Resnagging Guidelines for the Lower River Murray

Department for Environment and Water
March, 2021

Government of South Australia
Department for Environment and Water

Department for Environment and Water
Government of South Australia
April 2021

81-95 Waymouth St, ADELAIDE SA 5000
Telephone +61 (8) 8463 6946
Facsimile +61 (8) 8463 6999
ABN 36702093234

www.environment.sa.gov.au

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ISBN 978-1-925964-87-5

Preferred way to cite this publication

Dec E, & Marklund, M (2021). *Resnagging Guidelines for the Lower River Murray,* DEW Technical report 2021/04, Government of South Australia, Department for Environment and Water, Adelaide.

Foreword

Habitat degradation due to historical removal of instream woody habitat (commonly referred to as snags) is thought to have greatly contributed to declines in native fish populations. Many Australian fish species now experience restricted habitats, which are reduced to small and highly fragmented populations, leaving them increasingly vulnerable to extreme environmental events. It is currently understood that the Lower River Murray is at its maximum carrying capacity, meaning that without the introduction of new habitat there will be no natural way to replenish native fish populations.

Community groups particularly fishing groups have been interested in resnagging reaches of the Lower River Murray for some time. As such, the attraction of the Department for Environment and Water's recent resnagging projects has been far higher than anticipated. Interest groups have since contacted the agency expressing their desire to assist or undertake their own projects. However, rebuilding this important habitat can be a complex process and requires considerable skills and knowledge to enable project delivery. Whilst community groups are keen to lead in the delivery of resnagging works, many lack the capacity to do so.

These Guidelines have been prepared for organisations and interest groups to plan for projects that focus on re-introducing snags as a type of instream habitat restoration. The Guidelines include recommendations and considerations for site selection, approvals, technical and equipment requirements, work health and safety obligations and risk management requirements. Other constructed habitat restoration designs, such as fish hotels and lunkers are not included in the guidelines but may be subject to similar considerations.

Images above: Rootballs and timber used for a resnagging in the River Murray adjacent to Banrock Station Wetland.

Contents

What are snags?

Snags represent favoured habitat for a range of riverine animals, particularly native fishes. In the River Murray, snags typically comprise of whole trees or their limbs, trunks and root masses that have fallen, or been washed, into rivers, anabranches or creeks. These may be partly, fully or intermittently submerged by water, and generally are the result of natural tree death and events like flooding, storms and droughts.

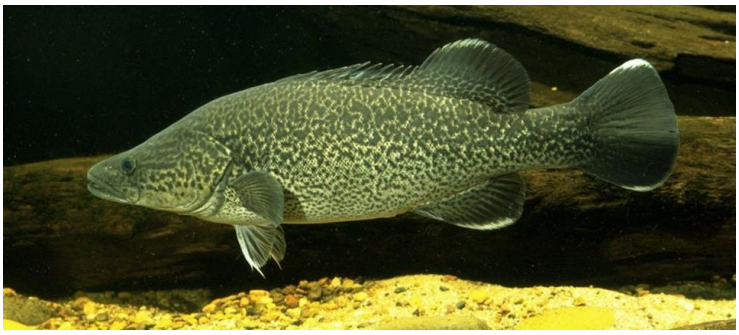


Figure 1: Image of a Murray cod in a snag

Restoring in-stream habitat by resnagging the River Murray

Riverland communities are closely connected to the River Murray and rely on it for economic, social, cultural and recreational well-being. Over time, the health of the River Murray has been significantly affected by river regulation, over-use of water resources and drought. Resnagging projects are undertaken to rebuild in-stream woody habitat as a means to restore the ecology of the River Murray. In time and with continued effort, resnagging projects will support the increase of local fish populations and contribute to sustaining native fish for future generations.

Why resnag the Murray River?

Figure 2: New snags in the Murray River adjacent to Banrock Station Wetland, South Australia

Historically, the South Australian River Murray was de-snagged to aid boat navigation, reduce flood damage and beautify the river. In the 1990s, this practice was abolished as it became clear that snags played an important role in creating riverine habitat.

Habitat degradation due to historical removal of snags is thought to have greatly contributed to declines in native fish populations, which have reduced by more than 90% across Australia since European colonisation (MDBA 2020 as cited in MDBA 2003). Many Australian species now experience restricted habitats which are reduced to small and highly fragmented populations, leaving them increasingly vulnerable to extreme environmental events.

The Lower River Murray is now at its maximum carrying capacity, meaning that without the introduction of new habitat, there is no natural way to replenish native fish populations.

What are the benefits of resnagging?

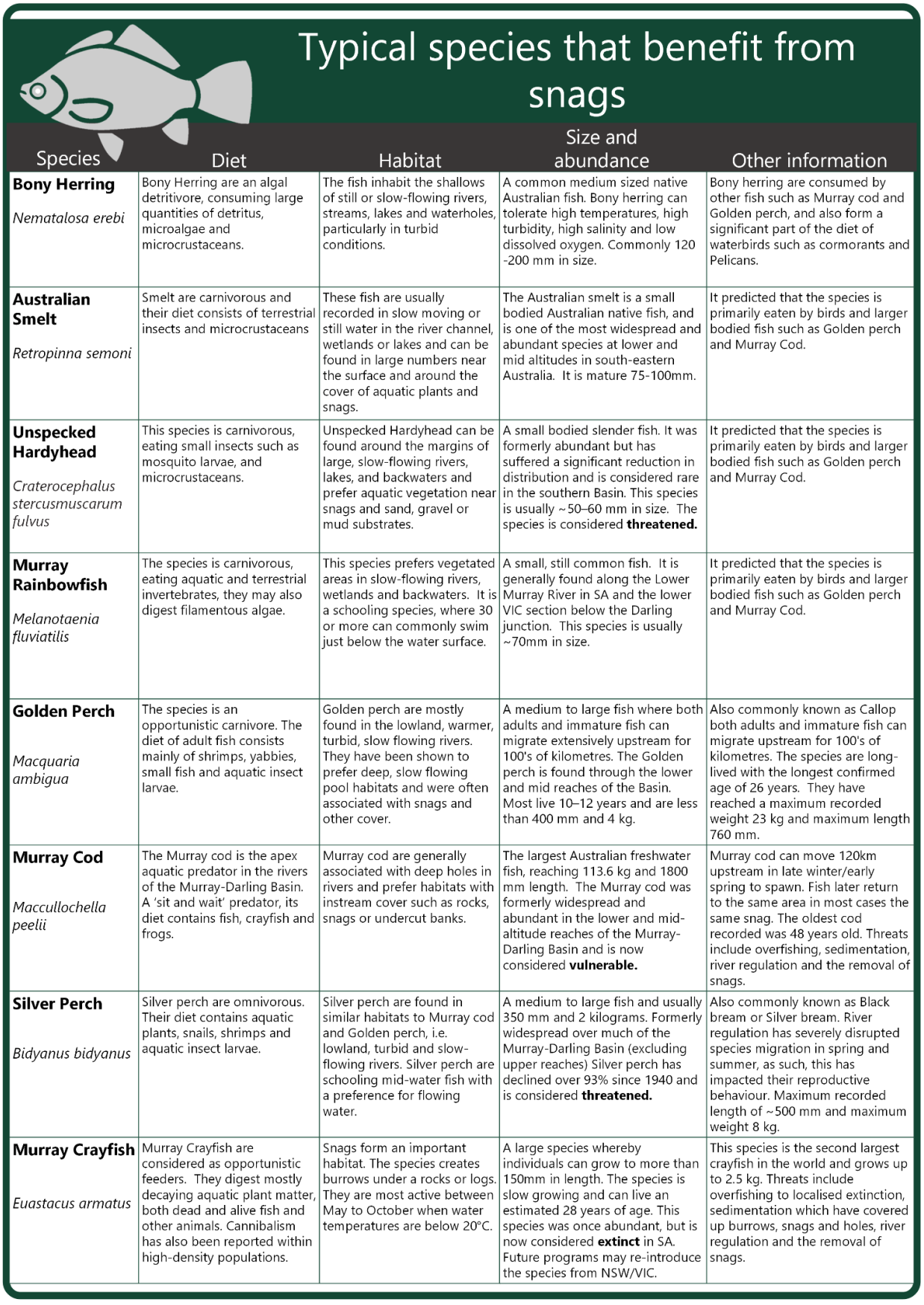
New snags play a critical role in river ecosystems by promoting a range of in-stream morphological and ecological processes. These include:

- Increased habitat for bacteria, algae, micro-organisms, native fish, invertebrates and crustaceans
- Indirectly support water birds and predatory marsupial populations
- Increased food sources for native fish
- Support native fish breeding by providing additional surfaces for eggs to attach to
- Protect native fish populations by providing a place of refuge from larger predators
- Snags that are close to each other support a bigger population of native fish which will be more resilient to changing climate conditions
- Additional snags can provide support to broader populations of aquatic life and therefore will increase the abundance of species in the River Murray

Typical species that benefit from snags at various life stages can be found in **Error! Reference source not found.**.

The question about whether resnagging actually works has been researched over a number of years. Long term monitoring has been conducted further upstream in the River Murray, where testing over several years has found a range of different native species are using new snags in the same way as natural snags and that populations do in-fact increase as a result of the increased habitat. In addition, projects that have been recently conducted in the lower reaches of the River Murray have found that native fish have already been observed using the new structures including juvenile Murray cod, bony herring and Australian smelt. Therefore the continuation of resnagging programs is an important method that will help sustain native fish populations for future generations.

Figure 3: Typical species that benefit from snags



Typical species that benefit from snags

Species	Diet	Habitat	Size and abundance	Other information
Bony Herring *Nematalosa erebi*	Bony Herring are an algal detritivore, consuming large quantities of detritus, microalgae and microcrustaceans.	The fish inhabit the shallows of still or slow-flowing rivers, streams, lakes and waterholes, particularly in turbid conditions.	A common medium sized native Australian fish. Bony herring can tolerate high temperatures, high turbidity, high salinity and low dissolved oxygen. Commonly 120 -200 mm in size.	Bony herring are consumed by other fish such as Murray cod and Golden perch, and also form a significant part of the diet of waterbirds such as cormorants and Pelicans.
Australian Smelt *Retropinna semoni*	Smelt are carnivorous and their diet consists of terrestrial insects and microcrustaceans	These fish are usually recorded in slow moving or still water in the river channel, wetlands or lakes and can be found in large numbers near the surface and around the cover of aquatic plants and snags.	The Australian smelt is a small bodied Australian native fish, and is one of the most widespread and abundant species at lower and mid altitudes in south-eastern Australia. It is mature 75-100mm.	It predicted that the species is primarily eaten by birds and larger bodied fish such as Golden perch and Murray Cod.
Unspecked Hardyhead *Craterocephalus stercusmuscarum fulvus*	This species is carnivorous, eating small insects such as mosquito larvae, and microcrustaceans.	Unspecked Hardyhead can be found around the margins of large, slow-flowing rivers, lakes, and backwaters and prefer aquatic vegetation near snags and sand, gravel or mud substrates.	A small bodied slender fish. It was formerly abundant but has suffered a significant reduction in distribution and is considered rare in the southern Basin. This species is usually ~50–60 mm in size. The species is considered **threatened.**	It predicted that the species is primarily eaten by birds and larger bodied fish such as Golden perch and Murray Cod.
Murray Rainbowfish *Melanotaenia fluviatilis*	The species is carnivorous, eating aquatic and terrestrial invertebrates, they may also digest filamentous algae.	This species prefers vegetated areas in slow-flowing rivers, wetlands and backwaters. It is a schooling species, where 30 or more can commonly swim just below the water surface.	A small, still common fish. It is generally found along the Lower Murray River in SA and the lower VIC section below the Darling junction. This species is usually ~70mm in size.	It predicted that the species is primarily eaten by birds and larger bodied fish such as Golden perch and Murray Cod.
Golden Perch *Macquaria ambigua*	The species is an opportunistic carnivore. The diet of adult fish consists mainly of shrimps, yabbies, small fish and aquatic insect larvae.	Golden perch are mostly found in the lowland, warmer, turbid, slow flowing rivers. They have been shown to prefer deep, slow flowing pool habitats and were often associated with snags and other cover.	A medium to large fish where both adults and immature fish can migrate extensively upstream for 100's of kilometres. The Golden perch is found through the lower and mid reaches of the Basin. Most live 10–12 years and are less than 400 mm and 4 kg.	Also commonly known as Callop both adults and immature fish can migrate upstream for 100's of kilometres. The species are long-lived with the longest confirmed age of 26 years. They have reached a maximum recorded weight 23 kg and maximum length 760 mm.
Murray Cod *Maccullochella peelii*	The Murray cod is the apex aquatic predator in the rivers of the Murray-Darling Basin. A 'sit and wait' predator, its diet contains fish, crayfish and frogs.	Murray cod are generally associated with deep holes in rivers and prefer habitats with instream cover such as rocks, snags or undercut banks.	The largest Australian freshwater fish, reaching 113.6 kg and 1800 mm length. The Murray cod was formerly widespread and abundant in the lower and mid-altitude reaches of the Murray-Darling Basin and is now considered **vulnerable.**	Murray cod can move 120km upstream in late winter/early spring to spawn. Fish later return to the same area in most cases the same snag. The oldest cod recorded was 48 years old. Threats include overfishing, sedimentation, river regulation and the removal of snags.
Silver Perch *Bidyanus bidyanus*	Silver perch are omnivorous. Their diet contains aquatic plants, snails, shrimps and aquatic insect larvae.	Silver perch are found in similar habitats to Murray cod and Golden perch, i.e. lowland, turbid and slow-flowing rivers. Silver perch are schooling mid-water fish with a preference for flowing water.	A medium to large fish and usually 350 mm and 2 kilograms. Formerly widespread over much of the Murray-Darling Basin (excluding upper reaches) Silver perch has declined over 93% since 1940 and is considered **threatened.**	Also commonly known as Black bream or Silver bream. River regulation has severely disrupted species migration in spring and summer, as such, this has impacted their reproductive behaviour. Maximum recorded length of ~500 mm and maximum weight 8 kg.
Murray Crayfish *Euastacus armatus*	Murray Crayfish are considered as opportunistic feeders. They digest mostly decaying aquatic plant matter, both dead and alive fish and other animals. Cannibalism has also been reported within high-density populations.	Snags form an important habitat. The species creates burrows under a rocks or logs. They are most active between May to October when water temperatures are below 20°C.	A large species whereby individuals can grow to more than 150mm in length. The species is slow growing and can live an estimated 28 years of age. This species was once abundant, but is now considered **extinct** in SA. Future programs may re-introduce the species from NSW/VIC.	This species is the second largest crayfish in the world and grows up to 2.5 kg. Threats include overfishing to localised extinction, sedimentation which have covered up burrows, snags and holes, river regulation and the removal of snags.

Adapted from: Fishes of the Murray-Darling Basin – Fact Sheets (MDBC, 2007)

Project Planning

Below is a flow diagram (Figure 4) outlining general planning and management processes required for a resnagging project. It is important to initially define the project objectives. For example, objectives may be to improve habitat and increase the numbers of fish in a particular region. Resnagging will help with providing habitat and complexity to the river, and may contribute to achieving the objective, but success will be dependent upon considerations related to site selection, project delivery and management.

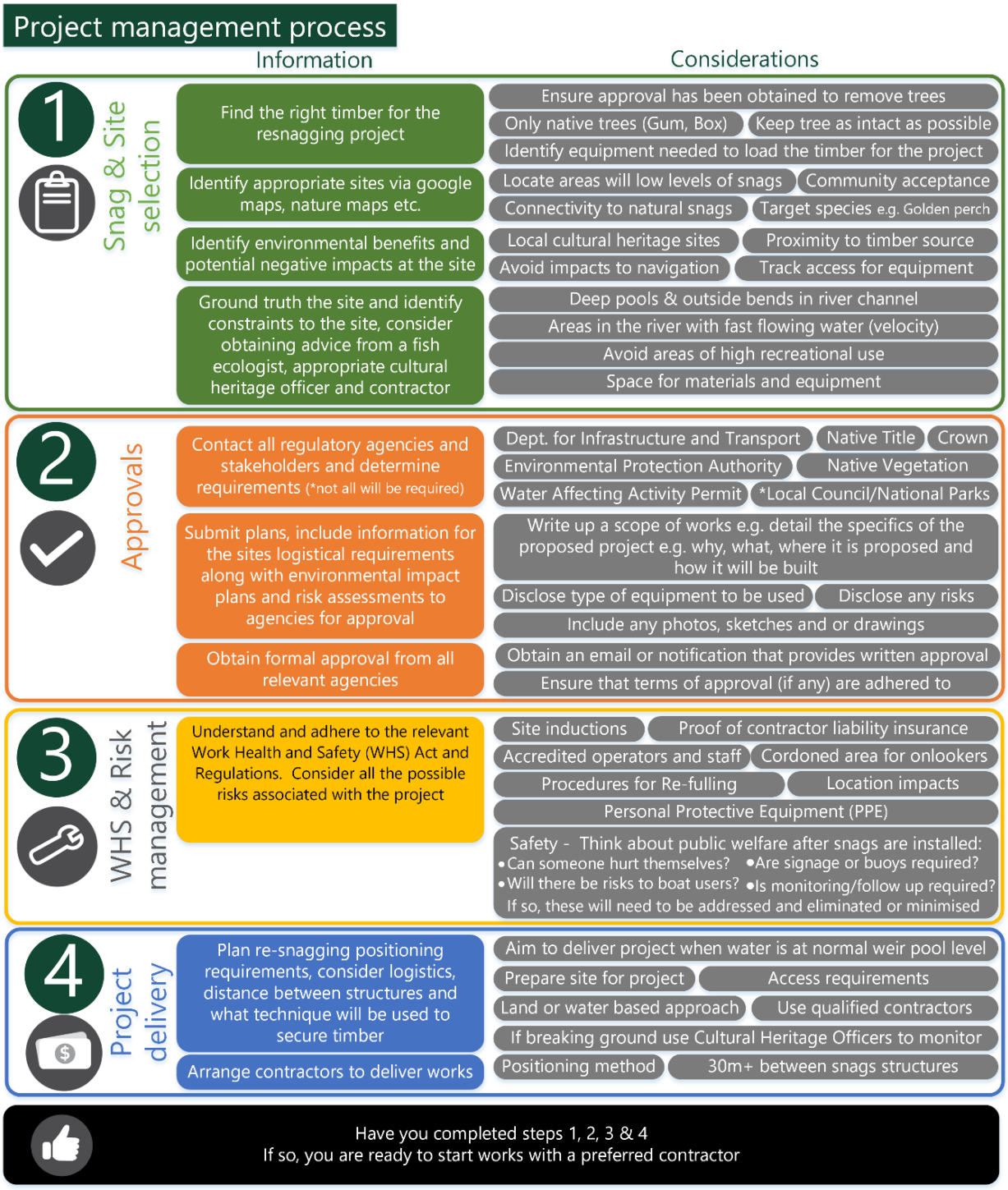


Figure 4: Adapted from (Nicol et al. (2004)

1 Snag & Site Selection

Under natural conditions trees would simply fall into our rivers or creeks, and become snags. Nonetheless, natural replenishment of snags following systematic removal can take hundreds of years. This means reintroduction of snags in rivers and creeks is required if the impact of de-snagging is to be remediated in shorter time frames. Nevertheless, snag and site selection is critical to the success of any resnagging program. Below are some important considerations related to snag and site selection.

1.1 What to look for in a snag?

The most suitable timber for resnagging projects are large hardwood native trees, which have been recently felled. However these are often difficult to find and need approval to be removed. Native Australian riverine animals have become uniquely adapted to native hardwood timbers including both Redgum and Black box species. The dense hardwood not only is preferred by the animals, it is safer for resnagging too, as it can stabilise and secure in the riverbed quickly.

Do not use exotic species (e.g. willow) as they are generally too light, can be difficult to stabilise and will decay rapidly once positioned. In addition, some invasive species have the capacity to re-sprout when re-settled and are of little ecological benefit to native biota. Be wary of using timber that has been felled and out of the ground for some time. Some native timbers such as Redgum dry out quite quickly and therefore are too light and buoyant, causing havoc for positioning and exposing potential risks downstream if they become loose.

Plus if the timber is very dry and has been out of the ground for many months or years, it will most likely be providing terrestrial habitat to land based animals and removing it for resnagging would disrupt what is already a healthy land based habitat.

1.2 Source location of trees for resnagging

Sourcing trees, rootballs and logs can be a major constraint to resnagging projects. With luck, sometimes it is possible to source timber for free. It is important to remember that logs and rootballs should only be sourced from sites where tree clearing has been approved. One option could be to contact the local council and/or an arborist to source trees which are already assigned to be felled in the area. Most agencies and arborists would rather timbers be put to a beneficial use and may even offer other in-kind support (e.g. equipment, labour, help with approvals) to assist with the project.

Maintaining tree complexity and transporting the timber is problematic. It is incredibly difficult to move timbers of this size and it is near impossible to fit a whole tree with roots, trunk and limbs onto a truck. Also, the larger the structure, the more services will be required to assist with its transport (e.g. police escort or power lines moved). It is therefore critical to be flexible with timber sources and make the best use of the dimensions of timber that are made available at the time. The handling costs for transporting timbers will often be the greatest overall cost to the project. Depending on the method of installation, it is highly probable that large machinery will be required to both load and offload trees to their new instream location. As such, it is important to develop a plan based on the size of the timber pieces, the intended structure and the desired outcomes of the project.

Figure 5: Tree providing land based habitat and is too dry for resnagging

Do not use timbers that have been out of the ground for some time. The trees are too dry, will float and be difficult to position in the water. **Error! Reference source not found.** is an example of the type of tree that will be too difficult for resnagging work. This tree has been out of the ground for several years, will float

and already has established vegetation surrounding it, therefore it is already providing valuable terrestrial habitat and should be left for that purpose.

1.3 Current presence of instream woody habitat

The location of resnagging sites in the broader riverscape, including proximity to existing snags, will influence the overall success of a resnagging project. Random placement of snags anywhere into the river may benefit fish, however it is likely more beneficial in reaches where new snags will be spatially connected to existing habitat. Targeting an area with known fish populations will also encourage faster colonisation of new snags.

If possible check your potential site with someone who has a depth sounder. That way you can map the contour of the bank and the deeper sections of water to get a better understanding of how the structure will lay when in place. Avoid laying your snag on very steep banks and on top of already existing snags, the snag might roll or not lay as you initially thought it might.

1.4 Hydraulic habitat and species

South Australian reaches of the River Murray are distinct from upstream reaches and characterised by a series of six sequential weirs (locally referred to as 'locks'). The weirs control water level and flow, and have transformed the river into a lentic environment (still or slow moving) that under low flows is reminiscent of a series of cascading lakes. This is a primary cause of decline of some fish species in SA, particularly Murray cod, which prefer flowing water (lotic) habitats.

The aquatic habitat used by Murray cod, is thus comprised of a structural element (the 'snag') and a hydraulic element, which can be viewed as water velocity. Substantial evidence suggests a preference of Murray cod for habitats with water velocities approaching 0.3 m/s or greater. Water velocities of this value were a common feature of the river prior to regulation in SA. As such, resnagging of sites with water velocities of around 0.3m/s best match pre-European settlement conditions, and will provide the greatest likelihood of success. Reaches with these water velocities can generally be found within 10-15 km downstream of locks, and in certain flowing anabranches. Also for this reason, backwaters, wetlands, and slow-flowing anabranches and creeks are not considered suitable for resnagging in South Australia.

Optimal locations for resnagging sites are in meanders of moderate bends and in the 1st or the 4th quarter of the outer bend, where deeper and faster flowing water can be found (see Figure 6). Research has also shown that species like Murray cod prefer snags in deeper water but close to the bank. The outside of the bend is normally were erosion occurs and hence tends to be the deep side. Placing snags close to the bank creates ideal habitat, in addition, they will divert water away from the bank and reduce the risk of erosion. To decrease risks to navigation, snags should be positioned along the bank and not in the middle of the River and especially away from areas within close proximity to an anabranch or creek junction. In doing so could redirect water and change the way that the water course flows.

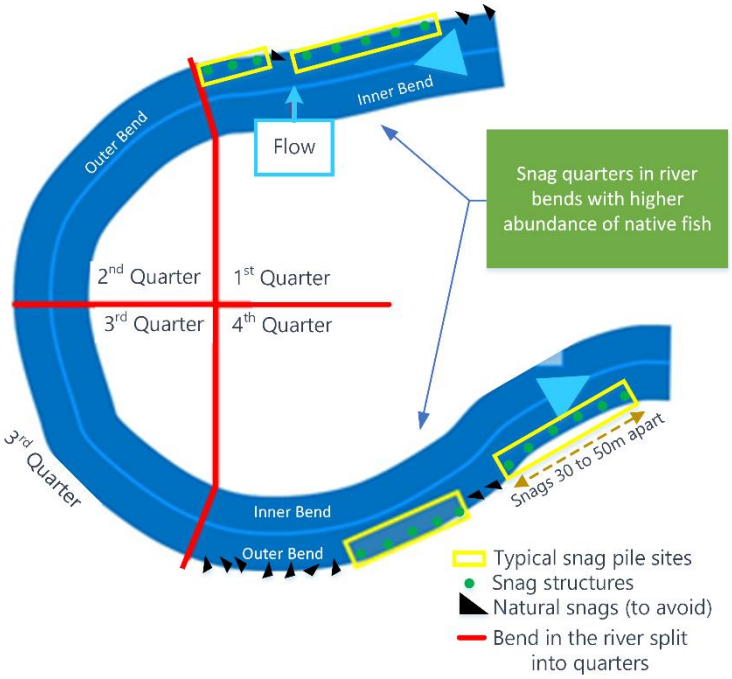


Figure 6: Bend Scale used to determine potential sites. Adapted from Nicol et al. (2002).

Monitoring has shown that a range of different native species use reintroduced snags, and populations can increase in abundance when introduced to rivers in appropriate locations. In the upper Murray, introduced snags are used by many species, including Murray cod, trout cod and golden perch, and use of introduced snags is similar to natural snag piles. Placement and position of snags,

however, can influence how quickly and if species start to utilise the structures. Some species of fish are found to prefer the 1st quarter of a bend (see Figure 6), while Murray cod were more abundant in the 1st and 4th quarter. Conversely Golden perch were less specific in their preferences and could be found in almost the same abundances across the 1st, 3rd and 4th quarter of a bend (Nicol et al. (2002)).

1.5 Positioning of the Snag

If possible, keep the rootballs and timbers as intact as possible, as maintaining tree complexity is key to creating a great new micro habitat. It is also better if the introduced timber contains forks, and hollows to make it more desirable by fish as it will provide refuge and safety for juvenile or small bodied species. In addition, and if practicable, consider leaving 2.5 to 3 metres of the trunk attached to the rootball, this will enable introduced habitat to stretch further into the river.

If placing snags into creeks (instead of the main river channel) trim any branches that might trap debris, in doing so it will reduce the impact to the stream flow and/or bank stability.

As viewed in **Error! Reference source not found.**, aim to position rootballs and or timber at angles between ~25 to ~45 degrees in a downstream direction from the edge of the bank. Snags should be observed to have water movement and flow between limbs, branches etc. and mimic naturally occurring habitat. Therefore it is important not to have snag structures positioned too close together so as to not over crowd the site with too many structures, this will reduce flow and not entice fish to the snag. One way to avoid overcrowding is to space the structures 30 to 50 meters apart along the bank (see Figure 6: Bend Scale used to determine potential sites. Adapted from Nicol et al. (2002).. This spacing should be applied whether there are new

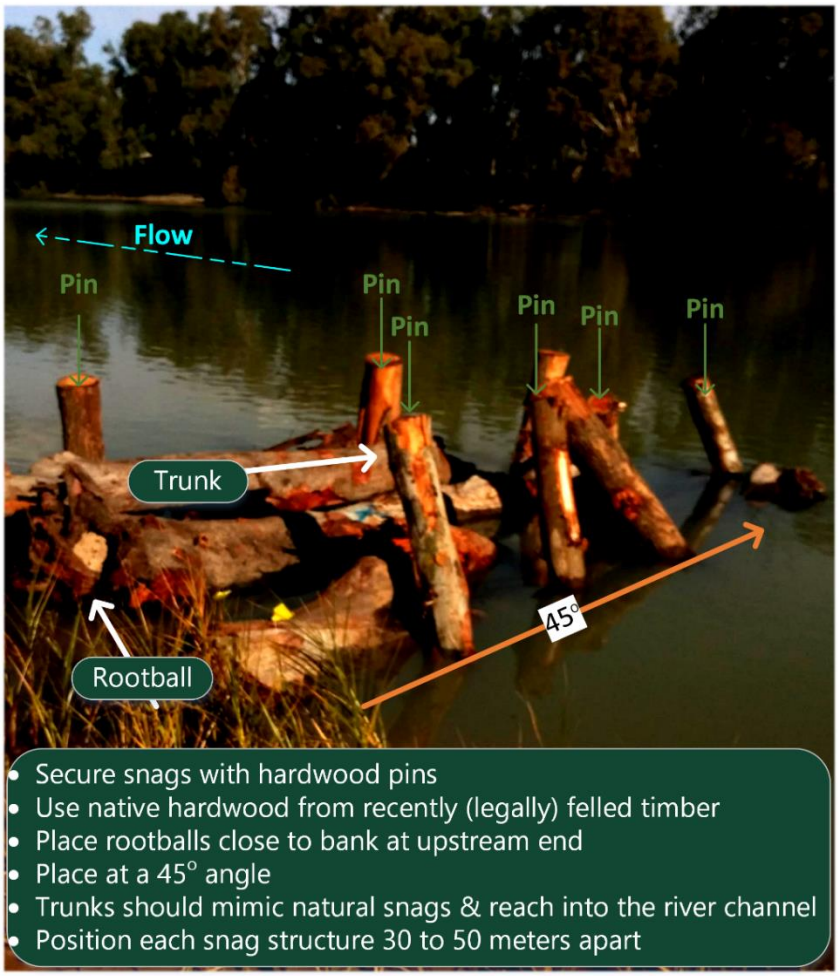


Figure 7: How to position your new snag

reintroduced snags or naturally occurring snags. Once positioned, the structures must be pinned to secure them in their desired position or secured in a method that will not move or impact downstream river users.

1.6 Access to sites and potential constraints

One of the greatest considerations, which will need to be realised early in the planning phase, is the access requirements for a potential site. Resnagging projects require heavy machinery to achieve the projects objectives. Poor access may limit what sites can feasibly be re-snagged. Considerations need to address a variety of factors to ensure that equipment will have suitable access to the river e.g. infrastructure load limits, appropriate road access, laydown area (materials and equipment area) and truck turn-around, as well as vegetation type, abundance and protruding branches.

It is important to make an initial assessment of the potential disruption to threatened species populations and cultural heritage in the area and ensure that there will be no foreseeable adverse impact during, or as a result of the works planned to be undertaken.

If possible choose sites that have established access tracks to ensure minimal disturbance and to reduce site rehabilitation requirements. Depending on the site, planners may need to pay to prepare access tracks for the easy movement of equipment and trucks. If this is the case, native vegetation clearance approvals will be required.

Planners must also consider leaving enough room at sites for a laydown area to store timber and equipment as well as providing a turn-around for trucks.

1.7 Cultural Heritage in the River Murray

The SA River Murray is a highly significant cultural landscape to multiple First Nations groups. These First Nations groups have tangible links to their ancestors and Country and hold Native Title in established areas of the Lower Murray region. The River Murray itself is the life blood of the Country for First Nations communities, bringing together their community through living culture. Of particular significance is the ability to hunt and catch native Australian fish, some of which form key aspects in local Aboriginal stories. The Murray Cod especially is attributed to the creation of the Murray River and there is archaeological evidence of First Nations consuming native fish which dates back at least 25,000 years prior to European colonisation.

First Nations communities across the River Murray Region have proved to be highly supportive of resnagging as a habitat restoration initiative. Generally, there is a particular interest in opportunities for their communities to collaborate with future resnagging initiatives, as well as post-construction fish monitoring programs. The Department for Environment and Water recommends that local First Nations communities be engaged were possible, to contribute their local knowledge and to enable collaboration for future resnagging projects.

1.8 Sites to avoid

Selecting sites can be challenging, as there are many considerations to be made. What may look like a perfect site for resnagging may have other uses that are more or equally important to the local community. To ensure safety and to reduce liability from injury, resnagging activities should be focussed along the bank, not in the middle of the waterway and far away from high use public swimming and boating areas such as those around townships and well trafficked public parks. The locations should also be positioned away from boat ramps and not be commonly used as a mooring site for boats, houseboats or other river vessels. Consider alerting water vessel users of the new habitat structures by positioning reflective signage on new snags and ensuring the design of the new snags includes a way to secure it in place (e.g. with timber piles or pins) to prevent the snag from moving, and damaging other peoples (third party) property.

1.9 Fish monitoring

It is advisable to conduct fish monitoring prior to installing snags as this will later demonstrate if the new snags are being used for their intended purpose. If possible, ongoing monitoring over several years may provide greater data certainty and inform stakeholders on whether the new structures have made a difference to species abundance over time.

2 Approvals

Resnagging works often require the involvement of a number of agencies and various legislative approvals will be required to be obtained. Under current legislation and policy most of the following approvals are required, or may need to be considered for SA resnagging projects (Table 1).

Table 1: Approvals that apply to Resnagging Projects

Agency	Legislation	Reason for Approval
Navigation -		
Department for Infrastructure and Transport (DIT)	*Harbors and Navigation Act 1993*	Approval is required to place any objects into the river, which have potential to obstruct navigation or to create a hazard to boating. It is likely that risk mitigation strategies will be required as part of the installation. Approval requirements may differ per site and depending on the installation method used.
Cultural Heritage		
South Australian Native Title Service/River Murray Mallee Aboriginal Corporation	*Aboriginal Heritage Act 1988* and *Native Title Act 1993*	If Native Title exists in the area, notification is required to be made to the Native Title Holder. Involvement of First Nations should also be sought as waterways are likely to be of high cultural importance.
Water Quality		
Environmental Protection Authority (EPA)	*Environment Protection Act 1993*	Input from the EPA must be sought if works have potential to introduce soil into the river. Under the *Environmental Protection Act 1993*, a person must not undertake an activity that might pollute the environment unless all reasonable measures have been taken to prevent or minimise any environmental harm.
Landholder approval		
Department for Environment and Water (Crown Lands)	Section 56A consent pursuant to the *Crown Land Management Act 2009*	Any works on Crown land requires approval from Crown Lands DEW.
Department for Environment and Water (Director of National Parks, DEW)	*National Parks and Wildlife Act 1972*	Some activities within National Parks require approval from National Parks DEW, including using a vehicle outside of an existing track. It is also prohibited to pollute or foul any water in a National Park.
Local Council	*Local Government Act 1999*	* Works on council land or requiring access to/use of council land may require approval from the relevant council
Works on a Waterway		
Murraylands and Riverland Landscape Board	*Landscape South Australia Act 2019*	A Water Affecting Activity Permit will be required to place a solid object or material into a watercourse.
Native Vegetation-		

Agency	Legislation	Reason for Approval
Department for Environment and Water (Native Vegetation Council, DEW)	*Native Vegetation Act 1991*	* Approval is required from the Native Vegetation Council to clear any native vegetation. This includes severing off branches, limbs, or trunks or creating any other damage to native vegetation. Exemptions exists for clearing vegetation to maintain tracks not more than 5m in width.

Note: Dependant on applicant/site this approval may not be required.

2.1 Navigation

To meet the requirements of Section 25 of the Harbours and Navigation Act 1993 the following risk mitigation methods should be applied:

- Avoid areas with boating access ramps or marinas and high recreational use (such as swimming and camping). Narrow channels and areas where boat traffic is limited by available depth may also be unsuitable.
- Make sure the snags are properly anchored with timber pins or alternative anchoring mechanism to avoid wood re-floating after installation or placement.
- Consider installing signage (in the river and or on the bank) that alerts river users of the new snag as a potential hazard. Consult with DIT before installing any signage in water, to ensure suitability of content and location.
- Use yellow buoys to mark the snag sites if they are submerged at normal pool level and can't be seen by river users under normal operating conditions. However it might not be necessary if snags are above the water surface and visible at normal pool level. In this instance signage would be more appropriate.
- It is recommended that the rootballs and snags are positioned close to the riverbank and near or in line with existing snags (this has also ecological benefits) to avoid navigational and erosion risks (refer to
- Snag & Site Selection for more details).
- It is possible that the project manager will be asked to notify the community in the local paper. Please refer to the conditions of the approval to ensure compliance.

Please submit applications or requests for further information to: dit.recreationalboatingunit@sa.gov.au

2.2 Cultural Heritage

There are many areas particularly along the river that are rich in culture to local aboriginal groups. When planning any resnagging work, be kind and avoid areas that are known to be culturally sensitive. Shells and scar trees are common indicators that the area has been frequented by traditional owners. To ensure that appropriate consideration is given:

- Look for possible indicators on the bank, the equipment tree storage area and anticipated access track/s
- Seek guidance from traditional owners or an archaeologist about the chosen site/s
- Engage traditional owners in the works, especially if ground will be moved to access the bank for positioning works.

2.3 Water Quality

To meet the requirements of the *Environment Protection Act 1993* the following mitigation methods should be applied:

- Detail the proposed measures to prevent or minimise any environmental harm
- Ensure appropriate controls will be in place at all times to ensure that no foreign materials or large amounts of soil can pollute the River.
- Be mindful of fuels on site for machinery (refer to Section 4.5 for further detail)
- Ensure that the EPA understands the preferred construction method that will be used to anchor snags.

2.4 Landholder Approval

If works require use or access to private land, an agreement of consent should be sought before the start of the project to enter and conduct any work on their land.

If works require use or access to public land, consent will be required from the responsible land manager. This would generally fall to one of the following agencies:

- DEW Crown Lands branch for any works on Crown land.
- National Parks, DEW, for works and or activities proposed within National Parks
- Local Council, for works on council land or requiring access to/use of council land

Written consent should be sought as early as possible as it may be required to support permit applications

2.5 Works on a Waterway

To assist with the approvals process for undertaking works on a waterway the application should include:

- Detail of the proposed re-snagging works and why they are proposed;
- Site location details about where the snags are proposed to be placed;
- Include letter of consent from the land owner/manager where required;
- Details of the method of how the snags will be installed or placed. Don't forget to include any detail on any access works that may be required, such as works on the bank of the river for machinery access.
- Include photos, sketches and or drawings

Further information can be found on the Landscape.sa.gov.au website or emailed to MREnquiries@sa.gov.au

2.6 Native Vegetation

Native vegetation in most parts of South Australia is protected by the *Native Vegetation Act 1991*. If you want to clear native vegetation for any reason, you need to:

- Avoid clearing and or impacts to native vegetation where possible;
- Minimise impacts to native vegetation where unable to avoid impacts completely;
- Avoid disturbing high value (threatened and vulnerable species) vegetation since the Native Vegetation Council are unlikely to approve any clearance of vulnerable or endangered species.

Small scale clearance applications can be submitted by a landholder without the assistance of an accredited consultant. For larger clearance an assessment and report by an accredited consultant will be required.

Further information can be found on https://www.environment.sa.gov.au/topics/native-vegetation/interactive-guide or call the Native Vegetation Branch on (08) 8303 9777.

3 WHS and Risk Management

3.1 Work Health and Safety considerations

Installing snags can be dangerous, since it involves working closely around water, and requires the use of experienced and licensed operators for all machinery. While planning your project make sure to understand and adhere to the relevant Work Health and Safety (WHS) Act and Regulations.

A WHS plan will be required and involved personnel will have to be inducted onto the site.

3.2 Risk management preparation

Ensure it is clear and understood by all parties who is responsible for the works and who is responsible for ensuring compliance with any agency that has issued project approvals. Responsible parties may include but are not limited to the project manager, manager, procured contractors and site supervisor's. Parties must be familiar with the requirements/conditions of all legislation, permits and approvals. It is recommended that all responsibilities are detailed in writing prior to works commencing.

Plan out what needs to happen from tree pick-up, through to construction and post construction:

- Consider where snags could go along the River and alternative options should the potential snag position be inappropriate.
- Work out how many trees/rootballs will fit on one truck so as to not overload the truck
- Plan transport requirements accordingly (e.g. amount of trips, distance, hours required, police escorts etc)
- Consider what equipment will be used to load/unload the trees/rootball onto the trucks
- Consider potential no go zones (for safety, or to protect habitat, heritage values etc)
- Plan where an appropriate laydown area for equipment and materials should be located, taking into consideration vegetation and root zones of adjacent trees
- Prepare a site induction sheet as a risk mitigation, to show contractors and their staff the site. This would include informing them on any constraints or issues and what should be done in the event of an incident.

3.3 Risk management during transport and construction

To ensure that your project runs smoothly please consider the below items to ensure that risks can be eliminated, minimised or managed appropriately.

1) **Accredited operators**
    a. Ensure that any machinery used is operated by licensed and/or accredited staff, ensure equipment has been appropriately surveyed and operators have a certificate of operation. Request a certificate of insurance for public liability.
    b. If a water based approach is undertaken, a barge operator with an experienced/accredited coxswain licence will be required. Marine Safety rules and regulations will need to be followed.
2) **Transport**
    a. Make sure to follow any road rules while transporting the snags. If the tree portion is larger than 4 meters in width (3.5 metres in Adelaide Metropolitan Area) you may need to apply for approval and have an escort (refer to the Department for Infrastructure and Transport for further details). Make sure your track and gates etc. have enough clearance for large vehicles. If there is any infrastructure, such as culverts or bridges along the

route from tree pickup to the resnagging site, ensure that they can handle the weight of trucks and the heavy timbers that will be loaded in them.

3) Power lines

a. Look out for overhead power lines. It is recommended that you contact SA Power Networks to install 'tiger tails' on the closest lines prior to construction or cordon off areas near power lines. Make sure to have a good clearance to any power lines when transporting your snags, minimum distance with a spotter should be 3 meters or more.

4 Project Delivery

4.1 Logistics

Installation of snags can be done either through a land based approach or a water based approach and with a variety of equipment and methods. Three methods are found below:

1) **Land based with excavator, long reach excavator or crane;**
   This approach will require the use of an excavator or crane with various attachments including a log grab, a bucket and a hydraulic pile driving hammer. Ensure an appropriately sized excavator or crane is used and that there is no risk of the machine tipping over.
2) **A water based approach with a barge and excavator;**
   A water based approach can be useful for sites which are highly vegetated and/or where high, unstable banks prevents resnagging to occur from the bank. This approach will require the use of a barge as well as an excavator with various attachments to move and position the trees including a log grab and a hydraulic pile driving hammer. As above, ensure appropriate sized machinery is used for moving and positioning the trees.
3) **Land based cable dragging**
   This is a land based approach that uses a cable and a winch to drag trees into the final position. This method may require water traffic controls under an "Aquatic Activity Licence" issued by DIT for a section of the river or anabranch closed so that the resnagging project can be undertaken. This approach would require an online application to provide authority to restrict and direct traffic during the works. For further information on the requirements of this resnagging installation approach email dit.recreationalboatingunit@sa.gov.au

Regardless of which method is selected, it is important that all relevant WHS provisions are in place prior to works commencing and that an accredited contractor is used.

4.2 Techniques to anchor timber

Australian wood is relatively immobile in our river systems mainly due to three factors;

- Lower average stream power of our rivers,
- Higher density of wood; and
- A complex branching structure of trees meaning that logs easily anchor in position.

All snags installed or placed in a waterway should be securely anchored in place, this will minimise the chance of them being dislodged and moving into the river channel or floating away. If not secured, these introduced structures could impact other assets (third party impacts). Structures most at risk include but are not limited to, culverts, bridges, pontoons, and pump sites. Due to their weight most snags require the assistance of an excavator to place them in the river, these machines can also be used to drive piles, like pins, to hold the snags in place (refer to Section 1.5).

4.3 Costs

When seeking quotes from qualified contractors it is recommended that potential contractors visit each of the proposed sites before submitting quotes. This will ensure that the suggested equipment is suitable for the site, reducing potential budget blowouts and lengthy time delays in finding alternative equipment or methods for delivery. It is worth asking the contractor on their anticipated timeframes for project delivery, as this may assist with choosing a suitable supplier.

4.4 Timing

Although resnagging is theoretically possible throughout the year, it is recommended that works be undertaken during low flows (seen typically in late summer through to mid-winter). This is generally when the pool level is lower and while banks are more exposed, and therefore potentially the access to sites may be better.

4.5 Planning for delivery

It is important to prepare for the delivery of on ground works. These tips may help:

- Before work starts, discuss the plan and any concerns with a qualified contractor. They will be able to assess the risk associated with the work and best approach to take to conduct resnagging work.
- Prepare a site induction, to show contractors and their staff the site, and any constraints or issues, landholder requirements or obstacles that may be present.
- Before starting work, mark out on the bank where a potential snags/structures could be positioned, walk it out and ensure that you leave enough space between the snags (30-50 metres between structures) and apply this distancing between new and natural snags.
- Mark out no go zones (for safety and/or protect habitat or cultural heritage values).
- Mark out laydown area for equipment and materials.
- Remember to inform neighbours immediately downstream of works so that any pumping activity can be taken into consideration during operations to ensure that pump inlet areas are not detrimentally impacted through high turbidity.
- Heavy machinery requires fuels and oils, which have the potential to impact on the environment. To mitigate any risk involved with the usage of these liquids be sure to store and refuel in an appropriate and safe way, as well as store them in appropriate containers.
- Take before photos to demonstrate condition of site before disturbance.

4.6 During works

The operation of equipment on sensitive riverbanks also has the potential to contribute to bank instability or collapse due to groundcover removal and soil disturbance. Attention should therefore be paramount when working with heavy equipment on riverbanks. They have the potential to collapse the banks with their weight, damage vegetation (trees, shrubs and ground cover), disrupt soils and cause overtipping of plant and/or machinery. It is imperative that the work be undertaken through a contractor whose staff are accredited to operate the required machinery. Project managers should obtain copies of certificates or licences (e.g. white card, chainsaw operator licence or coxswains licence, certificates of survey, or certificate of operation) and insurance certificates.

4.7 Incidents

If an incident occurs on site, stop work and take appropriate action, seek medical attention. Refer to SafeWork SA for further information on what to do in the event of an incident.

4.8 Cultural heritage uncovery

If any cultural material are unexpectedly found (not including ancestral remains):

- Stop work and stabilise the area;
- Call Traditional Owners contact person or if unknown contact Aboriginal Affairs and Reconciliation (AAR) and inform them that you believe you have disturbed cultural remains;

- Traditional Owners will either ask for photos or inspect the site in person. If deemed to be cultural there will need to protect the site. If not, then continue works under the *South Australian Aboriginal Heritage Act 1988*.

For suspected ancestral remains

- Stop work and stabilise the area;
- Call the Traditional Owners and police/ coroner.
- Police to determine if remains are human and require investigation (if this is the case it will become an active crime scene). If they deemed to be ancestral remains there will need to protect the site. If not, then continue works under the *South Australian Aboriginal Heritage Act 1988*.

4.9 Completion of works

Once construction is complete take some photos displaying snag positioning and signage or buoys (if specified), and arrange for a post works inspection (if required by approvals). After the resnagging project is complete, the site is required to be restored to its former condition. Ensure any construction or associated materials (e.g. sediment controls, access signage etc.) are removed from site and tidy up any disruption caused by equipment or timber debris.

Distributing local native seeds on the area used for tree storage or undertaking a complementary native vegetation re-planting project alongside the adjacent river bank, is a good way to assist with natural snags falling into the river in the future.

It is considered best practice to check the results of the resnagging project by undertaking monitoring six months after works. This will give fish some time to explore and settle into the new habitat. It is critical to understand that this project is not an immediate fix and that this type of habitat restoration project will still take several years to see a noticeable increase to native fish populations.

Site selection and equipment used for DEW pilot project

A water based approach with a barge was used for the DEW resnagging pilot project.

During the scoping phase, a site visit was conducted to make sure there was sufficient space for trucks to enter and move around the site and to ensure area was set aside for storing rootballs and timber during the works. Ramps were also created for the excavator to access the barge.

During this time Cultural Heritage Advisors were on site to ensure that no Aboriginal Heritage objects were uncovered, discovered or damaged.

Trees were trimmed for trucks to fit on access tracks and semi-tippers were used to transport rootballs from the tree source to the sites (Banrock station, Bookpurnong and Overland Corner).

An excavator aboard a barge was then used to position the rootballs and timber in the river along the bank. Lastly, native timber pins were driven into the ground with a vibrating driving plate to hold the snags permanently in their final position.

The equipment used for this project was:

- 30 tonne excavator with licenced operator to load timber into an awaiting truck
- Semi-tipper truck for the transport of timber to sites
- 24 tonne excavator with licenced operator for offloading rootballs and timber and for positioning works
- Barge for better access to riverbank and reduced land and vegetation disturbance
- Chainsaw and licenced chainsaw operator to create points on pins to assist with placement

Figure 8: Moving of rootballs and timber to create new habitat in the main river channel

Recommendations for Resnagging projects

- ✓ Fully investigate the approvals and permissions you will need at the beginning of the project in order to avoid delays.
- ✓ Be sure of land ownership and tenure of the intended resnagging site as this will affect the approvals necessary.
- ✓ Have a clear design in mind before installing the snags, this will make it easier to describe the method of delivery to approving agencies and for contractors to understand the work and provide an accurate quote.
- ✓ Obtaining expert opinions can boost confidence and motivation in a project, e.g. talk to people who have completed resnagging projects, ground truth the site with a contractor, and consider contacting a fish ecologist (e.g. SARDI-Aquatic Sciences, DEW, or other professional organisations) to provide a site assessment.
- ✓ Make your implementation plan as detailed as possible.
- ✓ Take into account present and likely future water level fluctuations.
- ✓ Have a diverse group of stakeholders involved, it can result in significant in-kind contribution and broaden expertise.
- ✓ Try coordinate the sourcing of the logs to coincide with the day of the resnagging, this will reduce double handling and keep costs down.
- ✓ Restore any areas impacted during installation works back to their original condition. Where possible consider revegetation work alongside re-snagged sites with native hard wood to replace installed snags in years to come.

Further reading

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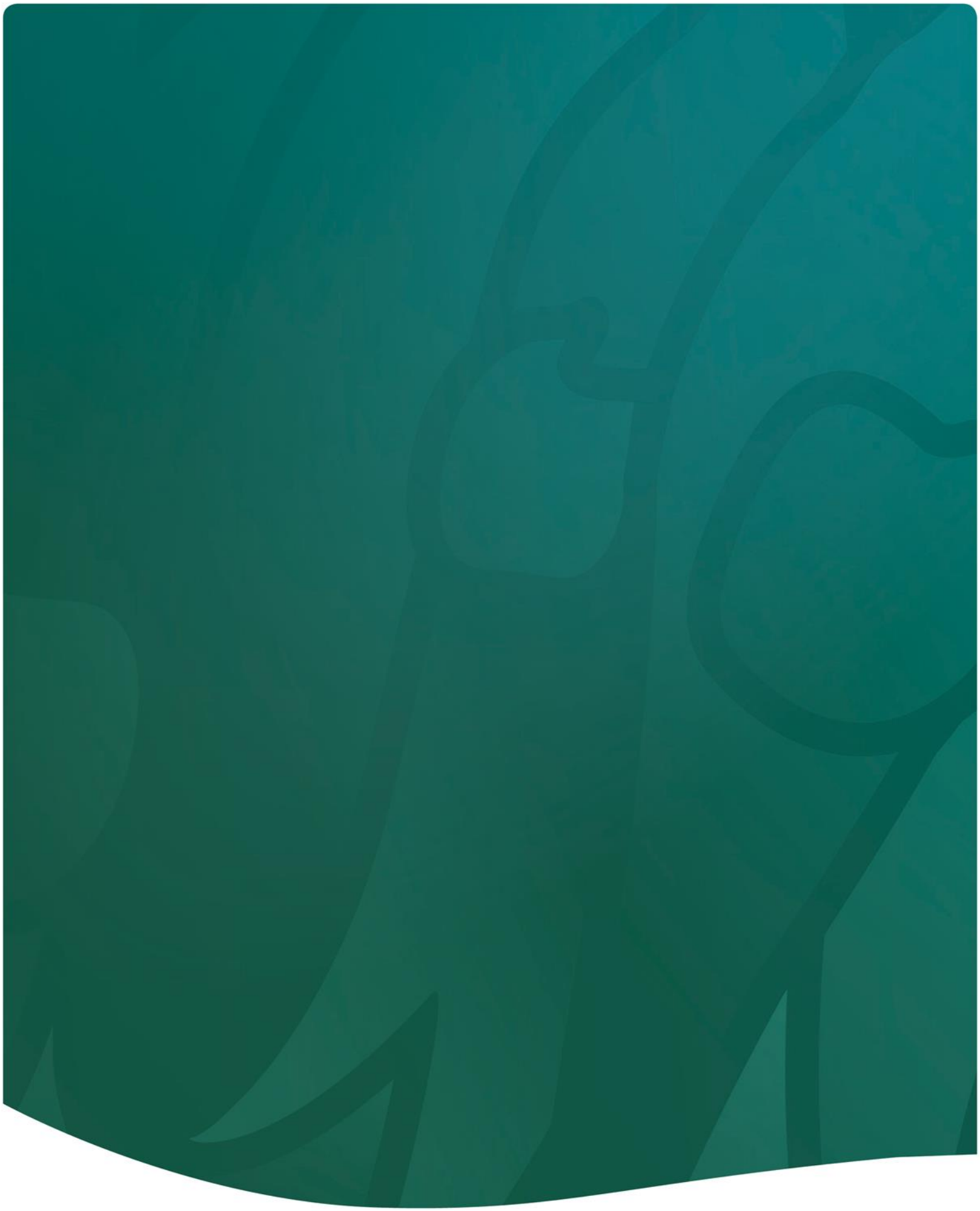
Acknowledgments

This work forms part of the $155 million South Australian Riverland Floodplains Integrated Infrastructure Program (SARFIIP) to improve the health and resilience of Riverland floodplains. SARFIIP is funded by the Australian Government through the Murray–Darling Basin Authority (MDBA) and implemented by the Department for Environment and Water (DEW) in partnership with SA Water.

DEW greatly appreciates and acknowledges the following contributors to these guidelines

- Chris Bice (SARDI)
- Tumi Bjornson (formerly DEW)
- Natalie Dando (MDBA)
- Brenton Zampatti (CSIRO)



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