

Salamander Waters Estate: biodiversity of a highly modified environment

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Salamander Waters Estate is a highly modified area designated as a long-term development project by the Port Stephens Council in New South Wales. Over the past two decades most of the planned changes have already been completed. A sports complex, a car park and two ponds with a connecting channel were constructed in 2004-5, and the first of two residential housing estates was completed in 2015-16. Regular, on-going bird surveys of the site suggest that development, to date, has not adversely affected bird life, in fact, the ponds and channel introduced a permanent water source of benefit to all native fauna.

Records drawn from a variety of sources show that the site supports a healthy variety of native species, most were locally resident, some were migratory, and some were of special interest either due to their classification under the NSW *Biodiversity Conservation Act 2016* or because they were generally uncommon in the Hunter Region. Sixteen amphibians (one classified as vulnerable in NSW); twenty seven mammals, including eight marsupials (seven vulnerable); two reptiles, and 155 bird species (seven vulnerable) have been recorded at Salamander Waters Estate. Eighty-two species of plants and trees have been recorded.

Bird species which have been recorded at the site include seven species which currently are classified as vulnerable in NSW: Wompoo Fruit-Dove *Ptilinopus magnificus*; White-throated Needletail *Hirundapus caudacutus*; Fork-tailed Swift *Apus pacificus*; Powerful Owl *Ninox strenua*; Osprey *Pandion haliaetus*; Little Eagle *Hieraaetus morphnoides*; White-bellied Sea-Eagle *Haliaeetus leucogaster*; Glossy Black-Cockatoo *Calyptrorhynchus lathami*; Varied Sittella *Daphoenositta chrysoptera* and Satin Flycatcher *Myiagra cyanoleuca*.

Also, several non-avian species listed as vulnerable in NSW have been recorded: Wallum Froglet *Crinia tinnula*; Squirrel Glider *Petaurus norfolcensis*; Little Bent-winged Bat *Miniopterus australis*; Eastern Coastal Free-tailed Bat *Micronomus norfolkensis*; Greater Broad-nosed Bat *Scoteanax rueppellii*; Southern Myotis *Myotis macropus*; Grey-headed Flying Fox *Pteropus poliocephalus* and Koala *Phascolarctos cinereus*.

Although the Stage 1 housing development does not appear to have had a major impact on native flora and fauna, the planned Stage 2 development, which will be twice the size of Stage 1, has the potential to place the existing flora and fauna under considerable pressure. Further development of the site will need to incorporate carefully considered measures to ensure the on-going protection of the site's rich biodiversity, a district asset well recognized by local and visiting birdwatchers.

INTRODUCTION AND OBJECTIVES

The study site, zoned "Residential" in 2000 under the Port Stephens Environmental Plan (<https://www.portstephens.gov.au>) is a 20 ha, partially modified parcel of land located off Tarrant Road in Salamander Bay, NSW (at 32°43'53"S; 152°04'44" E). Originally the site consisted of native woodland and an abandoned sand mine. A development project is underway at the site, which is now known as Salamander Waters Estate (Conacher Travers Pty Ltd 1998-1999; Andrews

Neil 2007). Site assessments and environmental studies were carried out prior to and during the project's development, which is approximately 70% complete. Development to date has created four definable habitat zones (see "Site Descriptions" below). Habitat demarcation is largely due to the positioning of the ponds and channel, designed to provide drainage and irrigation to the sports complex which is built on fill from the adjacent Waste Disposal Facility. The presence of a permanent water source appears to have attracted wildlife, particularly birds. Over the past two

decades the site has been monitored monthly by the authors and visited regularly by members of the local Tomaree Bird Club and the Hunter Bird Observers Club (HBOC). The final site development stage, a proposed 12-ha 66-lot residential sector, remains at the preliminary concept level (<https://www.portstephens.gov.au> (McDaid 2020).

The objectives of this paper are to describe the location of the study site and its habitats and wildlife, with particular emphasis on avian species. Our intention is to update knowledge of the area's natural complexity, prior to the next stage of residential development, to emphasise the high degree of environmental sensitivity needed in order to protect and preserve the site's rich biodiversity, and to highlight the site's potential to enhance the general public's experience of nature.

METHODS

Between 2008 and 2022, monthly bird surveys were carried out by the authors. The 2-3 hr walking surveys were conducted in accordance with Birddata protocol (<https://www.birddata.birdlife.org.au/>) and covered, to the fullest extent possible, all habitats within an approximate 500 m radius. Additional data from field trip reports submitted to Port Stephens Council by the Tomaree Bird Watchers (Tomaree Bird Watchers 1999-2000) and from HBOC records (available at <https://birddata.birdlife.org.au/>), and eBird and Birddata records (<https://ebird.org/Australia/>; accessed 23/04/2022; <https://www.birddata.birdlife.org.au/>; accessed 23/04/2022) were collected. The multi-sourced records were cross-checked to eliminate duplication. Sightings recorded during ecological assessments of the area were also tabulated (Conacher Travers 1998-1999; Andrews Neil 2007). All avian species were ranked according to their HBOC classification (Williams 2020), then loosely grouped by their preferred habitat.

The site's development history was provided by the Port Stephens Council (Conacher Travers 1998-1999; Andrews Neil 2007; McDaid 2020). That history assisted in our establishment of pre-development baseline flora and fauna estimates and in the identification of threatened species as defined under the NSW *Biodiversity Conservation Act 2016* (BC Act).

Size and distance measurements pertaining to the study site were obtained using Google Earth (<https://www.google.au/earth> accessed 13/04/2022). Distances between the study site and nearby wetlands were measured from the centre of the study site to the centre of the main wet areas of the wetlands.

Site descriptions

The approximately 20-ha study site is located west of Soldiers Point Road, and is bounded by Tarrant Road, the Salamander Waste Disposal and Recycling facilities to the north, and the Cromarty Bay estuarine saltmarsh to the west. The completed first stage of Council's planned residential development is situated along part of the eastern boundary, and an as-yet undeveloped area of forest lies to the south-east between the Old Soldiers Point Road (now disused) and Port Stephens Drive.

The varied elements of the study site, excluding the housing development, were loosely classified into four habitat types (Figure 1). The four identified habitats are comprised of: mature sclerophyll forest (Habitat 1), open playing fields (the sports complex, Habitat 2); estuarine swamp (Habitat 3); and two leachate ponds connected by a channel (Habitat 4). Two additional wetland areas are located nearby – Wanda Wetlands and Mambo Wetlands – as is the relatively sheltered Cromarty Bay (Figure 2).

HABITAT 1 – Forest (Sub-areas 12, 13 and 14).

Sub-area 12 has been described as remnant forest (Andrews Neil 2005, Annex B). The canopy consists mostly of Smooth-barked Apple *Angophora costata* and Blackbutt *Eucalyptus pilularis*. The understorey is mainly Old Man Banksia *Banksia serrata* and Smooth Geebung *Persoonia levis*. The varied ground cover is dominated by Bracken *Pteridium esculentum* and grasses (Andrews Neil 2007). Sub-area 12 contains the site of the planned 66 lot Stage 2 residential development.

Sub-area 13 consists of a low-lying, paperbark forest adjacent to an area of estuarine swamp. The canopy overstorey in this region is predominantly Swamp Mahogany *Eucalyptus robusta* and Broad-leafed Paperbark *Melaleuca quinquenervia* with an understorey of ferns and a ground cover of Cord Rush *Restio tetraphyllus* (Andrews Neil 2007).

Sub-area 14 is formed by a built embankment which serves as a nature corridor that separates the Stage 1 residential area from the northern pond, while also protecting a small area of environmentally threatened *Lepironia* (Grey Sedge) swamp. The embankment is covered in a variety of shrubs and grasses. The *Lepironia* swamp contains Broad-leafed Paperbark and Swamp Mahogany standing in an area permanently inundated with up to 0.5m of water (Andrews Neil 2007).

HABITAT 2 – The sports complex (Sub-areas 4 and 5).

The sports complex, including a large clubhouse and parking area, is bordered by estuarine swamp to the west, two connected ponds to the east, and forest to the south. Tarrant Rd, which provides access to the Waste Disposal Centre and Recycling Depot, forms the northern boundary, beyond which lies a busy industrial area.

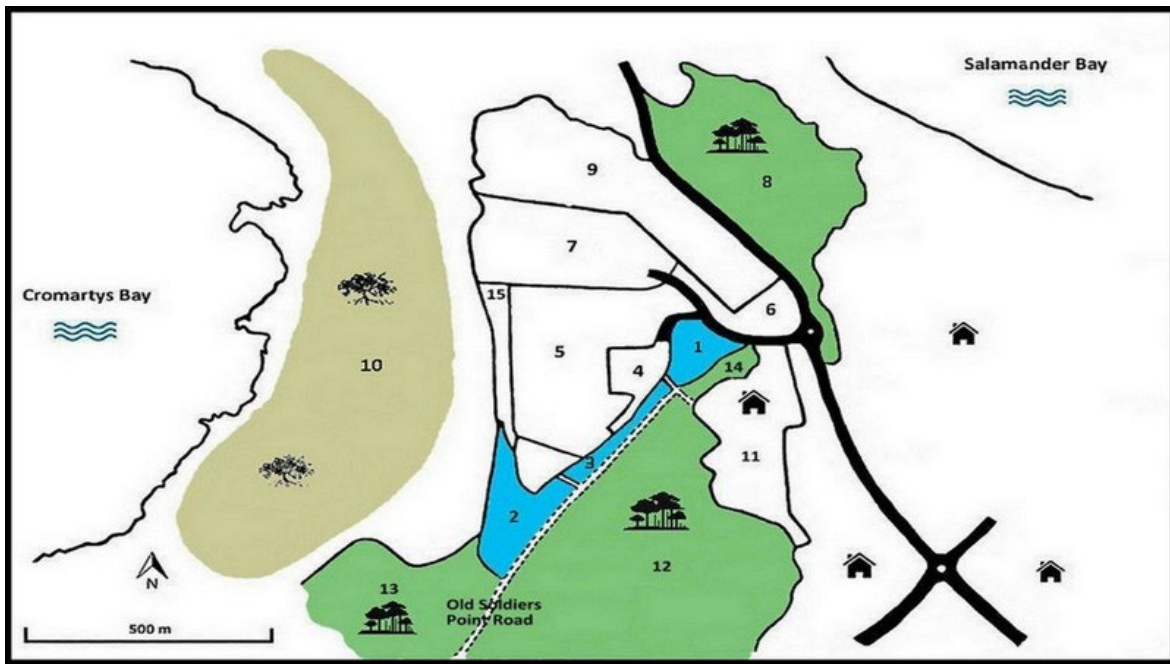


Figure 1. The Salamander Waters Estate Study Site and its sub-areas. (Codes: 1. Pond 1. 2. Pond 2. 3. Connecting channel. 4. Clubhouse and carpark. 5. Playing fields. 6. Recycling facility. 7. Waste disposal facility. 8. Wanda Wetlands. 9. Industrial area. 10. Estuarine Swamp. 11. Stage 1 Residential development (completed). 12. Proposed Stage 2 residential development. 13. Low-lying sclerophyll forest. 14. Nature strip. 15. Service corridor.)

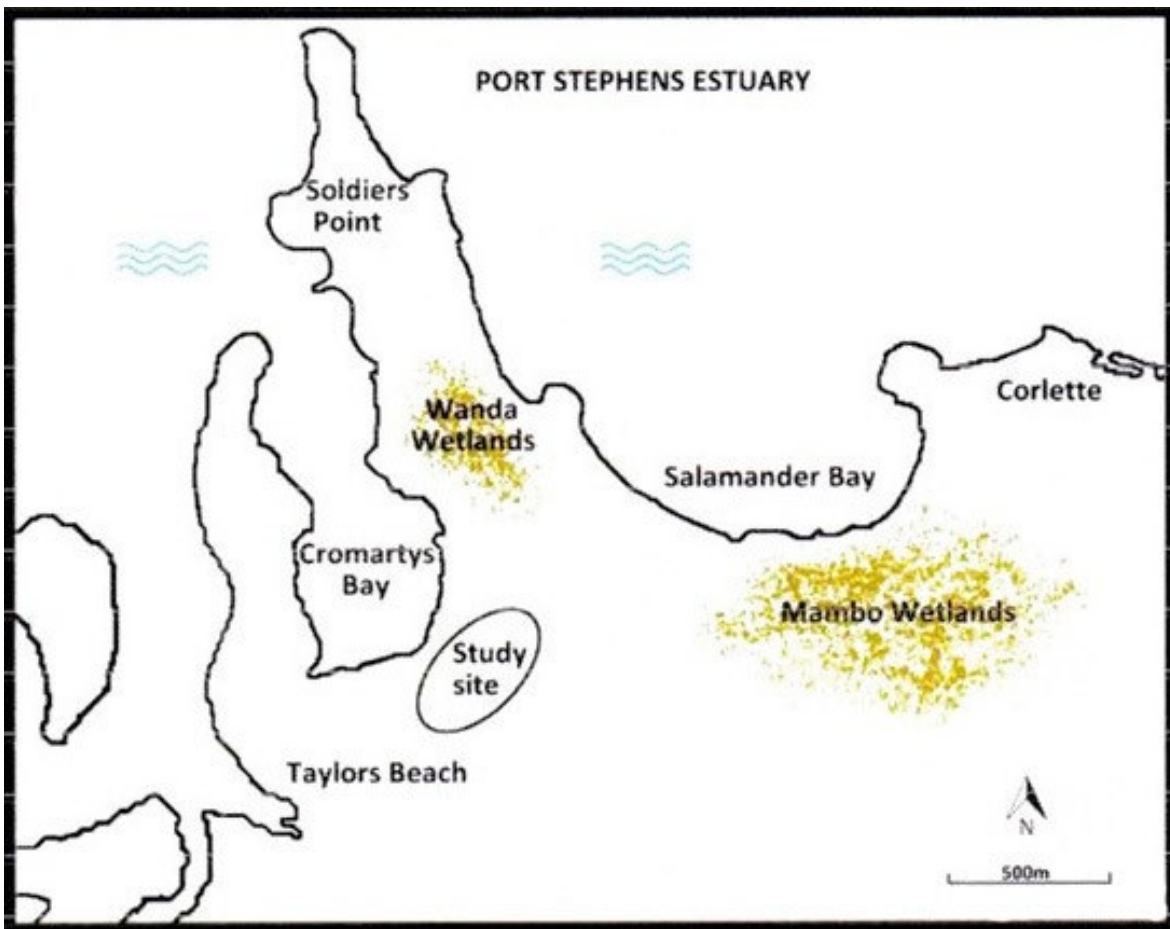


Figure 2. The study site in relation to neighbouring wetlands (Adapted from Google Maps).

HABITAT 3 – Estuarine Swamp (Sub-area 10).

The Estuarine Swamp lies between the sporting complex and Cromartys Bay. A levee protects the playing fields from tidal inundation, and provides vehicular access for mowing, maintenance and reclamation. The majority of the swamp area is covered with mangrove forest. Scattered patches of grassy groundcover occur in the littoral zone.

HABITAT 4 – The ponds and connecting channel (Sub-areas 1, 2 and 3).

The two connected ponds, constructed in 2004-5, intersect the playing fields, the forested areas and the Stage 1 housing development. The ponds are contained by dykes and are designed as aerated catchment basins for leach-water from the playing fields. A pumping system partially filters the pond water which can then be reused to irrigate the playing fields (McDaid 2020).

The smaller, shallower, northern pond (Pond 1) is somewhat rectangular in shape, 150m long and 120m across at the widest point. There is a heavy growth of Broad-leafed Paperbark on small mud islands and in the standing water. Fallen trees have been left to lie in the water. Water levels in the shallowest sections of Pond 1 can become depleted during summer and may completely dry up during severe drought conditions.

The southern pond (Pond 2) is deeper, larger, more open and slightly more rectangular (190m long and 120m across at the widest point). There are no islands in this pond. Flooded Swamp Mahogany and Broad-leafed Paperbark trees stand or lie in the water, and the pond's edges are lined with a thick margin of rushes (possibly *Phragmites australis*).

RESULTS

The collated data yielded a combined species site count of 155 birds; 16 amphibians; 27 mammals, including 8 marsupials; 2 reptiles and 82 plant species, recorded over a period of approximately 24 years (Tables 1, 5 and 6). A list of all the bird species is presented in the Appendix. The majority (144 of 155) of the avian species were Category 1 birds (i.e., common or relatively common species within the Hunter Region (Williams 2020)). The recording frequency suggested that 60 of those Category 1 species were site residents, and regular observation of young birds suggests that most resident birds breed within the study site. There were confirmed breeding records for 33 species.

The majority of the 155 avian species recorded were woodland birds (69%). The remainder were classified as either waterbirds (22%) or raptors (9%) (Table 1). Habitat 3 (the estuarine swamp) was not

formally surveyed as this area was not accessible by foot. From the vantage point of the levee, egrets, ibis and spoonbills could be seen foraging in Habitat 3 at low tide. The three other main habitats were surveyed regularly, with the forest areas (Sub-areas 12, 13 and 14) having the highest species diversity (Table 2). Annually 75-101 bird species were recorded during the years spanning 2008-2021 (Table 3). There was limited survey effort in 2022.

Ten avian species, which are listed *inter alia* in Table 4, are classified as Category 2, i.e., they are species of special interest for the Hunter Region (Williams 2020). Five of those species were confirmed by sightings by the authors: White-throated Needletail *Hirundapus caudacutus*; Osprey *Pandion haliaetus* (which nested successfully in eleven seasons); Glossy Black-Cockatoo *Calyptorhynchus lathami*; White-bellied Sea-Eagle *Haliaeetus leucogaster* and Varied Sittella *Daphoenositta chrysoptera*. The five other Category 2 species: Wompoo Fruit-Dove *Ptilinopus magnificus*; Fork-tailed Swift *Apus pacificus*; Little Eagle *Hieraetus morphnoides*; Powerful Owl *Ninox strenua*; and Satin Flycatcher *Myiagra cyanoleuca*; were reported elsewhere (Conacher Travers 1998-1999; Tomaree Bird Watchers 1999-2000; Andrews Neil 2007). A further five species are listed in Table 4 as important local records – Plumed Whistling-Duck *Dendrocygna eytoni*, Peaceful Dove *Geopelia placida*, Latham's Snipe *Gallinago hardwickii*, Spiny-cheeked Honeyeater *Acanthagenys rufogularis* and White-browed Woodswallow *Artamus superciliosus*. Latham's Snipe, a summer migrant of international interest, was often recorded at the site in years when low water levels exposed muddy areas.

The non-avian animal species recorded at the study site are summarised in Table 5. Eight of those species are classified as vulnerable under either the NSW *Environmental Planning and Assessment Act 1979*, the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* or the NSW *Biodiversity Conservation Act 2016*; they are listed in Table 4. The vulnerable non-avian species included one amphibian: Wallum Froglet *Crinia tinnula*; six mammals: Squirrel Glider *Petaurus norfolcensis*; Little Bent-winged Bat *Miniopterus australis*; Eastern Coastal Free-tailed Bat *Micronomus norfolkensis*; Greater Broad-nosed Bat *Scoteanax rueppellii*; Southern Myotis *Myotis macropus*; Grey-headed Flying Fox *Pteropus poliocephalus*; and one marsupial: Koala *Phascolarctos cinereus* (Conacher Travers 1998-1999; Andrews Neil 2007). Solitary Koala and Koala with young were observed by the authors.

Table 1. Bird species recorded at the study site between 1998-2022, grouped by guild and by HBOC category classification.

Guild	No of species recorded	No. of resident species	HBOC category classification								
			1	1C	1L	1M	2R	2T	2U	V/ 2T	V
Woodland birds	107	43	72	0	4	25	1	2	1	1	1
Waterbirds	34	15	26	1	2	4	0	0	0		0
Raptors	14	2	7	2	1	0	0	2	1	1	0
Total species	155	60	105	3	7	29	1	4	2	3	1
Percentage of total species:		38.7	68	1.9	4.5	19	0.7	2.6	1.3	1.9	0.7

HBOC category classification (from Williams 2020).

Cat.1: Common or relatively common within the Hunter Region.

1C=cryptic; 1L=locationally restricted; 1M=moves regularly

Cat.2: Of special interest for the Region.

2R=rarely recorded regionally; 2T=has threatened status; 2U=uncommon in Hunter Region; V=vulnerable

Table 2. Bird species recorded in the three main habitats, grouped by guild and by the HBOC category classification.

Guild	No of species recorded	No. of resident species	HBOC category classification								
			1	1C	1L	1M	2R	2T	2U	V/ 2T	V
Habitat 1: Forest											
Woodland birds	96	40	65	0	3	22	1	2	1	1	1
Waterbirds	1	1	1	0	0	0	0	0	0	0	0
Raptors	11	1	6	2	1	0	0	0	1	1	0
Total species	108	42	72	2	4	22	1	2	2	2	1
Habitat 2: Open area (sports complex)											
Woodland birds	19	2	17	0	0	1	0	1	0	0	0
Waterbirds	6	1	6	0	0	0	0	0	0	0	0
Raptors	2	1	2	0	0	0	0	0	0	0	0
Total species	27	4	25	0	0	1	0	1	0	0	0
Habitat 4: Ponds and connecting channel											
Woodland birds	5	3	1	0	1	3	0	0	0	0	0
Waterbirds	32	14	25	1	2	3					
Raptors	3	1	2	0	0	0	0	1	0	0	0
Total species	40	18	28	1	3	6	0	1	0	0	0

For HBOC classifications, see the footnote to **Table 1**.

Table 3. Annual species totals from surveys 2008-2022.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Woodland birds	71	68	64	61	52	55	61	55	70	59	53	58	56	59	42
Waterbirds	24	25	20	23	19	23	23	25	24	25	22	21	19	20	15
Raptors	6	4	3	0	4	4	2	3	4	4	5	2	2	2	1
Annual totals	101	97	87	84	75	82	86	83	98	88	80	81	77	81	58

Note: Limited survey effort in 2022.

Table 4. Species of special interest which were recorded at the study site.

Birds	Status
Plumed Whistling-Duck	Uncommon visitor to study site
Wompoo Fruit-Dove	Vulnerable in NSW
Peaceful Dove	Uncommon visitor to study site
White-throated Needletail	Summer migrant, Vulnerable in NSW
Fork-tailed Swift	Uncommon summer migrant
Latham's Snipe	Summer migrant of international interest
Powerful Owl	Vulnerable in NSW
Osprey	Vulnerable in NSW
Little Eagle	Vulnerable in NSW
White-bellied Sea Eagle	Vulnerable in NSW
Spiny-cheeked Honeyeater	Uncommon visitor to study site
Varied Sittella	Vulnerable in NSW
White-browed Woodswallow	Uncommon visitor to study site
Satin Flycatcher	Rare summer migrant to the Hunter Region
Amphibians	Amphibians
Wallum Froglet	Vulnerable in NSW
Mammals	Mammals
Little Bent-winged Bat	Vulnerable in NSW
Eastern Free-tailed Bat	Vulnerable in NSW
Greater Broad-nosed Bat	Vulnerable in NSW
Grey-headed Flying Fox	Vulnerable in NSW
Large-footed Myotis	Vulnerable in NSW
Koala	Endangered in NSW
Squirrel Glider	Vulnerable in NSW

Table 5. Non-avian fauna list for Salamander Wetlands estate (sources: Conacher Travers 1998; Tomaree Bird Watchers 1999-2000; Andrews Neil 2007; this study).

	Total species seen	No. of Vulnerable species	Conacher Travers (1998)	Tomaree Bird Watchers (1999-2000)	Andrews Neil (2007)	This work
Amphibians	16	1	12		10	
Mammals	27	7	20	3	11	2
Reptiles	2				1	2

Table 6. Total numbers of plant species recorded at Salamander Wetlands Estate and the numbers of weed species (source: Andrews Neil 2007).

Plant Group	No. Species	Weed Sp.
Flowering Plants	26	4
Ferns	5	1
Lilies	3	
Vines	5	1
Grass & Sedge	12	3
Herb & Spurge	4	
Legumes	13	1
Small Shrubs & Trees	14	
Total Species	82	10

Professional assessments of the site's plant species and vegetation communities (**Table 6**) found no threatened flora but recommended the retention of a 2-ha *Lepironia* swamp (Conacher Travers 1998-1999; Andrews Neil 2007).

DISCUSSION

The report of the first site assessment, commissioned by Port Stephens Council and conducted prior to construction of the ponds and the sports complex, appeared fragmented and it was not fully accessible to the authors (Conacher Travers 1998-1999).

The second site assessment was carried out prior to the commencement of the Stage 1 residential development, and after the completion of further ERM flora and fauna surveys (Environmental Resources Management Australia Pty Ltd 2005). The combined data from the two site assessments provided an historical base for the subsequent data which was collected by the authors.

Port Stephens Council, acting on advice from the environmental assessments, carried out revegetation specific to the uptake of moisture (phytocapping) in some site areas (McDaid 2020). The small, environmentally sensitive area of *Lepironia* swamp has been protected, by a combination of dykes and fencing, and the growth of native vegetation within the narrow nature corridor that separates the residential area from the ponds appears robust (Andrews Neil 2007). Survey plans for the 66-lot Stage 2 residential development appear to acknowledge the need for an extension of the existing wildlife corridor (Andrews Neil 2007).

Although the study site has undergone considerable disturbance over the past two decades, regular site monitoring indicates that wildlife populations within the various habitats remain healthy.

HABITAT 1 – Forest (Sub-areas 12, 13 and 14).

Conacher Travers (*in* Andrews Neil 2007) concluded that development of these three sub-areas would not have a significant effect on threatened species, therefore, their report did not provide any recommendations designed to ameliorate the impact of development. This opinion was apparently based upon the assumption that habitats within the site also occurred within local conservation reserves (Andrews Neil 2007). It should be noted that the adjacent habitats at Mambo Wetlands and Wanda Wetlands are likely to already contain their full

complement of species, and territorial pressure caused by the infiltration of species under stress in adjacent sites could have adverse effects on the populations in both areas.

These three forested sub-areas are notable in that they provide habitat for woodland birds, which comprised 67.7% of the study site's total avian population. Several woodland species classified as Category 2 (species of special interest for the Hunter Region) were associated with this habitat: White-throated Needle-tail; Glossy Black-Cockatoo; White-bellied Sea-Eagle; Varied Sittella; Wompoo Fruit-Dove; Fork-tailed Swift; Little Eagle; Powerful Owl; and Satin Flycatcher.

The Andrews Neil report did not find any threatened flora in this habitat, but it did identify a threat to the *Lepironia* swamp (now protected) and a number of threatened faunal species in the area, which included Squirrel Glider, Koala, tree-roosting microchiropteran bats, Grey-headed Flying Fox, Wallum Froglet and Powerful Owl (Andrews Neil 2007).

Andrews Neil (2007) made special reference to the proposed Stage 2 development site, recommending that further residential development should be confined to the eastern and northern section of the proposed site to better enable the retention of hollow-bearing trees and wildlife foraging resources. They also recommended the construction of an adequate ecological buffer for preferred Koala habitat (in Sub-area 12). A further recommendation involved the extension and maintenance of the established Koala corridor developed for the Stage 1 residential site (in Sub-area 14).

HABITAT 2 – The sports complex (Sub-areas 4 and 5).

The well-maintained playing fields are a regular venue for weekend team sport and annual school events. Although the birds retreated during these large events they returned quickly afterwards and did not appear to be fazed by lesser activities like training and unstructured play which took place during the week. It was not uncommon to find a mix of Australian Wood Duck *Chenonetta jubata* (50+ birds), Purple Swamphen *Porphyrio porphyrio*, Australian Magpie *Gymnorhina tibicen*, Magpie-lark *Grallina cyanoleuca* and Laughing Kookaburra *Dacelo novaeguineae* busily foraging in the grass for insects and worms, particularly after mowing and watering. A fence line and a slim verge of shrubbery (width 2m) separate the playing fields from the daily noise and business of large trucks and

earth-moving equipment operating at the Waste Disposal Depot, the Recycling Centre and passing traffic along the Tarrant Road access. Since 2013 a pair of Osprey have successfully nested in a mobile phone tower adjacent to this boundary fence. Dogs are prohibited but were frequently encountered, both on and off leash. Car park traffic, apart from during maintenance activity, is minimal on weekdays. During early mornings and late afternoons, insectivores, particularly Welcome Swallow *Hirundo neoxena*, could often be seen hawking for insects above the playing fields and the car park.

HABITAT 4 – The ponds and connecting channel (Sub-areas 1, 2 and 3).

The manner in which the ponds and the connecting channel intersect the study site provides relatively easy access to safe, reliable and sheltered water sources for fauna from all habitats. The ponds, which are approximately 1 km from both Cromarty Bay and Salamander Bay, are also frequented by estuarine birds, especially cormorants, and there may also have been some interchange of birds between the nearby Wanda and Mambo Wetlands.

Between 2010 and 2015, Australian White Ibis *Threskiornis moluccus* began to colonize Pond 1. A successful rookery was established in 2015 (Wooding 2016). Smaller numbers of active nests were observed in subsequent breeding seasons, suggesting that Pond 1 may serve as an alternative ibis nesting location when overcrowding occurs at the Wanda and Mambo Wetlands, especially in times of inland drought when coastal populations increase.

A combination of standing and fallen trees provided roosts, cover and nesting areas for many avian species including Australasian Darter *Anhinga novaehollandiae*; Little Black Cormorant *Phalacrocorax sulcirostris*; Little Pied Cormorant *Microcarbo melanoleucos*; and occasionally Black Swan *Cygnus atratus*. The noisy excavation and construction of the Stage 1 residential project (approximately 100-200 m from Pond 1) coincided with the 2015 ibis breeding event, but did not appear to disturb the ibis or any of the other waterbirds routinely found in Pond 1, mainly dabbling ducks, Gallinules (Purple Swamphen and Dusky Moorhen *Gallinula tenebrosa*) and Royal Spoonbill *Platalea regia* (LW pers. obs.). When the shallow water in Pond 1 retreated during summer the exposed muddy edges usually attracted Latham's Snipe (1-5 birds). Small numbers of Nankeen Night-Heron *Nycticorax*

caledonicus could often be spotted roosting in the Broad-leafed Paperbark on the pond's small islands.

Pond 2 is deeper, quieter, and more remote than Pond 1. Human activity is mostly restricted to dog-walking along what remains of the now abandoned Old Soldiers Point Road, which lies along the pond's eastern boundary. The pond's relative isolation provided secluded nesting habitat for many avian species including pairs of Australasian Darter *Anhinga novaehollandiae*, and a pair of Black Swan which nested there annually. Cormorants, and occasionally a White-bellied Sea-Eagle, perched in the tops of the leafless, drowned trees, and in summer White-breasted Woodswallow *Artamus leucorhynchus* lined up to roost along the bare branches. Diving ducks (e.g. Hardhead *Aythya australis* and Musk Duck *Biziura lobata*) and Australasian Grebe *Tachybaptus novaehollandiae* took advantage of the pond's depth and some Australian Reed-Warbler *Acrocephalus australis* could be heard calling from the pond's thick margin of rushes.

The connecting channel, 280m long and approximately 2.5m wide, carries excess water from the southern pond to the northern pond which, in turn, expels any overflow into the district drainage system. The channel's banks are densely edged with native shrubs and mature trees, predominantly Swamp Mahogany and Blackbutt. Wrens and finches frequented this area, and both species of kingfisher (Azure Kingfisher *Ceyx azureus* and Sacred Kingfisher *Todiramphus sanctus*) used the overhanging branches as hunting perches. Pairs of Sacred Kingfisher nested in the tree hollows and arboreal termite mounds.

CONCLUSIONS

Although the natural quality of the study site was previously disturbed by sand mining, and more recently by the construction of playing fields and residential housing, some development features i.e., the construction of ponds and a wildlife corridor, coupled with the retention of a significant expanse of native forest, appear to have offset any negative effects that development might have had on the site's wildlife population. While the present study was primarily bird-focused, non-avian species were often observed by the authors. The impressive variety of bird species, several of which are threatened species and/or are of special interest for the Hunter Region is an indication of current habitat healthiness. The site has become a popular destination for local birdwatchers. Visiting

birdwatchers are attracted to the site, and subsequently the region, by the information available about the site on-line and in tourist brochures.

To maintain this important district asset when undertaking the next development stage, it is essential that Council pays particular attention to the maximum retention of winter-flowering shrubs and trees, hollow-bearing trees, and Koala habitat. The existing nature corridor should also be extended, widened, and encouraged to become more vigorous, while still providing access for maintenance, safety vehicles and public foot traffic. It is hoped that, with the right care, the area's rich biodiversity can be maintained for the benefit of all concerned.

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Appendix: Salamander Waters Estate birdlist (from 1998-2022 surveys)

Brown Quail <i>Synoicus ypsilophorus</i>	Brown Goshawk <i>Accipiter fasciatus</i>
Plumed Whistling-Duck <i>Dendrocygna eytoni</i>	White-bellied Sea Eagle <i>Haliaeetus leucogaster</i>
Musk Duck <i>Biziura lobata</i>	Whistling Kite <i>Haliastur sphenurus</i>
Black Swan <i>Cygnus atratus</i>	Rainbow Bee-eater <i>Merops ornatus</i>
Australian Wood Duck <i>Chenonetta jubata</i>	Dollarbird <i>Eurystomus orientalis</i>
Grey Teal <i>Anas gracilis</i>	Azure Kingfisher <i>Ceyx azureus</i>
Chestnut Teal <i>Anas castanea</i>	Sacred Kingfisher <i>Todiramphus sanctus</i>
Pacific Black Duck <i>Anas superciliosa</i>	Laughing Kookaburra <i>Dacelo novaeguineae</i>
Mallard x Pacific Black Duck (hybrid) <i>A. platyrhynchos/superciliosa</i>	Nankeen Kestrel <i>Falco cenchroides</i>
Hardhead <i>Aythya australis</i>	Australian Hobby <i>Falco longipennis</i>
Australasian Grebe <i>Tachybaptus novaehollandiae</i>	Peregrine Falcon <i>Falco peregrinus</i>
Rock Dove <i>Columba livia</i>	Yellow-tailed Black-Cockatoo <i>Calyptorhynchus funereus</i>
White-headed Pigeon <i>Columba leucomela</i>	Glossy Black-Cockatoo <i>Calyptorhynchus lathami</i>
Spotted Dove <i>Streptopelia chinensis</i>	Galah <i>Eolophus roseicapilla</i>
Crested Pigeon <i>Ocyphaps lophotes</i>	Long-billed Corella <i>Cacatua tenuirostris</i>
Peaceful Dove <i>Geopelia placida</i>	Little Corella <i>Cacatua sanguinea</i>
Bar-shouldered Dove <i>Geopelia humeralis</i>	Sulphur-crested Cockatoo <i>Cacatua galerita</i>
Wompoo Fruit-Dove <i>Megaloprepia magnifica</i>	Red-rumped Parrot <i>Psephotus haematonotus</i>
Tawny Frogmouth <i>Podargus strigoides</i>	Eastern Rosella <i>Platycercus eximius</i>
Pheasant Coucal <i>Centropus phasianinus</i>	Musk Lorikeet <i>Glossopsitta concinna</i>
Eastern Koel <i>Eudynamis orientalis</i>	Rainbow Lorikeet <i>Trichoglossus moluccanus</i>
White-throated Needletail <i>Hirundapus caudacutus</i>	Scaly-breasted Lorikeet <i>Trichoglossus chlorolepidotus</i>
Fork-tailed Swift <i>Apus pacificus</i>	White-throated Treecreeper <i>Cormobates leucophaea</i>
Channel-billed Cuckoo <i>Scythrops novaehollandiae</i>	Variiegated Fairy-wren <i>Malurus lamberti</i>
Horsfield's Bronze-Cuckoo <i>Chalcites basalis</i>	Superb Fairy-wren <i>Malurus cyaneus</i>
Shining Bronze-Cuckoo <i>Chalcites lucidus</i>	Southern Emu-wren <i>Stipiturus malachurus</i>
Fan-tailed Cuckoo <i>Cacomantis flabelliformis</i>	White-cheeked Honeyeater <i>Phylidonyris niger</i>
Brush Cuckoo <i>Cacomantis variolosus</i>	New Holland Honeyeater <i>Phylidonyris novaehollandiae</i>
Pallid Cuckoo <i>Cacomantis pallidus</i>	Brown Honeyeater <i>Lichmera indistincta</i>
Buff-banded Rail <i>Gallirallus philippensis</i>	Blue-faced Honeyeater <i>Entomyzon cyanotis</i>
Dusky Moorhen <i>Gallinula tenebrosa</i>	White-naped Honeyeater <i>Melithreptus lunatus</i>
Eurasian Coot <i>Fulica atra</i>	Brown-headed Honeyeater <i>Melithreptus brevirostris</i>
Purple Swamphen <i>Porphyrio porphyrio</i>	White-eared Honeyeater <i>Nesoptilotis leucotis</i>
Royal Spoonbill <i>Platalea regia</i>	Striped Honeyeater <i>Plectorhyncha lanceolata</i>
Australian White Ibis <i>Threskiornis moluccus</i>	Noisy Friarbird <i>Philemon corniculatus</i>
Straw-necked Ibis <i>Threskiornis spinicollis</i>	Scarlet Honeyeater <i>Myzomela sanguinolenta</i>
Nankeen Night-Heron <i>Nycticorax caledonicus</i>	Eastern Spinebill <i>Acanthorhynchus tenuirostris</i>
Striated Heron <i>Butorides striata</i>	Lewin's Honeyeater <i>Meliphaga lewinii</i>
Cattle Egret <i>Bubulcus ibis</i>	Spiny-cheeked Honeyeater <i>Acanthagenys rufogularis</i>
Great Egret <i>Ardea alba</i>	Little Wattlebird <i>Anthochaera chrysoptera</i>
Plumed Egret <i>Ardea plumifera</i>	Red Wattlebird <i>Anthochaera carunculata</i>
White-faced Heron <i>Egretta novaehollandiae</i>	White-plumed Honeyeater <i>Ptilotula penicillata</i>
Little Egret <i>Egretta garzetta</i>	Fuscous Honeyeater <i>Ptilotula fusca</i>
Australian Pelican <i>Pelecanus conspicillatus</i>	Yellow-faced Honeyeater <i>Caligavis chrysops</i>
Little Pied Cormorant <i>Microcarbo melanoleucos</i>	Yellow-tufted Honeyeater <i>Lichenostomus melanops</i>
Great Cormorant <i>Phalacrocorax carbo</i>	Noisy Miner <i>Manorina melanocephala</i>
Little Black Cormorant <i>Phalacrocorax sulcirostris</i>	Spotted Pardalote <i>Pardalotus punctatus</i>
Pied Cormorant <i>Phalacrocorax varius</i>	Striated Pardalote <i>Pardalotus striatus</i>
Australasian Darter <i>Anhinga novaehollandiae</i>	Brown Gerygone <i>Gerygone mouki</i>
Black-fronted Dotterel <i>Elsayornis melanops</i>	White-throated Gerygone <i>Gerygone olivacea</i>
Masked Lapwing <i>Vanellus miles</i>	White-browed Scrubwren <i>Sericornis frontalis</i>
Latham's Snipe <i>Gallinago hardwickii</i>	Yellow Thornbill <i>Acanthiza nana</i>
Silver Gull <i>Larus novaehollandiae</i>	Striated Thornbill <i>Acanthiza lineata</i>
Powerful Owl <i>Ninox strenua</i>	Brown Thornbill <i>Acanthiza pusilla</i>
Southern Boobook <i>Ninox boobook</i>	
Osprey <i>Pandion haliaetus</i>	
Black-shouldered Kite <i>Elanus axillaris</i>	
Little Eagle <i>Hieraaetus morphnoides</i>	
Swamp Harrier <i>Circus approximans</i>	
Grey Goshawk <i>Accipiter novaehollandiae</i>	

Appendix (cont'd)

Buff-rumped Thornbill <i>Acanthiza reguloides</i>	Spangled Drongo <i>Dicrurus bracteatus</i>
Varied Sittella <i>Daphoenositta chrysoptera</i>	Leaden Flycatcher <i>Myiagra rubecula</i>
Australasian Figbird <i>Sphecotheres vieilloti</i>	Satin Flycatcher <i>Myiagra cyanoleuca</i>
Olive-backed Oriole <i>Oriolus sagittatus</i>	Restless Flycatcher <i>Myiagra inquieta</i>
Rufous Whistler <i>Pachycephala rufiventris</i>	Magpie Lark <i>Grallina cyanoleuca</i>
Golden Whistler <i>Pachycephala pectoralis</i>	Black-faced Monarch <i>Monarcha melanopsis</i>
Grey Shrike-thrush <i>Colluricincla harmonica</i>	Torresian Crow <i>Corvus orru</i>
Eastern Whipbird <i>Psophodes olivaceus</i>	Australian Raven <i>Corvus coronoides</i>
Black-faced Cuckoo-shrike <i>Coracina novaehollandiae</i>	Eastern Yellow Robin <i>Eopsaltria australis</i>
Common Cicadabird <i>Edolisoma tenuirostre</i>	Australian Reed-Warbler <i>Acrocephalus australis</i>
Australian Magpie <i>Gymnorhina tibicen</i>	Tawny Grassbird <i>Megalurus timoriensis</i>
Pied Currawong <i>Strepera graculina</i>	Little Grassbird <i>Megalurus gramineus</i>
Grey Butcherbird <i>Cracticus torquatus</i>	Fairy Martin <i>Petrochelidon ariel</i>
Pied Butcherbird <i>Cracticus nigrogularis</i>	Tree Martin <i>Petrochelidon nigricans</i>
White-browed Woodswallow <i>Artamus superciliosus</i>	Welcome Swallow <i>Hirundo neoxena</i>
White-breasted Woodswallow <i>Artamus leucoryn</i>	Silvereye <i>Zosterops lateralis</i>
Willie Wagtail <i>Rhipidura leucophrys</i>	Common Starling <i>Sturnus vulgaris</i>
Rufous Fantail <i>Rhipidura rufifrons</i>	Common Myna <i>Acridotheres tristis</i>
Grey Fantail <i>Rhipidura albiscapa</i>	Mistletoebird <i>Dicaeum hirundinaceum</i>
	Red-browed Finch <i>Neochmia temporalis</i>
	Australasian Pipit <i>Anthus australis</i>