RESEARCH 15

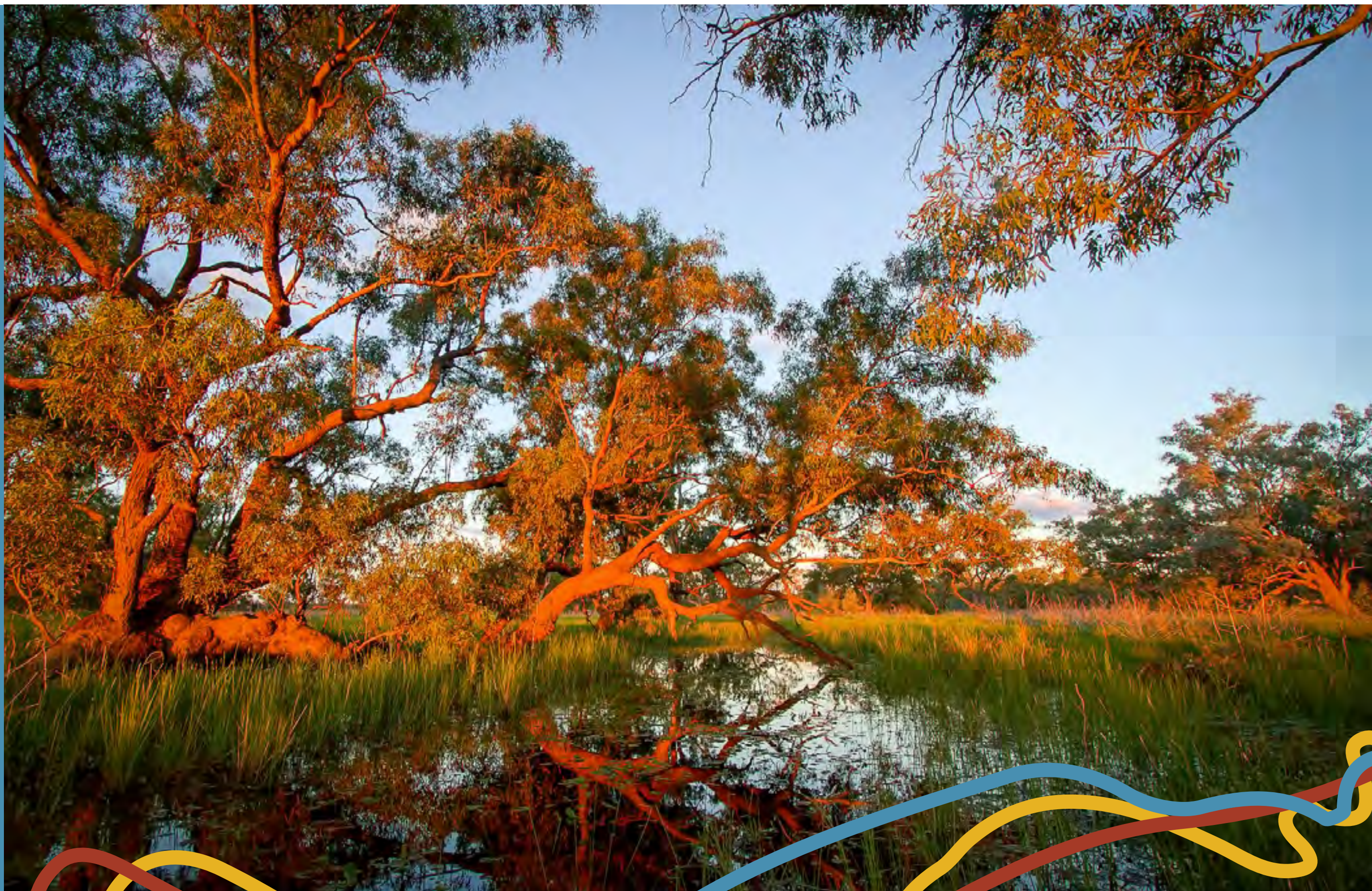
2017-054

WHAT ARE THE CARP VIRUS BIOCONTROL RISKS AND HOW CAN THEY BE MANAGED?

NATIONAL CARP CONTROL PLAN

Social, economic and ecological risk assessment for use of Cyprinid herpesvirus 3 (CyHV-3) for carp biocontrol in Australia

VOLUME 2: Assessment of risks to Matters of National Environmental Significance



This suite of documents contains those listed below.

NCCP TECHNICAL PAPERS

1. Carp biocontrol background
2. Epidemiology and release strategies
3. Carp biocontrol and water quality
4. Carp virus species specificity
5. Potential socio-economic impacts of carp biocontrol
6. NCCP implementation
7. NCCP engagement report
8. NCCP Murray and Murrumbidgee case study
9. NCCP Lachlan case study

NCCP RESEARCH (peer reviewed)

Will carp virus biocontrol be effective?

1. 2016-153: Preparing for Cyprinid herpesvirus 3: A carp biomass estimate for eastern Australia
2. 2018-120: Population dynamics and carp biomass estimates for Australia
3. 2017-148: Exploring genetic biocontrol options that could work synergistically with the carp virus
4. 2016-170: Development of hydrological, ecological and epidemiological modelling
5. 2017-135: Essential studies on Cyprinid herpesvirus 3 (CyHV-3) prior to release of the virus in Australian waters
6. 2020-104: Evaluating the role of direct fish-to-fish contact on horizontal transmission of koi herpesvirus
7. 2019-163 Understanding the genetics and genomics of carp strains and susceptibility to CyHV-3
8. 2017-094: Review of carp control via commercial exploitation

What are the carp virus biocontrol risks and how can they be managed?

9. 2017-055 and 2017-056: Water-quality risk assessment of carp biocontrol for Australian waterways
10. 2016-183: Cyprinid herpesvirus 3 and its relevance to humans
11. 2017-127: Defining best practice for viral susceptibility testing of non-target species to Cyprinid herpesvirus 3
12. 2019-176: Determination of the susceptibility of Silver Perch, Murray Cod and Rainbow Trout to infection with CyHV-3
13. 2016-152 and 2018-189: The socio-economic impact assessment and stakeholder engagement
    Appendix 1: Getting the National Carp Control Plan right: Ensuring the plan addresses
    community and stakeholder needs, interests and concerns
    Appendix 2: Findings of community attitude surveys
    Appendix 3: Socio-economic impact assessment — commercial carp fishers
    Appendix 4: Socio-economic impact assessment — tourism sector
    Appendix 5: Stakeholder interviews
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    Appendix 7: Socio-economic impact assessment — recreational fishing sector
    Appendix 8: Socio-economic impact assessment — koi hobbyists and businesses
    Appendix 9: Engaging with the NCCP: Summary of a stakeholder workshop
14. 2017-237: Risks, costs and water industry response
15. 2017-054: Social, economic and ecological risk assessment for use of Cyprinid herpesvirus 3
    (CyHV-3) for carp biocontrol in Australia
    Volume 1: Review of the literature, outbreak scenarios, exposure pathways and case studies
    Volume 2: Assessment of risks to Matters of National Environmental Significance
    Volume 3: Assessment of social risks
16. 2016-158: Development of strategies to optimise release and clean-up strategies
17. 2016-180: Assessment of options for utilisation of virus-infected carp
18. 2017-104: The likely medium- to long-term ecological outcomes of major carp population reductions
19. 2016-132: Expected benefits and costs associated with carp control in the Murray-Darling Basin

NCCP PLANNING INVESTIGATIONS

1. 2018-112: Carp questionnaire survey and community mapping tool
2. 2018-190: Biosecurity strategy for the koi (*Cyprinus carpio*) industry
3. 2017-222: Engineering options for the NCCP
4. NCCP Lachlan case study (in house) (refer to Technical Paper 9)
5. 2018-209: Various NCCP operations case studies for the Murray and Murrumbidgee river systems
   (refer to Technical Paper 8)

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Biocontrol of European Carp

Ecological risk assessment for the release of Cyprinid herpesvirus 3 (CyHV-3) for carp biocontrol in Australia

Volume 2: assessment of risks to Matters of National Environmental Significance

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February 2020

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We would also like to thank the NCCP project teams whose work has provided critical insights into the biomass of carp on a continental scale, the likely impacts of carp mortality on water quality, and aspects of the likely behaviour of CyHV-3 as a biocontrol for carp across a range of freshwater ecosystems.

Over-and-above these teams, we would like to recognise the outstanding contributions of the many key researchers and water managers whose expertise in a range of areas has enabled us to make judgements about ecological risk. We are particularly grateful to Dr Jon Marshall for his comments on, and contributions to, the case study for the Moonie River Catchment; and to Dr Danial Stratford for his invaluable editorial and scientific review.

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INTRODUCTION

The Australian Government has invested in the development of a National Carp Control Plan (NCCP) to explore the potential use of *Cyprinid herpesvirus 3* (CyHV-3) for the biological control of carp in Australia. Carp occur in every state and territory except the Northern Territory and are now the dominant fish species within the Murray-Darling Basin. The ecological impacts of carp include increased turbidity, intensified algal blooms and reduced abundance of macrophytes, invertebrates and some native fish.

One of the core objectives of the NCCP is to undertake research and development to address knowledge gaps, and to better understand and manage risks to support the potential release of CyHV-3, subsequent clean-up, and the recovery of native fish and ecosystems. The ecological and social risk assessment detailed in the three volumes of this report was one of the projects funded through the NCCP.

The **ecological** component of the assessment was undertaken in two parts:

(a) A compilation of the science and epidemiology of CyHV-3 and an assessment of outbreak scenarios, exposure pathways and case studies (Volume I of this report)

(b) An assessment of the risks that the proposed release of CyHV-3 may pose to the assets that have been described under the EPBC ACT[1] as Matters of National Environmental Significance (MNES) (Volume 2 of this report).

Part (a) above provided the underpinning for part (b), but also gave a more comprehensive assessment of the environmental risks that may be associated with the release of CyHV-3. Part (b) was directed specifically at the needs of the Strategic Assessment that will be required by the Department of Environment and Energy, under the EPBC Act, if the release of CyHV-3 is judged to be feasible.

The standalone **social** component of the assessment is documented in Volume 3 of this report. This assessment included two forms of stakeholder interaction and was undertaken to evaluate perceptions about the risks attached to the proposed release of CyHV-3.

KEY FINDINGS

The **ecological risk assessment** made use of outbreak scenarios, exposure pathways and case studies to evaluate risks to species and ecological communities at a national scale. The development of outbreak scenarios enabled key aspects of the epidemiology of CyHV-3 to be considered in an Australian context. This included a range of outbreak settings, such as ephemeral

[1] Environment Protection and Biodiversity Conservation Act 1999

wetlands, perennial and disconnected river systems and lakes and other impoundments, as well as consideration of the implications of high-flow and lower-flow seasons. The outbreak scenarios were informed by the spawning behaviour of carp, and by the importance of aggregations and water temperature to the perpetuation of CyHV-3.

- Although aggressive outbreaks of CyHV-3 were considered possible in most settings, impacts on water quality are likely to require a relatively high carp biomass density and relatively poor connectivity of the waterway in which the outbreak occurs. In this context, impacts on water quality may include a reduction in dissolved oxygen as a result of increased biological oxygen demand (possibly to the point of anoxia), an increase in the likelihood of widespread cyanobacterial blooms as a result of an increase in phosphorous and dissolved organic carbon, and an increase in the risks associated with proliferating waterborne spoilage and other microorganisms. Native fish (small-bodied and large-bodied) and crustaceans are most at risk from low dissolved oxygen – in particular, species with a limited geographic range or a reliance on a small number of local populations. These and other aquatic and terrestrial water users, including waterbirds, will also be at risk from cyanobacterial blooms. Colonial-nesting waterbirds are more at risk than those that nest individually, as are the waterbird functional groups (such as the piscivorous seabirds and large waders) that are most closely associated with water.
- High-risk settings for the impacts of an outbreak of CyHV-3 on food webs include ephemeral wetlands during high-flow seasons, when the floodplains are inundated and a maximal number of breeding piscivorous waterbirds are present; and some permanent lakes and irrigation reservoirs that may act as a refugia for breeding waterbirds during lower-flow seasons. The emphasis on breeding (as opposed to nesting) waterbirds is relevant, as chicks are more likely to be stressed by the removal or suppression of juvenile carp than are adult birds. The removal of juvenile carp may result in piscivorous waterbirds switching to other prey species – including the juvenile large-bodied native fish, adult or juvenile small-bodied native fish, frogs and frog spawn, crustaceans and turtle eggs or hatchlings – and this may place stress on some important local populations.
- Botulism outbreaks in wildlife follow a highly-probabilistic process and are potentially a concern in any wetland, lake or waterhole where carcass accumulation occurs in the presence of large numbers of waterbirds. Although most terrestrial and aquatic species will be at risk in the event of an outbreak of type C (or C/D mosaic) botulism, fatalities are generally most striking amongst waterbirds – in particular, those that include insects in their diet.

These assessments speak to the risks faced by individuals, and by local populations. The risks faced by a species as a whole will reflect the exposure of individuals (as above) as well as a raft of population-level factors, such as the strength and geographic distribution of its population across Australia and the effectiveness of its recruitment or rejuvenation strategies.

A range of mitigations was considered for each of the identified exposure pathways. Following the dictates of the Department of Environment and Energy, these addressed, in decreasing order of preference, the avoidance, mitigation and offsetting of risk and ongoing adaptive management of residual threats. Risks to native species or communities can be avoided chiefly through the strategy for release of CyHV-3, which should consider the implications of high-flow and lower-flow seasons for impacts in different settings and geographical locations. The partial removal of carp from waterways, ahead of the release of the virus, may provide another means by which water quality risks can be avoided. This strategy is likely to be particularly attractive in waterways that are prone to low flows or to the formation of disconnected waterholes. Risks that cannot be avoided may be mitigated, and this will be chiefly through the removal of carp carcasses or the use of water regulation to flush carcasses or the products of carcass decomposition (including cyanobacterial blooms) from sensitive areas. Offsetting the harm from any remaining risks will focus largely on the release of farmed species at strategic locations. The effectiveness of this will in most cases be bolstered through wild-caught broodstock. Ongoing adaptive management will include programmed monitoring of water quality data from the Murray-Darling Basin and beyond, as well as the programmed monitoring of key or indicator species.

The **assessment of EPBC Act MNES** covered the breadth of natural and built assets that might be exposed through the proposed release of CyHV-3. This included threatened and migratory species, as well as threatened ecological communities, Ramsar wetlands, World Heritage Properties, National Heritage Places, Commonwealth Marine areas, the Great Barrier Reef Marine Park and Commonwealth Lands. The assessment for threatened and migratory species focussed on the likelihood of a Major impact at a national level, while the balance of assessments was undertaken using the Department of Environment and Energy's significant impact criteria. With risk mitigations in place, Medium risks remained for some large-bodied and small-bodied native fish, shorebirds, large waders and native frogs. Species that are micro-endemic within areas that also include a high biomass density of carp were maximally exposed from a geographic standpoint, although the risk estimates also reflected exposure to (as relevant) poor water quality, food web disturbances and an outbreak of botulism. The only non-negligible residual risks for MNES assets other than threatened and migratory species were attributed to a range of Ramsar wetlands and two of the National Heritage properties (the Cowra Japanese Gardens and Cultural Centre and Centennial Park).

The **social risk assessment** was undertaken to evaluate perceptions about ecological and other risks attached to the proposed release of CyHV-3. The assessment showed that while communities are accepting of the use of CyHV-3 to control invasive carp in Australian waterways, their acceptance is dependent on familiarity with the NCCP, personal interactions with waterways, knowledge of carp impacts and values, and their sense of community responsibility towards environmental stewardship. Uncertainty underpinned baseline concerns about the possible impact of CyHV-3 on humans, and on animals other than carp. The results underscored the need for proactive and effective communication across a range of social strata, with clear messaging about both strategy for the release of the virus and site-specific plans for the clean-up and disposal of carcasses.

ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment was informed by an assimilation of the grey and published literature, and by the outputs of companion projects undertaken through the NCCP.

The review (Volume I of this report) encompassed the characteristics of Australia's freshwater waterways, the species and ecological communities that may be at risk in the event of an outbreak of CyHV-3, the ecology of carp in Australia and the underpinning for its success as an invasive species, the epidemiology of CyHV-3 in farmed and wild carp, and the impacts of fish kills on water quality, risk of botulism and food webs. The review provided an assimilation of key works from the published and grey literature. As they became available, the reports of other NCCP projects were also included. These included, in particular, the carp biomass modelling study (Stuart *et al*., 2019), and the water quality research (Walsh *et al.*, 2018) and modelling (Hipsey *et al*., 2019) studies. The report of the epidemiological modelling study (Durr *et al*., 2019a, 2019b and 2019c) was released in draft format immediately prior to the release of this risk assessment. An abstract from the epidemiological modelling study was included and key assumptions and conclusions were cross-checked for consistency with the outcomes of this risk assessment.

An expert elicitation study was embedded within the review and sought to clarify some of the critical questions concerning the role that juvenile carp may play as a food source for nesting piscivorous waterbirds. A quantitative joint-distribution modelling study was also carried out, with the aim of exploring the likelihood that other invasive species would rebound given the removal or suppression of carp. This study identified goldfish, tench, redfin perch, roach, Oriental weatherloach and eastern mosquitofish as invasive species whose habitat is currently correlated with that of carp. Dietary overlap, affinity for the highly-turbid waters that are likely to remain for the short-medium term, and shifts in pressures on zooplankton and phytoplankton, are all factors that may influence the likelihood that one or more of these species would benefit substantially from the removal or suppression of carp. Goldfish and eastern mosquitofish already coexist with carp in robust populations that include, in the case of goldfish, some hybridisation. Tench compete directly with carp and occupy a similar ecological niche and, although currently inhibited by carp, and likely to benefit from their removal or suppression, are considered far less destructive from an ecological standpoint. Redfin perch are a predatory species, and their success in the event of carp removal or suppression will relate to their ability to feed in turbid waters. As redfin perch also predate on other juvenile non-native fish, this may lead to secondary impacts that are more difficult to predict. Less is known about the ecology of roach or Oriental weatherloach in Australia, although both are substantially smaller fish than carp and neither is likely to recruit as effectively in high-flow seasons.

The assessment of ecological risk (Volume I of this report) built on the reviews and evaluations described above. One of the most striking characteristics of the assessment was the breadth of ecological assets (including species, communities and places) and settings that it was required to encompass in order to evaluate the possible impacts of CyHV-3 at a national scale. A national scale was chosen as the virus is likely to spread naturally from the place(s) of introduction, or through the translocation of affected live fish or carcasses, during one or several seasons. In order to address the breadth of concerns associated with release at a national scale, the assessment included outbreak scenarios for a range of freshwater environments, nine key exposure pathways describing the ways in which the release of CyHV-3 could result in harm to the environment, and a series of detailed case studies.

The outbreak scenarios focussed individually on ephemeral wetland settings, lakes and reservoirs, and riverine settings. Across these, the importance of aggregation events, carp biomass density and water temperature were underscored. The scenarios focussed on the events that are likely to unfold under a maximally aggressive outbreak. In most settings, this will correspond to the period immediately after release of the virus. In disconnected riverine environments, however, outbreaks are more likely to be aggressive during the dry season following from reconnection of the river system – that is, after affected fish have had an opportunity to be redistributed through the population.

Although aggressive outbreaks of CyHV-3 were considered possible in most settings, impacts on water quality are likely to require a relatively high carp biomass density and relatively poor connectivity of the waterway in which the outbreak occurs. In this context, impacts on water quality may include a reduction in dissolved oxygen as a result of increased biological oxygen demand (possibly to the point of anoxia), an increase in the likelihood of widespread cyanobacterial blooms as a result of an increase in phosphorous and dissolved organic carbon, and an increase in the risks associated with proliferating waterborne spoilage and other microorganisms. High-risk settings for impacts on water quality include spring or autumn outbreaks within the seasonally-disconnected waterholes that characterise many dryland river systems (for example, the Moonie River in Queensland), and spring and summer outbreaks within ephemeral wetlands during lower-flow seasons when aquatic biota are concentrated in available wetland or off-channel habitat (for example, the Barmah-Millewa Forest in New South Wales and Victoria). Conversely, it is relatively less likely that water quality will be diminished in the event of an outbreak of CyHV-3 within deep and flowing waterways such as the Murray River channel. Although there is a range in the susceptibility of individual species to low dissolved oxygen, most will be affected if levels lower than 3 mg/L persist. The Basin Plan target of ≥50 percent saturation (or a dissolved oxygen of approximately 4.5 mg/L at 20C) is widely regarded as the appropriate critical value for Australian freshwater river channels and anabranch creeks.

The accumulation of decomposing carcasses may also initiate a widespread cyanobacterial bloom. Some species of cyanobacteria are toxic, and this will have a direct impact on aquatic and terrestrial animals – including livestock and humans. As cyanotoxins may also bioaccumulate in animal tissue, a toxic threshold can be breached through repeated low-dose exposure. When the conditions change, or the substrate is depleted, the bloom will collapse and die. This results in a substantial increase in biological oxygen demand and a precipitous drop in dissolved oxygen. The impact of a collapsed bloom on dissolved oxygen is likely to exceed the impact of carcass decomposition (above) and will have a marked effect on water-breathing aquatic life.

Relatively less is known about the impact of decomposing fish carcasses on the proliferation of waterborne microorganisms. Carp gut flora and spoilage organisms may be present in high numbers, as might *E. coli*, some *Pseudomonas spp* and other opportunistic microorganisms. Shiga toxin-producing *E. coli* (STEC) has been isolated from ponds, streams, wells and water troughs, and have been found to survive for months in manure and water-trough sediments. *Aeromonas spp* have also been found in irrigation water, rivers, springs, groundwater, estuaries and oceans and are of public health concern. The decomposition of carp carcasses in mesocosms has resulted in a decrease in signature lake bacteria, and an increase in environmental copiotrophs and fish gut bacteria. Potentially, some changes to the bacterial flora may persist once waterways have returned to an otherwise healthy state. Aquatic and terrestrial animals that have faced other challenges arising from an outbreak of CyHV-3 (for example, a cyanobacterial bloom) are likely to be stressed and immunocompromised and may have a diminished resistance to waterborne microorganisms that are pathogenic for their species or functional group. These possibilities notwithstanding, very little evidence was found within the published or grey literature to substantiate a link between substantive fish kills in Australian freshwater environments and the proliferation of, or disease resulting from, waterborne microorganisms.

The mitigation of risks associated with diminished water quality will rest largely on the timely removal of carp and other carcasses, noting that carcasses will in general only float for 1 to 3 days following death. Although the timely removal of carp carcasses is likely to be a practical proposition in some settings (for example, urban lakes and some irrigation reservoirs), the magnitude of the task or the accessibility of waterways may in other settings be problematic. This is likely to be the case in some seasonally-disconnected dryland rivers, for example, where the population is sparse and the monitoring of, and access to, individual disconnected waterholes, may not be practical. The collection of carcasses may also be difficult in some wetland settings – in particular, during a high-flow season when the floodplains are inundated, and access is limited to shallow-draft water craft. As an alternative, or adjunct, to the removal of carcasses and carcass materials, it may be practical in some situations to make use of regulatory structures to flush carcass materials or cyanobacterial blooms from affected areas and to refresh the quality of the water. Within the Chowilla Floodplain in South Australia, for example, the sophisticated Chowilla regulator and ancillary structures enable water to be directed to particular parts of the wetland complex, even when flows through the Murray River channel are relatively low.

High-risk settings for the impacts of an outbreak of CyHV-3 on food webs include ephemeral wetlands during high-flow seasons when the floodplains are inundated, and a maximal number of breeding waterbirds are present (for example the Macquarie Marshes in New South Wales); and some permanent lakes and irrigation reservoirs that may act as a refugia for breeding waterbirds during lower-flow seasons (for example, Kow Swamp in Victoria). In this context, the effects on food webs may include stress to the chicks of (in particular) colonial-nesting piscivorous waterbirds following the removal or suppression of juvenile carp, as well as an impact on native species as a result of prey-switching.

Mitigation of the food web effects of an outbreak of CyHV-3 on breeding waterbirds will largely be limited to consideration of the timing of virus introduction into a naïve population of carp. In some catchments, for example, it may be beneficial to ensure that the virus is introduced during a relatively lower-flow season. The situation is complex, however, as two caveats to this approach are that: (a) breeding waterbirds taking dry-season refuge in permanent lakes and impoundments within the same catchment may then be exposed; and (b) the impacts of the virus on water quality may then be more significant. Mitigation of the effects of prey-switching will again rest on timing, with the aim being to avoid high-flow seasons when a wide range of native species will be taking advantage of inundated floodplains. It may also be beneficial to plan for the restocking of key ecological communities with (in particular) juvenile native fish. This strategy may in turn be aided by sourcing broodstock from key catchments and wetlands, to ensure that restocked juveniles have an optimum local fitness when released.

Botulism outbreaks in wildlife follow a highly-probabilistic process and are potentially a concern in many wetland, lake and waterhole settings. Most terrestrial animals (including livestock) are susceptible to type C (or C/D mosaic) botulinum toxin, the most likely form of botulism in Australian wildlife. Humans, however, are not susceptible, and fish are only partly susceptible. Waterbirds are commonly the most affected, and while all waterbird species are susceptible those that consume insects and those that are more closely affiliated with water are likely to be most at risk. Botulism outbreaks in wildlife may arise in two key ways: (a) through the death of animals carrying spores within their gastrointestinal tracts, and the initiation of what is termed the 'carcass-maggot cycle'; or (b) through the germination of spores within the environment. In both cases, the germination of spores is triggered by anaerobic conditions and the presence of a suitable organic substrate. Under the first pathway (a) large numbers of carp carcasses might result in the initiation of an outbreak of botulism. Under the second pathway (b) the accumulation of carp carcasses might result in a drop in dissolved oxygen within an aquatic environment; or might result in the initiation of a widespread cyanobacterial bloom, which then dies and results in a drop in dissolved oxygen. The mitigation of risks associated with botulism in wildlife will again focus on the timely removal of carcasses and the possible use of regulatory structures to divert water to affected areas. These considerations notwithstanding, Agriculture Victoria (for example) have investigated numerous major blackwater events and fish kills in Victorian waterways and wetlands and have not to-date identified any cases of botulism in associated waterbirds. The peer-reviewed literature is also absent of robust evidence for the role of large fish kills as initiators of botulism outbreaks in natural settings.

ASSESSMENT OF EPBC ACT MNES

The assessment of risks to assets defined under the EPBC Act as Matters of National Environmental Significance (MNES) was undertaken to provide the core material for a Strategic Assessment (Volume 2 of this report). The Strategic Assessment will be required under the EPBC Act if the Australian Government considers the proposed release of CyHV-3 to be feasible and chooses to take it forward.

The assessment of EPBC Act MNES included the following:

- Threatened species
  - Critically endangered species
  - Endangered species
  - Vulnerable species
- Migratory species
- Threatened ecological communities
  - Critically endangered communities
  - Endangered communities
  - Vulnerable communities

- Ramsar wetlands of international importance
- World Heritage Properties
- National Heritage Places
- Commonwealth Marine areas
- Great Barrier Reef Marine Park
- Commonwealth Lands.

The assessment for threatened and migratory species was undertaken using a five-point likelihood scale and a risk scenario that represented Major impact at a national level. The assessments for the balance of MNES assets were undertaken using a simpler dichotomous scale based on the existence of a real chance or possibility of observing a significant impact. Criteria for significant impacts on each category of MNES are provided by the Department of Environment and Energy.[2]

For assessments other than for Commonwealth Lands, evaluation was undertaken: (a) without risk management measures; and (b) with risk management measures (that is, residual risk). Risk management included measures to avoid, mitigate and offset risks and to provide for ongoing adaptive management. Throughout the evaluation of risk management measures, it was assumed that resources would be sufficient to encompass the activities in the location(s) described. Although the evaluation focused on outcomes following directly from the release of the virus, it was also assumed that resources would encompass surveillance and (if required) ongoing mitigation during years subsequent to the release of the virus.

A summary of the outcomes of the assessments for threatened and migratory species is given in Figure 1 (unmanaged risks) and Figure 2 (managed or residual risks). No unmanaged risks were considered Extreme. High unmanaged risks were recorded for large- and small-bodied native fish, shorebirds, large waders and native frogs. With management measures in place, no High risks remained, although a range of Medium risks remained for large-bodied and small-bodied native fish, shorebirds, large waders and native frogs. These included risks associated with poor water quality (whether from low dissolved oxygen [DO], widespread cyanobacterial blooms or proliferating microorganisms), food web disturbances (including the removal of juvenile carp as a dominant and stable food source, and the impacts of prey-switching as a result of this) or an outbreak of type C (or C/D mosaic) botulism. Under the assessment framework used for threatened and migratory species a Medium risk equated to the view that a Major impact at a national level is unlikely – that is, uncommon, although the outcome has been known to occur in a range of circumstances.

[2] Matters of National Environmental Significance, Significant Impact Guidelines 1.1 (see: https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance)

Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies, Significant impact guidelines 1.2 (See: https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-12-actions-or-impacting-upon-commonwealth-land-and-actions)

Figure 1 Summary of unmanaged risks for threatened and migratory species

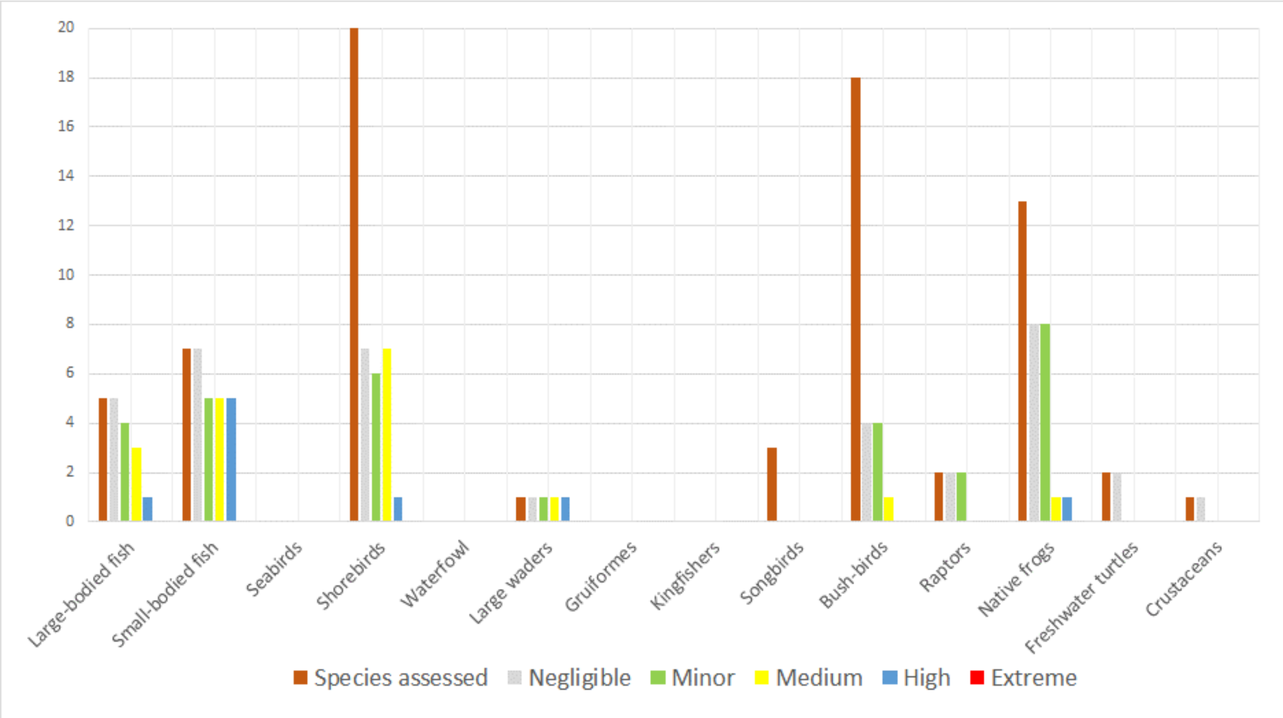
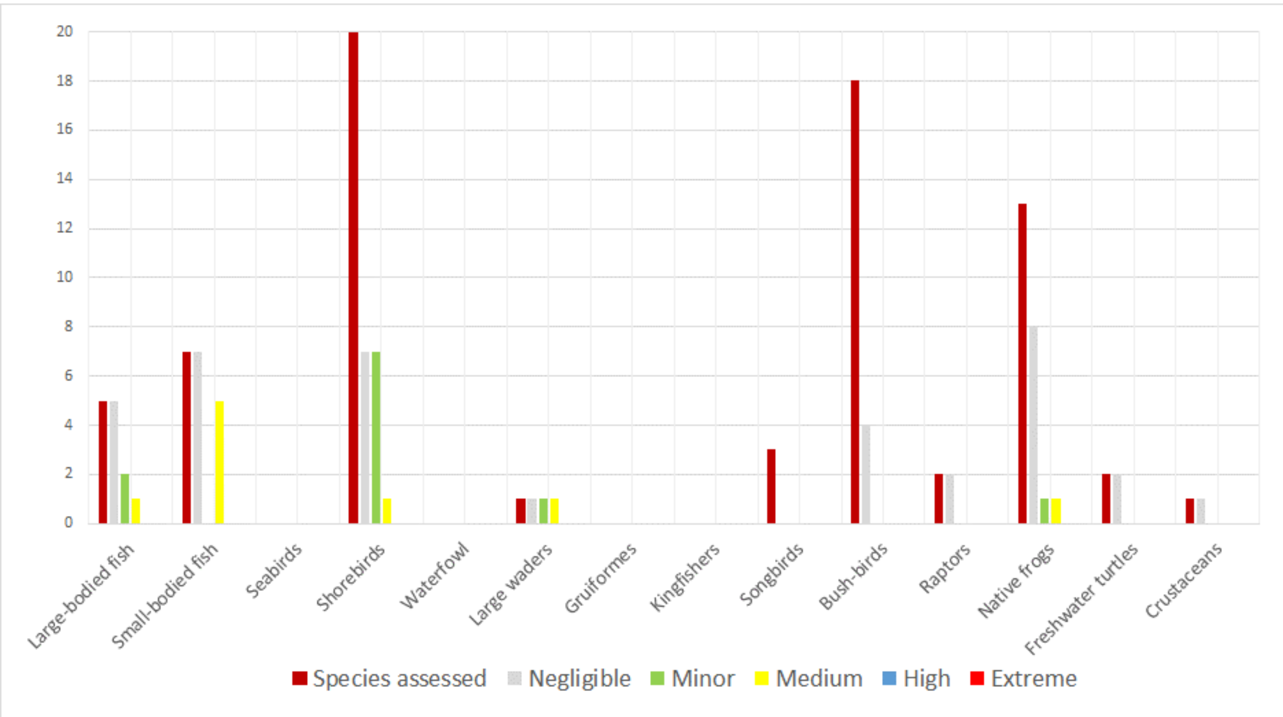


Figure 2 Summary of residual risks for threatened and migratory species



When management measures were considered, the only non-negligible risks for the balance of the MNES assets were attributed to Ramsar wetlands (including Ramsar wetlands of the northern Murray-Darling Basin, Ramsar wetlands of the southern Murray-Darling Basin and Wetlands within the Coorong and Lakes Alexandrina and Albert Wetland) and to two of the National Heritage properties (the Cowra Japanese Gardens and Cultural Centre and Centennial Park).

Additional planning could be undertaken to protect both the Cowra Japanese Gardens and Cultural Centre and Centennial Park, or to enable any harm that resulted from an outbreak of CyHV-3 to be rectified. In the case of the Cowra Japanese Gardens and Cultural Centre this might include vaccination of valuable ornamental Koi carp, a provision for restocking, or the use of effective biosecurity measures. Carp are a pest species within the Centennial Park ponds, and mitigation in this context would include additional resources for the immediate removal of carcasses and minimisation of harm to the amenity values of the park. The management of Ramsar wetlands will be more complex and is likely to require the development of a plan for each individual site. This plan would reiterate the values of each site, and the measures that can be taken to ensure that those values are protected or restored. These measures would address threats arising from the water quality effects of an outbreak of CyHV-3, as well as impacts on food webs or the risk of an outbreak of botulism. Additional analysis may be warranted to clarify the assets at stake within some categories of Commonwealth Land held by the Department of Defence and the Department of Finance.

RESIDUAL UNCERTAINTY

The breadth of this ecological risk assessment was considerable and, without any direct experience of the epidemiology of CyHV-3 in an Australian context, a degree of residual uncertainty is inevitable. In particular, this concerned the likely behaviour of the virus in a range of Australian freshwater settings and key components of the identified exposure pathways. Although largely beyond the scope of this assessment, there was also some residual uncertainty about the likely efficacy and practicality of some mitigations when applied in certain settings.

The likely behaviour of CyHV-3 was encapsulated in the detailed outbreak scenarios discussed above. Although the assumptions underpinning these scenarios concurred, in broad terms, with the NCCP's epidemiological modelling, it was recognised that the behaviour of an exotic disease in such diverse and complex settings cannot be predicted with certainty. It is possible, for example, that CyHV-3 will not penetrate local carp populations to the extent envisaged. It is equally possible, however, that the virus will be more successful than expected, or that particular characteristics of its epidemiology (such as the higher sensitivity of juvenile carp) will lead to an impact on carp populations that is more marked than modelling and qualitative assessment have suggested.

As noted, residual uncertainty also exists in respect of the identified exposure pathways.

The tolerance of each lifecycle stage of every native water-breathing aquatic species that may be exposed to low DO is not known, although this may be inferred with varying degrees of confidence from the literature about blackwater events. Similarly, whilst the NCCP water quality modelling studies showed that a dangerously low DO was only likely to occur within partially-connected or disconnected waterways, with a very high carp biomass density, there remained a degree of uncertainty about the importance of local conditions. A similar situation existed for widespread cyanobacterial blooms, with inference in that case based on the development and impacts of blooms that have occurred naturally throughout Australian freshwater waterways. Substantial uncertainty also surrounded the assessment of waterborne microorganisms that may be released into waterways with the decomposition of carp carcasses. In this case, uncertainty included the species of microorganisms that are likely to be involved, and their pathogenicity for particular functional groups and native species, as well as the persistence of epidemics within waterways after the dissolution of carcass materials.

In addition to the water quality pathways, substantial uncertainty remained in respect of the impact of CyHV-3 on food webs – in particular, in settings that include large numbers of nesting piscivorous waterbirds. The two aspects of this scenario included the putative effects of removing a stable and plentiful food source (juvenile carp), and the likelihood that piscivorous waterbirds would then switch to native fish, crustaceans, frogs and turtle eggs and young as an alternative source of food. Very little is currently known about the likelihood, and likely severity, of either pathway, and this was reflected in the conservative estimates.

Botulism in wildlife is considered to be an inherently probabilistic process, with relatively few outbreaks observed in Australia given the ubiquity of spores and the frequent alignment of suitable conditions. Compounding this is a paucity of reports specifically linking fish kills to outbreaks of type C (or C/D mosaic) botulism in waterbirds, despite the fact that substantial fish kills (as a result of blackwater events and other processes) are not uncommon within Australian waterways. This notwithstanding, it was recognised that concurrent outbreaks of CyHV-3 across a catchment or river system have the potential to create a uniquely high-risk scenario – in particular, given the co-occurrence of: (a) carp at a relatively high biomass density; and (b) large numbers of nesting waterbirds. In view of this, conservative estimates were assigned to this pathway. Type E botulism was ruled out of the case studies and assessment of MNES on the grounds that there is no evidence that it exists within Australia. This was considered a practical and realistic standpoint, although it was also noted that there has not been a systematic search for type E *C. botulinum* across Australian waterways, and that none of the experts consulted was willing to state categorically that type E is an exotic strain. The importance of type E is twofold: (a) it is primarily a disease of fish (although waterbirds are severely impacted), and therefore more likely to arise in the context of a widespread and multifocal fish kill; and (b) it is highly-toxic (frequently fatal) to humans.

SOCIAL RISK ASSESSMENT

The social risk assessment was undertaken to evaluate perceptions about ecological and other risks attached to the proposed release of CyHV-3. This standalone work was based on qualitative and quantitative analysis of stakeholder surveys.

The qualitative survey focussed on interviews with a range of stakeholders, including recreational fishers and water sports enthusiasts, farmers and irrigators, retirees, Indigenous Australians and the general public more broadly. Respondents were members of local communities who in many cases possessed both local knowledge and practical experience dealing with the effects of significant environmental issues such as blackwater events. The quantitative component of the social risk assessment focussed on the deployment and analysis of a national survey. The survey was informed by an analysis of social groups and demographic profiling, with a focus on those who lived on or close to major waterways and those from urban settings. In total, 2,026 people participated in an online survey that was developed and administered by Taverner Research (an online market-research provider).

The social risk assessment showed that while communities are accepting of the use of CyHV-3 to control invasive carp in Australian waterways, their acceptance is dependent on familiarity with the NCCP, personal interactions with waterways, knowledge of carp impacts and values, and their sense of community responsibility towards environmental stewardship. The assessment showed that those who agree in general that carp control is necessary – and can recognise potential ecological benefits of carp control – are also more likely to accept the release of CyHV-3 as a possible means to this end. This trend meant that people who live within the Murray-Darlin Basin and are closely involved with the river system, better appreciate the need for carp control. This group, however, was also attuned to the ecological and other risks associated with the proposed release of CyHV3 – in particular, the risks associated with the accumulation of decomposing carp carcasses. Uncertainty underpinned baseline concerns about the possible impact of CyHV-3 on humans, and on animals other than carp. These concerns extended to agricultural products irrigated with water from waterways in which the virus was active. Whether linked to these concerns, or to the effects of carcass accumulation and decomposition, anxiety about the control of carp using CyHV-3 was negatively correlated with acceptance of the virus. This result underscored the need for proactive and effective communication across a range of social strata, with clear messaging about both strategy for the release of the virus and site-specific plans for the clean-up and disposal of carcasses.

Part IV Assessment of EPBC Act Matters of National Environmental Significance

An assessment of the risks to EPBC Act Matters of National Environmental Significance that may be affected by the release of *Cyprinid herpesvirus 3* (CyHV-3) for carp biocontrol in Australia

1 Introduction

Important note: this part of the overarching ecological risk assessment is only lightly referenced.

Readers are directed to the systematic review in Part II for corroboration of the underlying science, and to Part III for the discussion about outbreak scenarios, exposure pathways and case studies.

Parts I, II and III are documented in Volume 1 of this report.

The assessment of risks to assets defined under the EPBC Act as Matters of National Environmental Significance (MNES) was undertaken to provide the core material for a Strategic Assessment. The Strategic Assessment will be required under the EPBC Act if the Australian Government considers the proposed release of CyHV-3 to be feasible and chooses to take it forward.

The assessment of EPBC Act MNES included the following:

- Threatened species
  - Critically endangered species
  - Endangered species
  - Vulnerable species
- Migratory species
- Threatened ecological communities
  - Critically endangered communities
  - Endangered communities
  - Vulnerable communities
- Ramsar wetlands of international importance
- World Heritage Properties
- National Heritage Places
- Commonwealth Marine areas
- Great Barrier Reef Marine Park
- Commonwealth Lands

2 Methodology

2.1 Screening spatial analysis: all MNES assets

A preliminary screening spatial analysis was undertaken to identify MNES assets whose location or distribution overlapped with that of carp. The distribution of carp defines the extent of the 'action' which, under EPBC Act terminology, is the proposed release of CyHV-3. The screening analysis used the spatial datasets provided by the Department of Environment and Energy. The analysis was conservative in the sense that spatial datasets for both carp and MNES assets are buffered and imprecise. This meant that a high proportion of the MNES assets identified through the screening analysis had little or no real overlap with carp. The approach was, however, sensitive, and it is believed that few of the MNES assets likely to be relevant to this assessment were excluded through the screening analysis.

The outcomes of the screening analysis were then refined by removing assets whose location or distribution was limited to a state or territory where the carp biomass density is not sufficient for an outbreak of CyHV-3 to result in a 'real chance or possibility'[3] of harm. This excluded Western Australia, the Northern Territory, Tasmania and any Australian island territories. An exclusion was also applied to species that only occurred in the coastal parts of Queensland north of Brisbane.

2.2 Assessment framework for threatened and migratory species

The criteria provided by the Department of Environment and Energy for the assessment of the significance of impacts on threatened and migratory species (Part I: Section 2.2) were remapped to a qualitative five-point evaluation framework. This framework provided greater precision and discrimination in the assessment of risks to threatened and migratory species, and an improved ability to assess impacts at a national level.

The framework centred on scales that described a **Major** impact at the national level for threatened species (Table 1) and for migratory species (Table 2). The scale for threatened species included separate criteria for impacts arising from the following:

- Direct harm to species
- Impact on the quality of water or habitat
- Impact on food and other resources
- Impact on breeding cycle
- Impact on species connectivity and migration.

The assessment focussed on the events that are likely to unfold under a maximally aggressive outbreak. In most settings, this will correspond to the period immediately after release of the

[3] As defined in the Department of Environment and Energy's Matters of National Environmental Significance, Significant Impact Guidelines (see: https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance)

virus. In disconnected riverine environments, however, outbreaks are more likely to be aggressive during the dry season following from reconnection of the river system – that is, after affected fish have had an opportunity to be redistributed through the population.

The likelihood that Major consequences would be realised for either threatened species or migratory species, given exposure to each of the pathways discussed in Part III: Section 2, was assessed using the five-point scale shown in Table 3. The combination of likelihood and Major consequences was then evaluated using the risk matrix in Table 4. The process was repeated with mitigations in place (Section 2.4), and an estimate for residual risk was obtained.

The assessment of risk for threatened and migratory species also referenced qualitative descriptors for the extent of overlap between the distribution of carp and that of each species, and the distribution of the species within that overlap. These descriptors are shown in Table 5.

Table 1 Scenario describing a Major impact on a threatened species

Areas of impact	Scenario: Major impact on threatened species	
	National impact given a range of outbreak scenarios	Temporal scale of recovery
Direct harm to species	Direct harm to a species results in a discernible impact on the strength and genetic diversity of its population at a national level. This may result from: • The effective loss of a population in one or more locations • The loss of a substantive component of the population within a bioregion or catchment • The loss of a substantive component of one or more important populations.[4]	Recovery of the population strength and genetic diversity at a national level measured in years to decades.
Impact on the quality of water or habitat	The quality of a discernible proportion of the water or habitat across a species' natural range (national level) is reduced to the point of being incompatible with the species' requirements. This may result from: • Water quality or habitat made incompatible with a species' requirements in one or more locations. • Water quality or habitat made incompatible with a species' requirements across a substantive proportion of a bioregion or catchment • Water quality or habitat made incompatible with a species' requirements across a substantive component of one or more important populations.	Recovery of habitat requires ecosystem-level adjustment, with minor improvement measured in weeks and complete recovery at a national level measured in months. Recovery of water quality measured in weeks to months.

[4] **Important populations** have been defined by the Department of Environment and Energy as those necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans (where they exist for a given species) or populations that are:
- Key source populations either for breeding or dispersal
- Necessary for maintaining genetic diversity, or
- Near the limit of the species' range.

Areas of impact	Scenario: Major impact on threatened species	
	National impact given a range of outbreak scenarios	Temporal scale of recovery
Impact on food and other resources	Discernible impact on the strength of food webs throughout most of the species' natural range (national level). This may result from: • Effective loss of food sources, or other critical resources, at one or more locations • Loss of food sources, or other critical resources, across a substantive proportion of a bioregion or catchment • Loss of food sources, or other critical resources, across a substantive component of one or more important populations.	Recovery of food webs requires ecosystem-level adjustment, with minor improvement measured in months, and complete recovery at a national level measured in years to decades.
Impact on breeding cycle	For a given breeding season, or a single calendar year, discernible reduction in the recruitment of a species at a national level. This may result from: • The effective failure of a breeding cycle in one or more locations • The effective failure of a breeding cycle across a substantive proportion of a bioregion or catchment • The effective failure of a breeding cycle across a substantive component of one or more important populations.	Population adjustment to reduced recruitment measured in years.
Impact on species connectivity and migration	Reduction in the connectivity at a national level results in a discernible failure of migration for breeding or other purposes. This may result from: • The effective isolation of a population in one or more locations and the failure of migration for breeding or other purposes • The effective fragmentation of a substantive proportion of the population within a bioregion or catchment and the failure of migration for breeding or other purposes • The effective fragmentation of a substantive component of one or more important populations and the failure of migration for breeding or other purposes.	Habitat recovery and reconnection of the population at a national level measured in years to decades.

Table 2 Scenario describing a Major impact on a migratory species

Areas of impact	Temporal scale of recovery
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat[5] for a migratory species.	Recovery of habitat requires ecosystem-level adjustment, with minor improvement measured in weeks and complete recovery at a national level measured in months. Recovery of water quality measured in weeks to months.

[5] An area of **important habitat** for a migratory species has been defined by the Department of Environment and Energy to include:

- Habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species
- Habitat that is of critical importance to the species at particular life-cycle stages
- Habitat utilised by a migratory species which is at the limit of the species range
- Habitat within an area where the species is declining.

Areas of impact	Temporal scale of recovery
Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion[6] of the population[7] of a migratory species.	Population adjustment to reduced recruitment measured in years.

Table 3 Scale for the evaluation of likelihoods

Likelihood	Description
Negligible	There is not a real chance or possibility that the outcome will occur
Rare	The outcome is very unlikely to occur, and only in exceptional circumstances (no record of occurring but not impossible)
Unlikely	The outcome uncommon, although known to occur in a range of circumstances
Possible	The outcome may occur
Likely	The outcome is expected to occur in most circumstances

Table 4 Scale for the evaluation of risk

Consequences	Likelihood	Risk
Major	Negligible	Negligible
	Rare	Minor
	Unlikely	Medium
	Possible	High
	Likely	Extreme

Table 5 Scale for describing the populations of threatened and migratory species

Term	Meaning
Species overlap with the distribution of carp	
Low	Less than 25% overlap
Moderate	Between 25 and 75% overlap
High	More than 75% overlap
Species distribution within carp habitat	
Diffuse	Occurs evenly throughout the overlap with carp
Sporadic	Occurs in discrete and localised populations within the overlap with carp
Micro-endemic	Single discrete and localised population

[6] The meaning of an **ecologically-significant proportion** of the population varies with the species. The Department of Environment and Energy suggests that the factors that should be considered include the species' population status, genetic distinctiveness and species-specific behavioural patterns (for example, site fidelity and dispersal rates).

[7] A **population**, in relation to migratory species, has been defined by the Department of Environment and Energy as the entire population or any geographically-separate part of the population of any species or lower taxon of wild animals, a significant proportion of whose members cyclically and predictably cross one or more national jurisdictional boundaries including Australia.

2.3 Assessment framework for other MNES assets

A simpler assessment framework was adopted for MNES assets other than threatened and migratory species. These include threatened ecological communities, Ramsar wetlands, National Heritage Places, World Heritage Properties, Commonwealth Marine Areas and the Great Barrier Reef Marine Park.

The Department of Environment and Energy's significant impact criteria[8] were identified for each of these categories of MNES asset. For each asset, or group of assets, a determination was then made as to whether there is a real chance or possibility (a non-negligible likelihood) that one or more of these criteria would be realised. For assets other than Commonwealth Lands, the assessment was repeated with mitigation measures in place (Section 2.4) and an estimate for residual risk was obtained.

2.4 Management of risks to MNES assets

The Department of Environment and Energy's framework for the assessment and management of risks to MNES assets[9] describes the application of measures in the following four key steps:

- Avoidance of impacts
- Mitigation of impacts
- Offsetting impacts
- Ongoing adaptive management.

These steps represent the Department's order of preference, such that (for example) the avoidance of risks should be sought before the identification of measure to offset potential harm.

The analysis of exposure pathways within the ecological risk assessment (Part III: Section 2) identified management measures that could be applied to treat the likelihood of water quality effects following from an outbreak of CyHV-3 (including low DO, widespread cyanobacterial blooms and the proliferation of waterborne microorganisms), the likelihood of food webs (including the removal of a dominant and stable source of food and the effects of prey-switching) and the likelihood of an outbreak of botulism. The likelihood that other invasive species will expand their range or increase in number was discussed in Part II: Section 8.

Throughout the evaluation of risk management measures (in this section, and in Parts II and III of the report) it was assumed that resources would be sufficient to encompass the activities in the location(s) described. Although the evaluation focused on outcomes following directly from the release of the virus, it was also assumed that resources would encompass surveillance and, if required, ongoing mitigation during years subsequent to the release of the virus.

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[8] Matters of National Environmental Significance, Significant Impact Guidelines (see: https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance)

Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies, Significant impact guidelines 1.2 (See: https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-12-actions-or-impacting-upon-commonwealth-land-and-actions)

[9] See: https://www.environment.gov.au/resource/guide-undertaking-strategic-assessments

2.4.1 Water quality risks

Avoidance of the water quality effects that may be associated with an outbreak of CyHV-3 (including low DO, widespread cyanobacterial blooms and the proliferation of waterborne microorganisms) may be achieved in part by releasing the virus under conditions least likely to result in these outcomes, and by the proactive management of environmental flows. Water quality effects are most likely to be associated with relatively lower-flow seasons, when spawning carp are concentrated in off-channel waters or diminished waterbodies (including disconnected waterholes within perennial watercourses). The exceptions to this generalisation are permanent lakes or reservoirs, or the main channel of the Murray River, both of which are likely to be more resilient to water stress and to retain a reasonably consistent water level or flow in all but severely drought-affected seasons. Environmental flows are complex, and while there may be situations where regulatory structures permit their use to direct waters in such a way as to avoid the water quality effects of an outbreak of CyHV-3 in a high-value setting, proper consideration must also be given to both the environmental impacts of the altered flow at that location (for example, the untimely stimulation of spawning in some native fish) and the upstream and downstream impacts that such flows may have on the environment and on other water users.

The partial removal of carp from waterways ahead of the release of the virus may be another means by which water quality risks can be avoided. This strategy is likely to be particularly attractive in waterways that are prone to low flows or the formation of disconnected waterholes. In these scenarios, the effect of high carp biomass density will be exacerbated by the concentration that occurs as pools shrink in volume and the inevitable background decline in water quality. A range of conventional and innovative methods could be employed to reduce carp numbers, including trapping and electrofishing. These methods were reviewed in Part II: Section 3.4. Consideration should also be given to the effect this strategy may have on the pre-spawning aggregation of carp and the likely effectiveness of density-dependent virus transmission during spawning itself.

Mitigation of the effects of poor water quality associated with an outbreak of CyHV-3 will focus largely on the removal of carp carcasses. This will include both the physical removal of carcasses and the use of environmental watering (or irrigation flows) to flush carcasses, carcass materials or pockets of poor water quality (including pockets of low DO, cyanobacterial blooms or proliferating waterborne microorganisms) from an affected area, or to channel carcasses and carcass materials to a place where they can be more easily collected and removed. In the case of low DO, the overarching goal will be to prevent the level of oxygenation within a given waterbody falling below approximately 3 to 4 mg/L, or to enable it to return to that level. Comparison parameters for cyanobacterial blooms, or waterborne microorganisms, are less clear-cut and will generally be established on a case-by-case basis. The cost and practicality of removing carcasses and carcass materials will vary substantially with the location and physical characteristics of sites, and with the level of flow in or through a waterway. Urban and peri-urban settings (including lakes, rivers, creeks and wetland complexes) are likely to be the most easily accessed and cleaned. Access to large ephemeral wetland complexes through the Murray River and its tributaries may be more challenging – in particular, when flows are high, and the floodplains are inundated. Access to some riverine environments may also be challenging, although in this setting it is likely to be low flows (seasonal low flows or drought) with the disconnection of waterholes that present the more significant difficulties. The methods used to access particular waterways or waterbodies will also be site-specific, and care may need to be exercised in some areas to ensure that harm to valuable natural assets (including any threatened species that may be exposed to harm as a result of mitigation measures) or built assets (for example, the Brewarrina Fish Traps) is avoided.

Offsetting the effects of poor water associated with an outbreak of CyHV-3 quality on native species will in general focus on the release of farmed aquatic species. This is a broadly established strategy for large-bodied native fish, although there is currently less emphasis on the substantial breeding of small-bodied native fish, frogs and turtles. Some species of crustacean (those that are suited to pond or dam aquaculture) are widely farmed, but others less so. It is likely that the success of the strategy could be augmented through wild-caught broodstock, as the fitness of the progeny of these animals in the wild is likely to be higher than for aquaculture lines. For micro-endemic species (for example, the trout cod or Murray hardyhead) broodstock should be obtained from populations that are particularly important to the species' resilience. Longer-term offsetting activities may include the improvement of river health (for example, the construction of sophisticated fishways or improvements to riparian land management).

Ongoing adaptive management of the effects of poor water quality associated with outbreaks of CyHV-3 will focus on monitoring the relationship between water quality data from the Murray-Darling Basin and beyond and the health of MNES and other key environmental assets. Water quality is currently monitored throughout many of the river systems colonised by carp, and much of the data from these activities is available through web-based portals. Ongoing adaptive management would include a regime for the extraction and analysis of this data, as well as the data collected through other processes targeted at the management of CyHV-3 or other environmental concerns. Programmed monitoring of threatened species would also be required. This should include ongoing assessment of population strength – in particular, the abundance of micro-endemic species in areas where outbreaks and mitigations have occurred. The strategy for adaptive management should also extend to consideration of the effects of measures such as environmental watering on other aspects of the environment, and on other water users. Environmental watering may, for example, induce unseasonal spawning in some species.

2.4.2 Food web risks

The food web effects that may be associated with an outbreak of CyHV-3 include the impact of removing a likely dominant and stable source of food from breeding waterbird populations and the subsequent impacts of prey-switching to native species. Native species that may be affected by prey-switching include juvenile large-bodied fish, small-bodied fish, frogs, turtle eggs and hatchlings and crustaceans. Major waterbird breeding events and aggregations generally coincide with peak flows – notably, the inundation of ephemeral wetlands and their floodplains. An aggressive outbreak of CyHV-3 is possible under these conditions and may extend in some settings to a secondary outbreak amongst juvenile carp.

Avoidance of the food web effects that may be associated with an outbreak of CyHV-3 may be achieved in part by releasing the virus under conditions least likely to result in these outcomes. In particular, this would require avoiding an aggressive outbreak of CyHV-3 at a location and time when waterbirds are breeding in large numbers.

Mitigation of the food web effects that may be associated with an outbreak of CyHV-3 is likely to be restricted to the augmentation of local native populations with farmed juveniles. As noted above, while large-bodied fish, some small-bodied fish (for example, the Murray hardyhead) and some crustaceans have been farmed and released on a broad scale, other functional groups and species have not. Although breeding programs exist for some of these remaining functional groups and species – in particular, threatened species of frog – these have not to-date been designed for catchment-level replenishment and the practicalities of that would need to be determined.

Offsetting the food web effects that may be associated with an outbreak of CyHV-3 will again focus on the release of farmed juveniles. This may include large-bodied and small-bodied native fish, frogs, turtles and crustaceans. Wetland restoration may also be valuable in some settings, and environmental flows might be considered to encourage waterbird breeding events.

Ongoing adaptive management of the food web risks that may be associated with an outbreak of CyHV-3 will focus on monitoring the impact of CyHV-3 on juvenile carp – in particular, following a major spawning event – and the subsequent impact this has on local populations of breeding waterbirds. Although it is likely that the correlation of major carp spawning events with major waterbird breeding events will mean that juvenile carp constitute an important part of the diet of breeding waterbirds, there is little published research to substantiate this (Part II: Section 7). Likewise, there is little research examining the impact of removing a key source of food during a waterbird breeding event – both on the survivability of chicks, and in respect of prey-switching and the targeting of alternative species.

2.4.3 Risk of an outbreak of botulism

The likelihood of an outbreak of Type C (or C/D mosaic) botulism will be highest when carp carcasses accumulate at a place and time where waterbirds are most abundant. Although major waterbird breeding and nesting events are likely to occur on inundated ephemeral wetlands and floodplains where the carp biomass density is low, carcasses may nevertheless accumulate in certain places in numbers sufficient to precipitate an outbreak of botulism. An outbreak of CyHV-3 may also precipitate a significant water quality event (low DO or a widespread cyanobacterial bloom), and this in turn may result in the germination of environmental spores of *C. botulinum* and initiation of an outbreak amongst waterbirds.

Avoidance of an outbreak of Type C (or C/D mosaic) botulism in waterbirds will focus on avoiding outbreaks of CyHV-3 within major waterbird breeding and nesting events. This will minimise the likelihood that an outbreak of botulism will be initiated directly through the carcass-maggot cycle, as well as the likelihood that waterbirds will be exposed to environmental spores of *C. botulinum* that germinate in response to the water effects of an outbreak of CyHV-3.

Mitigation of an outbreak of Type C (or C/D mosaic) botulism will focus on removing carp carcasses and carcass materials from areas that include where significant numbers of waterbirds are present. As described above, this may include the physical removal of carcasses as well as the use of environmental watering or irrigation flows to flush carcasses or carcass materials from particular areas or to channel carcasses and carcass materials to a place where they can be more easily collected and removed.

Offsetting the impacts of an outbreak of Type C (or C/D mosaic) botulism may be problematic as waterbirds are not currently bred in captivity in numbers likely to have an impact on renewing the population strength in an affected area. It is remotely possible that some of the relatively sedentary threatened species, such as the Australasian bittern, might be captured in other locations and rehomed in areas that have been affected by an outbreak of botulism. This approach has been adopted in other contexts – the bush-stone curlew (*Burhinus grallarius*), for example, has been bred in a sanctuary but permitted to fly out into Canberra environs at night to feed. It may also be possible to stimulate waterbird breeding using environmental or irrigation flows.

Adaptive management of the risk of an outbreak of Type C (or C/D mosaic) botulism will focus on monitoring the development of outbreaks of botulism and better understanding their probabilistic nature.

3 Threatened and migratory species

3.1 Threatened and migratory species relevant to this assessment

3.1.1 Large-bodied native fish

Threatened large-bodied native fish species whose habitat overlap with carp include the critically endangered silver perch (*Bidyanus bidyanus*), the endangered trout cod (*Maccullochella macquariensis*) and Macquarie perch (*Macquaria australasica*), and the vulnerable Murray cod (*Maccullochella peelii*). The vulnerable diadromous Australian grayling (*Prototroctes maraena*) was also included. The large-bodied native fish are physically similar to carp, and cohabit closely, and their exposure to harm as a result of an outbreak of CyHV-3 was assessed individually. The endangered Mary River Cod (*Maccullochella mariensis*) is restricted to the Mary River catchment, north of Brisbane, and was not included in the assessment. Likewise, the vulnerable Australian lungfish (*Neoceratodus forsteri*) whose native range is restricted to the Mary River and Burnett River catchments.

3.1.2 Small-bodied native fish

This is a mixed group including wetland or floodplain specialists, and foraging generalists. The <u>wetland or floodplain specialists</u> within this group that are listed under the EPBC Act and whose distribution overlaps with that of carp include the critically endangered flathead galaxias (*Galaxias rostratus*), the endangered Murray hardyhead (*Craterocephalus fluviatilis*) and the vulnerable eastern dwarf galaxias (*Galaxiella pusila*). The listed <u>foraging generalists</u> whose distribution overlaps with that of carp include the endangered barred galaxias (*Galaxias fuscus*) and Oxleyan pygmy perch (*Nannoperca oxleyana*), and the vulnerable variegated pygmy perch (*Nannoperca variegate*) and Yarra pygmy perch (*Nannoperca obscura*).

3.1.3 Waterbirds

Noting that there is a range of ways in which the term 'waterbird' has been used in the scientific and science-policy literature, the following was adopted as a framework for this assessment and report:

- Seabirds, including pelicans, cormorants and darters
- Shorebirds (order Charadriiformes), including waders, gulls, terns, dotterels and plovers
- Waterfowl, including ducks, geese and swans (order Anseriformes) as well as the grebes
- Large waders (order Ciconiiformes), including the storks, herons, egrets, ibises, spoonbills and others
- Cranes rails, crakes, coots, moorhens, swamphens and waterhens (order Gruiformes)
- Kingfishers (order Coraciiformes, family *Alcedinidae*)
- Songbirds (order Passeriformes, the passerine birds).

This structure is used widely in the context of conservation and builds on the principle that waterbirds are those that inhabit or depend on bodies of water or wetland areas. With this in mind, the raptors that are associated with waterbodies were included in the assessment. A further group of 'bush-birds' was also included, insofar as these are birds such as kookaburras and galahs that may be linked inexorably to the ecology and ecological values of particular water-based ecological communities. Loons (divers) of the order Gaviiformes were not included on the list as they are not present in Australia.

Seabirds:

• No threatened seabirds whose distribution overlaps with carp	-

Shorebirds:

• Northern Siberian bar-tailed godwit (*Limosa lapponica menzbieri*)	Critically endangered
• Curlew sandpiper (*Calidris ferruginea*), the great knot (*Calidris tenuirostris*) and eastern curlew (*Numenius madagascariensis*)	Critically endangered and migratory
• Red knot (*Calidris canutus*) and lesser sand plover / Mongolian plover (*Charadrius mongolus*)	Endangered and migratory
• Australian painted snipe (*Rostratula australis*)	Endangered
• Bar-tailed godwit / western Alaskan bar-tailed godwit (*Limosa lapponica bauera*)	Vulnerable and migratory
• Common sandpiper (*Actitis hypoleucos*); ruddy turnstone (*Arenaria interpres*); sharp-tailed sandpiper (*Calidris acuminate*); pectoral sandpiper (*Calidris melanotos*); red-necked stint (*Calidris ruficollis*); double-banded plover (*Charadrius bicinctus*); white-winged tern / white-winged black tern (*Chlidonias leucopterus*); Latham's snipe / Japanese snipe (*Gallinago hardwickii*); ruff / reeve, a sandpiper (*Philomachus pugnax*); common greenshank (*Tringa nebularia*); marsh sandpiper / little greenshank (*Tringa stagnatilis*); and black-tailed godwit (*Limonsa limosa*).	Migratory only

Waterfowl:

• No threatened waterfowl whose distribution overlaps with carp	-

Large waders:

• Australasian bittern (*Botaurus poiciloptilus*)	Endangered

Gruiformes:

• No threatened Gruiformes whose distribution overlaps with carp	-

Kingfishers:

- No threatened kingfishers whose distribution overlaps with carp — -

Songbirds:

- Mallee emu wren (*Stipiturus mallee*) — Endangered
- Thick-billed grass wren (*Amytornis modestus*) — Vulnerable
- Satin flycatcher (*Myiagra cyanoleuca*) and rufous fantail (*Rhipidura rufifrons*) — Migratory

Bush-birds:

- Regent honeyeater (*Anthochaera phrygia*), swift parrot (*Lathamus discolour*) and the plains-wanderer (*Pedionomus torquatus*). — Critically endangered
- Rufous scrub-bird (*Atrichornis rufescens*), red-tailed black cockatoo (*Calyptorhynchus banksii graptogyne*) and the black-eared miner (*Manorina melanotis*) — Endangered
- Painted honeyeater (*Grantiella picta*), malleefowl (*Leipoa ocellata*), red-lored whistler (*Pachycephala rufogularis*), regent parrot (eastern) (*Polytelis anthopeplus monarchoides*), superb parrot (*Polytelis swainsonii*) and the mallee western whipbird (*Psophodes leucogaster leucogaster*) — Vulnerable
- Fork-tailed swift (*Apus pacificus*); oriental cuckoo / Horsfield's cuckoo (*Cuculus optatus*); white-throated needletail (*Hirundapus caudacutus*); grey wagtail (*Motacilla cinerea*); yellow wagtail (*Motacilla flava*); and the little curlew / little whimbrel (*Numenius minutus*) — Migratory

Raptors:

- Red goshawk (*Erythrotriorchis radiatus*) — Vulnerable
- Eastern osprey (*Pandion cristatus*) — Migratory

3.1.4 Frogs

Two hundred and eight species of frog are currently recognised within Australia, although some others await description.

Of these, the southern corroboree frog (*Pseudophryne corroboree*) and northern corroboree frog (*Pseudophryne pengilleyi*) have a distribution that overlaps with that of carp and are listed under the EPBC Act as critically endangered. In addition, the following five species are endangered: the booroolong frog (*Litoria booroolongensis*); yellow-spotted tree frog / yellow-spotted bell frog (*Litoria castanea*); spotted tree frog (*Litoria spenceri*); Fleay's frog (*Mixophyes fleayi*); and the giant barred frog / southern barred frog (*Mixophyes iteratus*). A further five species are vulnerable: the giant burrowing frog (*Heleioporus australiacus*); green and golden bell frog (*Litoria aurea*);

littlejohn's tree frog / heath frog (*Litoria littlejohni*); growling grass frog / southern bell frog / green and golden frog / warty swamp frog (*Litoria raniformis*); and the stuttering frog / southern barred frog (*Mixophyes balbus*).

Overall, approximately 18 percent of the frog species within Australia are listed under the EPBC act as threatened.

3.1.5 Freshwater turtles

Australia is home to 23 species of freshwater turtle. Of these, the Bellinger River snapping turtle (George's snapping turtle or George's helmeted turtle: *Wollumbinia georgesi*) has a distribution that overlaps with that of carp and is listed under the EPBC Act as critically endangered; while the Bell's turtle (western saw-shelled turtle, Namoi River turtle or Bell's saw-shelled turtle: *Wollumbinia belli*) is listed as vulnerable.

3.1.6 Crustaceans

Australia has a wide range of native (macro) crustaceans, including crayfish, lobsters, prawns, shrimps and crabs, a subset of which inhabit freshwater ecosystems that may include carp. Of these, only the endangered Glenelg spiny freshwater crayfish (*Euastacus bispinosus*) is listed under the EPBC Act.

3.2 Assessment of risks to threatened and migratory species

Information about the distribution, diet, breeding/spawning and migration, and habitat, of the species described in this part of the assessment (Sections 3.2.1 to 3.2.6) was adapted from the Australian Government Species Profile and Threats Database and the linked Conservation Advice statements. These resources were accessed through the Department of Environment and Energy's internet site.[10]

3.2.1 Large-bodied native fish

3.2.1.1 Silver perch (critically endangered)

Distribution: although once widespread and abundant throughout most of the Murray-Darling river system, silver perch may now be restricted to a single, sizeable, self-sustaining population in the reach of the mid-Murray River from the Yarrawonga Weir to the Torrumbarry Weir, and then to the Euston Weir and downstream. Recent monitoring indicates this population may now extend down to the South Australian border and up into the lower Darling River. The reasons for the marked decline in the wild population of silver perch are not well understood, although may include the impacts of river regulation on eggs, larvae and adults; loss of juveniles and adult fish within non-viable irrigation channels; thermal pollution with cold-water pulses from weirs; and

[10] See: http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna

widespread degradation of habitat, including de-snagging and siltation of the benthic environment. Invasive fish may compete for resources, predate upon eggs and juveniles and, in the case of carp, contribute actively to the ongoing degradation of habitat.

Using the descriptors given in Table 5, silver perch have a high (effectively 100%) overlap with carp, and within this are micro-endemic (Figure 3). From a purely geographical standpoint, this combination places the silver perch at maximum exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 3 Distribution of silver perch and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of silver perch)

Diet: silver perch are an omnivorous species, with a diet that includes insects, small crustaceans and vegetation.

Spawning and migration: evidence indicates that silver perch reproduction is relatively flexible in terms of flow conditions and temperature. Reproduction can occur in within-channel flows and floods and at relatively cool water temperatures, although a threshold of 23C is generally preferred. Spawning at lower temperatures (including as low as 17C) may be associated with lower larval survival. Spawning occurs in faster-flowing areas of the river, and generally over gravel or rock rubble substrates. Spawning is not flood-dependent but does appear to be dependent on suitable flows and suitable flood events do appear to maximise spawning efforts and presumably recruitment. Silver perch are a strongly migratory fish, and their long-distance (generally upstream) movements offset the subsequent passive downstream drift of eggs, larvae and juveniles.

Habitat: silver perch have a predilection for in-channel lotic waters. This includes a preference for lotic spawning habitats. Silver perch are not generally found on inundated floodplains, and their limited geographical distribution means that they are not often found in impoundments (including lakes and irrigation reservoirs) unless farmed juveniles have been introduced into those settings.

Unmanaged risk: the exposure of silver perch to the water quality effects of an outbreak of CyHV-3 is likely to be lessened by their mobility and strong preference for lotic habitat (including spawning habitat). Silver perch are also slightly more tolerant of low DO than some larger fish (for example, the Murray cod) although this advantage is unlikely to be protective in most settings where significant and wide-reaching hypoxia is occurring. The most plausible scenario for the exposure of silver perch to the water quality effects of an outbreak of CyHV-3 is the accumulation of large numbers of carp carcasses in off-channel habitats of the Barmah-Millewa Forest during a lower-flow season when the floodplains are not inundated. Although an aggressive outbreak of CyHV-3 is not unlikely in this setting, silver perch are more likely to remain in lotic sections of the main channel or in major anabranch habitats. Likewise, juvenile silver perch are not likely to share nursery habitat with large numbers of juvenile carp and are therefore not likely to have a high exposure in the event of prey-switching by nesting waterbirds. Silver perch and other fish are relatively tolerant of type C (or C/D mosaic) botulinum toxin.

These considerations, when viewed in conjunction with the distribution of carp (above), led to the ratings for likelihood and risk shown in Table 6. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 6 Unmanged and managed (residual) risks for silver perch

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Unlikely	Medium	Rare	Minor
	Impact on the quality of water or habitat	Unlikely	Medium	Rare	Minor
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Rare	Minor
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for silver perch are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of silver perch, mitigations will be focussed on the mid-Murray River reach within which the remaining sustainable breeding population of silver perch is localised. With these mitigations available if required, the managed (residual) likelihoods and risks for silver perch are given in Table 6. The only non-negligible (Minor) risks remaining after management follow from the effects of a widespread cyanobacterial bloom. Conversely, silver perch are one of the species most likely to benefit from an improvement in the quality of water and integrity of river substrate that may follow from a reduction in carp abundance.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for the silver perch. The Department of Environment makes this comment (emphasis added): “*Recovery Plan required, only a National Recovery Plan can effectively coordinate attempts to re-establish lost, formerly significant populations through conservation stocking and translocation using broodfish sourced from the middle Murray Region population, which may now have greater resistance to alien pathogens likely involved in the loss of original populations. Re-establishing formerly significant populations is a priority, because currently* ***there is only one strong, viable natural population in the middle Murray Region****, which leaves the species vulnerable to extinction or further severe decline from catastrophic events. Coordination between the states, as facilitated by a National Recovery Plan, will also be important in fostering recovery actions generally. A National Recovery Plan will also more easily facilitate relevant monitoring, research and management of the current middle Murray Region population*”.

3.2.1.2 Trout cod (endangered)

Distribution: trout cod have declined markedly in distribution and abundance since European settlement, and the single naturally-occurring population is restricted to a small (approximately 120 km) lotic stretch of the Murray River from Yarrawonga Weir to the Barmah-Millewa Forest, and occasionally downstream to Gunbower.

Using the descriptors given in Table 5, trout cod have a high (effectively 100%) overlap with carp, and within this are micro-endemic (Figure 4). From a purely geographical standpoint, the combination of high overlap and micro-endemic remnant population places the trout cod at high exposure.

Figure 4 Distribution of trout cod and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of trout cod)

Diet: the diet of trout cod includes aquatic insects and crustaceans such as yabbies, crayfish and shrimps. The species may also leap from the water to take insects just above the surface. Larger trout cod will take Macquarie perch and other native or introduced fish and frogs.

Spawning and migration: trout cod are believed to form pairs and spawn annually during late September to late October, when water temperatures are between 14 and 22C. In contrast to Murray cod, trout cod do not generally migrate to spawning grounds although some individuals may move from the main channel to off-channel branches or to floodplains in the event of a significant flood.

Habitat: trout cod occupy positions close to riverbanks in comparatively deep and rapidly moving water with a high abundance of large woody debris.

Unmanaged risk: although trout cod and Murray cod (below) are physically and physiologically very similar species, three key factors mean that they may be more exposed to the possible effects of an outbreak of CyHV-3: (i) their geographical distribution and population strength are very much more limited than those of Murray cod; (ii) they tend not to undertake spawning migrations and are considered a less mobile species; and (iii) in the event of floods they may occupy floodplain habitats more frequently than Murray cod. These considerations mean that trout cod may be more likely to encounter a water quality event and less likely to evade it by migrating to cleaner or more oxygenated water. The tolerance of trout cod to low DO, cyanobacterial blooms and microorganisms is likely to be similar to that of Murray cod, and amongst the lowest of the native fish species. Juvenile trout cod may be more exposed to prey-switching by piscivorous waterbirds than juvenile Murray cod, given that trout cod may make more use of floodplain environments.

A Major impact on trout cod effectively means a discernible impact on the single self-sustaining population of trout cod between Yarrawonga and the Barmah-Millewa Forest (possibly downstream to Gunbower). Within this reach, trout cod occupy (in decreasing order of preference) the river channel and deeper anabranches, off-channel waters such as Barmah Lake and, in high-flow seasons, the inundated floodplain. An outbreak of CyHV-3 within the Murray River channel or deeper anabranches is unlikely to differ markedly between high-flow and lower-flow seasons, as water will in either event be diverted through these to service irrigation needs. An outbreak in this reach is unlikely to result in impacts on water quality (including low DO, cyanobacterial blooms and the proliferation of waterborne microorganisms). In lower-flow seasons, carp will spawn in, and remain constrained to, the permanently-inundated off-channel waters (including Barmah Lake). An outbreak under these conditions might result in the accumulation of carp carcasses and impacts on water quality and trout cod that have established within these deeper off-channel waters (and juvenile trout cod, later in the season) could potentially be exposed. Exposed trout cod are less likely to move away from poor water than are Murray cod. The Barmah-Millewa Forest floodplain is a focus for the recruitment of carp during high-flow seasons, and some trout cod may also make use of the floodplain during these times. If carp juveniles were removed by an outbreak of CyHV-3, then trout cod juveniles could potentially be targeted by nesting waterbirds.

These considerations, when viewed in conjunction with the distribution of carp (above), led to the ratings for likelihood and risk shown in Table 7. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 7 Unmanged and managed (residual) risks for trout cod

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for trout cod are those stemming from the water quality effects of an outbreak of CyHV-3 and from prey-switching. The mitigations for these risks were outlined in Section 2.4. In the case of trout cod, mitigations will be focussed on the mid-Murray River reach within which the remaining sustainable breeding population of trout cod is localised (including off-channel waters such as Barmah Lake). With these mitigations available if required, the managed (residual) likelihoods and risks for trout cod are given in Table 7. These residual risks reflect the observation that the behaviour and very limited distribution of the trout cod mean that it is arguably the most exposed of the large-bodied native fish to any harmful effects that may follow from an outbreak of CyHV-3. Although there is not a real chance or possibility of harm to the population that remains within the mid-Murray River channel, smaller populations that have established within the off-channel waters of the Barmah-Millewa Forest and similar environments might be exposed to a short-term impact on populations, habitat and area of occupancy, and breeding cycles; or a significant impact arising from the introduction of disease.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan,[11] however, has been in effect since 2008. This includes a detailed strategy for the recovery of the species. The Plan highlights the criticality of the mid-Murray population to the survival of this species.

[11] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-trout-cod-maccullochella-macquariensis

3.2.1.3 Macquarie perch (endangered)

Distribution: Macquarie perch are closely related to golden perch, although a specialised upland species and localised within the upper reaches of the Mitta Mitta, Ovens, Broken, Campaspe and Goulburn Rivers in northern Victoria and the upper reaches of the Lachlan and Murrumbidgee Rivers in southern New South Wales. A larger translocated population exists in the Yarra River and in Lake Eildon in the Goulburn River catchment. It is also found in low numbers in the Mongarlowe River in the Shoalhaven catchment, where the population is considered likely to be the result of a translocation from the Murray-Darling Basin.

Using the descriptors given in Table 5, Macquarie perch have a high (greater than 75%) overlap with carp, although the rivers in which overlap occurs are likely to have a low or very low carp biomass density. Within their overlap with carp, Macquarie perch are distributed sporadically in discrete and localised populations (Figure 5). From a purely geographical standpoint, this combination places Macquarie perch at a comparatively low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 5 Distribution of Macquarie perch and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of Macquarie perch)

Diet: this species is essentially a bottom feeder and only takes a small proportion of its food at the water surface. Diet is composed largely of adult insects and larvae.

Spawning and migration: spawning occurs just above riffles (shallow running water), where rivers have a base of rubble (small boulders, pebbles and gravel). The eggs, which are adhesive, stick to the gravel, and newly-hatched yolk sac larvae shelter amongst pebbles. Some fish use the same river each year for spawning. Migrations are undertaken by fish resident in lakes, but not otherwise.

Habitat: Macquarie perch is a riverine, schooling species that prefers clear, deep water and rocky holes. Refuge is also important, and may include aquatic vegetation, large boulders, debris and overhanging banks.

Unmanaged risk: because the geographical distribution of the Macquarie perch is restricted to lotic upland rivers where the biomass density of carp is low or very low, there is little likelihood of exposure to the water quality effects of CyHV-3. The exception to this may be waterholes in poorly connected reaches of upland rivers during low-flow seasons, where a cyanobacterial bloom is possible. There is little likelihood of exposure to prey-switching, given that large waterbird breeding events are not associated with upland rivers. Macquarie perch and other fish are relatively tolerant of type C (or C/D mosaic) botulinum toxin. On balance, Macquarie perch are likely to be one of the least-exposed of the large-bodied native fish to the possible effects of an outbreak of CyHV-3.

These considerations, when viewed in conjunction with the distribution of carp (above), led to the ratings for likelihood and risk shown in Table 8. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 8 Unmanged and managed (residual) risks for Macquarie perch

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for Macquarie perch are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of Macquarie perch, mitigations will be focussed on the upland rivers of the Murray-Darling Basin. Although the collection of carcasses from these areas will be possible in some locations, the monitoring of upland streams and rivers in forested land may be compromised by difficulties with site access. That notwithstanding, there is not a real chance or possibility that, after mitigation where possible, outbreaks of CyHV-3 would result in a Major impact on Macquarie perch (Table 8).

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan,[12] however, was published in 2019. This includes a detailed strategy for the recovery of the species.

3.2.1.4 Murray cod (vulnerable)

Distribution: although breeding populations of Murray cod can be found throughout the Murray-Darling Basin (except for the upper reaches of some tributaries) there has been substantial decline in their population strength since European settlement. Important populations of Murray cod are listed in the species' National Recovery Plan.[13]

Using the descriptors given in Table 5, Murray cod have a high (effectively 100%) overlap with carp, and within this are diffusely distributed (Figure 6). From a purely geographical standpoint, this combination places Murray cod at a comparatively moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 6 Distribution of Murray cod and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of Murray cod)

Diet: adult Murray cod are the apex predator in Australian waterways and typically feed on (in decreasing order) crustaceans (including crayfish, yabbies and shrimp), native and invasive fish and, occasionally, smaller waterbirds and terrestrial animals.

Spawning and migration: Murray cod migrate upstream prior to spawning in late spring or early summer when the water attains a temperature of between 16 and 21C. Larvae then drift downstream before settling out in suitable protected habitat within main channels.

Habitat: Murray cod are long-lived and utilise a diverse range of habitats. These range from clear rocky streams, such as those found in the upper western slopes of New South Wales and the Australian Capital Territory, to slower-flowing and turbid lowland rivers and billabongs, such as those of the lower Darling River. Murray cod are considered a main-channel specialist, with only

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[12] See: http://www.environment.gov.au/biodiversity/threatened/publications/recovery/macquaria-australasica-2018

[13] See: http://www.environment.gov.au/resource/national-recovery-plan-murray-cod-maccullochella-peelii-peelii

limited use of minor anabranches, creeks and inundated floodplain habitats. Murray cod also occupy many permanent and semi-permanent impoundments, including lakes and irrigation reservoirs. Their localisation within these settings is often a result of barriers (regulatory structures) and their populations may be augmented through the release of farmed juveniles. Adult Murray cod are solitary and highly-territorial and will return to their territory following spawning.

Unmanaged risk: the Murray cod's preference for deeper lotic habitats means that its exposure to the water quality effects of the accumulation of carp carcasses (including low DO, cyanobacterial blooms and waterborne microorganisms) is likely to be lower than some other large and small-bodied native fish. If exposure were to occur, however, Murray cod are amongst the least tolerant of native fish to low DO – in particular, in warmer waters. This includes low DO associated with the decomposition of carp carcasses as well as the precipitous fall in DO that follows from the die-off of a cyanobacterial bloom. Murray cod are not generally present in significant numbers on inundated floodplains where waterbirds gather to feed on juvenile carp, and for this reason will have relatively low exposure to the effects of prey-switching following the widespread death of juvenile carp. All species of fish are relatively resistant to the effects of type C (or C/D mosaic) botulinum toxin, although as the apex predator in most freshwater settings Murray cod may be relatively more likely to consume large amounts of toxin.

A Major impact on Murray cod will typically result from a devastating impact at one or more locations, with a substantial proportion of at least one catchment or bioregion affected. Although a wide range of scenarios are possible, a Major impact on Murray cod is most likely to follow from outbreaks in one or more of the following settings:

- Permanent lakes and impoundments, where rainfall and flow are less important than the density of the carp population (for example, Kow Swamp)
- Disconnected waterholes within ephemeral river systems during a typically-dry spring or during drought years (for example, the Moonie River Catchment or the lower Darling River)
- Ephemeral wetland / floodplain environments during lower-flow seasons (for example, Barmah-Millewa Forest or the Chowilla Floodplain).

These considerations, when viewed in conjunction with the distribution of carp (above), led to the ratings for likelihood and risk shown in Table 9. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 9 Unmanged and managed (residual) risks for Murray cod

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Unlikely	Medium	Rare	Minor
	Impact on the quality of water or habitat	Unlikely	Medium	Rare	Minor
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Rare	Minor
	Impact on species connectivity and migration	Unlikely	Medium	Rare	Minor
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Unlikely	Medium	Rare	Minor
	Impact on the quality of water or habitat	Unlikely	Medium	Rare	Minor
	Impact on food and other resources	Rare	Minor	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Impact on breeding cycle	Unlikely	Medium	Rare	Minor
	Impact on species connectivity and migration	Unlikely	Medium	Rare	Minor
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for Murray Cod are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of Murray cod, mitigations should focus on the important populations outlined in the species' National recovery Plan (below). With these mitigations available if required, the managed (residual) likelihoods and risks for Murray cod are given in Table 9. The only non-negligible (Minor) risks remaining after management follow from exposure to low DO or cyanobacterial blooms.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan,[14] however, has been in effect since 2010. This includes a detailed strategy for the recovery of the species. The Plan also identifies *important populations* that should be given priority protection and highlights populations subject to serious threatening processes that require attention.

3.2.1.5 Australian grayling (vulnerable)

Distribution: the Australian grayling occurs in streams and rivers on the eastern and southern flanks of the Great Dividing Range, from Sydney southwards to the Otway Ranges of Victoria and in Tasmania. It is believed to be absent from the inland Murray-Darling system.

Using the descriptors given in Table 5, Australian grayling have a low (less than 25%) overlap with carp, and within this are distributed sporadically (Figure 7). Importantly, populations of Australian grayling that do overlap with carp are likely to incur low to very low carp biomass densities. From a purely geographical standpoint, this combination places the Australian grayling at very low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

[14] See: http://www.environment.gov.au/resource/national-recovery-plan-murray-cod-maccullochella-peelii-peelii

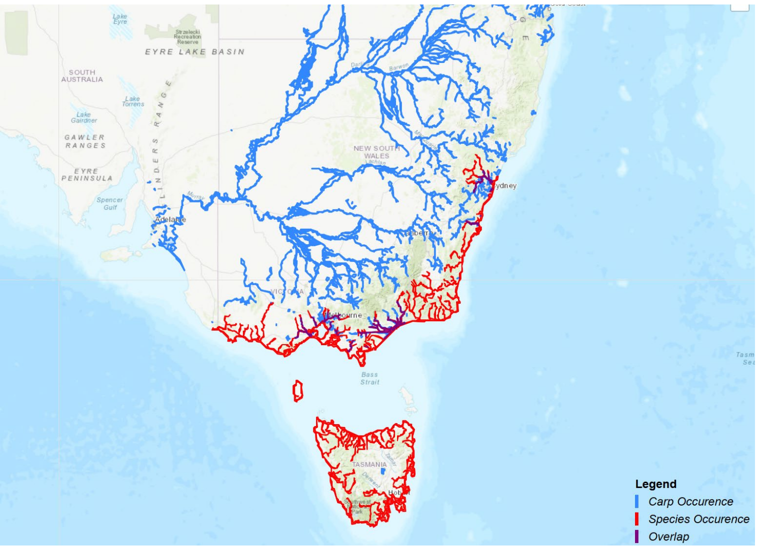

Figure 7 Distribution of the Australian grayling and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Australian grayling)

Diet: Australian Grayling are omnivorous, feeding on a variety of small aquatic organisms, including crustaceans (such as cladocerans), insects and their larvae and algae. Non-aquatic insects have also been taken from the water surface by this species.

Spawning and migration: the Australian grayling is considered to be diadromous, spending part of its lifecycle in freshwater and at least part of the larval or juvenile stages in coastal seas. Spawning occurs in freshwater from late summer to early winter, with precise timing dependant primarily on water temperature and flow. Initiation of spawning appears to be caused by an increase in river flows from seasonal rains, coupled with a decrease in water temperatures to 12 to 13C. Eggs are scattered over the substrate and newly hatched larvae drift downstream and out to sea, where they remain for approximately six months. Juveniles then return to the freshwater environment around November of their first year, where they remain for the remainder of their lives. Most Australian Grayling die after their second year, soon after spawning, however a small proportion reach five years of age. The species undergoes large, annual fluctuations in population numbers, depending on prevailing conditions. The species' high fecundity means that it is capable of explosive population increases when conditions are favourable.

Habitat: adults (including pre-spawning and spawning adults) inhabit cool, clear, freshwater streams with gravel substrate and areas alternating between pools and riffle zones. Australian grayling have been found over 100 km upstream from the sea.

Unmanaged risk: waterways occupied by mature Australian grayling are lotic and, where carp exist, they are at a low or very low biomass density. The young of Australian grayling are further protected through their location in the marine (c.f. freshwater) environment. Australian grayling also has an ability to rejuvenate a population rapidly upon removal of a stress. Collectively, there is not a real chance or possibility that an outbreak of CyHV-3 would result in a long-term impact on population strength of the Australian grayling. This is shown in the ratings in Table 10. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 10 Unmanged and managed (residual) risks for the Australian grayling

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the distribution and diadromous nature of the Australian grayling mean that there is not a real chance or possibility of exposure to any of the impact areas outlined in Table 10.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan,[15] however, was published in 2008. This includes a detailed strategy for the recovery of the species.

3.2.2 Small-bodied native fish

3.2.2.1 Flathead galaxias (critically endangered)

Distribution: the flathead galaxias is now presumed locally extinct from the Lachlan, Murrumbidgee and lower Murray River catchments in New South Wales and the lower Murray River in South Australia. The species may be present still in billabongs, dams, lagoons and other waterways in the upper Murray River catchment, but only a small number of individuals have been

[15] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-australian-grayling-prototroctes-maraena

collected from this area over the past 15 years. There may also be populations of the species existing in billabongs and lagoons in the Murray-Darling Basin in Victoria, including (from east to west) the Mitta Mitta, the Kiewa, the Ovens, the Loddon and the Goulburn river catchments, and the Corop Lakes system, but surveys have only detected the species in these areas inconsistently and rarely.

Using the descriptors given in Table 5, the flathead galaxias has a high (effectively 100%) overlap with carp, and within this area is micro-endemic (Figure 8). From a purely geographical standpoint, this combination places the flathead galaxias at maximal exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 8 Distribution of the flathead galaxias and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the flathead galaxias)

Diet: the flathead galaxias feeds predominately on aquatic insects and microcrustaceans.

Spawning and migration: the flathead galaxias spawns in spring, in August and September, when water temperatures rise above 10.5C. Eggs are demersal, round and slightly adhesive. Eggs are spawned randomly and can be at multiple sites to reduce risk of all being lost by impact at one location and settle on the bottom of the water habitat where adults are inhabiting. Although there are indications that the flathead galaxias has a preference for moving upstream in November and December, little is currently known about their movements.

Habitat: the flathead galaxias inhabits a variety of habitats including billabongs, lakes, swamps and rivers, with a preference for still or slow-flowing waters. The species has a preference for schooling in midwater.

Unmanaged risk: the small-bodied native fish (including both the wetland and floodplain specialists, and the foraging generalists) are relatively more tolerant of low DO than are most of the large-bodied fish, and may survive for some time while the DO concentration remains above about 1 mg/L. Relative tolerance to low DO may mean that the small-bodied native fish as a functional group are likely to be less affected by the fall in DO that may accompany an outbreak of CyHV-3 in some settings. Small-bodied native fish will not, however, be more tolerant of cyanotoxins. The highest risk scenario for most small-bodied species will be an aggressive outbreak of CyHV-3 in a contracted waterway, in a lower-flow setting. Both adults and juvenile small-bodied native fish may also be exposed to the effects of prey-switching following the removal of a high proportion of juvenile carp. Exposure to prey-switching is most likely to occur in a high-flow season when ephemeral wetlands and floodplains are inundated, and large numbers of nesting waterbirds are also likely to be present. Some threatened species of small-bodied fish are reliant on a limited number of local populations, meaning that impacts on local populations – whether the result of poor water quality or prey-switching – may have broader impacts on species sustainability.

These considerations, when viewed in conjunction with the distribution of the flathead galaxias carp (above), led to the ratings for likelihood and risk shown in Table 11. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 11 Unmanged and managed (residual) risks for the flathead galaxias

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for flathead galaxias are those stemming from the water quality effects of an outbreak of CyHV-3 and from exposure to prey-switching. The mitigations for these risks were outlined in Section 2.4. Although micro-endemic and critically endangered, flathead galaxias are distributed over a relatively large area within the Murray-Darling Basin and risk mitigation measures would need to be effective across this area. With these mitigations available if required, the managed (residual) likelihoods and risks for the flathead galaxias are given in Table 11. The only non-negligible (Medium) risks remaining after management follow from the exposure of Murray hardyhead to low DO or a widespread cyanobacterial bloom.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for this species. The Department of Environment and Energy notes that, "*Recovery Plan not required, many of the threats to the flathead galaxias are threats to other EPBC Act-listed threatened fish species that occur within the Murray-Darling Basin*".

3.2.2.2 Murray hardyhead (endangered)

Distribution: the Murray hardyhead was endemic to the lowland reaches of the Murray and Murrumbidgee rivers and their tributaries, floodplain billabongs and lakes. The species formerly was abundant from Lake Alexandrina, near the mouth of the Murray River, to as far upstream as Yarrawonga on the Murray and Narrandera on the Murrumbidgee River. The Murray hardyhead has undergone a severe reduction in range and abundance. The species is extinct in the Murrumbidgee system, and is now found in the middle and lower reaches of the Murray River, in a small number of saline basin lakes in Victoria and South Australia, and in the Lower Lakes (Alexandrina and Albert). Amongst this extant population, four (micro-endemic) management units have been identified through genetic data.

Using the descriptors given in Table 5, the Murray hardyhead has a high (effectively 100%) overlap with carp, and within this are sporadically distributed (Figure 9). From a purely geographical standpoint, this combination places the Murray hardyhead at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 9 Distribution of the Murray hardyhead and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Murray hardyhead)

Diet: the Murray hardyhead's diet consists predominantly of microcrustaceans, with larger individuals also eating larger food items such as dipteran larvae and some aquatic insects and algae.

Spawning and migration: the species is a batch spawner with a breeding season from September to March and peak spawning activity in spring. Individuals spawned early in a breeding season can reach maturity and breed in the same season. Eggs with adhesive filaments are laid amongst aquatic vegetation (particularly, eel grass). The abundance of adults declines at the end of the breeding season, with replacement by the maturing young-of-the-year cohort. The sustainability of the species is therefore heavily dependent on yearly recruitment.

Habitat: although Murray hardyhead are found around the margins of lakes, wetlands, backwaters and billabongs, they prefer open water, shallow, slow flowing or still habitats, with sand or silt substrates. They can also be found in deeper habitats with dense aquatic vegetation. The Murray Hardyhead is mostly recorded in saline waters that may be moderately acidic to highly alkaline, have relatively low turbidity, wide ranging temperatures (8-34 C) and variable DO (3.5-25.0 mg/L), although their presence in these harsh environments may reflect marginal refugia rather than preferred habitat.

Unmanaged risk: see flathead galaxias (above) for a description of the risk factors for small-bodied native fish. These risk factors, when viewed in conjunction with the distribution of Murray hardyhead and carp (above), led to the ratings for likelihood and risk shown in Table 12. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 12 Unmanged and managed (residual) risks for the Murray hardyhead

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for Murray hardyhead are those stemming from the water quality effects of an outbreak of CyHV-3 and from prey-switching. The mitigations for these risks were outlined in Section 2.4. In the case of Murray hardyhead, mitigations will be focussed on the four remnant populations in the middle and lower reaches of the Murray River, in a small number of saline basin lakes in Victoria and South Australia, and in the Lower Lakes. With these mitigations available if required, the managed (residual) likelihoods and risks for the Murray hardyhead are given in Table 12. The only non-negligible (Medium) risks remaining after management follow from the exposure of Murray hardyhead to low DO or a widespread cyanobacterial bloom.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan[16] was published in 2008.

3.2.2.3 Barred galaxias (endangered)

Distribution: the barred galaxias is endemic to the Goulburn River system in central Victoria. It is now restricted to a small upland area extending along the south-eastern portion from the Delatite River system in the north-east, southward to the upper reaches of the Goulburn River near Woods Point, and then westward to a hybrid population in the Sunday Creek system near Mt Disappointment, just north of Melbourne. Most of the twelve extant subpopulations are effectively geographically isolated from each other by the presence of trout and it is unlikely that any gene flow exists between these subpopulations.

Using the descriptors given in Table 5, the barred galaxias has a low (likely less than 25%) overlap with carp, and within this area is micro-endemic (Figure 10). From a purely geographical standpoint, this combination places the barred galaxias at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 10 Distribution of the barred galaxias and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the barred galaxias)

Diet: the barred galaxias feeds in the upstream end of pools, where the incoming water from the riffle or cascade zone may bring drifting prey items. It feeds on both drifting and benthic invertebrates. Nocturnal feeding has been noted. No work has been conducted on diet though terrestrial insects may be an important component.

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[16] See: http://www.environment.gov.au/biodiversity/threatened/publications/national-recovery-plan-murray-hardyhead-craterocephalus-fluviatilis-2008

Spawning and migration: spawning occurs in streams that are fresh, slightly acidic (5.7 to 7.1 pH), moderate-to-fast flowing, shallow, well oxygenated, clear and cool waters (8.4 to 10C), and generally upstream of pools. They are often the only freshwater native fish in the systems it occupies and usually found with Central Highlands spiny crayfish. Spawning occurs from mid-August to late September. Fecundity is low (mean approximately 80 eggs). The eggs are adhesive, about 2.2 mm diameter and laid on the side or underneath large rocks in fast-flowing, shallow water. Hatching occurs after about a month, and newly-hatched larvae are about 8-12 mm in length. Growth rates are slow, and adults live to about 15 years of age. The barred galaxias is non-migratory and has little ability to recolonise areas after local extinctions or population stresses.

Habitat: the barred galaxias is a cold-adapted fish, usually found in very heavily shaded streams that rarely exceed 15C during summer and usually reach 1 to 3C during winter. They prefer small-to-medium-sized (0.7 to 11 m wide), moderately to fast flowing, steep gradient, shallow (0.1 to 0.4 m deep) streams that include some pools (to 3 m). The usual sequence of instream habitat consists of pools interconnected by rapids, small and large cascades, and some small waterfalls. In larger streams the steep gradient sections containing cascades, pools and waterfalls are interspersed with relatively long, low gradient sections containing pools and runs. Stream substrate consists of bedrock, boulder, cobble, with smaller amounts of pebble, gravel and sand, and streams are usually well shaded by dense overhanging riparian vegetation.

Unmanaged risk: see flathead galaxias (above) for a description of the risk factors for small-bodied native fish. Superseding these generic risk factors, however, is the barred galaxias preference for cold, shallow and fast-moving streams. Even where carp co-exist in these streams, their biomass density will be extremely low, and this combined with the rapid passage of water is likely to negate any possibility of water quality effects resulting from an outbreak of CyHV-3. Streams with these characteristics do not support breeding waterbirds, and there is no possibility of exposure to prey-switching in the event of an outbreak of CyHV-3. Botulism does not occur in these settings. Collectively, these considerations mean that there is not a real chance or possibility that barred galaxias will be exposed to any of the impact areas outlined in Table 13. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 13 Unmanged and managed (residual) risks for the barred galaxias

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: there is not a real chance or possibility that barred galaxias will be exposed to any of the impact areas outlined in Table 13.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan[17] was published in 2010.

3.2.2.4 Oxleyan pygmy perch (endangered)

Distribution: the Oxleyan pygmy perch is confined primarily to dystrophic, acidic, freshwater systems draining through sandy coastal lowlands and 'wallum' heaths (Banksia dominated heathlands) between north-eastern New South Wales and south-eastern Queensland (including Fraser, Stradbroke and Moreton islands). They have been recorded from Coongul Creek on Fraser Island, Queensland, south to Tick Gate Swamp near the township of Wooli in New South Wales.

Using the descriptors given in Table 5, the Oxleyan pygmy perch has a low (less than 25%) overlap with carp, and within this is sporadically distributed (Figure 11). From a purely geographical standpoint, this combination places the Oxleyan pygmy perch at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

[17] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-barred-galaxias-galaxias-fuscus

Figure 11 Distribution of the Oxleyan pygmy perch and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Oxleyan pygmy perch)

Diet: Oxleyan pygmy perch are mainly carnivorous, feeding on small crustaceans, aquatic insects, diatoms and filamentous algae.

Spawning and migration: Oxleyan pygmy perch have an extended breeding season from early spring through to late autumn, although spawning is concentrated from October to December, when water temperatures exceed 20C. A few eggs are laid every second day throughout the course of the breeding season and are scattered over the bottom substrate or aquatic vegetation. At 25C the eggs of aquarium-reared fish hatch in approximately two days and begin feeding five days after hatching.

Habitat: Oxleyan pygmy perch are generally found only in slow-flowing pools and backwaters of river channels and tributaries as well as in swampy drainages, lakes, ponds and dams. Wallum heath communities have a well-distributed annual rainfall and freshwater lakes, creeks and wetlands feature prominently throughout the region. Waterbodies in the wallum heath are characterised by very low salinity, low magnesium; calcium hardness and acid conditions (pH 3 to 7). Habitats range from low conductivity, clear waters with a pH of 6 to 6.5, to darkly stained dystrophic waters of pH 4 to 6, over siliceous sands, aquatic vegetation or plant debris. The generally high organic acid content of these water bodies is derived from leachates from swamps and riparian vegetation, particularly Melaleucas.

Unmanaged risk: see flathead galaxias (above) for a description of the risk factors for small-bodied native fish. Superseding these generic risk factors, however, is the Oxleyan pygmy perch's restriction to the warm coastal streams of wallum heathlands in northern New South Wales and southern Queensland. Even where carp co-exist in these streams, their biomass density will be extremely low and this combined with the rapid passage of water is likely to negate any possibility of water quality effects resulting from an outbreak of CyHV-3. Streams in these habitats do not support breeding waterbirds, and there is no possibility of exposure to prey-switching in the event of an outbreak of CyHV-3. Botulism does not occur in these settings. Collectively, these considerations mean that there is not a real chance or possibility that the Oxleyan pygmy perch will be exposed to any of the impact areas outlined in Table 14. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 14 Unmanged and managed (residual) risks for the Oxleyan pygmy perch

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Impact on species connectivity and migration	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: there is not a real chance or possibility that Oxleyan pygmy perch will be exposed to any of the impact areas outlined in Table 14.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan[18] was published in 2006.

3.2.2.5 Eastern dwarf galaxias (vulnerable)

Distribution: the eastern dwarf galaxias occurs from the Mitchell River Basin in central Gippsland, Victoria, to the Cortina Lakes, near the Coorong in South Australia. The species also occurs in Tasmania, where it is restricted to lowland areas in the far north-west and far north-east of the State, as well as on Flinders Island. Distribution of populations is generally disjunct and patchy, due to the nature of its lowland, shallow, swampy habitat.

Using the descriptors given in Table 5, the eastern dwarf galaxias has a low (likely less than 25%) overlap with carp, and within this are sporadically distributed (Figure 12). From a purely

[18] See: http://www.environment.gov.au/resource/oxleyan-pygmy-perch-nannoperca-oxleyana-recovery-plan

geographical standpoint, this combination places the eastern dwarf galaxias at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 12 Distribution of the eastern dwarf galaxias and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the eastern dwarf galaxias)

Diet: the eastern dwarf galaxias is a generalist carnivore and feeds mostly in the water column on a variety of aquatic invertebrates including insect larvae, small crustaceans, water fleas, seed shrimp and terrestrial insects that fall into the water.

Spawning and migration: the eastern dwarf galaxias is the only galaxiid known to exhibit sexual dimorphism. The species spawns in late winter to spring, however newly hatched juveniles have been detected as early as April and as late as December. Females lay between 65 and 250 adhesive eggs, one at a time, over a period of 7 to 14 days. The eggs are attached usually on the underside of aquatic vegetation or on a hard surface such as a rock or timber.

Habitat: the eastern dwarf galaxias occurs in slow-flowing and still, shallow, permanent and temporary freshwater habitats such as swamps, drains and the backwaters of streams and creeks, often (but not always) containing dense aquatic macrophytes and emergent plants. In larger pools, it is usually found amongst marginal vegetation. Some wetlands where it occurs may partially or completely dry up during summer and such wetlands rely on seasonal flooding plus linkages to other sites where the species occurs, for recolonisation.

Unmanaged risk: see flathead galaxias (above) for a description of the risk factors for small-bodied native fish. These risk factors, when viewed in conjunction with the distribution of eastern dwarf galaxias and carp (above), led to the ratings for likelihood and risk shown in Table 15. These ratings reflected a tension between: (a) the relatively low overlap between carp and eastern dwarf galaxias, and the low likelihood that the species would be found in places where carp biomass was high; and (b) the propensity of the eastern dwarf galaxias for lentic, shallow habitat that is at a relatively high risk of water quality effects in the event of an outbreak of CyHV-3. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 15 Unmanged and managed (residual) risks for the eastern dwarf galaxias

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the eastern dwarf galaxias are those stemming from the water quality effects of an outbreak of CyHV-3 and from prey-switching. The mitigations for these risks were outlined in Section 2.4. In the case of silver perch, mitigations will be focussed on waterways from the Mitchell River Basin in central Gippsland, Victoria, to the Cortina Lakes, near the Coorong in South Australia. With these mitigations available if required, the managed (residual) likelihoods and risks for the eastern dwarf galaxias are given in Table 15. The only non-negligible (Medium) risks remaining after management follow from the exposure of eastern dwarf galaxias to low DO or a widespread cyanobacterial bloom.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species.

A National Recovery Plan[19] was published in 2010.

3.2.2.6 Variegated pygmy perch (vulnerable)

Distribution: the variegated pygmy perch has been found in approximately 20 locations in South Australia and western Victoria, including: Ewen's Pond (an isolated sink hole), Piccaninnie Ponds

[19] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-dwarf-galaxias-galaxiella-pusilla

and the Eight Mile Creek drainage system near Mt Gambier in south-east South Australia; the Deep Creek system in eastern South Australia; and several creeks in the Glenelg River system in south-west Victoria.

Using the descriptors given in Table 5, the variegated pygmy perch has a moderate (likely 25 to 50%) overlap with carp, and within this is sporadically distributed (Figure 13). From a purely geographical standpoint, this combination places the variegated pygmy perch at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 13 Distribution of the variegated pygmy perch and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the variegated pygmy perch)

Diet: the variegated pygmy perch's diet consists predominantly of insects, insect larvae and microcrustaceans.

Spawning and migration: the species spawns between mid-July and mid-November. Eggs are deposited demersally (near the bottom of the water), to adhere to aquatic plants, and receive no parental guarding.

Habitat: the variegated pygmy perch inhabits relatively shallow freshwater streams with moderate-to-high waterflow and high levels of aquatic vegetation. Although it is strongly associated with high cover of submerged and emergent aquatic vegetation and occasional woody habitat, it prefers clear water. It can be found in fresh and slightly brackish waters, mostly over substrates of gravel, cobble or boulders in the absence of silt.

Unmanaged risk: see flathead galaxias (above) for a description of the risk factors for small-bodied native fish. These risk factors, when viewed in conjunction with the distribution of variegated pygmy perch and carp (above), led to the ratings for likelihood and risk shown in Table 16. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 16 Unmanged and managed (residual) risks for the variegated pygmy perch

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the variegated pygmy perch are those stemming from the water quality effects of an outbreak of CyHV-3 and fromprey-switching. The mitigations for these risks were outlined in Section 2.4. In the case of pygmy perch, mitigations will be focussed on the 20 locations in South Australia and western Victoria in which it can be found. With these mitigations available if required, the managed (residual) likelihoods and risks for the variegated pygmy perch are given in Table 16. The only non-negligible (Medium) risks remaining after management follow from the exposure of variegated pygmy perch to low DO or a widespread cyanobacterial bloom.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan[20] was published in 2010.

3.2.2.7 Yarra pygmy perch (vulnerable)

Distribution: the Yarra pygmy perch was almost certainly once more widespread but has declined in both distribution and abundance since European settlement of Australia. The fragmented and patchy nature of its remaining habitat across the landscape, and variability of this habitat between seasons and years, makes the species extremely vulnerable to local extinctions. The species was rescued from Lake Alexandrina and Lake Bonney, and a program for release back into these areas has begun. The Yarra pygmy perch is known to remain in approximately 42 locations between the

[20] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-variegated-pygmy-perch-nannoperca-variegata

Bunyip River basin in West Gippsland westward through southern Victoria and in south-eastern South Australia, as far west as Lake Alexandrina and the Finniss River, near the mouth of the Murray River.

Using the descriptors given in Table 5, the Yarra pygmy perch has a moderate (likely 25 to 50%) overlap with carp, and within this is sporadically distributed (Figure 14). From a purely geographical standpoint, this combination places the Yarra pygmy perch at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

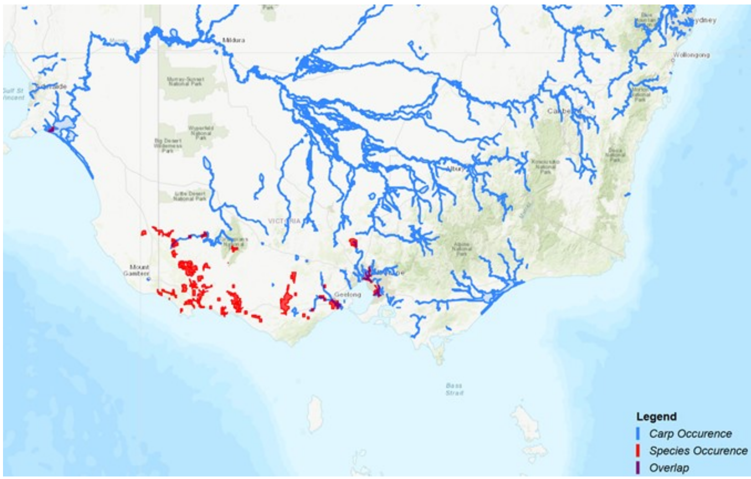

Figure 14 Distribution of the Yarra pygmy perch and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Yarra pygmy perch)

Diet: the Yarra pygmy perch's diet consists predominantly of insects, insect larvae and planktonic crustaceans.

Spawning and migration: the species is short lived (1 to 5 years) and probably has poor dispersal ability, as suggested by the strong genetic structure. It spawns during spring (September to October) at water temperatures of 16 to 24C. Very little is known of the breeding biology of this species, although it is assumed that breeding behaviour is similar to the closely related southern pygmy perch (*Nannoperca australis*) which lays demersal, non-adhesive eggs over aquatic vegetation and the substrate.

Habitat: the Yarra pygmy perch typically occurs in lakes, ponds and slow-flowing rivers, although prefers small-medium sized, relatively shallow (1 to 2 metre) freshwater streams with moderate to high flow. It is a demersal species that completes its life cycle in freshwater. It is usually associated with large amounts of aquatic vegetation (particularly emergent vegetation) and log snags in clear, fresh to slightly brackish water.

Unmanaged risk: see flathead galaxias (above) for a description of the risk factors for small-bodied native fish. These risk factors, when viewed in conjunction with the distribution of Yarra pygmy perch and carp (above), led to the ratings for likelihood and risk shown in Table 17. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 17 Unmanged and managed (residual) risks for the Yarra pygmy perch

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Low dissolved oxygen	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
	Impact on species connectivity and migration	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the Yarra pygmy perch are those stemming from the water quality effects of an outbreak of CyHV-3 and from prey-switching. The mitigations for these risks were outlined in Section 2.4. In the case of Yarra pygmy perch, mitigations will be focussed on the approximately 42 locations between the Bunyip River basin in West Gippsland westward through southern Victoria and in south-eastern South Australia, as far west as Lake Alexandrina and the Finniss River, near the mouth of the Murray River. With these mitigations available if required, the managed (residual) likelihoods and risks for the Yarra pygmy perch are given in Table 17. The only non-negligible (Medium) risks remaining after management follow from the exposure of Yarra pygmy perch to low DO or a widespread cyanobacterial bloom.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan for this species. A National Recovery Plan[21] was published in 2010.

[21] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-yarry-pygmy-perch-nannoperca-obscura

3.2.3 Waterbirds

3.2.3.1 Seabirds

The seabirds (also termed 'piscivores') encompass the pelicans, cormorants and darters. Gulls and terns are sometimes included in this group, although most species are more correctly classed as shorebirds (below). Many seabirds are migratory or nomadic, and most are colonial nesters. None of the seabirds whose distribution overlaps with that of carp are listed under the EPBC Act as threatened or listed under international agreements for the protection of migratory species to which Australia is a party.

3.2.3.2 Shorebirds

With a small number of exceptions, the shorebirds are principally migrant non-breeding visitors to Australia and are principally found in coastal habitats. Most of the inland sightings are likely to be birds in transit from one part of the coast to another. Shorebirds that fit this generalisation have a low overlap with carp in Australia, and low (effectively very low) exposure to risks associated with an outbreak of CyHV-3. The Coorong (and to a lesser extent, the Lower Lakes) is one site where the carp biomass density can be substantive and where many shorebird species can be found.

In view of this, a screening process was undertaken to identify shorebird species that regularly occur in parts of inland Australia where carp also exist in a moderate or high biomass density – principally, the Murray-Darling Basin. The outcomes of this process are illustrated in Table 25.

Two threatened species (the curlew sandpiper and the Australian painted snipe) and five species that are migratory only (the sharp-tailed sandpiper, red-necked stint, Latham's snipe, common greenshank and the marsh sandpiper) were identified as having a moderate exposure to carp. These species are examined individually below.

3.2.3.3 Curlew sandpiper (critically endangered and migratory)

Distribution: in Australia, curlew sandpipers occur around the coasts and are also quite widespread inland, though in smaller numbers. Records occur in all states during the non-breeding period, and also during the breeding season when many non-breeding one-year-old birds remain in Australia rather than migrating north.

Using the descriptors given in Table 5, curlew sandpipers have a low to moderate overlap with carp (possibly more than 25%, although this is a very conservative estimate), and within this are distributed sporadically (Figure 15). From a purely geographical standpoint, this combination places the curlew sandpiper at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

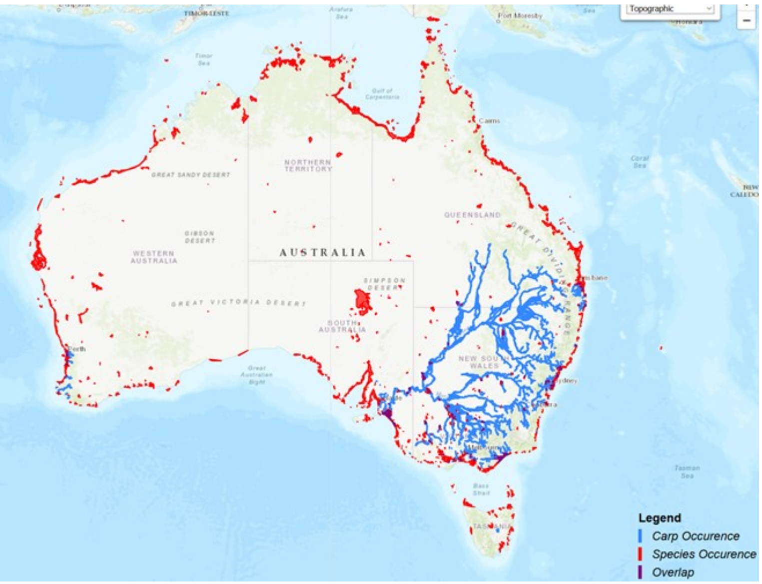

Figure 15 Distribution of the curlew sandpiper and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the curlew sandpiper)

Diet: curlew sandpipers forage mainly on invertebrates, including worms, molluscs, crustaceans, and insects, as well as seeds.

Roosting: curlew sandpipers generally roost on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands, occasionally roosting in dunes during very high tides and sometimes in saltmarsh.

Habitat: curlew sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They are also recorded inland, though less often, including around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand. They occur in both fresh and brackish waters. Occasionally they are recorded around floodwaters.

Unmanaged risk: although adult and nesting shorebirds (including curlew sandpipers) are closely associated with water, they are likely to be less exposed (at a population level) than seabirds to the harmful effects of either a widespread cyanobacterial bloom or proliferating waterborne microorganisms as they are not strictly colonial nesters. This will mean that stresses are more likely to be exerted on individuals, or certain groups of individuals, than on a local population as a whole, and individuals may be more able or likely to take action to avoid such stressors – including seeking alternative nesting sites. Shorebirds are likely also to be found in nesting groups and, in some settings (in particular, disconnected waterholes within dry river systems) where the likelihood that an outbreak of CyHV-3 will result in an impact on water quality is relatively higher. Shorebirds have a broad diet that may include occasional small fish and this (in conjunction with the fact that they are not colonial nesters) means that they are unlikely to be exposed in the event of the sudden removal of juvenile carp. The diet and feeding behaviour of shorebirds, however, may place them at a relatively higher risk in the event of an outbreak of type C (or C/D mosaic) botulism that has been initiated or maintained through the carcass-maggot cycle. This would apply across all species of shorebird and may be of particular concern in settings such as the Macquarie

Marshes and the Lower Lakes and Coorong where large numbers of waterbirds (including shorebirds) are likely to support the initiation and maintenance of the carcass-maggot cycle.

These considerations, when viewed in conjunction with the distribution of carp (above), led to the ratings for likelihood and risk shown in Table 18. This included ratings for both threatened and migratory species. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 18 Unmanged and managed (residual) risks for the curlew sandpiper

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Unlikely	Medium	Rare	Minor
	Impact on the quality of water or habitat	Unlikely	Medium	Rare	Minor
	Impact on food and other resources	Unlikely	Medium	Rare	Minor
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Unlikely	Medium	Rare	Minor
	Impact on the quality of water or habitat	Unlikely	Medium	Rare	Minor
	Impact on food and other resources	Unlikely	Medium	Rare	Minor
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the curlew sandpiper are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the curlew sandpiper, mitigations may need to be reasonably widespread across the distribution of carp – that is to say, while sporadic, the curlew sandpiper can inhabit much of the distribution of carp in Australia (Figure 15). With these mitigations available if required, the managed (residual) likelihoods and risks for curlew sandpiper are given in Table 18. The non-negligible (Medium and Minor) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms, respectively.

Recovery Plans and Threat Abatement Plans: There is no Threat Abatement Plan or Recovery Plan for this species. The Department of Environment and Energy notes that, "*Recovery Plan not required, for Calidris ferruginea as the approved conservation advice for the species provides sufficient direction to implement priority actions and mitigate against key threats*".

3.2.3.4 Australian painted snipe (endangered)

Distribution: the Australian painted snipe has been recorded at wetlands in all states of Australia. It is most common in eastern Australia, where it has been recorded at scattered locations throughout much of Queensland, New South Wales, Victoria and south-eastern South Australia. It has been recorded less frequently at a smaller number of more scattered locations farther west in South Australia, the Northern Territory and Western Australia.

Using the descriptors given in Table 5, the Australian painted snipe has a moderate (likely 25 to 50%) overlap with carp, and within this are distributed sporadically (Figure 16). From a purely geographical standpoint, this combination places the Australian painted snipe at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

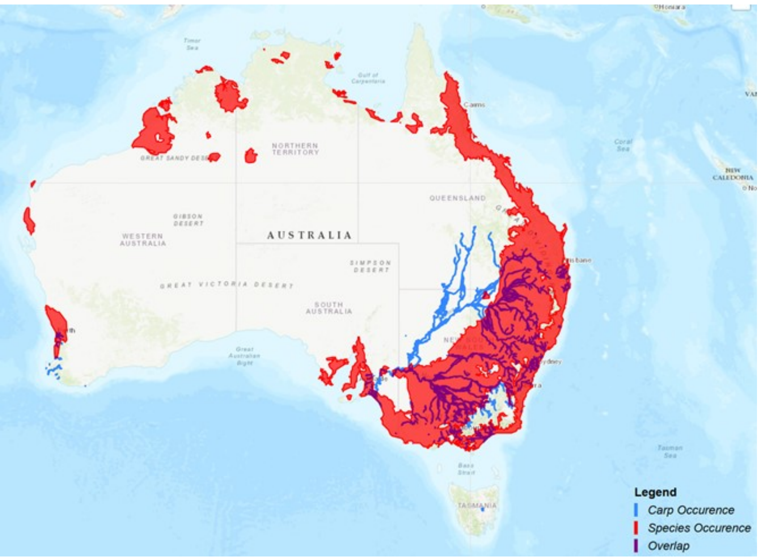

Figure 16 Distribution of the Australian painted snipe and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Australian painted snipe)

Diet: the Australian painted snipe eats vegetation, seeds, insects, worms and molluscs, crustaceans and other invertebrates.

Roosting: the Australian painted snipe loafs on the ground under clumps of lignum, tea-tree and similar dense bushes. This species has been recorded foraging under clumps of tea-trees but most records are from daytime roost sites and the foraging habitat requirements of this species are not well understood and may be quite specific.

Habitat: the Australian painted snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains.

Unmanaged risk: see the curlew sandpiper (above) for a description of the risk factors for shorebirds. These risk factors, when viewed in conjunction with the distributions of the Australian painted snipe and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 19. As this species is not migratory, the ratings are for threatened species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 19 Unmanged and managed (residual) risks for the Australian painted snipe

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Possible	High	Unlikely	Medium
	Impact on breeding cycle	Possible	High	Unlikely	Medium
Microorganisms with	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on the quality of water or habitat	Unlikely	Medium	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
decomposing carcasses	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Rare	Minor
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the Australian painted snipe are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the Australian painted snipe, mitigations will need to be reasonably widespread across the distribution of carp. With these mitigations available if required, the managed (residual) likelihoods and risks for Australian painted snipe are given in Table 19. The non-negligible (Medium) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for this species. The Department of Environment and Energy notes that, "*Recovery Plan required, stopping the decline and supporting the recovery of this species is complex and involves a highly adaptive management process and the requirement for a high level of: planning to abate the threats; cross-jurisdictional co-ordination; co-ordination between managers; support by key stakeholders; and prioritisation of actions*".

3.2.3.5 Sharp-tailed sandpiper (migratory)

Distribution: the sharp-tailed sandpiper is widespread across the south-east of Australia, including both inland and coastal locations and in both freshwater and saline habitats. Many inland records are of birds on passage.

Using the descriptors given in Table 5, the sharp-tailed sandpiper has a low to moderate overlap with carp (possibly more than 25%, although this is a very conservative estimate), and within this are distributed sporadically (Figure 17). From a purely geographical standpoint, this combination places the sharp-tailed sandpiper at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

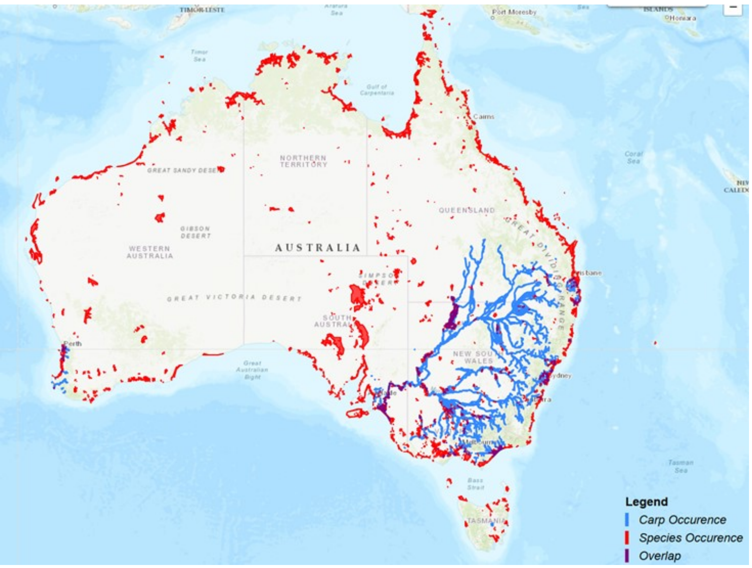

Figure 17 Distribution of the sharp-tailed sandpiper and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the sharp-tailed sandpiper)

Diet: the sharp-tailed sandpiper forages on seeds, worms, molluscs, crustaceans and insects.

Roosting: roosting occurs at the edges of wetlands, on wet open mud or sand, in shallow water, or in short sparse vegetation, such as grass or saltmarsh. Occasionally, they roost on sandy beaches, stony shores or on rocks in water.

Habitat: the sharp-tailed sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation. This includes lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline salt lakes inland. They also occur in saltworks and sewage farms. They use flooded paddocks, sedgelands and other ephemeral wetlands, but leave when they dry. They use intertidal mudflats in sheltered bays, inlets, estuaries or seashores, and also swamps and creeks lined with mangroves. They tend to occupy coastal mudflats mainly after ephemeral terrestrial wetlands have dried out, moving back during the wet season.

Unmanaged risk: see the curlew sandpiper (above) for a description of the risk factors for shorebirds. These risk factors, when viewed in conjunction with the distributions of the sharp-tailed sandpiper and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 20. As this species is migratory, and not a threatened species, the ratings are for migratory species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 20 Unmanged and managed (residual) risks for the sharp-tailed sandpiper

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Rare	Minor	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Negligible	Negligible	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Botulism	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Unlikely	Medium	Rare	Minor

Risk mitigation and residual risk: the key risks for the sharp-tailed sandpiper are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the sharp-tailed sandpiper, mitigations will need to be reasonably widespread across the distribution of carp. With these mitigations available if required, the managed (residual) likelihoods and risks for sharp-tailed sandpiper are given in Table 20. The non-negligible (Medium and Minor) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms, respectively.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for this species.

3.2.3.6 Red-necked stint (migratory)

Distribution: the red-necked stint is distributed along most of the Australian coastline with large densities on the Victorian and Tasmanian coasts. The red-necked stint has been recorded in all coastal regions and found inland in all states when conditions are suitable. The species probably travels in flocks and has been observed to feed in dense flocks.

Using the descriptors given in Table 5, the red-necked stint has a low to moderate overlap with carp (possibly more than 25%, although this is a very conservative estimate), and within this are distributed sporadically (Figure 18). From a purely geographical standpoint, this combination places the red-necked stint at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

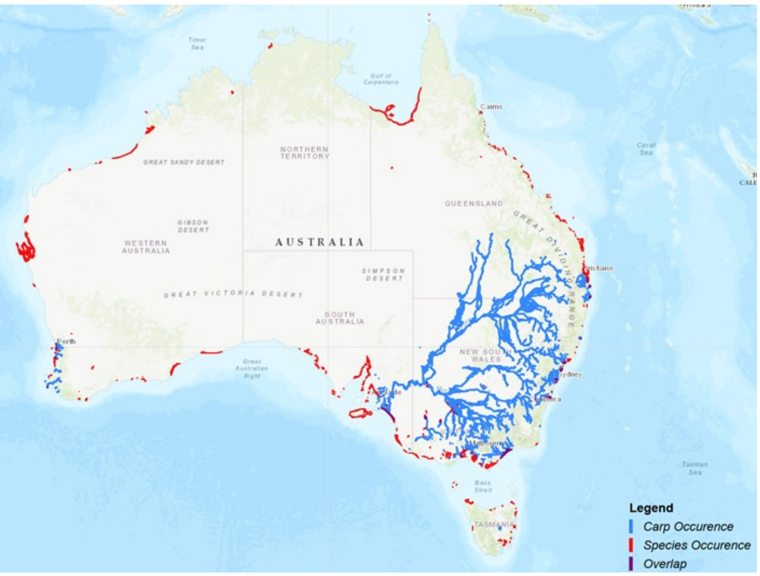

Figure 18 Distribution of the red-necked stint and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the red-necked stint)

Diet: the red-necked stint forages on plant seeds (such as from *Ruppia spp*. and *Polygonum spp*.) and on a range of marine worms, molluscs, snails and slugs, shrimps, spiders, beetles, flies and ants.

Roosting: the red-necked stint roosts on sheltered beaches, spits, banks or islets, of sand, mud, coral or shingle, sometimes in saltmarsh or other vegetation. They occasionally roost on exposed reefs or shoals. Large numbers sometimes roost on ocean beaches, though it is probably not a preferred habitat and use of this habitat may increase when high numbers of birds are present.

Habitat: the red-necked stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. Occasionally they have been recorded on exposed or ocean beaches, and sometimes on stony or rocky shores, reefs or shoals. They also occur in saltworks and sewage farms; saltmarsh; ephemeral or permanent shallow wetlands near the coast or inland, including lagoons, lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in salt flats. They sometimes use flooded paddocks or damp grasslands. They have occasionally been recorded on dry gibber plains, with little or no perennial vegetation.

Unmanaged risk: see the curlew sandpiper (above) for a description of the risk factors for shorebirds. These risk factors, when viewed in conjunction with the distributions of the red-necked stint and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 21. As this species is migratory, and not a threatened species, the ratings are for migratory species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 21 Unmanged and managed (residual) risks for the red-necked stint

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Rare	Minor	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Negligible	Negligible	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Botulism	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Unlikely	Medium	Rare	Minor

Risk mitigation and residual risk: the key risks for the red-necked stint are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the red-necked stint, mitigations will need to be reasonably widespread across the distribution of carp. With these mitigations available if required, the managed (residual) likelihoods and risks for red-necked stint are given in Table 21. The non-negligible (Medium and Minor) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms, respectively.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for this species.

3.2.3.7 Latham's snipe / Japanese snipe (migratory)

Distribution: Latham's Snipe is a non-breeding visitor to south-eastern Australia and is a passage migrant through northern Australia. The species has been recorded along the east coast of Australia from Cape York Peninsula through to south-eastern South Australia. The range extends inland over the eastern tablelands in south-eastern Queensland (and occasionally from Rockhampton in the north), and to west of the Great Dividing Range in New South Wales. The species is widespread in Tasmania and is found in all regions of Victoria except for the north-west. Most birds spend the non-breeding period at sites located south of the Richmond River in New South Wales. In Australia, Latham's Snipe occurs in permanent and ephemeral wetlands.

Using the descriptors given in Table 5, the Latham’s snipe has a low to moderate overlap with carp (possibly more than 25%, although this is a very conservative estimate), and within this are distributed sporadically (Figure 19). From a purely geographical standpoint, this combination places the Latham’s snipe at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

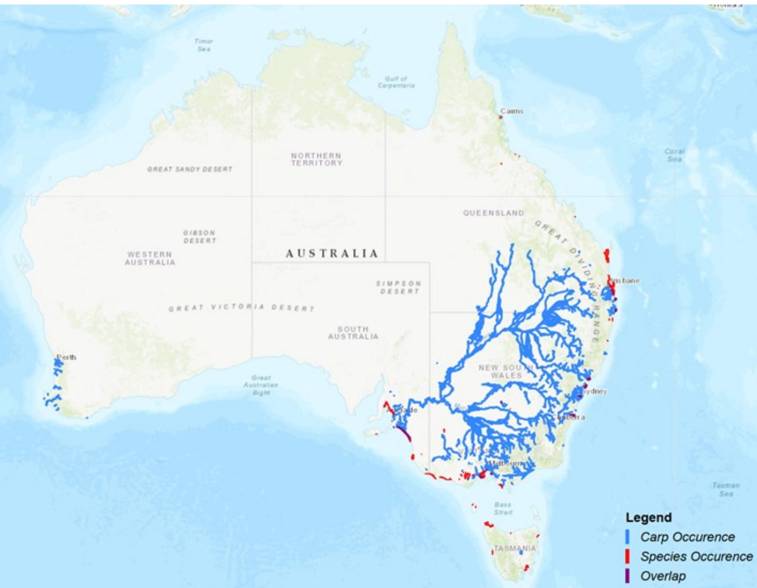

Figure 19 Distribution of the Latham’s snipe and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Latham’s snipe)

Diet: Latham's Snipe is an omnivorous species that feeds on seeds and other plant material, and on invertebrates including insects (mainly flies and beetles), earthworms and spiders and occasionally molluscs, isopods and centipedes.

Roosting: Latham’s snipe roost on the ground near (or sometimes in) their foraging areas, usually in sites that provide some degree of shelter (for example, beside or under clumps of vegetation, among dense tea-tree, in forests, in drainage ditches or plough marks, among boulders, or in shallow water if cover is unavailable).

Habitat: Latham's Snipe occurs in permanent and ephemeral wetlands up to 2000 m above sea-level. They usually inhabit open, freshwater wetlands with low, dense vegetation (e.g. swamps, flooded grasslands or heathlands, around bogs and other water bodies). However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity.

Unmanaged risk: see the curlew sandpiper (above) for a description of the risk factors for shorebirds. These risk factors, when viewed in conjunction with the distributions of the Latham's snipe and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 22. As this species is migratory, and not a threatened species, the ratings are for migratory species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 22 Unmanged and managed (residual) risks for the Latham's snipe

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Rare	Minor	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Negligible	Negligible	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Botulism	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Unlikely	Medium	Rare	Minor

Risk mitigation and residual risk: the key risks for Latham's snipe are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of Latham's snipe, mitigations would not need to extend far inland from the Great Dividing Range. With these mitigations available if required, the managed (residual) likelihoods and risks for Latham's snipe are given in Table 22. The non-negligible (Medium and Minor) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms, respectively.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for this species.

3.2.3.8 Common greenshank (migratory)

Distribution: this species occurs in all types of wetlands and has the widest distribution of any shorebird in Australia.

Using the descriptors given in Table 5, the common greenshank has a low to moderate overlap with carp (possibly more than 25%, although this is a very conservative estimate), and within this are distributed sporadically (Figure 20). From a purely geographical standpoint, this combination places the common greenshank at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

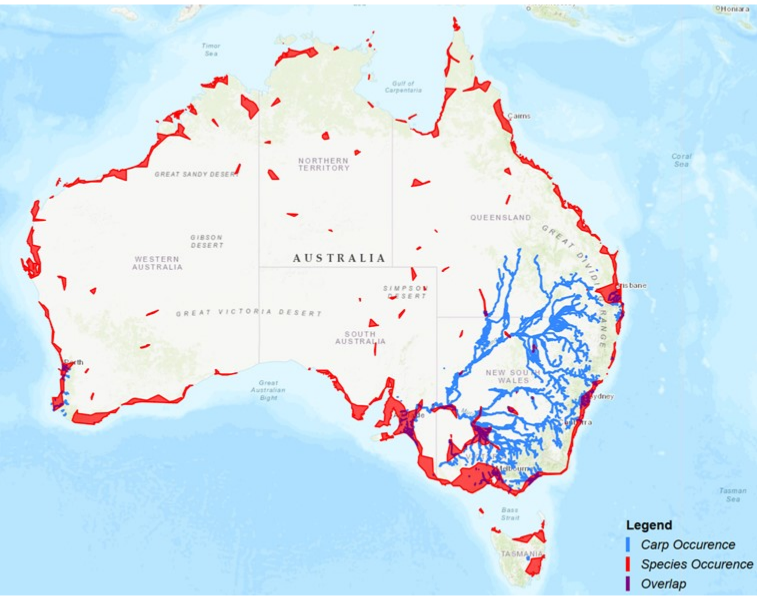

Figure 20 Distribution of the common greenshank and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the common greenshank)

Diet: the common greenshank is carnivorous. In Australia is has been recorded eating molluscs, crustaceans, insects, and occasionally fish and frogs. Elsewhere, it has also been recorded eating annelids, lizards, and rodents.

Roosting: the common greenshank roosts and loafs round wetlands, in shallow pools and puddles, or slightly elevated on rocks, sandbanks or small muddy islets. Occasionally the species will perch and roost on stakes.

Habitat: the common greenshank is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. Habitats include embayments, harbours, river estuaries, deltas and lagoons and are recorded less often in round tidal pools, rock-flats and rock platforms. The species uses both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and salt flats. It will also use artificial wetlands, including sewage farms and saltworks dams, inundated rice crops and bores. The edges of the wetlands used are generally of mud or clay, occasionally of sand, and may be bare or with emergent or fringing vegetation, including short sedges and saltmarsh, mangroves, thickets of rushes, and dead or live trees.

Unmanaged risk: see the curlew sandpiper (above) for a description of the risk factors for shorebirds. These risk factors, when viewed in conjunction with the distributions of the common greenshank and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 23. As this species is migratory, and not a threatened species, the ratings are for migratory species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 23 Unmanged and managed (residual) risks for the common greenshank

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Rare	Minor	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Negligible	Negligible	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Botulism	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Unlikely	Medium	Rare	Minor

Risk mitigation and residual risk: the key risks for the common greenshank are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the common greenshank, mitigations will need to be reasonably widespread across the distribution of carp. With these mitigations available if required, the managed (residual) likelihoods and risks for common greenshank are given in Table 23. The non-negligible (Medium and Minor) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms, respectively.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for this species.

3.2.3.9 Marsh sandpiper / little greenshank (migratory)

Distribution: the marsh sandpiper is found on coastal and inland wetlands throughout Australia.

Using the descriptors given in Table 5, the marsh sandpiper has a low to moderate overlap with carp (possibly more than 25%, although this is a very conservative estimate), and within this are distributed sporadically (Figure 21). From a purely geographical standpoint, this combination places the marsh sandpiper at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

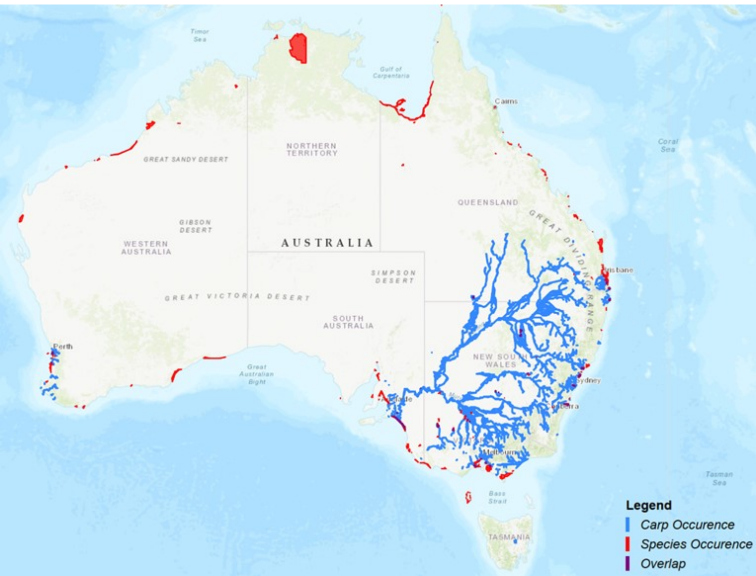

Figure 21 Distribution of the marsh sandpiper and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the marsh sandpiper)

Diet: the marsh sandpiper is carnivorous, eating insects, molluscs and crustaceans. Plant material has been found in stomachs, although this may have been ingested incidentally. There is a recent record of a fish being carried to shore and eaten.

Roosting: the marsh sandpiper roosts on tidal mudflats, near low saltmarsh, and around inland swamps.

Habitat: the marsh sandpiper lives in permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes.

In north Australia they prefer intertidal mudflats, although surveys in Kakadu National Park recorded more birds around shallow freshwater lakes than in areas influenced by tide.

Unmanaged risk: see the curlew sandpiper (above) for a description of the risk factors for shorebirds. These risk factors, when viewed in conjunction with the distributions of the marsh sandpiper and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 24. As this species is migratory, and not a threatened species, the ratings are for migratory species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 24 Unmanged and managed (residual) risks for the marsh sandpiper

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Rare	Minor	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Negligible	Negligible	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Botulism	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Unlikely	Medium	Rare	Minor
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Unlikely	Medium	Rare	Minor

Risk mitigation and residual risk: the key risks for the marsh sandpiper are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the marsh sandpiper, mitigations will need to be reasonably widespread across the distribution of carp. With these mitigations available if required, the managed (residual) likelihoods and risks for marsh sandpiper are given in Table 24. The non-negligible (Medium and Minor) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms, respectively.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for this species.

Table 25 Exposure of threatened and migratory shorebirds from a geographical stanpoint

EPBC listing	Migratory	Species	Distribution in Australia	Breeds in Australia	Population overlap categorisation	Population distribution categorisation	Geographical exposure
Critically endangered	Yes	Northern Siberian bar-tailed godwit	Recorded in the coastal areas of all Australian states. It is widespread in the Torres Strait and along the east and south-east coasts of Queensland, NSW and Victoria. In Tasmania, the bar-tailed godwit has mostly been recorded on the south-east coast. In South Australia it has mostly been recorded around coasts from Lake Alexandrina to Denial Bay. In Western Australia it is widespread around the coast, from Eyre to Derby. Populations have also been recorded in the northern Australia, from Darwin east to the Gulf of Carpentaria. The bar-tailed godwit is a regular migrant to Christmas Island, Norfolk Island, Lord Howe Island. It has also been recorded on subantarctic islands such as Macquarie Island, Snares Islands, Auckland Islands and Campbell Islands. During the non-breeding period, predominantly in the north and north-west of Western Australia and in south-eastern Asia.	No	Low	Diffuse	Low
Critically endangered	Yes	Curlew sandpiper	In Australia, Curlew Sandpipers occur around the coasts and are also quite widespread inland, though in smaller numbers. Records occur in all states during the non-breeding period, and also during the breeding season when many non-breeding one-year-old birds remain in Australia rather than migrating north.	No	Moderate	Sporadic	Moderate
Critically endangered	Yes	Great knot	The Great Knot has been recorded around the entirety of the Australian coast, with a few scattered records inland.	Yes	Low	Sporadic	Low
Critically endangered	Yes	Eastern curlew	Within Australia, the eastern curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions including Tasmania. Eastern curlews are rarely recorded inland. The eastern curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass	No	Low	Sporadic	Low
Endangered	Yes	Red knot	The Red Knot is common in all the main suitable habitats around the coast of Australia.	No	Low	Sporadic	Low
Endangered	Yes	Lesser sand plover	Within Australia, the Lesser Sand-Plover is widespread in coastal regions and has been recorded in all states. It mainly occurs in northern and eastern Australia, in south-eastern parts of the Gulf of Carpentaria, western Cape York Peninsula and islands in Torres Strait, and along the entire east coast, though it occasionally also occurs inland.	No	Low	Sporadic	Low

EPBC listing	Migratory	Species	Distribution in Australia	Breeds in Australia	Population overlap categorisation	Population distribution categorisation	Geographical exposure
Endangered	No	Australian painted snipe	The Australian Painted Snipe has been recorded at wetlands in all states of Australia. It is most common in eastern Australia, where it has been recorded at scattered locations throughout much of Queensland, NSW, Victoria and south-eastern South Australia. It has been recorded less frequently at a smaller number of more scattered locations farther west in South Australia, the Northern Territory and Western Australia. The Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains.	Yes	Moderate	Sporadic	Moderate
Vulnerable	Yes	Bar-tailed godwit	The bar-tailed godwit has been recorded in the coastal areas of all Australian states. It is widespread in the Torres Strait and along the east and south-east coasts of Queensland, NSW and Victoria. In Tasmania, the bar-tailed godwit has mostly been recorded on the south-east coast. In South Australia it has mostly been recorded around coasts from Lake Alexandrina to Denial Bay. In Western Australia it is widespread around the coast, from Eyre to Derby. Populations have also been recorded in the northern Australia, from Darwin east to the Gulf of Carpentaria. The bar-tailed godwit is a regular migrant to Christmas Island, Norfolk Island, Lord Howe Island. It has also been recorded on subantarctic islands such as Macquarie Island, Snares Islands, Auckland Islands and Campbell Islands.	No	Low	Sporadic	Low
-	Yes	Common sandpiper	Found along all coastlines of Australia and in many areas inland, the Common Sandpiper is widespread in small numbers. The population when in Australia is concentrated in northern Australia (Queensland and Northern Territory) and western Australia.	No	Low	Sporadic	Low
-	Yes	Ruddy turnstone	The Ruddy Turnstone is widespread around the Australian coastline during its non-breeding period of the year, including from Tasmania in the south to Darwin in the north and many coastal areas in between. It is found in most coastal regions, with occasional records of inland populations. It strongly prefers rocky shores or beaches where there are large deposits of rotting seaweed.	No	Low	Sporadic	Low
-	Yes	Sharp-tailed sandpiper	The Sharp-Tailed Sandpiper is widespread across the south-east of Australia, including both inland and coastal locations and in both freshwater and saline habitats. Many inland records are of birds on passage.	No	Moderate	Diffuse	Moderate
-	Yes	Pectoral sandpiper	The Pectoral Sandpiper occurs throughout Australia. Populations are principally coastal, with occasional (in-transit) records from inland areas.	No	Low	Sporadic	Low
-	Yes	Red-necked stint	The red-necked stint is distributed along most of the Australian coastline with large densities on the Victorian and Tasmanian coasts. The Red-necked Stint has been recorded in all coastal regions and found inland in all states when conditions are suitable. The Red-necked Stint probably travels in flocks and has been observed to feed in dense flocks.		Moderate	Sporadic	Moderate

EPBC listing	Migratory	Species	Distribution in Australia	Breeds in Australia	Population overlap categorisation	Population distribution categorisation	Geographical exposure
-	Yes	Double-banded plover	The Double-banded Plover can be found in both coastal and inland areas. During the non-breeding season, it is common in eastern and southern Australia, mainly between the Tropic of Capricorn and western Eyre Peninsula, with occasional records in northern Queensland and Western Australia. The greatest numbers are found in Tasmania and Victoria, but numbers diminish to the north and west of these regions	No	Low	Sporadic	Low
-	Yes	White-winged tern / white-winged black tern	The species is a non-breeding migrant to Australia, where it is widespread and common along south-western, northern and central-eastern coasts, with only scattered records of small numbers along the coasts elsewhere in southern Australia.	No	Low	Sporadic	Low
-	Yes	Latham's snipe / Japanese snipe	Latham's Snipe is a non-breeding visitor to south-eastern Australia and is a passage migrant through northern Australia. The species has been recorded along the east coast of Australia from Cape York Peninsula through to south-eastern South Australia. The range extends inland over the eastern tablelands in south-eastern Queensland (and occasionally from Rockhampton in the north), and to west of the Great Dividing Range in New South Wales. The species is widespread in Tasmania and is found in all regions of Victoria except for the north-west. Most birds spend the non-breeding period at sites located south of the Richmond River in New South Wales. In Australia, Latham's Snipe occurs in permanent and ephemeral wetlands.	No	Moderate	Sporadic	Moderate
-	Yes	Ruff / reeve	The Ruff is a rare but regular visitor to Australia, being recorded in coastal locations within all States and Territories.	No	Low	Sporadic	Low
-	Yes	Common greenshank	The species occurs in all types of wetlands and has the widest distribution of any shorebird in Australia.	No	Moderate	Sporadic	Moderate
-	Yes	Marsh sandpiper / little greenshank	The Marsh Sandpiper is found on coastal and inland wetlands throughout Australia.	No	Moderate	Sporadic	Moderate
-	Yes	Black-tailed godwit	Although the Black-tailed Godwit is found in all states and territories of Australia, it prefers coastal regions and the largest populations are found on the north coast between Darwin and Weipa.	No	Low	Sporadic	Low

3.2.3.10 Waterfowl

Waterfowl can be divided loosely into herbivores (including swans and geese) and ducks (which includes the dabbling and diving ducks and grebes). Dabbling ducks feed in shallow water and are more likely to have a diet with more aquatic plants and insects, while diving ducks feed deeper in the water and typically eat more fish or crustaceans. The diet of grebes consists mainly of small fish and aquatic invertebrates. Waterfowl may congregate to nest in loosely-defined areas, but do not form colonies. Although some waterfowl in the northern hemisphere migrate to escape harsh winters, the same does not occur in Australia. None of the waterfowl whose distribution overlaps with that of carp are listed under the EPBC Act as threatened or listed under international agreements for the protection of migratory species to which Australia is a party.

3.2.3.11 Large waders

The large waders include the storks, herons, egrets, ibises and spoonbills. These birds are carnivorous with a diet that may include fish, reptiles, amphibians, crustaceans, molluscs and aquatic insects. Many of the large waders are colonial nesters, and many are at least partially migratory. The endangered Australasian bittern is the single large wader, whose distribution overlaps with carp, that is listed under the EPBC Act.

Distribution: the Australasian bittern occurs from south-east Queensland to south-east South Australia as far as the Adelaide Region, southern Eyre Peninsula, Tasmania and in the south-west of Western Australia. The Australasian Bittern also occurs in New Zealand and New Caledonia. In New South Wales, it occurs along the coast and is also frequently recorded in the Murray-Darling Basin, notably in floodplain wetlands of the Murray, Murrumbidgee, Lachlan, Macquarie and Gwydir Rivers. In Victoria, it is recorded mostly in the southern coastal areas and in the Murray River region of central northern Victoria. In South Australia, it is confined to the south-east, ranging north to the Murray River corridor and the Adelaide region, and west to the southern Eyre Peninsula and Kangaroo Island.

Using the descriptors given in Table 5, the Australasian bittern has a moderate (likely 25 to 50%) overlap with carp, and within this are distributed sporadically (Figure 22). From a purely geographical standpoint, this combination places the Australasian bittern at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

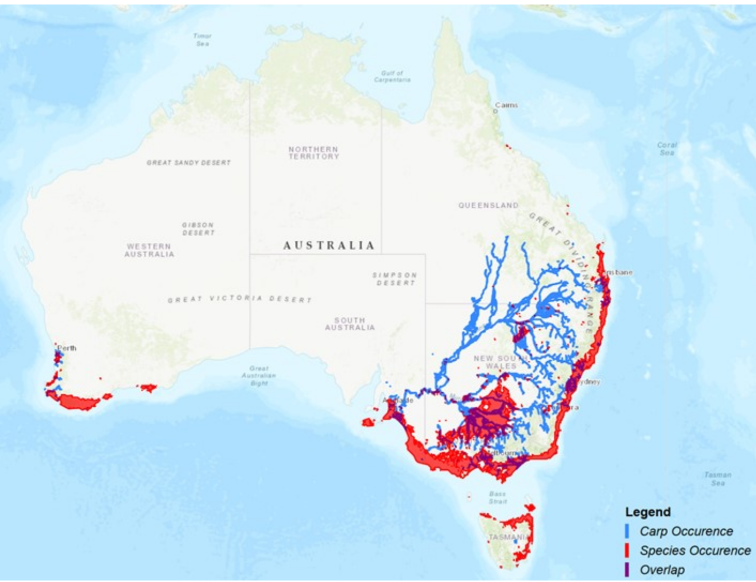

Figure 22 Distribution of the Australasian bittern and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Australasian bittern)

Diet: the Australasian bittern hides during the day and feeds chiefly at night on frogs, fish, yabbies, spiders, insects and snails. Feeding platforms may be constructed over deeper water from reeds that have been trampled by the bird. These platforms are often littered with the remains of prey.

Roosting: the Australasian bittern breeds from October to January, with nests built in secluded places on a similar platform of reeds. It is not a colonial nester.

Habitat: the Australasian bittern favours permanent freshwater wetlands with tall, dense vegetation, particularly bulrushes and spike-rushes.

Unmanaged risk: large waders are in continual contact with the waterbodies within their habitat and are likely to be exposed to cyanotoxins and proliferating microorganisms. As it is not a colonial nester, however, the Australasian bittern may be more able to move away from affected water relatively easily. The broad diet of the Australasian bittern is also likely to mean that it would be less exposed than strictly piscivorous species in the event of the sudden removal of juvenile carp. As this diet includes insects, however, the Australasian bittern may be relatively more exposed in the event of an outbreak of Type C (or C/D mosaic) botulism that has been initiated or maintained through the carcass-maggot cycle. This would be of most concern in settings such as the Macquarie Marshes and the Lower Lakes and Coorong which support very large numbers of nesting waterbirds during higher-flow seasons and may thus be more likely to experience an outbreak of botulism.

These considerations, when viewed in conjunction with the distributions of the Australasian bittern and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 26. As this species is not migratory, the ratings are for threatened species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 26 Unmanged and managed (residual) risks for the Australasian bittern

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Possible	High	Unlikely	Medium
	Impact on breeding cycle	Possible	High	Unlikely	Medium
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on the quality of water or habitat	Unlikely	Medium	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Rare	Minor
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the Australasian bittern are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the Australasian bittern, mitigations will need to be reasonably widespread across the distribution of carp. With these mitigations available if required, the managed (residual) likelihoods and risks for Australasian bittern are given in Table 26. The non-negligible (Medium) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms.

Recovery Plans and Threat Abatement Plans: there is no Threat Abatement Plan or Recovery Plan for this species. The Department of Environment and Energy notes that, "*Recovery Plan required, it occurs across multiple state boundaries and requires a complex suite of recovery and threat abatement actions in terms of addressing threats, such as water management in the Murray-Darling Basin. In addition, the implementation of recovery and threat abatement actions will involve a wide variety of land managers and other stakeholders across these state boundaries*".

3.2.3.12 Gruiformes

The Gruiformes include rails, crakes, coots, moorhens and waterhens. This order of waterbird is very large, with more than 160 recognised species, most of which are omnivorous (with a diet that may include molluscs, frogs, small fish and insects). The order also includes cranes and brolgas, some of which are phenotypically similar to herons and other large waders and share some aspects of behaviour and preferred habitat. Gruiformes are not migratory and are not colonial nesters, although may congregate in loosely defined areas. None of the birds in this category whose distribution overlaps with that of carp, is listed under the EPBC Act as threatened.

3.2.3.13 Kingfishers

While the kingfishers are often associated with waterbodies and are regarded as piscivorous (owing to their name), many species live away from water and have a broader diet that includes small crustaceans, invertebrates and other small prey. The laughing Kookaburra is an example of this. None of the kingfishers whose distribution overlaps with that of carp are listed under the EPBC Act as threatened or listed under international agreements for the protection of migratory species to which Australia is a party.

3.2.3.14 Songbirds

The songbirds are small, perching birds of the order Passeriformes (the passerine birds). With more than 110 families and more than 6,000 identified species worldwide, Passeriformes is the largest order of birds and among the most diverse orders of terrestrial vertebrates. The diet of passerine birds varies amongst species, and may include seeds, insects and small crustaceans. Some passerine birds, such as the clamorous warbler, are true waterbirds. Others may be present in wetlands and other water-focussed ecosystems, whether permanently or as an opportunistic means by which to gain refuge from drought and other environmental stresses. A single species of songbird whose distribution overlaps with that of carp is listed under the EPBC Act as endangered (mallee emu wren) while another is listed as vulnerable (thick-billed grass wren). In addition to this, the satin flycatcher and the rufous fantail are listed under international agreements for the protection of migratory species to which Australia is a party.

3.2.3.14.1 Mallee emu wren (endangered) and thick-billed grass wren (vulnerable)

Both species favour spinifex-dominated (*Triodia sp*.) habitats within in arid or semi-arid environments. Although the spatial distribution of the mallee emu wren and the thick-billed grass wren (as supplied by the Department of Environment and Energy) overlap in principle with the distribution of carp, both species favour spinifex-dominated habitats within in arid or semi-arid environments. Neither species is riparian nor occupies wetlands, and neither will be placed at risk in the event of an outbreak of CyHV-3 in carp.

A Recovery Plan for the Mallee emu wren was published in 2016.[22] A Threat Abatement Plan for predation by feral cats was published in 2015.[23] A Recovery Plan for the eastern subspecies of the thick-billed grass wren was published in 2003.[24] Threat Abatement Plans for predation by feral cats (2015),[25] for competition and land degradation by rabbits (2016)[26] and for competition and land degradation by unmanaged goats (2008)[27] have also been published.

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[22] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/three-mallee-birds

[23] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats

[24] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/thick-billed-grasswren-eastern-subspecies-amytornis-textilis-modestus-north-1902-recovery

[25] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats

[26] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016

[27] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-unmanaged-goats

3.2.3.14.2 Satin flycatcher and the rufous fantail (migratory)

The satin flycatcher is found along the east coast of Australia from far northern Queensland to Tasmania, including south-eastern South Australia. It is not a commonly seen species, especially in the far south of its range, where it is a summer breeding migrant. The satin flycatcher is found in tall forests, preferring wetter habitats such as heavily forested gullies. It takes insects on the wing, foraging actively from perches in the mid to upper canopy. Satin flycatchers are migratory, moving north in autumn to spend winter in northern Australia and New Guinea. They return south in spring to spend summer in south-eastern Australia.

The rufous fantail occurs in coastal and near coastal districts of northern and eastern Australia. It mainly inhabits wet sclerophyll forests. The rufous fantail is insectivorous, foraging mainly in the low to middle strata of forests, sometimes in or below the canopy or on the ground. It is a migratory species, being virtually absent from south-east Australia in winter.

The satin flycatcher and rufous fantail both occupy forest habitats in spring and summer and are not riparian or wetland species. Neither species was recorded against any of the case studies considered within the assessment. The exposure of these species to harm as a result of an outbreak of CyHV-3 is likely to be limited to cyanobacterial blooms or outbreaks of botulism, although the likelihood of either is remote.

3.2.3.15 Bush-birds

The bush-birds are a heterogeneous and informally-defined catchall category that encompasses the range of species that may roost, forage and nest in riparian or floodplain forests (including river red gums) but are not generally considered to be true waterbirds. This group encompasses some of the psittacines (cockatoos, cockatiels, corellas, parrots, rosellas, and budgerigars) as well as honeyeaters, frogmouths, curlews and others. The regent honeyeater, swift parrot and the plains-wanderer are critically endangered; while the rufous scrub-bird, red-tailed black cockatoo, and black-eared miner are endangered. In addition to these, the painted honeyeater, malleefowl, red-lored whistler, regent parrot (eastern), superb parrot and Mallee western whipbird are vulnerable. Bush-birds underpin the listing of a number of Ramsar wetlands. The vulnerable superb parrot, for example, is referenced in the environmental character descriptions for both the Barmah-Millewa Forest and Macquarie Marshes Ramsar sites; while the regent parrot is referenced in the environmental character description for the Riverland (including parts of the Chowilla Floodplain) Ramsar site. In addition to these, the following seven species are listed under international agreements for the protection of migratory species to which Australia is a party: the fork-tailed swift, oriental cuckoo / Horsfield's cuckoo, white-throated needletail, grey wagtail, yellow wagtail and the little curlew / little whimbrel.

A screening process was undertaken to identify bush-bird species that regularly occur in parts of inland Australia where carp also exist in a moderate or high biomass density – principally, the Murray-Darling Basin. The screening process also sought to identify those species that are likely to be associated closely with waterbodies or waterways, as opposed to forest, woodland, Mallee and other forms of habitat. The outcomes of this process are illustrated in Table 31. Of the list of threatened and migratory species given above, the critically-endangered regent honeyeater and swift parrot had moderate exposure, as did the vulnerable regent parrot and superb parrot. These species are examined individually below.

3.2.3.15.1 Regent honeyeater (critically endangered)

Distribution: the regent honeyeater is endemic to mainland south-eastern Australia. It has a patchy distribution which extends from south-east Queensland, through New South Wales (New South Wales) and the Australian Capital Territory (Australian Capital Territory), to central Victoria. Records are widely distributed across its range, but it is only found regularly at a few localities in New South Wales and Victoria where most of the sightings have been recorded. There are four known key breeding areas: three in New South Wales and one in Victoria.

Using the descriptors given in Table 5, the regent honeyeater has a moderate (likely 25 to 50%) overlap with carp, and within this are distributed sporadically (Figure 23). From a purely geographical standpoint, this combination places the regent honeyeater at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

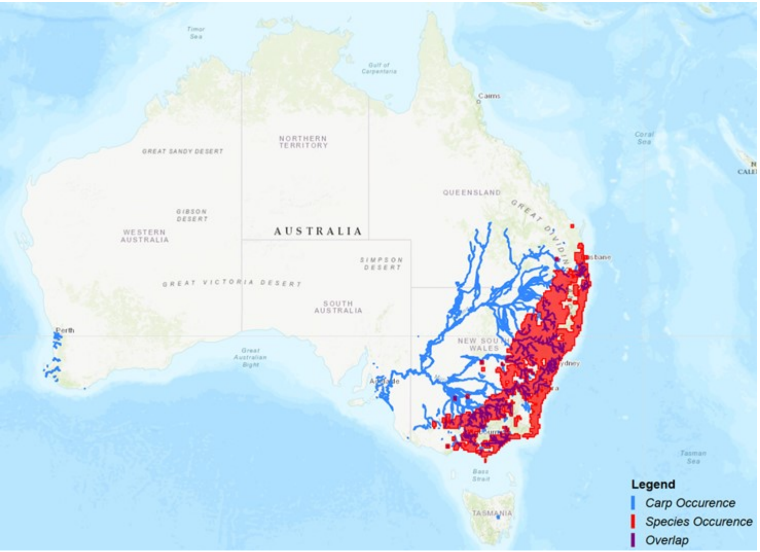

Figure 23 Distribution of the regent honeyeater and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the regent honeyeater)

Diet: the regent honeyeater's diet primarily consists of nectar, but also includes invertebrates (mostly insects) and their exudates (for example, lerps and honeydew), and occasionally fruit.

Roosting: the regent honeyeater roosts communally in small groups or large flocks, in trees with dense foliage. Foraging trees are rarely used as roosting sites.

Habitat: the regent honeyeater mostly inhabits inland slopes of the Great Dividing Range, in areas of low to moderate relief with moist, fertile soils. It is most commonly associated with box-ironbark eucalypt woodland and dry sclerophyll forest, but also inhabits riparian vegetation such as sheoak where it feeds on needle-leaved mistletoe and sometimes breeds. It sometimes utilises lowland coastal forest, which may act as a refuge when its usual habitat is affected by drought.

Unmanaged risk: bush-birds such as the regent honeyeater might be exposed to harm as a result of an outbreak of CyHV-3 through drinking water contaminated with cyanotoxins or waterborne microorganisms, or through an outbreak of botulism. Bush-birds do not nest in close proximity to water, and most will be able to move away from an affected area or source water and food from an unaffected area. An exception to this may be an aggressive outbreak of CyHV-3 within an isolated waterbody at a time when the waterbody is providing drought refuge. Bush-birds that include insects within their diet might also be at risk in the event of an outbreak of type C (or C/D mosaic) botulism that had been initiated or maintained through the carcass-maggot cycle.

These considerations, when viewed in conjunction with the distributions of the regent honeyeater and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 27. As this species is not migratory, the ratings are for threatened species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 27 Unmanged and managed (residual) risks for the regent honeyeater

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the regent honeyeater are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the regent honeyeater, mitigations will need to be reasonably widespread across the eastern half of the distribution of carp. With these mitigations available if required, the managed (residual) likelihoods and risks for the regent honeyeater are given in Table 27. There are no non-negligible residual risks.

Recovery Plans and Threat Abatement Plans: a Recovery Plan for this species was published in 2016.[28] A Threat Abatement Plan for competition and land degradation by rabbits was published in 2017.[29]

3.2.3.15.2 Swift parrot (critically endangered)

Distribution: the swift parrot breeds in Tasmania during the summer and the entire population migrates north to mainland Australia for the winter. Whilst on the mainland the swift parrot is found principally in Victoria and New South Wales. In Victoria, swift parrots are predominantly found in the dry forests and woodlands of the box-ironbark region on the inland slopes of the Great Dividing Range. During periods of drought in central Victoria, swift parrots may concentrate in coastal drought refuge habitats in New South Wales. In New South Wales, swift parrots forage in forests and woodlands throughout the coastal and western slopes regions each year. Coastal regions tend to support larger numbers of birds when inland habitats are subjected to drought.

Using the descriptors given in Table 5, the swift parrot has a moderate (likely 25 to 50%) overlap with carp, and within this are distributed sporadically (Figure 24). From a purely geographical standpoint, this combination places the swift parrot at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

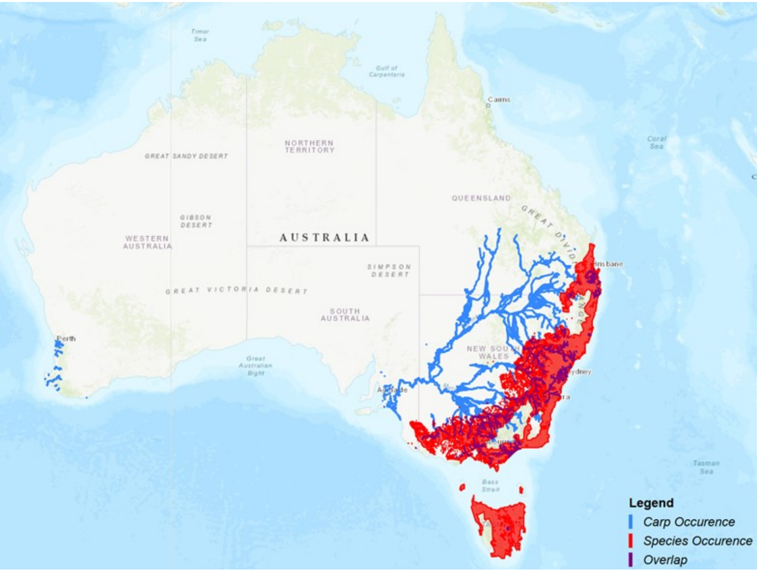

Figure 24 Distribution of the swift parrot and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the swift parrot)

Diet: the swift parrot forages on flowers and psyllid lerps in eucalypt species.

Roosting: non-breeding swift parrots roost in forage trees.

Habitat: non-breeding swift parrots preferentially feed in inland box-ironbark and grassy woodlands, and coastal swamp mahogany (*E. robusta*) and spotted gum (*Corymbia maculata*)

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[28] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-regent-honeyeater-anthochaera-phrygia-2016

[29] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016

woodland when in flower. Otherwise, the species is found in coastal forests from eastern Victorian to the central coast of New South Wales.

Unmanaged risk: risk factors for bush-birds as a functional group were outlined within the discussion of regent honeyeaters (above). The ratings for the swift parrot are likely to be similar to those of the regent honeyeater, as shown in Table 28. As this species is not migratory, the ratings are for threatened species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 28 Unmanged and managed (residual) risks for the swift parrot

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the swift parrot are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the swift parrot, mitigations will need to be reasonably widespread across the eastern half of the distribution of carp. With these mitigations available if required, the managed (residual) likelihoods and risks for swift parrot are given in Table 28. There are no non-negligible residual risks.

Recovery Plans and Threat Abatement Plans: a Recovery Plan for this species was published in 2012.[30] A Threat Abatement Plan for predation by feral cats was published in 2015.[31]

3.2.3.15.3 Regent parrot (vulnerable)

Distribution: the regent parrot (eastern) is confined to the semi-arid interior of south-eastern mainland Australia. In New South Wales the Regent Parrot (eastern) is confined to the southern

[30] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-swift-parrot-lathamus-discolor

[31] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats

Lower Western Region, mainly along the Murray River, from Kyalite, north west to Mallee Cliffs State Forest, and is also recorded near Wentworth and the Rufous River. Away from the Murray River, the subspecies is recorded at isolated localities including west of Moonlight Lake, Arumpo Station, and near Pooncarie. In Victoria, the subspecies is restricted to the Mallee district in three main areas: the first from Piangil, west to Manangatang and north to Robinvale; the second, in the region of Hattah-Kulkyne National Park, extending from near Kiamal north to near Carwarp and Nangiloc; and the third in the Wimmera River system, especially Wyperfeld National Park, south to Lake Hindmarsh. Elsewhere in Victoria, the regent parrot (eastern) is widespread but more scattered, from Nyah, south to Lake Hindmarsh and north to the Murray River west of Ned's Corner. In South Australia, the subspecies is restricted to the Murray-Mallee District.

Using the descriptors given in Table 5, the regent parrot has a moderate (likely 25 to 50%) overlap with carp, and within this are distributed sporadically (Figure 25). From a purely geographical standpoint, this combination places the regent parrot at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 25 Distribution of the regent parrot and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the regent parrot)

Diet: the regent parrot feeds mainly on the seeds of grasses and herbaceous plants, but also eats fruits, buds, flowers and, occasionally, insect larvae, psyllids and lerps.

Roosting: nests are most often located in river red gum and, occasionally, in black box, usually within 15 metres of permanent water (or sometimes actually standing in water).

Habitat: the regent parrot (eastern) primarily inhabits riparian or littoral river red gum forests or woodlands and adjacent black box woodlands. Nearby open Mallee woodland or shrubland, usually with a ground cover of spinifex or other grasses, supporting various eucalypts, especially Christmas mallee and yellow mallee, as well as Belah, Buloke or slender cypress pine also provide important habitat for this subspecies. They often occur in farmland, especially if the farmland supports remnant patches of woodland along roadsides or in paddocks.

Unmanaged risk: risk factors for bush-birds as a functional group were outlined within the discussion of regent honeyeaters (above). The risks faced by the regent parrot will encompass these factors but are likely to be slightly higher on account of the regent parrot's predilection for riparian forest – including some of the key ephemeral wetland and floodplain systems within the Murray-Darlin Basin. These considerations, when viewed in conjunction with the distributions of the regent parrot and carp (above), led to the ratings for likelihood and risk shown in Table 29. As this species is not migratory, the ratings are for threatened species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 29 Unmanged and managed (residual) risks for the regent parrot

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Unlikely	Medium	Negligible	Negligible
	Impact on the quality of water or habitat	Unlikely	Medium	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Unlikely	Medium	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the regent parrot are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of the regent parrot, mitigations will focus on the mid-lower Murray River and its tributaries. With these mitigations available if required, the managed (residual) likelihoods and risks for regent parrot are given in Table 29. There are no non-negligible residual risks.

Recovery Plans and Threat Abatement Plans: A Recovery Plan for this species was published in 2012.[32] A Threat Abatement Plan for competition and land degradation by rabbits was published in 2016.[33]

3.2.3.15.4 Superb parrot (vulnerable)

Distribution: the superb parrot is found in New South Wales and northern Victoria, where it occurs on the inland slopes of the Great Divide and on adjacent plains, especially along the major

[32] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-regent-parrot-eastern-subspecies-polytelis-anthopeplus-monarchoides

[33] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016

river-systems; vagrants have also been recorded in southern Queensland. In New South Wales, it mostly occurs west of the Great Divide, where it mainly inhabits the Riverina, the South-west Slope and Southern Tableland Regions. Its range extends north to around Narrabri and Wee Waa in the North-west Plain Region, from a line joining Coonabarabran and Narrabri, and extending at least as far west as Tottenham and Quambone, with occasional records even further west. In Victoria, the Superb Parrot is confined to the north of the State, with records mainly around Barmah State Forest/State Park, with occasional records near Strathmerton, in the Killawarra State Forest and near Mooroopna. The species has recently been recorded in southern Queensland near Eulo and also between Warwick and Goondiwindi.

Using the descriptors given in Table 5, the superb parrot has a moderate (likely 25 to 50%) overlap with carp, and within this are distributed sporadically (Figure 26). From a purely geographical standpoint, this combination places the superb parrot at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

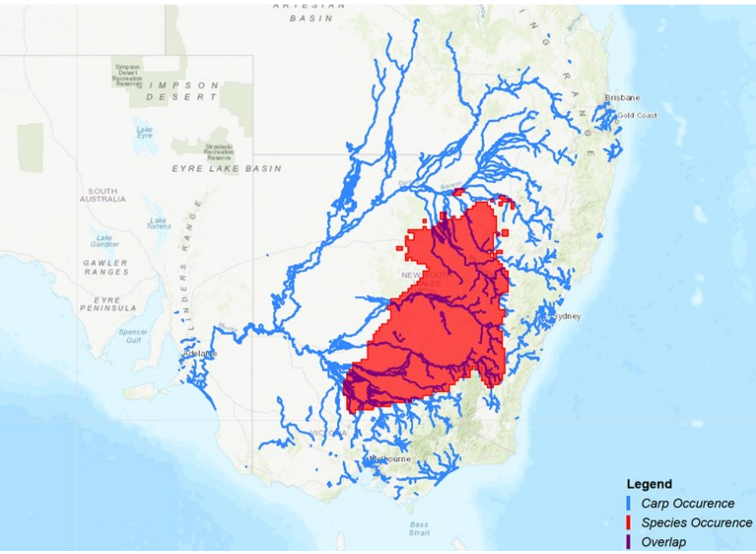

Figure 26 Distribution of the superb parrot and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the superb parrot)

Diet: when foraging on the ground, superb parrots often eat the seeds of plants such as the native ringed wallaby-grass, barley-grasses, as well as cereal crops including wheat, oats and canola; and spilt grain. They also eat the seed-pods of many understorey species of wattles such as gold-dust wattle, silver wattle and Deane's wattle and cultivated Cootamundra wattle. When foraging in the forest canopy, superb parrots eat the flowers and fruits of eucalypts, especially in spring and summer, the berries of mistletoe, such as box mistletoe and grey mistletoe, and, in winter, lerps from the foliage of eucalypts.

Roosting: in the Murray-Riverina, nest sites are usually located no further than 10 km from foraging habitat, and in the southwest Slopes Region, breeding and foraging habitats may coincide at some sites, and are no further than 10 km away at other sites.

Habitat: the superb parrot mainly inhabits forests and woodlands dominated by eucalypts, especially river red gums and box eucalypts such as yellow box or grey box. The species also seasonally occurs in box-pine and Boree (*Acacia pendula*) woodlands.

Unmanaged risk: risk factors for bush-birds as a functional group were outlined within the discussion of regent honeyeaters (above). The risks faced by the superb parrot will encompass these factors, with some adjustment to take account of its diet and habitat preferences. These considerations, when viewed in conjunction with the distributions of the superb parrot and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 30. As this species is not migratory, the ratings are for threatened species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 30 Unmanged and managed (residual) risks for the superb parrot

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the superb parrot are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of the superb parrot, mitigations will need to focus on the central Murray-Darling Basin. With these mitigations available if required, the managed (residual) likelihoods and risks for superb parrot are given in Table 30. The non-negligible (Medium) risks remaining after management follow from the effects of an outbreak of botulism and from widespread cyanobacterial blooms.

Recovery Plans and Threat Abatement Plans: A Recovery Plan for this species was published in 2011.[34] The Department of Environment and Energy notes that, “No Threat Abatement Plan has been identified as being relevant for this species”.

[34] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-superb-parrot-polytelis-swainsonii

Table 31 Exposure of threatened and migratory bush-birds from a geographical stanpoint

EPBC listing	Migratory	Species	Distribution and habitat in Australia	Breeds in Australia	Population overlap categorisation[35]	Population distribution categorisation	Geographical exposure
Critically endangered	No	Regent honeyeater	The Regent honeyeater is endemic to mainland south-eastern Australia. It has a patchy distribution which extends from south-east Queensland, through New South Wales (New South Wales) and the Australian Capital Territory (Australian Capital Territory), to central Victoria. Records are widely distributed across its range, but it is only found regularly at a few localities in New South Wales and Victoria where most of the sightings have been recorded. There are four known key breeding areas: three in New South Wales and one in Victoria. The species mostly inhabits inland slopes of the Great Dividing Range, in areas of low to moderate relief with moist, fertile soils. It is most commonly associated with box-ironbark eucalypt woodland and dry sclerophyll forest, but also inhabits riparian vegetation such as sheoak where it feeds on needle-leaved mistletoe and sometimes breeds. It sometimes utilises lowland coastal forest, which may act as a refuge when its usual habitat is affected by drought.	Yes	Moderate	Sporadic	Moderate
Critically endangered	No	Swift parrot	The swift parrot breeds in Tasmania during the summer and the entire population migrates north to mainland Australia for the winter. Whilst on the mainland the swift parrot is found principally in Victoria and New South Wales. In Victoria, swift parrots are predominantly found in the dry forests and woodlands of the box-ironbark region on the inland slopes of the Great Dividing Range. During periods of drought in central Victoria, swift parrots may concentrate in coastal drought refuge habitats in New South Wales. In New South Wales, swift parrots forage in forests and woodlands throughout the coastal and western slopes regions each year. Coastal regions tend to support larger numbers of birds when inland habitats are subjected to drought.	Yes Tasmania only	Moderate	Sporadic	Moderate

[35] Note that for Bush Birds, population overlap considers whether species are riparian or otherwise water-focussed

EPBC listing	Migratory	Species	Distribution and habitat in Australia	Breeds in Australia	Population overlap categorisation[35]	Population distribution categorisation	Geographical exposure
Critically endangered	No	Plains-wanderer	Plains-wanderers are distributed across north-central Victoria, southern New South Wales around the Riverina region, eastern South Australia and west-central Queensland. The species was historically recorded in south-east South Australia, eastern New South Wales and south-east Queensland however they are possibly no longer extant in these locations. Plains-wanderers inhabit sparse grasslands with c.50% bare ground, with most vegetation less than 5 cm in height.	Yes	Low	Sporadic	Low
Endangered	No	Rufous scrub-bird	The rufous scrub bird occurs in high-rainfall areas above 600 m sea level in south-eastern Queensland and north-eastern New South Wales. The species occurs in the Gibraltar Ranges, Border Ranges, the northern part of the McPherson Range and in parts of the Main Range, but formerly occurred in lowland habitats of the Richmond and Tweed River basins. The species occurs on Barrington Tops, Hastings Range and in the Dorrigo/Ebor area.	Yes	Low	Sporadic	Low
Endangered	No	Red-tailed black cockatoo	The southeastern red-tailed black cockatoo occurs in a discrete population on the border of south-western Victoria and south-eastern South Australia.	Yes	Low	Diffuse	Low
Endangered	No	Black-eared miner	Black-eared Miners are restricted to small, local colonies in the Mallee region of north-western Victoria, east to Hattah-Kulkyne National Park, and through the Murray Mallee of South Australia north to the Murray River, and to the far south-west corner of New South Wales. Black-eared Miners are restricted to mature Mallee eucalypt woodland, in areas that have not been burnt for at least 50 years and have not been cleared.	Yes	Low	Diffuse	Low
Vulnerable	No	Painted honeyeater	The species is sparsely distributed from south-eastern Australia to north-western Queensland and eastern Northern Territory. The greatest concentrations and almost all records of breeding come from south of 26ºS, on inland slopes of the Great Dividing Range between the Grampians, Victoria and Roma, Queensland.	Yes	Low	Sporadic	Low
Vulnerable	No	Malleefowl	The malleefowl occurs in dry / semi-arid regions of Western Australia, South Australia, Victoria and New South Wales – including the Murray-Darling Basin.	Yes	Low	Sporadic	Low
Vulnerable	No	Red-lored whistler	The Red-lored Whistler occurs in semi-arid regions of New South Wales, Victoria and South Australia. The core of the population is centred on the South Australia-Victoria border, where it occurs in the Murray-Mallee region and Upper South-East region (including Riverland Biosphere Reserve) of South Australia, and in the Big Desert and Sunset Country areas of Victoria. The Red-lored Whistler inhabits low mallee shrublands, heathlands and woodlands that have an open canopy and a moderately dense but patchy understorey.	Yes	Low	Sporadic	Low

EPBC listing	Migratory	Species	Distribution and habitat in Australia	Breeds in Australia	Population overlap categorisation[35]	Population distribution categorisation	Geographical exposure
Vulnerable	No	Regent parrot	The Regent Parrot (eastern) is confined to the semi-arid interior of southeastern mainland Australia. In New South Wales the Regent Parrot (eastern) is confined to the southern Lower Western Region, mainly along the Murray River, from Kyalite, north west to Mallee Cliffs State Forest, and is also recorded near Wentworth and the Rufous River. Away from the Murray River, the subspecies is recorded at isolated localities including west of Moonlight Lake, Arumpo Station, and near Pooncarie. In Victoria, the subspecies is restricted to the Mallee district in three main areas: the first from Piangil, west to Manangatang and north to Robinvale; the second, in the region of Hattah-Kulkyne National Park, extending from near Kiamal north to near Carwarp and Nangiloc; and the third in the Wimmera River system, especially Wyperfeld National Park, south to Lake Hindmarsh. Elsewhere in Victoria, the Regent Parrot (eastern) is widespread but more scattered, from Nyah, south to Lake Hindmarsh and north to the Murray River west of Neds Corner. In South Australia, the subspecies is restricted to the Murray-Mallee District.	Yes	Moderate	Sporadic	Moderate
Vulnerable	No	Superb parrot	The superb parrot is found in New South Wales and northern Victoria, where it occurs on the inland slopes of the Great Divide and on adjacent plains, especially along the major river-systems; vagrants have also been recorded in southern Queensland. In New South Wales, it mostly occurs west of the Great Divide, where it mainly inhabits the Riverina, the South-west Slope and Southern Tableland Regions. Its range extends north to around Narrabri and Wee Waa in the North-west Plain Region, from a line joining Coonabarabran and Narrabri, and extending at least as far west as Tottenham and Quambone, with occasional records even further west. In Victoria, the Superb Parrot is confined to the north of the State, with records mainly around Barmah State Forest/State Park, with occasional records near Strathmerton, in the Killawarra State Forest and near Mooroopna. The species has recently been recorded in southern Queensland near Eulo and also between Warwick and Goondiwindi.	Yes	Moderate	Sporadic	Moderate

EPBC listing	Migratory	Species	Distribution and habitat in Australia	Breeds in Australia	Population overlap categorisation[35]	Population distribution categorisation	Geographical exposure
Vulnerable	No	Mallee western whipbird	The Western Whipbird (eastern) occurs in three isolated regional populations in southern South Australia: the first on the southern Eyre Peninsula; the second on the south-western Yorke Peninsula; and the third in the Murray-Mallee region of south-eastern South Australia (perhaps extending across the border to western Victoria). It may also occur in a fourth isolated population in north-western Victoria. The Western Whipbird (eastern) inhabits Mallee and thicket vegetation in coastal and inland areas of southern South Australia. It usually occurs in habitats that have an open layer of Mallee and an understorey of dense shrubs. It occurs in Mallee scrub on sand flats, dunes and limestone that consists of an overstorey of Mallee eucalypts.	Yes	Low	Sporadic	Low
-	Yes	Fork-tailed swift	The Fork-tailed Swift is a non-breeding visitor to all states and territories of Australia. In Queensland there are scattered records of the Fork-tailed Swift in the Gulf Country, and a few records on Cape York Peninsula. In the north-east region there are many records east of the Great Divide from near Cooktown and south to Townsville. They are also widespread but scattered in coastal areas from 20° S, south to Brisbane and in much of the south south-eastern region. They are more widespread west of the Great Divide and are commonly found west of the line joining Chinchilla and Hughenden. They are found to the west between Richmond and Winton, Longreach, Gowan Range, Maraila National Park and Dirranbandi. They are rarely found further west to Windorah and Thargomindah. In New South Wales and Victoria, the Fork-tailed Swift is recorded in all regions. The species also occurs in Tasmania, South Australia, Western Australia, the Northern Territory and on offshore islands.	No	Low	Sporadic	Low
-	Yes	Oriental cuckoo	The Oriental Cuckoo is found across northern Australia and down the eastern seaboard as far as northern Victoria.	No	Low	Sporadic	Low

EPBC listing	Migratory	Species	Distribution and habitat in Australia	Breeds in Australia	Population overlap categorisation[35]	Population distribution categorisation	Geographical exposure
-	Yes	White-throated needletail	The White-throated Needletail is widespread in eastern and south-eastern Australia. In eastern Australia, it is recorded in all coastal regions of Queensland and New South Wales, extending inland to the western slopes of the Great Divide and occasionally onto the adjacent inland plains. Further south on the mainland, it is widespread in Victoria, though more so on and south of the Great Divide, and there are few records in western Victoria outside the Grampians and the South West. The species occurs in adjacent areas of south-eastern South Australia, where it extends west to the Yorke Peninsula and the Mount Lofty Ranges. It is also widespread in Tasmania. The species is essentially aerial, although occur most commonly above wooded areas, including open forest and rainforest, and may also fly between trees or in clearings, below the canopy, but they are less commonly recorded flying above woodland	No	Low	Sporadic	Low
-	Yes	Grey wagtail	The Grey Wagtail occurs in Western Australia, the Northern Territory, South Australia and Western Queensland.	No	Low	Sporadic	Low
-	Yes	Yellow wagtail	The Yellow Wagtail occurs across al Australian states and Territories.	No	Low	Sporadic	Low
-	Yes	Little curlew	Little Curlews generally spend the non-breeding season in northern Australia from Port Hedland in Western Australia to the Queensland coast. There are records of the species from inland Australia, and widespread but scattered records on the east coast. The species has also been recorded on Lord Howe Island, Cocos-Keeling Island and Christmas Island.	No	Low	Sporadic	Low

3.2.3.16 Raptors

The vulnerable red goshawk is the single threatened species of raptor with a distribution that overlaps with carp. The eastern osprey is listed under international agreements for the protection of migratory species to which Australia is a party.

3.2.3.16.1 Red goshawk (vulnerable)

Distribution: the red goshawk is sparsely dispersed across approximately 15 percent of coastal and sub-coastal Australia, from western Kimberley Division (north of 19°S) to north-eastern New South Wales (north of 33°) and occasionally on continental islands. Reported sightings in central Australia are likely to be individuals in transit (c.f. breeding). The Queensland Department of Natural Resources included the red goshawk in a list of species that 'may be found' in the Moonie River Catchment (DRN, 1999).

Using the descriptors given in Table 5, the red goshawk has a low (likely substantially less than 25%) overlap with carp, and within this are distributed sporadically (Figure 27). From a purely geographical standpoint, this combination places the red goshawk at very low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

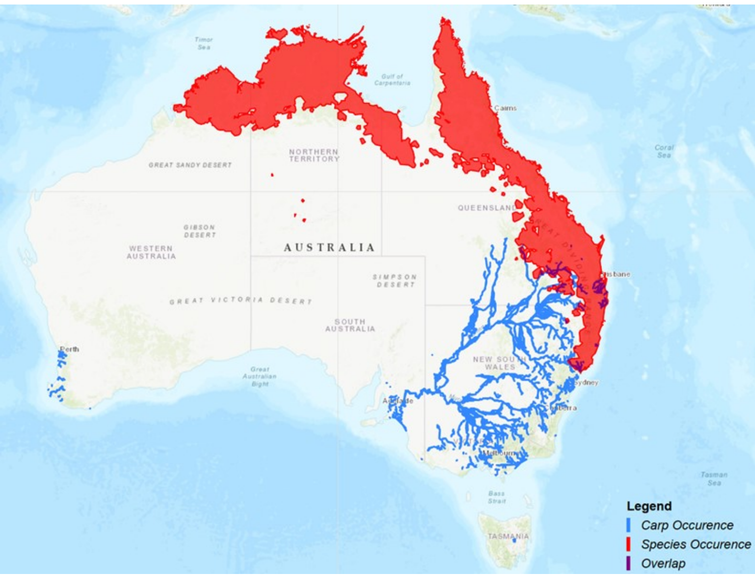

Figure 27 Distribution of the red goshawk and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the red goshawk)

Diet: the red goshawk feeds on live birds, including some larger waterbirds. It does not eat fish or carrion.

Roosting: as below.

Habitat: the red goshawk favours forested and woodland habitat (including riparian habitat) where it nests in the largest available trees. The Department of Environment and Energy notes that the species generally nests within 1 km of, and often beside permanent water.[36] This includes rivers, swamps and waterholes.

Unmanaged risk: the exposure of raptors to cyanotoxins would include drinking affected water and consuming affected waterbirds. As cyanotoxins can bioaccumulate, repeated low-dose exposures might in theory result in breaching the toxic threshold. The exposure of raptors to proliferating waterborne microorganisms may also be quite high, although the extent of uncertainty in respect of the particular microorganisms involved makes conclusions about the likely impact of this exposure difficult. Although there is evidence that some raptors are relatively resistant to type C (or C/D mosaic) botulinum toxin, there not any conclusive studies that show that this holds for Australian raptors. The more significant mitigating factor for the **red goshawk** is the likelihood that its geographic distribution only marginally overlaps with the most northern extent of the distribution of carp. The red goshawk is also extremely mobile, and likely to be able to avoid areas where an outbreak of CyHV-3 has led to a water quality effects or botulism. If it is present in the Moonie River Catchment and similar catchments in southern Queensland, then exposure to cyanotoxins or botulism is possible in those settings although extremely unlikely.

These considerations, when viewed in conjunction with the distributions of the eastern osprey and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 32. As this species is not migratory, the ratings are for threatened species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 32 Unmanged and managed (residual) risks for the red goshawk

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

[36] See: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=942

Risk mitigation and residual risk: the key risks for the red goshawk are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the red goshawk, mitigations will focus on northern part of the Murray-Darling Basin. With these mitigations available if required, the managed (residual) likelihoods and risks for red goshawk are given in Table 32. There are no non-negligible residual risks.

Recovery Plans and Threat Abatement Plans: a Recovery Plan for the red goshawk was published in 2012.[37] There is no Threat Abatement Plan for this species.

3.2.3.16.2 Eastern osprey (migratory)

Distribution: the breeding range of the eastern osprey extends around the northern coast of Australia (including many offshore islands) from Albany in Western Australia to Lake Macquarie in New South Wales; with a second isolated breeding population on the coast of South Australia, extending from Head of Bight east to Cape Spencer and Kangaroo Island. It is included in the list of species identified within the Coorong and Lakes Alexandrina and Albert, although the breeding population in South Australia is small and fragmented.

Using the descriptors given in Table 5, the eastern osprey has a low (likely substantially less than 25%) overlap with carp, and within this are distributed sporadically (Figure 28). From a purely geographical standpoint, this combination places the eastern osprey at very low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

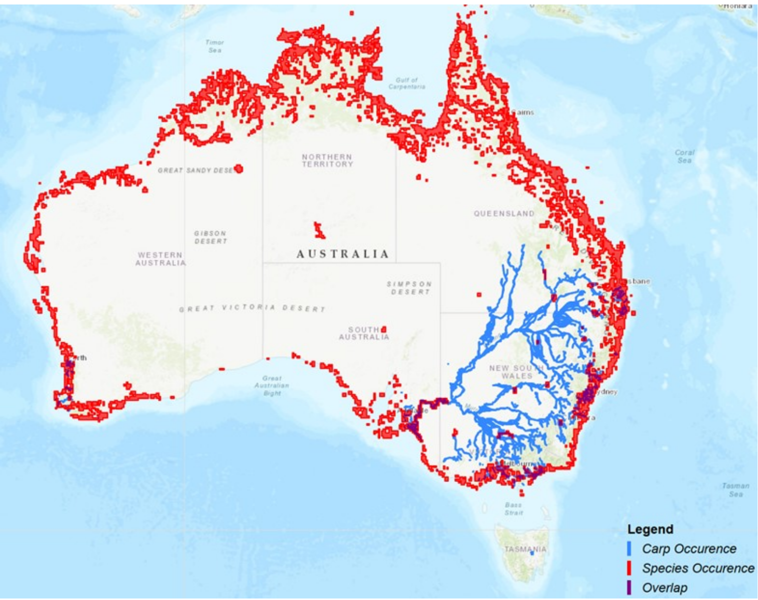

Figure 28 Distribution of the eastern osprey and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the eastern osprey)

Diet: Ospreys feed primarily on live fish, but may take molluscs, crustaceans, insects, reptiles, birds

[37] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-red-goshawk-erythrotriorchis-radiatus

and mammals.

Roosting: eastern osprey nests vary in size and shape, although are generally large and are mostly composed of sticks. They are constructed in a variety of natural and artificial sites including in dead or partly dead trees or bushes; on cliffs, rocks, rock stacks or islets; on the ground on rocky headlands, coral cays, deserted beaches, sandhills or saltmarshes; and on artificial nest platforms, pylons, jetties, lighthouses, navigation towers, cranes, exposed shipwrecks and offshore drilling rigs.

Habitat: Eastern ospreys occur in littoral and coastal habitats and terrestrial wetlands, although occasionally travel inland along major rivers, particularly in northern Australia.

Unmanaged risk: the exposure of raptors to cyanotoxins would include drinking affected water and consuming affected waterbirds. As cyanotoxins can bioaccumulate, repeated low-dose exposures might in theory result in breaching the toxic threshold. The exposure of raptors to proliferating waterborne microorganisms may also be quite high, although the extent of uncertainty in respect of the particular microorganisms involved makes conclusions about the likely impact of this exposure difficult. Although there is evidence that some raptors are relatively resistant to type C (or C/D mosaic) botulinum toxin, there not any conclusive studies that show that this holds for Australian raptors.

These considerations, when viewed in conjunction with the distributions of the eastern osprey and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 33. As this species is migratory but not threatened, the ratings are for migratory species only. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 33 Unmanged and managed (residual) risks for the eastern osprey

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Rare	Minor	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Rare	Minor	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Negligible	Negligible	Negligible	Negligible
Removal of a dominant and stable food source	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Negligible	Negligible	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of	Negligible	Negligible	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	an ecologically significant-proportion of the population of a migratory species.				
Botulism	Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species.	Rare	Minor	Negligible	Negligible
	Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant-proportion of the population of a migratory species.	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the eastern osprey are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the eastern osprey, mitigations will focus largely on the coastal extent of the distribution of carp, including the Lower Lakes and Coorong. With these mitigations available if required, the managed (residual) likelihoods and risks for eastern osprey are given in Table 33. There are no non-negligible residual risks.

Recovery Plans and Threat Abatement Plans: there is no Recovery Plan or Threat Abatement Plan for this species.

3.2.4 Frogs

3.2.4.1 Southern corroboree frog (critically endangered)

The southern corroboree frog historically occurred across sub-alpine areas within Koscuiszko National Park, from Smiggin Holes in the south, northwards to the Maragle Range about 5 km west of Cabramurra. The species is now restricted to the Jagungal Wilderness area in New South Wales in the northwest of its former range. It is now extinct, or in very reduced numbers, at previous locations, particularly Pretty Plain, Happy Jacks Plain, Finns Swamp, Whites River and the Smiggin Holes and the Guthega area south of the Snowy River.

Using the descriptors given in Table 5, the southern corroboree frog has a low (likely less than 25%) overlap with carp, and within this are sporadically distributed (Figure 29).

The minimal overlap between the distribution of the southern corroboree frog and that of carp, the very low biomass density of carp at high altitude (if present at all), and the low temperature of waterways within the alpine region in which it is endemic, mean that there is not a real chance or possibility that this species could be harmed as a result of an outbreak of CyHV-3.

Figure 29 Distribution of the southern corroboree frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the southern corroboree frog)

3.2.4.2 Northern corroboree frog (critically endangered)

The northern corroboree frog occurs in two populations: one in the Bogong Mountains/Fiery Range in New South Wales, and the other in the Brindabella Ranges in the Australian Capital Territory. Local extinctions have resulted in severe fragmentation. The Fiery Range population occurs from Yarrangobilly to Buccleuch State Forest at 850 to 1,520 metres. The Brindabella Range population occupies the area from California Flats to Mt Bimberi at 1,090 to 1,840 metres and is made up of two subpopulations, each represented by frogs that are slightly genetically different.

Using the descriptors given in Table 5, northern corroboree frog have a low (likely less than 25%) overlap with carp, and within this are sporadically distributed (Figure 30).

The minimal overlap between the distribution of the northern corroboree frog and that of carp, the very low biomass density of carp at high altitude (if present at all), and the low temperature of waterways within the two alpine regions, mean that there is not a real chance or possibility that this species could be harmed as a result of an outbreak of CyHV-3.

Figure 30 Distribution of the northern corroboree frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the northern corroboree frog)

3.2.4.3 Booroolong frog (endangered)

Distribution: the booroolong frog is restricted to tablelands and slopes in New South Wales and northeast Victoria at 200 to 1,300 metres. It is predominantly found along the western-flowing streams and their headwaters of the Great Dividing Range, and a small number of eastern-flowing streams in the north end of its range.

Using the descriptors given in Table 5, booroolong frog have a moderate (likely 25 to 50%) overlap with carp, and within this are micro-endemic with an estimated fewer than 5,000 individuals remaining in the wild (Figure 31). From a purely geographical standpoint, this combination places the booroolong frog at maximum exposure to the harmful effects of an outbreak of CyHV-3 in carp.

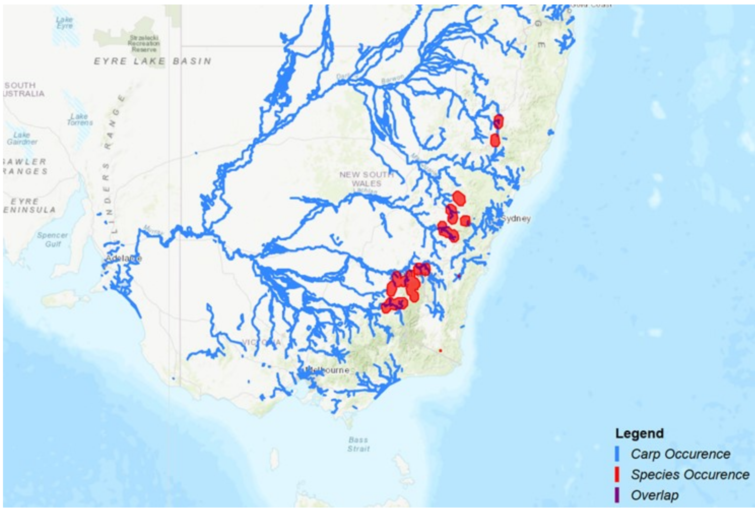

Figure 31 Distribution of the booroolong frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the booroolong frog)

Diet: the booroolong frog is a generalist predator of arthropods.

Breeding and movement: the booroolong frog is a seasonal breeder. Males begin calling in August, from exposed rocks or rock crevices, near shallow pools or runs. Breeding occurs during spring and early summer. Tadpoles metamorphose in late summer to early autumn. The eggs are small and pigmented and are laid in large numbers in submerged rock crevices. Tadpoles grow in slow flowing connected or isolated pools. The dispersal capabilities and non-breeding habitats of the species are unknown, but the species is relatively sedentary. The majority of individuals move less than 50 metres within a season, with maximum movements of up to 300 metres being recorded across seasons.

Habitat: the booroolong frog occurs along permanent streams with some fringing vegetation cover such as ferns, sedges or grasses. Adults occur on or near cobble banks and other rock structures within stream margins, or near slow-flowing connected or isolated pools that contain suitable rock habitats. Streams range from small slow-flowing creeks to large rivers in dissected mountainous country, tablelands, foothills and lowland plains.

Unmanaged risk: exposure of frogs to cyanotoxins as a result of a widespread bloom could arise from consuming affected insects or from contact with, and consumption of, affected water. Most frogs spawn in spring and summer and this is likely to coincide with the spawning of carp and an outbreak of CyHV-3. Both eggs and tadpoles may be exposed to cyanotoxins in the event of a widespread bloom. Although frogs have some ability to move between waterbodies, it is relatively unlikely that they would be able to avoid a widespread cyanobacterial bloom. Although an aggressive outbreak of CyHV-3 is more likely to lead to a widespread cyanobacterial bloom in a lower-flow setting, a bloom that coincided with inundation of wetland and floodplain habitat would be likely to impact on frog populations. Frogs may also be exposed to prey-switching if breeding piscivorous waterbirds feeding substantially on juvenile carp are faced with the sudden removal of this otherwise stable and abundant source of food. In some settings, this might include frog spawn and tadpoles. No references were identified to substantiate the occurrence of type C (or C/D mosaic) botulism in frogs, although some early papers about the physiology of botulinum toxin included reference to frog skeletal muscle paralysis. If this translates to exposure in type C (or C/D mosaic) outbreaks of botulism in wildlife, then frogs in most settings may be exposed where either the carcass-maggot cycle or the germination of environmental spores are plausible.

These considerations, when viewed in conjunction with the distribution of carp (above), and the habitat that the booroolong frog occupies, led to the ratings for likelihood and risk shown in Table 34. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 34 Unmanged and managed (residual) risks for the booroolong frog

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the booroolong frog are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of the booroolong frog, mitigations will be restricted to tablelands and slopes in New South Wales and northeast Victoria. With these mitigations available if required, the managed (residual) likelihoods and risks for booroolong frog are given in Table 34. The non-negligible (Medium and Minor) risks remaining after management follow from the effects of a widespread cyanobacterial bloom and from prey-switching, respectively.

Recovery Plans and Threat Abatement Plans: a Recovery Plan for this species was published in 2012.[38] A Threat Abatement Plan was published for infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016).[39]

3.2.4.4 Yellow-spotted tree frog (endangered)

Distribution: this species occurs in two disjunct populations. The northern population is centred around the town of Guyra on the New England Tableland, New South Wales, at altitudes between 1000 and 1500 m. The species occupies the headwaters of the western flowing Booroolong Creek and to a lesser extent those of the eastern flowing Anne River and Sarah River. Near Armidale, the species has been recorded from Commissioners Waters, a tributary of the eastern flowing Gara River. The southern population has a restricted distribution between Canberra and Bombala, New South Wales, on the Southern Tablelands at altitudes between 700 and 800 metres. The southern tablelands population suffered an extensive decline, with no confirmed records since 1980. The Yellow-spotted Bell Frog was formerly known from Namadgi and Kosciusko National Parks and extensive areas of grassland used for grazing.

Using the descriptors given in Table 5, the yellow-spotted tree frog has a low (likely less than 25%) overlap with carp, and within this is micro-endemic (Figure 32).

The minimal overlap between the distribution of the yellow-spotted tree frog and that of carp, the very low biomass density of carp in the places where remnant populations exist (if carp are present at all), and the low temperature of waterways within the two high-elevation areas (the north in particular) mean that there is not a real chance or possibility that this species could be harmed as a result of an outbreak of CyHV-3.

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[38] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/booroolong-frog-litoria-booroolongensis-national-recovery-plan

[39] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016.

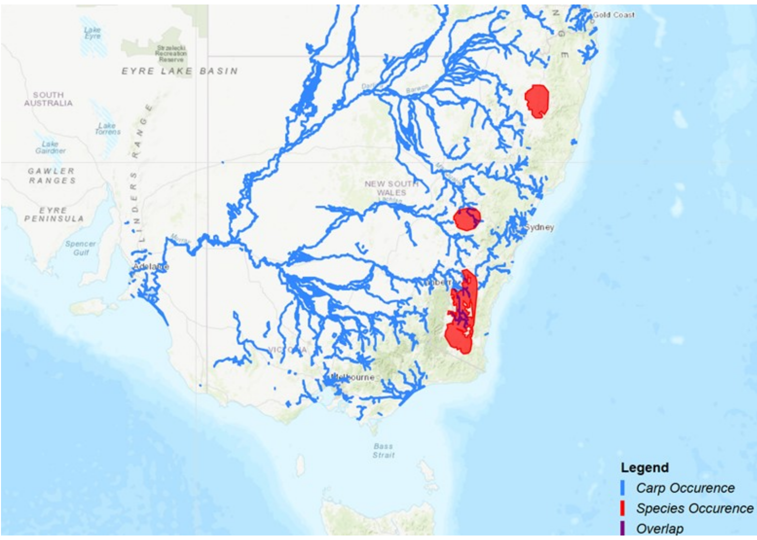

Figure 32 Distribution of yellow-spotted tree frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the yellow-spotted tree frog)

3.2.4.5 Spotted tree frog (endangered)

Distribution: the spotted tree frog is restricted predominantly to the western slopes of the Great Dividing Range, from Lake Eildon in the Central Highlands of Victoria to Mount Kosciuszko, New South Wales, at altitudes of 200 to 1,100 metres. The spotted tree frog is wholly distributed on public land from Kosciuszko National Park in New South Wales and Alpine National Park, Eildon National Park and Buffalo National Park, and several State Forests in Victoria.

Using the descriptors given in Table 5, the spotted tree frog has a low (likely less than 25%) overlap with carp, and within this is micro-endemic (Figure 33). From a purely geographical standpoint, this combination places the spotted tree frog at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 33 Distribution of the spotted tree frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the spotted tree frog)

Diet: adult spotted tree frogs are generalist insectivores, feeding on a variety of flying insects.

Breeding and movement: clutches of the spotted tree frog consist of 200 to 1,000 eggs. Eggs are laid in narrow spaces beneath large river stones within the stream and eggs are hidden as they adhere to the underside of the rock. The seasonal distribution of size classes of frogs and breeding activity suggest that eggs are laid in late spring/early summer and tadpoles reach metamorphosis in late summer to autumn.

Habitat: most populations of the spotted tree frog occurred in dissected, mountainous country, generally in areas with limited access and disturbance. It is found almost exclusively in association with rock habitats along streams. The spotted tree frog has been associated with a range of vegetation communities, from montane forest at high altitudes to wet and dry forest at moderate to low altitudes respectively. It occurs along sections of streams with steep banks, invariably in steeply dissected country or gorges with numerous rapids and waterfalls. The spotted tree frog is restricted to riffle and cascade stream sections with exposed rock banks, resulting in a highly patchy distribution along most streams.

Unmanaged risk: see the booroolong frog (above) for a description of the risk factors for Australian native frogs. These risk factors, when viewed in conjunction with the distributions of the spotted tree frog and carp (above), and the habitat it occupies, led to the ratings for likelihood and risk shown in Table 35. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 35 Unmanged and managed (residual) risks for the spotted tree frog

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the spotted tree frog are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of the spotted tree frog, mitigations will be restricted predominantly to the western slopes of the Great Dividing Range, from Lake Eildon in the Central Highlands of Victoria to Mount Kosciuszko, New South Wales. With these mitigations available if required, the managed (residual) likelihoods and risks for the spotted tree frog are given in Table 35. There are no remaining non-negligible risks.

Recovery Plans and Threat Abatement Plans: a Recovery Plan for this species was published in 2012.[40] A Threat Abatement Plan has been published for infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016).[41]

3.2.4.6 Fleay's frog (endangered)

Distribution: Fleay's frog is narrowly distributed in wet forests from the Conondale Range in south-east Queensland, south to Yabbra Scrub in north-east New South Wales

Using the descriptors given in Table 5, Fleay's frog has a low (likely less than 25%) overlap with carp, and within this are sporadically distributed (Figure 34).

The minimal overlap between the distribution of Fleay's frog and that of carp, and the very low biomass density of carp at high altitude (if present at all), mean that there is not a real chance or possibility that this species could be harmed as a result of an outbreak of CyHV-3.

Figure 34 Distribution of Fleay's frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of Fleay's frog)

3.2.4.7 Giant barred frog (endangered)

Distribution: the giant barred frog is distributed from Doongul Creek, Wongi State Forest, near Maryborough in south-eastern Queensland, south to Warrimoo in the Blue Mountains in New South Wales. The species is currently known from mid to low altitudes below 610 metres above sea level.

Using the descriptors given in Table 5, the giant barred frog has a low (likely less than 25%) overlap with carp, and within this is micro-endemic (Figure 35). From a purely geographical standpoint, this combination places the giant barred frog at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

[40] See: http://www.environment.gov.au/resource/spotted-tree-frog-1998-2002-recovery-plan

[41] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016

Figure 35 Distribution of the giant barred frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the giant barred frog)

Diet: adult giant barred frogs are generalist insectivores, feeding on a variety of flying insects.

Breeding and movement: the giant barred frog is a stream breeding species. Eggs are deposited out of the water, under overhanging banks or on steep banks of large pools. Displacement distances between diurnal refuges, after a night of activity, are small which suggests a high degree of fidelity to the previous day's shelter.

Habitat: the giant barred frog occurs in rainforests and wet sclerophyll forests in upper to lower catchment areas.

Unmanaged risk: see the booroolong frog (above) for a description of the risk factors for Australian native frogs. These risk factors, when viewed in conjunction with the distributions of the giant barred frog and carp (above), and the habitat it occupies, led to the ratings for likelihood and risk shown in Table 36. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 36 Unmanged and managed (residual) risks for the giant barred frog

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the giant barred frog are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of the giant barred frog, mitigations will be restricted to the area from Doongul Creek, Wongi State Forest, near Maryborough in south-eastern Queensland, south to Warrimoo in the Blue Mountains in New South Wales. With these mitigations available if required, the managed (residual) likelihoods and risks for the giant barred frog are given in Table 36. There are no remaining non-negligible risks.

Recovery Plans and Threat Abatement Plans: a Recovery Plan for this species was published in 2002.[42] Threat Abatement Plans were published for infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016)[43] and for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) (2017).[44]

3.2.4.8 Giant burrowing frog (vulnerable)

Distribution: the giant burrowing frog is confined to the eastern slopes of the Great Dividing Range and coastal regions from near Mt Coridudgy and Kings Cross in Wollemi National Park, New South Wales to Walhalla in the central highlands of eastern Victoria. The species exists as two distinct subpopulations: a northern population largely confined to the sandstone geology of the Sydney Basin and south to Jervis Bay, and a southern population occurring in disjunct regions from around Narooma southwards to eastern Victoria.

Using the descriptors given in Table 5, the giant burrowing frog has a low (likely less than 25%) overlap with carp, and within this is micro-endemic (Figure 36). From a purely geographical standpoint, this combination places the giant burrowing frog at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

[42] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-stream-frogs-south-east-queensland-2001-2005

[43] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016

[44] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017

Figure 36 Distribution of the giant burrowing frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the giant burrowing frog)

Diet: the species is considered a generalist terrestrial predator, including ants, beetles, spiders, scorpions, centipedes and cockroaches. Occasionally the diet includes aerial invertebrates such as moths.

Breeding and movement: breeding activity has been recorded throughout the year, but mating calls are most commonly heard in late summer or autumn following heavy rains. The giant burrowing frog is most commonly found on ridges away from breeding sites. Daylight hours are nearly always spent below ground in unformed burrows, but occasionally under logs or fallen branches, in grass trees or sitting on the leaf litter. This species also shows an ability to range widely with observations frequently occurring considerable distance from suitable riparian habitat, or other moist habitats. Studies suggest this species can move 200 to 300 metres a night and can take advantage of soft soil from the diggings of other animals.

Habitat: in the northern portion of its range, the giant burrowing frog occurs in hanging swamps on sandstone shelves and beside perennial creeks. In the southern portion of its range, the giant burrowing frog has been reported to occur in a wide range of forest communities including montane sclerophyll woodland, montane riparian woodland, as well as wet and dry sclerophyll forest.

Unmanaged risk: see the booroolong frog (above) for a description of the risk factors for Australian native frogs. These risk factors, when viewed in conjunction with the distributions of the giant burrowing frog and carp (above), and the terrestrial habitat it occupies, led to the ratings for likelihood and risk shown in Table 37. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 37 Unmanged and managed (residual) risks for the giant burrowing frog

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the giant burrowing frog are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of the giant burrowing frog, mitigations will be restricted to the eastern slopes of the Great Dividing Range and coastal regions from near Mt Coridudgy and Kings Cross in Wollemi National Park, New South Wales to Walhalla in the central highlands of eastern Victoria. With these mitigations available if required, the managed (residual) likelihoods and risks for the giant burrowing frog are given in Table 37. There are no remaining non-negligible risks.

Recovery Plans and Threat Abatement Plans: there is no Recovery Plan for this species. Threat Abatement Plans have been published for predation by feral cats (2015),[45] for infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016)[46] and for predation by the European red fox.[47]

3.2.4.9 Green and golden bell frog (vulnerable)

Distribution: the green and golden bell frog occurs mainly along coastal lowland areas of eastern New South Wales and Victoria. The most northern extent of the species distribution is from Yuraygir National Park near Grafton on the North Coast of New South Wales while the most southern extent of the species' distribution is in the vicinity of Lake Wellington, just west of Lakes Entrance in south-eastern Victoria. The furthest inland record of the species is at a recently discovered population near Hoskinstown in the Southern Tablelands of New South Wales. The species also occurs on Bowen Island in Jervis Bay, Kooragang Island and Broughton Island.

Using the descriptors given in Table 5, the green and golden bell frog has a low (likely less than 25%) overlap with carp, and within this is micro-endemic (Figure 37). From a purely geographical standpoint, this combination places the green and golden bell frog at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

[45] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats

[46] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016

[47] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox

Figure 37 Distribution of the green and golden bell frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the green and golden bell frog)

Diet: adult green and golden bell frogs are generalist insectivores, feeding on a variety of flying insects.

Breeding and movement: the species is known to breed during late winter to early autumn, but generally during September to February with a peak around January to February, after heavy rain or storms. The green and golden bell frog is highly mobile and may move among breeding sites.

Habitat: in New South Wales, the species commonly occupies disturbed habitats, and breeds largely in ephemeral ponds. However, in Victoria, it occupies habitats with little human disturbance and commonly breeds in permanent ponds, as well as ephemeral ponds.

Unmanaged risk: see the booroolong frog (above) for a description of the risk factors for Australian native frogs. These risk factors, when viewed in conjunction with the distributions of the green and golden bell frog and carp (above), led to the ratings for likelihood and risk shown in Table 38. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 38 Unmanged and managed (residual) risks for the green and golden bell frog

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the green and golden bell frog are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of the green and golden bell frog, mitigations will focus on the coastal lowland areas of eastern New South Wales and Victoria. With these mitigations available if required, the managed (residual) likelihoods and risks for the green and golden bell frog are given in Table 38. There are no remaining non-negligible risks.

Recovery Plans and Threat Abatement Plans: there is no Recovery Plan for this species. Threat Abatement Plans have been published for predation by feral cats (2015),[48] for infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016)[49] and for predation by the European red fox.[50]

3.2.4.10 Littlejohn's tree frog (vulnerable)

Distribution: Littlejohn's tree frog is confined to eastern New South Wales and north-east Victoria. The Frog occurs in scattered locations between the Watagan Mountains, New South Wales, to Buchan in Victoria. Despite its very large distribution there are very few records of Littlejohn's Tree Frog, and it is probably the least known and least frequently encountered frog in New South Wales.

Using the descriptors given in Table 5, the Littlejohn's tree frog has a low (likely less than 25%) overlap with carp, and within this is micro-endemic (Figure 38). From a purely geographical standpoint, this combination places the Littlejohn's tree frog at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

[48] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats

[49] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016

[50] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox

Figure 38 Distribution of the Littlejohn’s tree frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Littlejohn’s tree frog)

Diet: adult Littlejohn’s tree frogs are generalist insectivores, feeding on a variety of flying insects.

Breeding and movement: calling can occur at any time of year with a possible peak from February to April.

Habitat: Littlejohn's tree frog is known to inhabit forest, coastal woodland and heath from 100 to 950 metres above sea level, but the species is not associated with any specific vegetation types. Breeding habitat includes rocky streams and semi-permanent dams, still water in dams, ditches, isolated pools and flooded hollows, dams, creeks and lagoons, semi-permanent or permanent dams, ponds and creeks and temporary pools when sufficient run-off water is available.

Unmanaged risk: see the booroolong frog (above) for a description of the risk factors for Australian native frogs. These risk factors, when viewed in conjunction with the distributions of the Littlejohn’s tree frog and carp (above), led to the ratings for likelihood and risk shown in Table 39. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 39 Unmanged and managed (residual) risks for the Littlejohn’s tree frog

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the Littlejohn's tree frog are those stemming from the water quality effects of an outbreak of CyHV-3. The mitigations for these risks were outlined in Section 2.4. In the case of the Littlejohn's tree frog, mitigations will focus on eastern New South Wales and north-east Victoria. With these mitigations available if required, the managed (residual) likelihoods and risks for the Littlejohn's tree frog are given in Table 39. There are no remaining non-negligible risks.

Recovery Plans and Threat Abatement Plans: there is no Recovery Plan for this species. A Threat Abatement Plan was published for infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016).[51]

3.2.4.11 Growling grass frog (vulnerable)

Distribution: in New South Wales and the Australian Capital Territory, this species is currently widespread throughout the Murray River valley and has been recorded from six Catchment Management Areas in NSW: Lower Murray-Darling, Murrumbidgee, Murray, Lachlan, Central West and South East. The growling grass frog was previously widespread across Victoria and was absent only from the western desert regions and the eastern alpine regions, although persists now only in isolated populations in the greater Melbourne area, in the south-west of Victoria and a few sites in central Victoria and Gippsland. In South Australia, there are three distinct population: one group is located in the far south-east of the state (to near Keith) and adjoining Victorian populations; one group along the Murray River from Victoria to the coast; and a small group in the Mt Lofty Ranges. Growling grass frog populations in the Lower Lakes have declined significantly due to drought. The species also occurs in Tasmania.

Using the descriptors given in Table 5, growling grass frog have a moderate (likely 25 to 50%) overlap with carp, and within this are sporadically distributed (Figure 39). From a purely geographical standpoint, this combination places the growling grass frog at moderate exposure to the harmful effects of an outbreak of CyHV-3 in carp.

[51] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016

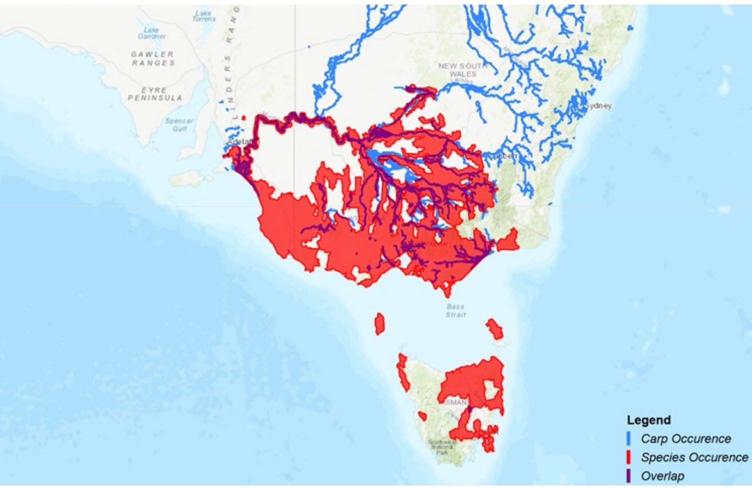

Figure 39 Distribution of the growling grass frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the growling grass frog)

Diet: the growling grass frog feeds principally on terrestrial invertebrates such as beetles, termites, cockroaches, moths, butterflies and various insect larvae.

Breeding and movement: growling grass frogs generally breed between November and March, following local flooding and a marked rise in water levels.

Habitat: the growling grass frog is generally located amongst emergent vegetation in or at the edges of still or slow-flowing water bodies such as lagoons, swamps, lakes, ponds and farm dams. The species can be found floating in warmer waters in temperatures between 18 to 25C.

Unmanaged risk: see the booroolong frog (above) for a description of the risk factors for Australian native frogs. These risk factors, when viewed in conjunction with the distributions of the growling grass frog and carp (above), and its propensity for aquatic habitat, led to the ratings for likelihood and risk shown in Table 40. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 40 Unmanged and managed (residual) risks for the growling grass frog

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Possible	High	Unlikely	Medium
	Impact on the quality of water or habitat	Possible	High	Unlikely	Medium
	Impact on food and other resources	Unlikely	Medium	Negligible	Negligible
	Impact on breeding cycle	Possible	High	Unlikely	Medium
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Possible	High	Rare	Minor
	Impact on breeding cycle	Possible	High	Rare	Minor
Botulism	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the growling grass frog are those stemming from the water quality effects of an outbreak of CyHV-3 and from prey-switching. The mitigations for these risks were outlined in Section 2.4. In the case of the growling grass frog, mitigations will be reasonably widespread across the southern Murray-Darling Basin. With these mitigations available if required, the managed (residual) likelihoods and risks for the growling grass frog are given in Table 40. There are no remaining non-negligible risks.

Recovery Plans and Threat Abatement Plans: a Recovery Plan for this species was published in 2012.[52] A Threat Abatement Plan was published for infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016).[53]

3.2.4.12 Stuttering frog (vulnerable)

Distribution: the Stuttering Frog is restricted to the eastern slopes of the Great Divide, from the Cann River catchment in far East Gippsland, Victoria, to tributaries of the Timbarra River near Drake, New South Wales.

Using the descriptors given in Table 5, the stuttering frog has a low (likely less than 25%) overlap with carp, and within this is sporadically distributed (Figure 40). From a purely geographical standpoint, this combination places the stuttering frog at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

[52] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-southern-bell-frog-litoria-raniformis

[53] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016

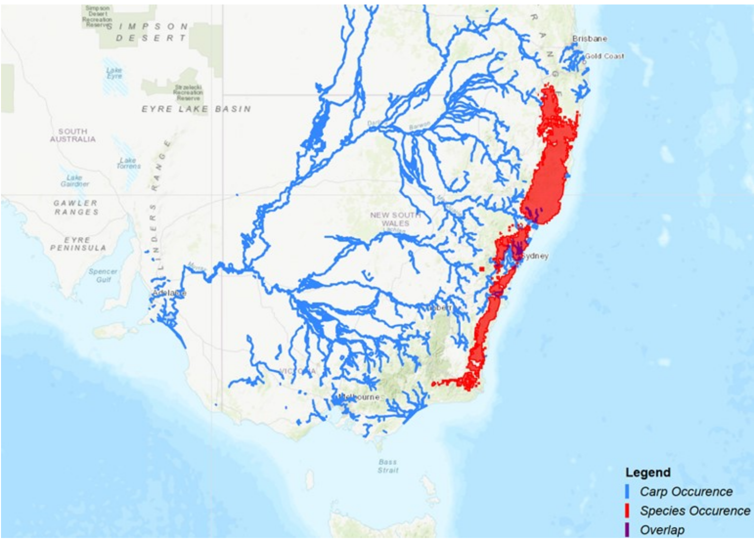

Figure 40 Distribution of the stuttering frog and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the stuttering frog)

Diet: adult stuttering frogs are generalist insectivores, feeding on a variety of flying insects.

Breeding and movement: a nest is constructed in the shallow running water (in the gravel or leaf litter) that occurs between pools in relatively wide, flat sections of mountain streams. The stuttering frog is mobile and may be found on roads some distance from its habitat during rain events.

Habitat: the stuttering frog is typically found in association with permanent streams through temperate and sub-tropical rainforest and wet sclerophyll forest, rarely in dry open tableland riparian vegetation, and also in moist gullies in dry forest.

Unmanaged risk: see the booroolong frog (above) for a description of the risk factors for Australian native frogs. These risk factors, when viewed in conjunction with the distributions of the stuttering frog and carp (above), led to the ratings for likelihood and risk shown in Table 41. The risks associated with other invasive species are discussed separately (Part II: Section 8).

Table 41 Unmanged and managed (residual) risks for the stuttering frog

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
Cyanobacterial blooms	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Rare	Minor	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Microorganisms with decomposing carcasses	Direct harm to species, with an impact on population strength	Rare	Minor	Negligible	Negligible
	Impact on the quality of water or habitat	Rare	Minor	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Rare	Minor	Negligible	Negligible
Increased predation with prey-switching	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible
Botulism	Direct harm to species, with an impact on population strength	Negligible	Negligible	Negligible	Negligible

Exposure pathway	Impact area	Unmanaged		Managed	
		Likelihood	Risk	Likelihood	Risk
	Impact on the quality of water or habitat	Negligible	Negligible	Negligible	Negligible
	Impact on food and other resources	Negligible	Negligible	Negligible	Negligible
	Impact on breeding cycle	Negligible	Negligible	Negligible	Negligible

Risk mitigation and residual risk: the key risks for the stuttering frog are those stemming from the water quality effects of an outbreak of CyHV-3 and from botulism. The mitigations for these risks were outlined in Section 2.4. In the case of the stuttering frog, mitigations will be restricted to the eastern slopes of the Great Divide, from the Cann River catchment in far East Gippsland, Victoria, to tributaries of the Timbarra River near Drake, New South Wales. With these mitigations available if required, the managed (residual) likelihoods and risks for the stuttering frog are given in Table 41. There are no remaining non-negligible risks.

Recovery Plans and Threat Abatement Plans: a Recovery Plan for this species was developed in 2012.[54] A Threat Abatement Plan was published for infection of amphibians with chytrid fungus resulting in chytridiomycosis (2016).[55]

3.2.5 Freshwater turtles

3.2.5.1 Bellinger River snapping turtle (critically endangered)

Distribution: the Bellinger River snapping turtle has a restricted distribution within the Bellinger catchment on the north coast of New South Wales. A key component of the species' decline is the decimating effect of a disease epidemic in 2015, in which 433 individual Bellinger River snapping turtles are confirmed to have died – noting that the actual number of deaths is likely to be much higher as the majority of affected animals were found on shore close to the river. The mortality rate observed amongst affected turtles found was approximately 97 percent, with at least a 14 to 27 percent of the population lost in the 60 km reach of the Bellinger River in which the species is endemic. The turtle is also found in scattered populations within the Kalang River (also within the Bellinger River catchment).

Using the descriptors given in Table 5, the Bellinger River snapping turtle has a low overlap with carp (if carp are present at all within most of its range), and within this is micro-endemic (Figure 40). From a purely geographical standpoint, this combination places the Bellinger River snapping turtle at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

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[54] See: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-stuttering-frog-mixophyes-balbus

[55] See: http://www.environment.gov.au/biodiversity/threatened/publications/tap/infection-amphibians-chytrid-fungus-resulting-chytridiomycosis-2016

Figure 41 Distribution of the Bellinger River snapping turtle and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Bellinger River snapping turtle)

Diet: the species' diet includes macroinvertebrates, as well as some terrestrial fruit and aquatic vegetation such as ribbonweed.

Breeding and movement: female Bellinger River snapping turtles are gravid between September and November and nest between October and December. The species does not migrate.

Habitat: this species has a preference for moderate to deep pools with a rocky substrate.

Unmanaged risk: although freshwater turtles as a functional group might be exposed to the water quality effects of an outbreak of CyHV-3 (principally cyanobacterial blooms and proliferating microorganisms), to prey-switching (eggs and juveniles) and possibly to botulism, the Bellinger River snapping turtle occurs only in a catchment where the carp biomass density is very low. In addition, this species has a preference for moderate to deep pools with a rocky substrate. On balance, there is not a real chance or possibility that the Bellinger River snapping turtle will be placed at risk in the event of an outbreak of CyHV-3.

The risks associated with other invasive species are discussed separately (Part II: Section 8.

Risk mitigation and residual risk: not required.

Recovery Plans and Threat Abatement Plans: there is not a Recovery Plan or Threat Abatement Plan for the Bellinger River snapping turtle. The Department of Environment and Energy notes that, "*Recovery Plan not required, a conservation advice is sufficient as the species is found only within the catchment of the northern New South Wales Bellinger River. Given this very localised distribution, and the rapid and effective emergency response initiated by the New South Wales government after the disease outbreak affecting this species, a Commonwealth Recovery Plan is unnecessary*".

3.2.5.2 Bell's turtle (vulnerable)

Distribution: Bell's turtle is found in upland streams of the Namoi (one subpopulation), Gwydir (one subpopulation) and Border Rivers (three subpopulations) catchments in the Murray-Darling Basin. It occurs in four rivers in New South Wales, including the Namoi River, Gwydir River, Severn River and Deepwater River. In Queensland it is restricted to a section of Bald Rock Creek in and adjacent to Girraween National Park. The species is locally abundant with many thousands in the Namoi and Gwydir rivers, but the other subpopulations are much smaller.

Using the descriptors given in Table 5, the Bell’s turtle has a low (likely less than 25%) overlap with carp, and within this is sporadically distributed (Figure 40). From a purely geographical standpoint, this combination places the Bell’s turtle at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 42 Distribution of the Bell’s turtle and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Bell’s turtle)

Diet: this species is largely herbivorous, eating plant material such as fine aquatic weeds, stems of plants up to 30 mm long and fallen terrestrial leaves. Bell’s turtle will also opportunistically eat invertebrates, including crayfish and aquatic insects.

Breeding and movement: Bell's Turtle nesting occurs between October and mid-January. The species does not migrate.

Habitat: this species is restricted to upland streams (between 600 and 1,100 metres) that contain permanent pools deeper than about 2 metres, granite boulders and bedrock. Its habitat is often complex, with underwater caverns formed by boulders, logs and overhanging banks. In areas of lower velocity, the typical substratum is coarse granitic sand overlain by fine silt, algal growth, and dense beds of macrophytes. It is absent from areas away from flowing streams, such as farm ponds and natural wetlands. Larger, deeper waterholes tend to have the most abundant local populations because they provide daytime refuges, with foraging in shallow pool areas and riffles occurring at night.

Unmanaged risk: although freshwater turtles as a functional group might be exposed to the water quality effects of an outbreak of CyHV-3 (principally cyanobacterial blooms and proliferating microorganisms), to prey-switching (eggs and juveniles) and possibly to botulism, the Bell’s turtle is restricted to upland streams (between 600 and 1100 m altitude) that contain permanent pools deeper than about 2 metres, granite boulders and bedrock. In these settings, the carp biomass density is very low. On balance, there is not a real chance or possibility that the Bell’s turtle will be placed at risk in the event of an outbreak of CyHV-3.

The risks associated with other invasive species are discussed separately (Part II: Section 8).

Risk mitigation and residual risk: not required.

Recovery Plans and Threat Abatement Plans: there is not a Recovery Plan or Threat Abatement Plan for Bell's turtle. The Department of Environment and Energy notes that, "*Recovery Plan not required, included on the Not Commenced List*".

3.2.6 Crustaceans

The endangered Glenelg spiny crayfish is the single threatened crustacean whose distribution overlaps with that of carp.

Distribution: the Glenelg spiny crayfish occurs in a very limited area within the Glenelg River Basin and associated tributaries, and in several spring-fed coastal streams.

Using the descriptors given in Table 5, the Glenelg spiny crayfish has a low (likely less than 25%) overlap with carp, and within this is sporadically distributed (Figure 43). From a purely geographical standpoint, this combination places the Glenelg spiny crayfish at low exposure to the harmful effects of an outbreak of CyHV-3 in carp.

Figure 43 Distribution of the Glenelg spiny crayfish and its overlap with carp

Source: Department of Environment and Energy (known distribution of carp and likely distribution of the Glenelg spiny crayfish)

Diet: the Glenelg spiny crayfish is an omnivore, foraging on organic material as well as actively predating on fish and other macroinvertebrates. They are also known to strike at living prey, such as fish and other aquatic invertebrates. Adult Glenelg spiny crayfish can move significant amounts of riverbed substrate and organic matter during foraging, and this action is thought to play a role in nutrient recycling and structural dynamics in the streams where crayfish occur.

Breeding and movement: the Glenelg spiny crayfish reproduce annually, with fertilisation occurring in during May to June, producing a large clutch of eggs. This species has a very limited dispersal and re-colonisation ability and are not able to move effectively over land without being subject to desiccation and predation.

Habitat: the Glenelg spiny crayfish require flowing water throughout the year and prefer in-stream habitat that includes undercut banks, cobbles, rock boulders and woody debris as refuges. They are considered a specialist species, with typically low tolerance to environmental conditions (namely DO), ensuring that species requires specific habitat requirements.

Unmanaged risk: crustaceans may be exposed to the water quality effects of an outbreak of CyHV-3 (including low DO, cyanobacterial blooms and the proliferation of waterborne microorganisms) as well as to prey-switching. Crustaceans may be contaminated with botulinum toxin and thus play an important role in the epidemiology of botulism outbreaks, although no references were identified linking type C (or C/D mosaic) botulism with clinical disease in crustaceans. The Glenelg spiny crayfish, however, is only found within the Glenelg catchment. While the carp biomass density within the Rocklands Reservoir has been estimated at approximately 180 kg/ha, the biomass density in the Glenelg River downstream from the reservoir where the crayfish is endemic is considerably lower – approximately 25 to 75 kg/ha (Stuart *et al.*, 2019). The high volume of water within the reservoir, and its depth (approximately 17 metres), mean that although an aggressive outbreak of CyHV-3 is possible it is not likely to result in the accumulation of carp carcasses in numbers sufficient to impact on water quality. The Glenelg River downstream from Rocklands is a substantial and lotic waterbody, and this in combination with a low carp biomass density mean that an aggressive outbreak is unlikely and that there is negligible opportunity for the accumulation of substantial numbers of carp carcasses in places other than local points of entrapment. On balance, there is not a real chance or possibility that the Glenelg spiny crayfish will be placed at risk in the event of an outbreak of CyHV-3.

The risks associated with other invasive species are discussed separately (Part II: Section 8).

Risk mitigation and residual risk: not required.

Recovery Plans and Threat Abatement Plans: there is no Recovery Plan or Threat Abatement Plan for the Glenelg spiny crayfish. The Department of Environment and Energy notes that, "*Recovery Plan not required, the approved conservation advice for the species provides sufficient direction to implement priority actions and mitigate against key threats*".

3.3 Assessment of uncertainty

The assessments for threatened and migratory species were conservative in all respects, reflecting substantial baseline uncertainty about species distribution, abundance, ecology and behaviour. There is also substantial uncertainty within the estimates provided about the likely exposure of particular species to the key pathways considered in this assessment (water quality, food webs and botulism). Underlying this is further uncertainty about the likelihood that particular pathways will be realised with the death of large numbers of carp in particular settings. These matters were explored in the ecological risk assessment documented in Part II and Part III of this report.

The assessment was undertaken at national scale, and with specific reference to an established definition for Major impacts at that scale (Section 2). Assessments undertaken at such a broad scale necessarily encompass considerable variation across settings (that is, in addition to the uncertainty outlined above). This variation is again reflected in the conservative estimates.

In view of the above, it is likely that consideration of impacts at a reduced scale (for example, a catchment or a particular reach of a river system) would result in improved confidence in the underlying science and reduced variability. The effect of this is likely to be a scaling back of the baseline conservative estimates for the species concerned.

4 Threatened ecological communities

4.1 Threatened ecological communities relevant to this assessment

A total of 82 threatened communities are currently listed by the Department of Environment and Energy. These include two communities that are vulnerable, 43 that are endangered and 34 that are critically endangered. There are also two communities that are listed as approval disallowed and one that is currently ineligible.

Of these communities, 33 were ruled out of further consideration using a screening analysis. This considered whether each community overlapped with carp habitat (using the spatial dataset for carp habitat provided by the Department) and, for those that did, whether it was placed in a state or territory where the carp biomass density may be sufficient for an outbreak of CyHV-3 to result in a real chance or possibility of harm. This excluded Western Australia, the Northern Territory, Tasmania and any Australian island territories. Communities were also excluded (if the spatial assessment had not already done so) if they related to alpine, desert, tropical, coastal (marine) or cave ecosystems.

The remaining 49 communities (Table 42) were then grouped according whether they were wetland, marsh or other freshwater-based communities (eight communities, two of which are listed as approval disallowed and one that is currently ineligible); or whether they were forest, woodland, grassland or other dryland communities (41 communities, all of which are classified as threatened).

The Swamps of the Fleurieu Peninsula, Coastal Upland Swamps in the Sydney Basin Bioregion and the Temperate Highland Peat Swamps on Sandstone were removed from the wetland, marsh or other freshwater-based communities as they do not include a permanent or spill-over population of carp, and there is not a real chance or possibility of exposure to harm as a result of an outbreak of CyHV-3. The remaining two currently listed wetland, marsh or other freshwater-based communities (that is, those whose status is not approval disallowed or currently ineligible) were analysed individually.

The possibility of harm to forest, woodland, grassland or other dryland communities was also considered to be remote, but these 41 communities were retained and were analysed as a group.

Table 42 Threatened ecological communities for further consideration

Community	Listing
Wetland, marsh or other freshwater-based	
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Critically Endangered
Swamps of the Fleurieu Peninsula	Critically Endangered
Coastal Upland Swamps in the Sydney Basin Bioregion	Endangered
Temperate Highland Peat Swamps on Sandstone	Endangered
Upland Wetlands of the New England Tablelands (New England Tableland Bioregion) and the Monaro Plateau (South Eastern Highlands Bioregion)	Endangered
River Murray and associated wetlands, floodplains and groundwater systems, from the junction	Approval Disallowed

Community	Listing
with the Darling River to the sea	
Wetlands and inner floodplains of the Macquarie Marshes	Approval Disallowed
Long lowland rivers of south eastern Queensland and northern New South Wales	Currently Ineligible
Forest, woodland, grassland or other dryland communities	
Blue Gum High Forest of the Sydney Basin Bioregion	Critically Endangered
Central Hunter Valley eucalypt forest and woodland	Critically Endangered
Cooks River/Castlereagh Ironbark Forest of the Sydney Basin Bioregion	Critically Endangered
Cumberland Plain Shale Woodlands and Shale-Gravel Transition Forest	Critically Endangered
Gippsland Red Gum (*Eucalyptus tereticornis* subsp. *mediana*) Grassy Woodland and Associated Native Grassland	Critically Endangered
Grassy Eucalypt Woodland of the Victorian Volcanic Plain	Critically Endangered
Hunter Valley Weeping Myall (*Acacia pendula*) Woodland	Critically Endangered
Illawarra and south coast lowland forest and woodland ecological community	Critically Endangered
Iron-grass Natural Temperate Grassland of South Australia	Critically Endangered
Littoral Rainforest and Coastal Vine Thickets of Eastern Australia	Critically Endangered
Lowland Grassy Woodland in the South East Corner Bioregion	Critically Endangered
Lowland Native Grasslands of Tasmania	Critically Endangered
Lowland Rainforest of Subtropical Australia	Critically Endangered
Natural Damp Grassland of the Victorian Coastal Plains	Critically Endangered
Natural Grasslands of the Murray Valley Plains	Critically Endangered
Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	Critically Endangered
Natural Temperate Grassland of the South Eastern Highlands	Critically Endangered
Natural Temperate Grassland of the Victorian Volcanic Plain	Critically Endangered
New England Peppermint (Eucalyptus *nova-anglica*) Grassy Woodlands	Critically Endangered
Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia	Critically Endangered
Shale Sandstone Transition Forest of the Sydney Basin Bioregion	Critically Endangered
Southern Highlands Shale Forest and Woodland in the Sydney Basin Bioregion	Critically Endangered
Swamp Tea-tree (*Melaleuca irbyana*) Forest of South-east Queensland	Critically Endangered
Turpentine-Ironbark Forest of the Sydney Basin Bioregion	Critically Endangered
Warkworth Sands Woodland of the Hunter Valley	Critically Endangered
Western Sydney Dry Rainforest and Moist Woodland on Shale	Critically Endangered
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered
Brigalow (*Acacia harpophylla* dominant and co-dominant)	Endangered
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	Endangered
Castlereagh Scribbly Gum and Agnes Banks Woodlands of the Sydney Basin Bioregion	Endangered
Coastal Swamp Oak (*Casuarina glauca*) Forest of New South Wales and South East Queensland ecological community	Endangered
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered
Eastern Suburbs Banksia Scrub of the Sydney Region	Endangered
Eyre Peninsula Blue Gum (*Eucalyptus petiolaris*) Woodland	Endangered
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-	Endangered

Community	Listing
eastern Australia	
Natural Grasslands of the Queensland Central Highlands and northern Fitzroy Basin	Endangered
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered
Silurian Limestone Pomaderris Shrubland of the South East Corner and Australian Alps Bioregions	Endangered
Upland Basalt Eucalypt Forests of the Sydney Basin Bioregion	Endangered
Weeping Myall Woodlands	Endangered
Eucalyptus ovata - *Callitris oblonga* Forest	Vulnerable

4.2 EPBC Act significant impact criteria

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:

- Reduce the extent of an ecological community
- Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines
- Adversely affect habitat critical to the survival of an ecological community
- Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns
- Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting
- Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to,
  - Assisting invasive species, that are harmful to the listed ecological community, to become established, or
  - Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community, or
- Interfere with the recovery of an ecological community.

4.3 Assessment of risks to threatened ecological communities

Of the five identified wetland, marsh or other freshwater-based communities (Table 42) the Swamps of the Fleurieu Peninsula, Coastal Upland Swamps in the Sydney Basin Bioregion and the Temperate Highland Peat Swamps on Sandstone were removed from the wetland, marsh or other freshwater-based communities as they do not include a permanent or spill-over population of carp, and there is not a real chance or possibility of exposure to harm as a result of an outbreak of CyHV-3. The remaining two currently listed wetland, marsh or other freshwater-based communities (that is, those whose status is not approval disallowed or currently ineligible) were analysed individually.

- Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains
- Upland Wetlands of the New England Tablelands (New England Tableland Bioregion) and the Monaro Plateau (South Eastern Highlands Bioregion).

The possibility of harm to forest, woodland, grassland or other dryland communities was also remote, but these communities were retained and analysed as a group.

4.3.1 Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains

Background: Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains (hereafter, Herbaceous Wetlands) are listed under the EPBC Act as critically endangered. A description of Herbaceous Wetlands and their key threats is given in the following publications:

- Approved Conservation Advice for the Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains[56]
- Commonwealth Listing Advice on Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains.[57]

The following discussion was adapted largely from these two publications.

Herbaceous Wetlands are temporary freshwater wetlands that are inundated on a seasonal basis, typically filling after winter-spring rains, and then drying out. They occur in Victoria, south-eastern South Australia and south-western New South Wales. The Herbaceous Wetlands ecological community is most extensive in Victoria, where it occurs primarily on the southern lowland plains. In New South Wales, distribution is limited to the Riverina and south-western slopes. The distribution in New South Wales is principally in the area east of Deniliquin, to the Murrumbidgee River, with possible outliers north to West Wyalong. Herbaceous Wetlands extend from the plains of western Victoria into south-eastern South Australia; east of Millicent to the Victorian border. Scattered occurrences also occur further west or north within South Australia, to the districts around Padthaway and Mt Scott.

The vegetation within Herbaceous Wetlands is generally treeless and dominated by an herbaceous ground layer, often with a considerable graminoid component and with forbs present. The herbaceous species present are characteristic of wetter locations and are typically absent or uncommon in any adjoining dryland grasslands and woodlands. The dominant plants present are subject to seasonal and site conditions, and the diversity of the flora may range from relatively species-poor to species-rich composition. Rainfall is the main water source. These wetlands are not dependent on overbank flooding from riverine systems. This wetland ecological community includes flora, fauna and micro-organisms and remains present in both wet and dry periods. When standing water is present, wetland plants are clearly evident, however during drought or seasonal dry periods plants may not be visible above ground. During dry periods aquatic and amphibious species persist as desiccated shoots, underground rootstocks or propagules (seeds, spores and eggs) in the ground. The ecological community rapidly reverts to its wet form upon inundation if

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[56] See: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/97-conservation-advice.pdf

[57] See: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/97-listing-advice.pdf

the hydrological and biological characteristics of the wetland are relatively intact. Herbaceous Wetlands provide habitat for a range of animals that rely on regular standing water during part of the year to provide food and other resources or to complete their life cycle.

Many fauna species that inhabit Herbaceous Wetlands may also occur in other types of wetland, including deeper marshes and other more permanent water bodies, or extend into adjoining non-wetland areas. Certain species, however, show distinct preferences for shallow, temporary waters and open grassy wetland vegetation. The main faunal groups that characteristically inhabit the ecological community include aquatic invertebrates, frogs, reptiles and waterbirds. Aquatic mammals and native fish tend to be absent in seasonal wetlands, as they require more permanent inundation. The absence of fish can increase opportunities for frogs and invertebrates to breed and complete their life cycles. Herbaceous Wetlands also provide feeding sites for a range of native waterbird species, including various species of ducks, water hens, ibises, egrets, herons, spoonbills, rails, bitterns and snipe; many of which prefer to feed in shallow or temporary waters. The high abundance and diversity of water invertebrates in the ecological community are a food source for waterbirds such as ducks and spoonbills. The vegetation supplies seeds, fruits and other material for other birds that are herbivores and omnivores. The waters of Herbaceous Wetlands may be too shallow, however, to provide suitable nesting habitat for many waterbird species, and especially those that require a long period to raise chicks, or that require trees or reedy thickets to nest.

Assessment of risk: although Herbaceous Wetlands do not typically include fish, it is likely that those inundated as a result of substantive overbank flows (as opposed to rainfall) will retain some spawning carp or juveniles. This is particularly likely for Herbaceous Wetlands in the Riverina district of New South Wales. In this scenario, an outbreak of CyHV-3 is only plausible if widespread transmission occurred during a pre-spawning aggregation event or during spawning itself. Following this, the wetland will quickly become isolated from the balance of floodplains, channels and ephemeral wetlands. As the wetland dries out, any trapped carp (and other fish) will be stranded and will die. In the light of this, an outbreak of CyHV-3 is unlikely to result in harm substantially in excess of the existing ecological process. It might be argued that by causing the death of trapped carp at a time when the remaining water within the wetland is substantial, an outbreak may in fact minimise development of poor water quality and the risk of a cyanobacterial bloom. If carp are trapped within an Herbaceous Wetland and die as a result of an outbreak of CyHV-3 (or when the water recedes), decomposition products may result in a higher nutrient load. Eutrophication has been identified as a threat to Herbaceous Wetlands. There is also the possibility of an outbreak of botulism which has the potential to result in significant direct harm to most of the higher faunal functional groups within a wetland community, and to considerably disrupt food webs and other aspects of the ecosystem balance. This possibility however, also exists when stranded fish die-off as a natural part of the ecology of Herbaceous Wetlands.

Risk mitigation and residual risk: although unlikely to be required, mitigation of any threat to Herbaceous Wetlands would rest on the timely removal of carp carcasses. Notwithstanding this, and recognising the possibilities outlined above, the majority of remnant Herbaceous Wetlands do not occur in areas proximal to watercourses with a high carp biomass density and there is very little likelihood that these wetlands will be exposed to harm as a result of an outbreak of CyHV-3. Wetlands that are inundated through substantive overbank flows from watercourses in which carp are prevalent may retain some juveniles or spawning adults. The death of these and any other fish when the wetland dries is a natural part of its ecology, as is the resulting eutrophication of sediment through the accumulation of fish carcasses and any increase in the risk of botulism or cyanobacterial blooms. On balance, and recognising the potential for carcass removal from particularly sensitive areas, there is not a real chance or possibility that an outbreak of CyHV-3 would result in the realisation of the significant impacts for ecological communities (as detailed in Section 4.2).

4.3.2 Upland Wetlands of the New England Tablelands (New England Tableland Bioregion) and the Monaro Plateau (South Eastern Highlands Bioregion)

Description: these wetlands occur in depressions in the landscape. The persistence of the wetlands throughout the year is dependent on the depth of the water in the wetland, the catchment area supplying the wetland with water, rainfall patterns, and either past or current disturbances. The vegetation ranges from closed to mid-dense sedgeland and grasslands which occur on the shores of open water or extend across shallow or dry wetlands. There are no shrub or tree species that occur naturally within this ecological community. These wetlands can occur in three general forms: near permanent (rarely dry); intermittent (often seasonally dry) and ephemeral (occasionally full).

Assessment of risk: these wetlands are not proximal to watercourses in which carp occur at a substantive biomass density.

Risk mitigation and residual risk: On balance, and recognising the potential for carcass removal from particularly sensitive areas, there is not a real chance or possibility that an outbreak of CyHV-3 would result in the realisation of the significant impacts for ecological communities (as detailed in Section 4.2).

4.3.3 Forest, woodland, grassland or other dryland communities

This group includes 41 diverse ecological communities whose occurrence may overlap with carp habitat. Of these, 27 are critically endangered and 14 are endangered (Table 42).

Assessment of risk: in some settings, forest, woodland, grassland and other dryland ecological communities may include (or be proximal to, and rely upon) a watercourse or waterbody. In theory, these communities might be exposed to harm as a result of the release of CyHV-3 through its indirect impacts on water quality – in particular, the contamination of water with cyanobacterial blooms, or with the organic products and microorganisms associated with carcass decomposition, and through the possibility of an increased risk of botulism. The effect of these exposures (alone or in combination) may be to cause stress to the faunal compartment of the community and, ultimately, may result in the death of individuals or individual species or their migration to other communities. This cascade of impacts might be exacerbated by drought or significant dry periods, when extant waterways are contracted, and alternative waterways may not be available to some species. The magnitude of these risks is, however, likely to be extremely low as the communities are by definition not riparian, or otherwise water-focussed, and in very few would the carp biomass density be substantive (if carp are present at all).

Risk mitigation and residual risk: if required, the risks identified above may be mitigated through the timely removal of carp carcasses. That notwithstanding, it is extremely unlikely that the forest, woodland, grassland or other dryland ecological communities will be exposed to significant impacts (as detailed in Section 4.2) as a result of an outbreak of CyHV-3. Where a risk exists, it will be localised to those communities that include (or are proximal to) a waterbody that contains a substantive biomass density of carp.

4.4 Assessment of uncertainty

Although the assessment of exposure (above) of threatened ecological communities to the effects of CyHV-3 could be made with a high degree of confidence, there remains some uncertainty about the likely behaviour of the virus in individual settings. The ecology of the communities examined is complex and fragile, and it is possible that some interactions between adult or juvenile carp and the environment of these communities may not be well understood.

5 Wetlands listed under the Ramsar Convention

5.1 Ramsar wetlands relevant to this assessment

Ramsar wetlands are those that are representative, rare or unique wetlands, or are important to the conservation of biological diversity.

Of the 66 Australian wetlands that are listed under the Ramsar Convention, a screening spatial analysis identified 29 that included carp habitat (as determined by the Department of Environment and Energy). Wetlands within Western Australia and Tasmania were then removed from this list, as the carp biomass density in these parts of Australia is too low (or zero) for an outbreak of CyHV-3 to result in any likelihood of discernible impact.

The remaining 25 Ramsar wetlands were included in the assessment. These were grouped (below) as within the northern or southern Murray-Darling Basin, as estuarine wetlands, or as other wetlands.

Ramsar wetlands within the northern Murray-Darling Basin:

- Currawinya Lakes (Currawinya National Park) (QLD)
- Gwydir Wetlands: Gingham and Lower Gwydir (Big Leather) Watercourses (NSW)
- Narran Lake Nature Reserve (NSW)
- Paroo River Wetlands (NSW)
- The Macquarie Marshes (NSW).

Ramsar wetlands within the southern Murray-Darling Basin:

- Banrock Station Wetland Complex (SA)
- Barmah Forest (VIC)
- Fivebough and Tuckerbil Swamps (NSW)
- Gunbower Forest (VIC))
- Hattah-Kulkyne Lakes (VIC)
- Kerang Wetlands (VIC)
- New South Wales Central Murray Forests (NSW)
- Riverland (SA).

Estuarine Ramsar wetlands:

- Corner Inlet (VIC)
- Gippsland Lakes (VIC)
- Glenelg Estuary and Discovery Bay Wetlands (VIC)
- Great Sandy Strait (including Great Sandy Strait, Tin Can Bay and Tin Can Inlet) (QLD)
- Hunter Estuary Wetlands (NSW)
- Moreton Bay (QLD)

- Port Phillip Bay (Western Shoreline) and Bellarine Peninsula (VIC)
- the Coorong, and Lakes Alexandrina and Albert Wetland (SA)
- Towra Point Nature Reserve (NSW)
- Western Port (VIC).

Other Ramsar wetlands:

- Hunter Estuary Wetlands (NSW)
- Lake Albacutya (VIC)
- Western District Lakes (VIC).

Division of the Murray-Darling Basin into northern and southern parts was undertaken using he classification provided by the Murray-Darling Basin Authority, as shown in Figure 44 below.

Figure 44 Northern and southern parts of the Murray-Darling Basin

Source: Murray-Darling Basin Authority (https://www.mdba.gov.au/discover-basin/Landscape/geography)

5.2 EPBC Act significant impact criteria

An action is likely to have a significant impact on the ecological character of a Ramsar wetland if there is a real chance or possibility that it will result in:

- Areas of the wetland being destroyed or substantially modified
- A substantial and measurable change in the hydrological regime of the wetland, for example, a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland
- The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependant upon the wetland being seriously affected
- A substantial and measurable change in the water quality of the wetland – for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland, or water temperature which may adversely impact on biodiversity, ecological integrity, social amenity or human health
- An invasive species that is harmful to the ecological character of the wetland being established (or an existing invasive species being spread) in the wetland.

In this context, the ecological character of a Ramsar wetland is the combination of the ecosystem components, processes and benefits/ services that characterise the wetland at a given point in time.

5.3 Assessment of risks to Ramsar wetlands

The third and fourth of the significant impact criteria (above) criteria are of key importance to the possible impacts of an outbreak of CyHV-3. For this reason, the assessment focussed on: (a) direct harm to the habitat or lifecycle of native species; and (b) changes to water quality, which may then lead to outcomes for biodiversity, ecological integrity, social amenity or human health. The risks associated with other invasive species are discussed separately.

5.3.1 Ramsar wetlands within the northern Murray-Darling Basin

Ramsar wetlands within the northern part of the Murray-Darling Basin lie either in the central western or far western areas. Central western wetlands include the Gwydir wetlands and Macquarie Marshes. While the climate in these areas is generally warm-to-hot and dry, it is significantly less so than in the far west. Rainfall is also generally more dependable and, while large parts of these wetlands are ephemeral, they are inundated more often than in the far west. The water quality is also generally higher in the central west, with a lower tendance to marked turbidity, less stratification and lower peak summer water temperatures. Ramsar wetlands in the far west include the Currawinya Lakes (Queensland), the Narran Lake Nature Reserve (New South Wales) and the Paroo River Wetlands (New South Wales). With some exceptions, Ramsar wetlands within the northern part Murray-Darling Basin are in general less regulated than wetlands in the southern part – in particular, the southern wetlands that are linked to the regulation of the Murray River.

Outbreak scenarios and exposure pathways: although each has a distinct set of natural assets, hydrology and risk profile, Ramsar wetlands in the northern Murray-Darling Basin are likely to be most exposed to impacts on water quality resulting from an outbreak of CyHV-3 during lower-flow seasons. At these times, carp will be concentrated and an outbreak of CyHV-3 more likely to be aggressive. Carp carcasses will also be concentrated and more likely to result in an impact on DO, an increase in the risk of cyanobacterial blooms, the proliferation of waterborne pathogens or an outbreak of botulism. Aquatic animals are most exposed to these effects – in particular, to low DO and the effects of cyanobacterial blooms. Waterbirds are more likely to be exposed to the effects of an outbreak of botulism or to the indirect effects of removing juvenile carp as a stable source of food. The population of breeding waterbirds, however, is likely to be substantially lower during lower-flow seasons, and there will be less opportunity for harm through either the direct effects of a decline in water quality or the indirect effects of an outbreak of CyHV-3 on the availability of juvenile carp as another wise stable source of food for nesting waterbird chicks. Likewise, there will be less opportunity for prey-switching to impact on native aquatic species – including small-bodied native fish and juvenile large-bodied native fish.

During high-flow seasons, when the floodplains and ephemeral wetlands are inundated, the population of waterbirds within Ramsar wetlands in the northern Murray-Darling Basin will be high. In this setting, an aggressive outbreak of CyHV-3 is possible if sufficient transmission occurs during the pre-spawning aggregation of carp. Transmission is likely, however, to be limited during summer months by the high temperature of shallow waters on the inundated floodplains and ephemeral wetlands. In late summer, as the water temperature falls, a resurgence of outbreaks of CyHV-3 may occur. This may have a marked effect on the highly-susceptible juvenile carp. At this time waterbirds may be exposed to a lowered availability of food for nesting chicks, and there may be an increase in the predation upon native aquatic fauna. These food web effects are uncertain and predicated heavily on the reliance of waterbirds on juvenile carp, which is itself an untested hypothesis.

The characteristics of outbreaks of CyHV-3 in the northern Murray-Darling Basin were examined in detail in the case study for the Moonie River Catchment and in the abbreviated case study for the Macquarie Marshes within the Discussion for the Ecological Risk Assessment. The case study for the Moonie River Catchment highlighted the potential for aggressive outbreaks of CyHV-3 within disconnected waterholes, with locally significant consequences for aquatic animals.

Assessment of risk: the considerations above point to an increased likelihood of either: (a) direct harm to the habitat or lifecycle of native species; or (b) changes to water quality, which may then lead to outcomes for biodiversity, ecological integrity, social amenity or human health; during lower-flow seasons. Harm to aquatic animals may be substantial under this scenario where aggressive outbreaks occur in disconnected waterholes or wetlands. Harm to colonially-nesting waterbirds is likely to be lower, however, as large numbers will not gather within these wetlands during lower-flow seasons.

Risk mitigation and residual risk: the impacts of carp carcasses on water quality may be mitigated through carcass removal, and this will be more practical in most settings during a lower-flow season. In extreme dry seasons, where outbreaks of CyHV-3 have occurred in disconnected waterholes, carcass removal would need to take place upon commencement of the outbreak, and daily thereafter, and this may not be practical in some remote settings – in particular, for wetlands within the far-western parts of New South Wales or Queensland. None of the Ramsar wetlands within the northern part of the Murray-Darling Basin can be regulated with the degree of control required to flush carcasses and materials from affected areas, and this option is unlikely to be feasible. The mitigation of risks associated with the sudden removal of a dominant and stable food source will focus on the strategic release of the virus within particular catchments at times when its impact is least likely to result in stress to large numbers of breeding waterbirds. It would also be beneficial to consider the reliance that piscivorous, carnivorous and omnivorous waterbirds are likely to have on carp in particular settings, given the extant populations of both waterbirds and carp and the breadth of alternative prey species.

On balance, and with consideration to the mitigation options available and their practicality, there is a real chance or possibility that the release of CyHV-3 would result in the exposure of Ramsar wetlands of the northern Murray-Darling Basin to the significant impacts detailed in Section 5.2. The likelihood of harm will be higher during lower-flow seasons, although the magnitude of impacts on breeding waterbirds will be lower.

5.3.2 Ramsar wetlands within the southern Murray-Darling Basin

Ramsar wetlands within the southern part of the Murray-Darling Basin are principally linked to one of the region's main rivers – in particular, the Murray, Murrumbidgee or Darling Rivers or their tributaries or anabranches. The wetlands differ in respect of their hydrology, which ranges from the relatively unregulated Fivebough and Tuckerbil Swamps (New South Wales) and Hattah-Kulkyne Lakes (Victoria); to the partly regulated Barmah Forest (Victoria), Banrock Station Wetland Complex (South Australia), Gunbower Forest (Victoria) and New South Wales Central Murray Forests (New South Wales); to the highly regulated Riverland (South Australia). The degree of regulation has an impact on the extent to which a particular wetland or wetland complex is exposed to variance in inundation from year-to-year, and the ability of managers to flush key parts of the wetland complex to refresh it or (potentially) to help clear the wetland of poor-quality water. The Kerang Wetlands (Victoria) are unusual in that they are maintained as irrigation reservoirs and recreation sites, and do not suffer the same extent of yearly variance in inundation extent.

Outbreak scenarios and exposure pathways: the trends in outbreak aggressiveness and the exposure of aquatic animals and waterbirds described for Ramsar wetlands in the northern Murray-Darling Basin (above) apply to those in the south. In general, however, the baseline water quality in the south will be higher, and the summer temperature of the water in channels or on the floodplains will be slightly lower. There is also, in general, a lower variance in the extent of inundation from year to year. When they occur, waterbird breeding events within Ramsar wetlands in the southern part of the Murray-Darling Basin are generally large and the wetland complexes are important to the lifecycles of many native aquatic species – including large-bodied and small-bodied native fish, frogs, turtles and crustaceans. Aggressive outbreaks of CyHV-3 are again more likely in lower-flow seasons, and while these may impact on aquatic animals there will be less impact on breeding waterbirds. This trend will be metred to some extent by the degree of regulation. The Chowilla regulator and associated structures, for example, can divert water to key parts of the Riverland Ramsar wetland to ensure that inundation occurs at optimal times and during periods when flow in the Murray River channel is comparatively low. This means that waterbird breeding events at this location are relatively more consistent than in unregulated wetlands. Inundation also means, however, that lower-flow concentration of carp is less likely, and there will be less opportunity of aggressive outbreaks of CyHV-3 or the accumulation of large numbers of carp carcasses. Outbreaks within irrigation reservoirs (including the Kerang Lakes) are likely to be reasonably similar from year-to-year. In lower-flow seasons, the population of breeding waterbirds may be substantial in these places as there will be limited inundation of adjacent ephemeral wetlands (including Gunbower, Barmah and the New South Wales Central Murray Forests).

Assessment of risk: again, the considerations above point to an increased likelihood of either: (a) direct harm to the habitat or lifecycle of native species; or (b) changes to water quality, which may then lead to outcomes for biodiversity, ecological integrity, social amenity or human health; during lower-flow seasons. Harm to aquatic animals may be substantial where aggressive outbreaks occur in disconnected waterholes or wetlands. Harm to colonially-nesting waterbirds is likely to be lower, however, as large numbers will not gather within these wetlands during lower-flow seasons. The key exception to this is the Kerang Wetlands, which are likely to remain inundated in lower-flow seasons and host large waterbird breeding events. To a lesser extent, the Riverland Ramsar wetland will also remain inundated during lower-flow seasons.

Risk mitigation and residual risk: as for the northern Murray-Darling Basin, the impacts of carp carcasses on water quality may potentially be mitigated through carcass removal and this will be more practical in most settings during a lower-flow season when accessibility is improved. The fine degree of control available for the regulation of the Riverland Ramsar wetland (and to a lesser extent, some other wetlands such as the Barmah Forest) might, under some conditions, be used to flush poor quality water or carcass materials from affected areas. The mitigation of risks associated with the sudden removal of a dominant and stable food source will focus on the strategic release of the virus within particular catchments at times when its impact is least likely to result in stress to large numbers of breeding waterbirds. It would also be beneficial to consider the reliance that piscivorous, carnivorous and omnivorous waterbirds are likely to have on carp in particular settings, given the extant populations of both waterbirds and carp and the breadth of alternative prey species.

On balance, and with consideration to the mitigation options available and their practicality, there is a real chance or possibility that the release of CyHV-3 would result in the exposure of Ramsar wetlands of the southern Murray-Darling Basin to the significant impacts detailed in Section 5.2. The likelihood of harm will be higher during lower-flow seasons, although the magnitude of impacts on breeding waterbirds will be lower.

5.3.3 Estuarine Ramsar wetlands

The character of estuarine Ramsar wetlands was examined within the case study for the Lower Lakes and Coorong. Other Ramsar wetlands in this category include Corner Inlet (Victoria), Gippsland Lakes (Victoria), Glenelg Estuary and Discovery Bay Wetlands (Victoria), Great Sandy Strait (including Great Sandy Strait, Hunter Estuary Wetlands (New South Wales), Tin Can Bay and Tin Can Inlet) (Queensland), Moreton Bay (Queensland), Port Phillip Bay (Western Shoreline) and Bellarine Peninsula (Victoria), the Coorong and Lakes Alexandrina and Albert Wetland (South Australia), Towra Point Nature Reserve (New South Wales) and Western Port (Victoria). Of these, only the Coorong and Lakes Alexandrina and Albert Wetland has a carp biomass density sufficient to enable an aggressive outbreak of CyHV-3 and the accumulation of carp carcasses in numbers that might result in an impact on water quality. Outbreaks of CyHV-3 within the remaining wetlands are extremely unlikely to be aggressive and may not be noticed.

The exposure of the Coorong and Lakes Alexandrina and Albert Wetland was characterised in the case study in Part III: Section 3.5. The likely character of an outbreak in this setting was summarised within the Discussion for the Ecological Risk Assessment in Part III: Section 4.

On balance, and with consideration to the mitigation options available and their practicality, there is a real chance or possibility that the release of CyHV-3 would result in the exposure of the Coorong and Lakes Alexandrina and Albert Wetland to the significant impacts detailed in Section 5.2. The likelihood of harm will be higher during lower-flow seasons, although the magnitude of impacts on breeding waterbirds will be lower.

5.3.4 Other Ramsar wetlands

Two further Ramsar wetlands were considered:

- Lake Albacutya (VIC)
- Western District Lakes (VIC).

Lake Albacutya is a eutrophic lake located in the Wimmera region of Victoria, Australia. It is one of a series of terminal lakes on the Wimmera River, which form the largest land-locked drainage system in Victoria. On the occasions that there is an overflow from Lake Hindmarsh to the south, water enters Outlet Creek which then feeds Lake Albacutya. When full, Lake Albacutya covers 5,500 ha, is 8 m deep and holds around 230 gigalitres. The lake generally fills and empties on a 20-year cycle, the longest dry period on record being 27 years. Being less saline than Lake Hindmarsh, Lake Albacutya supports a denser cover of vegetation during its dry phase.

The carp biomass density within Lake Hindmarsh is low (approximately 65 kg/ha, as modelled by Stuart *et al.*, 2019). Overflow from Lake Hindmarsh to Lake Albacutya will only occur during a high-flow season, when this very low biomass density is further diluted. These carp will then become stranded and die when the lake dries. It is possible that an outbreak of CyHV-3 within Lake Albacutya at a time when the water was regressing, and some carp remained, might be aggressive and might result in the accumulation of carcasses at the water’s edge. This effect however, would not be discernibly different from the die-off of carp (and other fish species) that occurs as a part of the lake’s natural ecological cycle.

On balance, there is not a real chance or possibility that an outbreak of CyHV-3 at Lake Albacutya will result in exposure to the significant impacts detailed in Section 5.2. This will include either: (a) direct harm to the habitat or lifecycle of native species; or (b) changes to water quality, which may then lead to outcomes for biodiversity, ecological integrity, social amenity or human health.

The **Western District Lakes** comprises nine lakes with a combined area of 329 square kilometres. These lakes vary in depth and salinity, from fresh water to hypersaline. The lakes include State Wildlife Reserves and Lake Reserves and serve as drought refuges for waterbirds. Several threatened plants occur within the site, including the endangered *Lepidium ashersonii*. The lakes are used for various purposes, including recreational fishing and duck hunting as well as grazing, commercial fishing, and wastewater disposal. The lakes lie in a basaltic grassland landscape at an altitude of 40 to 90 metres. The lakes included within this complex are:

- Lake Beeac (hypersaline, 662 ha)
- Lake Bookar (500 ha)
- Lake Colongulac (saline, 1,460 ha)
- Lake Corangamite (hypersaline, 23,300 ha)
- Lake Cundare (hypersaline, 395 ha)
- Lake Gnarpurt (saline, 2,350 ha)
- Lake Milangil (saline, 125 ha)
- Lake Murdeduke (saline, 1,550 ha)
- Lake Terangpom (fresh, 208 ha).

The Western Districts Lakes lie entirely within the Corangamite River Basin. The Basin is land-locked and covers approximately 420,000 ha. Owing to its isolation from the Murray-Darling Basis, the carp biomass density within the Western Districts Lakes is very low (approximately 50 kg/ha, as modelled by Stuart *et al.*, 2019). The Strategic Management Plan[58] does not mention carp amongst the pest species that require ongoing control.

On balance, there is not a real chance or possibility that an outbreak of CyHV-3 within the Western Districts Lakes will result in exposure to the significant impacts detailed in Section 5.2. This would include either: (a) direct harm to the habitat or lifecycle of native species; or (b) changes to water quality, which may then lead to outcomes for biodiversity, ecological integrity, social amenity or human health.

5.4 Assessment of uncertainty

There remains considerable uncertainty as to the importance of juvenile carp as a source of food for nesting waterbirds – in particular, colonially nesting waterbirds. The effect of the sudden removal of this source of food is also uncertain. It is possible that birds may switch prey to alternative species, including native species. It may also be possible that colonies of birds may leave their nests, including their chicks.

Aside from this, there is also some uncertainty about the likely behaviour of CyHV-3 in particular wetland settings. Wetland ecology is complex, as is the ecology of spawning and juvenile carp. The interaction of these in the context of an aggressive outbreak of CyHV-3 may result in some unexpected outcomes.

[58] See: https://parkweb.vic.gov.au/

6 World Heritage Properties

6.1 World Heritage Properties relevant to this assessment

Four World Heritage Properties that may include carp habitat were identified:[59]

- Gondwana Rainforests of Australia
- Greater Blue Mountains Area
- Tasmanian Wilderness
- Willandra Lakes Region.

The **Gondwana Rainforests of Australia**, formerly known as the Central Eastern Rainforest Reserves, are the most extensive area of subtropical rainforest in the world. The Queensland areas include the Main Range National Park, at its most northern point; and extending south, the Lamington, Mount Chinghee, Springbrook and Mount Barney national parks. The New South Wales areas include the Barrington Tops National Park, at its most southern point; and extending north, the Dorrigo, Mount Warning, New England, Mebbin, Nightcap, Border Ranges, Oxley Wild Rivers, Washpool, Willi Willi and Werrikimbe national parks. The Gondwana Rainforests of Australia also includes a range of reserves, conservation areas and state forests. Individual parks and reserves are grouped geographically into seven sections for listing on the Australian National Heritage List, from north to south:

- Main Range group, near Killarney in Queensland
- Focal Peak group, on the New South Wales-Queensland border
- Shield Volcano group, also on the New South Wales-Queensland border but within the McPherson and Tweed ranges
- Washpool and Gibraltar Range group, representing a contiguous area between Glen Innes and Grafton in New South Wales
- New England group, near Dorrigo in New South Wales
- Hastings-Macleay group, southeast of Armidale in New South Wales
- Barrington Tops group, north of Dungog in New South Wales.

Across these seven groups, the Gondwana Rainforests of Australia are characterised as steep and heavily forested, with waterfalls and rapidly flowing streams and rivers.

The **Greater Blue Mountains** World Heritage Property is a deeply incised sandstone tableland covering over a million ha within New South Wales and spread across eight separate national parks:

- Blue Mountains National Park

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[59] The Great Barrier Reef World Heritage Property is considered separately in Section 11.

- Gardens of Stone National Park
- Jenolan Karst conservation reserve
- Kanangra-Boyd National Park
- Nattai National Park
- Thirlmere Lakes National Park
- Wollemi National Park
- Yengo National Park.

The control of carp within Tasmania is almost complete, with very few remaining individuals in one location. For this reason, the likelihood of harm to the **Tasmanian Wilderness** World Heritage Property arising from the release of CyHV-3 is negligible.

The **Willandra Lakes Region** covers 2,400 square kilometres of semi-arid landscape in far south-western New South Wales. It comprises five large (and 14 smaller) dried, saline lake bed plains vegetated with saltbush communities, fringing sand dunes and woodlands with grassy understoreys. The original source for the lakes was a creek flowing from the Eastern Highlands to the Murray River. When the Willandra Billabong Creek ceased to replenish the lakes, they dried in series from south to north over a period of several thousand years, each becoming progressively more saline. Although a part of the Murray-Darling Basin, the absence of permanent water within the Willandra Lakes Region means that the likelihood of harm arising from the release of CyHV-3 is negligible.

6.2 EPBC Act significant impact criteria

An action is likely to have a significant impact on the World Heritage values of a declared World Heritage Property if there is a real chance or possibility that it will cause:

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

Additional criteria apply to World Heritage Properties with natural heritage values. These criteria express ways in which a proposed action (the release of CyHV-3) might, with real chance or possibility, result in harm to an asset’s natural heritage values. The criteria are divided into processes affecting an asset’s geology or landscape; biology or ecology; and wilderness, natural beauty or rare or unique environment values. Some of these criteria (for example, damage, modify, alter or obscure important geological formations in a World Heritage Property) are not relevant to the proposed release of CyHV-3 in Australia, and have been removed. The remaining relevant criteria are listed below.

Processes affecting geology or landscape:

- Substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a World Heritage Property.

Processes affecting biology or ecology:

- Reduce the diversity or modify the composition of plant and animal species in all or part of a World Heritage Property
- Fragment, isolate or substantially damage habitat important for the conservation of biological diversity in a World Heritage Property
- Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a World Heritage Property
- Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a World Heritage Property.

Processes affecting wilderness, natural beauty or rare or unique environmental values:

- Introduce noise, odours, pollutants or other intrusive elements with substantial, long-term or permanent impacts on relevant values.

These processes provided the framework for the assessment of possible harm to the identified World Heritage Properties.

6.3 Assessment of risks to World Heritage Properties

Of the four identified World Heritage Properties that may include carp habitat, the Gondwana Rainforests of Australia and the Greater Blue Mountains Area had a non-negligible likelihood of harm arising from the proposed release of CyHV-3. The risks to the natural heritage values of these two properties are assessed below.

6.3.1 Gondwana Rainforests of Australia

A brief synthesis of the World Heritage values for the Gondwana Rainforests of Australia has been provided by UNESCO: [60] *the Gondwana Rainforests of Australia is a serial property comprising the major remaining areas of rainforest in southeast Queensland and northeast New South Wales. It represents outstanding examples of major stages of the Earth's evolutionary history, ongoing geological and biological processes, and exceptional biological diversity. A wide range of plant and animal lineages and communities with ancient origins in Gondwana, many of which are restricted largely or entirely to the Gondwana Rainforests, survive in this collection of reserves. The Gondwana Rainforests also provides the principal habitat for many threatened species of plants and animals*.

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[60] See: https: //whc.unesco.org/en/List/368

Figure 45 Gondwana Rainforests of Australia World Heritage Property

Source: UNESCO (https: //whc.unesco.org/en/List/368)

Assessment of risk: although the Gondwana Rainforests of Australia cover a large area within two states, they have a topographical and ecological similarity that can be characterised as steep and heavily forested country, with waterfalls and rapidly flowing streams and rivers. Where carp occur, their biomass density is likely to be low or very low. Outbreaks of CyHV-3 in these settings are not likely to be aggressive, and there would be very little opportunity for the accumulation of carcasses in quantities sufficient to result in an impact in water quality or to increase the likelihood of an outbreak of botulism. Although the rainforest ecosystems include a wide diversity of terrestrial animals, they are not sites where waterbirds (in particular, colonially-nesting waterbirds) breed in large numbers. Likewise, birds and other terrestrial animals within these rainforests are not likely to have developed a dependency on juvenile carp as a source of food.

Risk mitigation and residual risk: the considerations above mean that is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Gondwana Rainforests of Australia to the significant impacts detailed in Section 6.2.

6.3.2 Greater Blue Mountains Area

A brief synthesis of the World Heritage values for the Greater Blue Mountains Area has been provided by UNESCO: [61] *the Greater Blue Mountains Area (GBMA) is a deeply incised sandstone*

[61] See: https: //whc.unesco.org/en/List/917

tableland that encompasses 1.03 million ha of eucalypt-dominated landscape just inland from Sydney, Australia's largest city, in south-eastern Australia. Spread across eight adjacent conservation reserves, it constitutes one of the largest and most intact tracts of protected bushland in Australia. It also supports an exceptional representation of the taxonomic, physiognomic and ecological diversity that eucalypts have developed: an outstanding illustration of the evolution of plant life. A number of rare and endemic taxa, including relict flora such as the Wollemi pine, also occur here. Ongoing research continues to reveal the rich scientific value of the area as more species are discovered. The geology and geomorphology of the property, which includes 300 metre cliffs, slot canyons and waterfalls, provides the physical conditions and visual backdrop to support these outstanding biological values. The property includes large areas of accessible wilderness in close proximity to 4.5 million people. Its exceptional biodiversity values are complemented by numerous others, including indigenous and post-European-settlement cultural values, geodiversity, water production, wilderness, recreation and natural beauty.

Figure 46 Greater Blue Mountains Area World Heritage Property

Source: UNESCO (https: //whc.unesco.org/en/List/917/gallery/)

Assessment of risk: the Blue Mountains and Kanangra-Boyd National Parks are proximal to the Abercrombie River National Park, which was included as a case study. The conclusions from the assessment for the Abercrombie River case study were applied to assess the likelihood of harm to the Greater Blue Mountains Area World Heritage Property. In brief, these conclusions were that the low biomass density of carp within this region, the lotic character of waterways and cool-to-cold climate will mean that an outbreak of CyHV-3 is not likely to be aggressive, and there would be very little opportunity for the accumulation of carcasses in quantities sufficient to result in an impact in water quality or to increase the likelihood of an outbreak of botulism. This region is not a site where waterbirds (in particular, colonially nesting waterbirds) breed in large numbers. Likewise, birds and other terrestrial animals within these rainforests are not likely to have developed a dependency on juvenile carp as a source of food.

Risk mitigation and residual risk: the considerations above mean that is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Gondwana Rainforests of Australia to the significant impacts detailed in Section 6.2. The possible exception to this concerns the proliferation of microorganisms (and release into the aquatic environment) with the decomposition of carp carcasses. This risk was retained within the case study for the Abercrombie River largely in recognition of the uncertainties associated with the species and pathogenicity (across native aquatic or terrestrial animals) of the microorganisms concerned. That said, given the lotic nature of the waterways within the Greater Blue Mountains, and without the accumulation of very large numbers of carp carcasses, the likelihood that this pathway would be realised is effectively negligible.

6.4 Assessment of uncertainty

The key uncertainty associated with this assessment concerns the extent to which microorganisms associated with the decomposition of carp carcases might proliferate within the lotic waters of the identified World Heritage Properties, and the pathogenicity of the species concerned for aquatic and terrestrial native animals. This uncertainty was carried throughout the ecological risk assessment and was judged to be non-significant in the context of these two World Heritage Properties.

7 National Heritage Places

7.1 National Heritage Places relevant to this assessment

The Australian National Heritage List is a list of National Heritage Places deemed to be of outstanding heritage significance to Australia. The list includes natural, historic and indigenous places. To be included on the list, a nominated place is assessed by the Australian Heritage Council against the following nine criteria:

- Importance in the course, or pattern, of Australia's natural or cultural history
- Possession of uncommon, rare or endangered aspects of Australia's natural or cultural history
- Potential to yield information that will contribute to an understanding of Australia's natural or cultural history
- Importance in demonstrating the principal characteristics of a class of Australia's natural or cultural places or environments
- Importance in exhibiting particular aesthetic characteristics valued by a community or cultural group
- Importance in demonstrating a high degree of creative or technical achievement at a particular period
- Strong or special association with a particular community or cultural group for social, cultural or spiritual reasons
- Special association with the life or works of a person, or group of persons, of importance in Australia's natural or cultural history, or
- Importance as part of Indigenous tradition.

A screening spatial analysis identified 68 National Heritage Places whose location overlapped with carp habitat. This analysis was undertaken using spatial datasets (including the spatial location of carp habitat) supplied by the Department of Environment and Energy. The imperfect nature of the two datasets meant that a significant number of places could safely be removed from the outcomes of this screening assessment, as explained below.

First, the following four National Heritage Places were removed from the list as they were also World Heritage listed and therefore assessed in Section 6 above.

- Gondwana Rainforests of Australia
- Greater Blue Mountains Area
- Greater Blue Mountains Area (additional values)
- Willandra Lakes Region.

Next, 33 of the remaining 64 National Heritage Places were removed as they had no link to a waterbody that might contain carp.

- Abbotsford Convent

- Aboriginal tent embassy site
- Arch of Victory and Avenue of Honour
- Australian Academy of Science building
- Australian War Memorial and Memorial Parade
- Bonegilla Migrant Camp (Block 19)
- City of Broken Hill
- Coal River precinct
- Cockatoo Island
- Colonial Sydney
- Flemington Racecourse
- Flora fossil site (Yea)
- Freemantle historic town
- Goldfields Water Supply Scheme, Western Australia
- Hambledon Cottage and Hambledon Reserve
- High Court / National Gallery precinct
- Kamay Botany Bay
- Moree Baths and Swimming Pool
- Myall Creek massacre and memorial site
- Old Government House (Government Domain)
- Old Parliament House and curtilage
- Parliament House and surrounds
- Parramatta female Factory and institutions precinct
- Pentridge Prison
- Sirius Apartments
- South Australian Old and New Parliament House
- South Head, Sydney
- St Margaret's Anglican Church
- Sydney Harbour Bridge
- Sydney Myer music bowl
- Sydney Opera House
- Thompson Square Conservation Area
- Wollombi Public School.

A further filter was applied to the remaining 31 National Heritage Places to remove the following seven for which there was no rational link between the values underpinning the listing of the place and the occurrence of carp in a waterbody within or adjacent to the place.

- Canberra and surrounding areas (Lake Burley-Griffin is a separate place)
- Canberra central national area and inner hills (Lake Burley-Griffin is a separate place)

- Caves Road
- Great North Road, Wiseman's Ferry to Bucketty
- Historic port of Maryborough (Queensland)
- Old Great North Road
- Point Cook Air Base.

The remaining 24 National Heritage Places were then categorised as shown below:

Aboriginal cultural and memorial sites:

- Brewarrina Aboriginal fish traps
- Coranderrk.

Historical built assets:

- Australian Cornish mining sites (Burra and Moonta)
- Castlemaine Diggings National Heritage Park
- Cowra Japanese Gardens and Cultural Centre
- Echuca Wharf
- Morgan Wharf
- Mount Gilead homestead and rural estate
- Randells Mannum Dock
- Snowy Mountains Scheme
- Tocal Homestead and rural estate.

Parks, reserves and conservation areas:

- Australian Alps National Park and Reserves
- Cooloola Great Sandy region
- Grampians National Park (Gariwerd)
- Ku-Ring-Gai Chase National Park (Lion, Long and Spectacle Island Nature Reserves)
- Mount Lofty Ranges
- Royal National Park and Garawarra State Conservation Area
- Yan Yean Water Supply Conservation Area.

Contemporary urban and rural assets and infrastructure:

- Adelaide Park lands and city layout
- Centennial Park
- Lake Burley-Griffin and lakeshore parklands
- Lake Burley-Griffin and lakeshore landscape
- Melbourne's Domain parklands and memorial precinct
- Melbourne Water Western Treatment Plant, Werribee.

7.2 EPBC Act significant impact criteria

An action is likely to have a significant impact on the National Heritage values of a National Heritage Place if there is a real chance or possibility that it will cause:

- One or more of the National Heritage values to be lost
- One or more of the National Heritage values to be degraded or damaged, or
- One or more of the National Heritage values to be notably altered, modified, obscured or diminished.

Additional criteria apply to National Heritage Places with specific natural heritage, cultural heritage or indigenous heritage values. These criteria express ways in which a proposed action (the release of CyHV-3) might, with real chance or possibility, result in harm to an asset's natural, cultural or indigenous heritage values.

The criteria for **natural heritage** are divided into processes affecting an asset's geology or landscape; biology or ecology; and wilderness, natural beauty or rare or unique environment values. Some of these criteria (for example, damage, modify, alter or obscure important geological formations in a National Heritage Place) are not relevant to the proposed release of CyHV-3 in Australia, and were removed. The remaining relevant criteria are listed below.

Processes affecting geology or landscape:

- Substantially increase concentrations of suspended sediment, nutrients, heavy metals, hydrocarbons, or other pollutants or substances in a river, wetland or water body in a National Heritage Place; permanently damage or obscure rock art or other cultural or ceremonial features with World Heritage values.

Processes affecting biology or ecology:

- Modify or inhibit ecological processes in a National Heritage Place
- Reduce the diversity or modify the composition of plant and animal species in a National Heritage Place
- Fragment or damage habitat important for the conservation of biological diversity in a National Heritage Place
- Cause a long-term reduction in rare, endemic or unique plant or animal populations or species in a National Heritage Place
- Fragment, isolate or substantially damage habitat for rare, endemic or unique animal populations or species in a National Heritage Place.

Processes affecting wilderness, natural beauty or rare or unique environmental values:

- Introduce noise, odours, pollutants or other intrusive elements with substantial or long-term impacts on relevant values.

The criteria for **cultural heritage** are divided into processes affecting an asset's historic heritage values, and other cultural heritage values. Again, some of the criteria (for example, permanently remove, destroy, damage or substantially disturb archaeological deposits or artefacts in a National Heritage Place) are not relevant to the proposed release of CyHV-3 in Australia and have been removed. The remaining relevant criteria are listed below.

Processes affecting historic heritage values:

- Involve activities in a National Heritage Place with substantial or long-term impacts on its values
- Make notable changes to the layout, spaces, form or species composition of a garden, landscape or setting of a National Heritage Place in a manner which is inconsistent with relevant values.

Processes affecting other cultural heritage values:

- Restrict or inhibit the continuing use of a National Heritage Place as a cultural or ceremonial site causing its values to notably diminish over time
- Permanently diminish the cultural value of a National Heritage Place for a community or group to which its National Heritage values relate
- Destroy or damage cultural or ceremonial, artefacts, features, or objects in a National Heritage Place.

The criteria for **indigenous cultural heritage** are listed below. One criterion that was not relevant to the proposed release of CyHV-3 in Australia (alter the setting of a National Heritage Place in a manner which is inconsistent with relevant values) was removed.

- Restrict or inhibit the continuing use of a National Heritage Place as a cultural or ceremonial site causing its values to notably diminish over time
- Permanently diminish the cultural value of a National Heritage Place for an Indigenous group to which its National Heritage values relate
- Remove, destroy, damage or substantially disturb archaeological deposits or cultural artefacts in a National Heritage Place
- Destroy, damage or permanently obscure rock art or other cultural or ceremonial, artefacts, features, or objects in a National Heritage Place
- Notably diminish the value of a National Heritage Place in demonstrating creative or technical achievement
- Permanently remove, destroy, damage or substantially alter Indigenous built structures in a National Heritage Place.

These processes provided the framework for the assessment of possible harm to the identified World Heritage Properties.

7.3 Assessment of risks to National Heritage Places

7.3.1 Aboriginal cultural and memorial sites

Assets within this category were assessed against the criteria for cultural heritage and for indigenous cultural heritage (above).

Brewarrina Aboriginal fish traps: these are complex stone constructions on the Barwon River at Brewarrina in western New South Wales (Figure 47). The carp biomass density within the Barwon River at this site is relatively high (approximately 500 kg/ha, as modelled by Stuart *et al.*, 2019). An outbreak of CyHV-3 at this site has the potential to be aggressive, and carp carcasses may accumulate in places of entrapment in numbers sufficient to result in impacts on water quality (including an increased risk of a cyanobacterial bloom). Although the ecological impacts are not directly relevant to the Brewarrina Fish Traps, the traps are likely to trap carp carcasses and this is likely to have a substantial impact on the utility and values of the site. This impact is, however, likely to be short-term (in the order of weeks) as the carcasses of fish will be broken down rapidly in the high heat of western New South Wales. Flood waters will then remove the carcass remnants. These short-term impacts could be mitigated through the removal of carp carcasses, although care would need to be taken to ensure that the use of mechanised equipment (if permitted by the custodians) did not damage or disturb the site.

On balance, and with consideration to the mitigation options available and their practicality, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Brewarrina Fish Traps to the significant impacts detailed in Section 7.2.

Figure 47 Brewarrina fish traps

Source: Go North BlogSpot (http: //gonorth2011.blogspot.com/2014/08/noises-of-western-towns.html)

Coranderrk: this was a Government reserve for Aborigines between 1863 and 1924. It is located approximately 50 km northeast of Melbourne. Under the protectionist policies of the time, the government provided land for Aboriginals who had been dispossessed of their traditional lands by the arrival of European settlers. The reserve was formally closed in 1924, with most residents removed to Lake Tyers Mission. Coranderrk Station (Figure 48) ran successfully for many years as an Aboriginal enterprise, selling wheat, hops and crafts on the burgeoning Melbourne market. As a result of the Aborigines Protection Act of 1886, around 60 residents were ejected from Coranderrk on the eve of the 1890s Depression. Their forced departure crippled Coranderrk as an enterprise, with only around 15 able-bodied men left to work the hitherto successful hop gardens. In March 1998, part of the Coranderrk Station was returned to the Wurundjeri Tribe Land Compensation and Cultural Heritage Council when the Indigenous Land Corporation purchased 0.81 km^2. This includes a stretch bordering the Yarra River, which is deep and lotic at this point and with a relatively low carp biomass density (between approximately 65 and 125 kg/ha, as modelled by Stuart *et al.*, 2019). It is very unlikely that an outbreak of CyHV-3 would result in an accumulation of carp carcasses sufficient to impact on water quality.

On balance, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of Coranderrk to the significant impacts detailed in Section 7.2.

Figure 48 Coranderrk Station circa 1860s

Source: Only Melbourne (https: //www.onlymelbourne.com.au/coranderrk)

7.3.2 Historical built assets

Assets within this category were assessed against the criteria for cultural heritage.

Australian Cornish mining sites (Burra and Moonta): a generation of Cornish miners, engineers and tradespeople worked in the copper mines of South Australia, including Burra and Moonta. The new colony of South Australia soon became known as the Copper Kingdom because of the importance of copper mining and its overseas export. Today Burra and Moonta are of outstanding national heritage significance as two places in Australia where Cornish mining technology, skills and culture is demonstrated to a high degree. Moonta is located on the Spencer Gulf and was not considered further. Burra is located on Burra Creek, approximately 160 km northeast of Adelaide. This creek terminates in an ephemeral wetland northwest of Morgan and is not connected with the Murray River. There is a single reference to carp in the Burra Environmental Water Management Plan,[62] and while the biomass density was not modelled by Stuart *et al.* (2019) it is not likely to be substantial. Burra Creek arises in the northern Mount Lofty Ranges, just above Burra, and its flow at that point is relatively lotic. It is very unlikely that an outbreak of CyHV-3 would result in an accumulation of carp carcasses sufficient to impact on water quality. On balance, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Australian Cornish mining sites (Burra and Moonta) to the significant impacts detailed in Section 7.2.

Castlemaine Diggings National Heritage Park: situated within regenerating box-ironbark forest, the mining remains and habitation sites illustrate the goldminers' working way of life, with its emphasis on manual labour, hardship, the utilisation of natural resources, the dependence on

[62] See: https: //www.water.vic.gov.au/

water and a lifestyle intimately connected with the earth. The park has a much higher diversity of mining remains and landscapes, with greater integrity, than any other Australian goldfield. The goldfield's many mining relics include shallow alluvial diggings, tracks, burial grounds, huts and fireplaces, puddling machines, sluices, tail races, quartz roasting kilns and early quartz mining and crushing sites. Visitors can see well-preserved artefacts and diverse mining sites, including miner's huts, Chinese market gardens, mine headframes, stone footings, shallow shafts and the Garfield Water Wheel, the biggest waterwheel in Australia at the time. The Park includes a reach of the Loddon River, which rises on the northern slopes of the Great Dividing Range east of Daylesford and descends to flow north into the Little Murray River, near Swan Hill in norther Victoria. Although carp are fished in the northern reaches of the Loddon River, close to its junction with the Little Murray, the biomass density is likely to be very low in the lotic upland southern reaches close to its origin. Given this, and the separation of cultural values of the Castlemaine Diggings from the river itself, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Castlemaine Diggings to the significant impacts detailed in Section 7.2.

Cowra Japanese Gardens and Cultural Centre: this is a registered cultural organisation covering 5 ha and including the graves of 231 Japanese soldiers who died in an escape from the internment camp that was located at the site. The gardens include an ornamental lake stocked with koi carp (Figure 49). These carp are susceptible to the CyHV-3. Although the pond is not directly connected with the Lachlan River, an outbreak of CyHV-3 would impact on the cultural values of the site as well as its amenity. These impacts are not likely to be long-lasting (approximately two weeks), although subsequent outbreaks are possible. Removal of carp carcasses is likely to be feasible, and there would be little opportunity for an accumulation to result in an impact on water quality. Restocking of the pond may be required if the outbreak is aggressive, although the cost of koi carp may be prohibitive. Vaccination may also be feasible, and aggressive biosecurity measures could be taken to help protect these high-value fish.

On balance, and notwithstanding the mitigations described above, there is a real chance or possibility that the release of CyHV-3 would result in the exposure of the Cowra Japanese Gardens and Cultural Centre to the significant impacts detailed in Section 7.2.

Figure 49 Feeding koi carp in the Cowra Japanese Garden

Source: Visit Cowra (https: //visitcowra.com.au/cowra-japanese-garden-cultural-centre)

Echuca Wharf: the development of the Echuca Wharf and the railway established a major trade route to Melbourne that contributed to the shift of colonial economic power out of Sydney for the first time in Australia's history. Echuca remained the entry point for much of the interior of the continent and a -major trading centre for nearly 20 years until the opening of the railway from Junee to Hay in 1882. The red-gum timber structure towers above the river and the surrounding landscape, the wharf is three stories high, allowing for the possible 10 metre variation in river height between summer and winter, and enabling the wharf to operate year-round. The longest extent of the wharf (332 metres), is evidenced by some remnant pylons which are visible at low water. Since the 1960s, the wharf and paddle-steamers have found a new life servicing the tourist trade. The river channel at Echuca maintains much of the character examined in the Case Study of the Yarrawonga-Tocumwal reach (Part III: Section 3.3). This reach is relatively lotic, and although the carp biomass density would be sufficient to enable an aggressive outbreak of CyHV-3 the depth and flow of the water are likely to be sufficient to ensure that carcass materials are redistributed. This will also mean that carcasses are in general less likely to be visible than might be the case in, for example, a shallow lake. Carcasses that become entrapped by the wharf's infrastructure or other structures could be removed relatively easily.

On balance, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Echuca Wharf to the significant impacts detailed in Section 7.2.

Figure 50 Echuca Wharf

Source: ABC News (https://www.abc.net.au/news/)

Morgan Wharf: although Morgan Wharf appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Morgan Wharf was not assessed further.

Mount Gilead homestead and rural estate: although Mount Gilead homestead and rural estate appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Mount Gilead homestead and rural estate was not assessed further.

Randells Mannum Dock: although Randells Mannum Dock appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Randells Mannum Dock was not assessed further.

Snowy Mountains Scheme: the Snowy Mountains Scheme is the largest public works engineering scheme ever undertaken in Australia. The scheme was constructed over a 25-year period from 1949 to 1974 by over 100,000 workers, many of whom migrated to Australia from Europe after World War Two. The scheme includes 80 kilometres of aqueduct pipelines, 13 major tunnels measuring over 145 kilometres, seven power stations (two deep underground), eight switching stations and control centres, and a number of large dams. It generates approximately 4,500 GW every year and provides nearly a third of all renewable energy fed into the eastern mainland grid, powering major cities like Sydney, Melbourne and Canberra. The scheme also provides over 2,300 GL of water annually for irrigation for large parts of inland New South Wales and Victoria to the west of the Great Dividing Range. Although the impoundments within the Snowy Mountains

Scheme include some carp, there are no pathways by which CyHV-3 might result in harm to the values or utility of the scheme.

Tocal Homestead and rural estate: although Tocal Homestead and rural estate appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Tocal Homestead and rural estate were not assessed further.

7.3.3 Parks, reserves and conservation areas

Assets within this category were assessed against the criteria for natural heritage. This included criteria for geology and landscape, as well as for biology and ecology.

Australian Alps National Park and Reserves: the Australian Alps National Parks and Reserves (AANP) are part of a unique Australian mountainous bioregion extending over New South Wales, the Australian Capital Territory and Victoria. The Australian Alps displays a mosaic of interactions between its natural and cultural environments. The natural landscapes of the Australian Alps contain extremely restricted alpine and sub-alpine environments and flora and fauna species, with the alpine zone occupying a very small area (approximately 25,000 ha). The Australian Alps provides a vital refuge for alpine and sub-alpine flora and fauna species, with a high level of richness and endemism across a wide range of taxa. The high peaks and plateaus of the AANP support a rich and unique assemblage of cold-climate specialist plant and animal species that have evolved unique physiological characteristics, enabling them to survive in an environment subject to extreme climate variation.

Notwithstanding its outstanding natural heritage value, the Australian Alps National Park and Reserves contain very few carp. On balance, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Australian Alps National Park to the significant impacts detailed in Section 7.2.

Cooloola Great Sandy region: although Cooloola Great Sandy region appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. There are also no carp in this area. The Cooloola Great Sandy region was not assessed further.

Grampians National Park (Gariwerd): the Grampians National Park is a dramatic landform with sweeping western slopes, craggy eastern peaks and massive sandstone cliffs that contrast with surrounding plains; extensive forests interrupted by water bodies; and rock outcrops, deeply fissured cliffs and weather-sculpted sandstone. The landscape represents the most important area for floristic richness and endemism in eastern inland Australia and is important for species richness of freshwater and terrestrial invertebrates. There is an outstanding display of geological features at the Grampians, and archaeological evidence telling the story of indigenous occupation over the last 20,000 years. The park also contains the densest concentration of rock art paintings in Victoria and has the single largest assemblage of Aboriginal art motifs in Victoria.

Although carp have invaded the Glenelg River system, which originates in the Grampians, they are principally restricted to Rocklands Reservoir and the parts of the river below this. The very low biomass density and the lotic character of this and other rivers within the Grampians mean that there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Grampians National Park (Gariwerd) to the significant impacts detailed in Section 7.2.

Ku-Ring-Gai Chase National Park, Lion, Long and Spectacle Island Nature Reserves: Ku-ring-gai Chase National Park and Long Island, Lion Island and Spectacle Island Nature Reserves contain an exceptional representation of the Sydney region biota, a region which is recognised as a nationally outstanding centre of biodiversity. The place contains a complex pattern of 24 plant communities, including heathland, woodland, open forest, swamps and warm temperate rainforest, with a high native plant species richness of over 1,000 species and an outstanding diversity of bird and other animal species. This diversity includes an outstanding representation of the species that are unique to the Sydney region, particularly those restricted to the Hawkesbury Sandstone landform. The place is an outstanding example of a centre of biodiversity.

Although the modelling of Stuart *et al.* (2019) concluded that a significant carp biomass density could be found in the streams of rainforest Ku-Ring-Gai Chase National Park and the saline waters of Broken Bay, these seem very unlikely. The streams of Ku-Ring-Gai Chase National Park arise within the park and are not connected to other river systems. Ku-Ring-Gai Chase National Park, Lion, Long and Spectacle Island Nature Reserves Plan of Management does not include carp.

On balance, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Ku-Ring-Gai Chase National Park, Lion, Long and Spectacle Island Nature Reserves to the significant impacts detailed in Section 7.2.

Mount Lofty Ranges: although Mount Lofty Ranges appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Mount Lofty Ranges were not assessed further.

Royal National Park and Garawarra State Conservation Area: the Royal National Park and Garawarra State Conservation Area (Garawarra SCA) constitute a major centre of temperate plant species richness, having one of the richest concentrations of plant species in temperate Australia with more than 1,000 species. The place is also extremely rich in perching birds, reptiles and butterflies and can be regarded as exemplifying the biodiverse Hawkesbury Sandstone environment.

The Royal National Park and Garawarra State Conservation Area are bisected by, and drain into, the Hacking River, which in turns drains to Port Hacking. The modelling of Stuart *et al.* (2019) did not show any carp within this river, which is not connected to any other river systems. On balance, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of the Royal National Park and Garawarra State Conservation Area to the significant impacts detailed in Section 7.2.

Yan Yean Water Supply Conservation Area: although Yan Yean Water Supply Conservation Area appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Yan Yean Water Supply Conservation Area were not assessed further.

7.3.4 Contemporary urban and rural assets and infrastructure

Assets within this category were assessed against the criteria for cultural heritage.

Adelaide Park lands and city layout: although Adelaide Park lands and city layout appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Adelaide Park lands and city layout were not assessed further.

Centennial Park: Centennial Park is the central park of three separate parks that make up the Centennial Parklands. It is defined by an iron palisade and sandstone boundary fence with decorative formal entry gates at regular intervals. Inside the fence, a formal carriageway runs around the Park with connecting roads and avenues. The Park is made up of a collection of landscapes that reflect different aspects and landscape traditions. In the northern section sandstone ridges and outcrops reflect the pre-park natural landscape while the central area is dominated by open grasslands and playing fields. Areas of native plantings such as paperbark trees are positioned as avenues and groves running from the main Paddington gate entrance as well as around the ponds that dominate the southern half of the Park. The ponds are the formalised remains of the original Lachlan Swamp and the later water reserve that occupied the area before the Park's creation. The northern boundary is dominated by a series of underground water reservoirs that reflect the site's use as a source of Sydney's water supply since the colonial period. The Park retains a collection of historic and contemporary statuary placed at intervals around the Park, including in the formal gardens, at road junctions and on prominent high points and vistas. Pavilions and public shelters are distributed throughout the Park setting. One such pavilion, the Federation Pavilion (1988), commemorates the 1901 Federation celebrations in the Park and includes what is known as the Federation Stone, which was part of the 1901 Federation Pavilion.

The ponds within Centennial park contain a significant population of carp. A community-based fishing program aims to control this population, in conjunction with fly fishing and the release of Australian bass (*Macquaria novemaculeata*). An outbreak of CyHV-3 within the ponds of Centennial Park has the potential to be aggressive and would lead to the accumulation of significant number of carp carcasses. Without a clean-up program, these would be likely to impact on water quality and the social amenity of the Park. The ponds ware shallow and clean up would not be technically difficult. It is also likely that clean up could be augmented through community involvement. An outbreak of CyHV-3 within the Centennial Park ponds is likely to be short-lived (approximately 2 to 3 weeks) but during this time there would be some impact on the utility and cultural values of the site. The park is also home to a significant camp of the threatened grey-headed flying fox (*Pteropus poliocephalus*). This camp, however, is well adapted to human presence, and would not be expected to be disturbed by clean-up activities. On balance, there is a real chance or possibility that the release of CyHV-3 would result in the exposure of Centennial Park to the significant impacts detailed in Section 7.2.

Lake Burley-Griffin and lakeshore parklands: although Lake Burley-Griffin and lakeshore parklands appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Lake Burley-Griffin and lakeshore parklands were not assessed further.

Lake Burley-Griffin and lakeshore landscape: although Lake Burley-Griffin and lakeshore landscape appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Lake Burley-Griffin and lakeshore landscape were not assessed further.

Melbourne's Domain parklands and memorial precinct: the Kings Domain Resting Place has outstanding National Heritage value to the nation for its association with Australia's national repatriation story. The resting place represents Indigenous communities asserting control to ensure the return and (re)burial of their ancestors is in accordance with their community's cultural protocols. The features which represent this value are the King's Domain Resting Place, including the burial place of 38 Indigenous people's remains from Victoria, the commemorative granite stone and plaque honouring Aboriginal people.

The precinct borders a reach of the Yarra River within Metropolitan Melbourne, and very close to the river mouth in Port Phillip Bay. The carp biomass density within this reach was modelled to be approximately 230 kg/ha (Stuart *et al.*, 2019). The river is strongly lotic within its terminal reach, and there is very little likelihood that an outbreak of CyHV-3 would result in the accumulation of carcasses in numbers sufficient to impact on water quality. Likewise, the visibility of the outbreak is unlikely to be marked. Carcasses that might be entrapped by infrastructure could easily be freed and returned to the current or removed. On balance, there is not a real chance or possibility that the release of CyHV-3 would result in the exposure of Melbourne's Domain parklands and memorial precinct to the significant impacts detailed in Section 7.2.

Melbourne Water Western Treatment Plant, Werribee: although Melbourne Water Western Treatment Plant, Werribee appeared within the database provided by the Department of Environment and Heritage, it is not listed on the website for National Heritage Places. Melbourne Water Western Treatment Plant, Werribee were not assessed further.

7.4 Assessment of uncertainty for National Heritage Places

This component of the assessment was associated with relatively little uncertainty, other than in respect of the detail of outbreaks characteristics in particular locations. These characteristics are not likely, however, to impact substantially on the extent of harm to the values of the assets concerned.

8 Commonwealth Marine Areas

8.1 Commonwealth Marine Areas relevant to this assessment

A Commonwealth Marine Area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone or over the continental shelf of Australia, that is not State or Northern Territory water. A Commonwealth Marine Area may reach from 3 to 200 nautical miles from the coast.

This assessment focussed on the possible impact of an outbreak of CyHV-3 on Australian freshwater waterways and impoundments. Estuarine environments that were included (for example, the Coorong) were located within state or territory waters. Commonwealth Marine Areas were not included.

8.2 EPBC Act significant impact criteria

Notwithstanding the above, an action will require approval if:

- The action is taken in a Commonwealth Marine Area and the action has, will have, or is likely to have a significant impact on the environment, or
- The action is taken outside a Commonwealth Marine Area and the action has, will have, or is likely to have a significant impact on the environment in a Commonwealth Marine Area.

An action is likely to have a significant impact on the environment in a Commonwealth Marine Area if there is a real chance or possibility that the action will:

- Result in a known or potential pest species becoming established in the Commonwealth Marine Area
- Modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth Marine Area results
- Have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution
- Result in a substantial change in air quality4 or water quality (including temperature) which may adversely impact on biodiversity, ecological integrity; social amenity or human health
- Result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, social amenity or human health may be
- Adversely affected, or
- Have a substantial adverse impact on heritage values of the Commonwealth Marine Area, including damage or destruction of an historic shipwreck.

8.3 Assessment of risks to Commonwealth Marine Areas

Although a plume from the Murray Mouth that included a significant load of carcass materials or carcass breakdown products, or cyanobacteria from a bloom linked to the decomposition of carcass materials, is a theoretical possibility, the modelling of Hipsey *et al.* (2019) has shown that the likelihood of this is extremely low. There are no other feasible pathways by which an outbreak of CyHV-3 in carp could result in a significant impact on Commonwealth Marine areas.

8.4 Measures to avoid, mitigate, offset and adaptively manage impacts

No mitigations are required.

8.5 Assessment of uncertainty

There was virtually no uncertainty associated with the decision to restrict the assessment to Australia’s freshwater waterways and impoundments.

9 Great Barrier Reef Marine Park

9.1 Great Barrier Reef Marine Park

Also listed as a World Heritage Area, the Great Barrier Reef is the world's largest coral reef ecosystem, supporting an abundant array of plants and animals. The Great Barrier Reef Marine Park Act 1975 established a marine park around the Great Barrier Reef in 1975. The Great Barrier Reef Marine Park, stretched along the coast of Queensland, is about 344,400 square kilometres.

This assessment focussed on the possible impact of an outbreak of CyHV-3 on Australian freshwater waterways and impoundments. The assessment did not extend to marine areas, including the Great Barrier Reef Marine Park.

9.2 EPBC Act significant impact criteria

Notwithstanding the above, an action will require approval if:

- the action is taken in the Great Barrier Reef Marine Park and the action has, will have, or is likely to have a significant impact on the environment, or
- the action is taken outside the Great Barrier Reef Marine Park and the action has, will have, or is likely to have a significant impact on the environment in the Great Barrier Reef Marine Park.

An action is likely to have a significant impact on the environment of the Great Barrier Reef Marine Park if there is a real chance or possibility that the action will:

- Modify, destroy, fragment, isolate or disturb an important, substantial, sensitive or vulnerable area of habitat or ecosystem component such that an adverse impact on marine ecosystem health, functioning or integrity in the Great Barrier Reef Marine Park results
- Have a substantial adverse effect on a population of a species or cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution
- Result in a substantial change in air quality or water quality (including temperature) which may adversely impact on biodiversity, ecological health or integrity or social amenity or human health
- Result in a known or potential pest species being introduced or becoming established in the Great Barrier Reef Marine Park
- Result in persistent organic chemicals, heavy metals, or other potentially harmful chemicals accumulating in the marine environment such that biodiversity, ecological integrity, or social amenity or human health may be adversely affected, or
- Have a substantial adverse impact on heritage values of the Great Barrier Reef Marine Park, including damage or destruction of an historic shipwreck.

9.3 Assessment of risks to the Great Barrier Reef Marine Park

There are no feasible pathways by which an outbreak of CyHV-3 in carp could result in a significant impact on the Great Barrier reef Marine Park.

9.4 Measures to avoid, mitigate, offset and adaptively manage impacts

No mitigations are required.

9.5 Assessment of uncertainty

There was virtually no uncertainty associated with the decision to restrict the assessment to Australia's freshwater waterways and impoundments.

10 Commonwealth Lands

10.1 EPBC Act significant impact criteria

Criteria to assess the significance of the impact of an action on Commonwealth Land have been provided by the Department of Environment and Energy.[63] These criteria are detailed and exhaustive, covering impacts on landscapes and soils, coastal landscapes and processes, ocean forms, ocean processes and ocean life, water resources, plants and animals, people and communities and impacts on heritage. There are also criteria in respect of pollutants, chemicals, and toxic substances.

From these lists, the following criteria were extracted as potentially relevant to the release of CyHV-3. The question that is asked is whether the action (the release of CyHV-3):

- Measurably reduce the quantity, quality or availability of surface or ground water?
- Generate smoke, fumes, chemicals, nutrients, or other pollutants which will substantially reduce local air quality or water quality?
- Cause a long-term decrease in, or threaten the viability of, a native animal population or populations, through death, injury or other harm to individuals?
- Displace or substantially limit the movement or dispersal of native animal populations?
- Substantially reduce or fragment available habitat for native species?
- Reduce or fragment available habitat for listed threatened species which is likely to displace a population, result in a long-term decline in a population, or threaten the viability of the species?
- Introduce exotic species which will substantially reduce habitat or resources for native species?
- Undertake large-scale controlled burning or any controlled burning in areas containing listed threatened species?
- Affect the health, safety, welfare or quality of life of the members of a community, through factors such as noise, odours, fumes, smoke, or other pollutants?
- Substantially diminish the heritage value of a heritage place for a community or group for which it is significant?
- Substantially alter the setting of a heritage place in a manner which is inconsistent with the heritage values of the place?
- Substantially restrict or inhibit the existing use of a heritage place as a cultural or ceremonial site?

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[63] See: https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-12-actions-or-impacting-upon-commonwealth-land-and-actions

10.2 Assessment of risks to Commonwealth Lands

A spatial analysis was undertaken to better understand the number and characteristics of Commonwealth Lands in Australia and, specifically, those that intersected the distribution of carp provided by the Department of Environment and Energy.

Of the 7,329 land parcels provided for this analysis, approximately 6% (449 properties) intersected the distribution of carp. Ownership of these 449 properties was then broken down as shown below:

- Department of Defence 199 (44%)
- National Capital Authority 106 (24%)
- Other 50 (11%)
- Department of Finance 35 (8%)
- Australia Post 33 (7%)
- Sydney Harbour Trust 14 (3%)
- Bundanoon Trust 12 (3%)

The **Department of Defence** holds significantly the most land parcels (199, or approximately 44%), followed by the National Capital Authority, the Department of Finance and Australia Post.

The Defence holdings were analysed further, as shown below:

- Military area 71 (36%)
- Bombing range 35 (18%)
- Lot 32 (16%)
- Other 29 (15%)
- Munitions test 18 (9%)
- Block 9 (5%)
- Volume 3 (2%)
- Port 1 (1%)
- RAAF 1 (1%)

This breakdown shows that military areas, bombing ranges and munitions testing facilities comprise approximately 62% of the Defence holdings that overlap with carp in Australia and almost 28% of all Commonwealth Lands that overlap. These lands are presumably subject to military use, and there is not a real chance or possibility that impacts following from the release of CyHV-3 in waterways within any given parcel would be considered significant. Similar conclusions were drawn for remaining Defence holdings, with the exception of the 32 (16%) parcels designated as Lots and the 29 (15%) parcels designated as Other. The purpose of these 61 parcels, which make up 31% of Defence holdings that overlap with the distribution of carp, was unknown.

The **National Capital Authority's** land parcels within the Australian Capital Territory were not analysed individually, although it was suspected that a substantial proportion of these parcels were identified as an artefact of the imprecision inherent in the underlying spatial dataset for carp in Australia. The National Heritage Places within the Australian Capital Territory were reviewed within Section 7, and none of these was considered at risk from the release of CyHV-3.

The nature and characteristics of the 35 land parcels held by the **Department of Finance** was not known. The 33 land parcels held by **Australia Post** are likely to be Post Office sites whose riverside locations intersect with the buffered distribution for carp. The likelihood of significant impacts arising at these sites as a result of the release of CyHV-3 was considered negligible.

The 14 land parcels owned by the **Sydney Harbour Trust** are within the harbour environs, and the likelihood of significant impacts arising at these sites as a result of the release of CyHV-3 was considered negligible. The 12 parcels held by the **Bundanoon Trust** are located on the Shoalhaven River, upstream of Nowra. This reach of the river is deep and lotic, and the carp biomass density is extremely low (if carp are present at all). The likelihood of significant impacts arising at these sites as a result of the release of CyHV-3 was considered negligible.

In concluding: further analysis of the 61 Lots and 'Other' Defence land parcels that intersect with the distribution of carp in Australia, and the 35 land parcels held by the Department of Finance, may be warranted. Aside from these, there is not a real chance or possibility that the release of CyHV-3 in Australia would result in significant impacts to Commonwealth Lands.

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NATIONAL CARP CONTROL PLAN

The National Carp Control Plan is managed by the
Fisheries Research and Development Corporation

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