

HUNTER ESTUARY WETLANDS RAMSAR SITE – KOORAGANG COMPONENT

FORMAL ASSESSMENT OF CHANGE

EXECUTIVE SUMMARY

Arcadis Australia Pacific Pty Ltd (Arcadis), in partnership with Umwelt (Australia) Pty Ltd (Umwelt), were engaged by the Department of the Environment and Energy (DoEE) to undertake a formal assessment of the Hunter Estuary Wetlands Ramsar Site (Kooragang component).¹

Objective and Approach

The objective of the formal assessment was to:

“determine if a change in ecological character of the Hunter Estuary Ramsar Site (Kooragang Component) has occurred due to chemical contamination, the significance of the change, and the cause of the change.” (DoEE, 2017).

The investigation takes the form of a formal assessment of change of ecological character undertaken in accordance with the *National Guidance on Notifying Change in Ecological Character of Australian Ramsar Wetlands (Article 3.2)*. The assessment investigated changes to critical components, processes and services influencing the ecological character of the site, as they relate to potential contamination issues.

Trigger for Formal Assessment

On the 3 September 2015, the NSW Government announced that PFAS contamination had been detected both on and offsite at the Department of Defence RAAF Base at Williamstown. An Expert Panel was convened to investigate the nature and extent of the contamination and recommend next steps to the NSW Government. This resulted in the NSW Environment Protection Authority advising the NSW Office of Environment and Heritage that there was a strong likelihood that PFAS had caused a change in the ecological character of the Hunter Estuary Ramsar site. OEH subsequently notified the Australian Ramsar Administrative Authority which initiated this formal assessment.

Findings

The National Guidance on Notifying Change in Ecological Character of Australian Ramsar Wetlands (Article 3.2) states that the formal assessment is the means whereby the evidence is weighed, the significance of the ‘change’ is determined, and a considered decision is reached by the relevant parties as to whether or not the change is sufficient to warrant a recommendation to the Administrative Authority that a notification should be made. In accordance with this guidance, this assessment investigated possible changes to critical components, processes and services (CPS) that define the ecological character of the Hunter Estuary Wetlands Ramsar Site (Kooragang component), particularly as they relate to potential chemical contamination issues.

In complex systems, it is often difficult to determine exact causation of change, even if there is a correlation between two or more variables. The outcomes from the assessment presented below show correlations between contaminant concentrations and CPS that suggest that chemical contaminants are impacting negatively on one of more of the CPS.

The Ramsar Convention advocates the application of a ‘precautionary’ approach to addressing changes in ecological character. If it is scientifically plausible but uncertain that actions, such as chemical contamination in this case, could lead to adverse change in ecological character then

¹ A list of terms and abbreviations is provided in Appendix G.

actions should be taken to avoid or diminish that adverse change. Additional work is recommended to reduce uncertainty surrounding the cause of the change and to develop appropriate responses to address likely changes.

Table E.1 summarises the findings from this assessment. Further detail is provided in the sections below.

Table E.1 – Summary of findings from this assessment.

Critical ecological components, processes and services	Potential impacts: scientifically plausible pathways of chemical contamination	Has Change Occurred?*
Intertidal mudflats	Intertidal mudflats are likely to be affected by chemical contamination in sediments. This could result in impacts on food sources to waterbirds. Possible indirect effects of nutrient contamination resulting in low dissolved oxygen levels.	Unknown, but considered likely
Food webs	Refer to birds, frogs, saltmarsh and intertidal mudflats.	Considered likely, but not yet evident in shorebirds (possibly due to ecological time lags).
Migratory shorebirds: Number of species of migratory shorebirds recorded at site annually	Heavy metals (lead) and PFAS: Bioaccumulation through the food chain and direct toxic effects via ingestion of algae, benthic organisms and small fish. Indirect impacts from poor water quality (e.g. low oxygen, algal blooms).	Unknown, but considered unlikely.
Migratory shorebirds: Abundance of migratory shorebirds recorded at the site in summer		Unknown, but considered likely.
Migratory shorebirds: Number of migratory shorebird roost sites	Unknown, but potential impacts unlikely to exist.	Yes, but unlikely to be due to chemical contamination
Eastern curlew (critically endangered)	Heavy metals (lead) and PFAS: Bioaccumulation through the food chain and direct toxic effects via ingestion of algae, benthic organisms and small fish.	Unknown, but considered likely
Saltmarsh community	Nutrients: Facilitating spread of salt tolerant weeds at the upper edge of the saltmarsh	Yes, but unlikely to be due to chemical contamination.
Green and golden bell frog (vulnerable)	Possibly direct toxic effects associated with exposure to heavy metals, PFAS, petroleum hydrocarbons, poly aromatic hydrocarbons, herbicides and pesticides and cyanide (although there is evidence of frogs existing and breeding in ponds with heavy metal contamination).	Unknown, but considered possible (absence of site-specific data)

* This report finds that the CPS listed in this table are at a high risk to chemical contamination present in the waters and sediments of the Kooragang component of the Ramsar site and that changes in the ecological character are likely to be occurring or are likely to occur in the future.

Ecological Assessment of Change Summary

The Hunter Estuary Wetlands was listed under the Ramsar Convention in 1984. An Ecological Character Description (ECD) for the Hunter Estuary Wetlands Kooragang Component was prepared in 2010 (Brereton and Taylor-Wood 2010). This identifies the following critical components, processes and services (CPS) that define the ecological character of the site:

- The food web and intertidal mudflats;
- The abundance and diversity of shorebirds with a particular focus on the eastern curlew and recently listed threatened species;
- *Sarcocornia* saltmarsh;
- Threatened wetland species including the green and golden bell frog and Australasian bittern; and
- Hydrology (tidal regime and freshwater inflows).

Limits of Acceptable Change (LAC) for the CPS were also set to establish lower bounds that could constitute a change in ecological character. No LAC was set for the potential impacts of chemical contamination on the CPS, although the site had been impacted by industrial processes prior to listing.

This formal assessment considered potential changes in these CPS due to chemical contamination. The outcomes are summarised below. The hydrology CPS was not included as hydrology is not influenced by chemical contamination.

The food web of the intertidal mudflats

The food web of the intertidal mudflats is critical in supporting migratory shorebirds. The infauna of the estuary provides an essential food source for a variety of avifauna. At low tide, shorebirds forage over the mudflats feeding on invertebrates in the mud and sand substrates (infauna).

At the time of listing, there was little information about the intertidal mudflat food webs of the Kooragang Estuary, leading to difficulty in describing a baseline condition and variability of this critical service (Brereton and Taylor-Wood, 2010) and no direct limit of acceptable change for food webs was developed. There is still no readily available assessment of the extent of intertidal mudflat habitat over time to understand whether there has been a change in the intertidal mudflat and the invertebrate fauna.

While the availability of foraging habitat and food is a critical supporting service for migratory shorebirds, any changes in the service may not be reflected in changes in the number of migratory shorebirds given that changes in the number of migratory shorebirds are unlikely to be due solely to changes in the food web in the Hunter estuary. That is, there are factors other than the availability of intertidal mudflats and food web that may impact on migratory shorebirds, including changes to habitats in the flyway external to Kooragang, at breeding grounds and stopover sites that also impact on shorebird numbers.

Risks to shorebird species are considered to exist via bioaccumulation of chemicals through the food chain via ingestion of algae, benthic organisms and small fish. It is considered likely that some chemicals are bioaccumulating in migratory shorebirds foraging in the intertidal mudflats particularly in the Fullerton Cove area and Stockton Sandspit.

There is evidence of bioaccumulation of chemical contaminants in the food web in Fullerton Cove with concentrations higher in fish compared to benthic invertebrates (AECOM, 2018). AECOM (2018) identified that there is potential for unacceptable risks to birds eating vegetation, invertebrates or fish from Fullerton Cove. However, the risk was considered to be acceptable for migratory species that only spend a portion of their time feeding in Fullerton Cove. Although migratory shorebirds would also be exposed to chemical contaminants at other locations along their migratory routes in the East Asian Australasian Flyway (EAAF) (extending from breeding grounds in the Russian tundra, Mongolia and Alaska southwards through east and south-east Asia to non-breeding areas in Indonesia, Papua New Guinea, Australia and New Zealand), they spend up to six months of the year at their primary feeding grounds at the southern extents of the Flyway. The Hunter Estuary Ramsar site is one such feeding

ground. Some juvenile birds will stay in Australia for up to three years before they start the full migration back to the breeding grounds.

Whilst there are significant knowledge gaps in describing the food web of the intertidal mudflats in the Kooragang component and its influence on the ecological character of the site, there is a clear and scientifically plausible risk that chemical contaminants are negatively impacting on this CPS.

Shorebirds

Shorebirds, particularly migratory species, are one of the principal justifications for listing of the Kooragang component of the Hunter Estuary Wetlands as a Ramsar Wetland of International Importance. The site contains foraging and roosting habitat for populations of migratory shorebirds during their non-breeding season.

The ECD set two LAC, as follows:

- the annual maximum summer count of migratory shorebirds should not be less than 5,000 birds in five (5) consecutive years; and
- For any given five (5) year period, the average of the annual maximum summer count of eastern curlew for the Hunter estuary should not be less than 600 birds.

The level of confidence for both of these LAC was low (Brereton and Taylor-Wood 2010). An analysis of long term (April 1999 to December 2017) shorebird data was undertaken to identify any changes in shorebird abundance. This showed a slight, albeit statistically non-significant, overall *increase* in migratory shorebird abundance.

The increase in migratory bird abundance is largely due to rehabilitation works at Tomago wetland and the return of sharp-tailed sandpipers in large numbers to this wetland from 2013 onwards.

Removing the influence of the Tomago wetland shows a declining trend in shorebird abundance, as measured by the annual maximum summer count of migratory shorebirds, to less than 5000 birds for the last three years of data. However, this does not constitute an exceedance of the LAC as the threshold is set at five (5) consecutive years.

At the time of listing in 1984, the Kooragang component of the Hunter Estuary Wetlands Ramsar site recorded 900 eastern curlews (*Numenius madagascariensis*), and between 1999 and 2007, there were regularly 400 to 600 eastern curlews (Herbert, 2007a). Analysis of monthly data from 2000 to 2017 shows a decline in abundance of the eastern curlew. This decline is more pronounced in the last four years (2014 to 2017).

While this analysis would indicate that the LAC for the eastern curlew has been exceeded, it is noted that there is a low level of confidence in the LAC. Further, this declining trend of the eastern curlew abundance is reported both nationally and globally (Hansen et al., 2016; Clemens et al 2016). In response, the eastern curlew was listed as 'critically endangered' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in 2015.

Notable changes have occurred for individual species of migratory shorebirds with national decline since 2015 recognised by listing the following species under the EPBC Act:

- bar-tailed godwit (*Limosa lapponica baueri*);
- curlew sandpiper (*Calidris ferruginea*)
- great knot (*Calidris tenuirostris*);
- red knot (*Calidris canutus*); and
- black-tailed godwit (*Limosa limosa*).

These species have also shown a decline in abundance from 2000 to 2017. However, these declines are similar to other coastal Ramsar sites in south-eastern Australia and global declining trends. The extent to which local impacts (e.g. chemical contamination and habitat changes, etc.) have individually contributed to the decline in migratory shorebird abundance at the Kooragang component of the Hunter Estuary is unclear.

While no LAC was set for migratory shorebird 'species diversity', due to an insufficient knowledge of what would constitute a change in ecological character, number of species present at the site could be considered to reflect species diversity. The recent survey data (1999 to 2017) does not show any change in number of species present at the site.

Restoration of estuarine habitats on Ash Island and Hexham Swamp is increasing habitat for migratory shorebirds in the Hunter estuary. Whether this has an effect on numbers of migratory shorebird at the Kooragang component of the Ramsar site, that is whether birds are preferentially using areas external to the Kooragang component, was not tested in this assessment as data for other sites external to the Kooragang component was not available for analysis. Supporting statements on changes in abundance of select shorebird species in the Hunter estuary was provided from a literature review by Hunter Bird Observers Club and updates of the EAAF counts (Clemens et al. 2016).

It is unclear whether declines in shorebird counts may be attributed directly to contamination given other potential confounding factors, including the following:

- changes in roost availability;
- impacts of repeated disturbances (high energetic cost that may compromise their capacity to build sufficient energy reserves for migration);
- poor water quality impacts;
- foraging habitat loss; and
- drought.

However, negative impacts on shorebirds caused by chemical contamination at the Kooragang component of the Hunter Estuary Ramsar site cannot be discounted as there is no known evidence that allows negative impacts to be ruled out.

Saltmarsh

At the time of listing in 1984, saltmarsh covered approximately 582 ha (Williams et al., 2000). Since listing, the extent of saltmarsh has continued to decline, most likely as a result of lags in the ecological responses to the drainage and reclamation works that took place in the lower Hunter Estuary from the late 1950s to 1980 and as a consequence of sea level rises.

Since 1993, a number of restoration projects have commenced in the Hunter estuary to restore saltmarsh shorebird and fish habitat. Notwithstanding localised increases in area of saltmarsh from restoration efforts, recent mapping (Kleinfelder, 2016) has identified that the current extent of saltmarsh within the Kooragang component of the Ramsar wetlands has continued to decline and is now estimated to cover approximately 289 ha. Although this exceeds the LAC, it is recognised that the confidence level for the LAC was low, and that the LAC did not appropriately consider the trajectory of changes occurring at the site at the time of listing.

There is no evidence that changes to saltmarsh extent are attributed to chemical contamination. This declining trend in saltmarsh habitat is recognised in estuaries across NSW and nationally. Saltmarsh was listed as an endangered ecological communities (EEC) under the state *Biodiversity Conservation Act 2016* (BC Act) and as vulnerable under the EPBC Act in 2013.

It is recommended that the recent monitoring in the Tomago wetlands of changes in saltmarsh in response to restoration works should continue to inform iterative management of the Kooragang component of the Ramsar site. Consideration should be given to expanding this monitoring program to assess other areas of saltmarsh in the Kooragang component.

Other Threatened Species

Two other nationally threatened species were highlighted in the ECD as critical to the ecological character of the site - the green and golden bell frog (*Litoria aurea*) and Australasian bittern (*Botaurus poiciloptilus*).

The LAC identified in the ECD for the green and golden bell frog was no more than two (2) years between successful breeding events (defined as the presence of a new first year adult cohort) in at

least one (1) of the three (3) known populations (Brereton and Taylor-Wood, 2010). The level of confidence for this LAC was recognised as low in the ECD due to the absence of long-term data on breeding events and population / movement dynamics (Brereton and Taylor-Wood, 2010).

There remains an absence of long-term data on breeding events, population and movement dynamics within the Kooragang component of the Ramsar site. This precludes an assessment of change in green and golden bell frogs and an assessment of any impacts associated with chemical contamination.

No LAC was set for the Australasian bittern. There is a paucity of data on the occurrence of the Australasian bittern in the Kooragang component of the Hunter Estuary Wetlands Ramsar site and gaps in the knowledge of the status of this species in the wider Hunter estuary. It is unknown whether rehabilitation works in Tomago and Hexham wetlands are altering the availability of habitat for this species, or whether chemical contamination may be impacting on this species. Ongoing monitoring would be required to better inform management of the species and its habitat.

Potential for Change Due to Chemical Contamination

Based on current scientific understandings, the CPS at most risk to chemical contamination are shorebirds and frogs. It is considered likely that some chemicals are bioaccumulating in migratory shorebirds foraging in the intertidal mudflats particularly in the Fullerton Cove area and Stockton Sandspit. Based on an analysis of the data available, the chemicals of primary concern at the Kooragang component of the Ramsar site were identified as lead and PFOS. These chemicals are associated with a range of effects, with lead exposure associated with neurological problems, kidney dysfunction, enzyme inhibition and anaemia, while PFOS exposures are associated with growth inhibition, histopathological effects, atrophied thymus, species diversity changes in a microcosm, and mortality.

Despite the significant data gaps that exist, there is sufficient evidence to indicate that the site has been potentially impacted by a number of contaminants. The screening-level assessment of the available data indicates that some contaminants are present in surface water, sediments, and biota at levels that may pose an unacceptable risk to ecological receptors. Some of these contaminants were likely present in greater concentrations at the time of listing in 1984, suggesting that contaminants which have declined (e.g. metals which have been flushed from the system and / or been 'capped' by deposits of less contaminated sediment) are unlikely to be responsible for any observed changes in ecological character since listing. However, for some persistent contaminants, effects may occur for many years after the initial release.

PFAS at the Ramsar site is predominantly associated with contamination released from RAAF Base Williamstown, where PFAS containing fire-fighting foams were commonly used, stored and disposed of, between the 1970s and mid-2000s (Taylor and Cosenza, 2016). Recent studies have shown that PFAS in Australian human blood serum levels are generally declining due to the removal of PFAS from many consumer goods (Toms et al, 2014), however, there are ongoing increases in concentrations in some biota at higher tropic levels due to biomagnification and bioaccumulation within the environment (Miller et al, 2015).

The findings of this assessment were based on a large quantity of recent, relevant and high quality data for PFAS at the site, and very limited data for other chemicals. Collection of additional site data, particularly for other potential contaminants, would be required to determine whether chemical impacts have resulted in a change in the ecological character of the Ramsar site.

Recommendations

Recommendations arising from this investigation include:

- consultation;
- reducing uncertainty in potential changes to ecological character of the site; and
- development of an action plan to improve understanding of the Ramsar site.

Consultation

Additional consultation that more actively engages with key stakeholders is recommended.

Data Gaps

There are significant data gaps with regards to the assessment of contaminant levels and associated risk within the Hunter Estuary Ramsar site. The following recommendations are made with regards to addressing these data gaps:

- conduct site specific sampling of sediment and surface water throughout the site.
- undertake detailed baseline surveys within the Ramsar site and assess factors such as invertebrate density or species distribution relative to contaminant levels.
- undertake direct toxicity testing of sediment and surface water collected from the site, to assess whether there is a cause-effect relationship between contaminants at the site and toxic effects such as reduced survival, growth inhibition, or reduced fertilisation.

Ramsar Status Assessment

There is possibility of a future change in ecological character associated with chemical contamination, however further information is required.

It is recommended that a watching brief is commenced. This should include development of an action plan, with relevant stakeholders. It is suggested that the action plan focus on improving knowledge of processes and change, to better inform decisions and management. Where relevant, resets to the LAC, based on best available science, should also be considered to improve their relevance and capacity to inform future formal assessments of change.

The action plan should also identify and implement options to fill knowledge gaps and adopt standardised and systematic surveys to allow for comparison of data sets to ensure that further assessments of change are based on the best available science and to identify the contribution of climate change to these changes, particularly for saltmarsh, mangroves and extent of tidal mudflats.

This may include:

- investigation of bioaccumulation of chemicals of concern in the foodweb;
- assessment of geomorphic change at the site;
- investigations of green and golden bell frog at the site;
- investigations of the current status of the Australasian Bittern at the site and potential threats associated with chemical contamination and saltmarsh restoration activities; and
- Review of the LAC to:
 - strengthen the level of confidence that a change in LAC would be a good indicator of a possible change in ecological character; and
 - improve their relevance and capacity to inform future formal assessments of change, including due to chemical contamination.

Longer term strategies for possible interventions may require approvals and environmental assessment or policy investigation and potentially include:

- modification of the boundaries of the Ramsar site;
- scoping and implementation of works, with other stakeholders, to improve north arm sandflats;
- investigation of the feasibility to improve tidal flows under Ramsar Road; and,
- consideration of whether Australasian Bittern is still a critical CPS for this site.