Second Australian Stream Management Conference
8-11 February 1999, Adelaide, South Australia

Providing for Fish Passage at Small Instream Structures in Victoria

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SUMMARY: It is preferable to design and build instream structures in a manner that inherently provides for fish passage. However where existing structures are to be modified or where it is not practical to modify the design of new structures to provide for fish movement, it will be more appropriate to install some type of dedicated fishway. This decision will be based on a number of site specific factors such as the fish species present, site topography, flow characteristics and the potentially increased costs. Over the years, a large number of instream structures have been built in Victoria without any provision for fish movement. Some of these are large dams and weirs that require a fully engineered device such as a fish lift or a vertical-slot fishway to facilitate fish movement. However, the vast majority of barriers are smaller structures, for which other options, such as rock fishways are considered more appropriate. There is also a need for those planning to install an instream structure to conform with the current legislative requirements and practices. Conditions regarding installations of instream structures have been formulated over many years in Victoria to minimise the impact on aquatic biota and maintain their natural environment. This paper discusses the legislative responsibilities associated with providing fish passage, along with examples of instream structures that impede fish passage. Solutions available to reduce the impact on fish movements, based on recent experience, are also discussed, with particular emphasis on the rock fishway type. A few such fishways have been constructed at various locations in Victoria in the recent past.

THE MAIN POINTS OF THIS PAPER

- Highlight problems created by instream structures to fish migrations
- Legislative requirements in place in Victoria for providing fish passage
- Solutions to reduce impact of instream structures on fish passage for coastal streams in Victoria

1. INTRODUCTION

Victoria's freshwater fish fauna constitute an important and often overlooked group of animals. Barriers to fish movement have been cited as contributing to the decline in populations and distribution of migratory species both in Australia and overseas. While the benefits of providing access for salmonids to breeding grounds in the northern hemisphere are spectacular and have long been recognised, concerns for the migrations of native fish in Australia have only recently been addressed.

Instream structures that have the potential to impede fish movement are both prevalent and widespread on natural waterways throughout Victoria. The recently completed Inventory of Fish Barriers in Victoria database (NRE 1997) identified approximately 2500 likely barriers to fish movement, these included at least 250 dams and weirs, many hundreds of flood and erosion control structures, tidal barriers, road crossings and culverts on natural waterways. It is estimated that up to half the available aquatic habitat in the coastal catchments of south-eastern Australia has been obstructed by artificial barriers (Harris 1984a).

It is well documented that instream barriers pose a threat to many native fish and this is supported in Victoria through a number of legislative Acts. These require provision for fish passage to be included in any new instream works unless it can be demonstrated that impeded movement is not likely to have a detrimental impact.

2. IMPACT OF INSTREAM BARRIERS

The most obvious and dramatic impact of an instream barrier is the direct exclusion of migratory fish moving to or from habitat essential for completion of their life-cycle, such as spawning grounds in estuaries or headwaters. Barriers may also result in a reduced diversity and abundance of accessible freshwater habitat. Ecosystem changes may result from exclusion of migratory species, loss of recolonisation opportunities after displacement by seasonal habitat changes such as drought, loss of water quality, floods, fish kills and angling pressure. Instream barriers may also lead to increased predation of fish by birds and other fish species along with the genetic isolation of fish populations. Fish moving downstream may also be affected, for example, larvae washed into dams can become disorientated and starve, or just not reach their downstream destination, while large fish can get injured from spillways, turbines and vertical drops onto concrete or rock sills.

The effect of a particular barrier on fish populations is dependent on factors including what species are present and their respective swimming abilities, the height and design of the barrier and frequency and timing of floods

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(i.e. hydraulic and hydrological conditions) that may inundate some barriers and permit fish movement. Some barriers may be passable by adept swimmers or by fish able to climb, yet completely restrict other species. Impacts due to an instream barrier will be further compounded by other factors such as reduced water quality, water temperature differential (thermal barrier), de-snagging and altered flow regimes.

Approximately 70% of the fish species present in the coastal catchments of south-eastern Australia (Harris 1984b), including a number of threatened species (CNR 1995), require access between fresh and saline waters either for survival or for maintenance of population abundance and distribution. Harris (1986) cites the loss of diadromous species above many dams in coastal areas as examples of local extinctions due to impeded fish movement. Koehn (1986) suggests that the absence of migratory species such as common galaxias, spotted galaxias and tupong in the upper Bunyip and Lang Lang Rivers in coastal Victoria may be related to difficulty in access. Free access along streams of the Murray-Darling river system is considered important to help ensure the long term survival of the 14 migratory species present in this region (Mallen-Cooper 1989).

3. TYPES OF BARRIERS

The most common instream barriers to fish movement prevalent in Victorian streams are described below.

3.1 Culverts

Culverts can impede fish passage due to any of the following reasons:

- ◊ the water velocity is too high because of the relatively smooth surface of the culvert surface, the constriction it imposes on the channel section or the culvert being installed at too steep a gradient;
- ◊ there are no resting areas upstream or downstream of the culvert. These allow the fish to both conserve energy before upstream passage and to rest upon completion of passage;
- ◊ there is insufficient water depth for fish to swim in the culvert. The minimum depth required for swimming varies with the fish species;
- ◊ the culvert is too long and provides no respite from the relatively high velocities in the culvert. Depending on the swimming abilities of the species in relation to water velocities and distance, the length of culvert can become critical; and,
- ◊ the outlet of a culvert is at or above the stream bed elevation, or scour has lowered the stream bed downstream of the culvert outfall creating an artificial barrier to fish.

3.2 Weirs and Regulating Structures

These structures are constructed across streams to control the upstream water level for diversions, for flow measuring or erosion control purposes. Apart from being physical barriers to fish movement, they can restrict the upstream passage of fish where the difference in water level creates velocity or depth conditions beyond the capabilities of the migrating fish species.

4. LEGISLATIVE REQUIREMENTS

There are many constraints to the installation of any instream structures in Victoria and among them are legislative requirements. Various Acts of State Parliament have been implemented in the form of regulations. The following legislation applies to instream structures in this State; *Lands Act* 1958, *Crown Land (Reserves) Act* 1978, *Conservation Forests and Lands Act* 1987, *Flora and Fauna Guarantee Act* 1988, *Water Act* 1989, *Planning and Environment Act* 1987, *Fisheries Act* 1995.

A number of Authorities have been delegated the function of ensuring compliance with the regulations within the Authority's jurisdiction. Therefore, approval is required from several responsible Authorities prior to proceeding with any instream structure. The responsible Authorities and their requirements are listed in the following sections.

4.1 Natural Resources & Environment (NRE)

The NRE has legislative control under more than one Act. Hence, an applicant needs to ensure that all appropriate approvals are obtained through the various branches of this Department.

Under the *Conservation Forest and Lands Act* 1987, Part 7, Schedule 3, indicates that "prior to the commencement of any works specified, a Public Authority must submit a plan of works to the Director General for comment on necessary measures to take for the protection of land, water and wildlife" as well as for "construction of dams, weirs or other structures, in or across watercourses which potentially interfere with the passage of fish, or the quality of aquatic habitat". Under the *Lands Act* 1987 and *Crown Land (Reserves) Act* 1978, the Department needs to consider whether the instream structure is on a waterway which may be on either Crown or freehold land. If the works are on Crown land, the application process requires exposure to a wide cross-section of community view-points. In the case of freehold land NRE has limited controls.

In cases where the prevention of passage of aquatic biota occurs as a result of the presence of instream structures, then the *Flora and Fauna Guarantee Act* 1988 is also applicable. Under the *Fisheries Act* 1995, protection of aquatic habitat has been recognised through two provisions relating to maintaining fish habitat and protection of specific fish species.

4.2 Planning Authority

The local planning authority (generally the Municipality) usually requires a planning permit and may also require an Environmental Effects Statement (EES) particularly in the case of structures that are to be within heritage rivers.
When approvals via planning permits or planning scheme amendments are being considered by the responsible Authority or the planning authority, the environment has to be considered in making a decision. This is a requirement of the *Planning and Environment Act* 1987.

4.3 Rural Water Authority (RWA)

Prior to an application being submitted to construct any instream structure or carry out works on a waterway, there is a need to determine whether the river, stream, creek or watercourse is a waterway, as defined under the *Water Act* 1989. If it has been determined to be a waterway, then a licence is required. In the case of works that are not on waterway then RWAs have no jurisdiction.

The licence to construct works on a waterway, *s.67* (*s.71* sets conditions such as standards of construction, qualifications of construction personnel, protection of the environment). In environmentally sensitive areas, an applicant must also conform with *s.49 & s.65*. It should be noted that under *s.70*, additional permits and licences may still be necessary from different organisations, to satisfy provisions of other relevant Acts.

4.4 Application Process

All relevant Authorities involved with instream structures will recommend to any applicant that they contact the other responsible Authorities, prior to submitting a licence application. This preliminary contact allows the applicant to gain a full and better understanding of the requirements of each Authority.

Following this initial contact it is usual for a joint site inspection to be undertaken with relevant agencies present. Any potential problem areas are discussed at this stage and the proposal may proceed or be re-evaluated at this point. Once general agreement on the viability of the proposal has been reached a formal application is forwarded to the relevant Authority. On receipt of the formal application by RWAs, preliminary analysis of the proposal is undertaken to determine the suitability of the proposal. Matters taken into account include any detrimental effect on the environment or other users as mentioned under *s.40* and *s.68* of the *Water Act* 1989.

Approval of the proposal by a RWA is dependent on approval of other relevant Authorities such as NRE and the local planning authority. If the proposal is not approved the applicant can appeal the decision via the Administrative Appeals Tribunal. Refer Chart 1 for an indicative flow chart outlining the application process prevalent in Victoria.

4.5 Application Assessment

Assessment of any instream structure proposal is undertaken in two parts, viz. infrastructure and stream flow analysis. The infrastructure of the proposed development is examined in detail to determine its suitability to the site. Included in this stage of the assessment is existence or requirement for any diversion works, operating arrangements and flooding characteristics of the site.

The purpose of the stream flow analysis is to determine the impact of stream flow with regard to meeting environmental, resource and structural requirements of the proposed works.

5. OPTIONS FOR PROVIDING FISH PASSAGE

It is preferable to design instream structures that inherently provide for fish movement. Guidelines for fish-friendly design of culverts, fords and other small structures are currently being finalised (O'Brien *et al.* in prep.) and it is hoped that the general information contained in these guidelines will allow works authorities to minimise the impact of new installations of these type of structures on fish passage. They provide key design criteria for the various structures and also include a number of case studies to assist design engineers. For situations where these guidelines are impractical due to site specific design problems, and also at the many structures already in place in Victoria it may be necessary to provide a separate fishway.

A number of designs for fishways have been used in Australia with varying degrees of success. For larger river systems, New South Wales Fisheries have constructed a number of successful vertical-slot fishways (Clay 1995; Mallen-Cooper 1992) - refer Figure 1 and a fish lift on the Murray River at Yarrawonga, while through the Victorian fishways program two further vertical-slot fishways have been constructed on the Broken Creek. These fishways are relatively expensive to construct. A less formal and significantly less expensive type of fishway utilising graded rock to simulate a small rapid has been trialled.

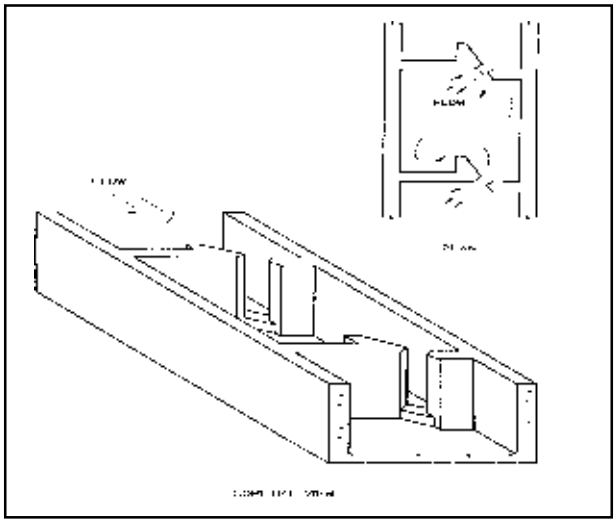

Figure 1: A Typical Vertical Slot Fishway

5.1 Rock Fishway Design Criteria for Coastal and Upland Streams in Victoria

The following design outline is appropriate for minimising the impact of low (less than 2m) weirs and rock chutes on the movement of native fish in small waterways within Victoria. The conditions provided are suitable for passage by the small (40-250mm) native fish that inhabit most of our waterways and in particular the migratory coastal species that require access to saline waters for completion of their life-cycle.

This type of fishway will, in most cases, be significantly less expensive to construct and maintain than other types. Due to their irregular nature, rock fishways provide a range of alternative water velocities and

depths to cater for differing behaviour of fish negotiating a barrier. These designs are not considered appropriate where larger fish are expected to require upstream access but are more generally appropriate for coastal and upland streams of Victoria. O'Brien (1997) found that a rock fishway installed on the lower Barwon River was highly successful at passing migratory coastal species of fish and further installations of this type of fishway have since occurred. Where adequate flows prevail, there is potential to modify these designs for use in inland systems such as the Murray-Darling Basin for use by larger fish species. This however requires further investigation. Overseas examples indicate that bypass channels are generally constructed at a much lower gradient (1:100) to cater for larger fish species, while NSW Fisheries have been installing Rock-ramp fishways using a different design. Further research work still needs to be undertaken to investigate the most successful way to construct fishways at various structures.

Two separate design options are available: an instream rock fishway constructed by modifying the existing stream profile (Figure 2), and an off-stream rock fishway or 'bypass channel'. Where practical the instream design is preferred as it provides for easier fishway entrance location and also for operation over a greater range of river levels. The decision as to which design to adopt will require the project engineer to assess a number of site specific factors including the impact of fishway upon the main purpose of the structure, discharge requirements to effectively operate the fishway, erosion prevention requirements and site topography. In addition, the likely stability of the fishway and potentially increased financial costs of providing environmentally appropriate structures will need to be considered.

Based on rock fishways constructed in the recent past, the following criteria are considered appropriate for whichever of these options adopted. Additional information specific for each type of installation is also included.

- The gradient should be consistent through the full length (apart from designated rest areas) of the structure and in most cases should be no steeper than 1V:18H. For drops of less than 750mm an increase in this gradient to 1V:16H is acceptable;
- Resting areas should be provided at intervals corresponding to 1.0m rises in elevation and consist of deeper pool areas with close to zero gradient at least 2.0m long;
- Construction is predominantly of graded rock with 40-50% of the base of the fishway scattered with large rocks. Rock sizes from 400-700mm equivalent Diameter are adequate, though larger rocks should be used on larger fishways or where stability during high flows is of concern. Gaps between rocks should be 300-400mm deep and 100-200mm wide. Large rocks should be embedded into the base of stream in a jutting position (the greater the height of these rocks the wider the range of flows at which the fishway will operate effectively) and packed with graded smaller (100-400mm) rocks and fine material to reduce movement under high flows. Weathered angular rocks are best as they provide a greater diversity of water velocities and depths and therefore greater opportunities for fish movement at a range of river discharges. The use of weathered rock (i.e. having rounded edges) will create less turbulence than quarried rock and result in a more natural 'rapid' that is easier for fish to navigate. This diversity may also enable a wider range of fish to negotiate a barrier as it will provide for fish with different swimming abilities and migratory requirements;
- Where required, the fishway should be lined with geotextile material to maintain adequate depth and minimize scouring of the fishway base;
- Fish moving up through the fishway should exit into relatively quiet water. This is achieved by extending the fish passage area to at least 2.0m upstream of the barrier; and,
- Fishways should be designed for optimum operation during periods of peak upstream fish movement, generally between September and February.

Figure 2: Rock fishway at Cowwarr knife-edge weir on the Thomson River *(photo: S.Heron)*

5.2 Construction Considerations

The following should be considered when undertaking fishway construction.

- where practical, works should be limited to the times of year when fish movement through the reach is at a minimum;
- modifications to existing habitat should be minimised as these may be important as spawning or rearing areas;
- the dispersivity and erodibility of the soil types at the site should be established and taken into account when planning construction activities and works should be accomplished in a manner that minimises siltation of the stream;
- cost efficiency may be achieved if locally available material, such as rocks, boulders and timber are used; and,
- areas where bare earth remains should be protected against erosion and preferably be planted with a vegetation cover. Natural matting may provide a

useful interim measure to reduce/prevent erosion until vegetation is re-established.

5.3 Alternatives to Fishway Construction

In some instances modifying the operating procedures at regulating structures can provide or enhance the frequency of fish passage. This is achieved by opening gates more frequently and for longer durations, especially when this is timed to coincide with periods of fish movements. Flow regulation and controlled releases from upstream storages can also be designed to inundate low level weirs to allow fish passage.

The use of several small structures that are passable by fish, rather than a single large weir or regulating structure may reduce the net impact on fish passage while still achieving the original purpose of the works.

6. CONCLUSIONS

Even small structures such as culverts and stream gauging stations can restrict essential fish movements and result in local extinctions of some fish species. Provision for fish passage is therefore an essential consideration for planners and designers of instream works. Legislation is now in place that requires fish migrations not be impeded and that a planning and approval process be followed prior to commencement of works. Through a state-wide fishway program, significant works are currently being undertaken to restore migration pathways past barriers that restrict fish movement.

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Chart 1: Fishway Application Process in Victoria