



Australian Government

Department of the Environment and Energy

National Recovery Plan for the White-throated Snapping Turtle (*Elseya albagula*)



February 2017

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Front Cover:

White-throated snapping turtle (*Elseya albagula*) in the Connors River, Queensland (© Stephen Zozaya and Jason Schaffer)

The Species Profile and Threats Database pages linked to this recovery plan is obtainable from: <http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>.

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Acronyms

BMRG	Burnett Mary Regional Group
DAF	Department of Agriculture and Fisheries (Queensland)
DNRM	Department of Natural Resources and Mines (Queensland)
DotE	Department of the Environment (Commonwealth), now replaced by DotEE
DotEE	Department of the Environment and Energy (Commonwealth)
DERM	Department of Environment and Resource Management (Queensland), now replaced by EHP
EHP	Department of Environment and Heritage Protection (Queensland)
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth)
EPA	Environment Protection Agency (Queensland), now replaced by EHP
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
MNES	Matters of National Environmental Significance
MRCCC	Mary River Catchment Coordinating Committee
NGO	Non-government organisation
QTC	Queensland Turtle Conservation
SPRAT	Species Profile and Threats database

1 Summary

1.1 White-throated snapping turtle (*Elseya albagula*)

Family:	Chelidae
IBRA Bioregions:	South east Queensland, Brigalow Belt South, Brigalow Belt North, Central Mackay Coast
Current status of taxon:	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth): Critically Endangered <i>Nature Conservation Act 1992</i> (Queensland): Endangered
Distribution and habitat:	The white-throated snapping turtle occurs in the Fitzroy, Mary and Burnett Rivers and associated smaller drainages in south eastern Queensland. It mostly inhabits areas with clear, flowing, well-oxygenated waters.

1.2 Habitat critical for survival

Habitat critical to the survival of this taxon is defined as:

- Riverine systems with permanent water, including waterholes, within the species' distribution.
- All currently known and new nesting sites.

1.3 Recovery plan objectives

The objectives of this recovery plan are to:

- ensure a self-sustaining healthy population structure in all catchments in which the white-throated snapping turtle occurs; and
- ensure an ecologically functional wild population of white-throated snapping turtle that, with limited species-specific management, has a high likelihood of persistence in nature.

1.4 Recovery strategies

The strategies to achieve the plan's objectives are to:

- Substantially improve the recruitment of hatchlings into the population;
- Reduce the incidence of adult mortality and injury;
- Maintain and/or improve stream flow and habitat quality throughout the species' distribution;
- Maintain and/or improve the connectivity within populations throughout each catchment; and
- Increase public awareness and participation in conservation of the species and its habitat.

1.5 Criteria for success

This recovery plan will be deemed successful if, within 10 years, all of the following have been achieved:

- A baseline population size has been established by undertaking comprehensive surveys throughout the species' distribution.
- Population trends have been determined through regular monitoring of known populations (including any new populations discovered), and show a positive trajectory.
- Hatching success has substantially increased.
- Substantial increase in juveniles recruiting into the population throughout the species' distribution.

- Mortality rates of adults have decreased to a level closer to natural mortality.
- Habitat quality, including water quality and connectivity, has improved for both juveniles and adults.
- Appropriate measures have been put in place to manage key threats to the turtle.
- Understanding of the biology and ecology of the turtle, including survivorship and habitat use, has increased.

1.6 Criteria for failure

This recovery plan will be deemed to have failed if, within 10 years, any of the following have occurred:

- Surveys to improve understanding of the biology and ecology of the turtle have not been conducted.
- Regular monitoring has not been conducted and population trends have not been assessed.
- Hatching success in the wild population has not increased.
- Hatchery programs have failed to result in the successful release and survival of hatchlings in the wild.
- Mortality rates of juveniles and adults have not decreased.
- Habitat quality, including water quality and connectivity, has not improved.
- Appropriate measures to manage key threats to the turtle have not been implemented.

2 Introduction

2.1 About the recovery plan

This document constitutes the 'National Recovery Plan for the White-throated Snapping Turtle (*Elseya albagula*)'. The plan considers the conservation requirements of the species across its range, identifies the actions to be taken to ensure the species' long-term viability in nature, and identifies the parties that will undertake those actions. The Minister determined that a national recovery plan was required as the species is subject to a number of threats across a broad distribution, and management of these threats would benefit from a coordinated approach.

Principal threats to the white-throated snapping turtle include: the loss of eggs and hatchlings due to predation and trampling; the construction of dams and weirs which result in fragmentation of preferred habitat, obstruction of migration within rivers, injury and death during over-topping and water releases; and inappropriate water allocation leading to low flow or cessation of flow, flooding of traditional nesting areas, and loss of riparian vegetation overhanging riverine habitat.

This recovery plan sets out the research and management actions necessary to stop the decline, and support the recovery, of the white-throated snapping turtle in Australian waters. The overall goal of this recovery plan is to achieve a self-sustaining wild population that has a high likelihood of persistence in nature, and to put in place long-term management arrangements that ensure sufficient juveniles are recruited into the population and white-throated snapping turtle habitat is appropriately managed.

To achieve this goal a range of strategies will be employed, including the development of a hatchery program and the implementation of projects to improve hatching success in the wild, and the modification of water infrastructure and operations to reduce the mortality of adult turtles and improve habitat quality and connectivity.

Accompanying Species Profile and Threats Database (SPRAT) pages provide background information on the biology, population status and threats to white-throated snapping turtle. SPRAT pages are available from: <http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>.

2.2 Conservation status

The white-throated snapping turtle was listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in November 2014. It is listed as Endangered under the Queensland *Nature Conservation Act 1992* and has not yet been assessed by the IUCN.

The Threatened Species Scientific Committee recommended listing the species as Critically Endangered as it has experienced a severe loss of eggs due to predation and nest bank trampling, resulting in a recruitment rate of only 1% each year. In the absence of appropriate management, a very severe population reduction of over 90% is projected to occur over the next three generation period, due to recruitment failure and loss of the existing adult cohort (DotE, 2014).

2.3 White-throated snapping turtle recovery team

Recovery teams provide advice and assist in coordinating actions outlined in recovery plans. They include representatives from organisations with a direct interest in the recovery of the species, including those involved in funding and those participating in actions that support the recovery of the species. The white-throated snapping turtle recovery team has the responsibility of providing advice, and coordinating and directing the implementation of recovery actions outlined in this recovery plan. The membership of the recovery team has yet to be determined, but may include individuals with relevant expertise from organisations such as the Department of Environment and Heritage Protection (EHP), Department of Natural Resources and Mines (DNRM), Department of the Environment and Energy (DotEE), non-government organisations (NGOs) and universities. Membership may change over time.

3 Background

3.1 Species description

The white-throated snapping turtle is one of the largest short-necked freshwater turtles in Australia. It had previously been regarded as part of the more common and widely distributed northern snapping turtle *Elseya dentata*, but was formally described as a separate species in 2006 (Thomson et al., 2006). It is the largest extant species of snapping turtle (*Elseya* spp.), with carapace lengths of up to 42 cm long in females and up to 30 cm in males. Adults are large and heavily built, with a large, robust head. Adult females commonly have irregular white or cream markings on the side and under surfaces of the head and neck. Males are easily distinguished from mature females by their much larger tail. Hatchlings and small juveniles have strongly serrated shell margins (Thomson et al., 2006).

The species is one of a number of freshwater turtles in Australia which can absorb oxygen from both the air and water (Clark et al., 2008). The ability to respire aquatically allows these species to extend their dive duration, which may reduce overall energy expenditure and reduce exposure to threats (particularly for juveniles) by reducing surfacing frequency (Mathie & Franklin, 2006; Storey et al., 2008; Fitzgibbon & Franklin, 2010). Aquatic respiration in the white-throated snapping turtle primarily occurs via active ventilation of the cloacal bursae (Fitzgibbon & Franklin, 2010). Adults may obtain up to 40–60% of their total oxygen requirements from aquatic respiration, but in hatchlings this may be up to 100%, with younger turtles having a higher reliance on aquatic respiration than adults (Mathie & Franklin, 2006; FitzGibbon & Franklin, 2010). The greater ability of small/young turtles to utilise aquatic respiration is likely attributable to their higher mass-specific cloacal bursae surface area (Mathie & Franklin, 2006).

3.2 Distribution

The white-throated snapping turtle is endemic to the Fitzroy, Mary and Burnett Rivers and associated smaller drainages in south-eastern Queensland (Figure 1). It occupies approximately 3300 km of riverine habitat: Fitzroy catchment (~2,150 km), Burnett catchment (~700 km) and Mary catchment (< 500 km) (Hamann et al., 2007). Its area of occupancy is estimated to be less than 500 km² (DotE,

2014). Adults in the Mary River are smaller on average than their respective counterparts in the Burnett River and the Fitzroy River (Limpus, 2008).

In the Fitzroy catchment the species occurs in greater abundance upstream of the Fitzroy River Barrage (Hamann et al., 2007). The lower reaches of Barambah Creek and the pools immediately downstream of Ned Churchward Weir support the two largest known populations in the Burnett catchment (Hamann et al., 2007). In the Mary catchment it has been recorded within several impoundments including the Mary River Barrage, Imbil Weir, Borumba Dam and Tallegalla Weir (Limpus, 2008).

The species' distribution has been fragmented by the construction of dam and weir structures, with generally deep, stagnant and variable water levels behind each impoundment structure being unsuitable for the species. The Burnett River has been fragmented into six sections ranging from 7 to 47 km in length, and representing only 40% of the original primary habitat available before commencement of impoundments (Hamann et al., 2007). However, as individuals may inhabit the impoundment area and some may move over or around such infrastructure, its habitat is not considered severely fragmented (DotE, 2014).

3.3 Population trends

The numbers of individuals in each of the three catchments within the species' distribution are generally unknown. An estimate of white-throated snapping turtle abundance in the Mary River (September–November 2006; March, May and June 2007) through snorkling surveys revealed that it was the most abundant species found, with an estimated population size of 895–3 580 individuals in the Mary River (Tables 6-2 & 6-4, Ecotone Environmental Services, 2007). However, sampling at multiple study sites throughout each catchment has demonstrated that there is generally a severe depletion of immature turtles in the populations (Ecotone Environmental Services, 2007; Hamann et al., 2007; Limpus, 2008; Limpus et al., 2011), with a substantial failure to recruit new adults into the breeding population generally in each catchment:

- Fitzroy: 0.5% of adults are new recruits to the breeding population (211 adult females examined);
- Burnett: 0.9% of adults were new recruits to the breeding populations (an additional 0.9% of the adults were identified to their 2nd breeding season) (331 adult females examined);
- Mary: 1.1% of adults are new recruits to the breeding population (175 adult females examined). Juveniles in surveys for Traveston Crossing Dam made up 19% of the population, with a high abundance of juveniles at the Traveston Crossing Dam site (~77% of turtles sampled) (Ecotone Environmental Services, 2007).

The present wild population is composed primarily of aging adults in each catchment. Given that this is a slow growing species estimated to reach maturity at about 15–20 years (Limpus, 2008), the population structure indicates that excessive egg loss has been operating on these populations for at least 20 years. Abundant evidence of nesting can be found in all three catchments, but almost 100% of eggs are predated or lost to trampling by stock (Hamann et al., 2007; Limpus, 2008; Limpus et al., 2011). These threats have likely led to a severe reduction in the adult population, which will continue in the future if recruitment failure is not addressed.

Indicative distribution of the white-throated snapping turtle
(*Elseya albagula*)

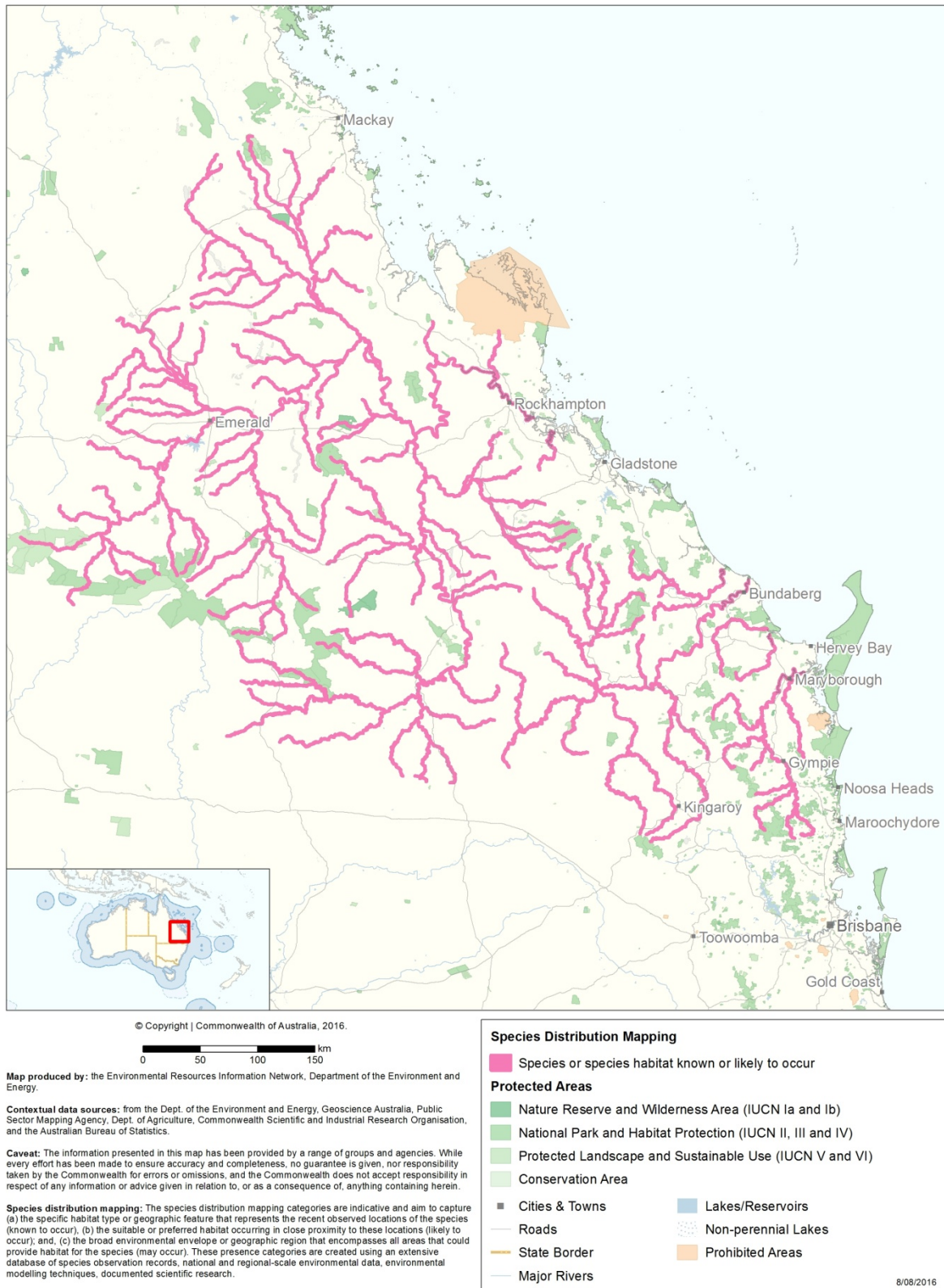


Figure 1: Indicative distribution of the white-throated snapping turtle (*Elseya albagula*)

3.4 Biology and ecology

3.4.1 Longevity

The life expectancy of the white-throated snapping turtle is unknown. However, the species is thought to reach maturity at around 15–20 years of age.

3.4.2 Genetics

Genetic analysis of the white-throated snapping turtle has found that there are two evolutionarily significant units (Fitzroy River basin and the Burnett/Mary River basins) (Todd et al., 2013).

3.4.3 Diet

The white-throated snapping turtle is a benthic foraging species. It is primarily herbivorous, feeding on fruit and buds of riparian vegetation that fall on the water (such as *Livistona*, *Ficus*, *Syzygium* and *Castanospermum australe*), leaves and stems of terrestrial plants, tree roots, filamentous algae (including *Mougeotia* and *Spirogyra*), and instream macrophytes (such as *Vallisneria*, *Schoenoplectus* and *Nitella*) (Rogers, 2000; Armstrong & Booth, 2005; Thomson et al., 2006; Limpus et al., 2011). The species changes its diet from being largely carnivorous (feeding on benthic invertebrates) when young, to largely herbivorous as it gets older, with juveniles consuming plant material when carapace length reaches about 6 cm (Limpus, 2008; Limpus et al., 2011). Animal material forms a small part of the diet of adults and includes freshwater sponges, carrion, cane toads and insect larvae (Thomson et al., 2006; Hamann et al., 2007). There is a strong correlation between turtle size (carapace length) and the proportion of plant material in the diet (Limpus, 2008).

The availability of within-river food resources is highly variable both seasonally and annually. Extended dry periods can result in the near total removal of extensive and dense macrophyte beds (Hamann et al., 2007), and floods can scour the river substrate, removing aquatic vegetation and invertebrate fauna (Limpus et al., 2002). Filamentous algae, which regrow quickly, may be the only readily available food for the white-throated snapping turtle following flood events; however, the species has also been observed foraging on submerged grass on inundated banks during flood conditions (Hamann et al., 2007). Protection of riffle zones and riparian vegetation is important for maintaining a good dietary ecology for the species (Hamann et al., 2007).

3.4.4 Movement patterns

The species has relatively small home ranges, commonly utilising stream lengths of less than 1 km. However, individuals may utilise relatively long sections of stream during their lives, and isolated long distance movements of up to 10 km have been recorded. These larger movements can exceed the length of the flowing stream fragments between dam and weir impoundments (Hamann et al., 2007). The turtle is more active around dusk and dawn, which is possibly associated with foraging, and utilises shallow depth habitats at night, receding back to deeper water during the day (Gordos et al., 2007). It does not appear to have a home range that has separate breeding and non-breeding zones, as is the case with the Mary River turtle (Hamann et al., 2007).

Movements may be in response to seasonal conditions. During dry periods turtles move into deeper pools which function as dry season refugia. On the onset of the wet season, they may move into riffle zones to access the abundant food resources in this habitat type (Limpus et al., 2011). Movements may also be associated with reproduction, with aggregations occurring adjacent to nesting banks at breeding time (Limpus et al., 2011).

3.4.5 Life history and breeding

The white-throated snapping turtle is slow growing, with adults growing at less than 0.5 cm per year (Hamann et al., 2007). It appears to reach sexual maturity at a relatively large size, with minimum sizes at maturity being 33.1 cm for females and 19.2 cm for males (Hamann et al., 2007). Age at first breeding is approximately 15–20 years (Limpus et al., 2011).

Most adult females will breed in each successive year, unless the turtle has been injured or debilitated, or the riverine habitat has been severely depleted through severe drought or excessive water extraction. A single clutch of eggs is laid per annual breeding season, averaging 14 eggs per clutch (Hamann et al., 2007; Limpus, 2008; Limpus et al., 2011). Breeding occurs during the dry season, when many individuals do not necessarily have access to flowing water habitat with its higher quality food availability (Limpus et al., 2011). However, the species appears to employ embryonic diapause, which delays embryonic development so that hatching occurs when environmental conditions are suitable (Hamann et al., 2007).

Nesting occurs primarily in the sand and loam alluvial deposits from previous flooding events. The species aggregates at certain sites to nest, and may nest in the same general area of a riverbank across a decade or more (Hamann et al., 2007; Limpus et al., 2011). Compared to most other freshwater turtles, it has an extended nesting season of around 7 months (Hamann et al., 2007). In the Fitzroy River catchment, the species aggregates to breed during May-December (Limpus et al., 2011). In the Burnett River catchment, nesting occurs from Autumn to Spring (May-September), with hatching occurring during Spring and Summer (Thomson et al., 2006; Hamann et al., 2007). In the Mary River catchment, nesting occurs in Autumn and Winter, with aggregations recorded during April-May and most clutches deposited during May-June (Limpus, 2008). However, in both the Burnett and Mary River catchments, gravid females may be found anytime during March-September (Hamann et al., 2007; Limpus, 2008).

Survivorship of adult turtles is high, while that of small juveniles is low (Blamires et al., Hamann et al., 2007). There are no estimates for the survivorship of eggs or small juveniles for this species across the distribution of the species. However, Micheli-Campbell et al. (2013) recorded 50% predation of tagged juvenile Mary River turtles, a species that utilises the same habitat as the white-throated snapping turtle in the Mary River. Twelve juveniles were tagged at 5–16 months of age and the predation occurred over a 9 month tagging project; it was inferred from turtle movement patterns that half the predators were likely fish and the other half likely birds or mammals. Iverson (1991), in a survey across a range of freshwater turtle species outside Australia, estimated an average survivorship across those species of approximately 0.2 per year. With depressed juvenile recruitment and an increase in adult mortality, a turtle species may quickly be decimated (Brooks et al., 1991).

The population growth rate (or decline rate) is highly responsive to changes in adult survivorship, as once adulthood is reached there are a potentially large number of breeding episodes (Heppell et al., 1996). Conversely, the population trajectory is less responsive to proportional changes in egg or juvenile survivorship (Heppell et al., 1996). Nevertheless, where egg predation rates are high, population growth rate will be constrained. With such a life history, a viable turtle population would be expected to have relatively high proportions of juveniles (Thompson, 1983).

3.4.6 Habitat

Water quality

The white-throated snapping turtle is a habitat specialist (Todd et al., 2013). Within the river system it prefers clear, flowing, well-oxygenated waters (Hamann et al., 2007). This preference appears to be associated with its physiological adaptation to extract oxygen from water via cloacal respiration (Mathie & Franklin, 2006; Clark et al., 2008).

A study on the cloacally-respiring turtle *Elseya irwini*, which has a similar reliance on and utilisation of aquatic respiration to *Elseya albagula*, demonstrated that increased suspended-sediment concentrations affected its utilisation of dissolved oxygen, and significantly reduced diving duration and increased surfacing frequency (Schaffer et al., 2015). Diving duration has also been shown to decrease at higher temperatures due to the reduced capacity of water to hold dissolved oxygen as temperature rises (Storey et al., 2008). Decreased diving duration may expose turtles to increased predation pressure, and declines in water quality are likely to have a greater impact on the survival of hatchlings and juveniles than adult turtles (Mathie & Franklin, 2006; Clarke et al., 2008).

Clear, well-oxygenated waters are more important in winter (the dry season), when bimodally respiring freshwater turtles switch from being obligate air breathers to facultative air breathers, which likely enables them to conserve energy through extended periods of inactivity in refugia (deep pools) (Gordos et al., 2003; Fielder, 2012).

The white-throated snapping turtle does occur in non-flowing waters; however, typically at much reduced densities (Hamann et al., 2007). It has been found in both shallow flowing pools less than 1 m deep, and deeper, slow flowing, well-oxygenated pools at least 6 m deep (Gordos et al., 2007; Hamann et al., 2007). Based on distribution records in the Fitzroy catchment (Limpus et al., 2011), it appears to be suited to the aerobic margins of large slow-flowing reaches and large non-flowing pools, and is unlikely to function well in the deeper habitats of larger pools if the pools have very low dissolved oxygen levels, especially under dry season conditions in standing water bodies (Limpus, 2008). The observations of *E. albagula* within impoundments of the Mary catchment are consistent with the conclusions drawn from studies in the Fitzroy catchment (Limpus, 2008).

The species is widely distributed in many impoundments throughout its distribution, but is generally scarce within reaches containing long-established standing water bodies impounded by dams or weirs (Hamann et al., 2007). However, it does occur in abundance in at least one impoundment in the Fitzroy catchment, namely the upstream reaches of the Fitzroy River Barrage (Hamann et al., 2007), which is also chronically turbid (Schaffer pers. comm., 2015). In the Mary catchment it has been recorded within several long-established impoundments including the Mary River Barrage, Imbil Weir, Borumba Dam and Tallegalla Weir (Limpus, 2008). Gordos et al. (2007) found no difference in diving and surfacing behaviour of the white-throated snapping turtle between a naturally flowing creek and a regulated reach downstream of a weir when releases were made.

Permanent and ephemeral water

The species has been recorded almost exclusively in permanent flowing reaches of streams. It has not been recorded where there are no permanent pools during the dry season and has not been recorded inhabiting ephemeral water bodies away from main watercourses, indicating that it has a limited capacity to cross dry paddocks or follow dry streambeds for extended distances. It does not appear to permanently inhabit brackish waters and its dispersal between rivers via the ocean appears to be limited (Hamann et al., 2007).

Microhabitat

The white-throated snapping turtle is generally found in sections of stream characterised by steep undercut banks, rocky or sand-gravel substrates, submerged boulders and/or log jams that are regularly used for shelter, and usually in close proximity to riffle zones (Hamann et al., 2007). It is rarely found in reaches without suitable refuges (Hamann et al., 2007). However, it does occur in abundance in the upstream reaches of the Fitzroy River Barrage which is not associated with habitat features such as rocks, logs and undercut banks (Hamann et al., 2007).

Nesting sites

Almost all nesting occurs on alluvial sand – loam banks deposited by floodwaters, which are often reworked with each significant flooding event (Limpus, 2008). Nests may occur in loose or compact soils, under a closed canopy or with less than 50% canopy cover, with a dense covering of grasses or with low or no vegetation (Hamann et al., 2007; Limpus et al., 2011).

In the Fitzroy catchment, nests are constructed on average at 17 m (with a range of 1–86 m) from the water's edge (Limpus et al., 2011). Nests are shallow, with a mean depth of 23 cm, and most nesting occurs on sloped banks with an average slope of 27 degrees (Limpus et al., 2011). In the Burnett catchment, nests were located on average around 15 m (but up to 60 m) from the water's edge and at a height of 3 m (up to 8 m) above water level, with a mean depth of 22 cm and a width of around 10 cm (Hamann et al., 2007). The tops of steep sloping banks appear to be important nesting habitat, as do

both sand and soil substrates (Hamann et al., 2007). There have been no detailed studies of breeding in the Mary catchment (Limpus, 2008).

The species aggregates to breed at a restricted number of sites. Aggregations have been found on the downstream side of impoundment structures in all three catchments (Hamann et al., 2007; Limpus et al., 2011). Known aggregation areas include:

- Fitzroy River catchment – high density aggregations occur in the upper reaches of the Fitzroy River Barrage impoundment (Hamann et al., 2007).
- Burnett River catchment – nesting occurs throughout the middle and lower catchment, with 90% of observed nesting occurring in the upper reaches of the Ben Anderson Barrage impoundment (Limpus, 2008; Hollier, 2012). High densities have also been observed below Bucca Weir (Kolan River) and the Ned Churchward Weir (Burnett River) (Hamann et al., 2007).
- Mary River catchment – traditional high density nesting banks occur near Tiaro, and a series of nesting banks supporting a lower density of nesting have been identified in the upstream reaches between Traveston and Kenilworth (Limpus 2008).

However, while aggregations have been recorded in certain reaches, the location of breeding sites may change over time (Limpus pers. comm., 2015).

Juvenile turtles

The habitat use of juveniles is unknown. Turtle nests can be tens of kilometres away from the feeding areas and it is not known where juveniles disperse to. It is possible that riffle zones are important habitat for juveniles as invertebrates form a greater part of their diet (Limpus pers. comm., 2015). Clear, flowing and well-oxygenated waters may also be of more importance for hatchlings and juveniles, which have a higher reliance on aquatic respiration than adults (Mathie & Franklin, 2006; FitzGibbon & Franklin, 2010).

3.4.7 Habitat critical to survival

Although there are knowledge gaps regarding the species' habitat use, the following areas may be regarded as representing habitat critical to the survival of the species:

- Riverine systems with permanent water, including waterholes, within the species' distribution.
- All currently known and new nesting sites.

Further research is required to more clearly define habitat critical to survival, particularly for hatchlings and juveniles.

4 Threats

4.1 Historical causes of decline

The white-throated snapping turtle is estimated to have lost more than 70% of its hatchling production and more than 70% of juveniles and sub-adults over at least 20 years (Limpus et al., 2011). The populations in all catchments consist of older individuals with approximately 1% recruitment into the population of each catchment per year. This severe loss of eggs can be attributed to predators, nest bank trampling and subsequent failure to produce immature age classes across the decades. Given the length of time over which this threat has operated, it is likely that it has already led to a severe reduction in the adult population (DotE, 2014).

The species has also suffered the conversion of 50% of its preferred flowing, riverine habitat to poor quality lentic habitat, in which it occurs in much lower densities. In addition, a loss of nesting banks has also likely occurred, and large numbers of adults are killed on dam and weir infrastructure (DotE, 2014).

4.2 Current threatening processes

Principal threats to the white-throated snapping turtle include: the loss of eggs and hatchlings due to predation and trampling; the construction of dams and weirs which result in fragmentation of preferred habitat, obstruction of upstream and downstream migration within rivers, and injury and death during over-topping and water releases; and water regulation leading to insufficient flow to provide well-oxygenated water for cloacal ventilation and food resources for the juvenile turtles, and inundation of traditional nesting areas and riparian vegetation overhanging riverine habitat due to impoundment of water. Each of these threats is discussed in turn below.

4.2.1 Predation and trampling at nesting sites

The principal threat to the white-throated snapping turtle is the excessive (near total) loss of eggs and hatchlings at the aggregated nesting areas in the Fitzroy, Burnett and Mary Catchments. This is due to predation by feral (fox, dog, pig, cat) and native (e.g. goannas, water rat) predators, and trampling of nests by cattle. This egg loss is continuing and has been occurring for at least a generation, with the majority of the population comprised of older adults with very low recruitment into the adult breeding population. Spencer et al. (2016) suggest that a single fox can destroy more than 95% of freshwater turtle nests in one area; with foxes only being introduced into Australia around 1870, freshwater turtles have not had time to evolve to cope with this increased predation on top of natural predators.

4.2.2 River regulation

River regulation threatens the species via:

- Fragmentation of preferred habitat. Deep water reaches of impoundments are largely anoxic and detrimental to cloacal ventilating species (Limpus et al., 2011). Impoundments also do not generally have the required food resources for juveniles or adults.
- Obstruction of migration within rivers. The white-throated snapping turtle may migrate tens of kilometres upstream or downstream to aggregate at traditional nesting sites (Limpus et al., 2011). Existing structures which facilitate fish passage past dams/weirs are not effective for facilitating the passage of the white-throated snapping turtle (Hamann et al., 2007; Limpus et al., 2011). In the long-term, obstruction of movement may reduce gene flow and result in inbreeding (Limpus et al., 2011).
- Injury and death. Turtles are injured or killed by striking hard surfaces during over-topping and water releases, drown in trash filter screens, and fall onto hard substrate during attempts to climb infrastructure walls from the downstream side when there are no flow events (Limpus et al., 2006; Hamann et al., 2007; Limpus et al., 2009; Limpus et al., 2011).
- Changes to in-stream habitat. Inappropriate water allocation leading to low or no flow may reduce oxygenation of the water and impede cloacal respiration. In impoundments, sandy/gravel substrates may be replaced by silt/mud, with associated changes in benthic invertebrate and vegetation communities, and filling in of deep sections of the stream bed and microhabitat features (Limpus et al., 2011).
- Alteration of nesting habitat. Reduction in the frequency of flood events inhibits the replenishment of sandbanks, especially within impoundments, and may result in nesting banks being overgrown with dense vegetation and the reduction of nesting habitat quality and availability (Hamann et al., 2007; Limpus et al., 2011).
- Flooding of nesting areas. Nests laid on the banks of water storages can flood when small inflows occur, as storages fill to a higher level than a flowing river during these times. Research from sympatric chelid turtle species indicates that significant egg mortality (up to 100%) would occur with inundation (McDougall et al., 2015).
- Loss of riparian vegetation (from infrastructure construction) overhanging riverine habitat. This leads to a reduction in fruit as food for adult turtles, and reduces bank stability and refugia provided by undercut banks and roots (Limpus et al., 2011).

- Reduction in food availability. In impoundments, the diets of freshwater turtles are depleted of aquatic plants or macroinvertebrates, with dietary specialists more affected than dietary generalists (Tucker et al., 2012). The white-throated snapping turtle consumed fewer subaquatic plants and wind-fallen fruits in impounded areas, which had substantially reduced plant species abundance and diversity when compared to natural flowing rivers (Tucker et al., 2012).

The Burnett River is fragmented into six flowing segments, amounting to approximately 40% of the original flowing river (Hamann et al., 2007). The Fitzroy River will be fragmented into two flowing reaches, that combined will equal 28% of the total length of the river when the planned Rookwood Weir is built and the Eden Bann Weir is raised (Limpus et al., 2011). There is considerable pressure on the Queensland government to provide water supply security for urban, agricultural and industrial use across the white-throated snapping turtle's distribution. Numerous dams exist in the Fitzroy catchment, with more planned (including Connors River Dam, and Nathan Dam on the Dawson River) (Limpus et al., 2011).

A study of the impact of dams and weirs on freshwater turtles in the Mary, Burnett and Fitzroy catchments determined that the larger the impoundment and the longer it had been in place, the lower the biodiversity of freshwater turtles living in the impoundment relative to outside the impoundment (Tucker, 2000). The species most likely to be lost were the slow maturing, cloacal-ventilating species, including the white-throated snapping turtle.

While individual impoundments are unlikely to threaten survival of the white-throated snapping turtle, cumulative impacts of multiple impoundments structures in a river system could be significant (Boardman, 1996). However, no studies have been undertaken to determine the cumulative impacts of multiple dams and weirs fragmenting and reducing available suitable habitat for this species.

4.2.3 Other threatening processes

Other threats to the white-throated snapping turtle include (Limpus et al., 2011):

- Recreational fishing. Direct impacts result from hooking injuries to the mouth and throat, or mortality when turtles are cut loose from fishing lines or break away with ingested hooks. Indirect impacts are caused by stocking of fish (top end predators) into dam impoundments, which increases predation pressure on juvenile turtles.
- Dense aquatic weeds in the river and weeds on river banks, which can alienate nesting habitat from breeding turtles.
- Extended drought periods, exacerbated by water extraction/regulation. With demand for water, natural river levels are drawn down lower than would naturally occur, causing the river to cease to flow for longer time periods. This is associated with a reduction in water quality, reductions in breeding rates due to an inability to access nesting banks, and presumed increased mortality of turtles.
- Road causeways can impede the movement of turtles along waterways due to excessive flow velocities.
- Land use activities may result in the clearing of riparian habitat, damage to stream banks and shallow water macrophyte beds from cattle and vehicle crossings, lowered water quality and increased sedimentation loads affecting nest bank sediment composition and increasing turbidity.

A summary of threatening processes facing the white-throated snapping turtle is outlined in Table 1. The priorities relate to the threatening processes discussed in sections 4.2.1–4.2.3, and guide the priorities assigned to recovery actions in section 7.

Table 1: Threatening processes and their priority

Drivers	Threatening process	Impact on species (stress)	Priority
Prevalence of predators	Predation at nesting sites	<ul style="list-style-type: none"> Excessive loss of eggs and hatchlings 	1
Livestock, people and vehicles accessing nesting banks	Trampling and crushing at nesting sites	<ul style="list-style-type: none"> Loss of eggs and hatchlings 	1
Cattle and vehicles crossing rivers	Trampling and crushing in-stream	<ul style="list-style-type: none"> Injury and mortality of adults 	3
River regulation	Construction of dams and weirs (new and existing)	<ul style="list-style-type: none"> Fragmentation of preferred habitat Obstruction of migration Inundation of nesting banks Injury and mortality at impoundment structures Loss of riparian vegetation 	1
	Operation of dams and weirs, and inappropriate water flow management	<ul style="list-style-type: none"> Altered flow regimes Lower flow and reduced oxygenation causing reduced survival of juveniles Altered water quality 	2
	Extended drought periods exacerbated by water extraction/regulation	<ul style="list-style-type: none"> Reduction in water quality, breeding rates and increased mortality Reduction in access to nest banks, breeding partners and habitat for juvenile turtles 	2
Recreation	Recreational fishing and boating	<ul style="list-style-type: none"> Injury and mortality Increased in-stream predation pressure from stocked fish 	3
Prevalence of invasive plants Spread of weeds through people and animals	Aquatic weeds	<ul style="list-style-type: none"> Obstruction of access to nesting habitat Reduction in food supply from native plants Loss of nesting habitat Invasive macrophytes affecting food supply Changed water quality 	3
Land use activities and riparian management	Sedimentation and riparian degradation	<ul style="list-style-type: none"> Increased sedimentation Loss of shading, food supply, in-stream habitat structures and riparian vegetation Increased nutrient loads Loss of nesting habitat 	2

5 Populations under particular pressure

The actions described in this recovery plan are designed to provide increased protection for the white-throated snapping turtle and its required habitat throughout its range, as all populations are under pressure. There is a severe depletion of immature turtles, and substantial recruitment failure, in the populations of each catchment (see section 3.3). Each catchment has been fragmented, and riverine habitats altered, by water infrastructure and flow regulation.

6 Objectives and strategies

The objectives of this recovery plan are to:

- ensure a self-sustaining healthy population structure in all catchments in which the white-throated snapping turtle occurs; and
- ensure an ecologically functional wild population of white-throated snapping turtle that, with limited species-specific management, has a high likelihood of persistence in nature.

The objectives are long-term and may not be achieved during the 10 year life of the plan. However, recovery actions should go towards achieving these objectives. The plan will be reviewed every five years.

The strategies to achieve the plan's objectives are to:

- Substantially improve the recruitment of hatchlings into the population;
- Minimise the incidence of adult mortality and injury above natural rates;
- Improve stream flow and habitat quality throughout the species' distribution;
- Improve the connectivity within populations throughout each catchment; and
- Increase public awareness and participation in conservation of the species and its habitat.

7 Actions to achieve the specific objectives

Actions identified for the recovery of the white-throated snapping turtle described below. It should be noted that some of the objectives are long-term and may not be achieved prior to the scheduled five-year review of the recovery plan. Priorities assigned to actions should be interpreted as follows:

Priority 1:	Taking prompt action is necessary in order to mitigate the key threats to the white-throated snapping turtle, and also to provide valuable information to help identify long-term population trends.
Priority 2:	Action would provide a more informed basis for the long-term management and recovery of the white-throated snapping turtle.

Priority 3: Action is desirable, but not critical, to the recovery of the white-throated snapping turtle or the assessment of trends in that recovery.

7.1 Strategy 1 – Substantially improve the recruitment of hatchlings into the population

Research actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
1a	Design a hatchery program to release large numbers of hatchlings into the rivers	1	<ul style="list-style-type: none"> A hatchery program is developed which includes: <ul style="list-style-type: none"> numbers, frequency, timing and locations for egg collection and hatchling release an investigation into the feasibility of headstarting turtles in captivity 	Research community; DEHP	
1b	Evaluate the relative survivorship of hatchlings from wild nests and captive incubated nests	1	<ul style="list-style-type: none"> A monitoring program is implemented to evaluate the survivorship and habitat use of hatchlings and young juvenile turtles in the wild The survivorship and habitat use of hatchlings and young juvenile turtles from the hatchery program are determined, and compared with hatchlings and young juvenile turtles from wild nests 	Research community; DEHP	
1c	Evaluation of the success of the hatchery program	1	<ul style="list-style-type: none"> The success of the hatchery program developed under Action 1a has been evaluated, including: <ul style="list-style-type: none"> an assessment of whether the survivorship of young turtles can be increased via a headstarting project, and by how much (if headstarting is feasible) determination of the optimal age for releasing captive bred turtles into the wild which maximises survivorship 	Research community; DEHP	
1d	Search for and map nesting sites in each catchment	1	<ul style="list-style-type: none"> Key nesting sites are identified and mapped in all catchments. Stream banks should be checked for signs of nesting particularly after rainfall. 	Research community; DEHP	
1e	Develop an effective means to control predators of eggs over a catchment scale	1	<ul style="list-style-type: none"> Explore a range of options (e.g. taste aversion, baiting, fumigation of fox dens, sniffer dogs to find dens) for predator control and evaluate their relative effectiveness 	Research community; DEHP; regional bodies	
1f	Determine the impact of	2	<ul style="list-style-type: none"> Predation rates on hatchlings are quantified 	Research community	

	introduced or translocated stocked fish on turtles		<ul style="list-style-type: none"> The impact of stocked fish on turtle populations is determined 		
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On-ground actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
1f	Implement the hatchery program (developed under Action 1a)	1	<ul style="list-style-type: none"> The hatchery program developed under Action 1a is implemented 	Research community; DEHP	
1g	Protect nests and nesting banks from predation, trampling and other disturbance	1	<ul style="list-style-type: none"> A program is implemented to erect and monitor physical structures around nests (e.g. 70-100 cm square plastic mesh covers, 10 cm grid-size, over nests) and key nesting reaches (e.g. fencing) in all catchments Access to key nesting banks by livestock, people and vehicles is restricted; and closed during the breeding season Monitor hatching success from protected nesting banks, and evaluate the effectiveness of nest protection actions <p>At least 70% of managed clutches produce hatchlings every year (depending on external factors such as floods, which may impede the measurement of hatching success)</p>	DEHP; community groups; regional bodies	
1h	Implement a predator control program in key areas of each catchment	1	<ul style="list-style-type: none"> A control program for foxes, dogs, pigs and cats is implemented in key nesting areas of each catchment Abundance of predators is reduced in key nesting areas A control program for native predators is considered 	DEHP; community groups; regional bodies	
1i	Manage water releases and water levels to avoid inundation of nesting banks during the incubation period	1	<ul style="list-style-type: none"> Inundation of nesting banks during the incubation period is avoided wherever feasible (e.g. by reducing water level fluctuations in storages: McDougall et al., 2015), taking into account requirements of water resource planning subordinate legislation and processes administered by DNRM 	DNRM; infrastructure operators	

7.2 Strategy 2 – Minimise the incidence of adult mortality and injury above natural rates

Research actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
2a	Determine adult population size	1	<ul style="list-style-type: none"> Targeted surveys have been undertaken throughout the species' distribution Total adult population size has been determined 		
2b	Determine rates of natural mortality	1	<ul style="list-style-type: none"> Rates of natural mortality in the adult population have been determined 		
2c	Design new water infrastructure to minimise the mortality and injury of adult turtles	1	<ul style="list-style-type: none"> Practical guidelines for the design of water infrastructure to minimise turtle mortality and injury are developed, including the cessation of stepped weir designs The guidelines are widely adopted and incorporated into a formal process for designing water infrastructure 	Research community; DEHP; infrastructure operators	
2d	Design modifications to existing water infrastructure to minimise the mortality and injury of adult turtles	1	<ul style="list-style-type: none"> Options to modify existing water infrastructure are explored, trialled and their effectiveness tested 	Research community; DEHP; infrastructure operators	
2e	Monitor changes in turtle injury/mortality rates in response to management changes to water infrastructure	1	<ul style="list-style-type: none"> A monitoring program is implemented which enables the assessment of injury and mortality rates of turtles at water infrastructure and connects this with infrastructure design/operation Movements of turtles in downstream pools are monitored using acoustic telemetry 	Research community; DEHP	

On-ground actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
2f	Modify water infrastructure and operations to minimise	1	<ul style="list-style-type: none"> Existing water infrastructure design and/or operation has been modified, where feasible and practicable, to prevent turtles colliding with hard substrate at impoundments 	Infrastructure operators	

	the mortality of adult turtles during flood events and regulated water releases		<ul style="list-style-type: none"> All future water infrastructure is constructed in accordance with the guidelines developed at Action 2a The rates of injury and mortality of adult turtles at impoundments have substantially decreased, as demonstrated by Action 2c 		
2g	Work with landholders to reduce the extent of cattle crossing rivers	1	<ul style="list-style-type: none"> Funding provided to landholders to undertake riparian fencing and offstream watering 	NRM bodies; landholders	
2h	Reduce the extent of turtle injury and mortality from recreational fishers and boaters	2	<ul style="list-style-type: none"> A position statement on the impact of stocked fish on the species has been prepared and presented to DAF Mortality of turtles from fish or crayfish traps is substantially reduced Injury to turtles from fish hooks is substantially reduced A position statement on avoiding the use of barbed and stainless steel fish hooks has been prepared and presented to DAF Incidence of boat strikes is reduced 	Recreational fishers and boaters; fishing clubs; DAF	

7.3 Strategy 3 – Improve stream flow and habitat quality throughout the species' distribution

Research actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
3a	Determine habitat requirements	1	<ul style="list-style-type: none"> Environmental flow requirements for successful hatching of clutches are determined (i.e. flows required to produce and maintain nest banks) Acoustic telemetry studies have been undertaken Habitat requirements of hatchlings and small juvenile turtles have been determined The relationship between cloacal respiration, diving ecology and prevailing environmental conditions has been determined 'Habitat critical to survival' is further defined 	Research community	
3b	Determine the impact of river regulation on the survivorship of	1	<ul style="list-style-type: none"> Natural survival rates of hatchlings and small juvenile turtles have been determined Impacts of regulated watercourses (or impoundments) on survival rates 		

	hatchlings and juveniles		of hatchlings and small juvenile turtles have been determined		
3c	Identify areas of optimal or sub-optimal habitat	1	<ul style="list-style-type: none"> Existing areas of optimal and suboptimal habitat are mapped in each catchment The presence/absence of any habitat-related limitations to breeding are documented Impacts on areas of optimal habitat are identified Sites with poor habitat conditions are reported to the recovery team 	Research community	

On-ground actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
3d	Ensure that water releases and extraction maintain adequate stream flow and water quality	2	<ul style="list-style-type: none"> Flowing, well-oxygenated waters are allowed for from impoundments, where feasible and practicable Cold water pollution and low aquatic oxygen are reduced by mixing water immediately above impoundment structures to reduce stratification of temperature and dissolved oxygen 	DNRM; infrastructure operators	
3e	Reduce the impact of pest/exotic plants on nesting and aquatic habitats	2	<ul style="list-style-type: none"> Weed control in key nesting and foraging reaches (preferably using selective strategic herbicide application) has been undertaken where required 	DEHP; regional bodies; community groups	
3f	Reduce the incidence of riparian clearing	2	<ul style="list-style-type: none"> Riparian clearing has been reduced through engagement with landholders and other key stakeholders, and increased compliance with relevant legislation 	DEHP; regional bodies	
3g	Restore the health of riparian vegetation	2	<ul style="list-style-type: none"> Riparian management and/or restoration measures have been implemented in key foraging reaches where required, including plants which are known fruit sources for the white-throated snapping turtle Link management measures to other existing programs, such as the 20 Million Trees program 	DEHP; regional bodies; community groups	
3h	Maintain nesting banks	1	<ul style="list-style-type: none"> Where necessary, rehabilitate nesting banks to ensure adequate 	DEHP; regional bodies;	

			sand/loam substrate and no- or low-density vegetation	community groups	
3i	Improve in-stream habitat	2	<ul style="list-style-type: none"> In-stream vegetation has been improved in key foraging reaches where required 	DEHP; regional bodies; community groups	
3j	Review water management plans to ensure environmental flow requirements for the species are met	2	<ul style="list-style-type: none"> Water management plans for all catchments are reviewed and include environmental flow requirements for the turtle. These include the need for: <ul style="list-style-type: none"> provision of baseflow to maintain riffle habitat for juvenile food and water quality maintenance of geomorphological flows that enable nesting banks to reform and limit vegetation encroachment on these banks review of waterhole drawdown rules to maintain refugial quality of key waterholes 	DNRM	

7.4 Strategy 4 – Improve the connectivity within populations throughout each catchment

Research actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
4a	Design water infrastructure to allow movement of turtles upstream and downstream with minimal injury and mortality	2	<ul style="list-style-type: none"> Options for allowing movement of turtles past water infrastructure are explored (designed, built and tested), and their effectiveness and costs evaluated 	Research community; DEHP; infrastructure operators	
4b	Monitor the movement of the species	2	<ul style="list-style-type: none"> Acoustic telemetry studies have been undertaken The scale and cues for movement are understood Long-distance and migratory patterns, e.g. for breeding, have been identified 	Research community; DEHP	

On-ground actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
4c	Modify water infrastructure	2	<ul style="list-style-type: none"> Existing and new water infrastructure incorporates methods, 	Infrastructure operators	

	design or operation to allow movement of turtles upstream and downstream with minimal injury and mortality		<p>as identified in Action 4a, to allow turtle movement past infrastructure</p> <ul style="list-style-type: none"> Turtles are moving past water infrastructure, as demonstrated via Action 4b 		
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7.5 Strategy 5 – Increase public awareness and participation in conservation of the species and its habitat

On-ground actions

Action	Description	Priority	Performance Criteria	Responsible Parties	Indicative Cost *priority 1 only
5a	Develop and implement a broad strategy to raise awareness and educate the general public about conservation for the species	2	<ul style="list-style-type: none"> Articles about white-throated snapping turtle conservation, including threats and recovery actions, are published in community newsletters, local bulletins and newspapers Informative displays and web-based social media are developed to educate the broader community about conservation of the turtle, particularly at nesting sites Public awareness before and after implementation of the strategy is measured Public awareness about conservation of the species has increased 	DEHP; community groups	
5b	Develop and implement a targeted strategy to promote the use of citizen science in relation to conservation for the species.	3	<ul style="list-style-type: none"> Articles are published in community newsletters and magazines to advertise the central repository for white-throated snapping turtle observations and encourage citizen scientist involvement in conservation of the species Citizen scientists and community groups are involved in implementing on-ground management actions, e.g. protection of nests and nesting areas (Action 1g), improvement of habitat in nesting and foraging reaches (Actions 3e,g,h,i) Promote the use of TurtleSAT by management agencies and the general public A central database is developed and used to record all sightings of the species 	NRM bodies; DEHP; research community; community groups	

8 Duration and cost of the recovery process

It is anticipated that the recovery process will not be achieved prior to the scheduled five-year review of the recovery plan. The *National Recovery Plan for the White-throated Snapping Turtle (Elseya albagula)* will therefore remain in place until such time as the Australian populations of the white-throated snapping turtle have improved to the point at which the populations no longer meet threatened species status under the EPBC Act.

The cost of implementation of this plan should be incorporated into the core business expenditure of the affected organisations, and through additional funds obtained for the explicit purpose of implementing this recovery plan. It is expected that state and Commonwealth agencies will use this plan to prioritise actions to protect the species' and enhance their recovery, and that projects will be undertaken according to agency priorities and available resources. In order to maximise the conservation outcomes and cost-effectiveness of this plan, it is intended that the proposed recovery actions complement, where possible, those of other protected matters.

Table 2: Summary of high priority recovery actions and estimated costs in (\$000's) for the first five years of implementation (these estimated costs do not take into account inflation over time).

Action	Cost					
	Year 1	Year 2	Year 3	Year 4	Year 5	Total
TOTAL						

9 Current management practices

9.1 Commonwealth

As the white-throated snapping turtle is protected under the EPBC Act, it is an offence to kill, injure, take, trade, keep, or move any individual without a permit on Commonwealth lands. In addition, all listed threatened species are considered matters of national environmental significance (MNES), and any action that may have an impact on MNES must be referred to the Minister of the Environment and Energy for approval. The Department of the Environment and Energy, as the Australian Government department responsible for administering the EPBC Act, maintains a suite of interactive tools that allow users to search, find and generate reports on information and data describing MNES. The conservation values atlas shows the location and spatial extent of conservation values (where sufficient information exists) and is available at: www.environment.gov.au/coasts/marineplans/cva/index.html.

The Commonwealth has developed threat abatement plans (TAPs) for feral cats, foxes and feral pigs:

- Threat abatement plan and background document for predation by the European red fox (DEWHA 2008a,b)
- Threat abatement plan and background document for predation by feral cats (DotE 2015a,b)
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (DEH 2005) – this plan ceased on 1 October 2015 and may soon be replaced by a revised plan.

9.2 Queensland

In Queensland, the white-throated snapping turtle is listed as Endangered under the Queensland *Nature Conservation Act 1992*. It is also ranked as a high priority species under EHP's Back on Track species prioritisation framework, which prioritises species based on those which face the greatest risk of extinction and have the greatest potential for recovery. The framework identifies common threats affecting a range of species, and identifies where to focus management actions and investment in order to maximise outcomes (Qld EHP 2012). A range of action documents have been developed based on this framework. Two – the Burnett Mary Actions for Biodiversity, and Fitzroy Actions for Biodiversity – include the white-throated snapping turtle (Qld DERM 2010a,b).

The Queensland EPA (now replaced by EHP) has developed the 'Management plan for the conservation of *Elseya* sp. [Burnett River] in the Burnett River Catchment' (Hamann et al., 2007), which is a comprehensive management plan for the white-throated snapping turtle. Many of the actions in the 'National Recovery Plan for the White-throated Snapping Turtle (*Elseya albagula*)' are based on actions in the Burnett River plan.

The Queensland EHP also undertakes long-term research, monitoring and conservation management of marine and freshwater turtles via the Queensland Turtle Conservation (QTC) project, which was created in 1975. The freshwater aspect focuses on turtle populations within the Burnett, Mary and Fitzroy River Catchments. Research and monitoring activities are undertaken by EHP staff and the QTC volunteer program. The data collected is collated within a central database, summarised in annual reports, and used to guide conservation management planning (EHP 2011).

Industry groups have developed some turtle management measures as part of water infrastructure projects. The 'Fitzroy River turtle (*Rheodytes leukops*) species management program' (GHD 2015) was developed as part of the Lower Fitzroy River Infrastructure Project. Informal guidelines for the design of water infrastructure to minimise turtle mortality and injury have also been developed, but have not been formally adopted (SunWater pers. comm., 2015).

The Burnett Catchment Care Association has received a grant under the Commonwealth's 20 Million Trees Programme to revegetate high priority riparian habitat for the white-throated snapping turtle and Australian lungfish (*Neoceratodus forsteri*) in the Burnett catchment. The project will involve green army teams, landholders and local job-seekers in revegetation activities, and work with local schools to set up monitoring programs and raise community awareness of these species. More information on this project (ID: 20MTR2-228) can be found at: <http://www.nrm.gov.au/national/20-million-trees/competitive-grants-round-two>.

The 'National Recovery Plan for the White-throated Snapping Turtle (*Elseya albagula*)' will complement these current management practices, and ensure that all threats to the white-throated snapping turtle are adequately identified, prioritised and addressed across the species' distribution.

10 Effects on other native species and biodiversity benefits

The adjacent catchments of the Fitzroy, Burnett and Mary Rivers of central and southeast Queensland support three species of locally endemic freshwater turtles, all of which are listed as threatened under the EPBC Act. These species are: the Mary River turtle (*Elusor macrurus*) which is listed as Endangered; the Fitzroy River turtle (*Rheodytes leukops*) which is listed as Vulnerable; and the white-throated snapping turtle (*Elseya albagula*) which is listed as Critically Endangered.

Reducing anthropogenic impacts from water regulation and recreational fishing activities, and supporting work to improve water quality in the Fitzroy, Burnett and Mary River catchments, will likely

benefit other EPBC-listed threatened species including freshwater turtles. Implementation of the white-throated snapping turtle recovery plan will also have positive outcomes for other species which utilise riverine habitats, and complement actions identified in the draft Mary River Threatened Species Recovery Plan (DotE & MRCCC, 2014), which covers five priority species in the Mary River catchment.

11 Social and economic considerations

Water regulation threatens the white-throated snapping turtle by reducing water quality, altering riverine habitat, obstructing migration along rivers, and increasing injury and mortality. Due to its distribution in the Fitzroy, Burnett and Mary River catchments which supply cities and towns in Queensland, populations of the species are adversely affected by water regulation in these catchments. As habitats critical to the survival of the species are identified, there is potential for water infrastructure to be restricted under the EPBC Act development assessment and approval process. However, there are also benefits to water supply as implementation of recovery actions under the plan should improve water quality.

Recreational fishing and boating activities also threaten the white-throated snapping turtle due to the species being caught and injured on fishing lines, from propeller and boat strikes, or drowned in lost redclaw cray traps (Limpus et al., 2011). The actions outlined in this recovery plan in relation to recreational fishing focus on reducing mortality and injury to turtles by changing fishing practices. Implementation of the plan is expected to have short-term negative impacts on recreational fishing and boating activities, but negligible impacts in the long-term once the industry has adopted new fishing practices.

The Recovery Team will work closely with stakeholders in the implementation of the recovery plan, in order to ensure protection and conservation of the white-throated snapping turtle, while at the same time minimising any social and economic impacts arising from implementing the recovery actions.

12 Affected interests

Organisations likely to be affected by the actions proposed in this plan include: Australian and state governments agencies, particularly those with environmental and water regulation responsibilities; private organisations responsible for water supply; recreational fishers; local Indigenous communities; researchers; catchment groups; conservation groups; and wildlife interest groups. This list, however, should not be considered exhaustive, as there may be other interest groups that would like to be included in the future or need to be considered when specialised tasks are required in the recovery process.

13 Consultation

The National Recovery Plan for the White-throated Snapping Turtle (*Elseya albagula*) has been developed through extensive consultation with a broad range of stakeholders. The consultation process included a workshop in Brisbane that brought together key species experts and conservation managers, from a range of different organisations, to categorise ongoing threats to species and identify knowledge gaps and potential management options. Workshop participants included representatives from DotE, EHP, DNRM, SunWater, SEQWater, catchment groups, Greening Australia and university researchers. A public consultation period was held during [to be inserted]. During the drafting process the Department of the Environment and Energy (Cwth) continued to work closely with key stakeholders.

14 Organisations/persons involved in evaluating the performance of the plan

This plan should be reviewed no later than five years from when it was endorsed and made publically available. The review will determine the performance of the plan and assess:

- whether the plan continues unchanged, is varied to remove completed actions, or varied to include new conservation priorities;
- whether a recovery plan is no longer necessary for the species as either conservation advice will suffice, or the species is removed from the threatened species list.

As part of this review, the listing status of the species will be assessed against the EPBC Act species listing criteria.

The review will be coordinated by DotEE in association with relevant Australian and state government agencies, and key stakeholder groups likely to be affected by the actions proposed in this plan. These are expected to include:

Government agencies

Department of the Environment and Energy (Cwth)
Department of Environment and Heritage Protection (Qld)
Department of Natural Resources and Mines (Qld)

Researchers and community groups

Catchment groups
Conservation groups
Universities and other research organisations
Recreational fishers and associations
Recreational boaters

Industry

SunWater
SEQWater

15 References

- Armstrong, G., & Booth, D. T. (2005). Dietary ecology of the Australian freshwater turtle (*Elseya* sp.: Chelonia: Chelidae) in the Burnett River, Queensland. *Wildlife Research* 32, 349-353.
- Blamires, S.J., Spencer, R-J., King, P., & Thompson, M.B. (2005). Population parameters and life-table analysis of two coexisting freshwater turtles: Are the Bellinger River turtle populations threatened? *Wildlife Research* 32, 339-347.
- Boardman N. K. (1996). Independent Review of Impacts of Walla Weir Proposal on Lungfish (*Neoceratodus forsteri*) and *Elseya* Tortoise. Unpublished report to the Federal Minister of the Environment.
- Brooks, R. J., Brown, G. P., & Galbraith (1991). Effects of a sudden increase in natural mortality of adults on a population of the common snapping turtle (*Chelydra serpentina*). *Canadian Journal of Zoology* 69 (5), 1314-1320.
- Clark N. J., Gordos M. A., & Franklin C. E. (2008). Diving behaviour, aquatic respiration, and blood respiratory properties: a comparison of hatchling and juvenile Australian turtles. *Journal of Zoology (London)* 275, 399-406.
- Department of the Environment (DotE) (2014). Conservation Advice *Elseya albagula* White-throated snapping turtle. Available on the Internet at: <http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>.
- Department of the Environment (DotE) (2015a). Threat abatement plan for predation by feral cats. Canberra: DotE. Available on the Internet at: <http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats>.
- Department of the Environment (DotE) (2015b). Background document for the threat abatement plan for predation by feral cats. Canberra: DotE. Available on the Internet at: <http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats>.
- Department of the Environment and Heritage (DEH) (2005). Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs. Canberra: DEH. Available on the Internet at: <https://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig>.
- Department of the Environment and the Mary River Catchment Coordinating Committee (DotE & MRCCC) (2014). Draft Mary River Threatened Species Recovery Plan. Canberra.
- Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008a). Threat abatement plan for predation by the European red fox. Canberra: DEWHA. Available on the Internet at: <http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox>.
- Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008b). Background document for the threat abatement plan for predation by the European red fox. Canberra: DEWHA. Available on the Internet at: <http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox>.
- Ecotone Environmental Services Pty. Ltd. (2007). *Traveston Crossing Dam project: Ecological study: Terrestrial fauna and freshwater turtles. Final Report*. Ecotone Environmental Services Pty Ltd, No. 2007/06, Tenterfield, NSW.

- Fielder, D. P. (2012). Seasonal and diel dive performance and behavioural ecology of the bimodally respiring freshwater turtle *Myuchelys bellii* of eastern Australia. *Journal of Comparative Physiology. A. Neuroethology, Sensory, Neural, and Behavioural Physiology* 198, 129-143.
- FitzGibbon, S. I., & Franklin, C. E. (2010). The importance of the cloacal bursae as the primary site of aquatic respiration in the freshwater turtle, *Elseya albagula*. *Australian Zoologist* 35, 276-282.
- GHD (2015). Fitzroy River turtle (*Rheodytes leukops*) species management program. Report for Gladstone Area Water Board and SunWater – Lower Fitzroy River Infrastructure Project.
- Gordos, M., Franklin, C. E., & Limpus, C. (2003). Seasonal changes in the diving performance of the bimodally respiring freshwater turtle *Rheodytes leukops* in a natural setting. *Canadian Journal of Zoology* 81, 617-625.
- Gordos et al (2007). Diving ecology of an undescribed freshwater turtle, *Elseya* sp. [Burnett River], from a pristine and hydrologically altered habitat. *Journal of Zoology* 272, 458-469.
- Hamann, M., Schäuble, C. S., Limpus, D. J., Emerick, S. P., & Limpus, C. J. (2007). Management plan for the conservation of *Elseya* sp. [Burnett River] in the Burnett River Catchment. Queensland Environmental Protection Agency.
- Heppell S. S., Crowder L. B., & Crouse, D. T. (1996). Models to evaluate headstarting as a management tool for long-lived turtles. *Ecological Applications* 6/, 556-565.
- Hollier, C. (2012). Effects of experimental flooding on egg survival of Krefft's River Turtle: Implications for freshwater turtle conservation. Thesis for Master of Environment, University of Melbourne
- Iverson, J. B. (1991). Patterns of survivorship in turtles (order Testudines). *Canadian Journal of Zoology* 69, 385-391.
- Limpus, C. J. (2008). Freshwater turtles in the Mary River, Queensland. Review of biological data for turtles in the Mary River, with emphasis on *Elusor macrurus* and *Elseya albagula*. Environmental Protection Agency Brisbane.
- Limpus, C. J. (2015). Personal communication at the White-throated snapping turtle (*Elseya albagula*) recovery plan workshop, 5 November 2015. Chief Scientist, Department of Environment and Heritage Protection, Queensland.
- Limpus, C., Limpus, D., & Hamann, M. (2002). Freshwater turtle populations in the area to be flooded by the Walla Weir, Burnett River, Queensland: Baseline study. *Memoirs of the Queensland Museum* 48, 155-168
- Limpus, C. J., Limpus, D. J., Parmenter, C. J., Hodge, J., Forest, M., & McLachlan J. (2011). The Biology and Management Strategies for Freshwater Turtles in the Fitzroy Catchment, with particular emphasis on *Elseya albagula* and *Rheodytes leukops*: A study initiated in response to the proposed construction of Rookwood Weir and the raising of Eden Bann Weir. Department of Environment and Resource Management Brisbane.
- McDougall, A. J., Espinoza, T., Hollier, C., Limpus, D. J., Limpus, C. J. (2015). A risk assessment approach to manage inundation of *Elseya albagula* nests in impounded waters: a win-win situation? *Environmental management* 55, 715-724.
- Mathie, N. J., & Franklin, C. E. (2006). The influence of body size on the diving behaviour and physiology of the bimodally respiring turtle *Elseya albagula*. *Journal of Comparative Physiology B* 176, 739-474.
- Micheli-Campbell, M. A., Campbell, H. A., Connell, M., Dwyer, R. G., & Franklin, C. E. (2013). Integrating telemetry with a predictive model to assess habitat preferences and juvenile survival in an endangered freshwater turtle. *Freshwater Biology* 58, 2253-2263.

- Queensland Department of Environment and Heritage Protection (Qld EHP) (2011). Marine and freshwater turtle monitoring. Viewed 8 April 2016. Available on the internet at: https://www.ehp.qld.gov.au/water/monitoring/assessment/turtle_monitoring.html
- Queensland Department of Environment and Heritage Protection (Qld EHP) (2012). Back on Track species prioritisation framework. Viewed 8 April 2016. Available on the internet at: <https://www.ehp.qld.gov.au/wildlife/prioritisation-framework/index.html>.
- Queensland Department of Environment and Resource Management (Qld DERM) (2010a). Fitzroy Natural Resource Management Region Back on track Actions for Biodiversity. Brisbane.
- Queensland Department of Environment and Resource Management (Qld DERM) (2010b). Burnett Mary Natural Resource Management Region Back on track Actions for Biodiversity. Brisbane.
- Rogers, V. M. (2000). Dietary ecology including dietary resource partitioning of four species of chelid turtle in a tributary of the Fitzroy River, central Queensland. Rockhampton: Unpublished B.Sc.Hon. thesis, School of Biological and Environmental Sciences, Central Queensland University, Rockhampton.
- Schaffer, J. R., Hamann, M., & Rowe, R. (2015). Muddy waters: the influence of high suspended-sediment concentration on the diving behaviour of a bimodally respiring freshwater turtle from north-eastern Australia. *Marine and Freshwater Research*.
- Spencer, R.-J., Van Dyke, J. U., & Thompson, M. B. (2016). The 'Ethological Trap': Functional and numerical responses of highly efficient invasive predators driving prey extinctions. *Ecological Applications*. Accepted Author Manuscript. doi: 10.1002/eap.1375. Available on the internet at: <http://onlinelibrary.wiley.com/doi/10.1002/eap.1375/full>.
- Storey, E. M., Kayes, S. M., De Vries, I., & Franklin, C. E. (2008). Effect of water depth, velocity and temperature on the surfacing frequency of the bimodally respiring turtle *Elseya albagula* 22, 840-846.
- SunWater (2015). Personal communication at the White-throated snapping turtle (*Elseya albagula*) recovery plan workshop, 5 November 2015.
- Thomson, S., Georges, A., Limpus, C. J. (2006). A new species of freshwater turtle in the genus *Elseya* (Testudines: Chelidae) from central coastal Queensland, Australia. *Chelonian Conserv Biol* 5(1),74-86.
- Todd, E. V., Blair, D., Farley, S., Farrington, L., Fitzsimmons, N. N., Georges, A., Limpus, C. J., & Jerry, D. R. (2013). Contemporary genetic structure reflects historical drainage isolation in an Australian snapping turtle, *Elseya albagula*. *Zoological Journal of the Linnean Society* 169, 200-214.
- Tucker, A. D. (Compiler) (2000). *Cumulative Effects of Dams and Weirs on Freshwater Turtles: Fitzroy, Burnett and Mary Catchments*. Queensland Parks and Wildlife Service. Unpublished report to Department of Natural Resources, Brisbane.
- Tucker, A. D., Guarino, F., & Priest, T. E. (2012). Where Lakes Were Once Rivers: Contrasts of Freshwater Turtle Diets in Dams and Rivers of Southeastern Queensland. *Chelonian Conservation and Biology* 11(1), 12-23.