AQUASAVE - NatureGlenelgTrust

Ecology, Monitoring, Conservation

Platypus habitat suitability survey of the River Torrens

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A letter of report to Green Adelaide

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Background

The feasibility of reintroducing platypus (*Ornithorhynchus anatinus*) into the River Torrens in South Australia is currently being assessed. This project was timed to follow a workshop that discussed key considerations to bringing the species back to the river system and it drew on the experiences of key players working with the species in eastern Australia. Importantly, the preliminary workshop helped determine what was important and what was likely to be less important regarding habitat suitability considerations.

This document contains the compilation of methods and outcomes of the platypus habitat suitability survey undertaken in February 2022 from the outlet to Kangaroo Creek Reservoir through to the mouth of the river at West Beach. Platypus food source availability - presence of yabbies, macroinvertebrates (freshwater prawns (*Macrobrachium*), freshwater shrimp (*Paratya*) and fish – was derived from data from Aquasave -NGT and SARDI, along with insight from hydrologic (Bond 2022; Whiterod 2022) reports and nutrient (Nguyen 2018) data to enable as comprehensive as possible assessment.

Methods

Sections of the river

This habitat suitability assessment focused on the River Torrens from Kangaroo Creek Reservoir to the ocean. The river was divided into eight sections that reflecting geomorphic, hydrologic and management differences (Figure 1, Table 1). Section 1 covered the river from the ocean to just upstream of Henley Beach Road (~6 km); section 2: just upstream of Henley Beach Road to Torrens Lake (~4 km); section 3: Torrens Lake to Second Creek weir (~7 km); section 4: Second Creek weir to Felixstow Reserve (~4.5 km); section 5: Felixstow Reserve to Lower North East Road (~4.5 km); section 6: Lower North East Road to Gorge Weir (~9 km); section 7: Gorge Weir to Sixth Creek (~4.8 km); and section 8: Sixth Creek to Kangaroo Creek Reservoir (~1.8 km).

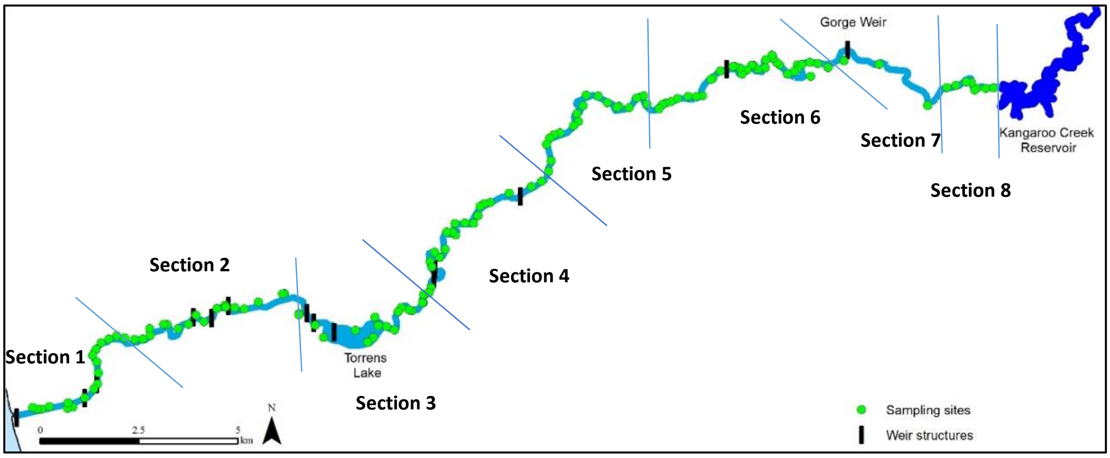


Figure 1. Sampling sites along the River Torrens from the outlet to Kangaroo Creek Reservoir.

Longitudinal sampling

Repeat habitat surveys were undertaken at 144 sites across the eight sections during February 2022 (Figure 1). The sites were approximately 200 m apart, but distances depended on site access. At each site, location, stream type (pool, riffle), bank vegetation, bank stability/erosion condition, predator accessibility (low, moderate, high) (dogs, foxes, cats), bank height (m), bank tree roots visibility, submerged habitat, instream substrate, water depth (m) and water temperature, pH, dissolved oxygen and electrical conductivity (YSI 556 multi-probe).

These parameters were recorded as each can have a direct or indirect effect on habitat suitability for platypus as follows:

Stream type: Platypus prefer a series of pool and riffle sequences for foraging diversity, with the presence of deeper pools important for foraging (McLachlan-Troup et al. 2010), thus the presence of pools or riffles was assessed.

Bank vegetation: Bank vegetation was assessed as water bodies choked with reeds including typha and phragmites can impede the ability of platypus to move freely between upstream and downstream sites, expose platypus to predators by forcing them onto the bank to move and decrease the ability to forage for food thus are less favourable to platypus. Presence of bank trees and vegetation provide cover, shade, bank stabilisation and increased protection from predators and was found to be greater where platypus had burrows in the Yarra River, Victoria (Serena et al. 1998). Bank vegetation can also provide habitat for benthic invertebrates and small fish, food sources for platypus, by providing habitat diversity, protection and food (Cummins 1993).

Bank stability: As platypus build their burrows in banks, the stability of the banks was assessed to detect natural banks, scoured banks or artificially reinforced banks. All of which can impact the preference or ability of platypus to build burrows.

Predator accessibility: Assessed to indicate the potential vulnerability platypus may have to land based predators such as foxes and dogs. Thick vegetation on the banks has the potential to not only reduce the access predators have to platypus but block their visibility from predators traversing the watercourse areas (Serena et al. 1998).

Bank height: Bank height was assessed as it can affect platypus ability to build burrows. Serena et al. (1998) found that burrows were only found in banks extending ≥ 0.5 m above the water in the Yarra River catchment, Victoria.

Bank tree root visibility: Rooted vegetation (e.g., roots that extend down into the watercourse along the bank) can prevent erosion and provide bank stability thus was assessed.

Submerged habitat: Assessed submerged habitat included rocks (small and large rocks), submerged aquatic vegetation and wood (sticks and logs), the presence of all of which can affect food including macrinvertebrates, invertebrates and fish abundance and diversity for platypus.

Instream habitat: Assessed as coarse bottom substrates are preferred by platypus for foraging over silt or fine matter (Serena et al. 2001). Increased sedimentation on rocks and plants can limit foraging opportunities for aquatic invertebrates, reducing productivity.

Water depth: Water depth preference for platypus is < 5 m for food foraging (Grant 1995) and dry exposed riverbeds increase predator access to platypus, thus water depth was assessed.

Water temperature, pH, dissolved oxygen and electrical conductivity: Assessed as these water parameters can impact on platypus food sources including diversity and abundance of macroinvertebrate, invertebrate and fish.

Figure 2. Selection of some differing habitats at sites sampled along River Torrens platypus habitat survey 2022.

Results

Habitat type and water depth

Most sites were a pool type, with only 26 sites of the 144 described as a riffle type (Figure 3). A slight increase in the number of riffles was noted in section 6 and 8 and no riffle types were found in section 1. Generally visible flow was low to non-existent throughout the survey. Six of the sites that were sampled were dry and were observed in sections 5 and 6. Water depth ranged from 0 to 5 m and was generally low throughout the surveyed River Torrens system with most sites having a depth below 1 m in sections 1, 6, 7 and 8 and the rest of the sections showing a combination of depths between 0.2–2.0 m. Some deeper areas (>3 m) were sampled in section 3 and section 6.

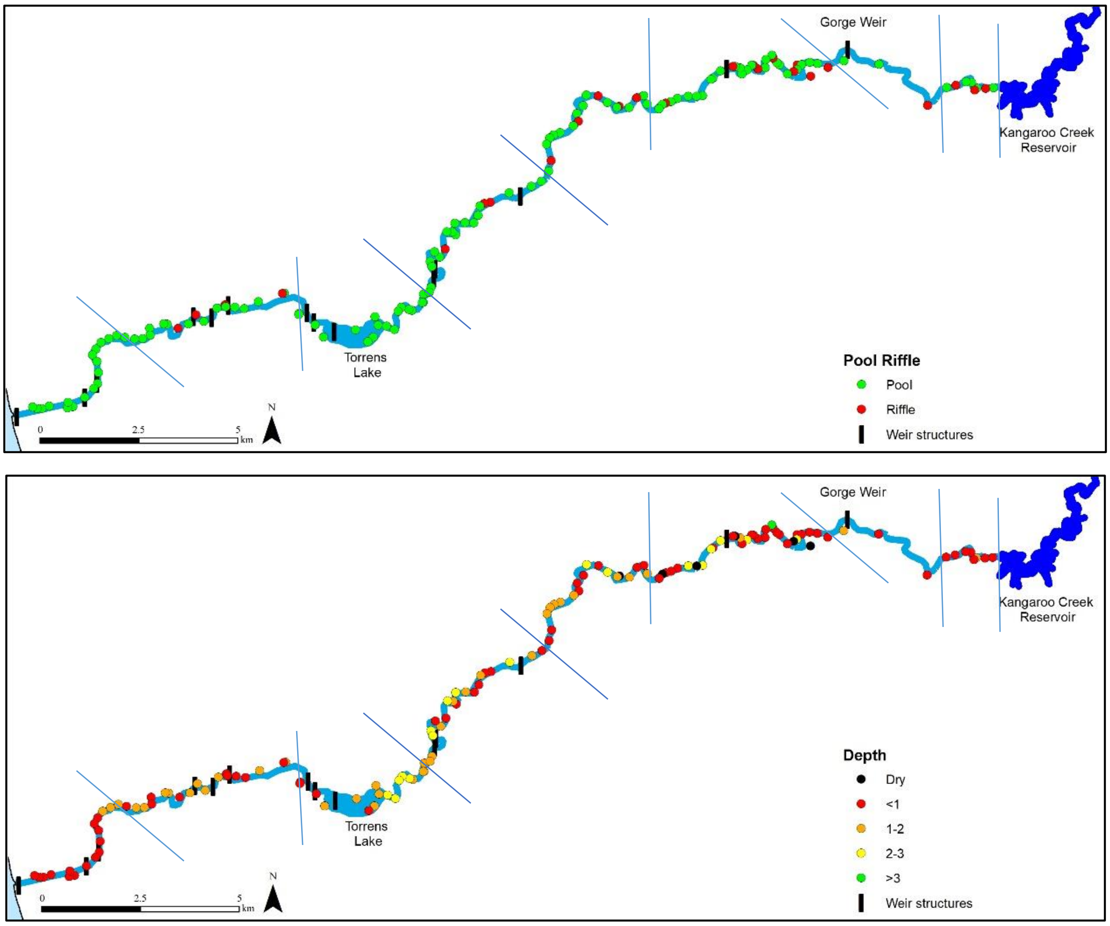


Figure 3. Pool / riffle type and depth in the River Torrens between the outlet and Kangaroo Creek Reservoir, February 2022.

Water temperature, pH, dissolved oxygen, and electrical conductivity

Sampling of water parameters was not possible at the six dry sites (Figure 4). The shallow water depth throughout other sampled sites suggests that they too may dry out during below average rainfall years. Water temperature ranged from 16.8 degrees to 28.9 degrees and temperatures generally increased progressively towards the coast (e.g., lowest in section 8, highest in section 1). Water temperatures in section 1 were generally above 27 degrees. From sections 2 to 5 it ranged from 20 to 25 degrees and dropped to below 20 degrees in sections 6 through to 8.

The pH ranged from 6.7 to 8.9 throughout the survey area. Slight acidity (<7) was only noted in sections 5 and 6 in a small sample of the sites (Figure 4). pH was mainly in the range of 7.5 to 8 in sections 1 to 3 and section 7 and slightly lower (7–7.5) in sections 4 to 6. The pH was generally more alkaline in section 8 (>8).

Dissolved oxygen ranged from 1.1 to 9.6 mgL^{-1} in the surveyed area. Some sites were found to have hypoxic water conditions (<2 mgL^{-1}), namely in the upstream part of section 1 and in sections 5 and 6 (Figure 4). The downstream region of section 1, section 4 and section 8 had the most sites with the high DO levels (>6 mgL^{-1}).

Electrical conductivity ranged from 483 to 2445 μScm^{-1} throughout the surveyed area. EC was lower in the downstream sections 1–3 (<1000 μScm^{-1}), highest in section 4 with most sites showing >2000 μScm^{-1} and varied between 1000–2445 μScm^{-1} in the remaining sections. EC was generally lower closest to the Gorge Weir in sections 6–8 (Figure 4).

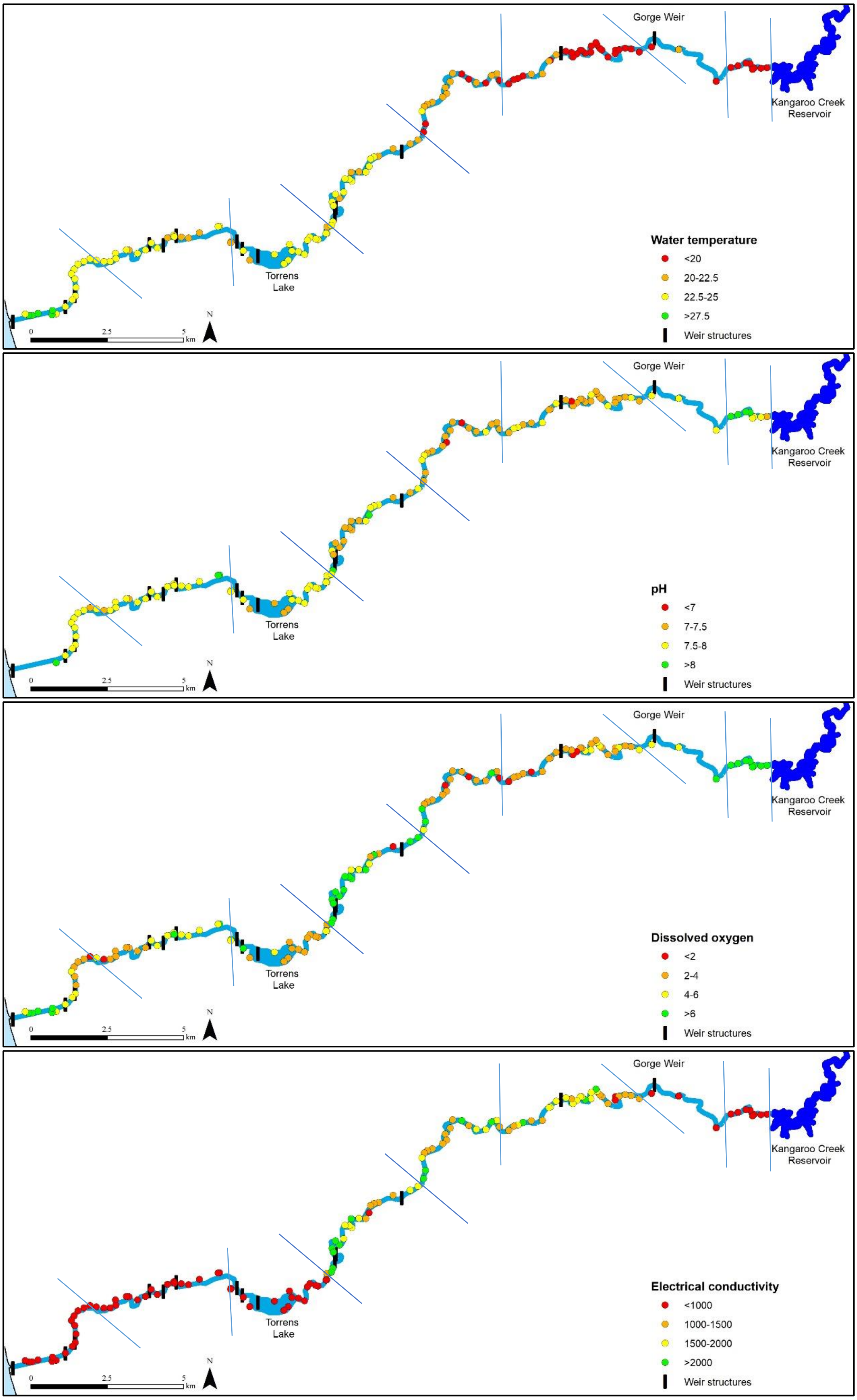


Figure 4. Water quality in the River Torrens between the outlet and Kangaroo Creek Reservoir, February 2022.

Bank vegetation

Emergent bank vegetation (*Typha* and *Phragmites*) on the south and north banks of the River Torrens from the outlet to the Kangaroo Creek Reservoir was largely present throughout the survey (Figure 5). Downstream of Gorge weir (sections 5 and 6) had a high density of *Typha* and *Phragmites* throughout much of the river sections on both sides of the bank which had encroached into most of the river. Lowest presence of *Typha* and *Phragmites* was found in sections 1 and 3. Section 7 had *Typha* and *Phragmites* present but at lower densities on both south and north banks and it did not encroach into or smother the riverbed. Limited emergent vegetation was sampled in section 8. The south and north banks were generally consistent with bank vegetation, however there were small number of sites throughout the surveyed area where emergent vegetation was absent on one side but present on the other side of the bank, as seen in figure 5, and may require some management to ensure it is appropriate habitat for platypus.

Both *Eucalyptus* trees and visible bank tree roots were recorded throughout most of the surveyed area but were lowest in the downstream part of section 1 (Figure 6). Less tree roots were noted in section 3 and 6 compared to sections 2, 4, 5, 7 and 8.

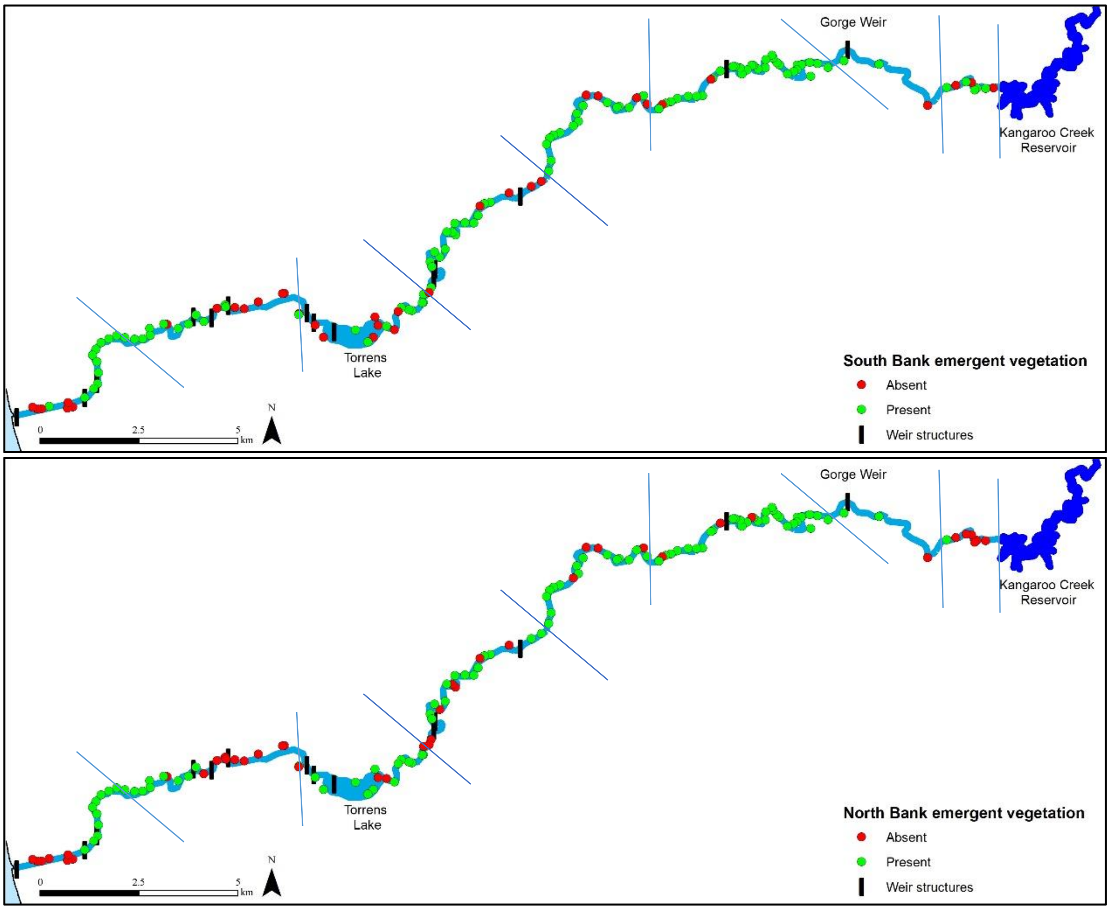


Figure 5. Emergent vegetation (Typha and Phragmites) recorded on the south and north banks of the River Torrens from the outlet to the Kangaroo Creek Reservoir.

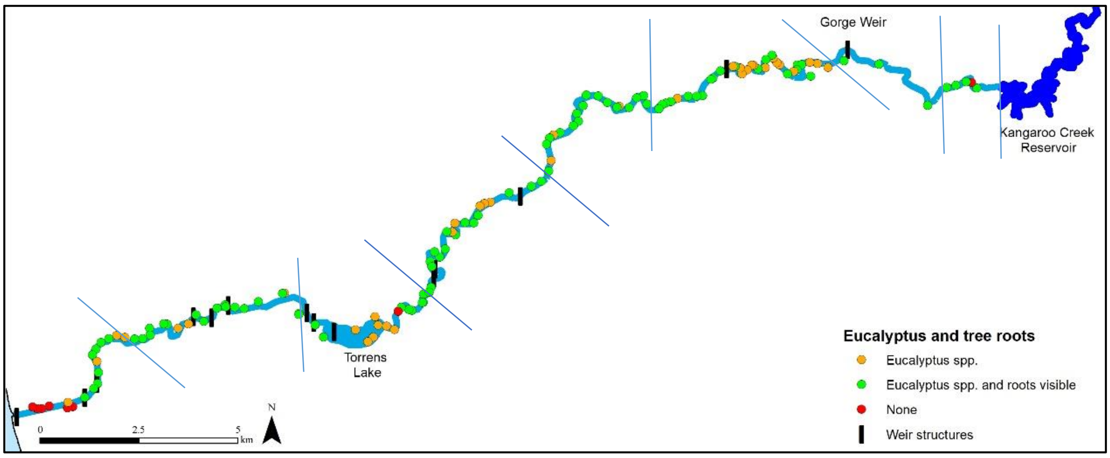
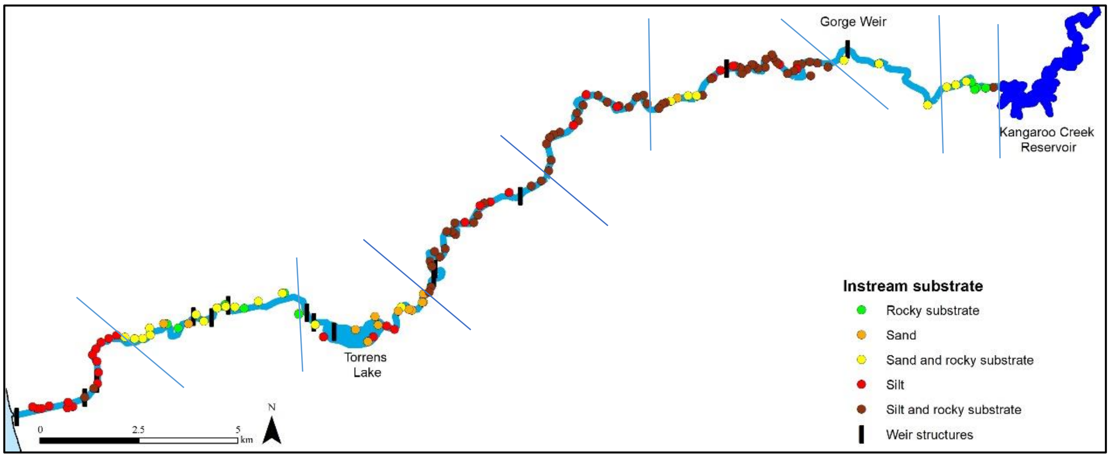


Figure 6. Eucalyptus trees and bank tree roots recorded on the banks of the River Torrens from the outlet to the Kangaroo Creek Reservoir.

Instream substrate and submerged habitat

A combination of instream substrate was recorded throughout the surveyed area including rocky substrate (rock, cobble, boulder), sand and silt (Figure 7). Silt was predominantly recorded in section 1 of the surveyed area. In section 2, the instream substrate was mainly composed of sand and rocky substrate. Section 3 had mainly sand and silt present. Sections 4–6 mainly had a combination of silt and rocky substrate. Section 7 was predominantly sand and rocky substrate and section 8 was predominantly rocky substrate.

Submerged habitat recorded included rocks (small and large rocks), submerged aquatic vegetation and wood (sticks and logs) (Figure 7). Submerged habitat predominantly included rocks and wood throughout the survey area. A small number of sites had submerged aquatic vegetation visible, namely in section 3 and one site in sections 1 and 6. Site 6 closer to Gorge Weir had a higher density and number of small rocks present than wood compared to other sites.



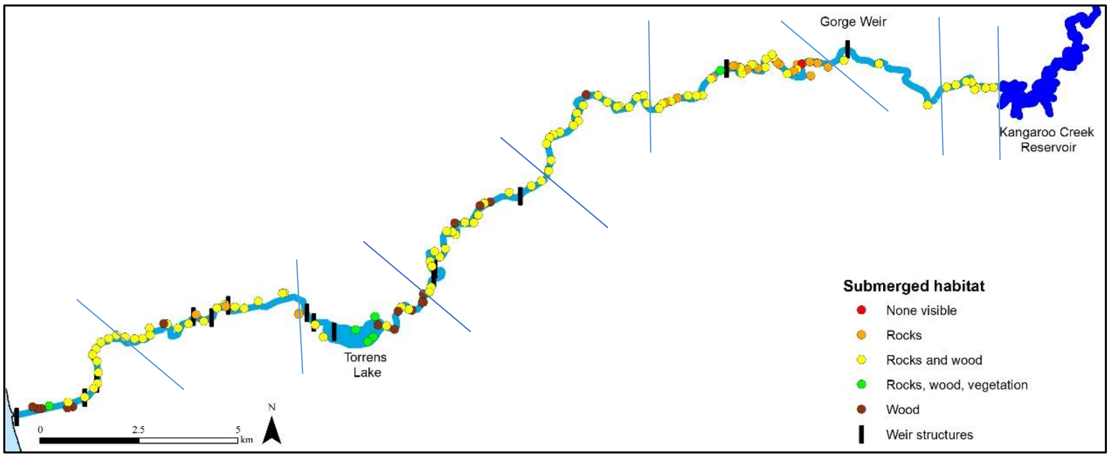


Figure 7. Instream substrate and submerged habitat recorded on the banks of the River Torrens from the outlet to the Kangaroo Creek Reservoir.

Bank height and predator access

Bank height varied between 0.2 m to 20 m on the south bank and 0.5 to 30 m on the north bank (Figure 8). Bank height in sections 1 and 3 was generally low, and highest bank heights were noted in section 4. Predator accessibility was rated on the amount of vegetation and ease of access for predators (dogs, cats, foxes) with low being not permeable i.e., high bank vegetation, moderate being accessible with effort and high was easily accessible i.e., lawned. Although predator accessibility did vary between the north and south banks in some areas, predominantly, sections 1 and 3 had the greatest amount of high predator accessibility, whilst sections 2 and 6 had more sites with low predator accessibility (Figure 9). Sections 4 and 5 generally had moderate accessibility. Section 8 had a combination of low, moderate and high predator accessibility.

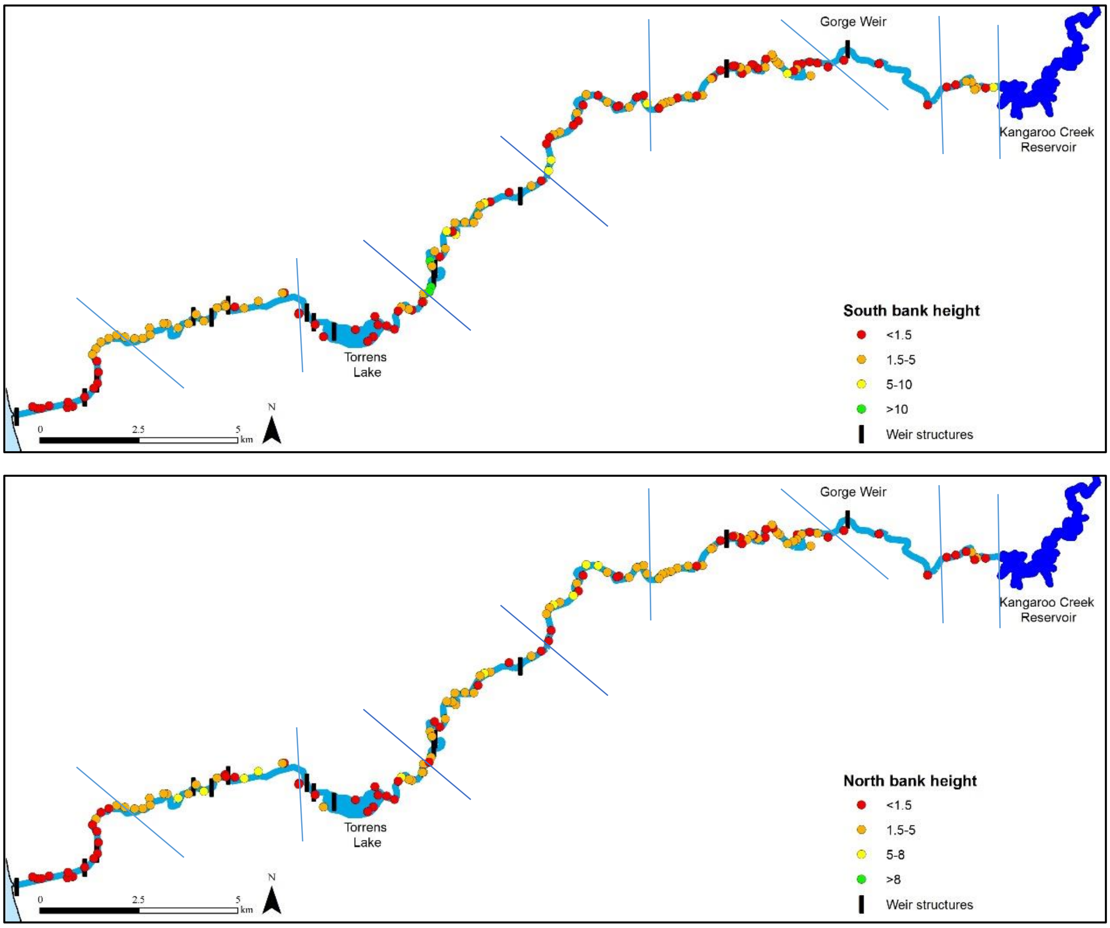
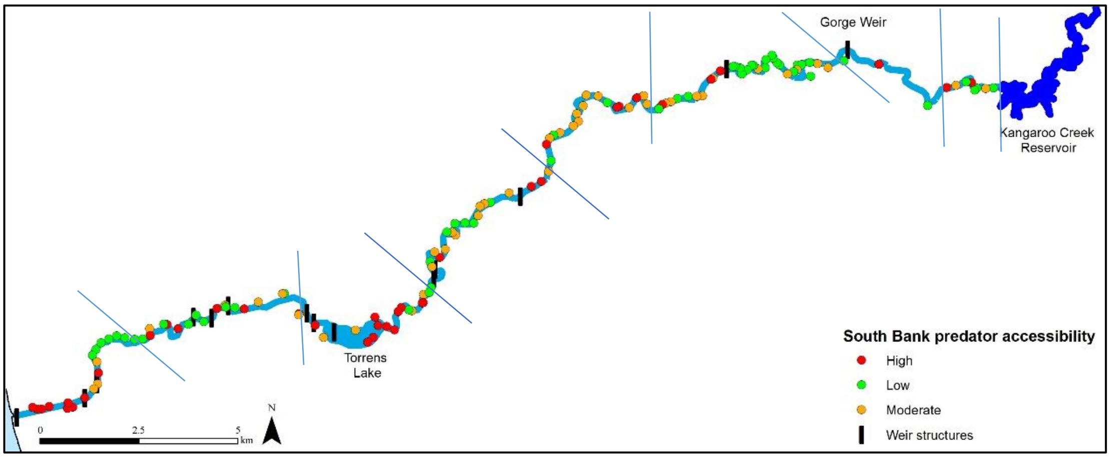


Figure 8. Bank height recorded on the south and north banks of the River Torrens from the outlet to the Kangaroo Creek Reservoir.



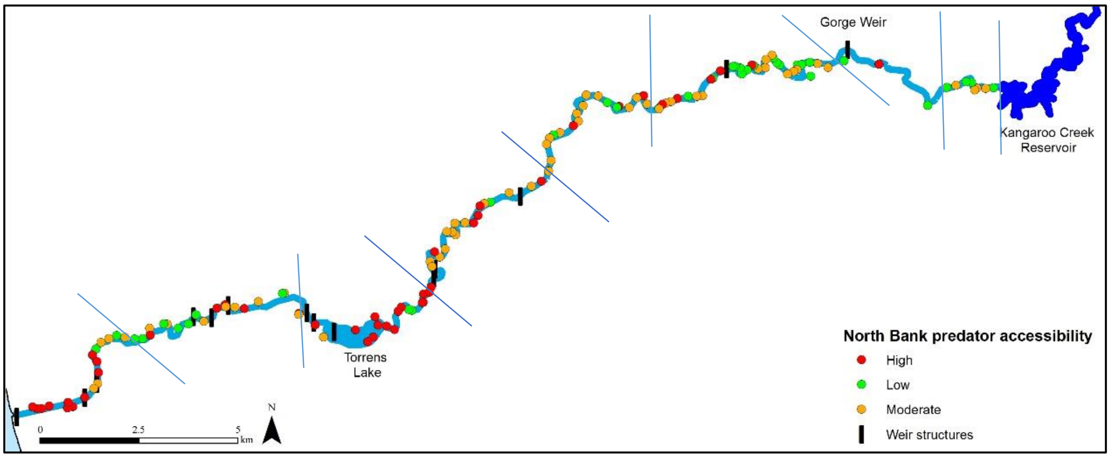


Figure 9. Bank predator accessibility recorded on the south and north banks of the River Torrens from the outlet to the Kangaroo Creek Reservoir.

Condition of bank

The condition of the bank varied throughout the survey area ranging from sites having no significant effect to scour, collapse or reinforcement (Figure 10). Reinforced sections were found scattered throughout the surveyed areas, but were mainly concentrated in sections 2, 3 and 6. Sections with evident scour included section 2, 3, 5 and 6. One example of a collapsed bank was noted in section 4. No visible erosion was evident in sections 7 and 8.

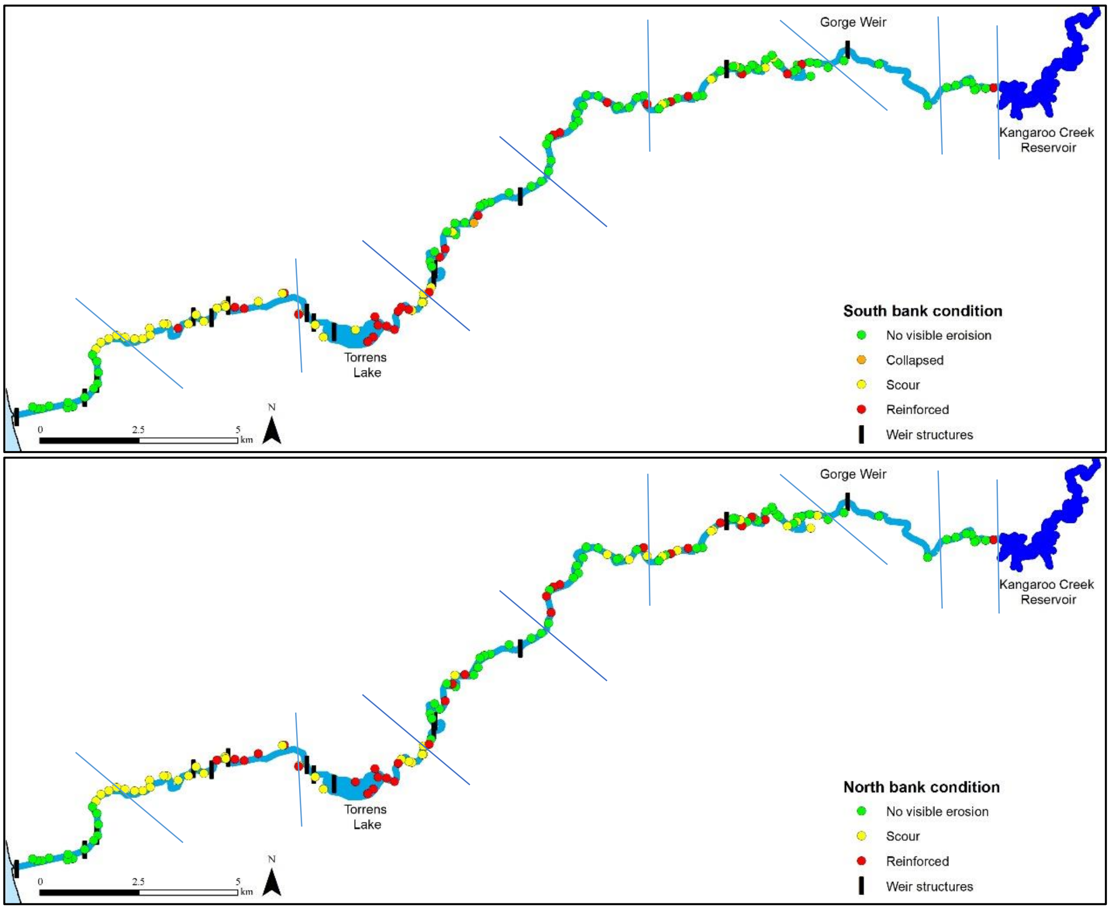


Figure 10. Condition of bank recorded on the south and north banks of the River Torrens from the outlet to the Kangaroo Creek Reservoir.

Table 1. Summary of habitat characteristics in each of the seven surveyed River Torrens sections, March 2022.

Habitat characteristic	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8
Pool / riffle	Pools	Pools, 3 riffle sites	Pools	Pools, 4 riffle sites	Pools, 5 riffle sites	Pools, riffles	Pools, riffles	Pools, riffles
Water depth (m)	Mainly <1	<1 – 2	<1 – 3	<1 – 3	Dry sites, <1 – 3	Dry sites, <1 – >3	<1 – 2	<1 – 2
Temperature (^oC)	22.5 – >27.5	20 – 25	20 – 25	20 – 25	<20 – 22.5	Mainly <20	<20	<20
pH	Mainly 7.5 – 8	Mainly 7.5 – 8	7 – 8	7 – 8	<7 – 8	<7 – 8	7.5 – 8	7 – >8
Dissolved oxygen (mgL^{-1})	2 –>6	<2 – >6	Mainly 2 – 4	Mainly >6, one site <2	<2 – >6	<2 – 6	4 – >6	>6
Electrical conductivity (μScm^{-1})	<1000	<1000	<1000	1000 – >2000	1000 – >2000	1000 - >2000	<1000	<1000
Sth bank emergent veg	Present in u/s sites	Present in d/s sites	Present in u/s sites	Present in d/s sites	Absent in 4 u/s sites	Mainly present	Present	Sites with present, absent
Nth bank emergent veg	Present in u/s sites	Present in d/s sites	Present	Present, few sites none	Absent in 4 u/s sites	Mainly present	Present	Mainly absent
Eucalyptus / tree roots	Lowest Eucalyptus, tree roots	Eucalyptus, tree roots	Low Eucalyptus, tree roots	Eucalyptus, tree roots	Eucalyptus, tree roots	Low Eucalyptus, tree roots	Eucalyptus, tree roots	Eucalyptus, tree roots
Instream habitat	Silt	Sand, rocky substrate	Silt, sand	Silt, rocky substrate	Silt, rocky substrate	Silt, sand, rocky substrate	Sand, rocky substrate	Sand, rocky substrate
Submerged habitat	Rocks, wood, 1 site veg	Rocks, wood	Rocks, wood, veg	Rocks, wood	Rocks, wood	Rocks, wood, 1 site veg	Rocks, wood	Rocks, wood
Sth bank height (m)	Mainly <1.5	1.5 – 5	Mainly <1.5	<1.5 – >10	<1.5 – 10	<1.5 – 10	<1.5	<1.5 – 10
Nth bank height	Mainly <1.5 m	1.5 – 8	Mainly <1.5	<1.5 – 8	<1.5 – 8	<1.5 – 5	<1.5	<1.5 – 5
Sth bank predator access	High/low	Range low–high	High	Mainly low–mod	Mainly mod	Mainly low	Mainly low	Range low–high
Nth bank predator access	High	Range low–high	High	Mainly mod	Mainly mod	Mainly low–mod	Mainly low	Range low–mod
Sth bank condition	Some scour	Reinforced and scour	Reinforced and scour	Majority no visible erosion	Reinforced and scour	Reinforced and scour	No visible erosion	No visible erosion
Nth bank condition	Some scour	Reinforced and scour	Reinforced and scour	Majority no visible erosion	Reinforced and scour	Reinforced and scour	No visible erosion	No visible erosion

Platypus food source availability and alien fish species

The availability of platypus food resources such as the Common Yabby (*Cherax destructor*), Freshwater Prawn (*Macrobrachium rosenbergii*), Freshwater Shrimp (*Paratya australiensis*) and small freshwater fish were extrapolated and summarised for the eight surveyed sections (based on Aquasave – NGT and SARDI data) (Table 2). The presence of these food resources is documented throughout the surveyed reach, however where no specific survey data is available in sections 5, 7 and 8, the presence of these species is still reasonable to infer. A more detailed study of macroinvertebrate availability has been summarised by (Madden et al. 2003; Sultana et al. 2019; Department for Environment and Water, South Australia 2020).

Predatory fish such as Redfin Perch (*Perca fluviatilis*), Brown Trout (*Salmo trutta*) and Rainbow Trout (*Oncorhynchus mykiss*) can compete with Platypus for food resources, reducing the effective productivity of areas for the species. Common Carp (*Cyprinus carpio*) and Goldfish (*Carassius auratus*) can impact on habitat quality, by increasing turbidity and dislodging aquatic plants, having an indirect effect on resource availability.

Alien fish species including Common Carp, Eastern Gambusia (*Gambusia holbrooki*), Goldfish and Redfin Perch were also documented through sections 1–4 and 6 and the presence of Eastern Gambusia in sections 5, 7 and 8 is expected. Brown Trout are present in sections 6 and 7 and expected to also be present in section 8. Rainbow Trout were documented in section 7 and presence in also expected in section 8 (Table 2).

*Table 2. Green and pink are based on records from Aquasave – NGT and SARDI, green are native species, pink are alien fish species and * species is where presence is a likely occurrence. # are potential food resource species, + are potential competitors or have an indirect effect on resource availability.*

Common name	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8
Carp Gudgeon#					*			
Climbing Galaxias#					*			
Common Galaxias#					*			
Congolli#								
Dwarf Flathead Gudgeon#					*			
Flathead Gudgeon#					*			*
Freshwater Catfish+					*			
Mountain Galaxias#							*	*
Murray Rainbowfish#								
Pouched Lamprey								
Western Bluespot Goby#								
Brown Trout+								*
Common Carp+					*			
Eastern Gambusia							*	*
Goldfish+					*			
Rainbow trout+								*
Redfin Perch+					*			
Common Yabby#								*
Freshwater Prawn#					*		*	*
Freshwater Shrimp#					*		*	*
Long-necked Turtle				*	*		*	*

Discussion

This report provides an insight to the potential suitability of the River Torrens between the outlet and Kangaroo Creek Reservoir for the translocation of platypus. It draws on the targeted habitat suitability survey, summary of yabby, macroinvertebrate (*Macrobrachium* and *Paratya*) and fish data from Aquasave-NGT and SARDI along with insight from hydrologic (Bond 2022; Whiterod 2022) reports and nutrient (Nguyen 2018) data to enable as comprehensive as possible assessment. Further information about macroinvertebrate food sources are provided by the Department for Environment and Water, South Australia (2022).

Habitat type and impact of water depth

Pool and riffle habitats varied across the surveyed area, however the majority of sections were dominated by pools. A lack of flowing water meant riffle habitats were largely not present. Rivers with riffle and pool sequences of 1–5 m depth are the preferred habitat for platypus (Bryant 1993; Ellem et al. 1998; Grant 2004) but they have been sighted in pools at depths of 0.49 to 2.0 m in north-eastern Queensland (Milione and Harding 2009). Platypus generally dive to a depth of less than 3 m (Bethge 2002). In the River Torrens surveyed area, water depth was generally shallow (<1 m), with some deep pools sampled. In particular, sections 2, 4, 5 and 7 had more extended areas with depths between 1 and 2 m which would fit in with the water depth habitat requirements for platypus. Exposed sections of riverbed were mainly observed near the confluence of sections 5 and 6 and would not be ideal for platypus as they would be left open to predation during similar river flow conditions. The water levels and exposed riverbeds are largely impacted by season and rainfall and further investigations may be warranted.

Flow regimes

Permanent flow regime have been identified as important to sustaining platypus populations (Griffiths et al. 2019). Hydrologic assessment (Bond 2022) demonstrated periods of cease-to-flow occur in the River Torrens, which may impact the habitat suitability for platypus. For example, low or no flow periods in the Torrens Lake, section 3, can lead to increased algal blooms, lowered dissolved oxygen levels and thus impact on platypus food availability. Bond (2022) indicated that fewer cease to flow periods occur upstream of Torrens Lake and in the vicinity of the gorge, suggesting that sections 4–8 may offer more suitable flow characteristics for the species. However, even these sections do still experience low flows that may impact on habitat quality. For example, cease-to-flow periods that lead to dry riverbeds, such as found in sections 5 and 6 can increase exposure of platypus to predation. Further, exploration of the flow regime downstream of the Gorge Weir, which was not considered by Bond (2022), identified long periods (e.g., 356 cease to flow days suggesting that section 6 is not suitable (Whiterod 2022). Section 8 is directly downstream of Kangaroo Creek Reservoir and experiences erratic flow water which may make this section less suitable for platypus, but it is unclear how these releases influence the flow regime of section 7. Whilst cease-to-flow characteristics vary across the site, the effects are generally secondary with a possible impact on productivity and food resources. There are also examples, such as on Kangaroo Island, where the system does has long cease-to-flow periods and yet the species had been persisting for over a century.

Water quality

The water quality thresholds are not clearly defined for platypus. However, previous research has examined indirect effect on food resources of macroinvertebrates that may influence suitability for platypus. The effects of EC on selected orders of adult macroinvertebrates in the Glenelg Hopkins, Merri and Barwon River Catchments in south-west Victoria, found that the abundance of many macroinvertebrate taxa decreased above 5000 µScm^{-1} (Kefford 1998). The salinity tolerances of the eggs and hatchlings of macroinvertebrate taxa ranged from 800 to >47000 µScm^{-1} with a mean of 17000 µScm^{-1} (Kefford et al. 2004). The EC did not exceed 2445 µScm^{-1} throughout the River Torrens surveyed area and was thus below the range deemed acceptable for many macroinvertebrate taxa. The pH remained close to neutral or alkaline, with the upstream sections 5–7 representing slightly alkaline reaches. Low dissolved oxygen levels in the upstream reaches, namely sections 5–6, may have been the result of low water levels and no or limited water flow. Indeed, hypoxic water conditions (<2 mgL^{-1}) were recorded in upstream part of section 1 and in sections 5 and 6. Except for section 6, where DO levels were generally above 6 mgL^{-1}, DO levels did not exceed 6 mgL^{-1} at over half the surveyed sites. Higher DO levels (>6 mgL^{-1}) were recorded in the downstream section of section 1 and in section 8. However, it should be noted that water was being released from Kangaroo Creek Reservoir on the day on sampling, thus would have contributed to the high DO levels noted in section 8. Serena and Pettigrove (2005) found no significant differences in mean summer concentrations of DO between reaches supporting a medium-density platypus population (DO range 5.7–9.5 mgL^{-1}) and reaches lacking a population (DO range 5.4–10.9 mgL^{-1}). Thus, DO in this range may be deemed as suitable for platypus. This range was mainly observed in areas of sections 1, 2, 4, 7 and 8.

Serena and Pettigrove (2005) established a link between total Kjeldahl nitrogen concentration (TKN) and platypus presence in the urban Melbourne waterways with reaches that recorded TKN concentrations of 0.80 mgL^{-1} and above lacking a resident platypus population. In studies of the River Torrens, over 2015 and 2017, TKN thresholds consistently exceeded these values within sections 4 and 5 (Nguyen 2018). Similarly, presence of platypus was correlated with total phosphorus, with no resident platypus populations found at levels of 0.098 or greater (Serena and Pettigrove 2005). Data from Nguyen (2018) from 2015 to 2017 showed total phosphorus levels were consistently exceeded in the lower section of the River Torrens from the Torrens Lake to St Peters Billabong, coverings sections 1–3 of this current habitat survey.

Bank vegetation

Bank vegetation habitat preferences for platypus include consolidated earth banks, bank tree roots (to consolidate the banks and protect burrows from collapsing), large trees in the riparian zone, and overhanging vegetation in the river channel (provide instream organic material and macroinvertebrate food) (Bryant 1993; Ellem et al. 1998; Serena et al. 2001). During the current habitat survey, Eucalyptus trees and tree roots were visible throughout most of the sampling area, except for sections 1, 3 and 6 which did not have a high quantity of these.

The presence of *Typha* and *Phragmites* in smaller quantities is tolerated, however platypus prefer areas where a dense invasion of these plants is not present as they can inhabit food foraging and movement along the channel (Griffiths and Weeks 2013). Low flows have allowed *Typha* and *Phragmites* to form into dense stands throughout section 6 in the River Torrens, often inhabiting the stream. Increased water flow could assist in the future management of these reeds. Lower densities of these were found throughout the rest of the system, and it was very limited in sections 1 and 3.

Instream substrate and submerged habitat

Platypuses prefer a complex instream bed substrate with a rocky substrate that includes a variety of gravel, small rocks, cobbles, and larger rocks and boulders (Grant 2004; Rohweder and Baverstock 1999; Serena et al. 2001). Sections 1 and 3 had predominantly silt as the substrate with a lack of complexity favoured by platypus. Indeed a negative correlation was demonstrated between the presence of a silt substrate and platypus presence in previous research (Serena et al. 2001). A more complex instream bed substrate which included rocks, cobbles, wood was observed mainly in sections 2, 4, 5, 6 and 7. Submerged habitat preferences by platypus include woody debris, in-stream organic matter, and rocks (Grant 2004; Serena et al. 2001). Instream submerged aquatic vegetation was scarcely visible throughout the survey, however, was noted in sections 1, 3 and 5. In section 6, rocks were predominantly visible, and there was not much wooden structure. Sections 2, 4 and 5 had the highest amounts of rock and wood present in them and could be described as better suited as platypus habitat in terms of submerged habitat.

Bank height, bank condition and predator access

Banks can play a large role in platypus habitat selection, with a general preference by platypus for banks that are consolidated with vegetation and greater than 0.95 m in height (Brunt et al. 2018). Platypus resting burrows can be constructed up to a length of 3 m, and the entrances are generally built above the water line (Bino et al. 2019). Bank height was low in sections 1 and 3 but did range in height throughout the rest of the surveyed area with most sections having banks 0.5 to 5 m in height.

Bank condition can influence the ability of platypus to form suitable resting burrows, with artificial reinforcements from concrete or steel, or collapsed banks deemed as unsuitable habitats. Overall, banks appeared to be mainly stable throughout the survey areas. However, certain sections did have visible bank reinforcement or scouring, namely in sections 1, 3, 4, 5 and 6. In section 4, the reinforcement and scouring in areas was only for a short distance (approximately 3–4 m) and in the other stated sections, bank reinforcement or scouring was only noted in small parts of the sections (i.e., Figure 4).

Predators, such as dogs, foxes and cats, that have access to platypus burrows or to platypus that are in shallows or on land can lead to the death of animals. For example, in Victoria, 13% of documented platypus mortalities were directly due to predation by dogs, foxes and raptors (Serena and Williams 2010a), whereas in Tasmania, 40% of documented platypus deaths were caused by attacks by dogs (Connolly et al. 1998). Predator ease of access to banks and the river varied along the surveyed stretch of the River Torrens with highest access found in sections 1 and 3. Sections 4 and 6 had lowest levels of predator access, and the remaining sites had a mixture of areas with low, moderate, and high accessibility. The majority of low accessibility sites had bank coverage with thick *Typha*, *Phragmites* and grass growth.

Figure 12. Bank condition in section 4.

Platypus food source availability and alien species

Common Yabby, *Machrobrachium*, *Paratya* and small fish were present throughout the surveyed area as a food source. Although no data was available for the sections closest to Kangaroo Creek Reservoir, it is anticipated that they would also be present there. The presence of alien fish species throughout most of the surveyed area may have indirect affects on Platypus. The presence of alien fish species throughout the majority of the surveyed area in Zukowski and Whiterod (2022) may have indirect effects on Platypus. Common Carp can impact platypus habitat by disturbing sediments, uprooting aquatic vegetation, elevating nutrient and turbidity levels and accelerating algal production (Matsuzaki et al. 2007; Miller and Crowl 2006). A strategy has been developed for Common Carp management in the Torrens Lake, Adelaide (Leigh et al. 2015) and Common Carp eradication programs have been undertaken i.e., (Whiterod 2016). Common Carp, Redfin Perch, Brown Trout and Rainbow Trout can have indirect effects on platypus through competition for food. Although there is some overlap in food resources between platypus and trout (Faragher et al. 1979), platypus tend to be bottom feeders, therefore food competition may be greatest with Common Carp, who are also bottom feeders, whereas Redfin Perch and Trout feed throughout the water column. Although trout do exhibit aggressive and territorial behaviour (Johnsson et al. 2000), the potential of trout to have direct impacts on platypus through this behaviour is unlikely given trout and platypus have been found to cohabit successfully for up to 100 years in many upland rivers of NSW (Faragher 1986).

Habitat suitability in sections

In terms of overall habitat suitability as sampled in this survey, it is evident that, under current managed flow regimes, some sections of the River Torrens appear less suitable for the species. Some of the surveyed sections of the River Torrens do seem to provide more appropriate conditions than others. For example, **section 1** does not have the appropriate instream habitat, consisting mainly of silt, has a lack of favoured vegetation including *Eucalyptus* trees and tree bank root systems, general high predator accessibility, and a lack of riffle areas, thus would not be deemed as a preferred habitat for platypus in its current condition. It is also anticipated that the section will experience extended periods of cease to flow, potentially further reducing its suitability for platypus. Section 1 does provide an expansive body of water and adds to the overall available habitat in the region. This section is undergoing change in terms of the Breakout Creek redevelopment with the habitat targeted in this restoration project focused on conserving other key species but not focused on trees along the watercourse.

Figure 13. Representation of habitat in section 1.

Section 2 of the River Torrens has a combination of possibly suitable habitat for platypus including *Eucalyptus* trees, bank tree root systems, sand and rocky substrate, presence of rocks and wood, higher bank heights, low to moderate predator accessibility, water depth of 1–2 m, with mainly pools but some riffle habitat and generally acceptable water quality levels, apart from hypoxic conditions recorded at two sites within this section. However, the hydrologic assessment of Bond (2022) revealed a high degree of cease to flow periods in this section that may make it less suitable for the species.

Figure 14. Representation of habitat in section 2.

Section 3 is dominated by the large, deep open body of water in the Torrens Lake, high predator accessibility, instream substrate of silt and low bank heights, habitat characteristics which are generally not favoured for platypus. This section does however have good water quality present and a mixture of wood, rock and vegetation in some areas. The Torrens Lakes experiences cyanobacteria blooms, which may make it less suitable for the species. Algal blooms can result in decreased dissolved oxygen levels leading to the decline of aquatic invertebrate biodiversity and abundance (Serena and Pettigrove 2005). Increased algal growth can also decrease platypus foraging efficiency by physically impeding food detection and capture (Serena and Pettigrove 2005).

Figure 15. Representation of habitat in section 3.

The habitat in **Section 4** consists of various habitat features favoured by platypus including the presence of rocky substrate, bank heights between 1-2 m, low to medium predator access, presence of bank vegetation, trees and bank tree roots. However, the presence of silt throughout some of this section and areas with reinforced banks are also evident. This section does experience cease to flow periods, which are generally short (e.g., average period is 3 days), although cumulative more than 90 cease to flow days were experienced in 2018 (Bond 2022). Whilst the prevailing flow regime may be suitable, further insight into the impacts of short time cease to flow periods is recommended.

Figure 16. Representation of habitat in section 4.

Habitat in **section 5** consisted of areas that may not be suitable habitat for platypus including dense typha and phragmites which encroached into the river channel and may reduce the amount of available foraging habitat for platypus. This section also has numerous dry areas which may increase the predation risk for platypus that tried to traverse the area during low/no flow periods. Information about flows for this section is also limited, however it may be like section 4 where the Second Creek monitoring gauge is located. Further investigations into flow conditions are recommended for this section of the river.

Figure 17. Representation of habitat in section 5.

Large parts of **section 6** were considered unsuitable or seasonably unsuitable for platypus as the area consisted of dry riverbed and there were areas of dense *Typha* and *Phragmites* near the banks and within the river channel which would reduce the available foraging habitat for platypus. In addition, this section was also shallow in most sampled areas but did have a combination of riffle and pool habitat. Very limited bank tree roots were visible. Whiterod (2022) demonstrated that this section experienced long periods of cease to flow over recent years (e.g., 356 cease to flow days in 2019), further suggesting an unsuitability for platypus.

Figure 18. Representation of habitat in section 6.

The River Torrens from downstream of Sixth Creek to the Gorge Weir (**section 7**) has a combination of habitat that may be suitable for platypus. Emergent vegetation, *Typha* and *Phragmites* is present in patches, however it does not encroach into and choke the river body. The presence of higher banks with *Eucalyptus* and tree bank roots and a more defined pool ripple pattern is apparent. However, there is presently no information on the flow regime (and extent of cease to flow periods) and how fluctuating flows from upstream in section 8 (see below) impact – further investigation of flow regimes is required.

Figure 19. Representation of habitat in section 7.

Although **section 8** showed promising results from a water quality, vegetation, bank height, predator access viewpoint, this section can vary in water depth greatly depending on rain and water releases from the Kangaroo Creek Reservoir. During dryer periods, this section can dry into a series of small pools and during high rain and flood periods water levels can rise by 20 m. This type of extreme flow would prevent platypus being able to have resting burrows in the bank below the water line during floods and would not provide enough water during dry times.

Figure 20. Representation of habitat in section 8.

From this investigation, sections four and seven likely provided the most currently suitable habitat, however even within these sections, there are stretches more or less likely to be suitable and a more detailed study should be undertaken if platypus are planned to be reintroduced. Within the other sections there are shorter stretches of habitat that may be suitable to support the species, however, a more in-depth survey is recommended to establish these. These stretches are disconnected by low water level or dry conditions, physical barriers, dense stands of emergent vegetation, areas of poor water quality. The species also has a requirement for overland movement, so consideration of the broader habitat suitability away from the river is necessary. The extent of possible habitat needs should be investigated in the context of what is required to support a functional, self-sustaining population of the platypus.

Further, two issues which were noticed during the survey in the River Torrens was the use of enclosed traps, such as opera house traps or yabby pots, which are used to capture yabbies and can still be used in the River Torrens but can be lethal to platypus. As platypus can only hold their breath for several minutes underwater, if they are captured in nets that are set entirely underwater they will likely drown (Serena and Williams 2010). There is a state-wide decision to eliminate this style of yabby pot by June 30, 2023, in South Australia in line with other states. The presence of litter such as fishing wire, elastic bands, plastic rings in the River Torrens, mainly in the Torrens Lake, can also result in severe injury or mortality (Serena and Williams 2010).

Although specific platypus habitat preferences and their relation to the River Torrens platypus habitat assessment have been discussed in this report, it should be stated that past studies have shown that platypuses do occur in a wide variety of habitats, some of which do not have all the featured characteristics or preferences, and sometimes in degraded agricultural settings (Bryant 1993; Ellem et al. 1998; Grant and Denny 1991; Milione and Harding 2009; Rohweder and Baverstock 1999; Serena et al. 2001).

Management recommendations

- Further flow assessments, namely downstream and upstream of Gorge weir. Increased flows are recommended to limit the number of cease to flow days, prevent further takeover of emergent vegetation (i.e. *Typha* and *Phragmites*) of the River body and limit the amount of algal blooms.
- Snapshot survey of current nutrients and suspended solid concentrations in the River Torrens in line with recommendations from Serena and Pettigrove (2005). Although TN, TP and SS may not directly affect platypus presence, the correlation between macroinvertebrate presence and TN / TP / SS should be further considered.
- Broader habitats suitability away from river e.g., to support overland movement.
- Insight into management of litter in the River Torrens.

Conclusions

The platypus River Torrens habitat assessment between the outlet and Kangaroo Creek Reservoir demonstrated that some sections of the River Torrens may be suitable in terms of habitat for platypus. However, further information should be gathered on flows and nutrients. As rainfall and seasonal effects can play a large role in the habitat suitability, further investigations should also examine areas of dry riverbed at varying conditions.

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