Forestry Commission Scotland
Coimisean na Coilltearachd Alba

Environmental Culverts

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What is a culvert?

Left: before installation

Right: culvert in situ

It had been identified that…

- **Improperly planned, or designed, culverts can be bad for fish and other wildlife as they contribute to:**

- ***inadequate water depth during migratory periods,***
- ***excessive water velocities,***
- ***cause vertical barriers (perching or hanging culverts),***
- ***and poor water quality***

Example of a perched/hanging culvert

= Bad for the environment & bad for the economy!

Tackling the problem

- As part of the aims of the **Water Framework Directive** the Scottish Executive has produced guidance on river crossings for migratory fish in an attempt to mitigate the impacts that culverts, and other crossings can cause.

  "Crossing and Migratory Fish Design Guidance"

  (2010)

  – *note it is guidance only!*

- The Guidance recommends design criteria of maximum velocity and minimum depth for allowing safe passage of fish through a culvert.

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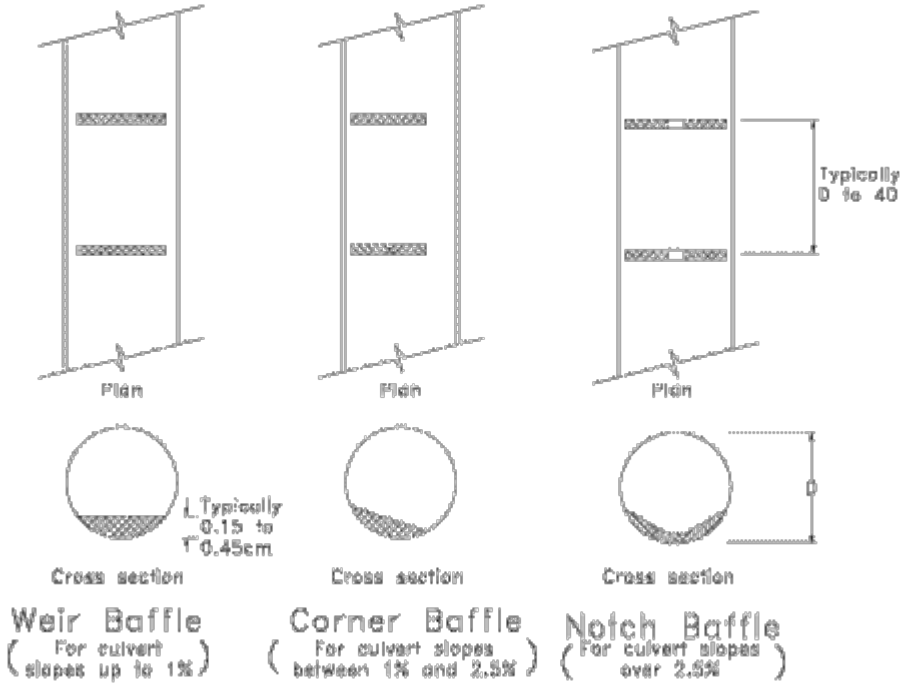
Baffle Styles for Circular Culverts (SE guidance)



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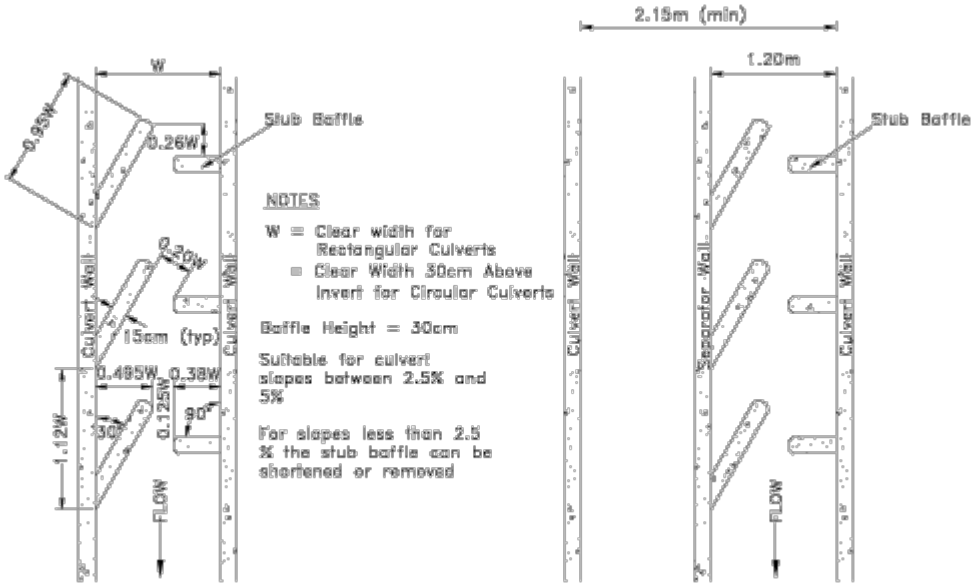
Offset Baffle Design



OFFSET BAFFLE PATTERN

SEPARATOR WALL FOR LARGER CULVERTS

So what are we doing to help?

Taking the Guidance on board

- A **retrofitted** (or baffled) culvert is one in which the bed characteristics of an existing culvert are modified or engineered to improve fish passage (W,H Pearson *et al,* 2006).

- Retrofitting culverts with **baffles** enables hydraulic and ecological continuity; providing favourable conditions for fish passage and improving water quality.

- Baffles **dissipate the kinetic energy** of water flowing through a culvert.

Interior wall of culvert

baffle

The benefits...

- The presence of baffles should help streambed material to accumulate in the culvert.
- This should therefore negate the need to consider parameters such as the target species, timing of migration, as well as fish passage hydrology simply because it mimics what already exists.
- Eliminating those parameters would make for less time spent on design, yet still satisfy environmental objective.

FCE Research

- Research into the effectiveness and feasibility of baffled culverts was undertaken by Forestry Civil Engineering 2010.

- Focused on 4 retrofitted culverts in different locations with different characteristics

example

Baffle arrangement

Typical streambed composition

Aims & Objectives

- To identify if the baffle arrangement was conducive to accumulation of sediment, similar in composition of that above and below the culvert.

- To identify if any of the FCE culverts display the qualities that make for ecological continuity, suitable maximum velocity and minimum depth required for safe fish passage; i.e. hydraulics verses ecology.

- To identify if retrofitting culverts is cost-cost effective compared with standard culvert installation.

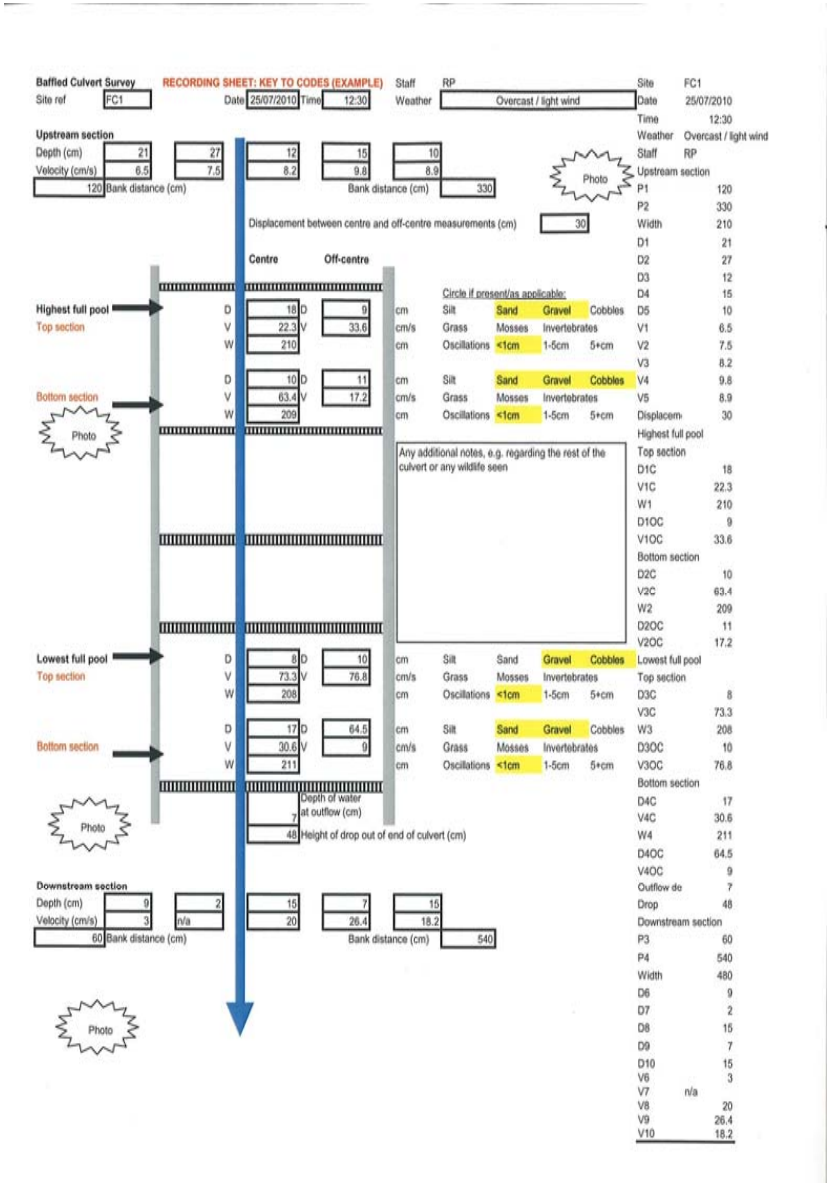
Culvert design & what to consider

- **Length of culvert** (based on geometry of the road fill). The longer the culvert the lower the maximum allowable velocity.
- **Fish passage requirements** (species and size determine velocity criteria)
- **Hydrology** – fish passage design flows in accordance with their requirements
- **Velocity and depth** (size, shape, roughness and slope of culvert in relation to velocity criteria requirements and throughout a range of flow levels). The smaller, weaker the fish, the lower the velocity and turbulence would be necessary.
- **Culvert elevation** - must be set so the low and high flows for channel backwater are at least as high as the water surface in the culvert.
- **Flood flow capacity** – undertake waterway calculation to determine adequate culvert size.
- **Channel profile** –suggest adjusting the upstream and/or downstream channel profiles to match culvert elevation if necessary.
- **Bed material** - recruit as soon as possible as a bare-bed condition could cause a barrier to fish.

Problems that baffles can cause

- Acting as a **hurdle** that fish may need to leap over.
- Baffles could block juvenile fish passage by creating **large-scale turbulence relative to the fish size**.
- Acting as weirs at low flow creating a **plunging pattern**, rather than a streaming pattern.
- In low flow, creation of small pools between baffles, **trapping fish.**
- **Snagging debris**. This can lead to complete blockage of the culvert and thus failure of the structure, as well as complete obstruction to fish. Blocked culverts can lead to flooding.

Field work and data collection Summary



- Weather conditions, date and time
- Photographs taken u/s, d/s and inside each culvert
- Water depth, velocity, and width measurements.
- Roughness of the water surface assessed visually using a scale of smooth water/oscillations <1cm, 1-5cm and 5+cm
- Streambed characteristics above (dominant grain size), inside and below the culverts observed.
- Other observations worthy of note recorded (e.g. invertebrates, build up of debris in culvert, bank vegetation, erosion, etc).
- Drawings were made illustrating activity and deposition throughout each culvert.

Recording velocity

Note recruitment of streambed material

Valeport, Model 801 Electromagnetic Open Channel Flow Meter

Results

- All the culverts fell within the maximum velocity criteria as recommended by the SE.
- Only 1 culvert provided the most suitable minimum depth for fish passage (of brown trout and sea trout, but not suitable for Salmon.
- The baffles allowed for recruitment of streambed material and resting pools.
- Ecological continuity of aquatic invertebrates was present.

Extra cost of installing baffles

Standard Cost:

12m x 1.5m diameter culvert = £2,186

Plus 10 hrs machine and operator at £35 per/hr = £350

Additional cost of installing baffles:

10cm diameter pipe (50m roll so enough to do more that one culvert) = £19.00

1 hour manpower (2 @ £20.00) to fit the baffles = £40.00

Galvanised wire (to tie in baffles) per kilo £3.00

(Source: FCE, 2010)

Total additional cost of installing a baffled culvert compared with a standard culvert = only **£62.00**

Conclusion

- FCE should install weir baffles with spacing less than the diameter. However, it is difficult to determine what the best baffle arrangement should be, as it is likely to **depend on the minimum depth of water in the natural watercourse**, slope, as well as the likely-hood of snagging debris, so will be different for each watercourse.

- Also knowing the type of fish and potential for them to use watercourse in advance.

- The height of the baffles should be determined by the **minimum flow levels**, therefore the FCE could develop a simple means of evaluating watercourses to identify characteristics, perhaps a matrix, that would determine baffle arrangement (angles of placement).

Forestry Civil Engineering should install baffles on all large culverts if the water course has been identified as having good, or the potential to provide good or improve biodiversity characteristics.

Have been in discussion with *'Polypipe'* with aim of designing a moulded baffled culvert for 'off the shelf' purchase.

Thank you for listening!

Kim Leech