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Fish-Friendly Irrigation

Fishway Inspection Manual

February 2023

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1 INTRODUCTION

The following manual and series of forms are intended for the inspection of fish passage facilities at low-level barriers (< 7 m) in the Lower Mekong Basin (LMB) to assess: design and requirements for maintenance. This can apply to “wet commissioning” a new fishway (i.e. the first test of a fishway with water) or to any existing fishway. The objective is to assess whether maintenance, modifications, refurbishment of fishways or constructing a new ones is required.

The manual is divided by the types of information to be collected:

- a) *prior to the site inspection*, which is similar to the background information needed to design a fishway (see MRC 2021 Design Guidelines for Fishways); and
- b) *during the site inspection*, which includes:
 - consultation;
 - confirmation of background data; and
 - assessment of the three components of design (Figure 1):
 - attraction* (fishway entrance and weir/gate design);
 - passage* (fishway channel design); and
 - exit* (location and conditions for a safe exit).

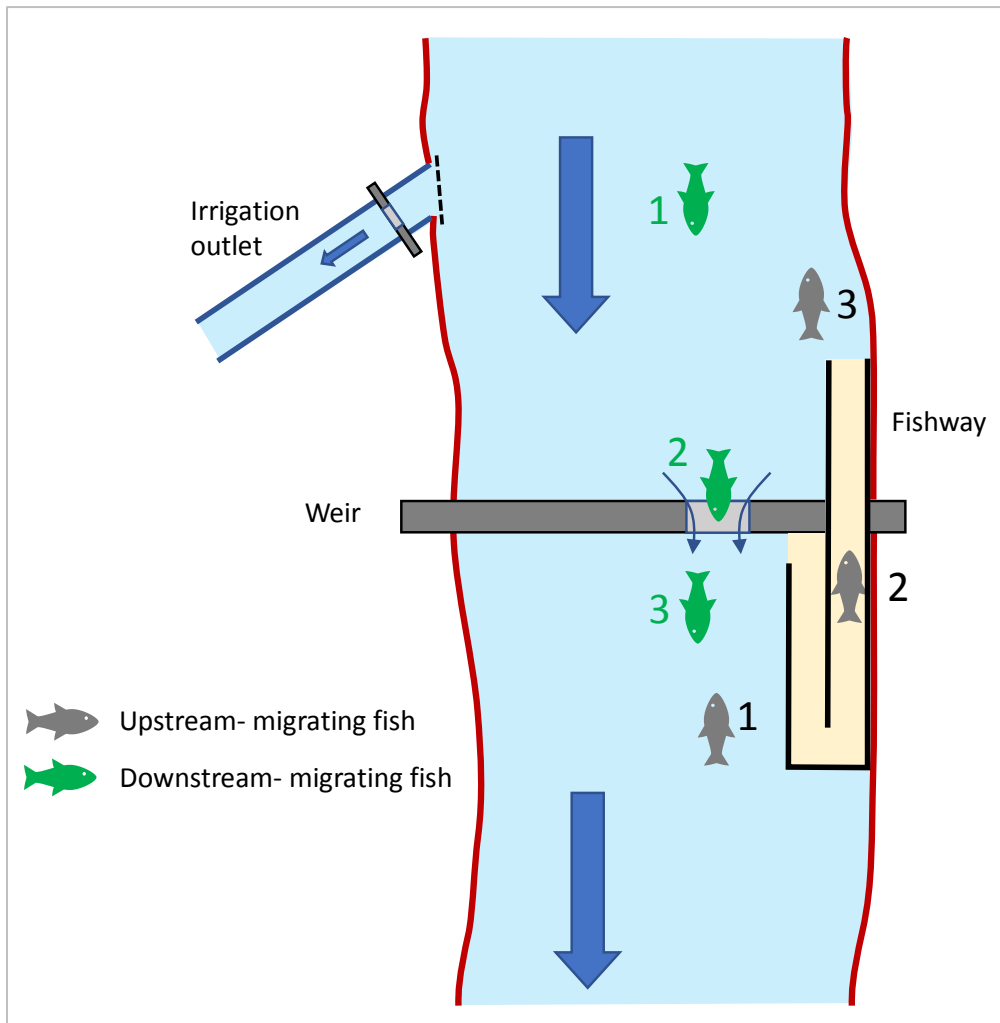


Figure 1.Components of fishway design: 1) Attraction, 2) Passage and 3) Exit

Intended users of this guideline

This manual is intended for practitioners such as scientists, engineers, and government staff responsible for inspecting and evaluating fishways. For government staff, a university degree in engineering or natural sciences is preferable, with experience in fieldwork. They should be trained in fishway design and fishway inspections. These staff members should understand the following:

- The MRC 2021 Guidelines for Fishway Design, including how:
 - the upstream and downstream water levels determine the operation of fishways,
 - the interaction of water velocity, turbulence and depth determines the passage of small and large fish,
 - the flow patterns downstream of barriers affect fish locating the entrance.
- engineering plans;
- fishway hydraulics;
- fish migration;

- how to measure water levels, gradient and head losses, using tapes and a surveyor's dumpy level;
- migratory fish behaviour near barriers, especially the response of fish approaching a weir and the influence of turbulence, high water velocity and recirculating flows;
- river hydrology and how to analyse and summarize daily flow data into monthly and yearly graphs;
- hydraulic calculations of discharge and fishway turbulence;
- interviewing skills.

Timing and number of inspections per site

To assess design and function, fish passage facilities need to have three separate inspections at: low ($Q < 75$ %ile), medium ($Q = 25-75$ %ile), and high flows ($Q > 75$ %ile). Fish in the LMB are generally migrating during these flows, and fish passage needs to be effective during these flow conditions.

To assess requirements for maintenance, inspections need to be annual.

Materials required for inspections

- Tape measure (5 m, 20 m, 50 m);
- Measuring staff;
- Surveyor's dumpy level;
- Current meter (sometimes called a 'flowmeter') to measure water velocity.

Resources and budget

To assess design and function

- 1 staff member, two weeks' preparation per site – complete Section 2 of this manual;
- 3 staff members for site visits – allow 1 day per site plus additional travel for remote sites;
- 1 staff member, one week follow-up and completion per site;
- Typically US\$5,000 per site.

Pre-site visit: Collect background information

1.1. Site location

Site name:	
Nearest village /town:	
Barrier reference no.	
Latitude:	
Longitude:	
Stream name:	

1.2. Contacts for site visit

Name	Title	Contact

1.3. Engineering plans

- Include a copy of the general arrangement drawing (overall plan of fishway and weir).
- If all engineering drawings are available, add to an appendix of the report.

Plan of fishway (general arrangement drawing), if available

1.3.1. Water levels from plans






	Fill out before site visit	Fill out during site visit (confirm design criteria)
Headwater: maximum		
typical (nominal)		
minimum		
Tailwater: maximum		
minimum		
Head differential (Max. difference in upstream and downstream water level)		

1.3.2. Design criteria from plans

	Fill out before site visit	Fill out during site visit (confirm design criteria)
Year of fishway construction	N/A	
Upstream passage		
Fishway design type		
Fishway exit invert		
Fishway entrance invert		
Pool-type fishways		
Pool length (per pool)		
Pool width (per pool)		
Pool depth: <u>Maximum</u> (maximum headwater less fishway exit invert)		
<u>Typical</u> (typical headwater less fishway exit invert)		
<u>Minimum</u> (minimum headwater less		

fishway exit invert)		
Turning pool dimensions (LxWxD)		
Resting pool dimensions (LxWxD)		
Design head loss per pool (mm) <input type="checkbox"/> check every pool in plans <input type="checkbox"/> use difference in adjacent baffle inverts		Copy summary from separate table in Section 3.6.3.1.
Gradient (head loss/pool length)		
Turbulence per pool (W/m ³)		Copy from Section 3.6.3.2
Baffle details e.g. <i>Vertical slot</i> : slot width <i>Cone</i> : depth, gap at invert and top, trapezoidal profile. <i>Submerged orifice</i> : HxW		
Trash rack or trash boom present		
DOWNSTREAM PASSAGE		
Through fishway (likely, unlikely)		
Choose: fixed crest/undershot (sluice) gate/overshot gate		
Exit depth on downstream apron at low flows		
Ratio: exit depth/head differential		

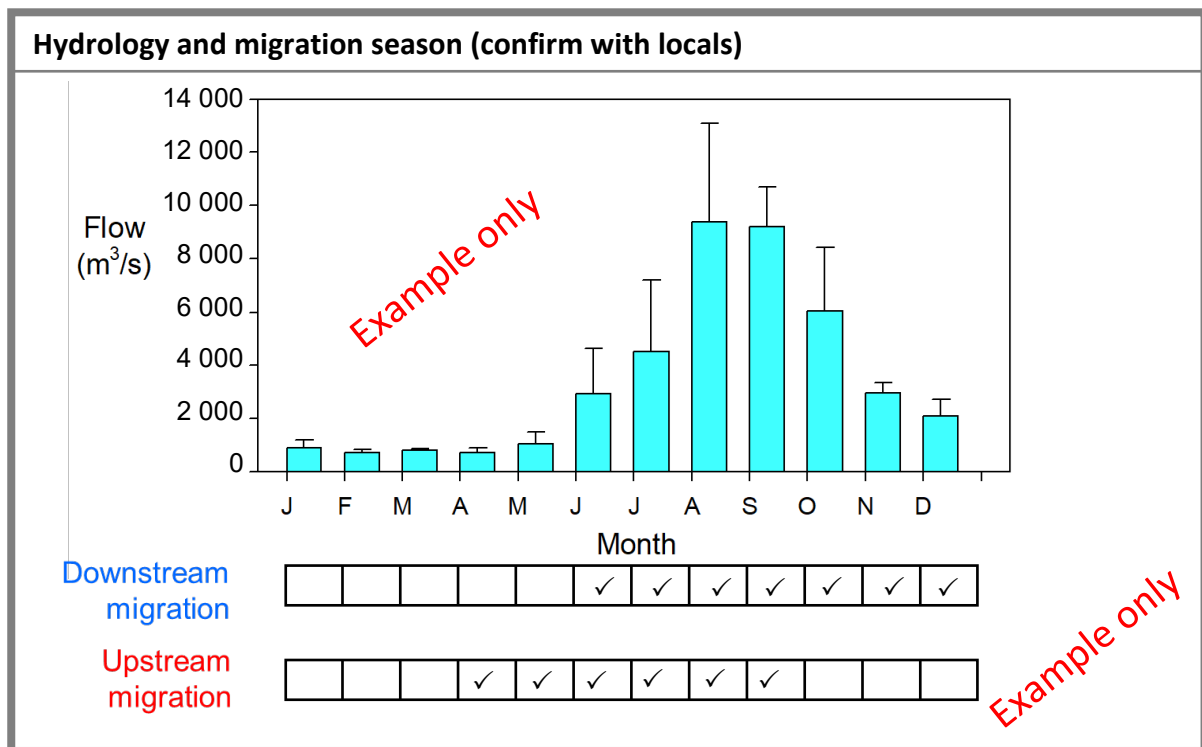
1.4. Biology – migratory fish size

		Fill out before site visit	Fill out during site visit
		Expected/known (✓, ✗)	Local on-site info. (✓, ✗)
Large 100–300 cm			
Medium 50–100 cm			
Small 10–50 cm			
Very small 2–10 cm			
Larvae < 2 cm			

1.5. Hydrology and migration season

□ Without specific data on fish and migration, assume fish are migrating on all flows.

	Fill out before site visit
Nearest gauging station	
Maximum flow	
Annual maximum flow (1 year ARI)	
Mean flow	
Minimum flow	
25 %ile (typical high flow)	
25–75 %ile (medium flows)	
75 %ile (typical low flow)	



2. SITE VISIT

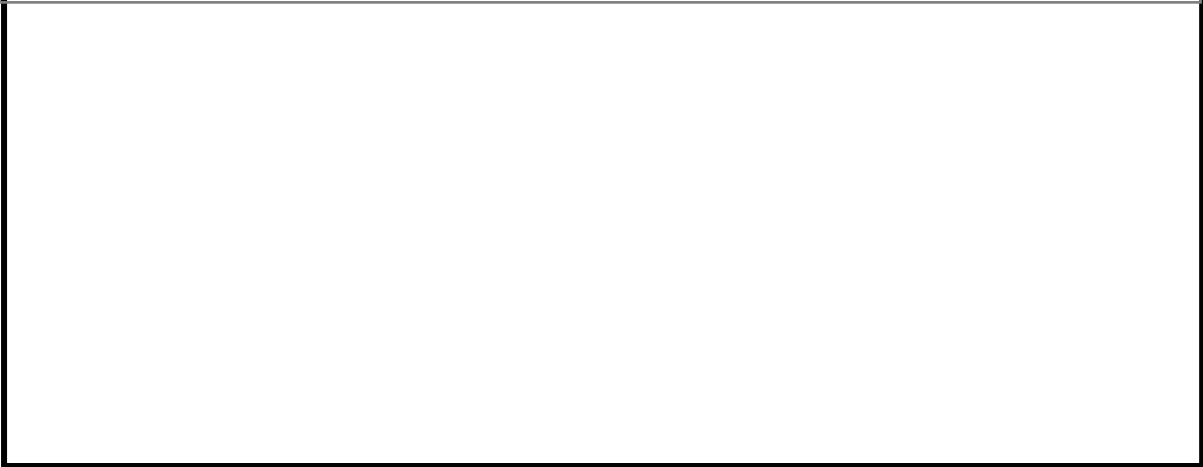
Fill out during site visit	
Date	
Flow: m ³ /s or: <i>Low</i> (Q<75 %ile), <i>Medium</i> (Q=25–75 %ile), or <i>High</i> (Q>25%ile).	

2.1. Consultation

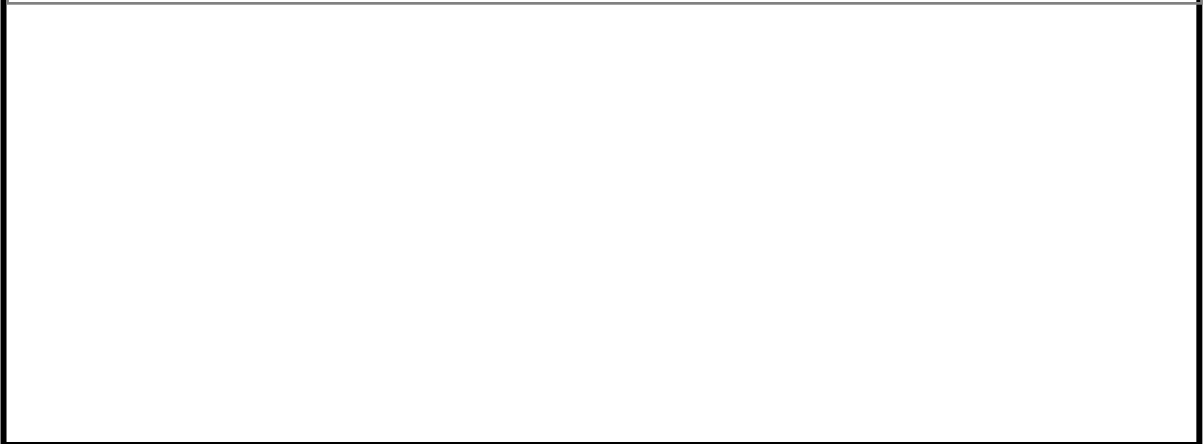
Fill out during site visit	
Meet with local villagers; Provincial Agriculture and Forestry Office (PAFO)/District Agriculture and Forestry Office (DAFO). List names:	
Discuss and record operation of: i) Water levels (compare with design [Sec. 2.3.1]) ii) fishway iii) sluice gates iv) irrigation offtake	
Discuss and record: Migratory fish size (Sec. 2.4) and Migration season (Sec. 2.5)	Fill out columns in Section 2.4 If necessary, edit migration season in Section 2.5
Record any fish passage issues identified locally (e.g. fish not using fishway, debris blocking fishway)	
Record any fisheries management issues identified locally (e.g. fishers in fishway, aggregations of fish below weir)	

2.2. Overview Plan

Sketch of site: barrier and fishway

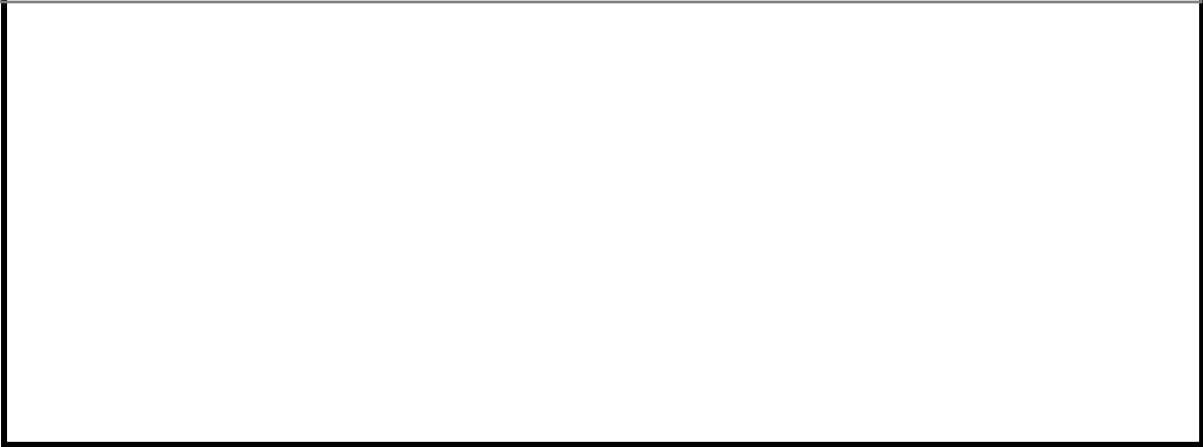


Sketch of fishway plan (fishway only)



2.3. Photographs

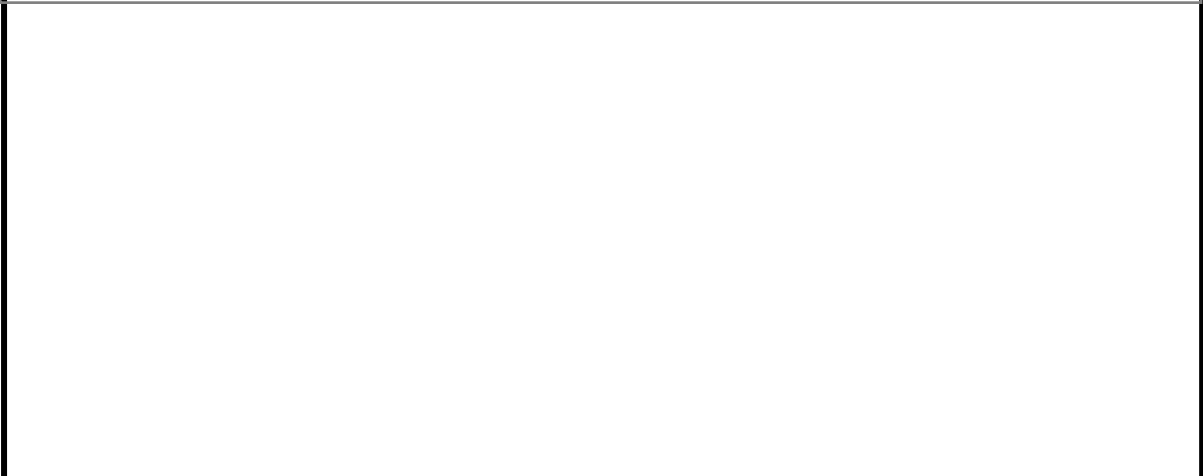
Whole weir



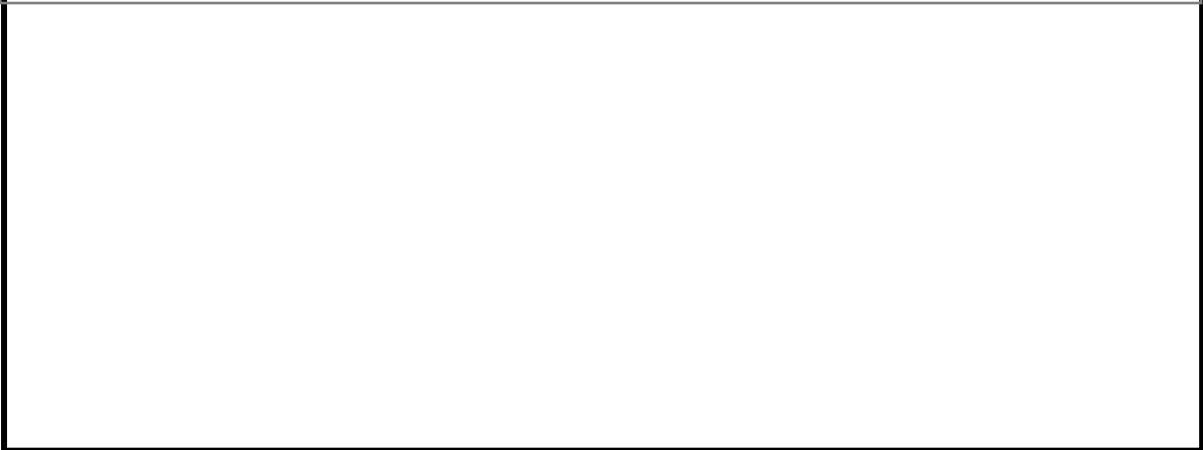
Left-hand abutment (looking downstream) and half of weir



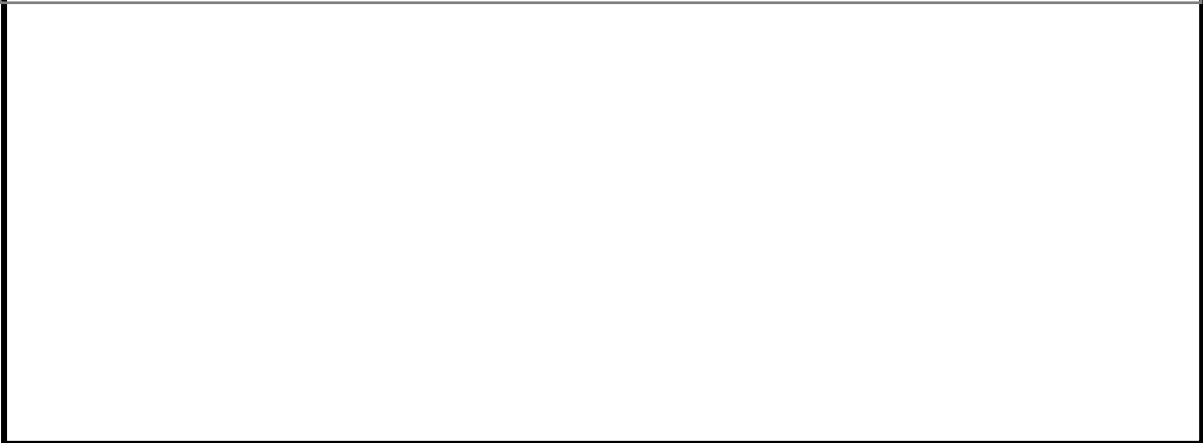
Right-hand abutment (looking downstream) and half of weir



Whole fishway



Detail of fishway entrance, including distance to weir



Detail of fishway exit



Detail of fishway pool



Detail of fishway baffle



2.4. Maintenance

Is the structural integrity sound?	Yes / No
Is there debris at trash rack?	Yes / No
Is there debris in the fishway?	Yes / No
Is there sediment in the fishway?	Yes / No
Is there sediment at the entrance?	Yes / No
Is there erosion of fishway surrounds?	Yes / No
Is there presence of erosion and the loss of tailwater?	Yes / No
Are the moving parts/ gates working?	Yes / No
Are the fishway covers (if installed) sound and safe?	Yes / No

2.5. Fishing in and near fishway

Do fishers use nets or traps in the fishway entry, channel or exit?	Yes / No
Do fishers block the fishway at any location? (Note: fishways only function when there are no blockages)	Yes / No
Do fishers use nets or traps in the river immediately <u>downstream</u> of the fishway?	Yes / No
Do fishers use nets or traps in the river immediately <u>upstream</u> of the fishway?	Yes / No

2.6. Upstream fish passage

2.6.1. Confirm design

- Use a surveyor's dumpy level and measuring tapes to confirm:

Water levels (Sec. 2.3.1),	Fill out columns in previous table in Section 2.3.1
Design criteria (Sec.2.3.2)	Fill out columns in previous table in Section 2.3.2

2.6.2. Assess attraction (to fishway entrance)

Is the fishway entrance at the <i>upstream limit of migration</i> ?	Yes / No
If no, can this be improved by: a) Gate/slucice management? b) Relocating entrance?	

c) Modifying abutments?	
Is the fishway entrance flow discrete flow easily detected by fish?	
If no, can this be improved by: a) Gate/slucice management? b) Relocating entrance? c) Modifying abutments?	
Are there other areas of fish attraction along the weir where fish would not find the fishway entrance?	Yes / No
If yes, can this be improved by gate/slucice management?	
Are there large recirculating flows along the bank that would disorient fish?	Yes / No

2.6.3. Assess passage (through fishway channel)

3.6.3.1 Maximum water velocity and pool depth

Maximum water velocity is calculated from the head loss per pool.

	Upstream level (cm)	Downstream level (cm)	Head loss (cm)	Minimum depth (cm)
	A	B	A-B	
Upstream				
Trash rack				
Exit				
Pool 1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
Entrance				
Downstream				

3.6.3.2 Turbulence

Calculate discharge (m³/s) <input type="checkbox"/> Use discharge formula in Fishway Design Guidelines <input type="checkbox"/> Will require specific measurements of slot width, orifice size or gaps between cones.	
Calculate pool volume (m³/s) <input type="checkbox"/> LxWxD	
Use average pool head loss from the previous section (Sec. 3.6.3.1)	
Calculate turbulence (W/m³)	

3.6.3.3 Evaluation

Note that head loss and turbulence must be suitable for the smallest fish at the site, and long fishways require lower head losses and turbulence.

		Fish size			
		Very small 2–15 cm	Small 15– 50 cm	Medium 50– 100 cm	Large 100– 300 cm
Present or expected (✓,✗)					
Head loss per pool (cm)	Suitable design specification for fish size	5cm	10	20	30
	On-site data Pool head loss range				
	Suitability (within 20% of suitable criteria) (✓,✗)				
Depth (cm)	Suitable design specification for fish size	50cm	100	150	250
	On-site data (depth range)				
	Suitability (within 20% of suitable criteria) (✓,✗)				
Turbulence (discharge/ pool volume: = (Q Δh γ)/V (Watts /m ³ ; Cd = 0.7)	Suitable design specification for fish size	25W/m ³	50	100	150
	On-site data (calculate from discharge estimate and pool dimensions)				
	Suitability (within 20% of suitable criteria) (✓,✗)				

2.6.4. Exit

Sketch of fishway exit and surrounds

Include approximate distances to irrigation offtake (if present), sluice gates or spillway.
Include obvious flow patterns.

Is the fishway exit within 5 m of the weir crest or sluice gate?	Yes / No
Are there moderate water velocities (> 0.3 m/s) sweeping across the fishway exit?	Yes / No
Are there moderate water velocities (>0.3 m/s) within 5 m of the fishway exit?	Yes / No
Is the fishway exit within 5 m of an irrigation offtake?	Yes / No
Are there moderate water velocities (> 0.3 m/s) at the irrigation offtake?	Yes / No
Notes	

2.7. Downstream fish passage

2.7.1. Confirm design

- Use surveyor's dumpy level and measuring tapes to confirm:

Design criteria (Sec. 2.3.2)	Fill out columns in previous table in Section 2.3.2
-------------------------------------	-----------------------------------------------------

2.7.2. Assess attraction

- To fishway/spillway/sluice gate entrance when migrating downstream.

Are fish guided to the downstream passage?	Yes / No
If not, can this be improved by: a) gate/sluice management? b) gate design?	
Are there other areas of fish attraction where fish would not find safe downstream passage, such as irrigation outlets?	Yes / No
If so, can this be improved a) gate/sluice management? b) management of irrigation offtakes? c) screening of irrigation offtakes?	

2.7.3. Assess passage

Is the downstream passage through: a) a fishway b) a fixed crest c) an undershot (sluice) gate d) an overshot gate	
Depth: a) a fishway b) a fixed crest c) an undershot (sluice) gate d) an overshot gate	

2.7.4. Assess exit

Exit depth (m) on downstream apron at: a) low flows $Q < 75$ %ile (m) b) medium flows $Q = 25-75$ %ile (m) c) high flows $Q > 75$ %ile (m)	a) b) c)
-----------------------------------------------------------------------------------------------------------------------------------------------------	----------------

Ratio: exit depth/head differential	
a) low flows (m)	a)
b) medium flows (m)	b)
c) high flows (m)	c)

3. SUMMARY EVALUATION

Which river flow was assessed?	High, medium, low
Which river flows are still to be assessed?	High, medium, low

		Recommended actions
Is maintenance required?	Yes / No	
Is fish harvest impacting fish passage?	Yes / No	

Evaluation: Meets fish passage requirements?	Recommendation: <input type="checkbox"/> No change <input type="checkbox"/> Further investigation <input type="checkbox"/> Modification <input type="checkbox"/> Refurbishment <input type="checkbox"/> Replacement
--------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

BIOLOGY AND HYDROLOGY (migration season, hydrology, and water levels for fishway operation)		
Does the fishway operate over the range of water levels when fish are migrating?	Yes / No	
UPSTREAM FISH PASSAGE		
Attraction	Yes / No	
Passage		
<i>Maximum water velocity</i>	Yes / No	
<i>Turbulence</i>	Yes / No	
<i>Pool depth</i>	Yes / No	
Exit	Yes / No	
DOWNSTREAM FISH PASSAGE		
Attraction	Yes / No	
Passage	Yes / No	
Exit	Yes / No	

Other notes, particularly on any defects requiring repair