Fauna Technical Note No. 15:

Guidelines for the design and maintenance of stream crossings for the passage of fish and other aquatic fauna – culverts

FPA
FOREST PRACTICES AUTHORITY

The Fauna Technical Note Series provides information for Forest Practices Officers on fauna management in production forests. These technical notes are advisory guidelines and should be read in conjunction with the requirements of the Forest Practices Code*. The planner will use expert judgement and available information to determine the extent and nature of field survey work required to meet decision-making requirements.*

The Technical Notes can be accessed on the Forest Practices Authority's website: www.fpa.tas.gov.au

1. Introduction

This technical note provides guidelines for design and maintenance of culverts to minimise disturbance to the passage of fish and other aquatic fauna at stream crossings, in keeping with the provisions of the *Forest Practices Code*. When deciding when and where to apply the measures recommended in these guidelines, priority should be given to those streams whose river sections (or immediately adjacent downstream river section) in the Conservation of Freshwater and Ecosystem Values (CFEV) database (https://wrt.tas.gov.au/cfev/navigator) that have a fish community where fish are judged to be present (i.e. where the CFEV attribute RS_FISH is NOT F0).

It should also be used to assist in the implementation of Threatened Fauna Adviser recommendations.

What are stream crossings?

A stream crossing is a structure built on a watercourse, providing vehicular access and allowing free water movement. Stream crossings include bridges, culverts, fords and causeways. A culvert is a channel or conduit for water underneath a road.

2. Impacts of culverts on fish and other aquatic fauna

Culverted stream crossings can inhibit the passage of fish and other aquatic fauna. Firstly, some species don't like to enter or pass through small dark tunnels, and if the outlet of the culvert is above the level of the stream, fauna travelling upstream may be unable or reluctant to enter the culvert. They are effectively stranded on the downstream side of the road crossing. Secondly, culverts concentrate stream flow and increase stream velocity by reducing the cross-section of the stream. Many species of aquatic fauna find it difficult to swim through the culvert against the water flow. The smooth walls of the culvert do not provide areas of slow flowing water within the structure that the fish can utilise and exacerbate the problem. In a normal stream environment, turbulent flow (created by rocks, pebbles and logs) produces pockets of slow flowing water such as eddies. Fish use these areas of low velocity water as resting places and for many species these areas are essential in order for the fish to swim large distances upstream.

Recent work by Walker (1999) has demonstrated that in some areas most culverts prevent fish passage in streams. Stream fish populations are dependent on free movement through the stream network (as are populations of other aquatic organisms such as crayfish and platypus) for their long term viability. Many native fish must migrate downstream to spawn and upstream as juveniles to replenish the population. A barrier may cause the local extinction of a population within a subcatchment if young fish cannot pass above it. Culverts therefore pose a significant conservation threat to populations of these species. Walker (1999) found that two factors largely control the impact of culverts on fish passage:

- water velocity within the culvert (largely determined by culvert slope and narrowing of the water course), and
- perching (suspension) of the culvert exit from the downstream water surface.

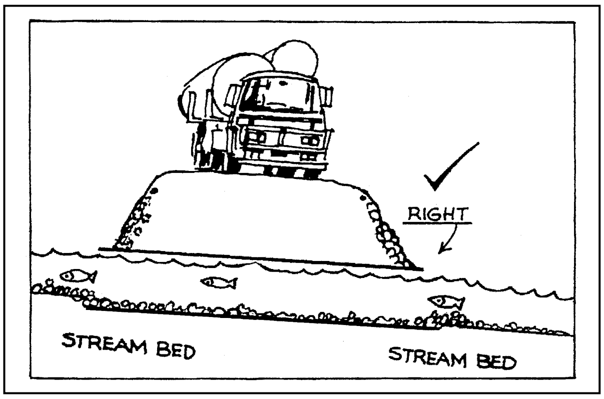
High water velocities within culverts are increased by smooth surfaces within the culvert and the slope of the culvert. Slopes of 0–2° generally allow fish passage. However, slopes greater than 2° effectively prohibit passage of all Tasmanian stream fish with the possible exception of *Galaxias brevipinnis* which has the ability to climb. Walker found that most culverts on roads in the Southern Forests have slopes greater than 2° and are significantly perched above the downstream stream surface preventing fish entering and passing through the culvert.

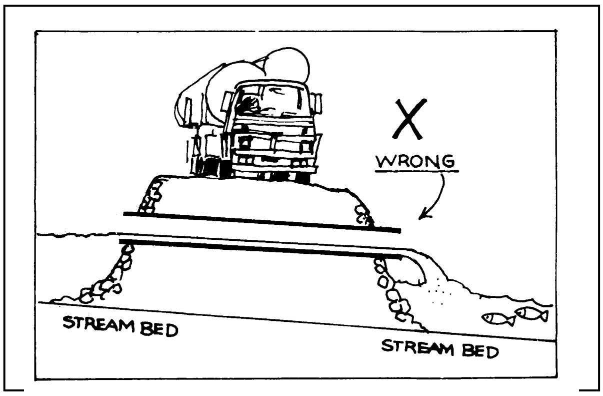
The following guidelines have been developed to assist Forest Practices Officers design and maintain culvert crossings in accordance with the *Forest Practices Code* provisions. The research into stream crossing design and impacts on aquatic organisms is continuing but in the interim these guidelines should be followed where feasible.

These guidelines should be used in conjunction with standard engineering or hydrodynamic rules which apply to the selection of appropriate culvert diameter for a particular catchment or road crossing.

3. New culvert crossings

- Where the stream slope is 2° or less the culvert slope should be between ½° and 2° to minimise silting up of pipes and excessive scouring at the discharge end.
- Where the stream slope is greater than 2° cylindrical culverts should not be used. (Ideally cylindrical culverts should not be used at all where fish passage is an issue.) Alternative open based culverts or culverts whose base can be moulded to the bed and natural slope of the river or stream should be used. The aim is to provide a culvert crossing which preserves the turbulent boundary layer on these steeper slopes.
- Disturbance to streamside and stream bank vegetation should be kept to an absolute minimum.
- Culvert pipe bases should be set at or just below the level of the natural stream bed.
- Culvert length should be minimised (culverts over 6 m in length are a barrier to fish passage, regardless of other factors).
- The inner culvert surface should be rough to slow water velocity, provide resting areas and allow some sedimentation. Bottom roughness should simulate natural stream bed morphology and should be composed of a non-eroding substance, or have concrete ‘baffles’ installed to an agreed design (seek further advice from the FPA Biodiversity Program staff).





4. Existing culvert crossings

Existing crossings must be inspected and maintained on a regular basis. Forest managers should also develop and implement a continuing strategy to assess the effectiveness of existing culvert crossings. Where it is necessary and feasible, existing culverts should be progressively upgraded in accordance with the following guidelines:

- If an existing culvert has a slope of between 0–2° but discharge is above the level of the stream water surface at low flows then the following restoration options should be considered:
  - The riffle crest at the downstream edge of the scour pool below the culvert outlet should be raised so that the water level in the downstream scour pool at low flows is at least above the lip of the culvert exit. Rocks used to raise the riffle bed must be of a minimum size (see Appendix 1). They must be placed evenly over the riffle crest and must armour the downstream edge of the riffle to prevent erosion. Disturbance to the stream bed should be minimal during this rehabilitation process. These sites should be inspected at regular intervals, as part of routine road and culvert maintenance programs.
- Where the existing culvert slope is greater than 2° and is limiting passage of fish and other aquatic fauna then the following restoration options should be considered:
  - The culvert should be replaced with a new crossing following the guidelines for new culverts above, or
  - Flow shelter structures (e.g. concrete 'baffles') may be inserted into the culvert floor. Seek further advice from the FPA Biodiversity Program staff.

For further advice contact staff of the FPA Biodiversity Program.

References

Forest Practices Board 2000, *Forest Practices Code*, Forest Practices Board, Hobart, Tasmania.

Walker, R. 1999, 'Examination of the barriers to movement of Tasmanian freshwater fish species', Honours Thesis, Zoology Department, University of Tasmania, Hobart.

Publication details

This Technical Note has been prepared by staff of FPA's Biodiversity Program in collaboration with Dr Peter Davies. It should be cited as:

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Appendix 1 Calculating minimum rock size

Single or double culverts

Rocks used to fill or armour the scour pool and/or armour riffles downstream of culvert outflows should have a diameter 1.2 to 2 times the figure calculated using the following equation:

D (cm) = 1000 x culvert diameter (m) x culvert slope

where D is the 'incipient diameter' (the diameter of rocks in the stream downstream of the culvert that are only moved by high flows)

Thus, for a 1.3 m diameter culvert, and a culvert slope of 4% (i.e. 0.04), the incipient diameter is 1000 x 1.3 x 0.04 = 52 cm.

The rocks should therefore be 1.2 to 2 times larger than this (i.e. 60 cm to 1 m diameter)

Complex culvert situation

Where more than one culvert diameter is used, and/or culverts are set at significantly different heights, replace the culvert diameter in the above equation with the estimated bankfull stream height, and the culvert slope with the stream slope (adjusting by 1.2), as follows:

D (cm) = 1000 x bankfull height (m) x 1.2 x local stream slope

Stream slope can either be measured using a clinometer or level, or can be roughly estimated by measuring the distance between nearest contours on a 1:25000 or 1:10000 map.

Thus, for a 1.1 m high bankfull stream height, and an average stream slope of 2% (i.e. 0.02), the incipient diameter D is 1000 x 1.1 x 1.5 x 0.02 = 33 cm.

The rocks should therefore be 1.2 to 2 times larger than this i.e. 45 cm to 70 cm diameter.

Document Summary Information

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Version Control

Version	**Date**	**Author(s)**	**Summary of changes**
0.1	8/13	FPA Bio Section	Initial draft with input from specialists and planners. This draft was based on an earlier version that has been available to planners as a draft since 2000. Trim ref 2014/144785
0.2	4/8/14	S Munks and P Davies with comment from P McIntosh	Incorporates comment/edits from P Davies and P McIntosh
0.3	29/09/14	S Munks and C Grove	Minor edits and uploaded to website as draft. New trim ref 2014/192035.
0.4	3/11/14	Amy Koch	Minor edits in response to FPAC (title and wording clarification)
1.0	26/11/14	Amy Koch	Remove draft watermark and indicate endorsement by the Board

Stages required for release outside FPA

Category of advice		**A2**
Stages	**Required/not required**	**Completed (date) for version 1.0**
Specialist	Required	May 2014
Line Manager	Required	July 2014
Peer/FPO/stakeholder review	Required	August 2014
CFPO	Required	August 2014
FPAC		31/10/14
Board after consultation with FPAC	Required	November 2014