Western Trout Minnow (*Galaxias truttaceus hesperius*) Recovery Plan

Western Australian Wildlife Management Program No. 47

Department of Environment and Conservation
Our environment, our future

Australian Government

Department of Fisheries
Government of Western Australia

SOUTHCOAST
NATURAL RESOURCE MANAGEMENT INC.

FOREWORD

Recovery Plans are developed within the framework laid down in Department of Environment and Conservation Policy Statements Nos 44 and 50.

Recovery Plans outline the recovery actions that are required to address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process.

Recovery Plans delineate, justify and schedule management actions necessary to support the recovery of threatened species and ecological communities. The attainment of objectives and the provision of funds necessary to implement actions is subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery Plans do not necessarily represent the views or the official position of individuals or organisations represented on the Recovery Team.

This Recovery Plan was approved by the Department of Environment and Conservation, Western Australia and prepared to be adopted as a National Recovery Plan under the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act). Approved Recovery Plans can be subject to modification as dictated by new findings, changes in status of the taxon or ecological community and the completion of recovery actions.

In Western Australia the conservation and protection of fish and their environment is the legislative responsibility of the Department of Fisheries Western Australia (DoF) under the *Fish Resources Management Act* 1994.

This Plan will operate within a 10 year time-frame, though it will remain in force unless reviewed and updated or replaced.

Information in this Recovery Plan was accurate on 14 May 2008.

RECOVERY PLAN PREPARATION

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Cover photograph by David Morgan (Freshwater Fish Group, Centre for Fish and Fisheries Research, Murdoch University).

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SUMMARY

Western Trout Minnow or Western Trout Galaxias *Galaxius truttaceus hesperius* Whitley, 1944

Family:	Galaxiidae
DEC Region:	South Coast
DEC District:	Albany
Current status of taxon:	Endangered (Western Australia) Critically Endangered (Commonwealth)
Recovery Team:	Southern freshwater fauna recovery team.

Habitat Critical for Survival of *Galaxius truttaceus hesperius*:

- The area of occupancy of the known populations (i.e. the Goodga suite (Goodga River, Black Cat Creek and Moates Lake), the Angove suite (Angove River and Angove Lake) and the upper Kent River).
- Additional occurrences of similar habitat that do not currently contain the species but may have done so in the past (i.e. King and Kalgan Rivers).

As an aquatic species, the habitat critical for the Western Trout Minnow is potentially influenced by all the land uses which are within the catchments of the critical habitat.

All wild and translocated populations of Western Trout Minnow are considered important populations. Each extant population will be treated as a genetically distinct unit.

Recovery Objectives:
The objectives of this Recovery Plan are to abate the identified threats to the Western Trout Minnow, and maintain or enhance *in situ* populations and distribution to ensure the long-term preservation of the subspecies in the wild.

Criteria for Success:
This Recovery Plan will be deemed successful if known populations of Western Trout Minnow are maintained and the distribution of the populations is not reduced.

Criteria for Failure:
This Recovery Plan will be deemed unsuccessful if the known populations of Western Trout Minnow have declined or the distribution of the populations is reduced.

Recovery Actions:

1. Define and map critical habitat and survey for additional populations.
2. Implement a monitoring program for the known populations.
3. Develop and implement strategies to prevent the introduction of invasive fish species.
4. Research the cause of the deaths of the fish from the drop-off of the Goodga River Gauging Station.
5. Maintain and improve the Goodga fishway.
6. Investigate and implement measures to facilitate upstream movement of the Angove suite population.
7. Investigate and implement strategies to cease recreational fishing in the Angove and Goodga catchments.
8. Obtain biological and ecological information for the separate populations.
9. Investigate the potential for *ex situ* populations.
10. Investigate the tolerances of the Western Trout Minnow to factors such as water temperature, salinity, turbidity and nutrients.
11. Fence off access of livestock to riparian habitat and revegetate where necessary.
12. Promote awareness of threatened aquatic species.

1 INTRODUCTION

Trout Minnow (*Galaxias truttaceus*) are small, freshwater fish endemic to the lakes and streams of southern Australia, including Victoria, Tasmania and southern Western Australia (Morgan *et al.* 1998; Allen *et al.* 2002). While there have been no published taxonomical studies since 1981 (McDowell & Frankenberg 1981), there are marked differences in morphology and biology between the western and eastern Australian populations, considered to be due to the degree of separation, reproductive isolation and exposure to different environmental conditions (McDowell & Frankenberg 1981; Humphries 1989; Morgan 2003). As such, the Western Australian populations have been accepted as a separate subspecies, the Western Trout Minnow (*Galaxias truttaceus hesperius*).

1.1 Conservation status

The Western Trout Minnow (*Galaxias truttaceus hesperius*) is currently listed as Endangered under the *Western Australia Wildlife Conservation Act* 1950 and Critically Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999.

In Western Australia the conservation and protection of fish and their environment is the legislative responsibility of the Department of Fisheries Western Australia (DoF) under the *Fish Resources Management Act* 1994. The listing of the Western Trout Minnow as a threatened species gives this fish species additional protection by the Western Australian Department of Environment and Conservation (DEC) under the *Western Australia Wildlife Conservation Act* 1950 and the Australian Government Department of the Environment, Water, Heritage and the Arts (DEWHA) under the *Environment Protection and Biodiversity Conservation Act* 1999.

1.2 Description

The Western Trout Minnow is a freshwater fish which grows to a maximum size of 12-14 cm (Allen *et al.* 2002). It is an elongated, relatively deep-bodied and scaleless galaxiid that is brown to olive in colour with pale-edged dark spots on its upper sides and a dark diagonal stripe below the eye, and with brown to orange fins (Morgan *et al.* 1998; Allen *et al.* 2002). Juveniles have a dark bar on their sides which fragments with age (McAleer 2005).

1.3 Distribution

Historically, the Western Trout Minnow has been recorded from the King, Kalgan and Goodga Rivers near Albany in south-western Western Australia (Morgan *et al.* 1998). Currently populations are known from three locations: the Goodga River extending into Moates Lake (Goodga suite), the Angove River extending into Angove Lake (Angove suite), and the upper Kent River (Figure 1, Table 1).

Table 1: The three locations from which Western Trout Minnow (*Galaxiella truttaceus hesperius*) are currently known, an approximate area of available habitat and the last year the population was surveyed.

Population	Land Status	Area km²	Year last surveyed
Goodga suite	Water Catchment Reserve, Nature Reserve 'Natural Environment', and private property	0.008	2007
Angove suite	Water Catchment Reserve, Nature Reserve 'Special Conservation', and private property	0.004	2007
Kent River	Private property	0.001	2005

Figure 1: The locations of the three current populations of Western Trout Minnow (*Galaxiella truttaceus hesperius*) (shown in red) in south-western Western Australia. Historically, the Western Trout Minnow has also been recorded from the King and Kalgan Rivers to the northeast of Albany. (Map prepared by Amy Mutton)

The Goodga suite population is restricted to a 4-kilometre stretch of the Goodga River upstream of Moates Lake, Black Cat Creek and Moates Lake, an area of approximately 0.008 km^2 habitat (TSSC 2008) (Figure 2, Table 1). Prior to the construction of the Goodga fishway in 2003 the fish were limited by a weir to only 2 km of the river habitat (see Section 4.1.1). The upper reaches of the Goodga River lie within a Water Catchment Reserve managed by the Water Corporation (Figure 3). The main channel of the Goodga River then

runs through 10 km of partially cleared farmland, timbered and with some remnant riparian vegetation, before entering the Goodga River Reserve, a 300-hectare 'A' class reserve. The Goodga River ends in Moates Lake in the adjacent Two Peoples Bay Nature Reserve. This area of the nature reserve is zoned as 'Natural Environment', restricting public access to by foot only (CALM 1995). Moates Lake then flows via wetlands into Gardener Lake, which is seasonally opened to Two Peoples Bay. This population of Western Trout Minnow is thought to be landlocked and appears not go beyond Moates Lake into Gardener Lake.

The Angove suite population is found along a 2-kilometre stretch of Angove River downstream of a gauging station (weir), and in Angove Lake, an area of approximately 0.004 km^2 habitat (TSSC 2008) (Figure 2, Table 1). The upper reaches of the Angove River lie within the same Water Catchment Reserve as the Goodga River (Figure 3). The reserve protects the drinking water source which is extracted from a pipehead dam on the Angove River above the gauging weir. The Angove River then drains into Angove Lake which is part of Two Peoples Bay Nature Reserve. A small section of Angove River and Angove Lake are separated from the rest of Two Peoples Nature Reserve by a 3-kilometre stretch of private property. This section of the nature reserve is zoned 'Special Conservation', only allowing public access for appropriate purposes on a permit basis (CALM 1995). This population of Western Trout Minnow is landlocked and completely separated from the Goodga suite population.

In 2005 specimens from a private property off the upper Kent River were identified as Western Trout Minnow (D. Morgan pers. comm. 2007). The available habitat for this Kent River population has been estimated to be 0.001 km^2 (1-kilometre stretch approximately 1 m in width), though surveys are needed to determine the actual extent of this population.

In 2004 twenty-five individuals each of Western Trout Minnow and the Spotted Minnow (*Galaxias maculatus*) were collected from the Goodga River and translocated into a wetland on private property in the upper Goodga catchment. Prior to the translocation, a survey of the wetland was conducted to ensure no additional fish species were within the wetland. This translocation is thought to have been unsuccessful, as no Western Trout or Spotted Minnows were observed during a survey of the wetlands in April 2008 by Murdoch University (MdU) and the DoF, at which time the wetlands had reduced substantially in size (D. Morgan pers. comm. 2008).

Figure 2: The distribution of the Goodga and Angove suite populations of the Western Trout Minnow (*Galaxiella truttaceus hesperius*) to the east of Albany in south-western Western Australia. (Map prepared by Amy Mutton)

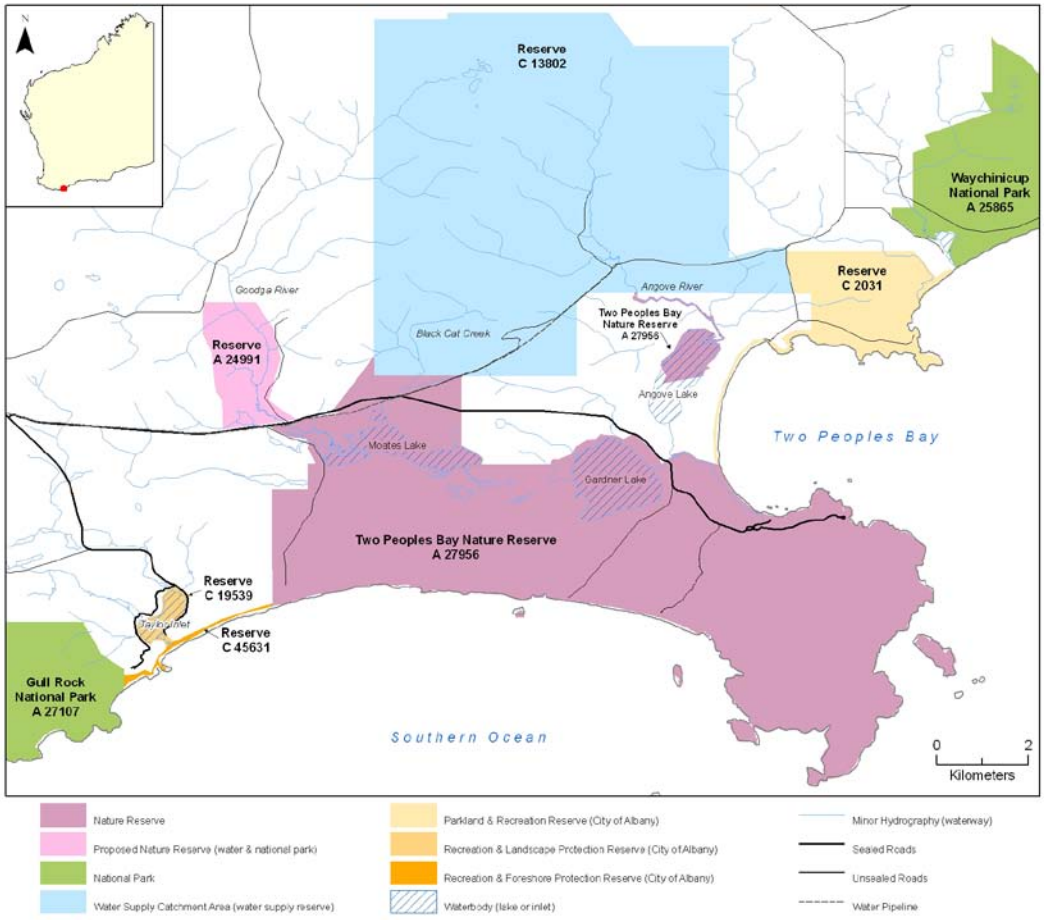

Figure 3: The land tenure of the area around the Goodga and Angove suite populations of the Western Trout Minnow (*Galaxiella truttaceus hesperius*) to the east of Albany in south-western Western Australia. (Map prepared by Amy Mutton)

1.4 Habitat requirements

The Trout Minnow (*Galaxias truttaceus*) is confined to the cooler climatic regions of southern Australia and has negligible growth during the warmer months, so it is thought that this species is a coldwater fish that is sensitive to higher water temperatures (Morgan 2003). Furthermore, Morgan (2003) observed that fish held in an aquarium suffered massive mortalities when water temperatures exceeded 30 ºC.

Little is known about the habitat requirements of the Western Trout Minnow. The juveniles and adults of the Goodga suite population occur in the narrow riverine environments of the Goodga River and Black Cat Creek, while the larval fish use Moates Lake as a nursery (Morgan 2003) (see Section 1.5). In the eastern states Trout Minnow is usually found in and around plants, rocks and logs on the shore margins of still or flowing rivers, streams and lakes (Morgan *et al.* 1998; Morgan 2003; McAleer 2005).

1.5 Biology and ecology

Research into the biology and ecology of the Western Trout Minnow has predominately focused on the Goodga River population (e.g. Morgan 2003; McAleer 2005), although there have also been comparative demographic surveys between Goodga and Angove Rivers (e.g. Morgan & Beatty 2005). These found distinct differences in the population demographics between the two populations during the same period, suggesting either growth is faster in the Angove River or that the spawning period is earlier. Hence, these populations are treated as genetically distinct units in this Recovery Plan. There is currently no information known on the characteristics of the Kent River population.

In south-eastern Australia there are both diadromous (i.e. migrates downstream to estuaries to spawn with larvae spending some time in the ocean) and landlocked populations of Trout Minnow (Humphries 1989). The Goodga and Angove populations of Western Trout Minnow are landlocked, although these fish still undergo an environmental/habitat transition during their development. In the Goodga River the adults migrate upstream prior to spawning which peaks during April and May (Morgan 2003). The increase in discharge and decrease in water temperature in autumn has been suggested to be the spawning cue. The larval fish are then transported downstream to Moates Lake, where they remain until spring. The juveniles (~40 mm total length) then migrate back into the Goodga River (Morgan 2003; Morgan & Beatty 2005). This upstream migration coincides with a change in the fish's colouration (McAleer 2005).

The larval fish in Moates Lake feed almost exclusively on dipteran larvae (McAleer 2005) and copepods (Morgan 2003). Juvenile and adult fish feed predominately on terrestrial fauna such as coleopterans and hymenopterans (Morgan 2003; McAleer 2005). Larger adults (>60 mm total length) were found to also consume decapods, teleost eggs and gastropods, demonstrating that although Western Trout Minnow are predominately surface feeders they also forage from the benthos (McAleer 2005).

The majority of the Western Trout Minnow in the Goodga River reach maturity at age two (>73 mm total length for females, >60 mm for males) (Morgan 2003). The population is dominated by fish under three years of age, with the older age classes (4 to 7 years of age) contributing less than 4% of the entire population.

2 HABITAT CRITICAL TO SURVIVAL

Habitat critical to survival for the Western Trout Minnow comprises:

- the area of occupancy of the known populations and similar habitat within 200 m of the known populations (i.e. the Goodga suite (Goodga River, Black Cat Creek and Moates Lake), the Angove suite (Angove River and Angove Lake), and the upper Kent River); and
- additional occurrences of similar habitat that do not currently contain the species but may have done so in the past and may be suitable for translocations (i.e. King and Kalgan Rivers).

As an aquatic species, the critical habitat for the Western Trout Minnow is potentially influenced by all the land uses which are within the catchments of the habitats critical.

Given that the Western Trout Minnow is listed as Endangered and Critically Endangered, all wild and translocated populations are considered important populations. All extant populations will be treated as genetically distinct units due to their physical isolation from each other, and the differences found between the demographics of the Goodga and Angove River populations (Morgan & Beatty 2006).

3 GUIDE FOR DECISION MAKERS

This document provides details of critical habitat, and current and possible future threats for the Western Trout Minnow. Land use planning and development within the defined critical

habitat or in the catchments of the water courses must take into account any potential impacts on Western Trout Minnow. No land use or development should be approved unless the proponents can demonstrate that they will not have a detrimental impact on the species, its habitat or potential habitat.

4 THREATS

The threatening processes for Western Trout Minnow are habitat reduction and obstructions to migration, introduced parasites, fish, aquatic weeds, destruction of riparian habitat, altered hydrology, salinity and fire. Climate change is an additional threat through its potential to change water flows and temperatures.

4.1 Habitat reduction and migration obstructions

River fragmentations, artificial instream structures, water withdrawal, reduction in water quality and loss of instream habitat all have considerable impacts on the distribution of aquatic biota. The current approximate extent of the Western Trout Minnow is 0.013 km², making this the most restricted freshwater fish in Western Australia (Morgan *et al.* 1998; Morgan 2003; Morgan & Beatty 2004; TSSC 2008).

The upper reaches of both the Goodga and Angove Rivers are in a Water Catchment Reserve and are regulated by weirs. Prior to the construction of a fishway in 2003, the Goodga River population of Western Trout Minnow was restricted to a 2-kilometre stretch of stream below a small gauging station (weir). The fishway increased the available habitat from 2 km to 4 km of river. The population in the Angove River is also restricted to approximately 2 km of river below three weirs and a number of natural cascades, a scenario similar to that in the Goodga River prior to the construction of a fishway (Morgan & Beatty 2006). The Water Corporation extracts water from the Angove River for domestic and industrial supply to the town of Albany.

4.1.1 Goodga Fishway

It was recognised by Morgan (2003) that the impassable gauging weir in the Goodga River was a significant threat to the sustainability of the population. The weir reduced the available habitat to the fish, prevented migration further upstream for spawning and increased the risk of predation by birds due to the congregation of the school downstream of the weir. As a result, a fishway was constructed in April 2003 to allow for the vertical movement of fish into

the section of river above the weir. The fishway was developed jointly by the DoF and MdU and funded by National Heritage Trust. The Department of Water (DoW) also aided in the construction.

An assessment of the effectiveness of the Goodga fishway has concluded it successful in increasing available habitat, and allowing spawning and recruitment of juveniles (Morgan & Beatty 2005). Prior to the fishway construction no Western Trout Minnow were captured above the weir, yet just 3 months after its construction 63 individuals were caught upstream of the weir. However, regular monitoring of the fishway has highlighted a couple of problems associated with the fishway (Morgan & Beatty 2005; Morgan & Beatty 2006):

- During monitoring large numbers of fish were found to fall over the weir wall, a substantial proportion of which died. It is unclear whether the fish died in the sampling equipment or after landing on the concrete footing at the base of the weir. Further research is needed into the cause of the deaths and the likelihood of success at reducing these mortalities with the introduction of a 'fish-slide' for the water flow over the weir (D. Morgan and S. Beatty pers. comm. 2007).
- The entrance to, and exit from, the fishway has been found at times to be blocked by aquatic plants, turtles and debris, requiring that the fishway is regularly checked and cleaned. The introduction of a 'trash' rack could also potentially aid in the prevention of debris entering and blocking the fishway.
- Although abundant in the downstream section of the Goodga River, including Moates Lake, the Swan River Goby (*Pseudogobius olorum*) was not captured on or above the fishway. This is possibly a result of the species being benthic and that the fishway entrance is elevated above the substrate. Modification of the fishway entrance could allow the upstream migration of the Swan River Goby as well.

4.2 Introduced Species

4.2.1 Cestodes

Both the Goodga (Morgan 2003) and Angove suite populations (D. Morgan and S. Beatty pers. comm. 2007) of Western Trout Minnow have been found to be infected with the parasite *Ligula intestinalis*, a Northern Hemisphere species of cestode. It is unknown whether the Kent River population is also infested. This cestode is known to infect numerous freshwater

fish species in the Northern Hemisphere but has only been relatively recently recorded in Australia (Morgan 2003).

Ligula intestinalis causes gonadal retardation and morphological deformation, severely affecting an individual's mobility (Owen & Arme 1965; Pollard 1974; Morgan 2003). Morgan (2003) found that 7% of juvenile Western Trout Minnow in the Goodga River population were infested with the parasite. No individuals over 80 mm total length were found to contain the parasite, suggesting that the impact of the cestode on the fish led to increased predation by birds (Morgan 2003).

The life cycle of *L. intestinalis* involves birds as the primary host. The parasite is then transferred into an aquatic system through avian faeces where it infects copepods, the primary food source for juvenile Western Trout Minnow in the lake systems. Currently there are no known control or eradication methods for *L. intestinalis*.

4.2.2 Introduced fish

The Goodga and Angove river systems are currently free from introduced fish (see Morgan *et al.* 2004). However, the Goodga Catchment is known to contain introduced fish such as the Mosquitofish (*Gambusia holbrooki*) in private property dams (Morgan *et al.* 1998). Mosquitofish is a known aggressor towards native fish in south-western Western Australia (Gill *et al.* 1999). There is a potential threat that this fish along with other species such as Rainbow Trout (*Oncoryhychus mykiss*), Brown Trout (*Salmo trutta*) and European/Redfin Perch (*Perca fluviatilis*) could be introduced, by human activity or flooding from an artificial structure, into the Goodga and Angove river systems with considerable impact on Western Trout Minnow. Dams within the catchment containing introduced fish should be located and those species eradicated and, where appropriate, replaced with native alternatives.

Recreational fishing poses a significant threat to the Western Trout Minnow as fishing activities greatly increase the risk of non-native fish being introduced into the waterways via marron traps, live bait and other fishing equipment. Fishing is allowed in Moates Lake although access is limited, but public access without a permit is not allowed to the lower Angove River and Angove Lake due to zoning as 'Special Conservation' within the Two Peoples Nature Reserve (CALM 1995).

The prevention of any invasive fish species from being introduced into the waterways currently containing extant populations of Western Trout Minnow is fundamental to the continued survival of the subspecies.

4.2.3 Introduced aquatic plants

The introduced aquatic plant *Typha orientalis* is present in the Goodga River. Observations have shown that this plant species is highly concentrated in areas below the Goodga weir, though no quantitative studies have been conducted on the impacts of the species. It is suspected, however, that water levels, food availability and the movement of the Western Trout Minnow would be greatly altered by this habitat alteration through the *Typha orientalis* blocking flows.

4.3 Livestock access to riparian habitat

Livestock can cause considerable damage to riparian habitat and increase erosion of banks. Currently much of the Two Peoples Bay Reserve is protected from cattle access, yet private property still allows stock access. Riparian habitat plays a key role in providing refuge and food resources for instream biota, including fish. Control of stock access to these areas is vital for the maintenance and protection of habitat critical for the Western Trout Minnow.

4.4 Altered hydrology and salinity

It is currently unknown whether, or to what extent, water extraction, flow alteration and increased salinity are impacting the Western Trout Minnow. In 2001 the extraction volume from the Angove River was increased from 1,800 ML/annum to 2,200 ML/annum in wet years[1], removing 67-82% of mean annual flow. Preliminary monitoring for environmental water requirements of the systems suggested no impacts from the water extraction, though further post-extraction monitoring is being conducted (Davies *et al.* 2001). The Kent River catchment has been recognised as a potential potable water supply for future development in Western Australia (NDSP 2007). If there are plans to extract water from this catchment in the future, research into the distribution and environmental requirements of the Western Trout Minnow and potential impacts on this species will need to be conducted beforehand.

There are blue gum plantations in the upper reaches of the Goodga catchment which are possibly altering the amount of groundwater recharge into the aquatic systems. Groundwater-

fed rivers such as the Goodga and Angove are cooler and, therefore, a change in the influx of that water source would impact the water temperature of the river. This is potentially a considerable issue for Western Trout Minnow which would be sensitive to increased temperature (Morgan 2003). Blue gum plantations may also be causing an increase in soil runoff and deposition as it has been noticed that there is an increase in 'sand plugs' in the Goodga River, which could be further habitat obstacles for instream biota (S. Comer pers. comm. 2008).

It is thought that salinity would be unlikely to be having a considerable impact on the Western Trout Minnow in the Goodga and Angove Rivers as the populations are land locked aquatic systems which naturally experience seasonal desiccation and higher salinity levels. However, the Kent River catchment is experiencing significant salinity issues, although the impact of this on the Western Trout Minnow is unknown.

4.5 Impacts of fires

Fires can have significant impacts on aquatic biota through a number of mechanisms, including increases in runoff and erosion of stream banks, greater suspended sediment and turbidity levels, rises in stream temperatures, and changes to water chemistry (Chessman 1986; Neary *et al.* 2008). The magnitude of these effects is largely dependent on the size, intensity and severity of the fire, the condition of the catchment at the time of the fire, and the rainfall events soon after the fire.

The impact of fire on the Western Trout Minnow is unknown but could potentially be significant due the isolation and relatively small distribution area of this subspecies and the narrowest of the rivers it currently occurs in. If a fire does occur in the habitat critical for Western Trout Minnow, the opportunity should be taken to monitor the impacts of fire on this subspecies.

5 AREAS AND POPULATIONS UNDER THREAT

The current and potential threatening processes which are affecting each of the known populations of Western Trout Minnow are listed in Table 2. The threatening processes for the Kent River population are unknown.

[1] This is the maximum extraction rate and actual extraction rates may not be the full volume.

Table 2: The current and potential threatening processes for each of the known populations of Western Trout Minnow (*Galaxiella truttaceus hesperius*).

Population	Current Threats	Potential Threats
Goodga suite	*Ligula intestinalis* *Typha orientalis*	Introduced fish Impacts of fire Climate change
Angove suite	Habitat restricted by weirs *Ligula intestinalis* Water extraction	Introduced fish Impacts of fire Climate change
Kent River	Unknown	Unknown

6 INTERNATIONAL OBLIGATIONS

This plan is fully consistent with the aims and recommendations of the Convention on Biological Diversity, ratified by Australia in 1993, and will assist in implementing Australia's responsibilities under that convention. This species is not specifically listed under any international treaty and, therefore, does not affect Australia's obligations under any of these treaties.

7 AFFECTED PARTIES

The main parties that are likely to be affected by this Recovery Plan are: Department of Fisheries Western Australia (DoF), Western Australian Department of Environment and Conservation (DEC), Department of Water Western Australia (DoW), Water Corporation, Murdoch University (MdU) and other universities, Local Government Authorities, and private landholders in the catchments of critical habitat.

The current distribution of Western Trout Minnow includes a number of land tenures, including Two Peoples Bay Nature Reserve (managed by DEC), a Water Catchment Reserve (managed by the Water Corporation) and private property. As an aquatic species, the habitat critical to this fish is also potentially affected by land uses which are not adjacent to the habitat but are within the catchments, which includes blue gum plantations.

In Western Australia the conservation of fish is the legislative responsibility of the DoF. The listing of the Western Trout Minnow as a threatened species also gives this fish species additional protection by DEC and DEWHA.

8 INDIGENOUS PEOPLE

The Two Peoples Bay area is known to contain many significant Indigenous cultural heritage sites of the Mineng people who occupied the area. Involvement and input in the implementation of the actions in this Recovery Plan will be sought from the indigenous

groups that have an active interest in the areas that include habitat for the Western Trout Minnow.

9 BENEFITS TO OTHER SPECIES

The implementation of the recovery actions in this Recovery Plan will benefit the fish and other aquatic fauna which occur in the same waterways as the Western Trout Minnow through habitat protection, prevention of the introduction of invasive fish and the maintenance of the hydrology of the river systems. The Goodga and Angove river systems both contain several other fish species, including the Vulnerable Balston's Pygmy Perch (*Nannatherina balstoni*) and Western Mud Minnow (*Galaxiella munda*) (Morgan *et al.* 1998; Morgan & Beatty 2005) (Table 3).

Table 3: The fish species known to occur in the Goodga and/or Angove River systems along with the Western Trout Minnow (*Galaxiella truttaceus hesperius*), their conservation status under State and Commonwealth (EPBC Act) legislation, and their distributions (Morgan *et al.* 1998).

Species	Status		Distribution
	WA	EPBC	
Western Pygmy Perch (*Edelia vittata*)	-	-	Endemic, though widespread throughout south-western Australia
Western Minnow (*Galaxiella occidentalis*)	-	-	Endemic, though widespread throughout south-western Australia
Spotted Minnow (*Galaxiella maculatus*)	-	-	Widely distributed throughout Southern Hemisphere
Western Mud Minnow (*Galaxiella munda*)	VU	-	From Margaret River in the west to Albany in the east and a pop. at Gingin, 100 km north of Perth
Swan River Hardyhead (*Leptatherina wallacei*)	-	-	From Moore River (Gingin) in the north to the Pallinup River (east of Albany)
Balston's Pygmy Perch (*Nannatherina balstoni*)	VU	VU	Coastal peat flats from Margaret River in the west to Albany in the east and a north pop. at Gingin
Swan River Goby (*Pseudogobius olorum*)	-	-	Coastal water bodies in south-western Australia, western Victoria and South Australia

The Two Peoples Bay area also contains several terrestrial endangered fauna and flora, including the Gilbert's Potoroo (*Potorous gilberti*), Noisy Scrub-bird (*Atrichornis clamosus*), Western Bristlebird (*Dasyornis longirostris*) and Western Ringtail Possum (*Pseudochierus occidentalis*). Actions for the recovery of the Western Trout Minnow will not contradict or negatively impact the recovery of any of the other threatened fauna or flora in the region.

10 SOCIAL AND ECONOMIC IMPACTS

The implementation of this Recovery Plan has the potential to have both economic and social impacts. Water is extracted from the Angove River to supply the town of Albany. There is the potential that the environmental flow requirements of the river for the sustainability of the instream biota could conflict with the current or proposed water extraction rates for the City

of Albany. In response to a request by the Water Corporation to be able to increase water extraction from the river, Davies *et al.* (2001) made an assessment of the environmental flow requirements of the river, and Close *et al.* (2004) developed a monitoring program to assess the impacts of increased water abstraction. It is important that this monitoring program is ongoing and that water extraction is altered if any adverse impacts are detected.

11 RECOVERY OBJECTIVE AND CRITERIA

11.1 Recovery objective

The objectives of this Recovery Plan are to abate the identified threats to the Western Trout Minnow, and maintain or enhance *in situ* populations and distribution to ensure the long-term preservation of the subspecies in the wild.

11.2 Criteria for success

This Recovery Plan will be deemed successful if known populations of Western Trout Minnow are maintained and the distribution of the populations is not reduced.

11.3 Criteria for failure

This Recovery Plan will be deemed unsuccessful if the known populations of Western Trout Minnow have declined or the distribution of the populations is reduced.

11.4 Evaluation

The Southern Freshwater Fauna Recovery Team, in consultation with DEC and DoF, will annually evaluate the performance of this Recovery Plan. The recovery actions carried out and any changes to management and recovery actions will be documented accordingly.

In accordance with the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), this adopted Recovery Plan will remain in force until revoked. The Recovery Plan must be reviewed at intervals of not longer than five years.

11.5 Existing conservation measures

In response to a request by the Water Corporation to be able to increase water extraction from the Angove River, the environmental flow requirements of the river was assessed (Davies *et al.* 2001) and a monitoring program developed to assess the impacts of increased water abstraction (Close *et al.* 2004).

A fishway was constructed on the weir on the Goodga River to allow the Western Trout Minnow to move above the weir, doubling the available river habitat for the population (Morgan & Beatty 2006). The fishway was developed jointly by DoF and MdU and funded by National Heritage Trust. The DoW also aided in the construction. This Goodga fishway is currently regularly monitored and cleaned by MdU.

The Two Peoples Bay Nature Reserve Management Plan (CALM 1995) zones the lower Angove River and Angove Lake as 'Special Conservation', restricting public access to the area. Access is only allowed for appropriate purposes on a permit basis. Moates Lake is zoned as 'Natural Environment' which restricts public access to by foot only.

12 ACTIONS

The following recovery actions are presented in order of descending priority but this should not prevent the implementation of 'lower' priority actions where opportunities arise and funding is available.

1. Define and map critical habitat and survey for additional populations.

A survey of current Western Trout Minnow habitat will be conducted to define and map critical habitat, identify areas that are being impacted by threats such as livestock access, and identify other nearby water bodies that contain exotic fish. This survey will also be extended to areas of potential Western Trout Minnow habitat in search for additional populations.

Responsibility: DoF, MdU, DEC
Completion date: Year 1
Cost: $40,000 in the first year.

2. Implement a monitoring program for the known populations.

Following from Action 1, an annual monitoring program will be implemented for the known populations of Western Trout Minnow (i.e. Goodga and Angove suites and upper Kent River).

Using non-destructive methods, data will be collected on the population's distribution and demographic variables such as age, recruitment and reproductive processes. Part of this program will also involve monitoring the status of the major threatening processes, with particular attention to the presence of invasive fish species.

Responsibility: DoF, Water Corporation
Completion date: Ongoing
Cost: $3,000 p.a. following the completion of Action 1

3. Develop and implement strategies to prevent the introduction of invasive fish species.

The prevention of invasive fish species establishing in the Angove or Goodga River systems must be a priority as this would potentially devastate the current populations of Western Trout Minnow. Therefore, DoF and the Recovery Team will develop and implement appropriate procedures to reduce the potential for invasive species entering these river systems. This will require significant stakeholder involvement and consultation including private landholders, scientists, DEC, DoW, Water Corporation, Local Government Authorities, the indigenous community and recreational users of the area. Potential strategies could include the removal of invasive fish species from nearby water bodies, ceasing recreational fishing in the river systems, and a public awareness campaign.

Responsibility: DoF
Completion date: Year 5
Cost: To be determined

4. Research the cause of the deaths of the fish from the drop-off of the Goodga River Gauging Station.

During Morgan and Beatty's (2005; 2006) monitoring of fish numbers using the Goodga fishway, large numbers of fish were found to have fallen over the gauging station (weir) wall, a substantial proportion of which had died. It was unclear whether the fish died in the sampling equipment or from landing on the concrete footing at the base of the weir. Therefore, further research will be conducted into the cause of the deaths, and the likelihood of success at reducing these mortalities, with the introduction of a 'fish-slide' for the water flow over the weir.

Responsibility: MdU, DoF, DoW
Completion date: Year 1
Cost: $6,000

5. Maintain and improve the Goodga fishway.

The Goodga fishway has been found to regularly become blocked by debris and, therefore, maintenance of the fishway is vital to allow the fish to utilise the structure. A general maintenance and monitoring strategy will be developed and implemented by the DoF, DoW, MdU, DEC and Water Corporation. This will need to include ensuring the entry, holding cells and exits of the fish ladder are clear of debris, ensuring the water level reaches above the entry and exit points, and general maintenance of the fishway.

Responsibility: DoF, DoW, MdU, DEC, Water Corporation
Completion date: Ongoing
Cost: $1,000 p.a.

6. Investigate and implement measures to facilitate upstream movement of the Angove suite population.

The Angove suite population of Western Trout Minnow is restricted to approximately 2 km of the Angove River below the first (i.e. the Angove River Gauging Station) of three dams across the river and Angove Lake, a scenario similar to that in the Goodga River prior to the construction of the Goodga fishway. Measures will be investigated (e.g. fishways or translocations), and if possible implemented, to facilitate the movement of Western Trout Minnow upstream from the gauging station to increase their available habitat.

Responsibility: DoF, DoW, Water Corporation
Completion date: Year 5
Cost: To be determined

7. Investigate and implement strategies to cease recreational fishing in the Angove and Goodga catchments.

Recreational fishing in the Angove and Goodga catchments currently poses a significant threat to the Western Trout Minnow through greatly increasing the risk of invasive fish species being introduced into the waterways. Therefore, strategies will be investigated and, if possible, implemented to cease recreational fishing in these catchments. Possible strategies include DoF establishing a Fish Habitat Protection Area and/or DEC zoning further areas of the Two Peoples Bay Nature Reserve as 'Special Conservation'. These strategies will require consultation with appropriate stakeholders (i.e. private landholders, DoW, Local Government Authorities, the indigenous community and recreational users of the area) and a public awareness campaign to promote the importance of preventing the introduction of invasive fish.

Responsibility: DoF, DEC
Completion date: Year 2
Cost: $10,000 ($5,000 p.a. for 2 years)

8. Obtain biological and ecological information for the separate populations.

Research into the biology and ecology of the Western Trout Minnow has predominately focused on the Goodga suite population (e.g. Morgan 2003; McAleer 2005), although there have also been comparative demographic surveys between Goodga and Angove Rivers (e.g. Morgan & Beatty 2005). Further research into the biological and ecological characteristics of each of the known populations will be conducted, which is particularly important where there is evidence for potentially genetically distinctive populations, and the threats from management decisions such as water extraction could impact the current populations. This research will focus on morphological and genetic differentiation, migration patterns, population demographics, habitat usage, environmental flow requirements and sympatric fish species.

Responsibility: Universities, DoF
Completion date: Year 3
Cost: $90,000 ($30,000 p.a. for 3 years)

9. Investigate the potential for *ex situ* populations.

The isolation and relatively small population sizes of the remaining populations of the Western Trout Minnow mean this fish is particularly vulnerable to local extinctions through stochastic events. Therefore, establishing an *ex situ* breeding population could be important in ensuring the continuation of this subspecies were there to be significant declines of the currently known extant *in situ* populations. As well, an *ex situ* population could be bred without the presence of *Ligula intestinalis* and be used for research into biological responses without significantly impacting the *in situ* populations. There are currently no *ex situ* populations of Western Trout Minnow. Therefore, research will be conducted into the potential of Western Trout Minnow being bred or reared in captivity.

Responsibility: DoF
Completion date: Year 2
Cost: $40,000

10. Investigate the tolerances of the Western Trout Minnow to factors such as water temperature, salinity, turbidity and nutrients.

The degree to which changes in water temperature, salinity, turbidity and nutrient levels could affect the current populations of Western Trout Minnow is unknown as the tolerance of these fish to these physiochemical factors is unknown. Therefore, tolerance trials to these physiochemical factors will be conducted for the Western Trout Minnow. These trials would be best conducted using fish from a breeding program to avoid reducing the wild stock (see Action 9).

Responsibility: Universities, DoF
Completion date: Year 5
Cost: $35,000 following the completion of Action 9

11. Fence off access of livestock to riparian habitat and revegetate where necessary.

As livestock can cause considerable damage to river banks and riparian vegetation, livestock access needs to be controlled for areas of critical habitat for the Western Trout Minnow. Areas of critical habitat that are currently being damaged by livestock identified under Action 1 will be fenced off. This will require consultation with the appropriate stakeholders (e.g. private landholders, DoW).

Responsibility: DEC, NRM groups, private landholders
Completion date: Year 5
Cost: To be determined

12. Promote awareness of threatened aquatic species.

Most of the general community and visitors to the Two Peoples Bay area are unaware of the Western Trout Minnow and other threatened fish species in the area. Community awareness and support for the conservation of the Western Trout Minnow will be developed through actions such as an information display at Two Peoples Bay, educational materials and activities. Community awareness is very important for the conservation of the threatened fish species as the introduction of invasive fish species is often deliberate without having a clear understanding of the consequences of such introductions.

Responsibility: DEC, DoF, DoW
Completion date: Ongoing
Cost: $1,000 p.a.

13 SUMMARY OF RECOVERY ACTIONS

These costings of the recovery actions are based on 2008 costs and will be reviewed as part of the evaluation of the Recovery Plan within 5 years of its implementation.

Action	**Responsibility**	**Year/Cost ($)**										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
1. Define and map critical habitat and survey for additional populations.	DoF, MdU, DEC	$40,000										$40,000
2. Implement a monitoring program for the known populations.	Dof, Water Corporation	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$30,000
3. Develop and implement strategies to prevent the introduction of invasive fish species.	DoF											To be determined
4. Research the cause of the deaths of the fish from the drop-off of the Goodga River Gauging Station.	MdU, DoF, DoW	$6,000										$6,000
5. Maintain and improve the Goodga fishway.	DoF, DoW, MdU, DEC, Water Corporation	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$10,000
6. Investigate and implement measures to facilitate upstream movement of the Angove suite population.	DoF, DoW, Water Corporation											To be determined
7. Investigate and implement strategies to cease recreational fishing in the Angove and Goodga catchments.	DoF, DEC	$5,000	$5,000									$10,000
8. Obtain biological and ecological information for the separate populations.	Universities, DoF	$30,000	$30,000	$30,000								$90,000
9. Investigate the potential for *ex situ* populations.	DoF		$40,000									$40,000
10. Investigate the tolerances of the Western Trout Minnow to factors such as water temperature, salinity, turbidity and nutrients.	Universities, DoF				$35,000							$35,000
11. Fence off access of livestock to riparian habitat and revegetate where necessary.	DEC, NRM groups, private landholders											To be determined
12. Promote awareness of threatened aquatic species.	DEC, DoF, DoW	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$10,000
Annual Cost		$86,000	$80,000	$35,000	$40,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$271,000+

Note: DEC = Department of Environment and Conservation Western Australia, DoF = Department of Fisheries Western Australia, DoW = Department of Water Western Australia, MdU = Murdoch University.

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