Culverts crossings in watercourses

Best practice guidelines for design and construction

Culvert crossings that are designed and constructed poorly can cause significant environmental harm and impact adjoining properties. Impacts includes but not limited to a barrier to fish passage, alternation to water flows, increased flooding, erosion and habitat destruction.

Purpose

This guideline has been developed to provide landholders with information and guidance on best practice design and construction techniques that minimises environmental and adjoining property impact and reduce ongoing maintenance costs when constructing, repairing or removing a culvert crossing in a watercourse. We want a good outcome for you and the environment.

The information in this guideline is provided for general information only and does not constitute site specific professional engineering advice.

Note: in this guideline, the term 'watercourse' includes waterway, creeks, rivers, lakes, springs, wetlands, on-stream dams, estuaries and other natural watercourses, whether modified or not.

Approvals

Section 104(4) of the *Landscape South Australia Act 2019* (the Act) requires a water affecting activity permit for a range of activities that could impact water resources. Constructing, repairing or removing a culvert crossing in a watercourse is a water affecting activity (WAA) and requires a permit application to be lodge to the board for assessment and permitting. Permit applications are assessed against the relevant water allocation plan or the Hills and Fleurieu Landscape Board WAA Control Policy.

Note: If you plan to construct a culvert crossing that is greater than 1 meter in height, you should contact your local council to determine if development approval is required before applying for a WAA permit. If the watercourse flows year-round and you need to undertake excavation work while standing or flowing water is present, you should contact the Environment Protection Authority (EPA) to determine whether a dredging license is required before applying for a WAA permit. Even if either development approval or an EPA license is granted, there may still be aspects of the crossing works that require a WAA permit.

What is a culvert?

A culvert is a structure that allows water to flow under an obstruction (i.e. road or track) from one side to the other. A culvert can be in a form of a round pipe or boxed – see figures 1 and 2 on the next page.

Figures 1 and 2: To the left is a dual boxed culvert and to the right is a dual piped culvert.

Site selection

Culverts should be located across a straight section of the watercourse where the flow line and stream power is concentrated in the center of the watercourse (see figure 3 below). Avoid locating culverts:

- At sharp angles to the stream
- Near sharp bends
- Near sections of unstable bank
- Across sinuous meandering waterways (as their migration rates may be increased due to changes in flow dynamics)
- At sites that will require the removal of vegetation (important for bank stabilisation).

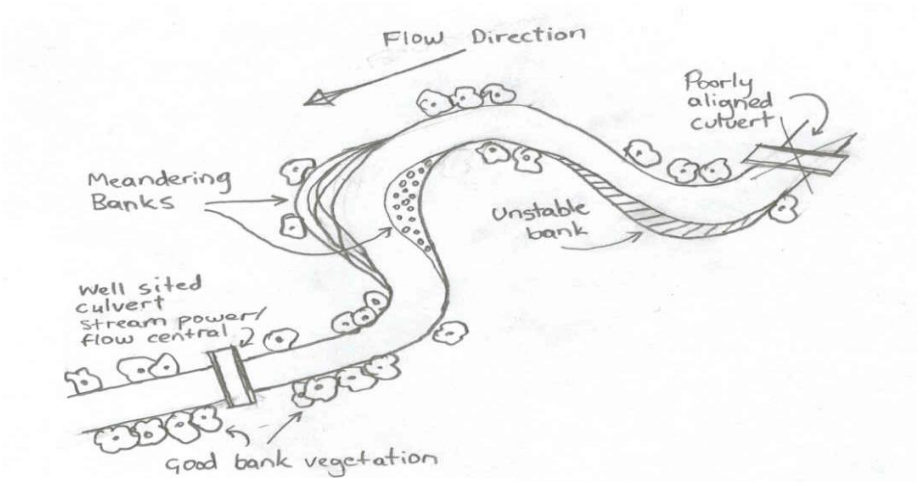


Figure 3: Site selection map.

Design considerations

Culvert sizing

In general culverts should be designed to replicate the same area of stream channel up to the flow depth of 0.5m. Culverts should not be perched above the streambed as this causes erosion downstream (higher stream speeds) and sedimentation upstream. This reduces access for normal fish passage and can cause ponding, (upstream of culvert) stagnation and water quality problems. Small dry weather access crossings are designed such that high flows and floodwaters will pass over and around the crossing and back into the watercourse downstream. The middle section of the crossing should always be lower than the left and right bank to enable higher flows to remain within the channel and not back up around the culvert. It must also enable the flood plains to "flood out" naturally and re enter the stream without causing erosion.

Scour pool stabilisation

The downstream end of the culvert is most vulnerable to scour and bank erosion. This particularly happens when floodwaters overtop the culvert. To prevent scouring and bank erosion downstream of it is recommended to excavate the lower the stream bed, then use rock armour to fill the bed back to the existing level. The rock armour should extend directly downstream of the culvert and at the end of the scour pool. The end of the scour pool can be defined as the distance of 10 X the height of the culvert, or if more than 1 pipe 13 X the height. The downstream banks are also stabilised with armour rock to prevent bank erosion as floodwaters move over the top of the culvert and back into the watercourse. See Figure 4 below showing scour pool protection.

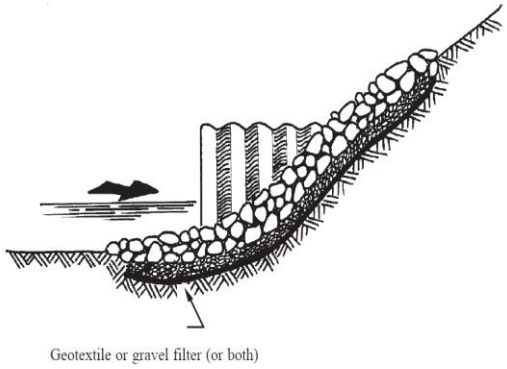


Figure 4: Sour pool outlet protection.

Materials

Rock armouring should only consists of rock that is hard and angular, not flat or round, and should incorporate a range of sizes. By incorporating a range of sizes, the rock will "lock" together and provide greater resistance to movement (see table 1 below for guidance). Finer rock material can be incorporated into the rock towards the surface where a flatter finish may be required. Some concrete may be used to bind the rock together and will generally provide a greater design life. If using concrete, ensure the surface of the concrete is rough not smooth and keep the concrete works contained to the area to avoid residue into the watercourse.
Concrete is alkaline and highly toxic to fish.

Material for the road base overtop of the culvert must be clean graded fill using large rock (50cm) small rock (10 –20cm) and a clean gravel for surfaces. Building site rubble is poor quality material and will erode. The rubble surface / raceway over the crossing should stretch further than the top of the creek banks as this area may be boggy during winter months and with heavy stock activity (erg dairy) may become unstable.

Culverts with multiple pipes must be stabilised in position using large armour rock around and between pipes. A small 2% cement mix used in the gravel surface can be used. This assists in stabilising surface material and resists erosion of surfaces during periods when floodwaters are passing over crossings.

Table 1: Erosion protection using rocks, size and grading.

	At 500mm depth rock protection		
Moderate flow velocity (up to 2.6 m/s)	**Rock size (mm)**	**Rock mass (kg)**	**Minimum % of larger rock required (refer to rock size column)**
	400	**100**	**0**
	300	**35**	**50**
	150	**2.5**	**90**

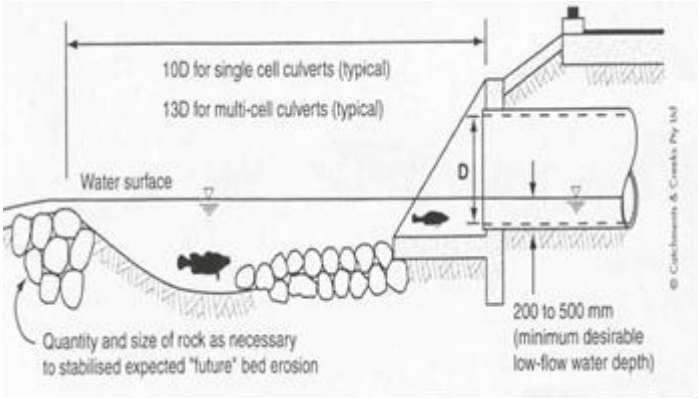
Fish passage considerations

Watercourses within the Mount Lofty Ranges are home to numerous threatened native fish species. Culverts in watercourses that include appropriate fish passage design elements can have a positive effect on the connectivity of fish habitat.

Fish passage design elements are required for watercourses with a stream order 3 or greater. If you don't know the stream order of your watercourse, contact us. Below are the requirements to support fish passage.

- A multiple-cell culvert should have a 'wet cell' minimum water depth of 50 to 200 millimetres to encourage fish passage.
- Maximise light penetration by maximising the height or diameter, and possibly by introducing skylights or grated stormwater inlets into the median strip of divided roads.
- Avoid using culverts on a watercourse that has a gradient of more than 2% slope (1:50). The gradient immediately downstream of the culvert should be less than 5 per cent (1:20) so fish can approach the culvert outlet.
- The culvert invert should be buried so a minimum of 20% of the diameter (round culvert) or 20% of the height (box culvert) lies below the channel bed.
- If possible, the culvert should be designed so its hydraulics are similar to that of the stream and the weakest fish species can swim through. The water depth should also allow the largest fish species to remain submerged.
- Lining the base of the culvert with a rough concrete finish and / or natural substrate will increase turbulence and make it easier for fish to swim through. Velocities of less than 0.3 metres per second will allow most native fish to swim through a 5 metre long culvert. Placing small rocks along the base may also help other species (e.g. platypuses and water rats) pass through the culvert.

- If a smooth bed culvert must be designed, then flow velocities for water depth up to 0.5 metres ideally should be no more than 0.3 m/s. Baffles or large angular rocks typical of the area can be cemented along the base of longer concrete culverts to reduce flow velocities and allow fish and invertebrates to pass through.
- In sand and gravel-based streams, natural bed material should be placed along the bed of the wet cells or allowed to deposit in these cells. The hydraulic design of these culverts should allow for this added bed roughness which facilitates upstream fish movement.
- In clay-based streams that do not experience significant movement of bed load sediment, artificial roughness units such as rounded stone, can be grouted across the bed of the wet cells to provide the desirable bed roughness and fish resting areas.
- Where conditions allow, construct pools at the inlet and outlet of the culvert to assist in the dissipation of flow energy and to act as resting areas for migrating fish. Fish resting pools should be at least two metres long along the direction of flow, be deep enough for fish to remain submerged, and contain rocks and vegetation to provide cover.
- Debris deflector walls can be used to reduce the impact of debris blockages on fish passage while also reducing maintenance costs.



Figures 5 and 6: Cross-sectional diagram of fish passage dimensional requirements and a finished culvert base with secured rock to increase water turbulence for fish.

Table 2: Preferred crossings for different classes of fish habitat

Classification	Stream characteristics	Preferred structure
Class 1 Major fish habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened fish species.	Bridge, arch structure or tunnel
Class 2 Moderate fish habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and / or fish observed inhabiting the area.	Bridge, arch structure, culvert or ford
Class 3 Minimal fish habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.	Culvert or ford
Class 4 Unlikely fish habitat	Named or unnamed waterway with intermittent flow following rain events only, little or no defined drainage channel, little or no flow or freestanding water or pools after rain events (e.g. dry gullies or shallow floodplain depressions with no permanent aquatic flora present).	Culvert or ford

Construction tips

- Mark out the site, including the approach to the culvert and its alignment across the watercourse.
- Subject to having any necessary approvals in place, remove native/non-native vegetation within the footprint of the culvert and where possible preserve it so that it can be replanted once construction is completed.
- Ensure all rock armouring used to line the bed and banks of the watercourse is keyed in to a depth of 300-500mm.
- Lay geotextile over the length of the rock armouring. Any joins in geotextile should overlap a minimum of 500mm and should be anchored to the soil foundations at 1m intervals.
- Carefully place rock so that the voids between larger rocks are filled with smaller rocks.

Monitoring and maintenance

All culverts in watercourses require maintenance over their life, and you should incorporate this activity into your property management. Regular monitoring and maintenance of culverts will prolong their life and help with the early identification of potential problems. Tips on monitoring and maintaining your culvert are summarised below.

1. Inspect during periods of low flow to ensure that fish passage across the structure is not blocked and for damage after significant flow events. Early intervention and repair of erosion will be much more effective and cost efficient in protecting the structure against more significant damage in the longer term.
2. Monitor the rock armouring at either end of the approach to the culvert for any sign of erosion. Repair as necessary.
3. Keep a stockpile of the rock, including any finer rock used on the surface to make sure you are able to respond quickly to maintenance requirements.

Penalties may apply

Undertaking a WA without a permit is an offence under the *Landscape South Australia Act 2019*. If you are unsure whether the works you are proposing will require a permit, contact Landscapes Hills and Fleurieu for advice before conducting any works.

Help and further information

This is a free service and is aimed at ensuring the best outcome for you, your property and your watercourse. We are here to help!

Landscapes Hills and Fleurieu

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