

# Draft Flora and Fauna Guarantee Action Statement

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## Glenelg Freshwater Mussel *Hyridella glenelgensis*

### Description

The Glenelg Freshwater Mussel *Hyridella glenelgensis* (Dennant 1898), is a bivalve mollusc up to 51 mm in length (Playford and Walker 2007). It is one of the smallest species of *Hyridella* (T. Raadik, pers. comm.). The shell is relatively thin, elongate and slightly rhomboid in shape (T. Raadik pers. comm.) with a prominent posterior ridge and low beaks strongly sculptured with V-shaped ridges. The beak sculpture continues across the shell surface, except for the posterior slope, with the ridges of the Vs crossing and appearing as wrinkles. The shell has a flaky covering (periostracum) which is olive-brown in juveniles and dark purple-brown in older individuals (McMichael and Hiscock 1958). Shell sculpture is stronger in juvenile shells and extends beyond the beak (Playford 2005). In older or worn specimens the sculpture is less prominent and the beaks can be eroded, making shell identification difficult (T. Raadik, pers. comm.). A similar hyriid species (nominally *H. narracanensis*) is found at Eight Mile Creek near Port Macdonnell in South Australia, but the taxonomy of this population requires further investigation (Playford and Walker 2007).

Two other bivalve species occur in the Glenelg-Wannon system and small specimens may be confused with *H. glenelgensis*. The large mussel, *Velesunio ambiguus*, grows to about 100 mm and lacks shell or beak sculpture. Small corbiculid bivalves (Family: Corbiculidae) grow to about 10 mm. The shells of both these species are more ovoid or rounded than Glenelg Freshwater Mussel, the profile is also rounded (rather than flattened) and the beak is near the middle of the shell, rather than at one end as in Glenelg Freshwater Mussel.

### Distribution

The Glenelg Freshwater Mussel has been rarely reported and is one of the least-known Australian hyriid mussels. It was described in 1898 from the Glenelg River at Roseneath, Victoria, with early records from 'Wannon Creek' (Hamilton), Crawford River (locality unknown) and 'Port Fairy' (McMichael and Hiscock 1958). There were no records from the late 1920s until 1990, when five individuals were found (Walker 1998; Walker *et al.* 2001). In 2000, a single mussel was located at the same site (M. Hammer, University of Adelaide, pers. comm.). Mussels were searched for and found further downstream in summer 2004-2005 (Walker and Playford 2004).

All known locations are from the Glenelg system, except for two undated (c. 1900-1930) shell specimens labelled 'Port Fairy' (Playford and Walker 2007). All recent records are from the Crawford River. The species may exist elsewhere in the Glenelg system, but this has not been confirmed and there are very few possible areas with suitable habitat. Playford (2005) suggested the Glenelg Freshwater Mussel may be a 'small stream' species as it has not been found in the main channel of the Glenelg River, despite extensive searches by Walker in 1990 (K. Walker, pers. comm. January 2009). The Port Fairy specimens suggest the species may also have historically extended east of the Glenelg system (Playford 2005).

The Crawford River flows through a variety of land tenures including: Hotspur State Forest, Crawford River Regional Park, Lake Crawford Wildlife Reserve (hunting), Public Land Water Frontage, plantations on public land and other Crown land (including several large blocks abutting the river).

### Habitat

At present, the Glenelg Freshwater Mussel is known only from the Crawford River, which is a medium-sized stream with alternating deep pools and shallow, faster flowing sections (Playford and Walker 2007). Freshwater mussels are sedentary and depend on local microhabitat including sediment and water (see Playford 2005).

The mussel is found in shallow and narrow stream stretches characterised by swift-flowing water, dense shade and high riparian cover. The riparian vegetation along the Crawford River includes *Eucalyptus* spp, Blackwood (*Acacia melanoxylon*) and Woolly Tea-tree (*Leptospermum lanigerum*). These species provide shade, buffer water temperatures and reduce growth of algal biofilms. In stream woody debris also stabilises pockets of sediment which provide firm anchoring points for mussels (Playford and Walker 2007). Deep, slow-flowing pools accumulate soft silt which can bury mussels or clog their respiratory, feeding and reproductive organs (Playford and Walker 2007). Mussels are generally absent where stock has damaged banks and riparian vegetation, leading to erosion and soft silty sediment (Walker and Playford 2004).

The Crawford River is recognised as one of the best quality stream stretches in the Glenelg catchment (Victorian Water Resources Data Warehouse), possibly due to its extensive coverage of native vegetation (Versace *et al.* 2008).

## Life history and ecology

Glenelg Freshwater Mussels live partially buried in the sediments with only the hind part of the shell emerging. They burrow using their hard, calcareous shell as a cutting blade and their strong muscular foot as an anchor, feeding on microscopic plankton and detritus using a siphon. Food particles are caught by cilia on large, plate-like gills, entangled in mucus and passed to palps that sort edible material for transfer to the mouth (Walker and Playford 2004).

Freshwater mussels are omnivorous filter feeders and feed across trophic levels on bacteria, algae, detritus, zooplankton, and dissolved organic matter.

The life history of the Glenelg Freshwater Mussel is little known, however it is likely to be similar to other hyriids. The mussel larva, (glochidia), have distinctive hooks and are brooded within the females' gills which are specially shaped to form marsupia (pouches) (Playford and Walker 2007). *Hyridella* species brood through the warmer months and release the glochidia opportunistically (Atkins 1979; Jones *et al.* 1986). The development of eggs and young within each female is synchronous, but different females in a population may contain embryos at different stages (Walker and Playford 2004). Embryogenesis in the related mussel, *H. australis*, requires about eight weeks in summer in a temperate area (Jones *et al.* 1986). Depending on female condition, glochidial release is promptly followed by the release and development of new eggs, ensuring serial clutches through the breeding season. Spawning interval is influenced by floods and changes in water temperature (Jones *et al.* 1986; Byrne 1998), condition of the female and perhaps access to host fish (Walker and Playford 2004). Larger mussels tend to have larger clutches which may number in the 10s or 100s of thousands (Byrne 1998). Once released the glochidia encyst in the gills of fin-fish and undergo a series of metamorphoses before a final transformation to a sediment-dwelling mussel. In Australia, numerous native and introduced fish are hosts for species of *Hyridella* (e.g. Walker *et al.* 2001).

Gender is determined from internal gill structure. Reproductive status can be compromised by hermaphroditism and parasitic infestations (Walker and Playford 2004). Size at sexual maturity is not known, but in related species occurs at 2-4 years of age (Jones *et al.* 1986; Byrne 1998). The population of Glenelg Freshwater Mussels in the Crawford River consists of several cohorts, including juveniles. This suggests reproduction and recruitment has been successful (Playford and Walker 2007). Recruitment in hyriids varies between locations and years. Some hyriid species survive for over 30 years but aging is difficult as the shell ridges generally are not annual 'growth rings' (see Walker and Playford 2004). Growth of *Hyridella* species is usually seasonal and temperature dependent, with little or no activity or growth in winter, as mussels burrow deeper and 'hibernate' (Walker 1981, Sheldon and Walker 1989).

Freshwater mussels affect the structure of their habitat by providing live and dead shells, moving through sediments, filtering particles (including phytoplankton) from the water and depositing organic matter (Vaughn *et al.* 2008, Ogilvie and Mitchell 1995). They therefore have high exposure to toxicants which are readily stored in their tissues (Jeffree *et al.* 1995). For studies on pesticides and other contaminants in mussels see Walker *et al.* (2001). Freshwater Mussels are preyed on by fish, turtles, water rats and birds.

The distributions of freshwater mussel species are likely to be limited by dispersal mechanisms and environmental tolerances of adults, juveniles, glochidia and their fish hosts. Larval and juvenile mussels are probably less tolerant than adults (Walker and Playford 2004). In general, freshwater mussels are confined to salinities less than 3 g/L (Walker 1981, 1998), but tolerances may be much lower for some species.

## Conservation status

### Victorian conservation status

The Glenelg Freshwater Mussel has been listed as "threatened" under the *Flora and Fauna Guarantee Act 1988*.

The Glenelg Freshwater Mussel is considered "critically endangered" in Victoria according to DSE's *Advisory List of Threatened Invertebrate Fauna in Victoria - 2009* (DSE in press).

## Threats

Freshwater mussels are in decline worldwide and they have been described as, 'the most threatened group of freshwater organisms' (Vaughn and Taylor 1999). There is evidence of reductions in both range and abundance in the Australian mussel fauna, and it has been suggested that further decline is imminent (e.g. Sheldon and Walker 1997; Walker *et al.* 2001). Freshwater mussels can live for decades and may recruit sporadically. They live buried in sediments and therefore changes in population structure may not be noticed (Playford 2005). Freshwater mussels, like most invertebrates, are generally not well known by the wider public, and their conservation is not foremost in people's minds (Yen and Butcher 1997).

There are very few Glenelg Freshwater Mussels surviving in a small area, so a stochastic event could possibly cause their extinction. The most serious threat to the Glenelg Freshwater Mussel is decline and destruction of its high quality stream habitat. Since European settlement in 1837 over two thirds of the Glenelg River catchment has been cleared for agriculture (SCA 1981). The quality of habitat is influenced by changes in the wider catchment that affect downstream

sites, and by changes at the actual sites. Maintenance of habitat quality requires actions throughout the catchment to protect both surface and ground water quality and quantity, as well as near-site actions to protect in-stream habitat (sediments, in-stream debris and riparian vegetation). Any further loss of riparian vegetation could significantly undermine habitat values for the mussel.

As a sediment dwelling filter-feeder, Glenelg Freshwater Mussels are particularly susceptible to changes in water conditions. Periods of no flow may limit delivery of food to mussels and high flows may also be detrimental as they destabilise sediment (Playford 2005).

The Crawford River catchment underwent dramatic changes in land use between 1995 and 2005 when the area of land under blue gum plantations expanded from zero to around 18,000 ha (~26% of the sub-catchment area) (SKM 2008). Prior to this softwood plantations had been established on private and public land. Although plantation establishment is now slowing, increases in agricultural cropping of up to 18.5% by 2030 are also predicted (SKM 2008).

Plantations and cropping can affect water conditions as they: alter groundwater flow and recharge; modify stream flow and flow regimes, change sediment load and movement, increase nutrient loads in streams and groundwater, increase chemical pollution and change saline discharge (SKM 2006). The effects of land-use change may take several years to be manifest, even though the changes have already taken place (SKM 2008). These effects may be compounded by predicted climatic change.

Although the Glenelg Freshwater Mussel was historically recorded from several sites in the Glenelg basin and south-west Victoria, it is now only known from the Crawford River; although there may be other unknown populations in the few streams with sufficiently high habitat values elsewhere in the Glenelg catchment. The species is therefore extremely vulnerable to population decline or extinction from catastrophic events including drought (short or long term cessation of flow, low water levels and poor water quality), wildfire and post-wildfire effects (ash, sediment, loss of shade and riparian inputs). Other threats include the decline of riparian vegetation, the impact of chemicals and toxins on water quality, changes in salinity, the introduction of Common Carp, climate change, potential stream bank collapse (with associated increased sedimentation loads) and possibly illegal collection.

<i>Standard threat</i>	<i>Source Of Threat</i>	<i>Explanation</i>
Genetic decline	Genetic decline - other	The Glenelg Freshwater Mussel has an extremely limited distribution which was much larger at European settlement. Despite having active larval hosts, freshwater mussels elsewhere show restricted gene flow between populations (Hughes <i>et al.</i> 2004), suggesting genetic decline may be occurring.
Groundwater - quality Surface water – quality	Groundwater - saline intrusion	Freshwater Mussels are sensitive to changes in water quality and require fresh water (Walker 1981, 1998). Land-use change could cause alterations to the hydrology of the sub-catchment and increase saline discharge (SKM 2006).
Groundwater - quantity	Groundwater - level changes Weather - flood, drought, storms	The Glenelg Freshwater Mussel probably relies on spring discharges to maintain water quality during dry periods. Reduction of groundwater levels could reduce discharge, drying habitats. This may be due to climatic change, or altered use of groundwater resources.
Habitat damage, loss or fragmentation	Animals - introduced herbivores Recreational activities	Glenelg Freshwater Mussels only occur where there is good riparian cover. Introduced livestock can graze or trample riparian vegetation, deposit faeces and pug up the river bank (Walker and Playford 2004) and instream shallows damaging the mussels and their habitat. Camping, bait collecting and fishing can also trample banks and contribute sediment and untreated effluent if not properly managed.
Habitat damage, loss or fragmentation	Animals – introduced predators	Common Carp ( <i>Cyprinus carpio</i> ) have been identified in the upper Glenelg catchment (MDBC c.2005). They threaten Glenelg Freshwater Mussels through alteration of habitat, direct predation and effects on fish fauna which host mussel glochidia.
Habitat damage, loss or fragmentation	Fire - wildfire	Wildfire in the subcatchment could result in loss of riparian cover and would allow increased inputs of sediment, nutrient runoff and changes to water quality and quantity.
Habitat damage or loss	Waterways - sedimentation or siltation	The Glenelg catchment is one of the most heavily eroded in Victoria, with eroded sediment filling many of the deeper pools (SKM 2001). Seventy percent of the tributaries of the Glenelg River are rated as being in 'poor'

		<p>to 'very poor' condition (SKM 2001). This severely restricts the areas that are suitable habitat for Glenelg Freshwater Mussels.</p> <p>There is a possibility that stream banks might collapse as a result of decreased rainfall and changes to water regimes leading to increased sedimentation.</p> <p>The 'Boulevard', and other unsealed roads in the Crawford River Regional Park can contribute sediment during road works or severe rainfall events.</p>
Loss of important habitat features	Fish host species	The Glenelg Freshwater Mussel relies on a fish host for its larval stage. Factors which affect the fish host will also affect the mussel.
Pollution/toxins	<p>Agricultural chemicals / effluent</p> <p>Timber plantations</p> <p>Recreational activities</p>	<p>Mussels are filter feeders and accumulate nutrients, pesticides and heavy metals from water (Walker <i>et al.</i> 2001). They pass these toxins on when they are preyed upon by birds, fish and/or mammals. The relationships between laboratory data on toxin levels and field exposure are not clear and each life stage has different exposures and sensitivities. Exposure routes include sediment, pore water (water between sediment particles), diet and surface water (Cope <i>et al.</i> 2008).</p> <p>Chemicals are used routinely in agriculture and in the establishment and maintenance of timber plantations in the catchment, but there has been little investigation of their effects on aquatic invertebrates including Glenelg Freshwater Mussel.</p> <p>The Crawford River Regional Park has numerous camp sites beside the river which may contribute pollutants.</p>
<p>Surface water - quality</p> <p>Surface water - quantity</p> <p>Groundwater - quantity</p>	<p>Timber plantations</p> <p>Land use changes - other</p>	<p>Between 1995 and 2005 the area of blue gum plantations in the Crawford basin expanded from zero to around 18,000 ha (~26% of the sub-catchment area). Only incremental change in the blue gum plantation area is anticipated beyond 2010 (SKM 2008). The volume of water available for surface water flow or recharge of deep aquifers is predicted to fall from about 90,000 ML/y (1990 land use conditions) to less than 60,000 ML/y or even less than 40,000 ML/y (SKM 2008). This is likely to affect flow of the Crawford River, particularly during low flow periods. No flow months could increase to as much as 30% of months (SKM 2008).</p> <p>Softwood plantations occur on private and public land adjacent to the Crawford River. In addition to effects on water quantity, plantation establishment (now largely completed), maintenance and harvesting could also influence water quality.</p> <p>There is also a prediction that cropping may expand from less than 1% of the catchment in 1990 to 18.5% (almost 13,000 ha) in 2030 (SKM 2008).</p>
<p>Surface water - quality</p> <p>Surface water - quantity</p> <p>Groundwater - quantity</p>	Timber harvesting	<p>Timber harvesting of plantations and native forests affects sediment, nutrients and other aspects of water quality and quantity (Campbell and Doeg 1989). Research indicates buffers of at least 50 m from waterways may be required to protect macro invertebrates (Barton and Davies 1993). Further research is needed to determine the appropriate width of buffer zones and enable the development of guidelines for the Crawford River subcatchment. The Victorian Code of Practice for timber production (DSE 2007) provides some protection to waterways during establishment, maintenance and harvesting of plantations, however the filter feeding habit of the Glenelg Freshwater Mussel makes it more vulnerable to declines in water quality and quantity. Current guidelines recommend buffers of only 20 m on streambanks. Stronger guidelines and larger buffers for the Crawford River subcatchment may benefit the mussels.</p>
Surface water – quality/regime	<p>Weather - flood, drought, storms</p> <p>Weather - climate change</p> <p>Water - level /</p>	<p>The Crawford River is one of only two stream stretches in the Glenelg catchment with an Index of Stream Condition score of 'good' or better (Victorian Water Resources Data Warehouse).</p> <p>Flow has been recorded in the Crawford River every month since 1970 until September 2005. In the following three years, zero flow was</p>

	flow changes	<p>recorded for six monthly totals indicating an increasingly dry river. This is of great concern and both climatic change and land-use change (see SKM 2008) are likely to further dry the river in the future.</p> <p>Studies of other mussel species found that drought conditions affected mussels directly and indirectly. Density declined regardless of whether the channel dried completely or remained wet but not flowing, whereas flowing streams maintained populations. Populations with higher pre-drought abundance were more likely to survive. Mussels are sensitive to low dissolved oxygen, warm temperatures and high biological oxygen demand (see Haag and Warren 2008).</p> <p>In dry periods, the Crawford River forms a series of deep pools with little or no flow between them. Although some aquatic species can seek refuge in the deeper pools, Glenelg Freshwater Mussels in dried sections are unlikely to survive.</p>
Taking by humans	Collection/harvesting of target species	<p>Direct loss of Glenelg Freshwater Mussels if harvested for food, bait, or by shell collectors.</p> <p>Excessive harvesting of fish species which are hosts for the larval stage of Glenelg Freshwater Mussel.</p>

### Important populations

<i>Location name</i>	<i>Land manager</i>	<i>Catchment</i>	<i>Bioregion</i>
Crawford River	various	Glenelg-Hopkins	Glenelg Plain

### Past management actions

The most significant conservation action to date was a review the biology and ecology of the species which confirmed it is still present in the Crawford River. The Glenelg Shire Planning Scheme includes an Environmental Significance Overlay on the lower Crawford River which aims to: maintain environmental diversity and quality of the water ways, prevent inappropriate development adjacent to the water way and prevent pollution of the water ways and degradation of habitat (Glenelg Planning Scheme ESO2). There are also a range of actions implemented by the Glenelg-Hopkins CMA across the Glenelg catchment to protect and improve habitat including management of carp.

<i>Action</i>	<i>Result explanation</i>
Conduct survey to determine abundance/extent of population	A report was commissioned from Playford and Walker (Adelaide University) to review the status, biology and ecology of Glenelg Freshwater Mussel, and was published as Playford and Walker (2007).
Develop or amend planning scheme overlays and schedules	The Crawford River has a linear Environmental Significance Overlay (ESO) from upstream of Hotspur to Dartmoor.

### Conservation objectives

#### Long term objective

To ensure that the Glenelg Freshwater Mussel can survive, flourish, and maintain its potential for evolutionary development in the wild.

#### Objectives of this Action Statement

- To increase the number of populations or individuals.
- To increase knowledge of biology, ecology or management requirements
- To secure populations or habitat from potentially incompatible land use or catastrophic loss
- To increase community awareness and support
- To increase the extent of habitat
- To improve condition of habitat

## Intended management actions

The intended management actions listed below are further elaborated in DSE's Actions for Biodiversity Conservation (ABC) system. Detailed information about the actions and locations, including priorities, is held in this system and will be provided annually to land managers and other authorities.

<i>Standard objective</i>	<i>Targets</i>	
To increase the number of populations or individuals.	<ul style="list-style-type: none"> <li>Population recruitment occurs successfully (gain of reproductively mature adults), at least once every 2-3 years.</li> <li>Captive management techniques evaluated.</li> <li>Reintroduction sites identified and plan developed.</li> </ul>	
<i>Action</i>	<i>Details</i>	<i>Responsible agents</i>
Maintain captive populations for research	<p>Investigate requirements for captive holding of populations and develop strict protocols.</p> <p>Monitor river flows and collect vulnerable Glenelg Freshwater Mussel individuals during low flow periods when localised extinctions are likely.</p> <p>Investigate captive breeding for potential reintroductions.</p>	DSE Statewide Services – South West
Identify potential sites for reintroduction / translocation	Identify potential sites within the Mussel's former range for reintroduction.	DSE Statewide Services – South West
Prepare a plan for reintroduction / translocation	Prepare plan for reintroduction. Define the biological, physico-chemical, physical and genetic considerations of reintroduction that would need to be considered and commission research into these. .	DSE Statewide Services – South West

<i>Standard objective</i>	<i>Targets</i>	
To increase knowledge of biology, ecology or management requirements.	<ul style="list-style-type: none"> <li>Demonstrable increase in knowledge of the biology, ecology and distribution of the Glenelg Freshwater Mussel, the threats and processes that aid in management and recovery of the species.</li> </ul>	
<i>Action</i>	<i>Details</i>	<i>Responsible agents</i>
Analyse population trends.	<p>Define a specific, effective and sensitive sampling protocol (based upon the work of Playford and Walker) and train staff.</p> <p>Undertake quantitative surveys to check if recruitment is still occurring. Analyse data and interpret any trends.</p>	DSE Statewide Services – South West
Assess habitat characteristics and/or condition.	Collect habitat data of known and any new populations (as per Playford 2005) so critical habitat variables can be determined.	DSE Statewide Services – South West
Assess threats.	At each Glenelg Freshwater Mussel site, or confirmed previous record site, assess threats (including the catchment). Review at each site visit.	DSE Statewide Services – South West
Conduct survey to locate additional populations.	Survey locations where the Glenelg Freshwater Mussel was previously recorded. Check additional sites with similar habitat features for populations (see above for sampling protocol).	DSE Statewide Services – South West
Conduct survey to locate suitable habitat.	Assess previous locations and sites with similar habitat features as potential relocation sites.	DSE Statewide Services – South West
Ensure records of species, communities and locations are documented on the relevant databases	Add all known records to Atlas of Victorian Wildlife and Biosites databases.	DSE Statewide Services – South West

Review conservation status	Review Victorian conservation status. Assist groups/individuals preparing nominations for EPBC listing or IUCN listing.	DSE Statewide Services – South West
Undertake genetic research	Commission research into taxonomy of the Glenelg Freshwater Mussel including what material can be taken non-destructively from mussels (or dead shells) to use for genetic work, definition of <i>Hyridella</i> species boundaries in south-east Australia, potential for hybridisation and taxonomic issues.	DSE Statewide Services – South West
Undertake research to identify key biological functions	Commission research into fish hosts of larval stage and how this affects distribution and recruitment of the Glenelg Freshwater Mussel, and any captive management. Commission research into aspects of life history including settlement, movement etc.	DSE Statewide Services – South West

<i>Standard objective</i>	<i>Targets</i>	
To secure populations or habitat from potentially incompatible land use or catastrophic loss.	<ul style="list-style-type: none"> <li>No avoidable loss or significant damage to Glenelg Freshwater Mussel populations or habitat.</li> <li>All agencies and landholders provided with information regarding the significance and management requirements of the Glenelg Freshwater Mussel.</li> </ul>	
<i>Action</i>	<i>Details</i>	<i>Responsible agents</i>
Amend Crown land reservation.	<p>Investigate consolidation of Crown land tenures (including Public Land Water Frontage) to form a 'Crawford River Streamside Reserve'.</p> <p>Review the classification of the Crawford River Regional Park to ensure that the reservation status can offer protection to Glenelg Freshwater Mussel and other significant species and communities.</p>	DSE Statewide Services – South West
Assess threats.	Work with the Shire and Glenelg Hopkins CMA to ensure applications to develop or conduct works or activities in the subcatchments which support Glenelg Freshwater Mussel habitat are referred to DSE for assessment to minimise impacts on species.	DSE Statewide Services – South West, Glenelg Shire, Glenelg Hopkins CMA
Develop or amend planning scheme overlays and schedules.	<p>Investigate modifying the ESO to include subcatchments of the lower Crawford River.</p> <p>Ensure environmental overlays in the planning scheme protect habitat of Glenelg Freshwater Mussel, riparian vegetation at least 100 m either side of stream and two kilometres upstream, and integrity of catchments.</p>	Glenelg Shire
Develop/revise management prescriptions and/or zoning for State forest	<p>Ensure the staff of DSE Land and Fire are aware of presence and requirements of Glenelg Freshwater Mussel.</p> <p>Review and if appropriate amend zoning within adjacent State forests.</p> <p>Work with DSE Land and Fire to develop specific guidelines for the Crawford catchment to minimise any potential impacts of forest operations on the mussel.</p>	DSE Statewide Services – South West
Develop, provide input to or implement park, reserve or land management plan	<p>Identify waters in Crawford River Regional Park which support Glenelg Freshwater Mussels and ensure management of the park considers the species.</p> <p>DSE to assist PV to prepare a management statement for the Crawford River Regional Park that highlights values and management actions to protect them.</p>	DSE Statewide Services – South West, Parks Victoria
Ensure confidentiality of the item's location	Exact locations of populations to remain confidential.	DSE Statewide Services – South West

Establish/maintain Recovery Team	Establish recovery team with members from DSE, researchers, GHCMA and others as required	DSE Statewide Services – South West
Liaise with government agencies	Liaise with Glenelg Shire re implementation of ESO and consideration of the Glenelg Freshwater Mussel when relevant in planning applications.  Liaise with Glenelg Shire and DPI re predicted rise in cropping in catchment and how this is managed.	DSE Statewide Services – South West
Liaise with government agencies	Ensure statutory bodies responsible for extraction of water from Crawford River catchment are aware of the Glenelg Freshwater Mussel.  With Glenelg Hopkins CMA, liaise with Wannon Water on groundwater and surface water extractions with regard to their effect on water quality (temp, DO, conductivity) and quantity. This is particularly important during periods of low flow and drought.	DSE Statewide Services
Liaise with private landholders	Contact landholders along Crawford River about mussel and its requirements; either directly, or through Landcare facilitator/group.	DSE Statewide Services – South West
Manage the impact of commercial harvesting of plants	Ensure the forestry industry is aware of the presence and requirements of the Glenelg Freshwater Mussel. Work with DSE Land and Fire and private forestry industry to develop specific guidelines for the Crawford catchment to minimise any potential impacts on the Mussel.	DSE Statewide Services – South West
Provide input into regional fire management and operations plans	Ensure that the species' requirements are considered in fire management and operations plans.	DSE Statewide Services – South West
Provide input to other regional plans	Ensure that the species' requirements are considered in catchment management plans, fisheries management plans and other plans relevant to the species.	DSE Statewide Services – South West

<i>Standard objective</i>	<i>Targets</i>	
To increase community awareness and support.	<ul style="list-style-type: none"> <li>All relevant organisations, landholders and other stakeholders understand the requirements of the Glenelg Freshwater Mussel.</li> </ul>	
<i>Action</i>	<i>Details</i>	<i>Responsible agents</i>
Develop, publish and distribute educational, technical or publicity material and/or displays.	Ensure that invertebrates, especially the Glenelg Freshwater Mussel are included in interpretation and publicity material.  Prepare fact sheet for distribution to researchers, naturalists, local landholders and anglers (via angling clubs and DPI field staff).	DSE Statewide Services – South West
Liaise with government agencies	Ensure that DSE, PV, DPI, Southern Rural Water, Glenelg Hopkins CMA, Glenelg Shire, EPA, CFA and Landcare groups working in the Crawford catchment are aware of the Glenelg Freshwater Mussel, its management requirements and the need to report sightings to the Victorian Biodiversity Atlas.	DSE Statewide Services – South West

<i>Standard objective</i>	<i>Targets</i>
To increase the extent of habitat.	<ul style="list-style-type: none"> <li>Measurable increase in the extent of riparian habitat in catchments where Glenelg Freshwater Mussel occurs, based on comparisons of aerial photography or other appropriate imagery.</li> </ul>

<i>Action</i>	<i>Details</i>	<i>Responsible agents</i>
Fence to allow natural regeneration.	Work with landholders to provide funding/advice to fence private land riparian zones along the Crawford River to allow regeneration/planting to restore riparian vegetation. Undertake restoration to establish buffer zones either side of the stream, and two kilometres upstream where possible (Diamond and Serveiss 2001 in Playford 2005).	Glenelg Hopkins CMA

<i>Standard objective</i>	<i>Targets</i>
To improve condition of habitat	<ul style="list-style-type: none"> <li>Demonstrable improvement in the biological and physical quality of riparian zones and instream habitat in catchments where Glenelg Freshwater Mussel occurs, based on comparisons of Index of Stream Condition assessments.</li> </ul>

  

<i>Action</i>	<i>Details</i>	<i>Responsible agents</i>
Control introduced animals.	<p>Include the Crawford River in a monitoring programme for Common Carp in the Glenelg basin. Control of Common Carp in the Crawford River is a high priority as it is one of the few waterways with a high stream condition index remaining in the Glenelg system.</p> <p>Undertake control of Common Carp to prevent them moving into the Crawford River.</p> <p>Assess potential impacts of Common Carp on the Glenelg Freshwater Mussel.</p>	Glenelg Hopkins CMA, DPI
Maintain vegetation structure.	Work with landholders to provide funding/advice to fence private land riparian zones of Crawford River to protect existing riparian vegetation. Buffers either side of stream and two kilometres upstream where possible.	DSE Statewide Services – South West
Manage the inappropriate use of pesticide/herbicides and non-target impacts.	Work with landholders, forestry companies and DPI to ensure best practice is developed and followed in the Crawford River catchment and that they are aware of Glenelg Freshwater Mussel and its ecology.	DSE Statewide Services – South West

It should be noted that several other threatened species and communities occur in the same area as the Glenelg Freshwater Mussel including: Glenelg Spiny Freshwater Crayfish (*Euastacus bispinosus*), Variegated Pigmy Perch (*Nannoperca variegata*) and Yarra Pigmy Perch (*Nannoperca obscura*) and Curly Sedge (*Carex tasmanica*). The protection and revegetation of riparian zones and the subcatchments of the lower Crawford River is likely to improve habitat quality for all of these species.

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## References

- Atkins L. 1979. Observations on the glochidial stage of the freshwater mussel *Hyridella* (*Hyridella*) *drapeta* (Iredale) (Mollusca: Pelecypoda). *Australian Journal of Marine and Freshwater Research* **30**, 411–416.
- Barton, J. L. and Davies, P. E. 1993. Buffer strips and streamwater contamination by atrazine and pyrethroids aerially applied to *Eucalyptus nitens* plantations. *Australian Forestry* **56**(3), 201-210.
- Byrne, M. 1998. Reproduction of river and lake populations of *Hyridella depressa* (Unionacea: Hyriidae) in New South Wales: implications for their conservation. *Hydrobiologia* **389**, 29-43.
- Campbell, I. C. and Doeg T. J. 1989. Impact of timber harvesting and production on streams: A review. *Australian Journal of Marine and Freshwater Research* **40**, 519-39
- Cope, W. G., Bringolf, R. B., Buchwalter, D. B., Newton, T. J., Ingersoll, C. G., Wang, N., Augspurger, T., Dwyer, F. J., Barnhart, M. C., Neves, R. J. and Hammer, E. 2008. Differential exposure, duration, and sensitivity of unionoidean bivalve life stages to environmental contaminants. *Journal of the North American Benthological Society*, **27**(2), 451-462.
- Diamond, J. M., and Serveiss, V. B. 2001. Identifying sources of stress to native aquatic fauna using a watershed ecological risk assessment framework. *Environmental Science and Technology* **35**, 4711-4718.
- Dennatt J. 1898. Description of a new species of *Unio* from the River Glenelg. *Proceedings of the Royal Society of Victoria* **10**, 112–113.
- DSE (2007) *Code of Practice for timber production*. Department of Sustainability and Environment, Melbourne.

- DSE (in press) Advisory List of Threatened Invertebrate Fauna in Victoria- 2009. Department of Sustainability and Environment., East Melbourne, Victoria
- Haag, W. R., Warren Jr., M. L. 2008. Effects of severe drought on freshwater mussel assemblages. *Transactions of the American Fisheries Society*, **137**(4): 1165-1178
- Hughes, J., Baker, A. M., and Bartlett, C. 2004. Past and present patterns of connectivity among populations of four cryptic species of freshwater mussels *Velesunio* spp. (Hyriidae) in central Australia. *Molecular Ecology*, **13**(10): 3197-3212.
- Jeffree, R., Markich, S. and Brown, P. 1993. Comparative accumulation of alkaline-earth metals by two freshwater mussel species from the Nepean River, Australia - Consistencies and a resolved paradox. *Australian Journal of Marine and Freshwater Research* **44**: 609-634.
- Jones H., Simpson, R. D. and Humphrey, C. L. 1986. The reproductive cycles and glochidia of freshwater mussels (Bivalvia: Hyriidae) of the Macleay River, northern New South Wales, Australia. *Malacologia* **27**: 185–202.
- McMichael D. F. and Hiscock I. D. 1958. A monograph of the fresh water mussels (Mollusca: Pelecypoda) of the Australian Region. *Australian Journal of Marine and Freshwater Research* **9**: 372–507.
- Murray Darling Basin Commission (c. 2005). MDBC Native Fish Strategy, Annual Implementation Report 2004–2005. [http://www.mdbc.gov.au/subs/annual\\_reports/NFS\\_Annual\\_implementation\\_report2004-05/annexes/vic/vic4.htm](http://www.mdbc.gov.au/subs/annual_reports/NFS_Annual_implementation_report2004-05/annexes/vic/vic4.htm)
- Ogilvie, S. C. and Mitchell, S. F. 1995. A model of mussel filtration in a shallow New Zealand lake, with reference to eutrophication control. *Archiv für Hydrobiologie*, **133**(4), 471-482.
- Playford, T. J. 2005. Conservation Status of the Endangered Glenelg River Mussel *Hyridella glenelgensis* (Dennant 1898) (Unionoida: Hyriidae) Honours Thesis, School of Earth and Environmental Sciences DP312, The University of Adelaide, SA 5005, Australia
- Playford, T. J. and Walker, K. F. 2007 Status of the endangered Glenelg River Mussel *Hyridella glenelgensis* (Unionoida: Hyriidae) in Australia. *Aquatic Conservation: Marine and Freshwater Ecosystems* **18**(5): 679-691.
- Sheldon, F. and Walker, K. F. 1989. Effects of hypoxia on oxygen consumption by two species of Freshwater Mussel (Unionacea : Hyriidae) from the River Murray. *Aust. J. Mar. Freshwater Res.*, **40**, 491-499.
- SCA (1981) *Glenelg Catchment project / Soil conservation*. Soil Conservation Authority: Kew, Victoria
- SKM ( 2001) *Stressed Rivers Project - Environmental flows study*. Sinclair Knight Merz ,Armadale, Victoria.
- SKM ( 2006) *Water and land use change study. Opportunities for land use planning to influence land use change and its outcomes*. Report to Glenelg Hopkins Catchment Management Authority and Water and Land Use Change Steering Committee. Project VW03647.
- SKM (2008) *Water and land use change in the catchment of the Crawford River*. Bendigo, Victoria.
- Vaughn, C. C., Nichols, S. J., Spooner, D. E. 2008. Community and foodweb ecology of freshwater mussels. *Journal of the North American Benthological Society*, **27**(2), 409-423.
- Vaughn, C. and Taylor, C 1999. Impoundments and the Decline of Freshwater Mussels: a Case Study of an Extinction Gradient. *Conservation Biology* **13**, 912-920.
- Versace, V.L., Ierodiaconou, D., Stagnitti, F., Hamilton, A. J., Walter, M.T., Mitchell, B. & Boland, A.M. 2008. Regional-scale models for relating land cover to basin surface-water quality using remotely sensed data in a GIS. *Environmental Monitoring and Assessment*, **142**(1-3): 171-184.
- Walker K. F., Byrne, M., Hickey, C. W. and Roper, D. S. (2001) Freshwater mussels (Hyriidae) of Australasia. In: Bauer, G. and Wächtler, K. (eds), *Ecology and Evolution of the Freshwater Mussels Unionoida*. Springer, Berlin: 5-31.
- Walker, K. F. and Playford, T. J. 2004. Investigations of the Glenelg Mussel, *Hyridella glenelgensis*. Interim Report to the Glenelg Hopkins Catchment Management Authority. University of Adelaide.
- Walker, K. F. 1981. *Ecology of freshwater mussels in the River Murray*. Australian Water Resources Council Technical paper 63, 119 pp.
- Walker, K. F. 1998. Molluscs of inland waters. In Beesley, P. L., Ross, G. J. B., and Well, A. (eds) *Molluscs: The southern synthesis*. pp. 59-65. CSIRO: Melbourne.
- Yen, A., and Butcher, R. 1997. *An overview of the conservation of non-marine invertebrates in Australia*. Environment Australia: Canberra.

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