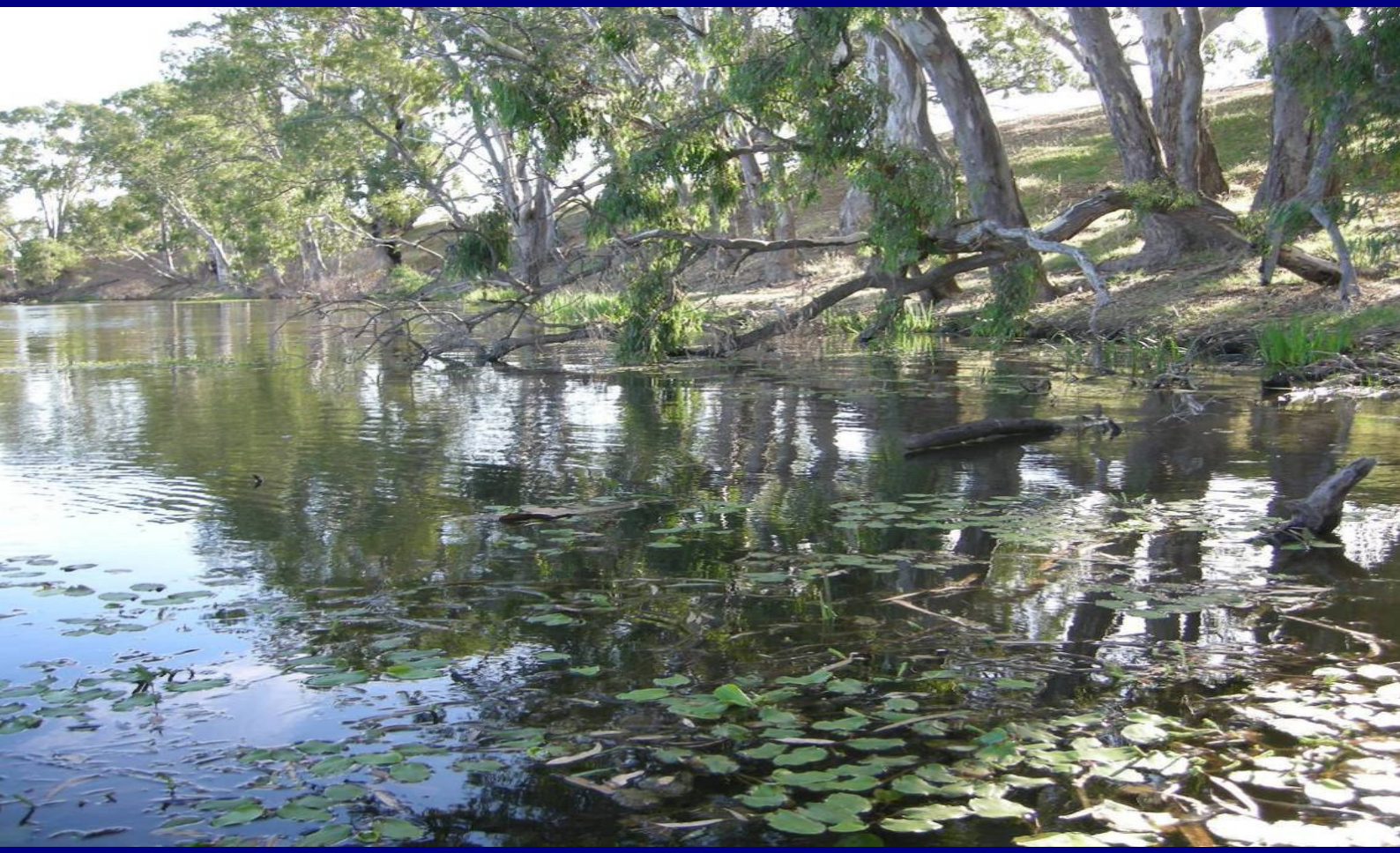
Department of Sustainability and Environment

PART A – Freshwater catfish survey of Tahbilk Lagoon, including management recommendations

Pam Clunie, Fern Hames, John McKenzie and Graeme Hackett, ARI

2008



Arthur Rylah Institute for Environmental Research

Report for the Goulburn Broken Catchment Management Authority

Victoria The Place To Be

Arthur Rylah Institute for Environmental Research Technical Series

PART A – Freshwater catfish survey of Tahbilk Lagoon, including management recommendations

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Front cover photo: Tahbilk Lagoon (Fern Hames).

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Contents

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Summary

Tahbilk Lagoon is a significant site, with a suite of recognised values, in particular the presence of the threatened Freshwater catfish *Tandanus tandanus*, the Watershield *Brasenia schreberi*, threatened Ecological Vegetation Classes (EVCs) and wetlands. The Goulburn-Broken Catchment Management Authority (GBCMA) provided funding in February 2008 for Freshwater Ecology, Arthur Rylah Institute for Environmental Research, to conduct fish surveys primarily designed to assess the status of a known population of Freshwater catfish. The GBCMA also sought guidance regarding appropriate management recommendations for the fish community as a whole, including in relation to management of existing barriers to fish movement. The Murray-Darling Basin Commission has funded the development of a Carp Management Plan for the lagoon; management recommendations and options are currently being identified and these surveys will effectively inform that process.

A range of habitat rehabilitation activities are already occurring at Tahbilk Lagoon and its surrounds, including revegetation and management of pest plant species. In addition, a broad suite of management issues relevant to the lagoon are currently being addressed by a range of stakeholders and managers, including management of flow regimes and water quality, alien fish species, aquatic weed control and facilitation of fish passage between the lagoon and the Goulburn River. Recommendations within this report consider options to manage existing and potential threats to native fish, and to protect and enhance existing values.

A total of six native and four introduced fish species were recorded in the February 2008 survey including two threatened species; Freshwater catfish and Murray-Darling rainbowfish *Melanotaenia fluviatilis*. High numbers of the threatened Murray Short-necked turtle *Emydura macquarii,* were also recorded. The suite of species is generally consistent with previous surveys and many of the species are typically found in such slow flow habitat where aquatic vegetation and woody structure are present. A relatively abundant population of Freshwater catfish still occurs within the lagoon, with a range of size classes recorded indicating successful recruitment. Tahbilk Lagoon represents the most southerly remnant population of Freshwater catfish in Victoria.

There are key characteristics of the Tahbilk Lagoon which have enabled the Freshwater catfish population to thrive. These include the lentic conditions, warmer water temperatures compared to the associated water temperatures within the Goulburn weir pools, and the presence of diverse habitats including shallow margins for breeding, abundant native aquatic vegetation and woody structure. Such characteristics should be maintained. Many of these characteristics are likely to have also enabled the threatened Watershield to thrive.

The absence of large-bodied native species (other than catfish) is most likely related to the presence of barriers and the lack of flow. Facilitation of fish passage is recommended through the removal or replacement of three existing crossings with full stream-width open bottom multi-box culverts (Part B of this report). The establishment of culverts would also provide opportunities to collect Carp *Cyprinus carpio*, PIT tag native fish to monitor fish movements, and produce educational signs for the public.

Fewer numbers of Carp were recorded during surveys than may have been expected (n=54), since large numbers of Carp have been sighted within the Lagoon in the past. It is likely the site represents a refuge and suitable spawning habitat for the species, with a

range of size classes recorded. High numbers of Redfin *Perca fluviatilis* were recorded during the surveys, in a range of size classes.

Water quality monitoring during the surveys indicates that dissolved oxygen levels at some sites are of concern, being <3.0mg/L. The limited flow exchange from the adjacent Goulburn River, and large infestations of the introduced Yellow Water Lily are likely to be contributing to poor water quality. Options to enable occasional small volumes of water from the Goulburn River through the Lagoon should be investigated with G-MW. Active control of infestations of both the Yellow Water Lily and Willows should be undertaken, using techniques and timing to minimise potential impacts to native species.

In addition to active rehabilitation actions within Tahbilk Lagoon, a range of educational opportunities are suggested to increase awareness of Freshwater catfish and other threatened species, control of Carp and facilitation of fish passage.

Introduction

1.1 Background

The Goulburn-Broken Catchment Management Authority (GBCMA) provided funding in 2008 for Freshwater Ecology, Arthur Rylah Institute for Environmental Research, to conduct fish surveys of the Tahbilk Lagoon. These surveys were primarily designed to assess the status of a known population of the threatened Freshwater catfish *Tandanus tandanus*. The GBCMA also sought guidance regarding appropriate management recommendations for the fish community as a whole, including management of existing barriers to fish movement. This project effectively supports management recommendations and options being identified during the current development of an Murray-Darling Basin Commission funded Carp Management Plan for the lagoon.

This report summarises the results of the fish surveys in February 2008 and provides specific recommendations regarding suitable management of the lagoon for Freshwater catfish (Part A). Part B provides recommendations regarding facilitation of fish passage at existing road crossings which are currently acting as barriers to movement.

This work links in well with a range of habitat rehabilitation activities already occurring at Tahbilk Lagoon and its surrounds, including revegetation and management of pest plant species. A broad suite of management issues relevant to the lagoon are also currently being addressed by a range of stakeholders and managers, including management of:

- flow regimes and water quality
- alien fish species
- aquatic weed control
- facilitation of fish passage between the lagoon and the Goulburn River.

In association with this project, the GBCMA also provided funding to develop an information board for the Tahbilk Wetlands Café regarding the significance of this species in the Lagoon, and to record catfish breeding behaviour using an underwater camera, for use as an educational tool.

1.2 Tahbilk Lagoon

The Tahbilk Lagoon is situated in central Victoria, approximately 10km south west of the Nagambie township (Figure 1). The lagoon is associated with the Goulburn River, and lies within the tailwaters of the Goulburn Weir Pool. The Goulburn Weir, which was constructed in 1890 and upgraded in the 1980s, is used for water diversion rather than storage and lifts the water level to enable diversion of gravity flows through offtake channels. The weir has created an extensive area of backwaters reaching south at least 8 km upstream.

The Tahbilk Lagoon is over 5 km long and covers an area of approximately 158 ha (400 acres) of water (283 ha/700 acres of wetland area). The lagoon is classified as a Deep Freshwater Marsh according to the Department of Sustainability and Environment (DSE) 1994 Wetland Categories (Appendix 1). The riparian zone along much of the lagoon appears in reasonable condition although it is generally narrow in width, and understorey and midstorey vegetation is limited. Grazing occurs in a few limited areas which is likely to be detrimental to bank stability, as well as limiting natural regeneration, causing soil compaction, spreading terrestrial weeds and reducing water quality.

The instream environment provides a variety of habitat components, including standing and fallen trees, fringing vegetation including Spikerush *Eleocharis* spp and Rushes *Juncus* spp., and a wide variety of aquatic species such as Ribbonweed *Vallisneria gigantea*, pondweed *Potamogeton* sp and milfoil *Myriophyllum* sp. (Photos 1 and 2). A recent brief survey of aquatic plant species present at the lagoon in 2007 recorded 16 native species (Damien Cook, aquatic ecologist consultant/Fiona McConachie, Greening Australia data).

Figure 1 – Location of Tahbilk Lagoon

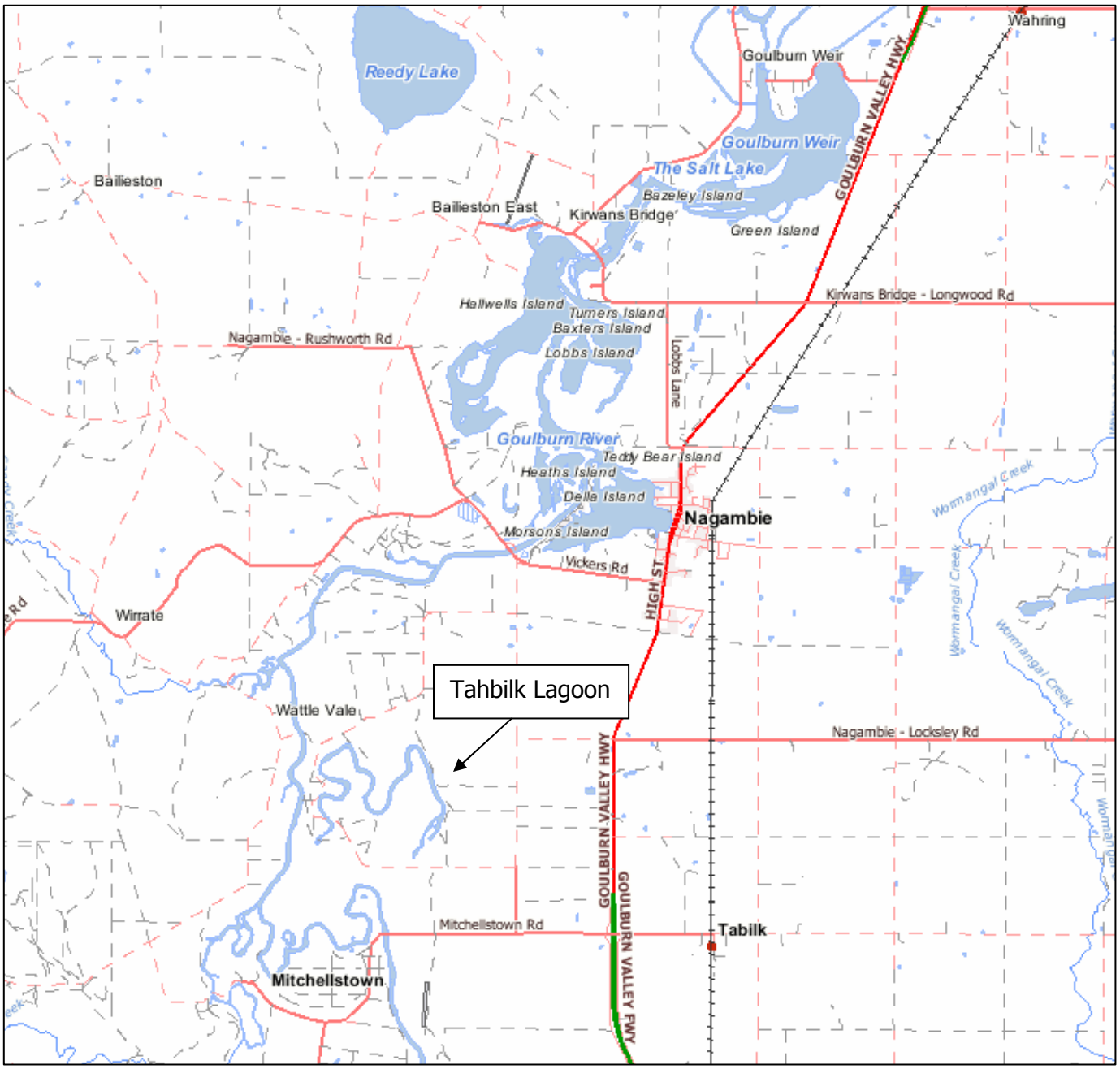


Photo 1 – Diversity of habitats within Tahbilk Lagoon. ***Photos Fern Hames***

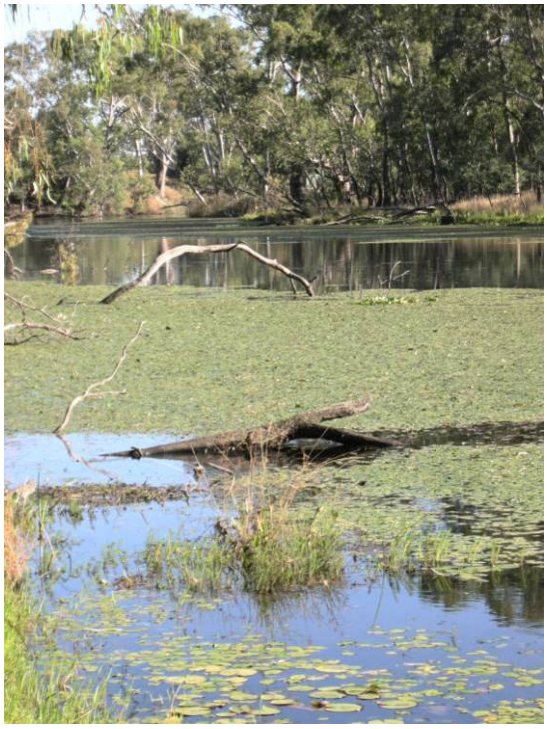


Photo 2 – Patches of the threatened Watershield are found throughout much of the lagoon. ***Photo Fern Hames***

1.3 Key Stakeholders and Managers

Key stakeholders and managers involved in the management of the Tahbilk Lagoon and its surrounds include Goulburn-Murray Water (G-MW), GBCMA, Tahbilk Winery, DSE, Greening Australia, adjoining landholders and Parks Victoria. Many other groups have some involvement and interest in the area, including the Nagambie Landcare group, the Nagambie Angling Club, Department of Primary Industries Fisheries Victoria, Broken Creek Field Naturalists Club, Bird Observers' Club of Australia, the Shire of Strathbogie and Field and Game Australia. G-MW is developing a Management Plan for the site which outlines existing roles and responsibilities of management authorities, and key issues.

G-MW manages water storages, delivery and drainage systems in the Goulburn-Murray region, and thus has direct involvement in the management of the lagoon's flow regime. G-MW holds freehold title of Tahbilk Lagoon and associated wetlands. Tahbilk Winery holds freehold title of land around the lagoon (see Appendix 2).

The GBCMA plays a key role in protection and enhancement of riparian, instream and wetland environments, and management of flow regimes and water quality. This area falls within Management Unit U1 (mid Goulburn) in the Goulburn-Broken CMA Regional River Health Strategy (GBCMA 2005). A suite of management actions are recommended to address threats within this stretch of river which are relevant to Tahbilk Lagoon (e.g. water quality, introduced flora, barriers to fish migration, erosion, flow deviation, loss of instream habitat and stock access).

DSE provides advice regarding management of flora and fauna, including threatened species and communities, and manages water allocation across the State including, in association with CMAs, the identification of priority drought refuges.

Greening Australia is currently involved in two federally funded programs at Tahbilk Lagoon (Envirofund and Community Water Grant), involving a flora assessment and identifying recommendations for management of native vegetation.

The Tahbilk Winery Pty Ltd, established in 1860, is the oldest family-owned winery in Victoria. The winery has freehold title over a significant area of land around the lagoon (1278ha), along with 11km frontage to the Goulburn River and plays a key role in the management of the site. The company runs a vineyard and winery, has a grazing licence, and facilitates tourism activities such as boat trips and nature walks. Revegetation works began in 1995, with development of tourist/interpretive facilities in 2004 including timber boardwalks, docking jetties for the Wetlands Pontoon and two bird hides. Tahbilk Winery is preparing a Management Plan for the site addressing a suite of issues to improve biodiversity including fencing, revegetation, weed control, and filtering of runoff into the lagoon. The Tabhilk Winery is a member of Land For Wildlife and is an inaugural member of the Nagambie Landcare group. Development of the site has been consistent with a Heritage overlay (Shire of Strathbogie).

The Land Conservation Council 1981 report recommended that Tahbilk Lagoon be declared a 'Wildlife Reserve' to be managed primarily to conserve the habitat of native animals, and for public recreation and education (where this does not conflict with the primary aim), and that grazing be permitted at the managing authority's discretion. The subsequent Environment Conservation Council 2001 report classified the lagoon as a 'Wildlife area' under the Natural Features Reserves. Prior to this management arrangement occurring, land tenure must be changed from G-MW freehold to reserve crown land under the *Crown Land Reserves Act* 1978 (G-MW in prep).

1.4 Key Management Issues

1.4.1 Threatened Flora and Fauna

Flora

The surrounding vegetation includes patches of significant Ecological Vegetation Classes. These include Floodplain Riparian Woodland/Floodplain Wetland Mosaic (254) (Vulnerable), Plains Grassy Woodland (55)(Endangered) and Grassy Woodland (175) (Endangered) (Appendix 3). Threatened flora species from the vicinity include Buloke *Allocasuarina luehmannii* and Common Joyweed *Alternanthera nodiflora* (DSE Flora Database records) and the nationally threatened Little Scurf pea *Cullen parvum* (Greening Australia recent data).

Of particular significance regarding aquatic species, is the presence of an abundant population of the threatened Watershield *Brasenia schreberi*. This species is classified as 'Vulnerable' in Victoria (DSE 2007) and is listed under the *Flora and Fauna Guarantee Act* 1988. In Victoria, the Watershield is known from the lower reaches of tributaries of the Murray River, and is now limited to backwater sites influenced by the Goulburn Weir pool. It occurs in areas of permanent water with an accumulating silt and litter layer (Rolf Weber, DSE, pers. comm.). The species grows in water of 0.3-3 m depth in a range of soil types, and is dispersed by stem fragments, hibernating turions (buds on the rhizomes), and seed (Rolf Weber, DSE, pers. comm.). Growth slows when water temperatures drop below 18^{o}C. Potential threats to this species include the presence of Carp through their feeding behaviour (SAC 1998), which can uproot plants. The presence of the introduced Yellow Water Lily is also likely to directly compete with the Watershield for nutrients and light (SAC 1998).

Terrestrial Fauna

A number of other threatened species have been recorded in the general vicinity of Tahbilk including Powerful Owls *Ninox strenua*, Grey-crowned Babblers *Potamostomus temporalis*, Hooded Robins *Melanodryas cucullata*, Diamond Firetail *Stagonopleura guttata* and Lace Goanna *Varanus varius* (Atlas of Victorian Wildlife, DSE). Recent surveys by Greening Australia in 2008 have also recorded Azure Kingfisher *Alcedo* azurea, Eastern Great Egret *Ardea* modesta, Brown Treecreeper *Climactiers picumnus victoriaea* and Royal Spoonbill *Platealea regia.* Tahbilk Lagoon has not been extensively surveyed for flora and fauna, however miscellaneous surveys have been undertaken including bird surveys by the Broken Creek Field Naturalists Club (in 1995) and Bird Observers' Club of Australia (between 1993 and 2007).

1.4.2 Aquatic Fauna

Fish surveys have previously been undertaken at Tahbilk Lagoon. Brumley *et al*. (1987) undertook general fish surveys in the early 1980s using gill nets, fyke nets and boat electrofishing, while in 2002 McGuckin (2002) surveyed the lagoon for the Nagambie Angling Club using fyke nets and bait traps. This information has been entered on the Aquatic Fauna Database (DSE). Peter Unmack and ANGFA (Australian and New Guinea Fish Association) have also undertaken miscellaneous surveys of the site. Table 1 summarises the suite of species recorded from various sources and their threatened classification; the details of some records is unclear and some have been revised.

Within the Goulburn system, a suite of species potentially occur, including large and small-bodied species. While there are no documented records of large-bodied species

including Murray cod, Silver perch and Blackfish within Tahbilk Lagoon, they are likely to have previously occurred in the area, and could potentially use the lagoon if fish passage was facilitated (see Part B). McGuckin (2002) noted a Tahbilk Winery staff member caught a Golden perch in the Lagoon in 2001. A recent Native Fish Australia report which collated anecdotal observations of fish within the Murray-Darling system provides useful information for the Goulburn River (Trueman 2007). Downstream of Seymour/Traawool, Murray cod *Maccullochella peelii peelii*, Macquarie perch *Macquaria australasica*, Golden perch *M. ambigua*, Silver perch *Bidyanus bidyanus*, Freshwater catfish and River blackfish *Gadopsis marmoratus* were considered abundant in the 1920s and 1930s. Recent surveys of the lower Goulburn River from 2003 to 2006 have recorded Murray cod (widespread and naturally reproducing), Golden perch (widespread, generally larger size classes), Trout cod (adults and larval fish in 2004), Silver perch (low numbers in 2003) and Blackfish (small, limited population) (Koster *et al*. 2006). These recent surveys also recorded abundant Australian smelt and Murray-Darling rainbowfish, while Flat-headed gudgeon and carp gudgeons were occasionally recorded in low numbers.

Table 1 – Existing records of aquatic fauna present at Tahbilk Lagoon

Scientific Name	Common Name	Source of Records	Threatened Classification
Native Fish			
Craterocephalus fluviatilis	Murray hardyhead[1]	McGuckin (2002) – refers to ANGFA records	Vul (EPBC), CE (DSE 2007), L
Galaxias rostratus	Flat-headed galaxias	Brumley *et al.* (1987), ANGFA surveys in 1990s	DD (DSE 2007)
Hypseleotris spp.	Carp gudgeon	McGuckin (2002)	
Macquaria ambigua	Golden perch	Brumley *et al.* (1987)[2]	
Macquaria australasica ?	Macquarie perch	*Aquatic Fauna Database - stocked 1986? NFA 13?*	End (EPBC), End DSE (2007), L
Melanotaenia fluviatilis	Murray-Darling rainbowfish	McGuckin (2002)[3]	DD (DSE 2007), L
Philypnodon grandiceps	Flat-headed gudgeon	Brumley *et al.* (1987), Unmack (1990)	
Retropinna semoni	Australian smelt	Unmack (1990)	
Tandanus tandanus	Freshwater catfish	Brumley *et al.* (1987), McGuckin (2002)	End (DSE 2007), L
Introduced Fish			
Carassius auratus	Goldfish	Brumley *et al*. (1987)	
Cyprinus carpio	Carp	Brumley *et al.* (1987)	
Gambusia holbrooki	Eastern gambusia	Brumley *et al.* (1987)	
Perca fluviatilis	Redfin	Brumley *et al.* (1987), Unmack (1990)	
Tinca tinca	Tench	Brumley *et al.* (1987)	
Turtles/Tortoises			
Chelodina expansa	Broad-shelled river turtle	McGuckin (2002)	End (DSE 2007), L
Chelodina longicollis	Long-necked tortoise	McGuckin (2002)	
Emydura macquarii	Short-necked tortoise	McGuckin (2002)	DD (DSE 2007), L

[1] McGuckin (2002) notes ANGFA members have captured Murray hardyhead. It is however likely that specimens were in fact Unspecked hardyhead *Craterocephalus stercusmuscarum fulvus* (DD, L)
[2] 10,000 Golden perch fry released in 1983/84, 50,000 Golden perch fry released in 1985/6
[3] Noted in McGuckin (2002) as being captured by ANGFA although not on Aquatic Fauna Database
L = Listed under the Victorian *Flora and Fauna Guarantee Act* 1988, EPBC = National *Environment Protection and Biodiversity Conservation Act* 1999, Vul = vulnerable, End = endangered, DD = data deficient

Murray hardyhead

While there is an anecdotal record of Murray hardyhead *Craterocephalus fluviatilis* within the Tahbilk Lagoon, it is very unlikely these fish occur there. McGuckin (2002) noted that ANGFA members had collected this species at the site. In the early 2000s, the taxonomic key to identify hardyheads was inadequate, particularly in relation to guidance in how to identify lateral line scale counts (Tarmo Raadik, DSE ARI, pers. comm.). While fish from Tahbilk were initially keyed out as Murray hardyhead, this is likely to be an incorrect identification. These fish are likely to have been the Unspecked hardyhead. The taxonomic key has subsequently been revised.

A draft National Recovery Plan has been produced for the Murray hardyhead (Backhouse *et al.* 2007, in prep). This species is endemic to the lower Murray-Darling River system in South Australia, Victoria and New South Wales. While once widespread and common throughout its range, the species has suffered an extensive decline in range and abundance. Now only found in a few isolated sites in northern Victoria and South Australia, all populations are threatened by rising salinity and declining water levels. The species has been found in still and slow-flowing waters including billabongs, lakes and margins and backwaters of lowland rivers. Site records include open-water and amongst aquatic plants such as fringing emergent rushes and macrophytes over silty and sandy substrates. In Victoria, most records are from saline ephemeral deflation basin lakes in the north including sites with very high salinities. Current populations are only known from four northern sites - Cardross Lakes and Lake Hawthorn, Round and Woorinen North lakes.

Macquarie perch

While the Aquatic Fauna Database indicates Macquarie perch may have been stocked in the lagoon in 1986, the details of this are unknown. There appear to be no more recent records of the species at the site, and the habitat is unlikely to be suitable. Macquarie Perch are generally found in cool, shaded upland streams which include deep rocky pools for shelter and shallow riffles for feeding and spawning. While naturally a riverine species, fish can exist in impoundments, where they are able to move up into feeder streams for spawning.

Macquarie Perch were once considered abundant in the Goulburn River up to around Jamieson, as well as inflowing rivers including the Big, Delatite, Howqua and Jamieson rivers (Wharton 1973). Wharton (1973) noted the species was abundant in the Goulburn below Lake Eildon until the 1930s and had largely gone by 1960. By the early 1980s, a few isolated populations occurred within this catchment, with Hughes Creek and the upper Sevens Creek the only ones to be considered viable (Cadwallader 1981). The species was introduced into the upper reaches of both creeks. Tunbridge and Rogan (2003) note that Macquarie perch are occasionally recorded in the Goulburn River or adjacent billabongs between the Goulburn weir and the Murray River. However surveys of the lower Goulburn between 2003 and 2006 failed to record the species. Surveys in 2006 and 2007 recorded a population of Macquarie perch persisting in the mid to lower reaches of Hughes Creek (ARI, 2007), which is approximately 15 km upstream of Tahbilk Lagoon.

Dwarf Flat-headed gudgeon

It is possible that the Dwarf Flat-headed gudgeon *Philypnodon macrostomus* may occur in the Tahbilk Lagoon. The species has a patchy distribution within the MDB, tends to be rare, and is not often found in large numbers. The species is not readily distinguished

during surveys, due to its similarity to the more common Flat-headed gudgeon. Distinguishing features include being less than 50 mm, darker than Flat-headed gudgeons, with a mouth which is larger and extends further under the eye, the shape of the tongue is rounded in profile, and gill covers are restricted (Tarmo Raadik, DSE ARI, pers. comm.).

Threatened Frogs

There are two species of threatened frog (Endangered - DSE 2007) which may potentially occur within Tahbilk Lagoon: Growling Grass Frogs *Litoria raniformis* and the Bibron's Toadlet *Pseudophryne bibronii* (Mike Smith, DSE ARI, pers. comm.). Growling Grass Frogs have apparently been recorded within the Lagoon, approximately 20 years ago (Fiona McConachie, Greening Australia, pers. comm.), although there are no records on the Aquatic Fauna Database. Growling Grass Frogs are large frogs which show a preference for slow moving water and are summer breeders. They are quite mobile and require clusters of suitable habitat. Carp are considered a threat to this species. The Bibron's Toadlet are smaller frogs which breed between February and June, laying eggs in terrestrial nests which are later inundated (Mike Smith, DSE ARI pers. comm.).

Alien Fish

Several alien fish species have been recorded within Tahbilk lagoon, including Carp, Redfin, Eastern gambusia *Gambusia holbrooki*, Goldfish *Carassius auratus* and Tench *Tinca tinca*. Carp and Eastern gambusia are categorised as noxious species. Redfin are a popular angling species, although limited recreational angling occurs at the site.

Samples of Redfin were collected during this survey program for an analysis of the prevalence of the EHN Virus within the MDB as part of a new MDBC funded research project (R. Whittington, Sydney University, pers. comm.). EHNV (Epizootic Haematopoietic Necrosis Virus) is an iridovirus first reported in Australia from dead Redfin at Lake Nillahcootie near Benalla in 1984. The disease can cause sudden high mortalities of Redfin. Limited trials have found that some native species including Silver perch, Macquarie perch, Mountain galaxias and the introduced Eastern gambusia are highly susceptible to the disease. Murray cod are considered susceptible to infection and a possible carrier species (Langdon 1989). The susceptibility of Freshwater catfish to this virus is unknown.

The MDBC has selected Tahbilk Lagoon as a site to implement a Carp Management Plan, and this plan is currently being developed. The draft plan considers options to manage Carp in the broader context of habitat restoration, and outlines key issues which need to be addressed to complement any actions to control Carp. These issues include flow management and fish passage, and installation of integrated Carp harvest and screening systems (Braysher *et al.*, in prep).

1.4.3 Freshwater Catfish

Freshwater catfish is classified as endangered in Victoria (DSE 2007) and is listed under the *Flora and Fauna Guarantee Act* 1988. It was once one of the most common fish species within the Murray-Darling Basin. The species has experienced a significant decline in both distribution and abundance throughout most of its range. In Victoria, records of fish captures are rare. Populations are currently known from only a few riverine sites (e.g. the Little Murray River near Swan Hill, and the Wimmera River – which is an introduced population), Gunbower Creek, and a few isolated impoundments (e.g. Cardross Lakes near Mildura, and a few small lakes in central Victoria). In terms of

the Goulburn River system, historically, catfish appear to have occurred as far upstream as Lake Eildon, and were commonly found in billabongs particularly from Thornton downstream (Trueman 2007). Current records are rare, with only occasional captures in sites such as Lake Nagambie and Major Creek. Downstream of Goulburn Weir, fish surveys have been undertaken on the lower Goulburn from 2003 onwards. Recent surveys have recorded one larval catfish and one juvenile catfish at Cable Hole, approximately 5-10km downstream of Goulburn Weir (Wayne Koster, DSE ARI, pers. comm. 2008). These individuals may have drifted downstream from upstream wetlands such as Tahbilk Lagoon, but it is also possible that a breeding population of this species exists in the lower Goulburn River. Further surveys are required to determine the status of Freshwater catfish in the river.

Tahbilk Lagoon therefore stands out as a significant natural population of catfish, in the context of the species' current range in Victoria and within the Goulburn system, as well as being a remnant population associated with a river. It is probably the most southerly known remnant population in Victoria.

Declines in the species have been observed since the 1930s, and particularly from the 1970s onwards. While the reasons for the species' decline are not well understood, it is likely that changes to flow regimes, sedimentation and predation by and competition from introduced species have contributed to its demise.

Freshwater catfish occur in a wide range of habitats, although it appears to favour slower flowing areas. Fish are often found in the vicinity of some form of structure such as aquatic vegetation, undercut banks and root masses, although the importance of particular habitat components is not well understood and represents an important area for future work. Adults do not seem to be generally migratory, with some observations of fish moving up to 5 km. Fish are however occasionally recorded moving through fishways. The swimming ability of Freshwater catfish and their ability to negotiate a range of water velocities has not been investigated. The species' reaction to barriers such as enclosed pipes and whether they will move through such structures is also unknown.

The species breeds between October and March across its range, and spawning appears to be primarily stimulated by rises in water temperature above 24^0C. Fish lay demersal eggs in nests, which may vary significantly in size (depressions of 0.5 to 2m in diameter). While the nests are commonly made of pebbles and stones, they can also be small depressions in muddy substrates. Whether there are variations in recruitment success between nests using different substrates is unknown. Laying eggs between interstices may be a valuable method to enable effective fanning of eggs and removal of sediment, and protection against predators. The male tends to guard the nest, chasing away predators, and fanning sediment off the eggs. There have been some observations of Freshwater catfish making nests out of mudballs, although how common this is is unknown. Freshwater catfish, which are largely considered solitary, are predominantly opportunistic carnivores. They are considered benthic in habit, although they can move throughout the water column to feed.

Limited work has been undertaken on the genetic composition of Freshwater catfish. There is one species within the Murray-Darling Basin, and a number of undescribed subspecies and new species in some coastal regions (Musyl and Keenan 1996, Jerry and Woodland 1997). Due to the decline of the species, many populations are now isolated from each other and the reduced number of fish breeding represents a likely reduction in

genetic variation (Keenan et al. 1996). Populations in dams and lakes tend to have lower genetic variation (heterozygosities) than fish in rivers, although a significant negative relationship between inbreeding (as measured by fluctuating asymmetry) and heterozygosity was not found in catfish (Keenan et al. 1996). Authorities in Queensland (Griffith University for Department of Natural Resources and Water) and New South Wales (NSW Department of Primary Industries - NSW Freshwater Threatened Species Monitoring Program) are both currently investigating genetic composition of Freshwater catfish. While no funds are currently available for genetic investigations of Freshwater catfish in Victoria, there are opportunities to have material analysed interstate. Fin clips of Freshwater catfish from Tahbilk Lagoon were collected during this survey for future genetic analysis.

1.4.2 Water Management

The operation of Lake Eildon upstream affects the hydrology of the Goulburn River, with a reversal of flow seasonality above the Goulburn weir. Maximum flow in summer and autumn is 6000-11,000ML/day and minimum flows in winter and spring are 120-250ML/day (EPA 2005).

Due to the influence of the Goulburn Weir Pool, Tahbilk Lagoon is permanently inundated. The Lagoon is generally kept at close to its full supply level, although rapid winter drawdowns can occur during maintenance of the weir. Water levels generally vary up to 30 cm. Some water within the lagoon is used by adjoining landowners for stock and domestic purposes, and by the winery for irrigation.

Tahbilk Lagoon was identified in the GBCMA Interim Drought Contingency Plan March 2007 (GBCMA 2007) as a high priority site to avoid local extinction of priority species (i.e. Freshwater catfish and the Watershield). Recommendations identified within this plan were to:

- Isolate from Goulburn Weir fluctuations and keep water levels topped up as required
- Prohibit recreational fishing.

DSE Water Sector, in consultation with CMAs, also identified a list of priority aquatic refuges. Tahbilk Lagoon is categorised as a 'critical priority site' which should be supplied in worse case scenarios.

Release of cold water from Lake Eildon has resulted in lower maximum water temperatures at least as far downstream of Lake Eildon as Lake Nagambie (Ryan *et al.* 2001). McGuckin (2002) noted that Tahbilk Lagoon is not affected by the cool water releases in the Goulburn River. During his surveys in November 2002, surface water temperatures in Tahbilk were 5^{o}C higher than in the nearby Goulburn River. Cooler water temperatures in summer would detrimentally affect the spawning and recruitment success of fish species such as Freshwater catfish.

GMW has installed a permanent recorder behind the cellars of Tahbilk Winery in the Goulburn River. This has been installed and is maintained by Thiess, and monitors temperature, water level, salinity and turbidity.

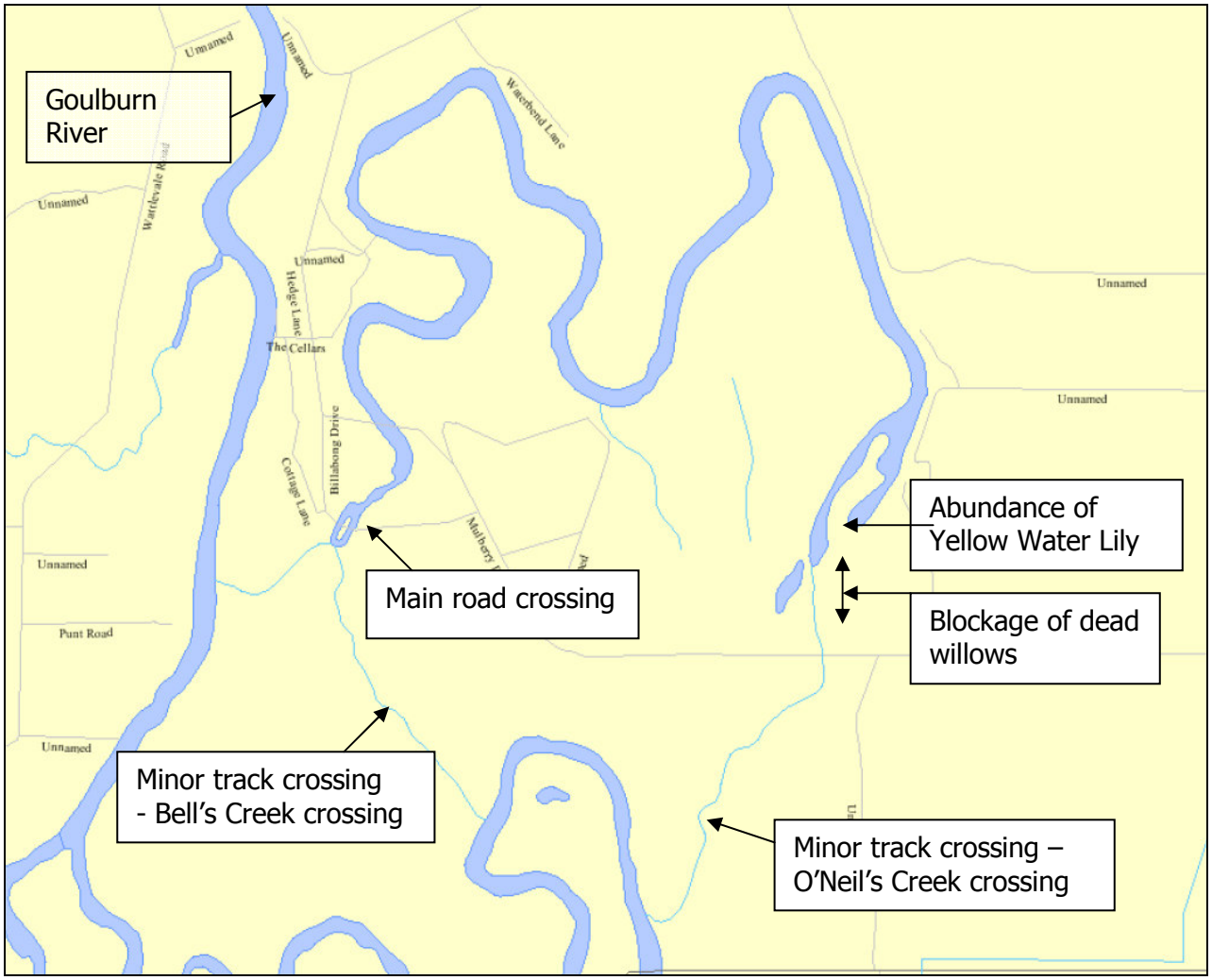


Figure 2 – Key features within Tahbilk Lagoon

1.4.4 Fish Passage

The Tahbilk Lagoon is cut off from the Goulburn River except in major floods, the last of which was in 1993. Appendix 4 indicates the pattern of floodwaters in the general area. The Lagoon loops around and potentially connects to the Goulburn River along three drainage lines (Figure 2). At the western site, which represents the main connection with the river, a major road crossing is located, where three large pipes only allow limited flow. The water level is 300ml below Full Supply Level (Bob McMaster, Tahbilk Winery). These pipes can be turned upwards to close off water leaving the lagoon (Photo 3). There are two other more minor barriers (O'Neil's Creek and Bell's Creek road crossings) on smaller tributaries entering the lagoon.

Any structure which lies across a stream or river potentially affects fish movement both up and downstream. Road crossings and pipes, such as those present at Tahbilk Lagoon represent both a physical barrier to flow as well as a behavioural barrier since fish often will not move through long dark pipes. Barriers can result in:

- restricted spawning migrations
- restricted movements to critical habitats as well as more general movement
- reduced dispersal of juvenile fish and recolonisation ability
- congregations of fish downstream of the structure
- genetically isolated populations up and downstream of the structure, and

- localised extinction of species above the barrier.

There are a number of pieces of legislation in Victoria which address the need to provide fish passage (*Water Act* 1989, *Fisheries Act* 1995, *Flora and Fauna Guarantee Act* 1988, *Conservation, Forests and Lands Act* 1987).

The existing barriers within the Tahbilk Lagoon and the flow management are likely to be key factors affecting the suite of fish species which potentially have access to the Lagoon. These factors would influence both its suitability as habitat, as well as the ability of fish to move in and out, and their ability to breed successfully. Large-bodied species including Murray cod, Silver perch and Golden perch migrate in spring and summer (primarily between September to January), moving upstream mainly during increases in river flow. Golden perch have also been recorded to move downstream (Wayne Koster, DSE ARI, pers. comm.). While Tahbilk Lagoon may provide suitable habitat components for such large-bodied species, recruitment success is often strongly linked to rises in water level, which is not currently experienced within the lagoon.

Recommendations for facilitation of fish passage are addressed in Part B of this report.

Photo 3: The road crossing over Billabong Drive has three pipes. ***Photo Fern Hames***

Photo 4: O'Neils inlet to Lagoon. ***Photo Fern Hames***

1.4.5 Aquatic Weeds

The Yellow Water Lily *Nymphaea mexicana* has been present within the Tahbilk Lagoon, and more widely within the Goulburn Weir Pool for many years. The Yellow Water Lily spreads vegetatively which enables colonisation to deeper areas (Sainty and Jacob 1981). The species is currently widespread through much of the lagoon, most particularly in the eastern end. Limited spraying programs have been undertaken within Tahbilk Lagoon for the Yellow Water Lily in the past. The impacts of abundant growth of aquatic weeds such as Yellow Water Lily include restriction of flow, build up of nutrients and organic matter in the water column and sediment in low flow areas. When plants die off, decomposing material can cause decreases in dissolved oxygen, which can be detrimental to fish.

G-MW has been involved in trialling a range of techniques to control aquatic weeds in recent years at sites within the Goulburn Weir Pool. Techniques include spraying with glyphosate and mechanical harvesting. Mechanical harvesting appears to be of limited effectiveness since plants grow back rapidly.

It is worthwhile to note that Tahbilk Lagoon has not been infested by Cabomba *Cabomba caroliniana* or Parrot's Feather *Myriophyllum aquaticum*, which are aquatic weeds found in other parts of the Goulburn Weir Pool.

Willows *Salix* spp. are also present in parts of the lagoon, primarily at the eastern end, where they have contributed to the restriction of flow. The GBCMA has provided funding in recent years to control Willows by trunk injection with glyphosate. This appears to have been largely effective in killing many of the Willows, although there is some evidence of regrowth. Additional control is required to kill any regrowth. The existing dead material also still represents a barrier to flow. Removal of this material would benefit the system by improving water flows.

1.4.7 Land Management

Adjacent landowners, including Tahbilk winery, hold grazing licences on G-MW land. Stock are able to access limited areas of the lagoon. Damage by grazing stock is potentially contributing to infilling of channels with sediment and thereby restricting fish passage, water flow and reducing water quality. Stock can cause soil compaction, limit natural regeneration and introduce and spread pest plants. The winery comprises a variety of crops and pasture, and vineyards and is currently addressing options to minimise runoff into the Lagoon.

2 Methods

2.1 Study Area

Figure 1 shows the location of the Tahbilk Lagoon. It is situated in central Victoria, approximately 10km south west of the Nagambie township, and lies in the tailwaters of the Goulburn Weir. The lagoon is over 5 km in length and is classified as a Deep Freshwater Marsh.

2.2 Fish Surveys

Fish surveys were undertaken at Tahbilk Lagoon between 18 and 21 February 2008. A suite of techniques were selected to enable an assessment of the overall fish community, although they primarily focused on methods to target Freshwater catfish, which can be difficult to capture. Techniques included boat electrofishing, fyke netting and bait traps.

A total of 19 sites were selected along the length of the lagoon for placement of fyke nets (20mm mesh size). Fyke net sites are shown in Figure 3. Habitat descriptions and location data (handheld Garmin GPS 72) were recorded and photos taken at each of the 19 fyke net sites; these are provided in Appendix 5. A total of 11 bait or light traps were placed at various locations over the sampling period, also shown in Figure 3. Sampling using a Smith-Root® 7.5 GPP boat-mounted electrofishing unit was undertaken at six sites across the lagoon to cover the available habitat types (500 Volts pulsed DC, 14 amps, 120Hz). Total electrofishing time was recorded for each day. Electrofishing sites are also indicated in Figure 3.

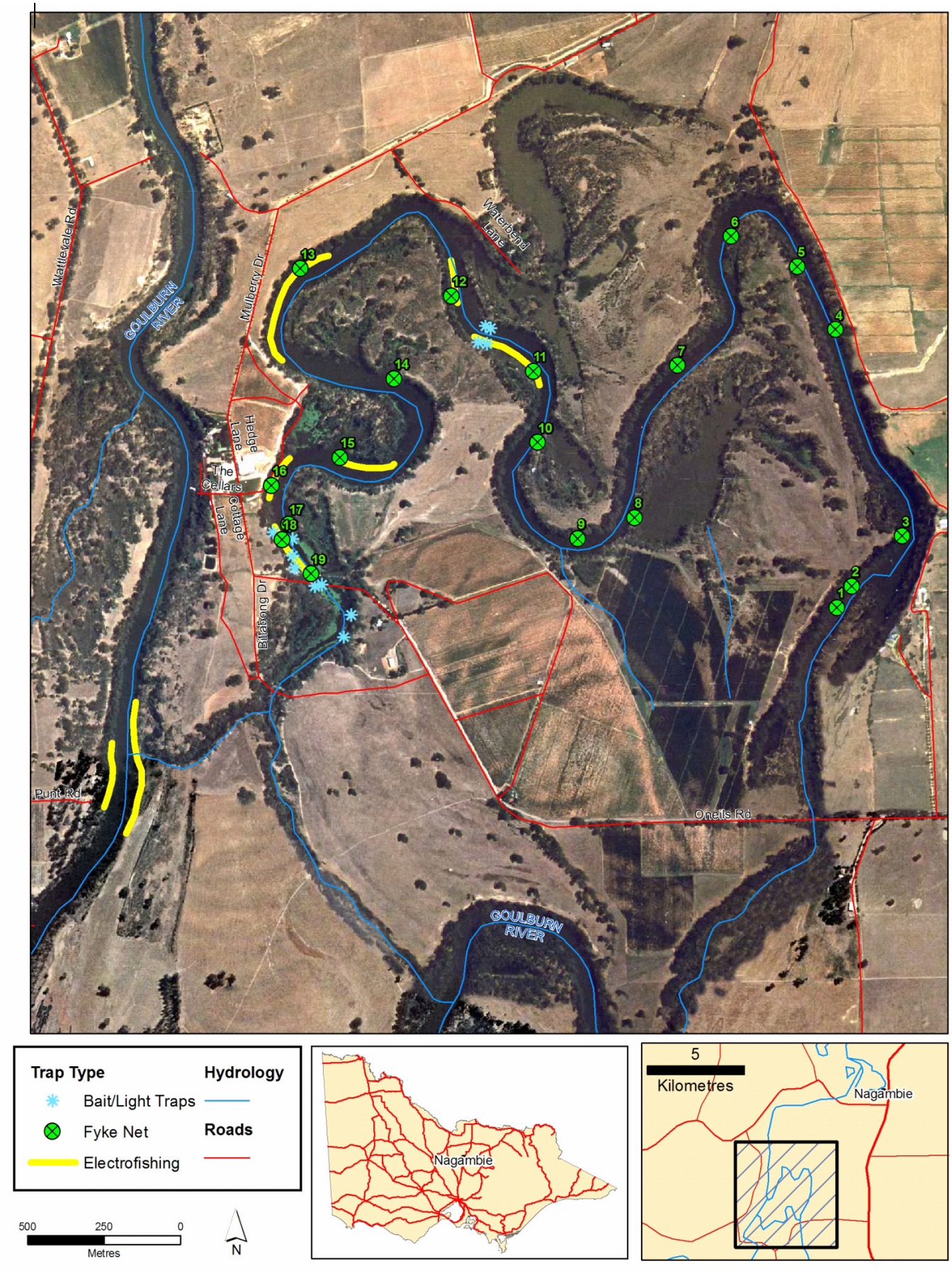
All fish collected were identified, counted and measured for length (mm) and returned to the water unharmed. Fish were measured to the nearest 1 mm, using length to caudal fork (LCF) or total length (TL). Fish that were seen but not captured were also recorded where they could be positively identified. Small fin clips were taken from Freshwater catfish for subsequent genetic analysis (Animal Ethics Committee AEC Approval 08/05). Larger size classes of Freshwater catfish (i.e. >300 mm) were also PIT (Passive Integrated Transponder) tagged, with the tags injected into the shoulder muscle behind the head. PIT tags are now commonly used in many fish surveys since PIT tag readers have been installed on many fishways within the Murray River, providing valuable data on fish movements. No PIT readers have yet been established in the Goulburn River, however PIT tagging catfish will still provide data relating to individuals growth if future surveys are conducted in the Lagoon.

In the case of the introduced Redfin, a subsample of fish were collected for future analysis of the presence of the EHN Virus. A subsample of gudgeons was also collected for subsequent identification in the laboratory to determine whether Dwarf Flat-headed gudgeons may be present.

2.3 Water Quality

Water quality readings were taken at four sites across the lagoon and one in the Goulburn River, using a TPS 90-FL Multimeter. Measurements included water temperature (^{o}C), electrical conductivity (uS/cm @water temperature), dissolved oxygen (mg/L) and pH. Readings were taken at three water depths.

Figure 3 – Location of fyke net, bait and light trap and electrofishing sites within the lagoon



3 Results

3.1 Fish Surveys

A total of six native and four introduced fish species were recorded in the surveys (Table 2). This suite of species recorded is generally consistent with previous records, although no Flat-headed galaxias *Galaxias rostratus*, Golden perch, Tench or Broad-shelled turtles were captured. Investigation of the subsample of gudgeons did not reveal any Dwarf Flat-headed gudgeons.

Of the six species of small-bodied fish, four species were collected in bait/light traps, while five were also collected with electrofishing (Table 2). Of the four species of large-bodied fish, all were captured with electrofishing as well as in fyke nets. Of the 22 Freshwater catfish collected, 15 fish were captured in fyke nets, and seven with electrofishing. Capture of fish by electrofishing was difficult, since the lagoon has abundant aquatic vegetation and snags and the water was relatively turbid. Many Carp were observed during electrofishing however could not be collected due to difficulties in capturing fish from amongst extensive snag structures.

The majority of electrofishing was undertaken during daylight hours between 19 and 21 February. Total electrofishing times were 1627 electrofishing seconds on 19/02, 799 electrofishing seconds on 20/02 and 743 electrofishing seconds on 21/02. Electrofishing focused on six areas of the lagoon, aiming to survey the range of habitat types along the lagoon (Figure 3). On 21/02, electrofishing was also undertaken in the lagoon outlet to the Goulburn River (924 electrofishing seconds) and within the Goulburn River approximately 200 metres up and downstream of the entrance to the lagoon (556 electrofishing seconds).

A total of 488 fish were observed and collected, as well as numerous additional Australian smelt and Eastern gambusia observed. Following the Australian smelt and Eastern gambusia, the most abundant species were Redfin, Carp, Flat-headed gudgeon, Goldfish, then Freshwater catfish.

The surveys recorded a range of size classes of Freshwater catfish in the lagoon (Figure 4). No catfish were observed within the creek entering the lagoon, or in the Goulburn River.

Eighty seven Redfin were recorded in a range of size classes. Fifty four Carp were recorded, including smaller size classes, most likely two year old fish (Figure 4).

The species recorded in the creek entering the lagoon comprised Flat-headed gudgeon (n=7), Redfin (n=5), Carp (n=4) and numerous Australian smelt and Gambusia. Within the Goulburn River, similar results were recorded (i.e. Flat-headed gudgeon n=3, Redfin n=3, Carp n=2 and numerous Australian smelt).

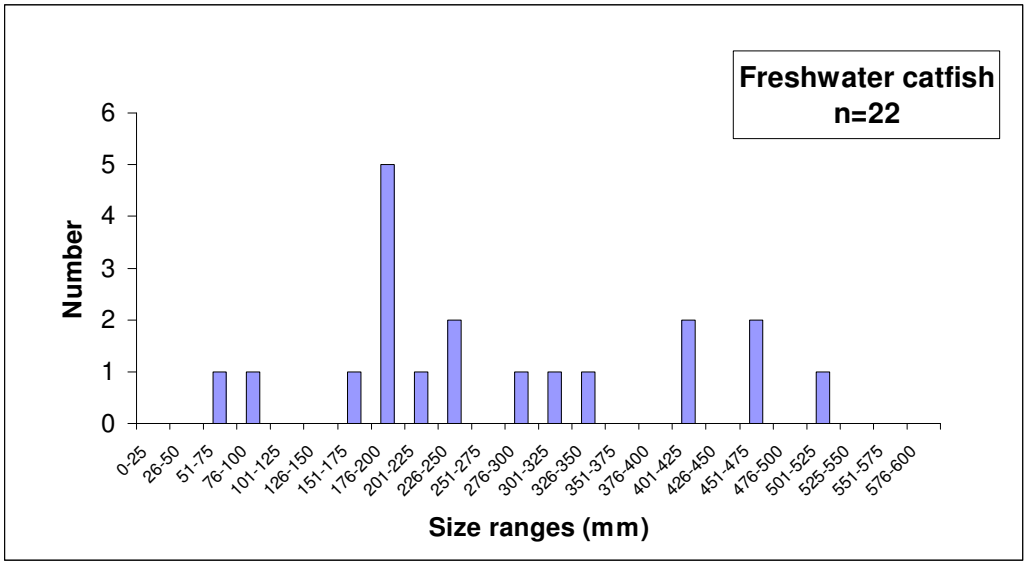
A total of 42 turtles were also captured within the lagoon, including 30 Murray Short-necked Turtles and 12 Long-necked Turtles. No Broad-shelled Turtles (threatened in Victoria) were recorded.

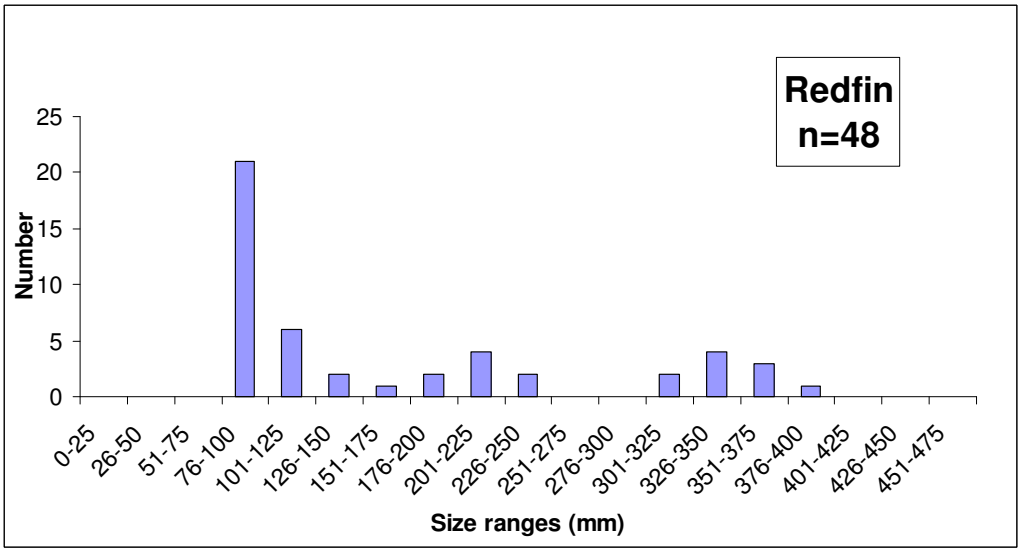
Table 2 – Species recorded by different gear types

Scientific name	Common name	Fyke net site number:	Electrofishing	Bait/light traps
Native Fish Species				
Craterocephalus stercusmuscarum fulvus	Unspecked hardyhead		*	
Hypseleotris spp.	Western Carp gudgeon species complex			*
Melanotaenia fluviatilis	Murray-Darling rainbowfish		*(dusk)	
Philypnodon grandiceps	Flat-headed gudgeon	3	*	*
Retropinna semoni	Australian smelt		*	*
Tandanus tandanus	Freshwater catfish	3,5,8,9,16,17	*	
Introduced Fish Species				
Carassius auratus	Goldfish	16	*	
Cyprinus carpio	Carp	2,3,7,9	*	
Gambusia holbrooki	Gambusia		*	*
Perca fluviatilus	Redfin	3,6,8,9,10,13,14,15	*	
Turtles/Tortoises				
Chelodina longicollis	Long-necked tortoise	3,8,9,11,12,13		
Emydura macquarii	Murray short-necked Turtle	3,5,6,7,9,11,12, 13,16,19		
Invertebrates				
	Yabbies	3, 11	*	
	Freshwater shrimp		*	*

Table 3 – Total numbers of fish recorded in survey (Tahbilk Lagoon, inlet channel and Goulburn River)

Scientific name	Common name	Total numbers	Mean length (mm)	Size range
Native Fish Species				
Craterocephalus stercusmuscarum fulvus	Unspecked hardyhead	1	33	-
Hypseleotris spp.	Western Carp gudgeon species complex	10	37	32-45
Melanotaenia fluviatilis	Murray-Darling rainbowfish	1	77	-
Philypnodon grandiceps	Flat-headed gudgeon	41	52	10-95
Retropinna semoni	Australian smelt	245 + hundreds observed	36	27-45
Tandanus tandanus	Freshwater catfish	24	257	73-506
Introduced Fish Species				
Carassius auratus	Goldfish	25	208	151-285
Cyprinus carpio	Carp	54	254	133-535
Gambusia holbrooki	Gambusia	1,000s	30	20-42
Perca fluviatilus	Redfin	87	167	76-380
Chelodina longicollis	Long-necked tortoise	12		
Emydura macquarii	Murray Short-necked Turtle	30		
	Yabbies			
	Freshwater shrimp			





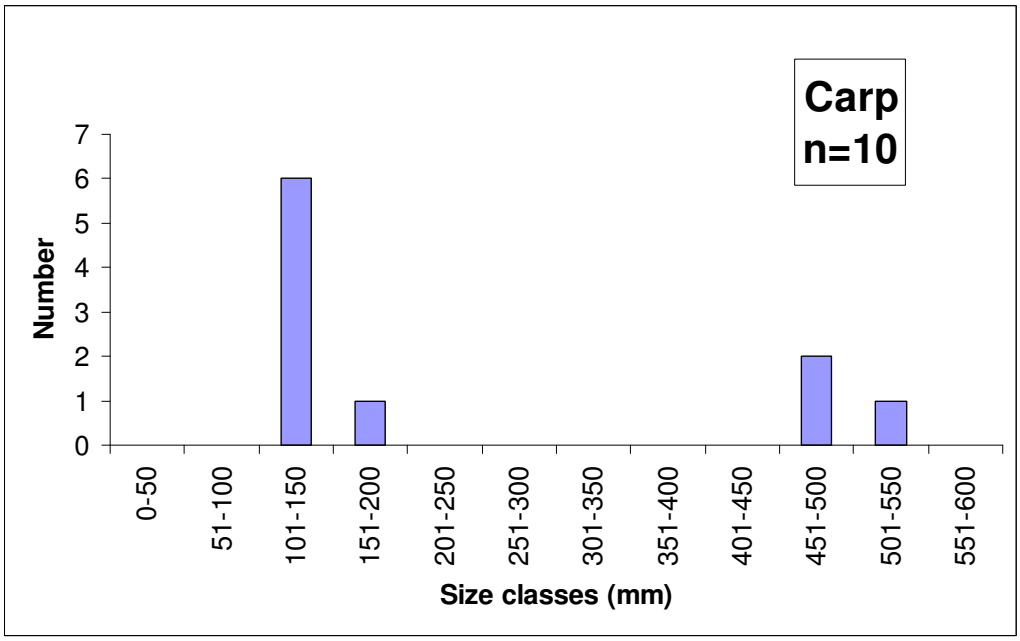


Figure 4: Histograms for Freshwater catfish, Redfin and Carp.

Photo 5: Three different sizes of Freshwater catfish captured. ***Photos Fern Hames***

3.2 Water Quality

Spot measurements of water quality indicated that there was variation across the lagoon, particularly in relation to dissolved oxygen (Table 4). Levels of dissolved oxygen predictably were low (<1 mg/L at depth) in shallow areas. Within the lagoon, dissolved oxygen levels at the surface ranged from 6.43 to 2.66 mg/L. The lowest readings were recorded near both ends of the lagoon i.e. at the western end around the footbridge and at the eastern end where there is abundant Yellow Water Lily. Surface conductivity also varied, from 59.5 to 261µs/cm, increasing with distance from the lagoon's main entrance.

Table 4 - Water quality measurements at Tahbilk Lagoon

	Dissolved oxygen (mg/L)	Temperature (ºC)	Conductivity (µs/cm)	pH
Goulburn River opp Tahbilk Lagoon				
Surface	6.28	22.8	59.5	6.36
1m depth	6.29	22.4	57.4	6.34
2m depth	6.11	21.8	57.4	6.37
Below Footbridge				
Surface	2.80	21.9	62.9	6.89
1m depth	1.86	20.7	64.2	6.75
2m depth	1.10	20.4	63.7	6.25
Boat ramp (CAT 19)				
Surface	5.19	21.9	102.7	7.77
1m depth	3.62	21.7	90.2	7.46
2m depth	0.84	19.6	79.1	6.97
CAT 10				
Surface	6.43	23.8	221.5	7.48
1m depth	6.35	23.7	215.5	7.43
2m depth	2.56	19.5	223.9	7.21
CAT 2				
Surface	2.66	23.0	261	7.20
1m depth	1.10	22.5	257	6.92
1.5m (bottom)	0.39	20.3	253	6.7

3.3 Habitat descriptions

Fish survey sites were established along the length of Tahbilk lagoon encompassing a range of habitat types and vegetation associations. Fyke nets were set at 19 sites and bait and light traps were set in three areas (Figure 3). Site descriptions and photos for each of the survey sites are provided in Appendix 5. The lagoon bank is typified by River Red Gum (*Eucalyptus camaldulensis*) with a variable understorey of wattles (particularly Silver Wattle *Acacia dealbata* and Blackwood *Acacia melanoxylon*) and native grasses. The lagoon edge varies from almost bare to well vegetated and supports a variety of sedges, rushes, and reeds. Exotic irises are also present. Survey sites included those supporting variable densities of aquatic vegetation, particularly the threatened Watershield *Brasenia schreberi* and the exotic Yellow Water Lily *Nymphaea mexicana.* Ribbon weed was also present at many sites. Instream woody habitat occurs along much of the lagoon and survey sites included those with and without such structure.

4 Discussion

4.1 Fish Community

The suite of species recorded during surveys is generally consistent with previous surveys, although no Flat-headed galaxias, Golden perch, Tench or Broad-shelled turtles were captured. It is surprising that Flat-headed galaxias were not recorded, since this species is known from still and slow flowing waters. The species however has a patchy distribution within the MDB (Lintermans 2007). It has been recorded from the Nagambie Lakes region and other sections of the Goulburn River in the past. Within the Murray-Darling Basin, the abundance of Tench is believed to have declined in a number of areas with the increase in Carp (Lintermans 2007).

Freshwater catfish represented the only large-bodied native fish species captured. It is possible that low numbers of other species such as Murray cod and Golden perch occur within the Lagoon, although the prevention of passage and lack of flow limits the suitability of the habitat for these species. Golden perch were stocked in the lagoon in the 1980s. A Tahbilk winery staff member captured a Golden perch in 2001 (McGuckin 2002). The absence of recent records suggests that while small numbers may still be present, they appear unlikely to have bred successfully in the Lagoon. There have been some more recent suggestions that stocking of Golden perch should be undertaken. It is possible Blackfish occurs in the lagoon, since this species undertakes limited movement, and shows a preference for slow flow habitats and woody structure which is used during breeding. The lack of records for this species suggests that if present, the species may only occur in very low numbers.

The five native species of small-bodied fish recorded are all known to occur in slow flowing habitats such as Tahbilk Lagoon, including areas with abundant aquatic vegetation, or some form of structure such as woody debris. Murray-Darling rainbowfish, Australian smelt and Western carp gudgeons lay eggs which adhere to aquatic vegetation, Flat-headed gudgeon eggs attach to rocks and woody structures, while Unspecked hardyhead eggs are demersal with adhesive strands (Lintermans 2007).

The large numbers of Short-necked and Long-necked turtles recorded during the surveys indicates there are abundant populations of both species at Tahbilk Lagoon. Both species are often found in such slow flow habitats. Long-necked turtles excavate holes in streambanks, and lay eggs which are then partially buried.

4.1.1 Freshwater Catfish

Tahbilk Lagoon represents a highly significant site for the conservation of Freshwater catfish in Victoria. In the context of the Goulburn River, Freshwater catfish were historically known to occur as far upstream as Lake Eildon, and were previously a common species within the system. Currently, there are occasional records from the Nagambie Lakes and upstream in Major Creek. Tahbilk Lagoon may represent the most southerly remnant population in Victoria.

The survey recorded a range of size classes, indicating there has been successful recruitment in recent years and that a self-sustaining population of Freshwater catfish persists in the lagoon. A total of 24 fish were recorded, which represents a relatively high number of individuals. This species is often difficult to capture, due to its largely benthic habit. The abundance of aquatic vegetation within the lagoon also limited the ability to see and capture Freshwater catfish using electrofishing. Fyke netting is often a useful

survey technique, although catch rates can vary significantly. The protocol of placing the end of the net out of the water to avoid potential drowning of air-breathing species such as platypus also can limit where nets can be laid i.e. only along water margins. Platypus have been seen in the area (Bob McMaster, Tahbilk Winery, pers. comm.)

Those fish <125mm are likely to have been spawned in this past breeding season (0+ fish), or last year's (1+ fish). Length histograms can be used to some extent to age fish although different cohorts tend to run together. Freshwater catfish can potentially breed from October to March, which represents a long breeding period. Growth rates also tend to vary greatly depending on food supply, fish density and habitat. Clearly however, appropriate conditions are occurring within Tahbilk Lagoon to enable consistent successful breeding events. This would include appropriate water temperatures (i.e. over 24^{o}C during spring and summer) to trigger breeding and successful recruitment. The slow flow conditions in particular are also important during the breeding season. Freshwater catfish are known to abandon their nest if rapid changes in water level occur during the breeding season. Freshwater catfish have declined in many river systems where flow patterns have changed significantly. Increased irrigation flows cause high velocities in rivers during summer periods, coinciding with spawning periods and thus creating non-preferred fast water habitats for the species.

It is difficult to age Freshwater catfish without using destructive techniques where the fish must be sacrificed. It was decided that fish would not be sacrificed for aging purposes for this project. In the past, aging of catfish generally used spines, which is unreliable, particularly in underestimating age over about four years (Tarmo Raadik, DSE ARI, pers. comm.). Otoliths (earstones) are now commonly used to age fish. These form from the deposition of bone-like material (calcium carbonate) laid down in layers over a fish's life. Some Freshwater catfish have been aged up to 11 years, although longevity is not well known. Five of the Freshwater catfish captured during the survey were greater than 400 mm in length; these fish are likely to be at least over three years of age.

While Freshwater catfish are found in a range of habitat types, they are most commonly found in backwaters and slow flowing environments such as Tahbilk Lagoon. They are often found in areas with abundant macrophytes. Limited habitat studies have found adults have some association with undercut banks, root masses, around willows or some form of structure while juveniles are often found amongst macrophytes, filamentous algae and leaf litter. In this survey, Freshwater catfish were recorded from a wide range of sites within the Lagoon, including areas where woody structure, aquatic and fringing vegetation were abundant (Appendix 5). Tahbilk Lagoon provides a diversity of habitat components suitable for Freshwater catfish. The number and variability of survey sites and number of Freshwater catfish recorded are not sufficient to make any analyses of specific habitat associations by catfish. This is an aspect of the species' ecology which requires further investigation. Radiotracking of a small number of Freshwater catfish within the Lagoon could help clarify specific habitat associations.

It is likely the species occurs throughout the area, and that nests are built in shallower margins during the breeding season. No nests were observed during the survey period, which would have been at the very end of the breeding season. Given the lack of gravel substrate, the abundance of aquatic vegetation, and the relatively turbid water, it would be difficult to identify nesting sites in most areas of the Lagoon. Freshwater catfish are often observed to build nests out of gravel substrate when available, although they will spawn in small depressions in muddy substrates. Whether there are variations in recruitment success between nests using different substrates is unknown. Laying eggs between interstices may be a valuable method to enable effective fanning of eggs and removal of sediment, and protection against predators.

4.1.2 Murray-Darling rainbowfish

Murray-Darling rainbowfish is primarily found in lowland parts of the Murray-Darling Basin and has a preference for slow flowing rivers, wetlands and billabongs. The species breeds in spring to summer once temperatures reach 20°C and eggs sink and become attached to aquatic vegetation via adhesive threads (Lintermans 2007). In Victoria, the species is primarily found in tributaries of the Murray River, such as the Goulburn and Broken rivers. Potential threats include loss of aquatic vegetation, predation of adults by Redfin and of juveniles by Gambusia, and cold water pollution (Lintermans 2007). Migratory behaviour is not well known, although some fish have been recorded moving through fishways, often in the afternoon and dusk. The species, which is known to school, primarily feeds on aquatic invertebrates and terrestrial arthropods (Cadwallader and Backhouse 1983). Surveys of the lower Goulburn River, from Cable Hole downstream, in recent years (2003-06) have consistently recorded Murray-Darling rainbowfish (Koster *et al*. 2006).

Photo 6: Murray-Darling rainbowfish. ***Photo MDBC, Gunther Schmida***

4.1.3 Introduced Fish

Carp

During previous visits to Tahbilk, large numbers of carp have been sighted jumping in the shallower areas of the lagoon (Fern Hames, DSE pers. obs.); these areas also support an abundance of aquatic plants, both native and introduced. During this recent survey fewer Carp than expected were observed. It is possible many Carp had reduced their activity levels with the declining water temperature. Water temperatures recorded at four sites across the lagoon ranged from 19.5-23.8°C. While Carp may move over a wide range of temperatures, there have been some observations of declines in movement when temperatures fall below 24°C (Koehn *et al.* 2000).

A total of 54 Carp were either observed or captured during the surveys, the majority through electrofishing. The abundance of aquatic vegetation and woody structure made it difficult to capture many of the observed Carp. Of those Carp measured (n=10) the majority were between 130 and 200mm in length (n=7). Growth rates of Carp can be highly variable and are influenced by factors such as water temperature, food availability and fish density. However, these fish are likely to be less than two years of age. This suggests that the species is breeding successfully within the lagoon.

Carp are ecological generalists that inhabit a variety of habitats, typically mid to low altitude areas of freshwater rivers, lakes and billabongs. They prefer warm slow flowing waters with a silty substrate. They are able to tolerate a wide variety of environmental conditions including high and low water temperatures and low oxygen concentrations (Clarke *et al*. 2000). There is a suite of detrimental impacts attributed to Carp, including decreased water quality, increased stream bank erosion and phytoplankton concentrations, decreased abundance and diversity of macrophytes and

macroinvertebrates, and competition with native fish for food and habitat (Koehn *et al*. 2000).

The specific impact of Carp on Freshwater catfish is not known, although it potentially could affect the species in terms of reproductive success, feeding behaviour and food availability. Both species are largely benthic feeders which have a preference for slow flowing habitats, thus there is potential for niche overlap. There have been no records of Carp feeding directly on Freshwater catfish, although there is potential for the bottom feeding behaviour of Carp to disrupt the nesting success of the species. The two species' diets overlap and whether competition for resources occurs is unknown. Increased erosion of streambanks and sedimentation could detrimentally affect the breeding success of Freshwater catfish by causing smothering of eggs and larvae in nests. Reductions in aquatic vegetation could also potentially be detrimental to Freshwater catfish.

It would appear that the permanent water conditions at Tahbilk Lagoon currently represent a refuge for Carp and suitable spawning sites. The MDBC has selected Tahbilk Lagoon as a site for implementation of a Pest Management Plan, primarily focussing on Carp. This plan is currently being developed and considers the pros and cons of a range of options to reduce numbers of Carp. Any actions which decrease the abundance of Carp at Tahbilk Lagoon are likely to benefit Freshwater catfish, as well as the suite of other native fish species.

Redfin

A total of 87 Redfin were either captured or observed during the surveys. Of those Redfin which were captured and measured (n=48), 45% measured between 76-100mm in size. While growth rates of Redfin can vary significantly this size class probably represents fish of between one and two years of age (Cadwallader and Backhouse 1983). It is clear that an abundant population of Redfin occurs within Tahbilk Lagoon.

The impact of Redfin on Freshwater catfish is not clearly understood, however both species show a preference for slow flowing habitats. Redfin are a highly piscivorous species and may compete for resources, as well as predate directly on Freshwater catfish eggs, larvae and juveniles. Redfin have been observed investigating Freshwater catfish nests (Pam Clunie, DSE, pers. obs); such activity may disrupt successful catfish spawning and recruitment. EHNV has also been reported from Redfin. Langdon (1989) found that a range of native species are highly susceptible to this disease, or are possible carriers. The susceptibility of Freshwater catfish to EHNV has never been tested. However, there have been anecdotal observations of rapid declines of Freshwater catfish in some areas in the past, and links to the prevalence of Redfin have been suggested (Trueman 2007). These observations include mass deaths of catfish in lagoons in the Goulburn River in the 1930s.

Photo 7: Redfin. ***Photo Fern Hames***

Goldfish

A total of 25 Goldfish were recorded during the survey. This species is widespread in Australia and is closely related to Carp, with which is has the ability to hybridise. Goldfish have a preferred habitat of still and slow flowing water, and can tolerate high water temperatures and low oxygen concentrations (Clark et al. 2000). Eggs are laid among aquatic plants and submerged objects in spring and summer. Impacts of Goldfish are not well understood although like Carp they may compete for food and habitat and cause increased turbidity (Brumley 1996).

Tench

Tench occur within the Murray-Darling system and throughout coastal rivers from NSW to SA and Tasmania. Their distribution is considered patchy and restricted to middle and upper reaches. They commonly occur in slow flowing areas with an abundance of macrophytes and deep holes. Eggs are laid over aquatic vegetation or on benthos in late spring and summer. Adults are largely carnivorous feeding on molluscs, insect larvae, small crustaceans and occasionally plant material (Brumley 1996). The impacts of Tench on native fish are not well understood. The abundance of Tench is believed to have declined with the increase in Carp. A comparison of numbers collected in surveys at Tahbilk over time corresponds to the overall decline in the species (Brumley *et al*. 1987 = 18 fish, McGuckin 2002 = 1, recent surveys = 0).

Eastern gambusia

Eastern gambusia were abundant within the Tahbilk Lagoon during this survey. This species is widespread and common across the Murray-Darling Basin. Gambusia are known to eat fish eggs, larvae, juveniles and adults, and it has been suggested that they have played a role in the decline in abundance or range of a number of species both in Australia and worldwide (Lloyd 1990). In Australia, these involve small bodied species such as gudgeons, Australian smelt and rainbowfish. It is not known whether Eastern gambusia represents a threat to Freshwater catfish. However, since Freshwater catfish nest in shallow, slow flowing areas along water margins, and Eastern gambusia are able to forage throughout the water column, it is possible Eastern gambusia may predate upon catfish eggs and larvae.

4.2 Watershield

This survey did not specifically include documentation of the current distribution of the threatened Watershield *Brasenia schreberi*. Previous observations by Rolf Weber (DSE, pers. comm.) indicated the species was largely restricted to the western third of the lagoon. However, it is evident that this species currently occurs across much of the lagoon, and is very abundant in some areas (Photo 8). This species occurs in some areas alongside the introduced Yellow Water Lily.

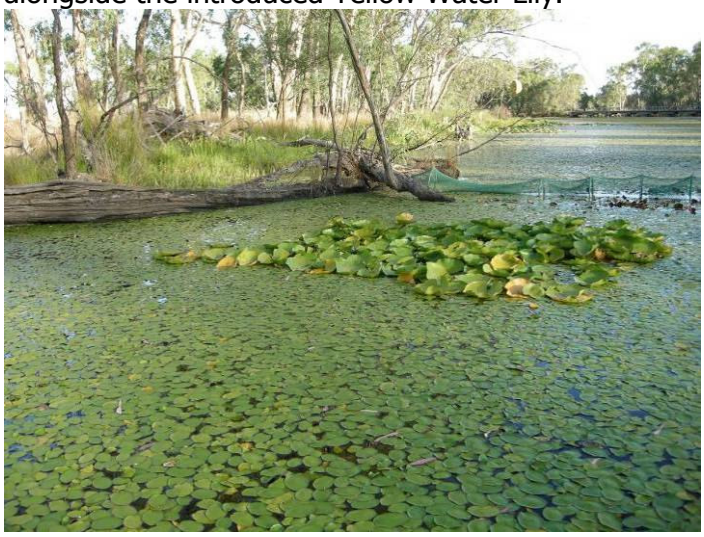


Photo 8: An abundance of the threatened Watershield, with a small infestation of the introduced Yellow Water Lily ***Photo Fern Hames***

4.3 Water Management

Water quality

Water quality results at Tahbilk Lagoon varied across sites, and predictably dropped with water depth. Monitoring of dissolved oxygen levels revealed some readings of concern. Readings of below 3.0 mg/L are generally considered to place aquatic life under stress. Several lagoon sites had readings much lower than this level.

Oxygen gets into water by diffusion from the surrounding air, by aeration through mixing of water, and as a waste product of photosynthesis. In lentic waters such as Tahbilk Lagoon, oxygen only enters the top layer of water, and deeper water tends to experience low dissolved oxygen concentrations due to decomposition of organic matter by bacteria. Concentrations of oxygen can decrease significantly during the night, due to respiration. For this survey, readings were generally taken around midday.

Limited trials have been undertaken on the tolerance of Freshwater catfish to various water quality parameters. This species can tolerate very high salinities of up to 23 400-26 400mg/L and dissolved oxygen levels of 0-2% saturation for limited periods (Ryan *et al.* 1999). The species appears much more tolerant to poor water quality conditions than many other native species. In general early life history stages of fish tend to be more susceptible to poor water conditions. Thus although Freshwater catfish may tolerate poor water quality conditions, the long-term impacts are not well understood.

Water flow

Due to the influence of the Goulburn Weir Pool, Tahbilk Lagoon is permanently inundated. The lagoon is generally kept at close to its full supply level, although rapid winter drawdowns can occur during maintenance of the weir. There is limited flow exchange with the Goulburn River through inlet and outlet channels, with channels infilled with sediment and colonised by weeds, and several road crossings which represent barriers to fish movement.

The lack of flow in and out of the lagoon is likely to be affecting water quality, the ability of fish to move in and out of the lagoon, and the suitability of the lagoon as habitat for a number of large bodied native fish species such as Golden perch. The feasibility of options to provide occasional 'flushes' of water into the lagoon should be investigated with Goulburn-Murray Water.

4.4 Fish Passage

Part B of this report specifically addresses options to facilitate passage for native fish species. Facilitation of fish passage should be considered a priority, while ensuring that there are no detrimental implications for the existing population of Freshwater catfish.

4.5 Aquatic Weeds

The Yellow Water Lily is currently a significant problem within Tahbilk Lagoon. The species occurs throughout the lagoon, and is particularly abundant in the eastern end. Abundant growth of such an aquatic plant can potentially be detrimental to sites such as Tahbilk Lagoon, through restriction of flow, build up of nutrients and organic matter in the water column and sediment in low flow areas. When plants die off, decomposing material can cause decreases in dissolved oxygen. The poor water quality recorded at the most eastern survey point demonstrates the influence of a heavy infestation of Yellow Water Lily on dissolved oxygen levels.

Goulburn-Murray Water and the Tahbilk Winery are involved in considering options for the control of this species. Goulburn-Murray Water is currently involved in trials to assess the impact of herbicide treatment and mechanical harvesting on a range of weeds and water quality, and a Reference Committee has been established. Chemical spraying appears to be the most effective technique of control.

While Freshwater catfish are often found in association with aquatic vegetation, the suitability of this aquatic weed as habitat is unknown. It is likely however that catfish would avoid areas with poor water quality, if other sites nearby offer more optimum water quality.

The section of dead Willows *Salix* spp. at the eastern end of the lagoon is also likely to be contributing to flow restriction. While recent works by GBCMA have killed the majority of the willows, these still represent a barrier to water movement.

Photo 9: Large infestation of Yellow Water Lily at eastern end of lagoon. Flower of Yellow Water Lily. ***Photos Fern Hames***

Photo 10: Willows at the eastern end of the lagoon. ***Photo Fern Hames***

5 Conclusions and Recommendations

Fish Community

The fish community within Tahbilk Lagoon comprises many of the species which would be expected in slow flow habitat where aquatic vegetation and woody structure is present. Of greatest significance is the presence of a relatively abundant, breeding population of the threatened Freshwater catfish. The presence of the threatened Murray-Darling rainbowfish is also significant as, although it was formerly widespread across the Murray-Darling Basin, it now has only patchy distribution and in Victoria is limited to the Murray, Goulburn and Broken Rivers (Lintermans 2007). The Murray-Darling rainbowfish is listed as threatened under the Victorian *Flora and Fauna Guarantee Act* 1988 both as an individual species and as part of the Lowland Riverine Fish Community of the Southern Murray-Darling Basin.

The absence of other large-bodied species which previously are likely to have occurred within this area of Goulburn River is most likely related to the lack of flow and presence of barriers to movement.

Management actions for Tahbilk Lagoon should be implemented to:

- maintain and enhance existing populations of native species, through protection and rehabilitation of habitat and control of threats
- facilitate the ability of other large-bodied native species, which potentially occur in the Goulburn River, to enter the lagoon, and
- control introduced fish species such as Carp.

Priority Site

This survey has validated the significance of the Tahbilk lagoon as an important site for Freshwater catfish, both in terms of location (as the southern most remnant population in the Murray-Darling Basin) and as an important site for Freshwater catfish refuge and recruitment. It is recommended that relevant agencies:

- Continue to recognise the significance of Tahbilk Lagoon, including through its classification as a 'high priority site' (GBCMA 2007) and as a 'priority aquatic refuge' (DSE).
- In the context of drought contingency planning, continue to support the recommendation to supply the lagoon with water in worse case scenarios (GBCMA 2007).

Management Actions to Maintain Freshwater Catfish

The persistence of a population of Freshwater catfish in Tahbilk Lagoon, which is recruiting, suggests existing conditions provide suitable habitat for this species. While a range of options to rehabilitate and improve conditions in Tahbilk Lagoon should be investigated and implemented, it is important that key characteristics which have enabled the Freshwater catfish to thrive should be maintained wherever possible i.e.

- lentic or slow flowing conditions. In particular, avoid rapid changes in water level during the breeding season (i.e. October to March),
- warmer water temperatures during summer as compared with associated water temperatures within the Goulburn weir and tailwaters,
- presence of a diversity of habitats including shallow and deeper areas, abundant native aquatic vegetation and woody structure.

Facilitation of Fish Passage - *Refer to Part B for specific recommendations to facilitate passage.*

- Part B recommends removal or replacement of the existing crossings with full stream-width open bottom multi-box culverts. This will potentially enable passage of additional native fish species in and out of the Lagoon.
- Any options to facilitate passage should consider potential implications to water level and water temperature within the Lagoon. Specific advice and guidance is required from G-MW regarding potential risks and management options to ensure that water levels are maintained in the Lagoon (particularly during the breeding season) and that no adverse changes in temperature regimes occur.
- The Tahbilk Lagoon Carp Management Plan is currently being developed (Braysher *et al*. in prep), which includes consideration of facilitation of fish passage.
- Part B notes establishment of Carp cages at culverts also provides the opportunity to collect and PIT tag fish. If Carp cages are established, there are a number of additional opportunities and benefits which can be gained. For example, Tahbilk staff could be trained in the collection and PIT tagging of fish from Carp cages, given their close association with the site. An automated PIT tag reader could be established on such structures which would provide valuable information on the movement of fish in and out of the Lagoon. An educational display board could also be established near the site of the Carp cage, to explain its purpose and operation. Such a display board could also explain the creation of culverts to facilitate fish passage.
- Regular annual fish surveys of the lagoon and adjacent river sites would enable assessment of any changes in lagoon fish populations potentially as a result of provision of fish passage. Such surveys would also enable monitoring of the ongoing status of this significant population, and build further knowledge on catfish recruitment, site preferences and habitat associations.

Water quality

Limited water quality monitoring during the fish surveys indicated that there is some variation across the Lagoon. Conductivity levels at the surface varied from 59.5 to 261 µs/cm, appearing to increase with distance from the main outlet to the lagoon. These levels are well within tolerance ranges for native fish. Dissolved oxygen levels also varied across the lagoon, and were quite low in some areas (i.e. <3.0mg/L), including where there are large infestations of the introduced Yellow Water Lily. Lack of flow and decomposition of organic matter would be contributing to low dissolved oxygen levels. Readings of <3.0mg/L are generally considered to place aquatic life under stress. While Freshwater catfish are able to tolerate low dissolved oxygen levels, the long-term impacts on this species and the fish community as a whole, including effects on breeding success, are not known. In general early life history stages of fish are more susceptible to impacts of poor water quality.

Recommendations in regard to water quality include:

- Establishment of permanent water quality monitoring sites across the lagoon would be beneficial. This would align with a specific recommendation of the Environmental Audit of the Goulburn River (EPA 2005) of establishing permanent water quality monitoring sites in Reach 2 (i.e. Goulburn weir pool and its backwaters.)
- Regular monitoring of water quality within the Lagoon would enable rapid identification of any water quality problems, and thereby guide management. It would also assist in the assessment of the impacts of particular management actions e.g. provision of water to the Lagoon, aquatic weed control etc.
- Options to enable delivery of occasional small volumes of water from the Goulburn River through the Lagoon should be investigated with G-MW. Provision of small volumes of water would potentially assist in maintaining adequate dissolved oxygen levels within the Lagoon.
- Removal of the mass of dead willow material at the end of the lagoon should facilitate improved water quality and flow.
- **Water temperature** – establishment of TIDBIT temperature dataloggers within the lagoon and in the nearby Goulburn River would also be worthwhile to clarify existing water temperature patterns, as well as provide baseline data.

Additional Management Actions for Freshwater catfish

Surveys

- Further fish surveys of other wetlands along the Goulburn River, particularly in the lower Goulburn, which specifically target Freshwater catfish would be worthwhile, to clarify the species' presence within this river system.

Education

- The planned establishment of an interpretive board in the vicinity of the Tahbilk Wetlands Café will outline the ecology of Freshwater catfish and the significance of Tahbilk Lagoon.
- Filming of nest sites at a site in central Victoria, where water clarity is high and gravely substrate is available, is planned for the next breeding season (i.e. October 2008-March 2009). This will provide a visual resource for the Tahbilk Winery and the GBCMA for educational purposes.
- The establishment of a live display of Freshwater catfish, and other fish species which occur within the Lagoon (both native and introduced) should be considered at the Tahbilk Wetlands Café. Educational material could also be developed in association with a display. A permit from the Department of Primary Industries, Fisheries Victoria would be required for such a display.
- While gravely substrates do not currently occur within the Tahbilk Lagoon, it may be worthwhile placing a limited amount of gravel in a defined, shallow area of the Lagoon where the boat cruises frequent. This could potentially allow visitors to see Freshwater catfish nesting and thus build understanding of the habitat requirements and advocacy for the species and for general habitat rehabilitation works. The availability of gravel material could also potentially enhance breeding success within the Lagoon. While it is unknown whether recruitment success is greater where gravely substrates are present, laying eggs between interstices may be a valuable method to enable effective fanning of eggs and removal of sediment, and protection against predators. Regular underwater filming of the

site could document use of the gravel and help assess effectiveness of the supply of such material.
- There is clear potential to promote ecological values and rehabilitation activities within Tahbilk Lagoon and its vicinity through Tahbilk Winery products. Discussions with Tahbilk Winery should consider the potential promotion of specific values including Freshwater catfish and the Watershield on bottle labels.

Genetics
- A genetic analysis of Freshwater catfish material from a range of sites within the Murray-Darling Basin, including Tahbilk Lagoon, is currently underway. The results of this work will assist in determining the significance of this population in the context of the species' overall distribution, including whether the level of genetic variation is too limited.

Radiotracking
- A small radiotracking program of a limited number of Freshwater catfish within the lagoon (i.e. 15-20 fish) could provide an indication of specific habitat usage and movement patterns within the area. If done in association with facilitating passage in and out of the lagoon, this could also provide insight into the ability of Freshwater catfish to negotiate structures. Investigating habitat usage could also clarify whether Freshwater catfish uses or avoids areas with large accumulations of the introduced Yellow Water Lily.

EHNV
- An MDBC project is currently underway to determine whether EHNV is present within defined finfish species in defined river catchments within the Murray Darling Basin. While Victorian catchments and Freshwater catfish are not currently included in this project, there may be potential to expand this project in the future. Samples of Redfin collected from Tahbilk Lagoon have been provided to the MDBC project for analysis. It would be worthwhile determining whether there is any future scope and value in collecting blood from Freshwater catfish within Tahbilk Lagoon to contribute to the MDBC project. No analysis of the susceptibility or occurrence of EHNV within Freshwater catfish has yet been undertaken.

Alien Fish Species

A number of alien fish species are present within the lagoon, in particular a range of size classes of Redfin and Carp. Both species are likely to be detrimental to Freshwater catfish. Tahbilk Lagoon may represent a refuge and suitable breeding site for Carp. Any actions to reduce numbers of alien fish species are likely to be beneficial to Freshwater catfish, through potential reductions in competition, predation, and habitat impacts.

- The draft Tahbilk Lagoon Carp Management Plan (Braysher *et al.* in prep) identifies priority actions relevant to the management of Carp including restoring fish passage, installing Carp harvest systems (Williams' cages), restoring regulated flow by removing woody weeds and reconnecting with the Goulburn River (including consideration of regulators) and installing Carp screens at key locations. Once completed, implementation of recommended actions of the plan should be pursued, in consultation with stakeholders.

Aquatic Weeds

Yellow Water Lily

Yellow Water Lily is currently a significant weed within the Tahbilk Lagoon, which is likely to be detrimental to conditions at the site in general, and specifically to Freshwater catfish and the Watershield.

- Consider options to control Yellow Water Lily, with an emphasis on ensuring there are no adverse impacts on both Freshwater catfish and the Watershield. Undertaking control programs in a number of stages and a patchy approach should limit potential impacts to the threatened species. Risks include spray drift and water quality issues when die off of material occurs.

Willows

- Options to remove the patch of dead and remnant willows in the eastern end of the lagoon should be considered, to potentially improve connection of the eastern end of the lagoon to the Goulburn River. Removal of willows is likely to cause a significant level of disturbance to the streambank and bed and thus should be undertaken to minimise impacts to Freshwater catfish e.g. particularly during the breeding season (October to March).

Land Management

- There is currently minimal access to the lagoon. Fencing of riparian zones should occur to prevent access of grazing animals to the Lagoon.
- Continue to undertake revegetation works, to enhance the quality of the riparian zone, in line with recommendations of Greening Australia, DSE and the GBCMA regarding appropriate species.
- Fencing and revegetation will enhance the associated instream environment, through filtering of runoff and nutrients as well as providing a future source of woody structure. It will also provide habitat to a suite of terrestrial fauna.

Recreational Fishing

The GBCMA Interim Drought Contingency Plan (GBCMA 2007) recommends that recreational fishing should be prohibited at Tahbilk Lagoon.

- Recreational fishing within the Tahbilk Lagoon should continue to be discouraged.

There have been some suggestions that stocking of Golden perch should be undertaken within Tahbilk Lagoon. It would appear that previous stockings have not been successful. Only limited fishing currently occurs within the Lagoon. If fish passage if facilitated, species such as Golden perch would be more likely to move in and out of the Lagoon. Golden perch are common throughout the lower Goulburn River, which provides fishing opportunities for this species in nearby areas.

Demonstration Site

- Continue to consider options to promote Tahbilk Lagoon as a 'Demonstration Reach' wetland, in line with the Murray-Darling Basin Native Fish Strategy program.
- Continue the collaborative approach of management of Tahbilk Lagoon. Recent meetings have established contact between the range of stakeholders involved, and interested, in management of the site. Consideration should be given to holding regular meetings of a core group of stakeholders

Management Regime for Watershield

As is the case with Freshwater catfish, the threatened Watershield appears to be thriving within the Tahbilk Lagoon. While a range of options to rehabilitate and improve conditions in Tahbilk Lagoon should be investigated and implemented, it is important that key characteristics of the site which make it suitable habitat for the Watershield are maintained. Most specifically, lentic or slow flow conditions and warmer water conditions should be maintained.

- Advice from an appropriate flora expert should be sought regarding appropriate management for the Watershield.
- Ecological requirements of Watershield should be investigated to further clarify appropriate management requirements.
- Control of the Yellow Water Lily is likely to be beneficial to the Watershield, if undertaken to minimise any detrimental impacts.

Other Flora and Fauna Values

- Undertake flora and fauna surveys of Tahbilk Lagoon and its surrounds to identify the suite of species which currently occur in the area. This will assist in determining the other values of the site and subsequently guide identification of appropriate management actions.
- Frog surveys should be undertaken between October and April, and would require monthly visits.

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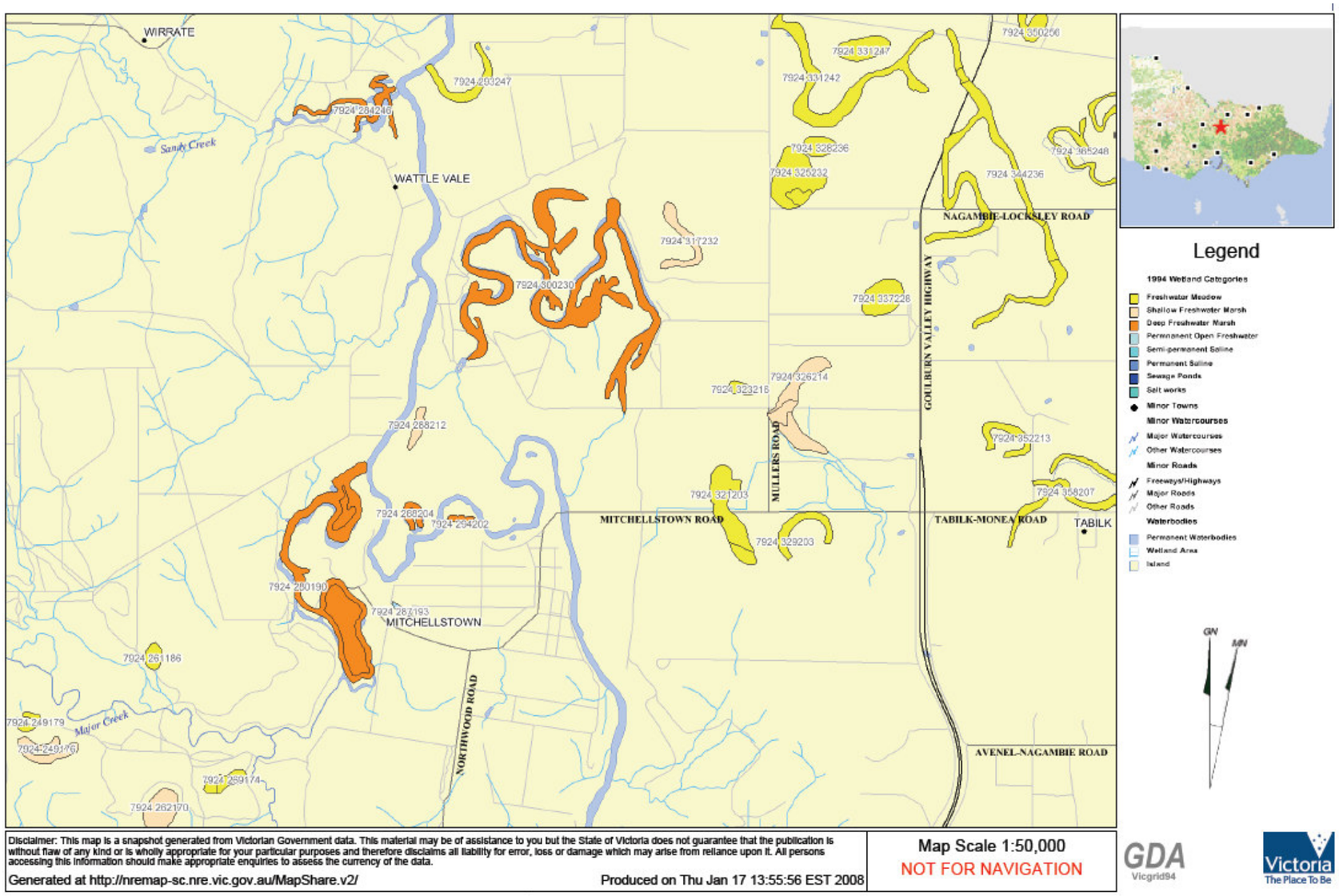
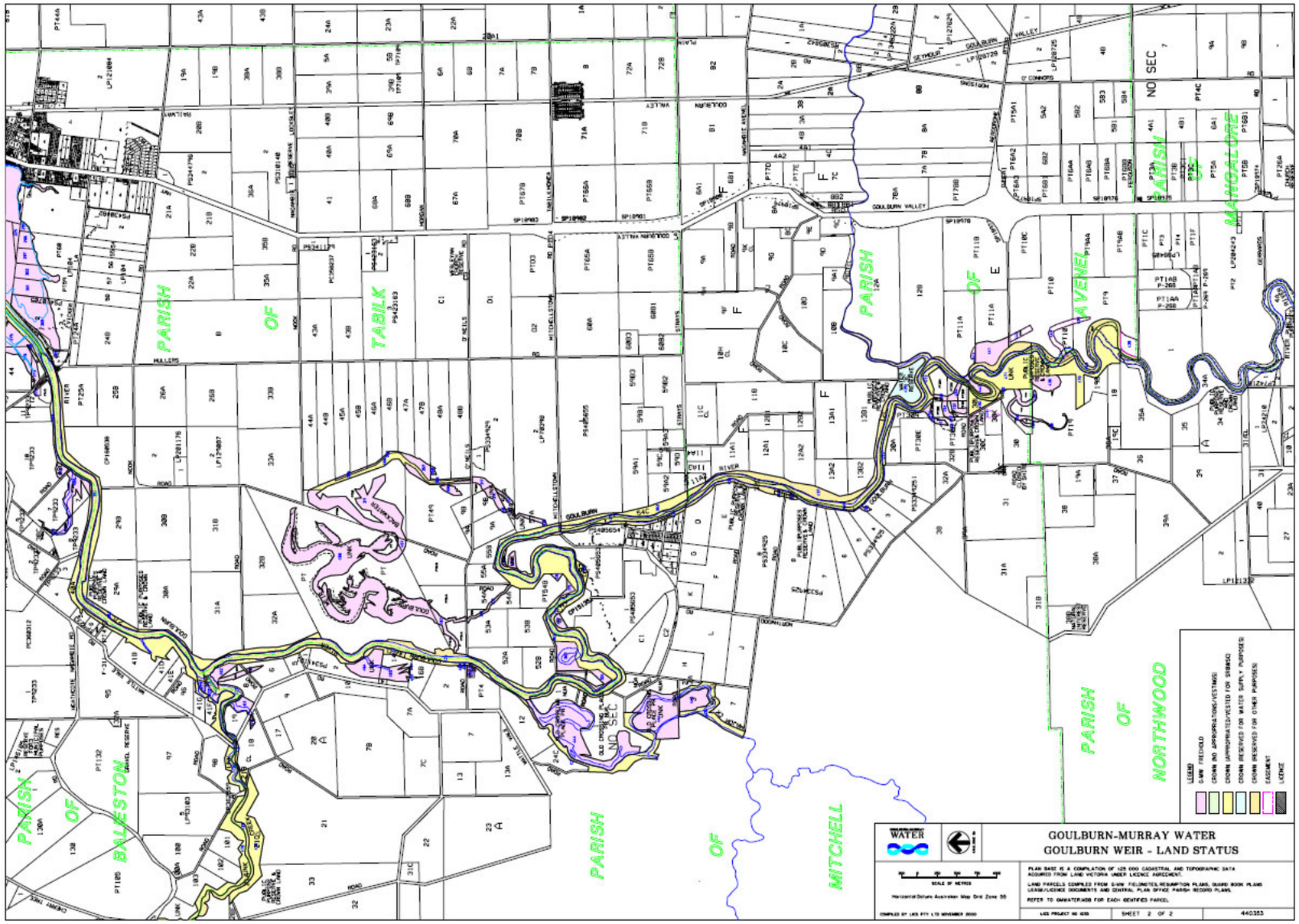
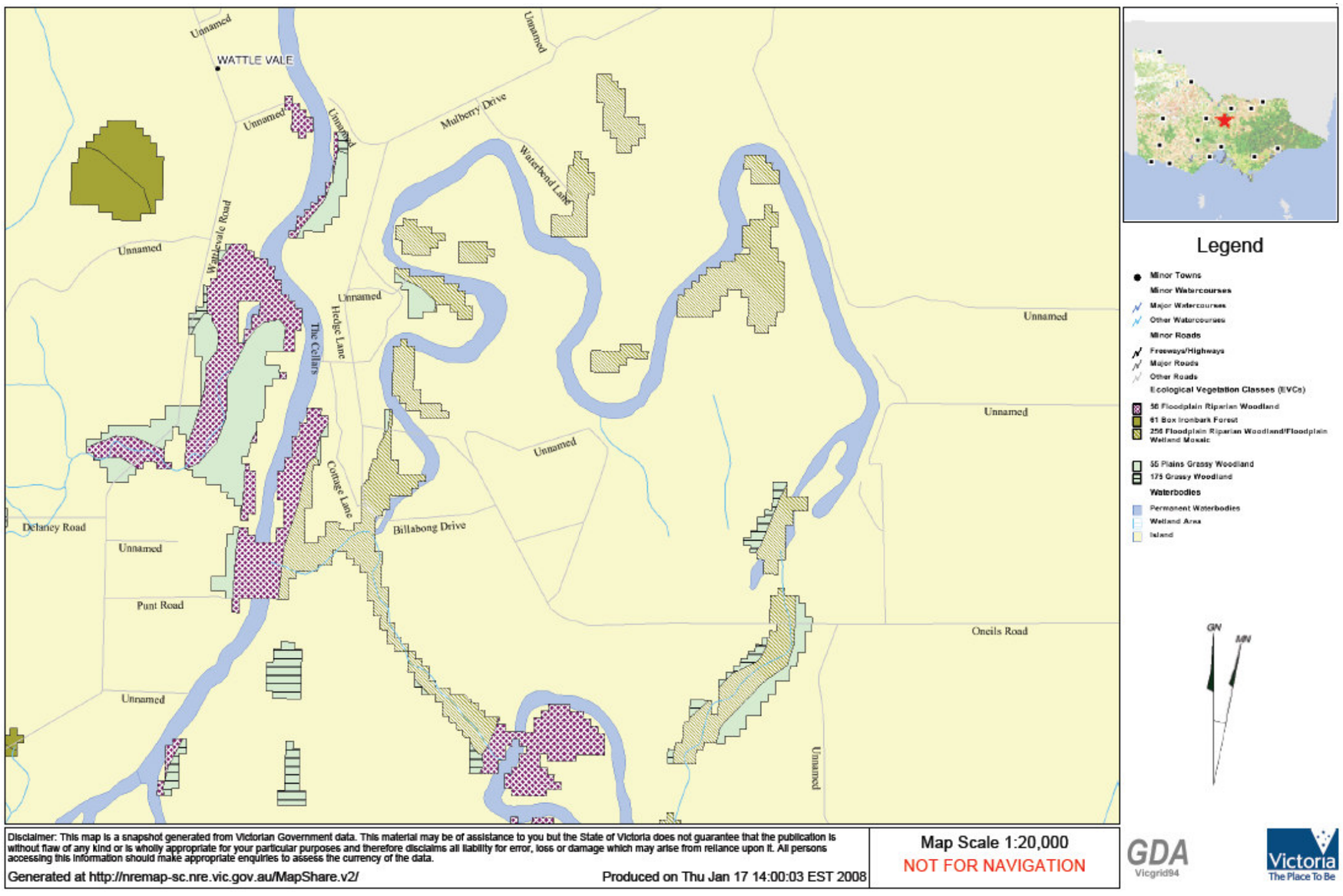
Appendix 1 – DSE Wetland Categories within Tahbilk Lagoon



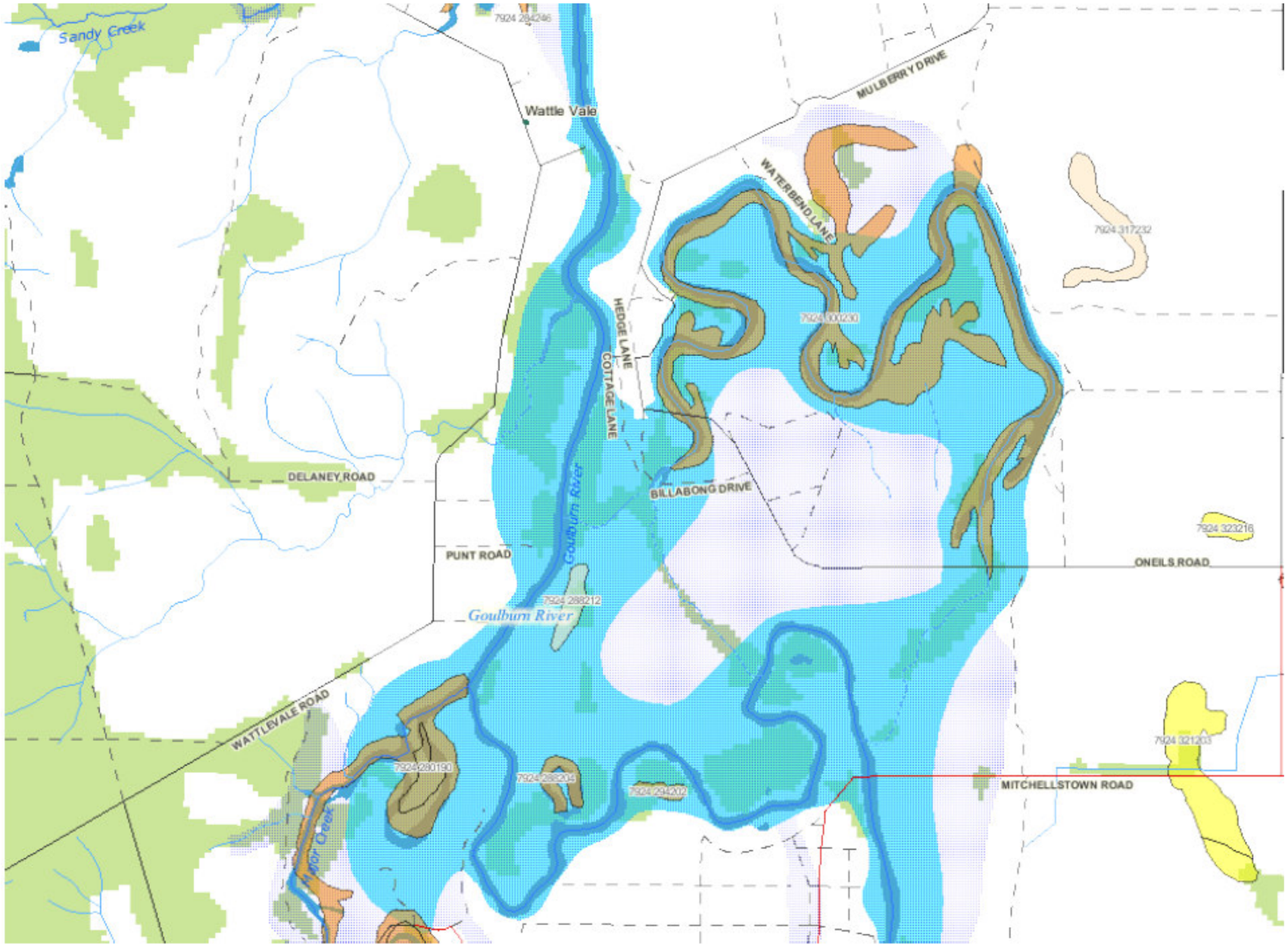
Appendix 2 – Land Tenure around Tahbilk Lagoon (G-MW map)



Appendix 3 – Ecological Vegetation Classes in the vicinity of Tahbilk Lagoon



Appendix 4 – Floodways in the vicinity of Tahbilk Lagoon



Appendix 5 – Habitat descriptions and photos for fyke net sites

Site Number	Grid Ref* (GDA)	Description	Photograph
1	0331270 5922280	Well within large area of abundant Yellow Water Lily (YWL), water restricted to narrow channel at end of lagoon, water approx 1m deep. Ribbon weed also abundant. Emergent stags, snags and stumps.	
2	0331327 5922360	Within but near beginning edge of abundant Yellow Water Lily. At entrance to Yellow Water Lily 'field'. Many standing stags and emergent snags. Water approx 1m deep.	
3	0331504 5922531	Adjacent to moderate-sized Yellow Water Lily patch, but in open water beside bank. Water depth 1.5m.	

4	0331263 5923190	No Yellow Water Lily. Water depth 1.6m. In open water at bank of long clear channel section, adjacent to rush patch along bank. Some instream debris. Gently sloping grassy bank, with River Red Gum (RRG) and grasses.	
5	0331138 5923399	Some instream woody debris, stumps, small patch reeds. Low bank approx 3m high with open River Red Gum, little understorey vegetation. Evident limited grazing.	
6	0330922 5923497	Some instream woody debris. Very low bank approx. 0.5-1.5m, River Red Gum, little understorey vegetation.	
7	0330747 5923072	Good level instream woody debris, reedy patches, water depth approx. 1m. Open River Red Gum on low bank approx. 3m high with little understorey vegetation.	

8	0330606 5922575	Off 'catfish spit', near entrance to side-lagoon. Some instream woody debris. Very low bank with open River Red Gum, some native grasses.	
9	0330420 5922507	Adjacent to 'Mud Bridge.' Good instream woody debris, stumps, large woody debris. Several reed and rush patches. Very low bank with River Red Gum.	
10	0330289 5922821	Tall stands of Cumbungi. Very low bank with River Red Gum separates from another side lagoon which is very shallow and infested with Yellow Water Lily.	
11	0330275 5923053	Amongst Yellow Water Lily. Approx. 20m out from bank, amongst stumps and other instream woody debris. Low bank has River Red Gum and good grassy understorey.	
12	0330008	Good instream woody debris.	

	5923302	Patches of reeds and exotic Iris, patches of YWL. Low 1-2m bank with River Red Gum and good understorey vegetation.	
13	0329512 5923391	Ribbon weed and reeds, plus exotic iris. Moderately steep bank with sparse River Red Gum and poor understorey vegetation.	
14	0329819 5923029	Very good large woody debris. Both Watershield and Yellow Water Lily abundant. At double entrance to another side-lagoon. Low bank with good riparian vegetation (RRG, native grasses).	
15	0329642 5922771	On a channel bend. Both Watershield and Yellow Water Lily abundant, as well as tall rushes. At boundary of YWL in shallow water on outer edge of bend and deeper channel. Dead standing trees, stumps and snags; good instream woody debris. Carp evident (jumping).	
16	0329419 5922680	No lillies or ribbon weed, some Watershield. Below Wetlands Café.	

		Some instream debris. Bank 3-4m high, with RRG.	
17	0329474 5922553	Amongst Watershield, YWL patches nearby, woody debris. Well vegetated, low bank with RRG	
18	0329453 5922503	Deeper water beyond shallow, YWL-filled bank zone. Bank 3-4m high, good instream woody debris.	
19	0329548 5922391	Adjacent to wooden foot bridge. Watershield abundant, good level woody debris. Low bank.	

* Data recorded with handheld Garmin GPS 72