Fish Habitat Guideline FHG 001

FISH PASSAGE IN STREAMS

Fisheries guidelines for design of stream crossings

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BACKGROUND

Introduction

Fish move widely in rivers and creeks throughout Queensland and Australia. Fish movement is usually associated with reproduction, feeding, escaping predators or dispersing to new habitats. This occurs between marine and freshwater habitats, and wholly within freshwater. Obstacles to this movement, such as stream crossings, can severely deplete fish populations, including recreational and commercial species such as barramundi, mullet, Mary River cod, silver perch, golden perch, sooty grunter and Australian bass.

Many Queensland streams are ephemeral (they may flow only during the wet season), and therefore crossings must be designed for both flood and drought conditions. Although fish do not move at the top of the flood, they may be stimulated to move by flood conditions. Consequently the period directly after the flood peak is often most important for fish movements. However, some fish species also need to move through crossings during periods of low flow.

Crossings are constructed for public roads and railways, as well as for access to private property. In Queensland, stream crossings are often built over major rivers, minor streams and creeks and cater for a variety of flow conditions. Crossings are also built over the estuarine reaches of streams and rivers. Tidal barriers can have a major impact on upstream populations of those fish that need to spawn in marine environments. Larvae and juveniles of these species, migrating upstream from the sea into freshwater, have limited swimming ability and are particularly vulnerable to barriers.

While there has been concern over the effects of dams and weirs on fish movements, simple structures such as road or rail crossings (which are not licensed under the *Fisheries Act 1994*) can also have significant effects. A poorly designed or installed culvert can affect the fish stocks of an entire drainage basin. These Guidelines identify the potential effects that stream crossings have on fisheries resources, and recommend ways in which these effects can be mitigated.

The information in these Guidelines is provided following consultation with major client groups and research colleagues. This information should be considered by those designing and/or constructing stream crossings so that the passage of native fish may be facilitated. Further information on design, siting or maintenance of stream crossings, or about the fisheries resources of a specific area (e.g. whether fish passage is an issue at all) may be obtained by contacting any of the regional DPI Fisheries offices listed in Appendix 1.

Stream Crossings in Queensland

A stream crossing is a structure on a waterway that provides access for traffic and allows free water passage. Stream crossings are generally bridges or culverts, but include low-level crossings such as fords and causeways. Culverts are channels or conduits that transport water beneath roads or other structures, and may be designed as an arch, a box, or a pipe (Fig. 1).

Arch culverts can be constructed from corrugated iron, concrete, brick or timber. Most arch culverts have concrete footings set into the stream bed and/or banks, and retain the natural stream bed as the functional watercourse.

Box culverts are prefabricated from reinforced concrete, and may be installed without a bottom, or with the bottom set above or below the stream bed.

Pipe culverts, also prefabricated, are usually constructed from corrugated iron or concrete, but may also be made from PVC or masonry. They may be installed on or below the stream bed. Concrete or corrugated iron pipe culverts are commonly used in Queensland.

Low-level crossings, sometimes with low-flow culverts, are used on low-lying minor roads and are usually concreted or modified natural stream beds.

Who Builds Stream Crossings?

Bridges and culverts can be commissioned by government departments (e.g. Main Roads, Queensland Rail), local governments, statutory authorities (e.g. Port Authority) and property owners (e.g. farmers, developers). Causeways tend to be used on private roads or infrequently used public roads. Stream crossings may be temporary or permanent (e.g. temporary crossings are often constructed during the building of bridges).

Why are Stream Crossings of Concern to Fisheries?

Disrupt fish movements

Queensland has streams that vary from those that only flow for a limited time each year, drying back to waterholes, to streams that flow all year. Fluctuating flow regimes impose restrictions on fish. The onset of flows is therefore an important factor in triggering breeding or migration. Australian fish have limited opportunities to migrate, and opportunities to do so need to be maximised. Any reduction of these opportunities is likely to significantly reduce the long term viability of fish populations.

During floods, streams carry large volumes of water, sometimes at high velocities. If a crossing has been designed such that the channel width is restricted, the velocity of water flowing through it will be further increased. Culverts in Queensland are primarily designed to be hydraulically efficient, to support high flows, and remove water quickly (e.g. they have smooth sides). Hydraulic efficiency is not always compatible with requirements for fish movement. While fish are stimulated to move in response to floods, the water velocity in culverts under flood conditions exceeds the swimming ability of many fish. Consequently, these fish are prevented from moving upstream and may be washed further downstream.

Fish migrating upstream in coastal eastern Australia often include larvae and juveniles of marine-spawning species, and smaller-sized adults. Survival and production of these species is reduced by barriers, which prevent juvenile fish from moving upstream to develop and mature. Generally, the swimming ability of fish increases with size. Smaller fish are weak swimmers and they are more likely to be hindered by fast flows at stream crossings. Most Australian native fish cannot jump obstacles. This is a problem if there is a drop at the stream crossing outlet (Fig. 2), particularly for fish moving upstream at times of moderate or low flow.

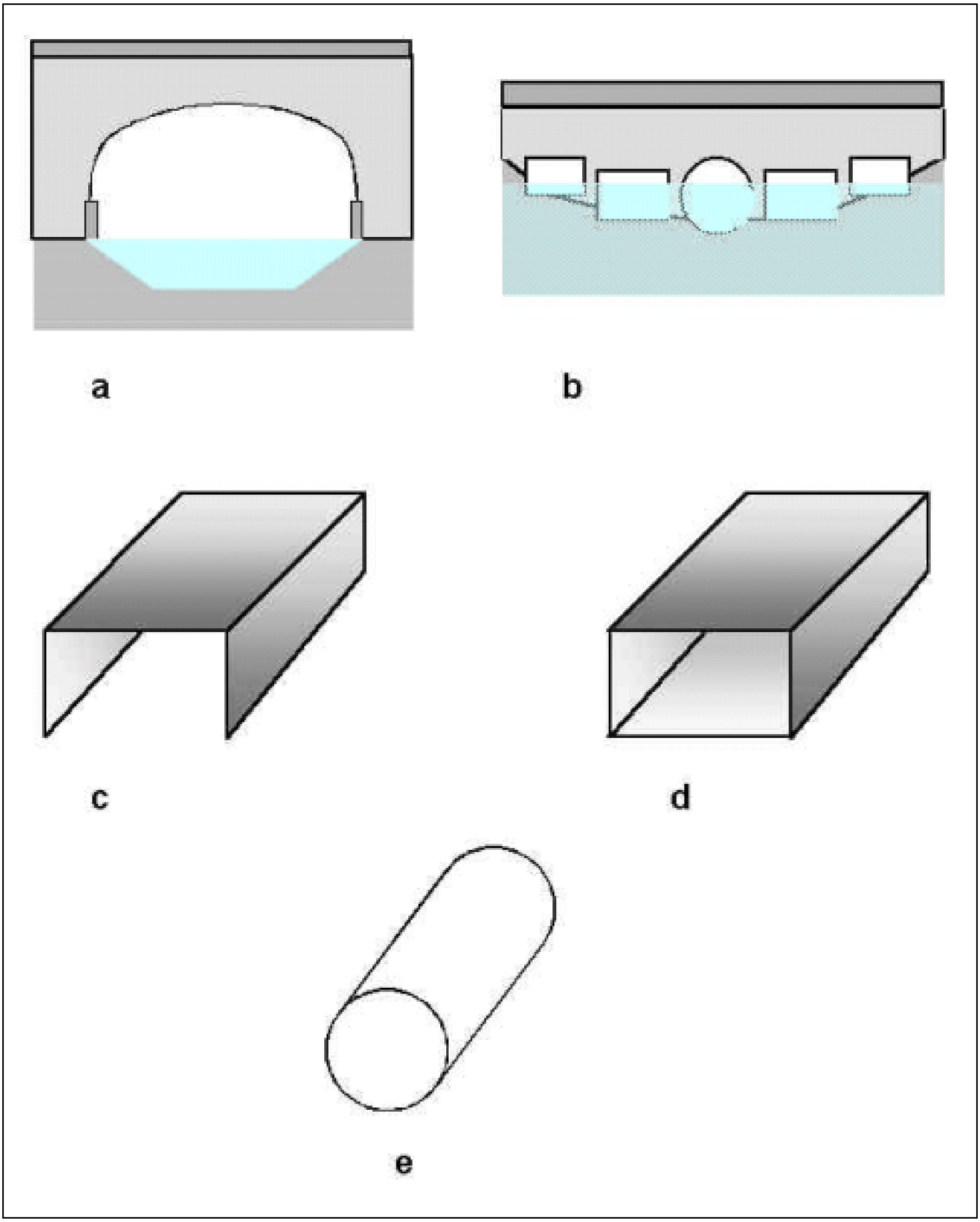

Figure 1. Different culvert shapes; *a*. arch culvert, *b*. multiple stacked culverts, *c*. open-bottom box culvert, *d*. closed-bottom box culvert, *e*. pipe culvert.

Fish passage can be impeded and/or prevented by a stream crossing if:

- the water velocity is too high;
- the water turbulence is too great;
- the culvert is too dark;
- the culvert is too long;
- the culvert is too narrow;
- the water in or over the crossing is too shallow;
- there is a drop on the downstream side of the crossing;
- the crossing has been placed at too great a slope;
- the crossing has not been maintained (i.e is overgrown or full of debris).

Deplete fish energy reserves

Fish swimming speed can be classified into three levels:

1) *Burst speed* – Fish can swim at high speeds for a short time (seconds), but tire rapidly. Fish rest between such bursts of intense activity. *Burst speed* is used to swim through an area of high water velocity, with rest in slower areas.
2) *Sustained speed* – Fish can swim at moderately high speeds for longer (minutes), but will be stressed and soon tire. *Sustained speed* may be used to swim the length of an unmodified culvert.
3) *Cruising speed* – Fish can swim at this speed continuously with little effort, and are not stressed. C*ruising speed* is used in slow-flow areas.

Fish forced to negotiate a stream crossing at *sustained* swimming speeds may have to make several attempts, severely depleting their energy reserves. Furthermore, making several attempts at passing a stream crossing can increase the time taken to reach spawning grounds. If spawning fish are delayed, their reproductive success, their ability to escape predators and their general condition can all be affected.

Increase fish mortality

Predation

Migrating adult, juvenile and larval fish delayed or trapped below crossings can suffer heavy mortality from recreational fishers and predators.

Siltation/sedimentation

Erosion and siltation are increased during peak flows if a culvert is too small or is clogged with plants or debris. A culvert that restricts the stream flow (thereby increasing water velocity) may also cause scouring of the stream bed and erosion of adjacent stream banks (Fig. 3) if the outlet is inadequately protected. This may create a drop at the culvert outlet. The sediment that is released is carried downstream and can smother fish spawning sites, eggs and affect food supplies.

Illness/Injury

Suspended silt can damage the mucous coating and irritate the respiratory systems of fish. High water velocities, turbulence and debris at stream crossings can injure fish, allowing subsequent bacterial and fungal infection. Exhaustion can reduce the ability of a fish's immune system to overcome illness or disease and to heal wounds.

Figure 2. Series of pipe culverts where erosion has created a drop at the outlet. Tully, Queensland.

Figure 3. Installation of culverts of insufficient size has resulted in erosion in the vicinity of the outlet, creating a large scour pool. Tully, Queensland.

FISHERIES REQUIREMENTS

What Can Be Done?

DPI Fisheries should be consulted during all phases of stream crossing design, siting or maintenance for advice on protection of fisheries stocks and habitats.

Timing of works

Time construction of instream sections of crossings to minimise conflict with fish migrations. Anyone planning instream works should first identify the species of fish present at the site and when these species migrate. This may be done by reference to Tables 1 and 2 (pp. 27, 33), which list known movement periods for a range of native fish. Fish are also listed by Drainage (Fig. 4) in Table 3 (p. 34). If more specific information is needed, a regional DPI Fisheries officer should be contacted (regional offices are listed in Appendix 1).

Whenever possible, instream work should be scheduled for the driest time of the year to minimise erosion, so long as there is minimum conflict with local fish migration. Instream construction should be completed as quickly as possible to lessen the impact on fish and habitats.

Siting

Local

Plan routes to minimise the impact on fish passage and fish habitat; e.g. roads and railways should avoid crossings in environmentally sensitive areas such as designated Fish Habitat Areas, known spawning grounds and nursery areas. Riffles and rapids should also be avoided, as they provide important habitat for insect larvae and fish. Sites where the channel is straight, unobstructed and well-defined, and where the gradient is shallow are preferred. This ensures that the crossing structure provides a direct entrance and exit for water flow, retains the natural direction of water flow and minimises erosion.

Catchment

Consider the implications of the planned crossing for the catchment. Other structures that are already in place downstream may be barriers to fish movement. The cumulative effect of these crossings may impede fish movements and affect reproductive success by depleting fish energy reserves (see p. 4). It is recommended that all structures should be a minimum of 100 m apart, and that developments should be planned to minimise stream crossings.

Construction methods

Site clearing and rehabilitation

Keep the removal of stream bank vegetation and disturbance to the natural banks and bed of the stream to an absolute minimum. Streamside vegetation shades the stream, preventing the water from becoming too warm for fish and provides cover from predators. The vegetation canopy also establishes a habitat for insects, a food source for fish.

Hand clearing of bank slopes at the site minimises erosion, siltation and the need for rehabilitation. Protective guards can be used to minimise damage to trees during clearing. A vegetated buffer zone of indigenous vegetation (at a density and structure similar to neighbouring undisturbed areas) should fringe all banks, waterways and wetlands.

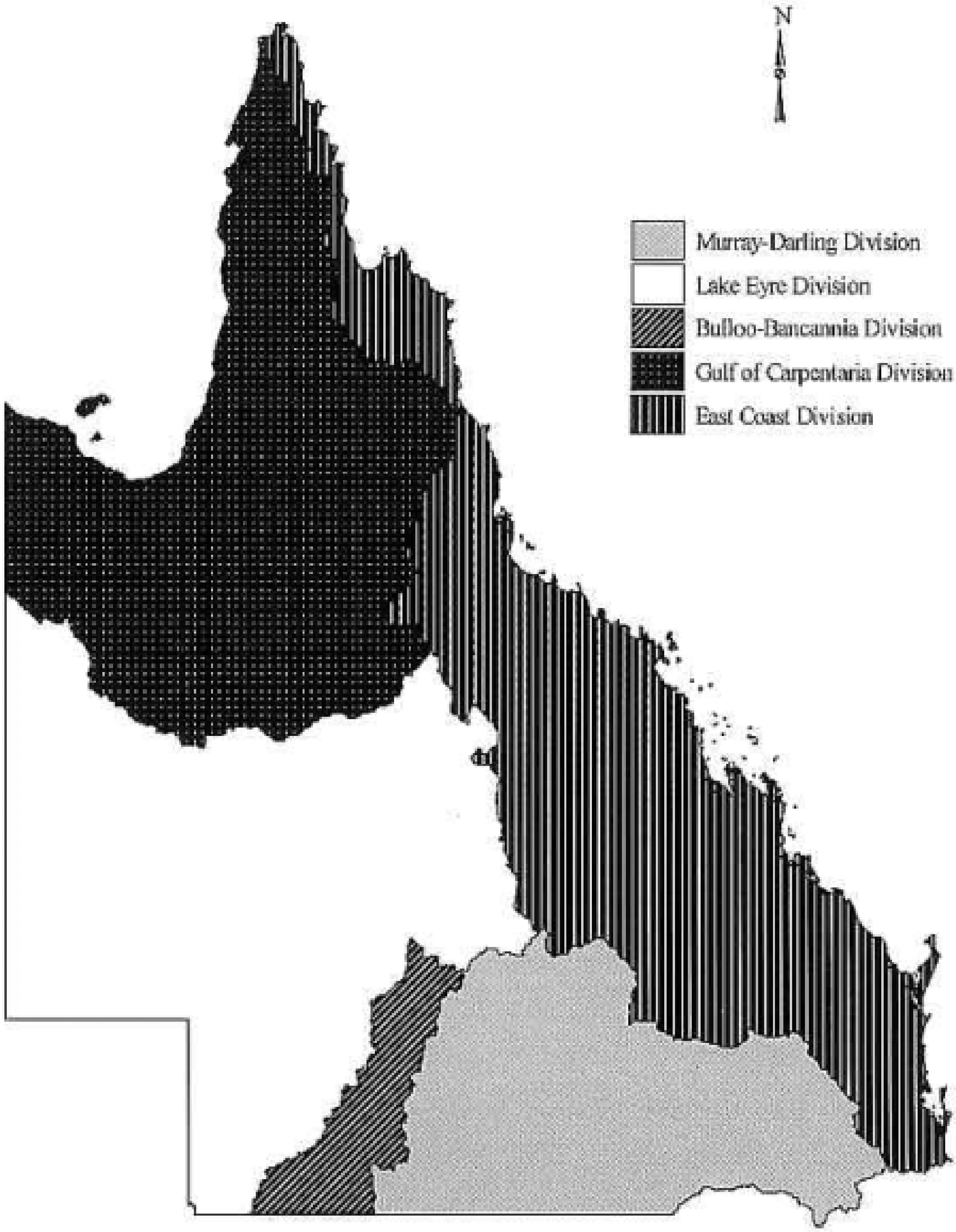

Figure 4. Queensland drainage divisions.

Control of erosion/silt

Minimise disturbance to the outer bank of stream bends during work and while gaining access. These are usually the most unstable banks and are prone to erosion. Heavy machinery should be excluded from fragile areas. Artificial riffles, which evenly distribute water flow across the stream bank, can prevent channelling and erosion, as well as providing aquatic habitat diversity. Vegetation is the preferred option to stabilise stream banks and minimise erosion.

Silt is most effectively controlled at the work site by working at times of low flow. Working in the dry eliminates conflict with downstream water users and fisheries. If the waterway has continuous flow, other control measures, such as flotation sediment curtains, should be used to minimise the effects of sediment downstream. It may be necessary to sample and analyse water quality before, during and after instream works.

All erosion and sediment control devices should be regularly maintained to ensure their effectiveness.

Modification of channel (fish habitat)

Avoid channelisation of meandering waterways. Where channels need to be significantly modified, the designs used should simulate natural watercourses by including meanders, pools, riffles, shaded and open sections, deep and shallow sections, and different types of substrata. Natural features such as rock outcrops and boulders should be retained.

After completion of instream works, all disturbed areas should be:

a) returned to their original condition (i.e stream slope and profile, and instream snags should be replaced);
b) stabilised to resist erosion;
c) replanted with native vegetation where cover has been removed or damaged.

Design Considerations

From the perspective of optimising fish passage, all permanent stream crossing structures should be either bridges or culverts. Bridges are the preferred crossings for stream sections used by fish. Bridges are also preferred for streams with actively eroding banks, as they usually alter the natural stream bed the least. Bridges and culverts should be sized to allow passage of anticipated flood volume, based on the design flow. Passage of debris should also be considered in the design of the stream crossing.

Bridge and open-bottom culvert designs that retain natural morphological features of stream width, stream bed composition, slope and cross-sectional area are preferred, as these facilitate the successful passage of fish. Culverts that are countersunk below the stream bed (Fig. 5) can also simulate natural conditions if natural materials are secured on the base of the culvert to increase roughness, thereby reducing water velocity.

Water velocity of 0.3 m/s or less over or through any instream structure is likely to facilitate passage of all species of native fishes. When velocities exceed 1 m/s, it is unlikely that fish will be able to migrate upstream.

Bridges

Bridges without instream support sections (Fig. 6) are the only crossings that pose no barrier to migrating fish. If bridge pylons are placed within the stream but are incorrectly spaced, eddies may be created around the pylons. These eddies could potentially delay migrating fish through confused flow signals, which disorientate and prevent fish from continuing the migration. Bridge construction may affect fish through increased erosion and siltation, the building of bunds, increase in noise, and loss of habitat at the site (i.e changes to the instream profile).

Solutions

Bridges should span the stream wherever possible to minimise instream impacts. If instream pylons are necessary, use the minimum number possible. Different pylon bases have different eddying effects, so a pylon base that minimises eddies should be incorporated within the design. Reducing eddying may aid fish passage and may minimise scouring which, in turn, could increase bridge life and decrease maintenance costs.

Grid bridges (Fig. 7) have been used successfully on the Burdekin River to withstand heavy floods. Constructed from railway lines and welded beams, with concrete abutments and piers, they range from 6-100 m in length and are relatively cheap to build.

Arch culverts

Arch culverts that retain the natural stream bed profile and original flow of water (Fig. 8) do not prevent fish passage. To maximise available light within the culvert, arch culverts should be no more than 6 m in length. Arch culverts, while relatively uncommon in Australia, are used extensively on public roads in North America. However, they are somewhat limited in high traffic loads due to their non-concentric shape. It should be noted that advantages of using arch culverts (e.g. increased light and free water flow) can be lost if they are not big enough (minimum width 3 m). It should also be noted that the installation of arch culverts entails excavation for the culvert footings which causes substantial disturbance to natural stream beds and banks. In some areas, stream channel erosion can undermine or wash out culvert footings.

Box and pipe culverts

If the use of the following types of culverts is unavoidable, then these should satisfy the criteria listed below.

Poorly designed and installed box and pipe culverts can both be a barrier to fish passage in all flow conditions. Pipe culverts create more problems for fish movements than do box culverts by reducing channel width at both high and low flows.

Listed below are factors that affect fish passage. The design of the crossing should incorporate the optimal requirements for each factor to maximise fish passage.

Water velocity

Velocity is a function of slope, roughness, culvert size and length. To control velocity, all of these parameters should be considered in the crossing design. Stream edges tend to have the lowest water velocities, which are favoured by migrating fish. Fish passage should be facilitated along stream edges as a priority.

Figure 5. Culverts can be countersunk below stream bed to prevent perching (Photo courtesy K. Bates).

Figure 6. Bridge with no instream sections. Brisbane, Queensland (Photo courtesy Main Roads Photo Visual Library).

Figure 7. Grid bridge. Burdekin River, Queensland (Photo courtesy A. Hogan).

Figure 8. Bottomless arch culvert (Photo courtesy R. Pritchard).

In natural streams, channel irregularities, pools, meanders and other such features provide zones of slow water where fish can rest (Fig. 9). No such areas exist in culverts. Velocities are nearly uniform throughout the length of a culvert and are usually greater than those in natural channels. Unmodified culverts require fish to swim relatively long distances at *sustained* or *burst speeds* without any rest.

In typical box culverts, velocities are highest at the water surface and lowest near the bottom and sides. Fish seek out the areas of slower water, following the easiest path through the structure. Circular culverts tend to increase the water velocity, and smooth pipes lack the slower water at the edges. Unmodified circular culverts can have water velocities of up to 3 m/s, exceeding the known *sustained* swimming speeds of any fish, and are least desirable for fish passage.

Solutions

If the water velocity in the culvert exceeds 0.3 m/s, modifications to reduce the velocity include:

- changing culvert roughness, slope or bed material by including baffles or rocks sized at 25% culvert width, spaced the same distance apart (Fig. 10) or using the natural stream bed;
- installing a larger size culvert than that required for hydraulic flow;
- replacing the existing crossing with culvert(s) of a different shape than that required for hydraulic flow;
- using a greater number of culverts;
- increasing the depth that the culvert is sunk below stream bed.

Baffles.—Culvert baffles, which have been used with some success in the United States, act as energy dissipaters (Fig. 11). They increase roughness, thereby lowering water velocities. Baffles change the flow pattern in their immediate vicinity, creating a sequence of slow and fast water zones. In a culvert with baffles, fish use burst speed to advance from one resting zone to another, and cruising speed to swim through resting zones. Therefore average water velocity can be higher than in a culvert without baffles. For multiple parallel culverts, only those near the stream banks are normally fitted with baffles. Studies in the United States and Canada have indicated that baffles may cause some problems, although the effect of baffle turbulence on fish is untested. Culvert baffles also tend to snag debris, and may therefore need additional maintenance.

Multiple culverts.—A multiple culvert structure built to stream width is more beneficial to migrating fish than a single culvert that does not span the stream, as multiple culverts allow water velocity to remain similar to the natural stream condition. Both box and pipe culverts can readily be incorporated in multiple culvert designs. Pipes can be used in mid-stream to move the bulk of the water flow efficiently, with box culverts installed at the stream edges where lower water velocities should allow fish passage. When installing multiple culverts, the culverts should be staggered in height, with the lowest in the middle of the stream channel, concentrating the water during low flow (Fig. 1).

Turbulence

Increasing the internal surface roughness of culverts increases water turbulence within the culvert barrel (Fig. 11). There may also be turbulence at the culvert inlet. The threshold level at which surface roughness decreases water velocity but does not create a turbulence barrier is not known (although turbulence of less than 30 Watts/m^3 has been successfully negotiated by migrating fish in fishways). Recent work in North America has shown that corrugated iron culverts are particularly problematic with respect to turbulence, and that turbulence barriers are critical for juvenile fish.

Figure 9. Irregularities in the bed and banks of natural streams create slow water areas that allow fish passage (Photo courtesy A. Hogan).

Figure 10. Placing rocks in the bottom of culverts can simulate the natural stream bed (Photo courtesy K. Bates).

While it is not known exactly how water turbulence presents a barrier to migrating fish, it is likely to be via the creation of eddies through which fish cannot swim. In turbulent water, fish would be unable to recognise the primary flow direction, would lose their orientation and therefore fail to negotiate the crossing.

Culvert illumination

Fish passage may be affected by the amount of natural light available in culverts, although further research is required to clarify this. Preliminary research shows that some native fish will not enter darkened passages (e.g. gudgeons, spangled perch), although the amount of light required has not yet been quantified. Other species will enter, but move more slowly, as they must find the most favourable path without the benefit of sight. This can delay fish for so long that they tire before completing the crossing and are swept back out.

Solutions

Culverts should not be totally dark. Short, wide box culverts provide the maximum light possible (Fig. 12). In certain cases, extra light can be provided by placing grates or skylights approximately every 2 m along the length of the culvert.

Culvert length

Long culverts can create a barrier to fish passage when combined with excessive water velocities. Fish cannot maintain *burst speeds* long enough to swim the entire length of most culverts. If the distance is too great (>6 m), fish may tire before reaching the other end, and be swept back downstream. Long culverts are also dark (Fig. 13), which may discourage some fish species from entering.

Solutions

Culverts should be less than 6 m if no resting areas are available and/or water velocities exceed 0.3 m/s. Longer culverts can allow fish passage if some of the other requirements for fish passage are met (e.g. lower water velocity, greater width and illumination).

Culvert width

If culvert structures are not as wide as the natural stream bed, water flow is restricted and water velocity increased. This creates a barrier for many native freshwater fish, as they are relatively poor swimmers. Narrow culverts are also dark, and tend to be vulnerable to debris accumulation and blockage. Large diameter culverts provide easy access and are easy to maintain.

Solutions

Individual culverts should be at least 600 mm wide, but the overall crossing structure should be as close as possible to the natural stream width (Fig. 14) to ensure minimum flow restriction.

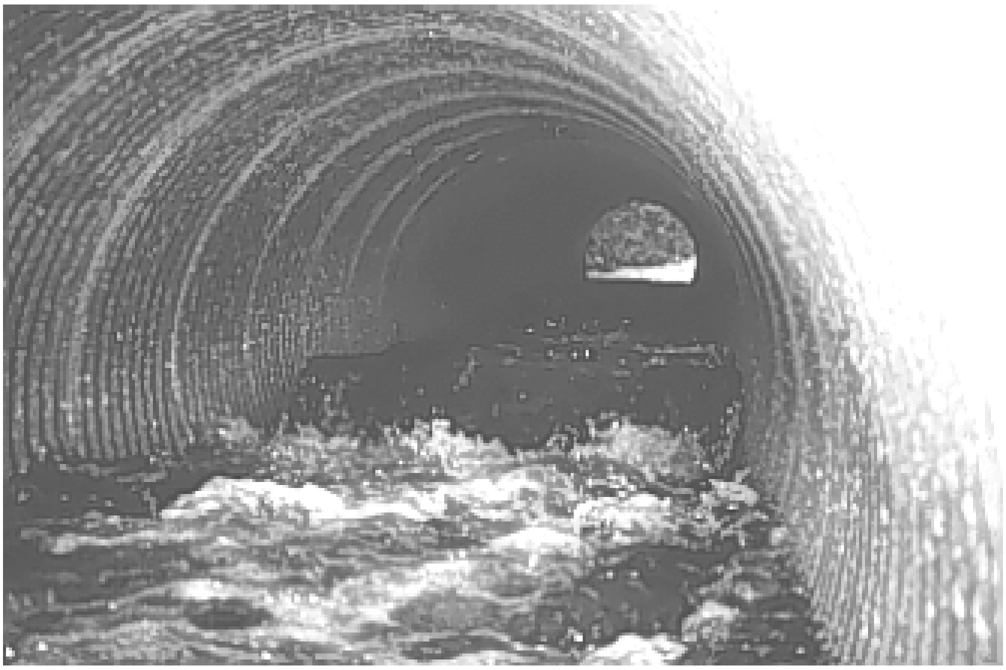

Figure 11. Baffles may be installed in culverts to increase barrel roughness and reduce water velocity (Photo courtesy K. Bates).

Figure 12. Short, wide culverts allow for maximum culvert illumination (Photo courtesy Main Roads Photo Visual Library).

Figure 13. Long culverts are dark (Photo courtesy Main Roads Photo Visual Library).

Figure 14. Crossing structures should be as wide as the stream to ensure that water flow is not restricted and water velocity is not increased. Tully, Queensland.

Culvert depth

Because culverts are designed to accommodate the very high flows experienced in floods, water depth at low flow is often insufficient for fish passage. The water depth in the culvert depends on its cross-sectional shape, e.g. box culverts tend to disperse flow to a greater extent than pipe culverts. This makes the water in a box culvert more shallow than it would be in a pipe, which concentrates water during low flows. Culvert aprons, used at culvert outlets to disperse outflow, also reduce water depth (Fig. 15).

Solutions

Fish need a minimum water depth of 0.2-0.5 m within the culvert to ensure their successful passage.

Elevation of culvert relative to stream bed

As mentioned previously, most Australian native fishes do not jump when faced with barriers. For stream crossings that are not at bed level, the drop created on the downstream side is usually impassable to most fish (Fig. 2). Fish that can jump (e.g. mullet) require deep pools with limited turbulence to jump from and to jump to. If the water depth in the culvert is too low (<0.2 m) and the water velocity over or through the culvert is too high (>0.3 m/s), those fish that do jump into the culvert may be swept back over the edge.

In actively eroding areas, perching may occur (Fig. 2). Special consideration should be given to culverts placed in channels that are degrading or are likely to degrade in the future (due to natural causes or changes in hydrology as a result of catchment land use changes). Bottomless culverts are preferred to minimise erosion in this instance.

Solutions

Water at the entrance and exit of the culvert should be at the level of the stream bed. There should not be a drop on the downstream side preventing fish from entering the culvert. Countersinking of culverts below stream bed (Fig. 5) is strongly recommended to prevent perching. All culverts should be designed with a specified minimum countersunk dimension. Twenty percent of the culvert diameter is considered appropriate.

Culvert slope or gradient

If culverts are placed at too great a slope (>1:100), most fish will be unable to negotiate them.

Solutions

Crossings should be placed in parts of the stream where slope is minimal.

Debris accumulation and overgrowth

By their size and location, culverts are vulnerable to debris accumulation. Culverts in low-flow areas may become overgrown (Fig. 16), which can present a physical barrier to fish. Often, the debris itself will not constitute a barrier, but when combined with other difficulties (such as increased water velocity and/or culvert length), the total effort required may exceed the swimming capability of the individual. Trapped debris may also cause injury to fish. This can impair their swimming ability, affect their spawning success and increase mortality.

Solutions

Wide, short box culverts are the most desirable to ensure minimum debris accumulation. Culverts should be regularly checked and debris removed, particularly prior to known fish migration periods.

Figure 15. Concrete aprons are used to disperse water flow at the culvert outlet (Photo courtesy Main Roads Photo Visual Library).

Figure 16. Culverts can become overgrown and clogged with sediment and/or debris if not regularly maintained. Tully, Queensland.

Low-level crossings

Low-level crossings such as fords and causeways (Fig. 17-20) may block fish passage in times of low flow due to poor siting, design or maintenance.

Siting

If low-level crossings are placed in streams where water flow is seasonally variable, water flow can be completely cut off in times of low flow. If the crossing is placed in a stream that has a significant slope, modification of the stream bed to enable vehicle passage (e.g. concreting) could result in the creation of a downstream drop (Fig. 18).

Solutions

Low-level crossings should be situated in parts of the stream where slope is minimal to reduce impacts on fish passage.

Design

If low-level crossings are created by filling in the natural stream bed (which raises the bed level), without incorporating low-flow culverts, an impassable barrier can be created at times of low flows. Concreting of the stream bed at a crossing can increase water velocity if it results in a smooth surface. Some crossings incorporate concreted rocks or boulders on their downstream side to reduce water velocity (Fig. 19, 20), however these may present a turbulence barrier to fish.

Solutions

The surface of low-level crossings should be constructed from erosion-proof material, such as cement or rock cobble. A rough surface is preferred to provide lower water velocities. Surface roughness can be increased by forming grooves or installing a series of wooden timbers on the surface, perpendicular to water flow.

Low-level crossings should also incorporate sufficient culverts to ensure a continuous year-round flow of water. Culverts placed at the stream margins, where water velocities are slower and fish tend to swim, will ensure successful upstream passage of fish. At low water levels, all water flow will occur through the culverts, and flow velocities through these culverts should be within the swimming capabilities of fish species likely to use the crossing. At high water levels, water flow occurs through the culverts and over the road surface.

Slow water areas need to be present along the stream banks to facilitate fish passage at low-level crossings. This is particularly important if no culverts have been used. Low velocity areas along stream edges can be created by extending the stream bank partway into the stream creating an ‘inlet’ (Fig. 21). By using *burst* swimming speed, fish may move along the stream bank into the inlet, recover in the inlet, then use *burst speed* to move out into the stream again.

Figure 17. Low-level crossing with low-flow culverts. Tully, Queensland.

Figure 18. Concreting of low-level crossings can result in a drop on the downstream side that is impassable to fish. Murray River, north Queensland.

Figure 19. Rocks or boulders may be concreted on the downstream side of a causeway to reduce water velocity. Weipa, Queensland (Photo courtesy D. J. Russell).

Figure 20. Concreted rocks and boulders can create a turbulence barrier to migrating fish. Tully, Queensland (Photo courtesy A. Hogan).

Maintenance

All instream crossings need to be regularly maintained to ensure continued fish passage. This is particularly important prior to known fish migration periods. Maintenance should include clearing of debris, clearing of silt/gravel build-up and regular erosion checks, especially following high flow (but not during fish migration, see Tables 1 and 2). It is also useful to observe stream crossings during high flows to ensure that they are functioning effectively, while still providing access for fish. Sediment traps and check dams should receive regular maintenance while in use.

Multiple culverts can be a hazard, in that they collect debris that would pass through a larger culvert. Debris can create a barrier in one culvert barrel while increasing the flow and velocity in the other barrels. Multiple culvert structures may therefore require additional maintenance.

If natural materials are used in low-level crossings, high flow events could result in rocks and sediment washing away and accumulating elsewhere. These accumulations may create a barrier to water flow. If low-flow culverts are present, they can become clogged with debris.

Culverts and low-level crossings should be periodically checked and maintained to stabilise sediment, control build-up and to remove debris, particularly prior to known fish migration periods.

Disposal of spoil

Spoil should be removed from stream banks and disposed of at designated dump sites. These sites should be away from the floodplain and above the tidal limit to ensure that spoil is not washed away. The extent of potential acid sulphate soil should be identified and if present, treated after consultation with the Queensland Acid Sulphate Soils Investigation Team (QASSIT).

Broken down or obsolete structures

Stream crossing structures which have not been maintained and are in disrepair can create considerable problems for fish movements by obstructing water flow, affecting the direction of stream flow and increasing debris accumulation. If structures have become obsolete, consideration should be given to removing them.

FOR FURTHER INFORMATION OR ADVICE REGARDING STREAM CROSSINGS, PLEASE CONTACT YOUR REGIONAL DPI FISHERIES OFFICER (REGIONAL OFFICES ARE LISTED IN APPENDIX 1).

Figure 21. Slow water areas can be created at the edges of low-level crossings by extending the stream banks into the stream to create an 'inlet'. Tully, Queensland.

The following requirements do not constitute a culvert design that would be adhered to in every respect. Rather, they are suggested solutions for individual problems and represent a starting point for design and further research. The inclusion of at least several of these requirements into culvert designs would assist the successful passage of Queensland native fish.

Summary Design Requirements

Type of stream crossing	Order of preference: bridge arch culvert open-bottom box culvert closed-bottom box culvert round (or pipe) culvert
Slope	as flat as possible; should not exceed 1:100.
Water depth	minimum 0.2-0.5 m.
Velocity	maximum 1 m/s, preferred 0.3 m/s.
Length	maximum 6 m without resting areas.
Width	to width of stream.
Bottom roughness	should simulate natural stream bed morphology.

The ‘ultimate culvert’ design is the ideal culvert from a fisheries perspective. Although arch culverts are preferred over other culvert designs, they are not commonly used in Queensland. Bottomless box culverts are common and, if designed and installed correctly, can be equally satisfactory for fish passage. If it is possible to satisfy all of the requirements listed below, then please do so. This will ensure successful and continuing fish passage.

The Ultimate Culvert

Type of stream crossing	open-bottom box culvert.
Material	roughened concrete.
Slope	as flat as possible.
Water depth	minimum 0.5 m.
Velocity	maximum 0.3 m/s.
Length	maximum 6 m.
Width	wide enough to ensure minimum flow restriction. Individual culverts minimum of 600 mm, total structure to extend across stream width.
Bottom roughness	natural stream bed

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Further information

Enquiries regarding The Integrated Maintenance Manual for Waterways, Wetlands, and Open Drains should be directed to:

The Waterways Program
Urban Management Division
Brisbane City Council
GPO Box 1434
Brisbane Q 4001

Phone (07) 3403 8888

Enquiries regarding grid bridges should be directed to:

Alan Griffiths
Director of Engineering Services
Dalrymple Shire Council
PO Box 233
CHARTERS TOWERS Q 4820

Phone (07) 4787 5600

Suggested Reading

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Table 1. Known movements, habitat and range of selected Queensland native fishes.

Name	Type of movement	Timing of movement	Habitat	Queensland range
Australian bass *(Macquaria novemaculeata)*	Adults river → estuary to spawn. Juveniles and adults upstream for dispersal and summer feeding.	May-August September-December	Coastal rivers, lakes, estuaries.	Coastal streams south of Mary River.
Australian smelt *(Retropinna semoni)*	Adults and juveniles move upstream.	Unknown	Lakes and slow-flowing areas with cover.	Murray-Darling Basin, Lake Eyre Basin, eastern coastal drainages south of Fitzroy River.
Banded grunter *(Amniataba percoides)*	Spawning/dispersal	August-April	All habitats, most numerous in still water.	Cape York, east coast.
Barcoo grunter *(Scortum barcoo)*	Move upstream to flowing waters after rains.	November-March	Still or slowly-flowing waters, often with high turbidity.	Internal drainages, Gulf of Carpentaria drainages.
Barramundi *(Lates calcarifer)*	Adults river → sea to spawn. Juveniles sea → river for dispersal/food and growth.	September-January September-March	Rivers, swamps, lagoons, storages, upstream as far as major waterfalls.	All Queensland coastal streams north of the Noosa River.
Blue or salmon catfish *(Arius graeffei)*	Adults sea → rivers to spawn. Can complete entire life cycle in freshwater.	August-April	Variety of habitats, prefers open water. Also found in deeper waters (usually >1 m water depth) with suitable prey.	Gulf, coastal drainages of north and eastern Qld.
Bony bream *(Nematolosa erebi)*	Adults and juveniles move upstream for dispersal.	August-April	Wide range of habitats, favour standing waters.	Gulf, Cape York West coast, Murray-Darling Basin, Lake Eyre Basin, North-eastern Qld coast.
Bull shark *(Carcharhinus leucas)*, other species enter freshwater	Unknown, probably for feeding and parasite control.	Unknown	Will penetrate far upstream, often as far as barramundi.	Particularly Gulf, Cape York and east coast including the Brisbane River.
Coal grunter *(Hephaestus carbo)*	Unknown	Unknown	Prefer clear, flowing water around snags.	Gulf, Cape York.
Common archer fish *(Toxotes chatareus)*	Unknown	Unknown	Near banks and overhanging vegetation, open water at night, prefer still water.	Gulf, eastern coastal drainages north of Pioneer River.

Table 1 contd.

Name	Type of movement	Timing of movement	Habitat	Queensland range
Common jollytail *(Galaxias maculatus)*	Adults river → estuary to spawn. Juveniles estuary → river.	April-July September-October	Still or gently-flowing environments.	Southern Qld coastal streams.
Eel-tailed catfish *(Tandanus tandanus)*	Move, but reasons for movement unknown.	Possibly following flow events	More abundant in lakes.	Murray-Darling Basin, eastern coastal drainages south of Cairns.
Empire gudgeon *(Hypseleotris compressa)*	Juveniles undertake massive migrations from flooded mangroves upstream along any flowing water, including road edges and agricultural drains, begin to settle out in pebble reaches.	January-April	All habitats from upstream flowing areas to coastal swampland.	Gulf, eastern coastal drainages.
Firetail gudgeon *(Hypseleotris galii)*	Move within freshwater, between habitats.	Unknown	Prefer areas with aquatic vegetation.	Eastern coast of Qld south of Fraser Island.
Freshwater mullet *(Myxus petardi)*	Adults river → estuary to spawn.	January-March	Slow-flowing areas, deep pools.	Eastern coastal rivers south of Burnett River.
Golden perch or Yellowbelly *(Macquaria ambigua sp.)* - 3 separate sub-species: Murray-Darling, Lake Eyre, Fitzroy-Dawson	Adults move upstream in floods for spawning. Juveniles move upstream for dispersal.	Following large flow events September-March	Warmer, turbid, sluggish streams or lakes.	Fitzroy Basin, Murray-Darling Basin, Lake Eyre Basin.
Honey blue-eye [2] *(Pseudomugil mellis)*	Unknown	Unknown	Still areas with extensive vegetation.	Eastern coastal drainages south of Fraser Island.
Hyrtl's tandan *(Neosilurus hyrtlii)*	Upstream movement from dry season refugia for spawning. Juveniles remain in temporary habitats.	November-April	Wide range of habitats.	Gulf, eastern coastal drainages, central desert drainages, Murray-Darling Basin.

2 - Vulnerable conservation status.

Table 1 contd.

Name	Type of movement	Timing of movement	Habitat	Queensland range
Jungle perch *(Kuhlia rupestris)*	Adults thought to move to inshore reefs to spawn, then return upstream. Juveniles upstream for growth.	November-February January-April	Fast-flowing perennial streams, coastal creeks, particularly very small streams on inshore islands and coastal floodplains. Females prefer headwaters.	Eastern coastal drainages north of Fraser Island.
Long tom *(Strongylura krefftii)*	Freshwater spawning species also found in estuaries. Adults move upstream particularly during a 'fresh'. Often found at base of overflowing weirs.	November-April	Rivers and offstream lagoons.	Gulf, eastern coastal drainages.
Long-finned eel *(Anguilla reinhardtii)*	Adults river → sea to spawn, also move within freshwater for habitat/dispersal. Juveniles sea → rivers for dispersal.	December-May September-March	Upstream over waterfalls, will move overland if damp.	Eastern coastal drainages.
Lungfish - see Queensland lungfish				
Mangrove jack *(Lutjanus argentimaculatus)*	Migrates to offshore areas to spawn. Reef/estuarine species but many juveniles move into freshwater for habitat, until about 40 cm in length.	Adults unknown Juveniles appear in estuaries and freshwater January-April	Rivers and tributaries, rather than still waters, upstream to first large waterfall.	Gulf, eastern coastal drainages.
Mary River cod [1] *(Macullochella peelii mariensis)*	Move within freshwater for habitat/dispersal, probably similar to Murray cod.	Unknown, may be similar to Murray cod	Variety of habitats.	Mary River and tributaries (south-east Qld).
Mouth almighty *(Glossamia aprion)*	Unknown	Unknown	All habitats, particularly weedy areas.	Gulf, Cape York, eastern coastal drainages.
Murray cod *(Macullochella peelii peelii)*	Adults move upstream within freshwater for spawning then return downstream. May move considerable distances.	September-November	Areas with cover and snags, prefer deep holes.	Murray-Darling Basin.

1 - endangered conservation status.

Table 1 contd.

Name	Type of movement	Timing of movement	Habitat	Queensland range
Northern saratoga *(Scleropages jardinii)*	Unknown, thought to be local movement (appear not to move great distances).	Unknown	Clear streams, fast-flowing waters and billabongs.	Northern Qld, from Jardine River to the Gulf. Also in Olive River and Harmer Creek.
Oxeye herring or Tarpon *(Megalops cyprinoides)*	Adults river → sea to breed. Juveniles return to freshwater.	December-March January-May	Variety of freshwater habitats. Will live in low oxygen conditions in very small waterholes.	All Australian tropical seas and adjacent drainages.
Oxleyan pigmy perch [1] *(Nannoperca oxleyana)*	Unknown	Unknown	Still or slowly flowing water with aquatic vegetation.	South-east Qld.
Purple-spotted gudgeon [5] *(Mogurnda adspersa, Mogurnda mogurnda)*	Unknown, probably move within freshwater for dispersal. Can climb significant waterfalls.	December-April	All habitats, particularly attracted to small flows.	Murray-Darling Basin, Cape York, Gulf, eastern coastal drainages.
Queensland lungfish *(Neoceratodus forsteri)*	Move up to 25 km within freshwater for habitat/dispersal.	Following increased flow events	Still or slow-flowing areas with deep pools.	South-east Qld rivers and reservoirs.
Red-tailed jungle perch *(Kuhlia marginata)*	Similar to *K. rupestris*, return to same site after spawning.	Unknown	Similar to jungle perch, but not as far upstream.	On east coast in wet tropics streams between the Bloomfield and Johnstone Rivers.
River blackfish *(Gadopsis marmoratus)*	Unknown	Unknown	Slow-flowing or still areas with rock cover and abundant snags.	Murray-Darling Basin south of Condamine River.
River stingray *(Dasyatis fluviorum)*	Unknown	Unknown	Flowing streams.	Gulf, Cape York.
Sea mullet *(Mugil cephalus)*	Adults move between sea and rivers for food, river → sea to spawn.	February-September	Close to coast or within coastal watercourses.	Eastern coastal drainages south of Townsville.
Short-finned eel *(Anguilla australis)*	Adults river → sea to spawn, also move within freshwater for habitat/dispersal. Juveniles sea → rivers for dispersal.	December-May September-January	Prefers still waters.	Eastern coastal drainages south of Caboolture River, possibly Murray-Darling Basin.

1 - endangered conservation status, 5 - restricted conservation status.

Table 1 contd.

Name	Type of movement	Timing of movement	Habitat	Queensland range
Silver batfish *(Monodactylus argenteus)*	Marine species but moves into freshwater.	Unknown	Estuaries, lower reaches.	Gulf, eastern coastal drainages.
Silver perch [3] *(Bidyanus bidyanus)*	Adults upstream in floods to spawn. Juveniles upstream after small rises in water level.	September-January Throughout year	Fast-flowing waters, especially rapids/races.	Murray-Darling Basin, south of Condamine River.
Sleepy cod *(Oxyleotris lineolatus, Oxyleotris selheimi)*	Juveniles move upstream (10-80 mm fish show high positive rheotaxis).	November-May	Weedy slow-flowing areas with snags and logs.	Gulf, Cape York, coastal drainages north of Fitzroy River.
Small-headed grunter [5] *(Scortum parviceps)*	Unknown	Unknown	Variety of habitats, particularly where there is flow.	Burdekin system.
Snub nosed garfish *(Arrhamphus sclerolepis)*	Moves into freshwater, breeds in weed beds. Can complete life history in freshwater.	September-April	Swim near surface, need weedy areas to spawn, also found over shallow sandy areas in current.	Gulf, eastern coastal drainages.
Sooty grunter *(Hephaestus fuliginosus)*	Adults move upstream to spawn in rapids. Juveniles move upstream and over flooded plains for dispersal.	August-February December-April	Varied environments, offstream lagoons. Most abundant fish in upstream reaches of many rivers.	Gulf, eastern coastal drainages north of Mackay.
South Pacific eel *(Anguilla obscura)*	As for *A. australis*	Unknown	Lower reaches, coastal lagoons.	Coastal drainages from Mackay to Cape York.
Southern saratoga [5] *(Scleropages leichardti)*	Unknown	Unknown	Upper reaches, turbid areas.	Eastern and south-eastern Qld.
Spangled perch/grunter *(Leiopotherapon unicolor)*	Adults move within freshwater, upstream to spawn and disperse. Juveniles move during heavy downpours for dispersal. Often found stranded in pools far from the nearest stream.	October-April Unknown	All habitats.	Gulf, Murray-Darling Basin, eastern coastal drainages, internal drainages.

3 - potentially threatened conservation status, 5 - restricted conservation status.

Table 1 contd.

Name	Type of movement	Timing of movement	Habitat	Queensland range
Striped goby *(Gobiomorphus australis)*	Adults unknown. Thought that young carried downstream and later migrate upstream.	Unknown Unknown	Muddy waterholes, slow flowing areas close to coast.	Coastal streams south of Maryborough.
Trout gudgeon (see purple-spotted) *(Mogurnda mogurnda)*	Adults unknown, probably move within freshwater for habitat. Juveniles move upstream, reason unknown.	February-March (limited observations) Unknown	Variety of environments.	Gulf, Cape York, north-eastern Qld, south-western Qld.
Welch's grunter *(Bidyanus welchi)*	Adults move within freshwater to spawn.	November-February	Sluggish flows, high turbidities.	Internal drainage streams of western Qld, central western Qld.
Western carp gudgeon *(Hypseleotris klunzingeri)*	Unknown, probably move within freshwater for habitat.	Unknown	Shoreline vegetation.	Murray-Darling Basin, coastal drainages south of Fitzroy River.

Table 2. Known movements, habitat and range of selected groups of Queensland native fishes.

Name	Type of movement	Timing of movement	Habitat	Queensland range
Goby (Gobiidae)	Larvae may be marine	Unknown	Flowing water near the sea, with sand or gravel bottoms and associated with weeds.	Far north Qld, western Qld, Gulf, Cape York, eastern Qld coast.
Perchlets, glassfish *(Ambassis spp)*	Adults and juveniles upstream for habitat/ dispersal.	September-February	Most habitats except torrential upstream areas, most abundant in lagoons.	Most areas, most streams.
Silver biddy, ponyfish, trevally, bream (2 spp), flathead, scats	Growth, feeding.	Unknown	Tidally influenced freshwater, sandy upstream reaches, lagoons (scats only).	All coastal streams.
Rainbowfish (Melanotaeniidae)	Unknown, probably move within freshwater for habitat/dispersal and feeding.	Any time there is a flow between August and April	Streams, lagoons and swamps near coast with low flow and high vegetation cover.	All streams.

Table 3. Selected native fish species found in each Queensland drainage division.

GULF OF CARPENTARIA

Common name	Species name
Barramundi	*Lates calcarifer*
Blue or salmon catfish	*Arius graeffei*
Coal grunter	*Hephaestus carbo*
Common archer fish	*Toxotes chatareus*
Empire gudgeon	*Hypseleotris compressa*
Goby	Gobiidae
Hyrtl's tandan	*Neosilurus hyrtlii*
Long tom	*Strongylura krefftii*
Long-finned eel	*Anguilla reinhardti*
Mangrove jack	*Lutjanus argentimaculatus*
Mouth almighty	*Glossamia aprion*
Northern saratoga	*Scleropages jardinii*
Rainbowfish	Melanotaeniidae
Silver batfish	*Monodactylus argenteus*
Sleepy cod	*Oxyleotris lineolatus*
Snub nosed garfish	*Arrhamphus sclerolepis*
Sooty grunter	*Hephaestus fuliginosus*
Spangled perch/grunter	*Leiopotherapon unicolor*
Tarpon	*Megalops cyprinoides*
Trout gudgeon	*Mogurnda mogurnda*

EAST COAST
Southern

Common name	Species name
Australian bass	*Macquaria novemaculeata*
Australian smelt	*Retropinna semoni*
Barramundi	*Lates calcarifer*
Blue or salmon catfish	*Arius graeffei*
Coal grunter	*Hephaestus carbo*
Common jollytail	*Galaxias maculatus*
Eel-tailed catfish	*Tandanus tandanus*
Empire gudgeon	*Hypseleotris compressa*
Firetail gudgeon	*Hypseleotris galii*
Freshwater mullet	*Myxus petardi*
Goby	Gobiidae
Honey blue-eye	*Pseudomugil mellis*
Hyrtl's tandan	*Neosilurus hyrtlii*
Jungle perch	*Kuhlia rupestris*
Long tom	*Strongylura krefftii*
Long-finned eel	*Anguilla reinhardti*
Mangrove jack	*Lutjanus argentimaculatus*
Mary River cod	*Macullochella peelii mariensis*

Table 3 contd.

Common name	**Species name**
Mouth almighty	*Glossamia aprion*
Oxleyan pygmy perch	*Nannoperca oxleyana*
Purple-spotted gudgeon	*Mogurnda adspersa*
Queensland lungfish	*Neoceratodus forsteri*
Rainbowfish	Melanotaeniidae
Sea mullet	*Mugil cephalus*
Short-finned eel	*Anguilla australis*
Silver batfish	*Monodactylus argenteus*
Small-headed grunter	*Scortum parviceps*
Snub nosed garfish	*Arrhamphus sclerolepis*
Spangled perch/grunter	*Leiopotherapon unicolor*
Striped gudgeon	*Gobiomorphus australis*
Tarpon	*Megalops cyprinoides*
Western carp gudgeon	*Hypseleotris klunzingeri*

EAST COAST
Central

Common name	**Species name**
Australian smelt	*Retropinna semoni*
Barramundi	*Lates calcarifer*
Blue or salmon catfish	*Arius graeffei*
Coal grunter	*Hephaestus carbo*
Common archer fish	*Toxotes chatareus*
Eel-tailed catfish	*Tandanus tandanus*
Empire gudgeon	*Hypseleotris compressa*
Goby	Gobiidae
Golden perch or yellowbelly	*Macquaria ambigua sp.*
Hyrtl's tandan	*Neosilurus hyrtlii*
Jungle perch	*Kuhlia rupestris*
Long tom	*Strongylura krefftii*
Long-finned eel	*Anguilla reinhardti*
Mangrove jack	*Lutjanus argentimaculatus*
Mouth almighty	*Glossamia aprion*
Purple-spotted gudgeon	*Mogurnda adspersa*
Sea mullet	*Mugil cephalus*
Silver batfish	*Monodactylus argenteus*
Sleepy cod	*Oxyleotris lineolatus*
Snub nosed garfish	*Arrhamphus sclerolepis*
Sooty grunter	*Hephaestus fuliginosus*
South Pacific eel	*Anguilla obscura*
Southern saratoga	*Scleropages leichardti*
Spangled perch/grunter	*Leiopotherapon unicolor*
Tarpon	*Megalops cyprinoides*

Table 3 contd.

EAST COAST
Northern

Common name	Species name
Barramundi	*Lates calcarifer*
Blue or salmon catfish	*Arius graeffei*
Bony bream	*Nematolosa erebi*
Coal grunter	*Hephaestus carbo*
Common archer fish	*Toxotes chatareus*
Empire gudgeon	*Hypseleotris compressa*
Goby	Gobiidae
Hyrtl's tandan	*Neosilurus hyrtlii*
Jungle perch	*Kuhlia rupestris*
Long tom	*Strongylura krefftii*
Long-finned eel	*Anguilla reinhardti*
Mangrove jack	*Lutjanus argentimaculatus*
Mouth almighty	*Glossamia aprion*
Purple-spotted gudgeon	*Mogurnda adspersa*
Rainbowfish	Melanotaeniidae
Red-tailed jungle perch	*Kuhlia marginata*
Silver batfish	*Monodactylus argenteus*
Sleepy cod	*Oxyleotris lineolatus*
Snub nosed garfish	*Arrhamphus sclerolepis*
Sooty grunter	*Hephaestus fuliginosus*
South Pacific eel	*Anguilla obscura*
Southern saratoga	*Scleropages leichardti*
Spangled perch/grunter	*Leiopotherapon unicolor*
Tarpon	*Megalops cyprinoides*
Trout gudgeon	*Mogurnda mogurnda*

MURRAY-DARLING

Common name	Species name
Australian smelt	*Retropinna semoni*
Bony bream	*Nematolosa erebi*
Eel-tailed catfish	*Tandanus tandanus*
Golden perch or yellowbelly	*Macquaria ambigua sp.*
Hyrtl's tandan	*Neosilurus hyrtlii*
Murray cod	*Macullochella peelii peelii*
Purple-spotted gudgeon	*Mogurnda adspersa*
River blackfish	*Gadopsis marmoratus*
Short-finned eel	*Anguilla australis*
Silver perch	*Bidyanus bidyanus*
Spangled perch/grunter	*Leiopotherapon unicolor*
Western carp gudgeon	*Hypseleotris klunzingeri*

Table 3 contd.

BULLOO-BANCANNIA

Common name	Species name
Barcoo grunter	*Scortum barcoo*
Goby	Gobiidae
Golden perch or yellowbelly	*Macquaria ambigua sp.*
Hyrtl's tandan	*Neosilurus hyrtlii*
Spangled perch/grunter	*Leiopotherapon unicolor*
Trout gudgeon	*Mogurnda mogurnda*
Welch's grunter	*Bidyanus welchi*

LAKE EYRE

Common name	Species name
Australian smelt	*Retropinna semoni*
Barcoo grunter	*Scortum barcoo*
Bony bream	*Nematolosa erebi*
Goby	Gobiidae
Golden perch or yellowbelly	*Macquaria ambigua sp.*
Hyrtl's tandan	*Neosilurus hyrtlii*
Spangled perch/grunter	*Leiopotherapon unicolor*
Trout gudgeon	*Mogurnda mogurnda*
Welch's grunter	*Bidyanus welchi*

DPI REGIONAL OFFICES

Southern Region

Office	Position	Phone	Address
Brisbane	*DPI Call Centre*	*13 25 23*	
Head Office	Principal Policy Officer	(07) 3224 2185	Forestry House 160 Mary Street PO Box 3129 **BRISBANE Q 4001**
Deception Bay	Principal Fisheries Biologist	(07) 3817 9525	Southern Fisheries Centre 13 Beach Road PO Box 76 **DECEPTION BAY Q 4508**
Bundaberg	Senior Fisheries Technician	(07) 4153 7833	Enterprise Street PO Box 1143 **BUNDABERG Q 4670**
Kingaroy	Extension Officer, Inland Fisheries	(07) 4160 0704	J Bjelke Petersen Research Station Goodger Road **KINGAROY Q 4610**
Rockhampton	Extension Officer, Resource Manag.	(07) 4936 0253	Cnr Bruce Hwy and Yeppoon Road PO Box 6014 **ROCKHAMPTON Q 4702**
Toowoomba	Project Officer	(07) 4688 1113	203 Tor Street PO Box 102 **TOOWOOMBA Q 4350**

Northern Region

Office	Position	Phone	Address
Cairns	Senior Principal Scientist	(07) 4035 0111	Northern Fisheries Centre 38-40 Tingira Street PO Box 5396 **CAIRNS Q 4870**
Mackay	Fisheries Biologist	(07) 4951 8035	Government offices Tennyson Street PO Box 668 **MACKAY Q 4740**

Northern Region contd.

Office	Position	Phone	Address
Townsville	Fisheries Biologist	(07) 4722 2654	Abbott Street, Oonoonba PO Box 1085 **TOWNSVILLE Q 4811**
Walkamin	Fisheries Biologist	(07) 4093 3834	Walkamin Research Station Kennedy Highway **WALKAMIN Q 4872**

Inland Fisheries (Boating and Fisheries Patrol)

Office	Position	Phone	Address
Longreach	District Officer	(07) 4658 4400	Landsborough Hwy PO Box 519 **LONGREACH Q 4730**
Roma	District Officer	(07) 4622 9999	Cnr Bowen and Spencer Streets PO Box 308 **ROMA Q 44 55**
Wondai	District Officer	(07) 4168 5990	PO Box 100 **WONDAI Q 4606**

CHECKLIST

Prior to works

Has contact been made with the local DPI Fisheries officer?

Have fish passage requirements been considered when choosing a crossing design?

Have the species of fish likely to be present in the area of the proposed stream crossing and the periods during which these species migrate been identified?

Has the most suitable time of year to build the proposed stream crossing with minimal impact on fish been determined?

Is the site of the proposed stream crossing a declared Fish Habitat Area, known fish spawning ground or nursery area?

Is the site of the proposed stream crossing in an area of straight channel and low slope?

Are there stream crossings or other instream structures downstream of the proposed site? If so, is the proposed structure at least 100 m away from these other structures?

Has DNR (freshwater areas) or DEH (tidal areas) been approached for authorisation to build the crossing?

During works

Is removal of stream bank vegetation and disturbance to the natural banks and bed of the stream being kept to a minimum?

Are bank slopes being hand cleared? If not, are protective guards being used to minimise damage to trees during clearing?

Is disturbance to the outside of creek bends being minimised?

Is vegetation, rather than revetment, being used to stabilise stream banks?

Will works be undertaken in the dry to control the release of silt at the site? If not, are alternative control measures such as flotation sediment curtains being used?

Are all erosion and sediment control devices being regularly maintained?

Are the morphological features of the waterway being retained? If not, will the new channel design simulate a natural watercourse?

Following completion of works

Have the disturbed areas been returned to their original profiles and condition?

Has the area been stabilised to resist erosion by replanting of native vegetation where cover has been removed or damaged?

Has a maintenance program been developed for the structure?

Are fish able to move through the crossing? If not, undertake maintenance or redesign the crossing structure.