Temporary Watercourse Crossing: Culverts

DRAINAGE CONTROL TECHNIQUE

Low Gradient		Velocity Control		Short Term	✓
Steep Gradient		Channel Lining		Medium-Long Term	
Outlet Control		Soil Treatment		Permanent	

TCC

Symbol

Photo 1 – Temporary culvert formed from recycled steel pipes

Photo 2 – Temporary crossing of minor drainage channel

Key Principles

1. Significant bank damage can occur during the installation and removal of these temporary watercourse crossings; therefore, extreme care must to be taken to minimise such damage.
2. It is important to minimise the risk of sediment-laden runoff from the approach roads being allowed to discharge directly into the watercourse without passing through an appropriate sediment trap or vegetative filter.
3. Critical design parameters are the flood immunity of the road surface and the structural integrity of the culverts during flood flows.
4. Critical operational issue is the minimisation of harm to the watercourse, including any sediment releases.

Design Information

The material contained within this fact sheet has been supplied for use by persons experienced in hydraulic engineering.

Temporary culvert crossing require both structural and hydraulic design. Their design requires input from both structural and hydraulic specialists.

Design parameters include expected traffic loads, required flood immunity, and expected hydraulic and debris loadings. The following information is supplied for general reference purposes only.

Culvert Structure:

Consideration should be given to the potential damage caused to the watercourse if the culverts wash away during a flood event. In critical locations it may be necessary to tether the pipes to the watercourse banks using cables or chains to prevent individual components of the culvert being washed down the watercourse during severe floods.

Sizing:

Where practicable, the hydraulic capacity of the culvert should be equivalent to the in-bank hydraulic capacity of the watercourse, or at least equal to the hydraulic capacity of the watercourse below the level of the road surface. The purpose of this requirement is to minimise the water level difference across the culvert at the point when the road surface is first overtopped. This reduces the risk of bank erosion caused when flood waters re-entering the downstream channel.

The culvert should consist of the largest diameter and greatest number of cells that will fit into the existing channel below the nominated road surface elevation.

The minimum recommended pipe size is 450mm.

The minimum recommended spacing between pipe cells is 300mm.

The culvert cells (pipes or box units) should extend at least 300mm beyond rock fill.

Discharge from the culvert should not cause excessive bed or bank erosion.

The recommended design standard for temporary culvert crossings is presented in Table 1.

Table 1 – Recommended design standard for temporary culverts [1]

Flow Conditions	Design Standard
Significant channel and/or overbank flood flows possible, but unlikely during life of structure	• Minimum 1 in 1 year design standard wherever reasonable and practicable. • Temporary crossing to be structurally sound during 1 in 1 year to 1 in 10 over-topping event depending on flood risk.
Significant channel and/or overbank flood flows likely (wet season)	• Minimum 1 in 2 year design standard wherever reasonable and practicable. • Temporary crossing designed to be structurally sound during a 1 in 10 year over-topping flood event.

[1] Design standard may be reduced in consultation with regulating authorities based on cost analysis, and waterway impact and risk assessment.

Unless otherwise supported by detailed hydraulic analysis, the head loss (ΔH) across a culvert at the point of flow overtopping should be limited to a maximum of 400mm.

The head loss 'H' (refer to Figure 1) across a culvert that is not being overtopped (i.e. all water is passing through culvert) can be approximated using the following formulas:

Concrete pipe/box culverts: $\Delta H \approx 1.7\,(V^2/2g)$ (Eqn 1)

Steel pipe projecting from fill: $\Delta H \approx 2.0\,(V^2/2g)$ (Eqn 2)

where:

ΔH = change in water level across the culvert [m]

V = average flow velocity through the culvert [m/s]

g = gravity [9.8m/s]

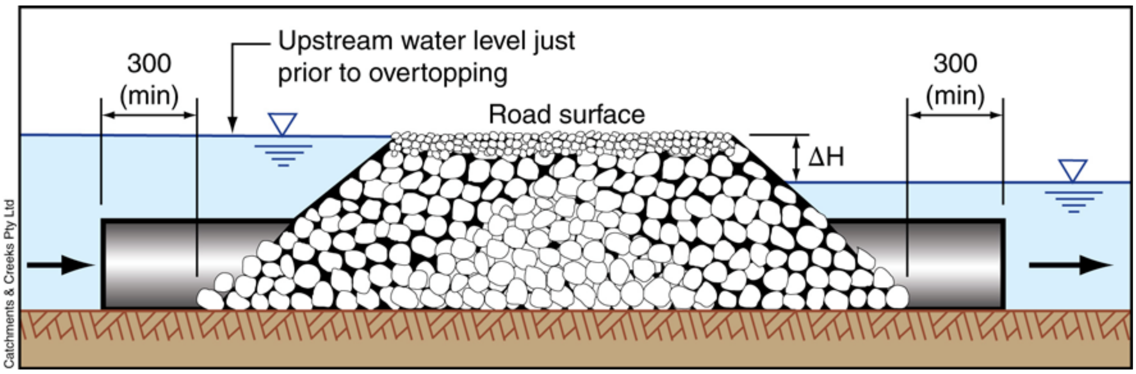

Figure 1 – Culvert hydraulics just prior to overtopping

Culvert pipes should be placed on a geotextile filter overlay covered with a bed of washed rock.

The pipes should be covered with a sufficient rock to prevent their damage by the expected road traffic—refer to manufacturer's specifications for the given pipe material.

The road surface is formed from a 150mm layer of 50 to 75mm washed aggregate.

Wherever practicable, the road surface over the pipes should be raised a minimum of 300mm above the adjoining floodplain elevation (Figure 2) to allow overtopping flows to initially pass around the structure. Such bypassing is not appropriate if the floodplain contains exposed, unstable soil.

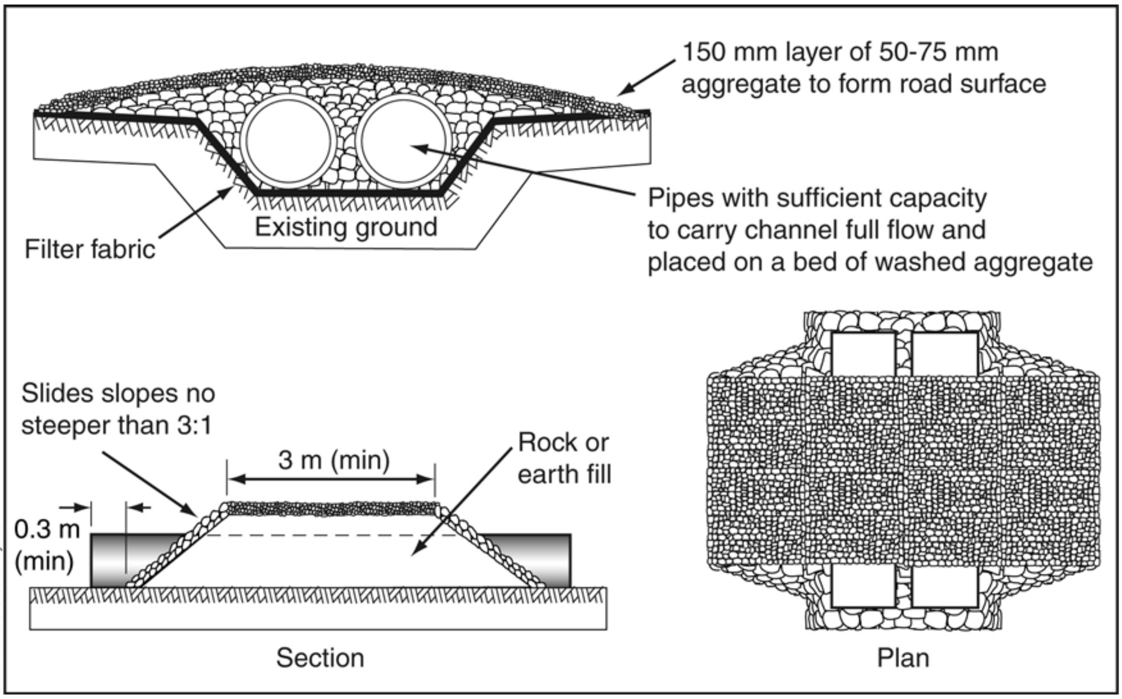

Figure 2 – Preferred arrangement of temporary culvert crossing in a minor stream with low-gradient overbank (floodplain) areas

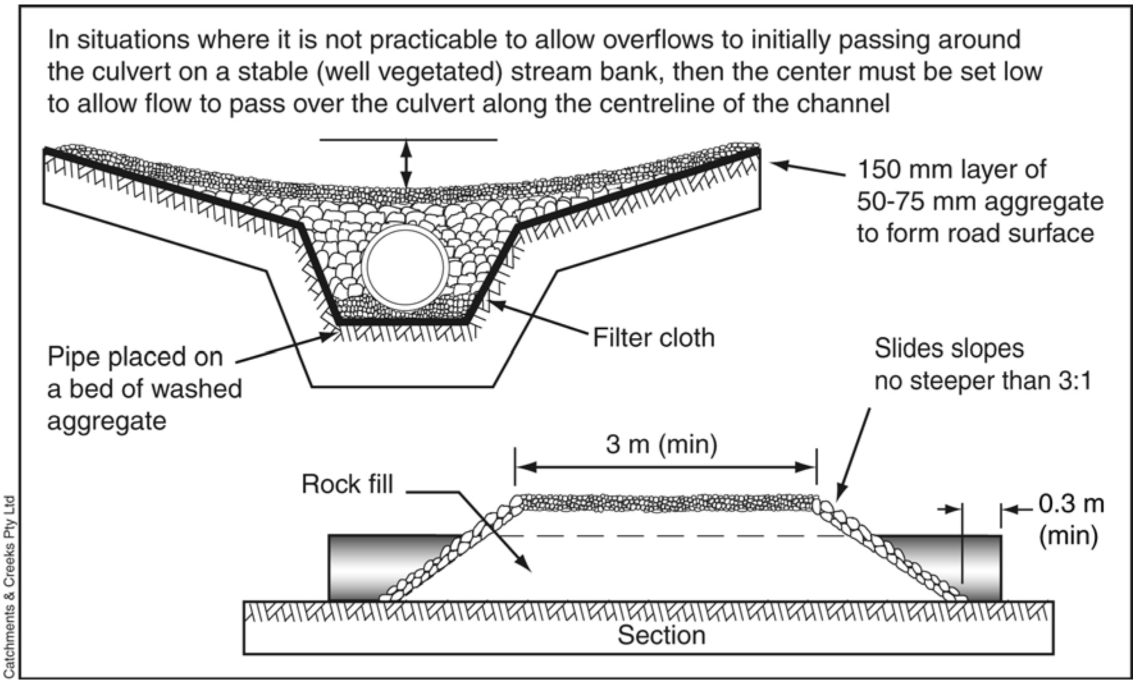

Figure 3 – Single cell culvert placed within a constricted channel with steep overbank slopes

The use of earth or soil as *fill material* placed within the waterway channel during construction of the temporary culvert crossing should be avoided wherever possible.

In wide riverbeds, the roadway embankment can be lowered below the channel banks (Figure 4) to reduce the hydraulic stress during initial overtopping of the culvert. This will reduce the required number of pipes.

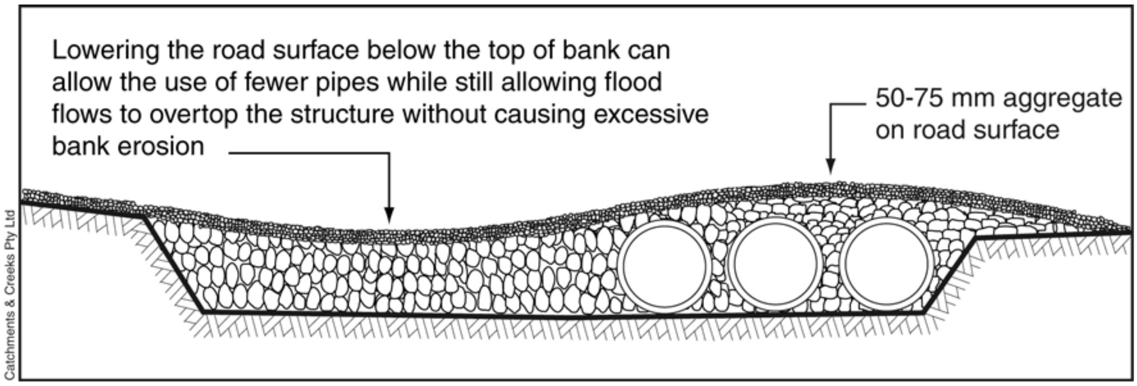

Figure 4 – Profile of temporary culvert crossing within a wide channel

On medium to high-speed roads, the access ramps usually need to be placed along a relatively straight alignment for safety reasons. In such cases, good vegetation coverage is highly desirable on the recessed banks to avoid erosion caused by turbulent eddies. Another benefit of this layout is that the recessed ramps help to create low velocity backwater areas that can be used by fish migrating upstream during flood events as resting areas.

If access ramps need to be cut into the channel banks (Figure 5), and these ramps cannot be cut perpendicular to the channel, then wherever practicable align the ramps such that they fall to the waterway in an upstream direction. The reason for this is to minimise bank erosion caused by eddies resulting from flood flows moving past access ramps that are cut into the channel banks. Pointing the ramps upstream will usually allow a gradual expansion of the stream flow followed by a sudden contraction of the flow at the ramp (which is the preferred hydraulic condition).

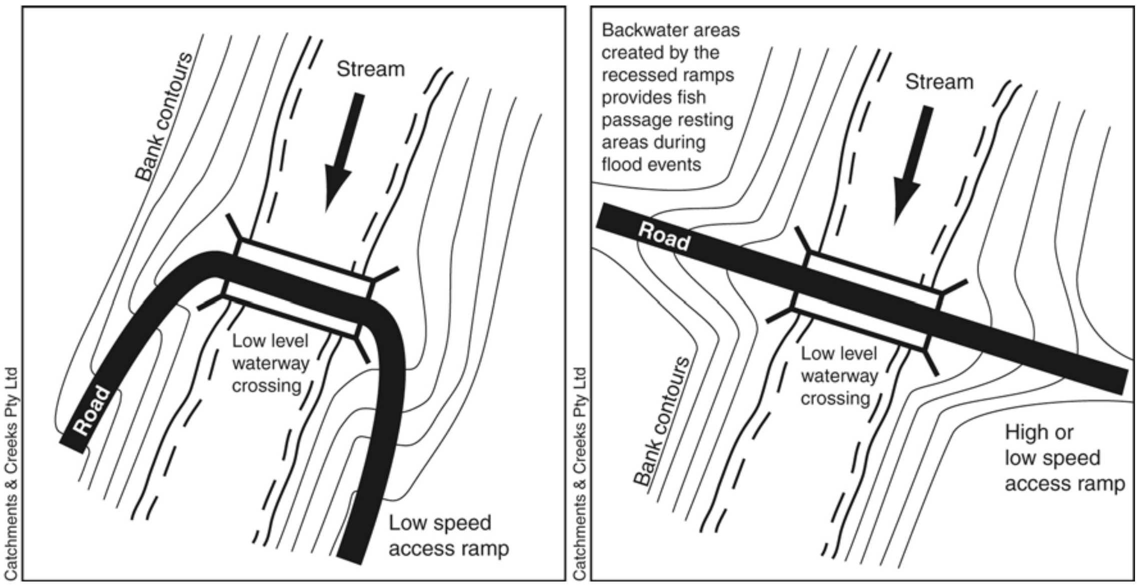

Figure 5 – Preferred alignment of access ramps

It is noted that if an access ramp's design results in a sudden expansion in the channel width, then eddies may form in the water during flood events and these eddies can then move downstream to locations where they can cause bank erosion. To avoid such erosion problems, sudden expansions in flow should be avoided.

Approach roads:

The approach roads should be stabilised (e.g. gravelled) and where practicable, should have appropriate flow diversions (Figure 6) installed to prevent sediment-laden runoff from the roads discharging untreated into the stream. Ideally the approach roads should be straight for at least 10m each side of the crossing, and should align perpendicular to waterway channel.

In locations where sediment-laden runoff from the approach ramps cannot be suitably treated to avoid harm to the watercourse, then these ramps should be stabilised (e.g. gravel, aggregate, or rock) depending of expected channel flow conditions.

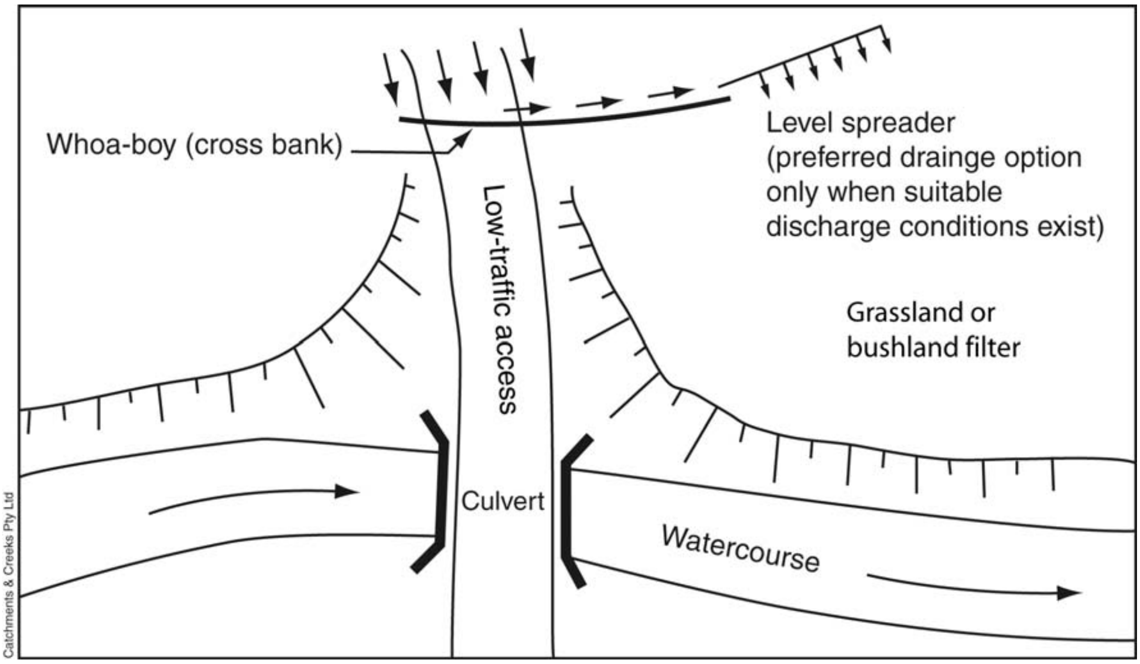

Figure 6 – Typical flow diversion placed on approach roads

Photo 3 – Using only fine aggregate to form the fill embankment can result in severe wash-outs if overtopped

Photo 4 – If the culvert has insufficient hydraulic capacity, then overtopping flows are likely to cause severe bank erosion

Legislative Requirements:

Legislative requirements, permits and approvals vary from state to state, and region to region. Typical permit and approval requirements include:

- Approval for works within a watercourse (typically a department of water resources or natural resources).
- Approval for disturbance to bed, banks, or riparian vegetation.
- Approval for importing materials into a watercourse to form the fill embankment.
- Approval for works that may interfere with fish passage (typically a fisheries authority).

Description

A temporary culvert crossing consists of one or more sections of pipe covered embedded in a suitable rock and aggregate embankment formed as a bridging structure across an open channel.

Temporary culvert crossings are commonly formed from recycled concrete or steep pipes.

Purpose

Used to provide dry weather access to a construction site, or to provide a traffic bypass route during construction of a permanent crossing.

The main purpose of these crossing is to minimise the risk of direct contamination of stream flow by construction traffic.

Limitations

These crossing are generally restricted to drainage channels and minor streams.

Temporary river crossing normally need a more substantial design, possibly involving a bridge structure. In northern Australia, temporary culvert crossings of wide riverbeds may be suitable during the dry season when high flows are most unlikely.

Advantages

A well-designed and operated culvert crossing can minimise sediment releases to streams during a variety of weather conditions.

Installation is often much quicker and cheaper than a temporary bridge crossing.

Culvert crossings have the potential to cause much less disturbance to the stream flow than a causeway or ford crossing.

Disadvantages

Significant damage can be done to the bed and banks of the watercourse during construction and removal of the culvert.

Most temporary culvert crossings will experience some degree of damage during flood events.

A culvert crossing is likely to have a greater adverse impact on fish passage compared to a temporary bridge crossing.

Unless appropriately designed, a culvert crossing can aggravate upstream flood levels, possibly causing damage to adjacent properties.

Temporary culvert crossings can increase the potential for bank erosion immediately adjacent to the crossing. Unfortunately, the use of extensive rock protection of the stream banks to avoid this problem will also increase the total area of bank disturbance.

Failure of a stream crossing or approach road can result in significant sediment loss.

Culvert crossings are highly susceptible to debris blockage.

Special Requirements

When the crossing is no longer required, all materials including pipes, rock, aggregate and filter cloth must be removed. Final clean up also includes restoration of the watercourse to its original condition and cross section.

Special attention will need to be paid to maintaining fish passage if the crossing is in place during a known fish migration period. Seek advice from local Fisheries officers.

Location

Ideally, temporary culvert crossings should be located on a straight section of a watercourse, well downstream of a sharp bend.

In any case, all crossings should be located in a position that will cause the least overall disturbance to the watercourse and associated riparian vegetation, especially to those areas that are required to remain in a 'natural' state.

Site Inspection

Temporary stream crossings should be inspected with great care because these structures can contribute to the discharge of sediment directly into a stream causing significant environmental harm. Such harm can occur during their construction, flood events, and during their decommissioning.

Check any overflow or bypass flow paths to make ensure the banks are stable.

Check for erosion cause by stormwater runoff passing down the approach roads.

Check for appropriate erosion controls and flow diversions on the approach roads.

Check for debris blockages.

Check the stability of the approach roads.

Materials

- Culverts: any commercial conduit that is suitable for the required traffic loading.
- Rock: minimum 150mm nominal rock size.
- Aggregate: 50–75mm clean aggregate.
- Geotextile fabric: heavy-duty, needle-punched, non-woven filter cloth (minimum 'bidim' A34 or equivalent).

Installation

1. Prior to commencing any works, obtain all necessary approvals and permits required to construct the temporary watercourse crossing, including permits for the disturbance of bank vegetation, aquatic vegetation (e.g. mangroves) and any temporary instream flow diversion barriers or sediment control measures.
2. Refer to approved plans for location and construction details. If there are questions or problems with the location or method of installation, contact the engineer or responsible on-site officer for assistance.
3. Ensure that the location of the crossing will not interfere with future construction works.
4. Prior to significant land clearing or construction of the approach ramps, establish all necessary sediment control measures and flow diversion works (instream and off-stream as required), clearing only those areas necessary for installation of these measures.
5. To the maximum degree practicable, construction activities and equipment must not operate within open flowing waters.
6. Maintain clearing and excavation of the watercourse bed and banks to a minimum. Initially clear only the area necessary to allow access for construction. Clear the remainder of the approach ramps only when adequate drainage and sediment controls are in place.
7. If flow diversion systems cannot be installed, then conduct bank excavations by pulling the soil away from the channel.
8. Where practicable, construct the watercourse crossing perpendicular to the channel.
9. Where practicable, the approach ramps should be straight for at least 10m and should be aligned with the crossing.
10. Where practicable, direct stormwater runoff from the approach ramps into stable drains, adjacent vegetation, or appropriate sediment traps to minimise the release of sediment into the watercourse.
11. Shape the channel, if necessary, to receive the pipe/s.
12. If highly erosive soils are detected, then appropriately stabilise such soils as soon as practicable.
13. Cover the crossing footing with heavy-duty filter cloth.
14. Cover the filter cloth with a minimum 150mm of clean, 50 to 75mm aggregate.
15. Place the specified size and number of culvert cells and align them with the direction of the downstream channel.
16. Ensure the pipes extend at least 300mm beyond the proposed extend of rock fill.
17. Fill between the pipe/s with 75 to 100mm aggregate.
18. Cover pipe/s with sufficient rock (minimum 300mm layer) to satisfy manufacturer's loading requirements to avoid damage to the pipe/s resulting from the expected traffic load. Slope of rock face upstream and downstream of the culvert no steeper than 3:1 (H:V).
19. Form the shape of the road surface in accordance with the plans and/or standard drawings.
20. Apply a suitable cover of aggregate over the rock fill to form the trafficable road surface.
21. Finish construction and stabilisation of the approach roads including the approach ramps each side of the bridge crossing.
22. Take all reasonable measures to prevent excess rock, debris and construction material from entering the watercourse, especially any still or flowing water.

23. If it is not practicable to stabilise the access ramps against erosion, then install flow diversion banks across the width of each access ramp adjacent the top of the channel bank, and at regular intervals down the ramps (as required) to prevent or minimise sediment-laden runoff flowing directly into the watercourse.
24. Appropriately stabilise any disturbed watercourse banks.
25. Stabilise all disturbed areas that are likely to be subjected to flowing water, including bypass and overflow areas, with rock or other suitable materials.

Maintenance

1. Temporary watercourse crossings should be inspected weekly and after any significant change in stream flow.
2. Debris trapped on or upstream of the crossing should be removed.
3. Repair any damage caused by construction traffic. If traffic has exposed bare soil, stabilised as appropriate. Maintain a minimum 200mm cover over the culverts.
4. Check for erosion of the formed embankment, channel scour, or rock displacement. Make all necessary repairs immediately.
5. Check the bypass floodway making sure the banks are stable.
6. Check for excessive erosion on the approach roads.
7. Check the conditions of any flow diversion channels/banks and the operating conditions of associated sediment traps.

Removal

1. Temporary watercourse crossings should be removed as soon as possible after alternative access is achieved or the culvert is no longer needed.
2. Remove all specified materials and dispose of in a suitable manner that will not cause an erosion or pollution hazard.
3. Restore the watercourse channel to its original cross-section, and smooth and appropriately stabilise and revegetate all disturbed areas.