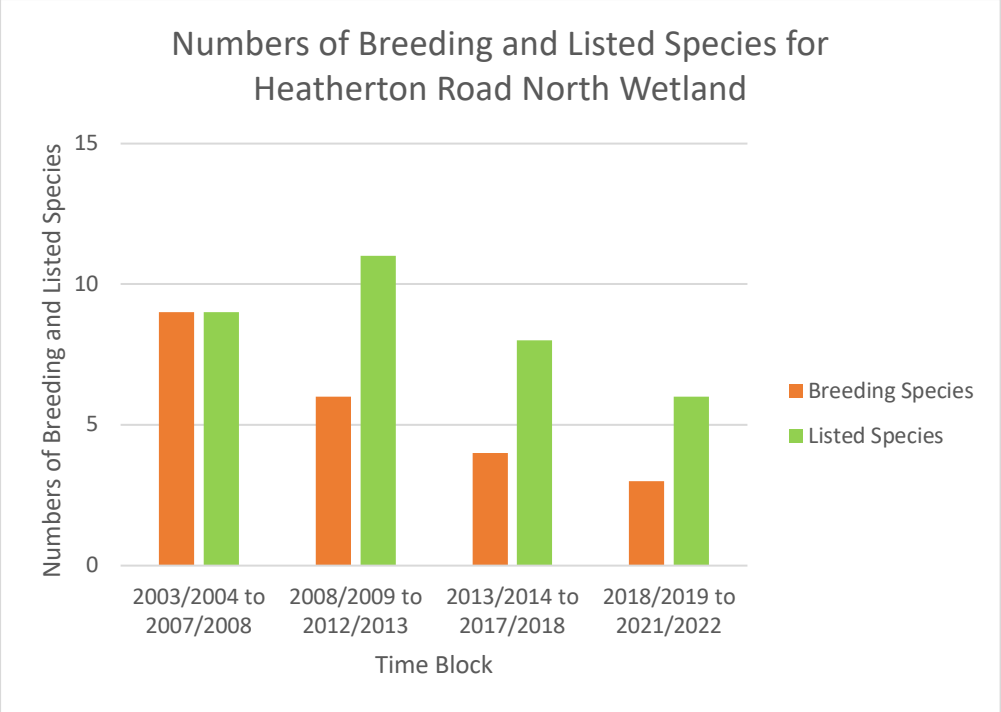


Figure H.28 *The numbers of Breeding and Listed Species recorded at Heatherton Road North Wetland. The numbers of Breeding Species (nine) recorded there during Block 1 elevated the wetland bird community to a 'Moderate' category. The Number of Breeding Species (six) and Listed Species (11) recorded there during Block 2 elevated the wetland bird community to a 'Moderate' category (see Figure H.27).*

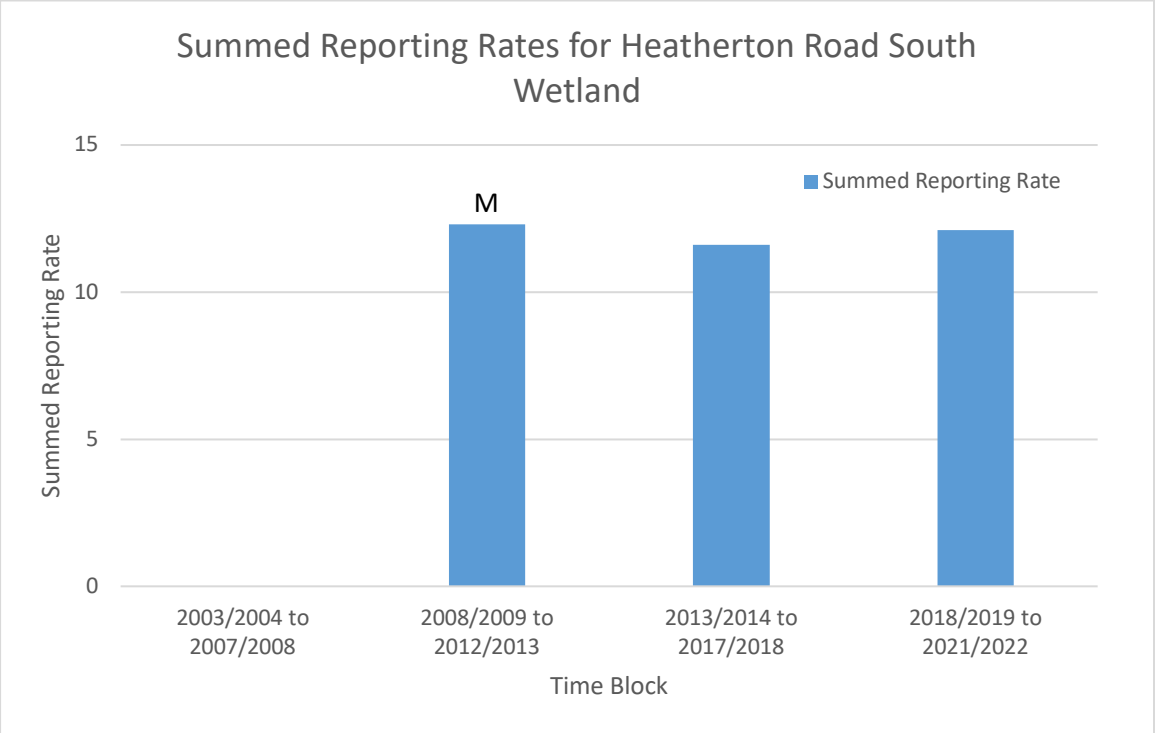


Figure H.29 *The wetland bird communities at Heatherton Road South Wetland are categorised as Poor for Blocks 2, 3 and 4 based on the Summed Reporting Rates. The Number of Listed Species recorded there during Block 2 elevated the wetland bird community to a 'Moderate' (M) category (see Figure H.30).*

Figure H.30 *The numbers of Breeding and Listed Species recorded at Heatherton Road South Wetland. The Number of Listed Species (12) recorded there during Block 2 elevated the wetland bird community to a 'Moderate' category (see Figure H.29).*

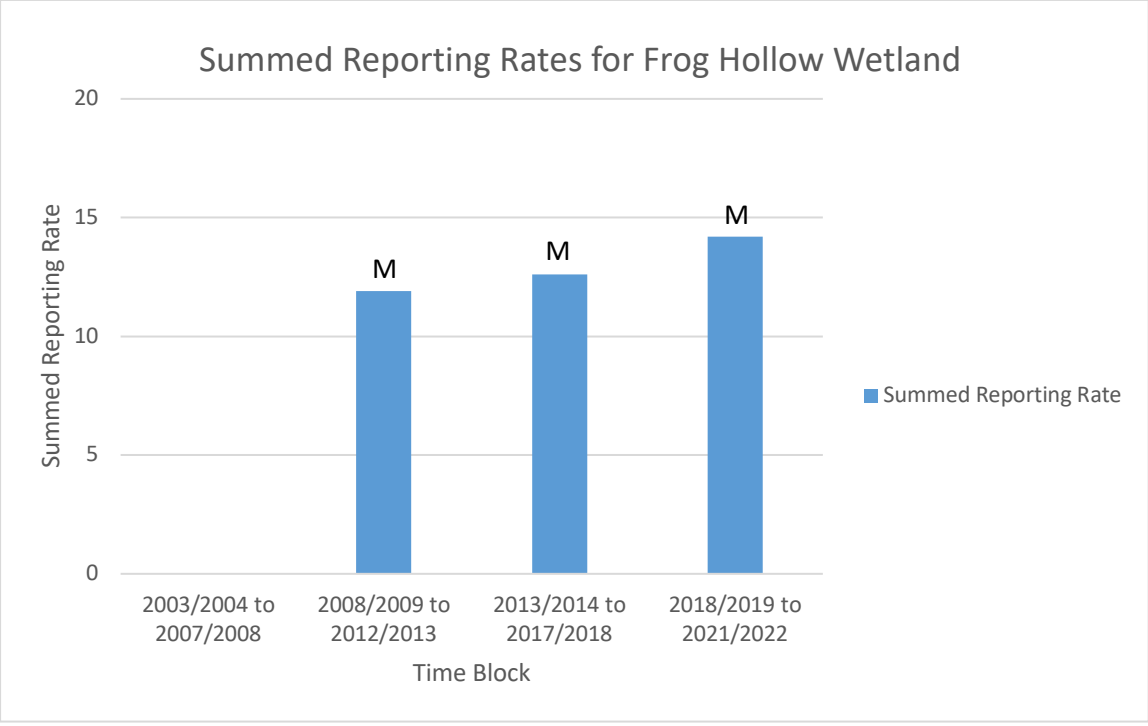


Figure H.31 *The wetland bird communities at Frog Hollow Wetland are categorised as Poor for Blocks 2, 3 and 4 based on the Summed Reporting Rates. The Number of Breeding Species recorded there during each block elevated the wetland bird community to a 'Moderate' (M) category (see Figure H.32).*

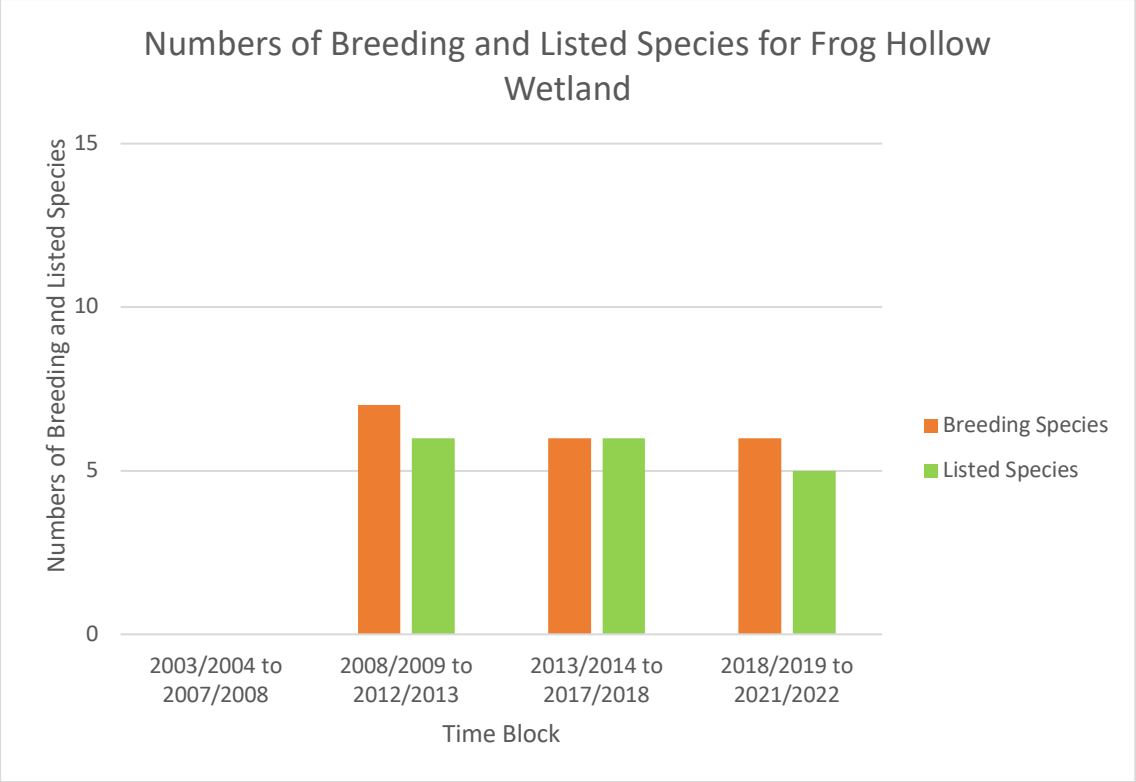


Figure H.32 *The numbers of Breeding and Listed Species recorded at Frog Hollow Wetland. The Number of Breeding Species (12) recorded there during Blocks 2, 3 and 4 elevated the wetland bird community to a 'Moderate' category (see Figure H.31).*

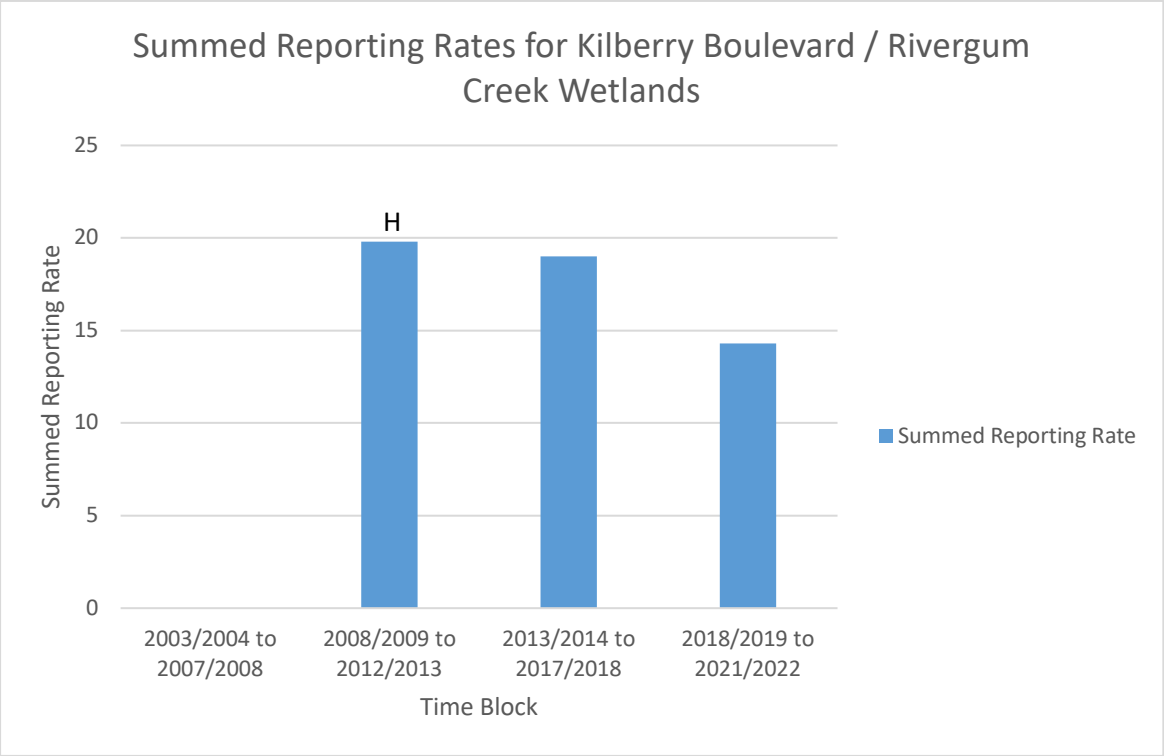


Figure H.33 *The wetland bird communities at Kilberry Boulevard / Rivergum Creek Wetlands are categorised as Moderate for Blocks 2, 3 and 4 based on the Summed Reporting Rates. The Number of Breeding Species recorded there during Block 2 elevated the wetland bird community to a 'High' (H) category (see Figure H.34).*

Figure H.34 *The numbers of Breeding and Listed Species recorded at Kilberry Boulevard / Rivergum Creek Wetlands. The Number of Breeding Species (12) recorded there during Block 2, elevated the wetland bird community to a 'High' category (see Figure H.33).*

Social value Wetlands

Karkarook Park

During Blocks 2, 3 and 4, Karkarook Park supported a wetland bird community categorised as Poor based on the Summed Reporting Rates of 17.0, 14.2 and 12.2, respectively (Figures H.35 and H.36). However, during Block 2, the number of Breeding (7) and Listed Species (11) recorded there elevated the community to a 'Moderate' category. During Block 3, the number of Listed Species (18) recorded there raised the bird community to a 'High' category. During Block 4, the number of Listed Species (11) recorded there elevated the community to a 'Moderate' category. The Numbers of Breeding Species and Listed Species recorded during blocks also showed a similar pattern with an increase from Block 2 to Block 3 followed by a big decrease to Block 4. The Average Annual Waterbird Richness and Summed Reporting Rate also showed declines from Block 2 to 3 and from Block 3 to 4. The reasons for this are uncertain but could be related to the popularity of the Park for people resulting in disturbance to waterbirds combined with the predominance of common species tolerant of people (e.g. Silver Gulls) excluding other species from the site.

Westgate Park Wetlands

During Blocks 1, 2 and 3, Westgate Park Wetlands had relatively stable Summed Reporting Rates of 13.1, 12.7 and 12.4, respectively, and wetland bird communities categorised as Poor based on these Summed Reporting Rates (Figure H.37 and H.38). However, During Block 1, the number of Breeding Species (12) recorded there elevated the community to a 'High' category. During Block 2, the

number of Breeding Species (7) recorded there elevated the community to a 'Moderate' category. During Block 3, the numbers of Breeding (and Listed) Species recorded there were not sufficient to elevate the wetland bird community to a higher category. Apart from the Summed Reporting Rate all other indices and statistics have shown substantial decreases from Block 1 (i.e. Millennium Drought) to Block 2 and Blocks to Block 3. The reasons for these declines are uncertain and are currently being investigated with the Friends of Westgate Park.

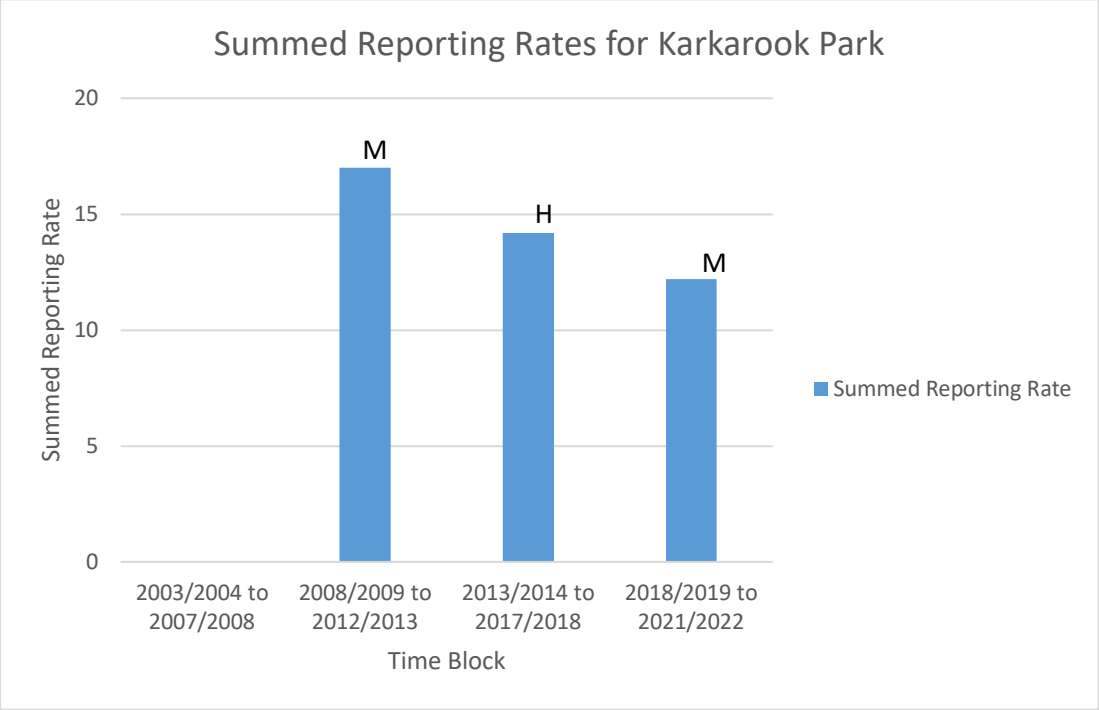


Figure H.35 *The wetland bird communities at Karkarook Park are categorised as Poor for Blocks 2, 3 and 4 based on the Summed Reporting Rates. The Number of Breeding Species and Listed Species recorded there during Block 2 elevated the wetland bird community to a 'Moderate' (M) category. During Bocks 3 and 4, the Number of Listed Species elevated the bird community to a 'High' (H) and 'Moderate' category, respectively (see Figure H.36).*

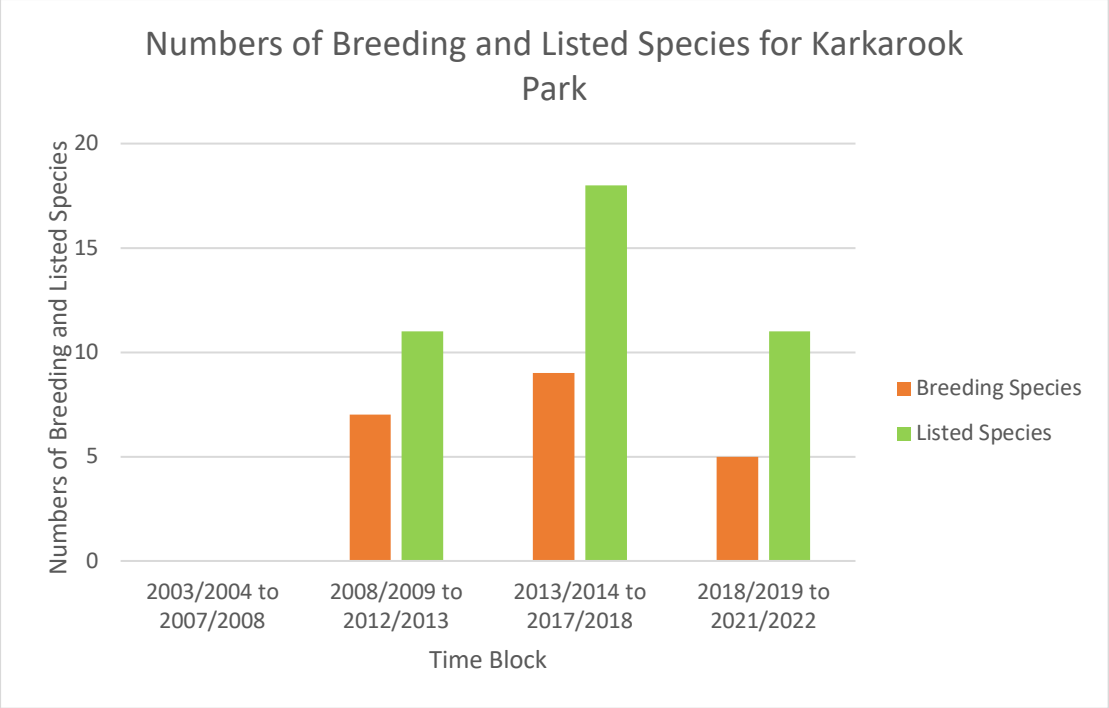


Figure H.36 *The numbers of Breeding and Listed Species recorded at Karkarook Park. The Number of Breeding Species (7) and Listed Species (11) recorded there during Block 2, elevated the wetland bird community to a 'Moderate' category. During Block 3, the Number of Listed Species (18) recorded there elevated the community to a 'High' category. During Bock 4, the Number of Listed Species (11) recorded there elevated the community to a 'Moderate' category (see Figure H.35).*

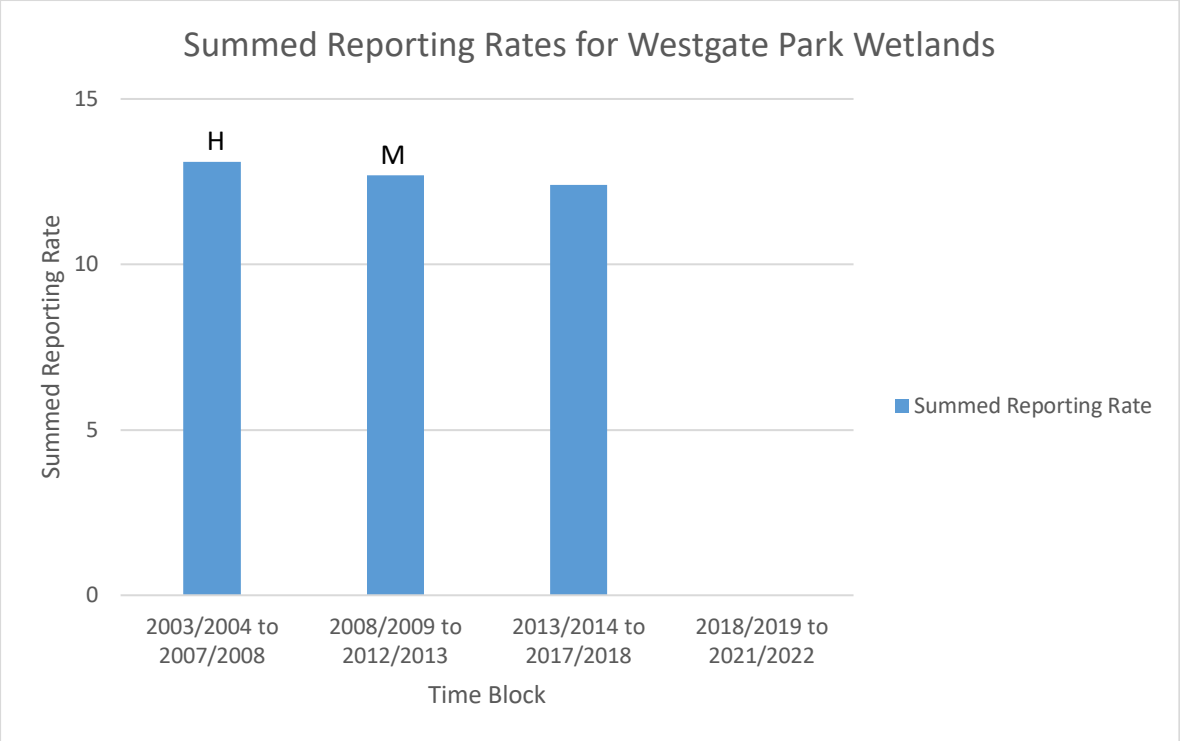


Figure H.37 *The wetland bird communities at Westgate Park Wetlands are categorised as Poor for Blocks 1, 2 and 3 based on the Summed Reporting Rates. The Number of Breeding Species recorded there during Blocks 1 and 2 elevated the wetland bird community to a 'High' (H) and 'Moderate' (M) category, respectively (see Figure H.38).*

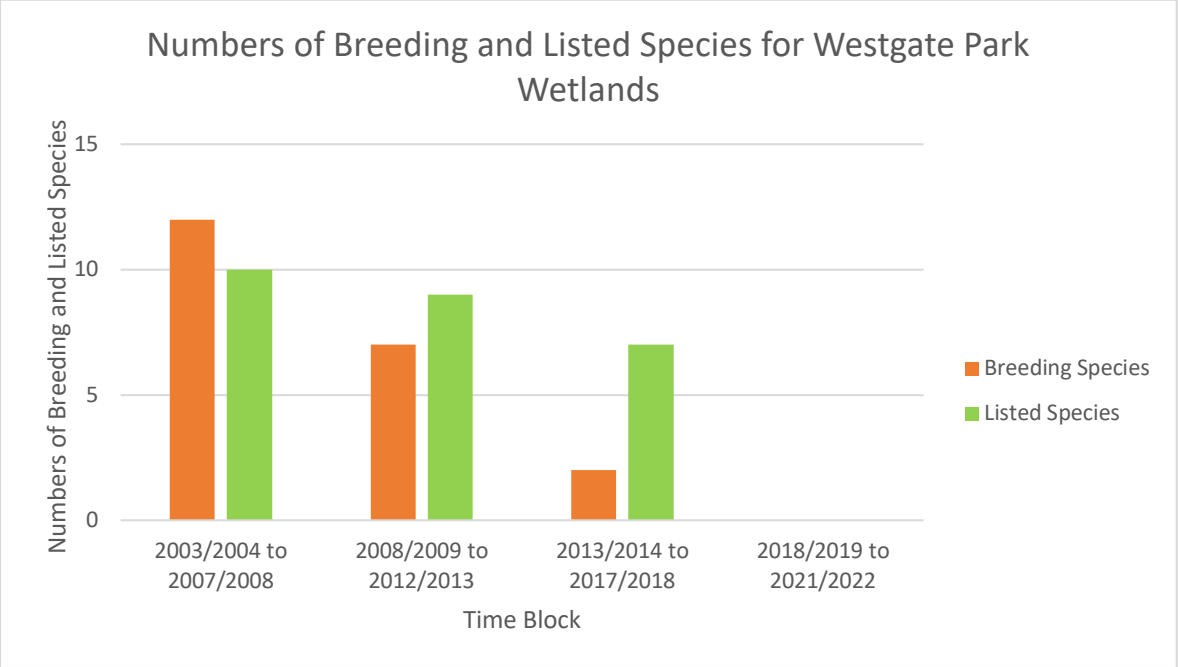


Figure H.38 *The numbers of Breeding and Listed Species recorded at Westgate Park Wetlands. The Number of Breeding Species) recorded there during Blocks 2 (12 species) and 3 (seven species) elevated the wetland bird communities to a 'High' and 'Moderate' category, respectively (see Figure H.37).*

Table H.1 *Wetland Bird Index scores for all wetlands with >20 robust surveys by Birdlife Australia, showing effect of listed and breeding species modifiers.*

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22
Albert Park Lake			Poor	
Bailey's Billabong			Very Poor	
Banyule Flats Billabong			Poor	
Berwick Springs Wetlands			Poor to Moderate through Listed Species	
Bittern Reservoir			Poor	
Blackburn Lake			Very Poor	Very Poor
Boggy Creek, Carrum			Poor	Poor
Bolin Bolin Billabong		Very Poor		
Braeside Park Wetlands	Very Poor to Moderate through Listed Species	Poor to High through Listed Species	Poor to Moderate through Listed Species	Poor to High through Breeding and Listed Species
Cheetham Saltfields			Moderate to Very High through Listed Species	
Cherry Lake				Poor
Coburg Lake			Poor	
Coolart Lagoon			Very Poor	Very Poor to Moderate through Breeding Species
Dandenong Valley Wetland (Rigby's Wetland)			Poor to Very High through Listed Species	Moderate Very High through Breeding Species
Koomba Park Wetland			Very Poor	Very Poor
Devilbend Reservoir	High	Moderate to High through Listed Species	Moderate	
Dwarf Galaxias Habitat Ponds			Very Poor	Very Poor

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22
Eastern Treatment Plant	Very high	Very high	Very high	Very high
Edithvale North Wetlands	Moderate to Very High through Listed Species	Moderate to High through Listed Species	Moderate to Very High through Listed Species	Moderate to High through Breeding and Listed Species
Edithvale South Wetlands	Moderate to Very High through Listed Species	Moderate to Very High through Listed Species	Poor to Very High through Listed Species	Poor to Very High through Listed Species
ETP - The Doughnut			Poor	
ETP South - Banyan Waterhole	Poor to High through Listed Species	Moderate to Very high through Listed Species	Moderate to Very high through Listed Species	Poor to High through Listed Species
ETP South - PARCS Wetland			Poor to Moderate through Listed Species	
ETP South - Rossiter Rd Lagoon			Poor to Moderate through Listed Species	Very Poor
ETP South - Serpentine Area			Poor to High through Listed Species	Poor to Moderate through Breeding Species
Frog Hollow Wetland		Poor to Moderate through Breeding Species	Poor to Moderate through Breeding Species	Poor to Moderate through Breeding Species
Golf Links Rd Wetland		Poor to Moderate through Breeding Species	Poor to Moderate through Breeding Species	
Hallam Valley Floodplain		Moderate to High through Breeding Species	Moderate	
Troups Creek Wetland		Moderate	Moderate	
Hallam Valley RB Wetland		Moderate to High through	Moderate	

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22
		Breeding Species		
Heatherton Rd North Wetland	Poor to Moderate through Breeding Species	Poor to Moderate through Breeding and Listed Species	Poor	Poor
Heatherton Rd South Wetland		Poor to Moderate through Listed Species	Poor	Poor
Jacana Wetlands			Poor	
Jells Park Lake			Poor to High through Breeding Species	Poor to Very high through Breeding Species
Karkarook Park		Poor to Moderate through Breeding and Listed Species	Poor to High through Listed Species	Poor to Moderate through Listed Species
Kilberry Boulevard/ Rivergum Creek Wetlands		Moderate to High through Breeding Species	Moderate	Moderate
Lysterfield Lake		Poor	Poor	
Mill Park Lakes			Moderate	
Morang Wetlands			Poor to High through Breeding Species	Poor to High through Breeding Species
Newells Paddock Wetlands			Poor	Poor
Newport Lakes		Poor to Moderate through Breeding and Listed Species	Poor to Moderate through Breeding Species	
Paisley Challis/ Jawbone Reserve		Moderate to Very High through Listed Species	Moderate to Very High through Listed Species	Moderate to Very High through Listed Species
RAAF Lake			Very Poor	

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22
Riddell Rd RB (Lakewood Nature Reserve)			Poor to Moderate through Breeding Species	
Ringwood Lake			Very Poor	Very Poor
Seaford Wetlands	Moderate to Very High through Listed Species	Moderate to Very High through Listed Species	Poor to Very high through Listed Species	Poor to Very High through Listed Species
Shepherd's Bush Billabong			Very Poor	
Waterways Estate Wetlands		Moderate	Moderate	
Swan Lake	Very Poor	Poor to High through Breeding and Listed Species	Poor to High through Listed Species	
Tirhatuan Wetlands			Very poor to Moderate through Breeding Species	Very poor to Moderate through Breeding Species
Tootgarook Swamp			Poor to Moderate through Listed Species	Poor
Truganina Swamp			Moderate to Very High through Listed Species	Poor to Moderate through Listed Species
Wannarkladdin Wetlands - East			Very Poor	
Wannarkladdin Wetlands - North			Very Poor	
Wannarkladdin Wetlands - West			Poor	Moderate to High through Breeding spp
Waterford Wetlands		Poor to Moderate through Breeding Species	Poor	
Western Port coastal wetlands	Very Poor to Very High through Listed Species	Poor to Very High through Listed Species	Moderate to Very High through Breeding and Listed Species	Poor to Very High through Listed Species

Wetland	2003/04 to 2007/08	2008/09 to 2012/13	2013/14 to 2017/18	2018/19 to 2021/22
Westgate Park Lakes	Poor to High through Breeding Species	Poor to Moderate through Breeding Species	Poor	
Winton Wetlands			Very Poor	Very Poor
Woodlands Estate Wetlands			Poor to High through Listed Species	
WTP - Habitat Ponds		Poor to Very high through Listed Species	Poor to Very high through Listed Species	Very Poor to Moderate through Listed Species
WTP - Lake Borrie	Poor to High through Listed Species	Poor to Very high through Listed Species		
WTP - Q4 Wetland			Poor to Moderate through Listed Species	
WTP - Summer Pond 1			Very Poor to Moderate through Listed Species	
WTP - Summer Pond 2		Poor to High through Listed Species	Poor to Very high through Listed Species	
WTP - T Section Lagoons		Poor to Very high through Listed Species	Poor to Very high through Listed Species	Poor to Very high through Listed Species
WTP - Western Lagoon		Poor to Very high through Listed Species	Poor to Very high through Listed Species	Poor to High through Listed Species
WTP -Walshes Lagoon		Very high	Very high	
Yan Yean Reservoir	Moderate		Poor to Moderate through Breeding and Listed Species	Moderate

978-1-921603-71-6 (PDF)

More Information

Healthy Waterways Strategy

Access the Mid-term Review Summary Report >>
Access the Mid-term Review Science Inquiry Report >>
Access the Implementation Inquiry Report >>

Contact: Waterway.Strategy@melbournewater.com.au