



Fact Sheet A: On-stream dams — Flow threshold 1–70 L/s

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Technical fact sheets in this series:

- Sheet A
On-stream dams
(1–70 L/s)
- Sheet B
Off-stream diversions
(10–520 L/s)
- Sheet C
Off-stream diversion with
a 50:50 flow split
(5–2000 L/s)



Dams or other water diversions without low-flow bypasses can stop the low flows (sometimes called environmental flows) that are critical for maintaining our sensitive water dependent ecosystems. A low-flow bypass can allow this flow in times of low flow and direct water into the dam when the flow becomes higher.

Landholders may capture better quality water with these devices installed. The first flows to reach a dam in rainfall events are often higher in salinity because they pick up salts from surface soils. Once flows increase, the level of salinity in the water is usually diluted and this water is captured by the dam.

This fact sheet is one of a series of three:

- A. on-stream dams (1–70 L/s)
- B. off-stream dams (10–520 L/s)
- C. off-stream dams with 50:50 flow split (5–2000 L/s).

If your site conditions are not covered by any of these fact sheets consult a qualified engineer to develop an appropriate design.

Definitions

Drainage path: a defined watercourse with bed and banks or a less defined area where water flows in wet times.

Low-flow bypass: prevents a water storage, dam or other form of diversion from harvesting the low flows (sometimes called environmental flows) that are critical in maintaining our sensitive water dependent ecosystems.

Orifice: pipe inlet flow control mechanism (end cap with hole that is placed in the pipe inlet)

On-stream dam: a dam constructed on or across a drainage path

Threshold water flow rate: the flow rate that must be exceeded before water can be harvested or collected; it is normally measured in litres per second (L/s) and will be specified in your water affecting activities permit.

How does a low-flow bypass device work?

A small weir collects and directs low flows into a diversion pipe and around the dam (Figure 1). The design of the weir, pipe diameter, pipe slope and flow control mechanism at the pipe inlet govern the amount of water diverted.

During low flows, water collects behind the weir where it is forced into the diversion pipe rather than flowing into the dam.

As flow rates increase the water rises behind the weir. Above the threshold flow rate, the capacity of the weir and diversion pipe is exceeded, the water overtops the weir and enters the dam.

How are they designed and constructed?

These devices are formed using simple materials and can be designed and constructed by skilled handy-people or civil works contractors who are experienced at using a survey (dumpy) level.

This type of low-flow bypass is structurally relatively simple and many aspects can be designed and constructed according to local conditions and available materials. You'll save time and money if you plan and construct your low-flow bypass at the same time as planning and constructing your dam. Afterthought bypasses are usually less than ideal and can cost more. Follow the instructions closely to ensure your structure carries the correct flow and won't block with sediment.

You will need

- ◆ Poly pipe – polypropylene (poly) pipe is recommended and available in a number of standard diameters
- ◆ End cap for the poly pipe
- ◆ Materials such as concrete and/or timber for the weir
- ◆ If necessary, a strong, long-life, UV-resistant commercial-grade plastic liner to ensure watertightness
- ◆ Materials such as concrete, timber and/or bricks for the shallow pit at the weir and the pipe outlet
- ◆ Hard angular rock of average 200 mm diameter (from gravel through to 300 mm diameter) for erosion control below the weir
- ◆ Steel droppers to hold the pipe outlet in place
- ◆ If necessary, wire netting such as chicken wire for debris control above the weir

The threshold flow rate on your permit governs the carrying capacity of the structure. It is the starting point for your calculations.

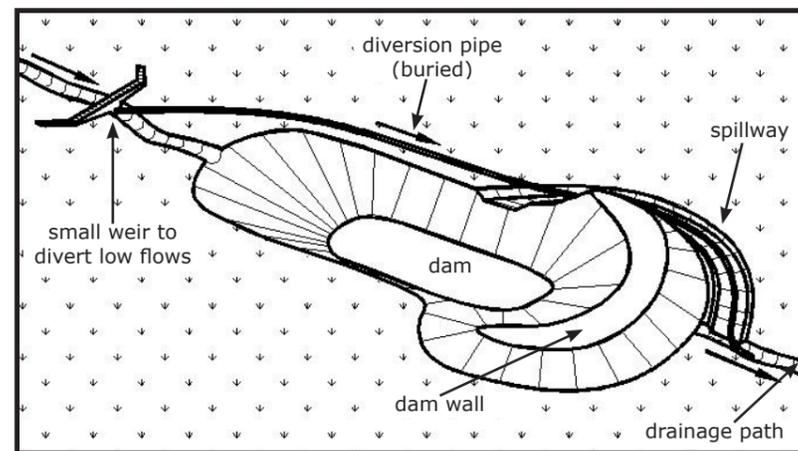


Figure 1: Layout of typical low-flow bypass

Step 1: Orifice and pipe diameter

Flow into the pipe is accurately governed by an inlet flow control mechanism, or orifice, which is cut into the centre of an end cap on the pipe inlet.

Use Figure 2 or 3 to determine your required orifice diameter. Read from the threshold flow rate on your permit (X-axis) to the orifice diameter (Y-axis) on the graph.

Select poly pipe with an 'internal' diameter at least 1.5 times larger than your required orifice diameter. Select an end cap to fit. Cut or drill the orifice of the calculated diameter into the end cap for the pipe.

Note: Pipes are usually referred to by their 'nominal' diameter, which is usually slightly larger than the 'internal' diameter. Check the pipe diameters at your local supplier and ask for the internal diameter.

Step 2: Pipe slope

Pipe slope is of critical importance to the functioning of the device. Incorrect pipe slope will not give your correct threshold flow rate and the pipe is more likely to block with sediment.

Determine the minimum slope by using Table 1.

No section of pipe can have a slope less than the minimum slope. To increase the pipe slope, shift the pipe inlet further upstream from the dam.

If you are enlarging an existing dam and are required to install a low flow by-pass, the pipe inlet and small weir may need to be located some distance upstream of the dam to meet the minimum slope requirement.

From this point the pipe should be laid at an even grade around the dam to the dam wall. The pipe should pass over the dam wall on top of the existing overflow spillway (Figure 4).

Before constructing the bypass, check the slopes using a survey (dumpy) level and tape measure. Get the slope as even as possible and avoid undulations.

The survey level can also be used to mark the route of the pipe on the ground so that it's at an even slope.

For a pipe laid at an even grade from its inlet to the dam spillway the slope is determined using the following equation:

$$\text{Slope (\%)} = \frac{\text{Height of pipe inlet above dam spillway (m)}}{\text{Length of pipe from inlet to dam spillway (m)}} \times 100$$

Allow for bends or curvature in the pipe when measuring its length.

If the pipe is laid unevenly, the calculated slope will be the average slope.

The flattest sections should still be steeper than the minimum slope. In some very flat locations where it may not be possible to achieve minimum pipe slope, a special design will be required. Consult a qualified engineer.

For new dams the pipe may be laid through the dam and the dam wall. Adequate seepage collars will be required to prevent piping failure of the dam wall.

Standard grade poly pipe laid directly on the ground can be crushed or damaged by stock. If stock access the area, the pipe should be buried.

Step 3: Weir design

The key design issue for the small weir that captures low flows, is to ensure the crest level – the level at which water overtops the weir – is correct.

This crest level must be 30 cm, or 2 times the orifice diameter, whichever is greater, above the centre of the orifice.

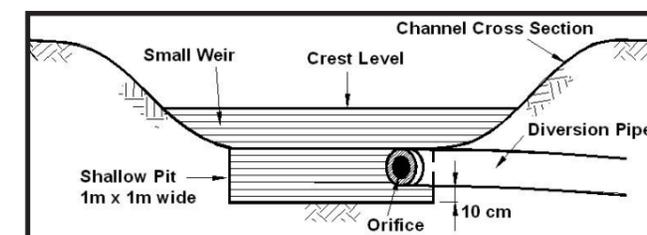


Figure 5: Impoundment and pipe inlet in channel

The weir structure includes a shallow pit which traps sediment to prevent pipe blockages and reduces the weir height, and thus erosion potential. Place the pipe inlet in the shallow pit (Figures 5, 6 and 7).

The small weir can be constructed from materials such as concrete and timber. It must be watertight (a plastic liner might help).

If the dam is located on a watercourse with no defined channel, levees may need to be constructed across the valley to direct flows into the weir and pipe inlet (Figures 6 and 7).

They should extend across the drainage path and end at higher ground on either side of the valley but should not increase the catchment area of the dam.

Determine the height of the levees based on local conditions. They should over-top in high flows so that flows are not overly concentrated and cause erosion. A minimum height of 10 cm above the weir level is recommended. Compact the levees well and sow with grass to prevent erosion.

Step 4: Shallow pit

The shallow pit collects sediment and prevents it from entering the pipe. It also allows the weir crest level to be lower, and thus be less prone to causing erosion.

Install the pit in the lowest point of the drainage path with its base level 10 cm below the bottom of the diversion pipe.

Form it with concrete, timber or bricks into a rectangle with a hard base (about 1 x 1 m wide) and hard sides. It can immediately abut the weir or be set back slightly. Figures 5, 6 and 7 show the layout and recommended dimensions of the pit.

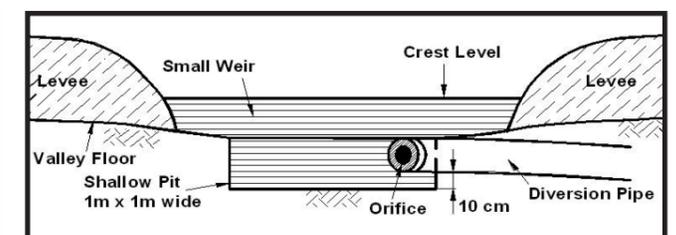


Figure 6: Impoundment and pipe inlet with levee banks

Step 5: Erosion control at weir

Water cascading over the weir is likely to cause erosion on its downstream side. To prevent this, protect the bed of the watercourse channel or drainage path with rock for a length of 5 times the weir height and extend the rocks up the banks to the height of the weir.

Excavate the area to be rock-protected to a depth of 30 cm and then fill it with rock. Make sure the rock is hard and angular, not soft or rounded, and in a range of sizes, from up to 300 mm in diameter down to small rock/gravel to fill the gaps between bigger rocks, and an average of about 200 mm diameter.

Set the rocks into the creek bed rather than placing them upon it. Place them so that they will contain flows, i.e. the finished level of the rock must be lower in the centre of the drainage path than at the edges. Encourage grass to grow over the rock by filling gaps in the rock with soil and casting seed over the finished area.

Step 6: Erosion control at pipe outlet

Water gushing out of the pipe outlet may also cause localised erosion. If the dam spillway is stable and erosion resistant, place the pipe outlet on the spillway. Otherwise, place the pipe outlet within the watercourse or drainage path, below the dam, at bed level. Angle the pipe downstream and not at the banks. Hold it in place with steel droppers either side of it and tie it to the droppers with strong wire.

Construct an energy dissipater (a pit) to prevent erosion. This pit can be similar to the inlet pit. It should be at least 3 times as deep as the pipe diameter, or a minimum of 30 cm deep, and square with sides at least 5 times as long as the pipe diameter, or a minimum of 1 metre long.

The pit may be formed with concrete, timber or bricks, but must be strong with no gaps in the walls or base. Pass the pipe through the upstream wall of the pit at base level and angle it directly at the downstream wall of the pit. The end of the pipe should be at least 4 times the pipe diameter from the downstream wall of the pit.

Maintenance

Observe the low-flow bypass in operation during the first few flow events after installation and monitor it regularly thereafter. Note and fix issues as they arise, particularly:

- ◆ blockage of the pipe inlet with debris
- ◆ blockage of the pipe with debris or silt
- ◆ sediment accumulation in the shallow pit
- ◆ leakage through the weir
- ◆ erosion downstream of the weir
- ◆ erosion at the pipe outlet.

Blockage of the pipe inlet orifice with debris (e.g. leaves, grass, sticks) may be an ongoing problem in watercourses with a high debris load. To reduce inlet blockage, construct a fence of wire netting (e.g. chicken wire) across the watercourse upstream of the shallow pit to trap debris. The netting should only be high enough to be effective in low flows, and be overtopped in high flows. It will require cleaning on a regular, but less frequent, basis.

Regularly remove sediment from the pit to stop it entering the pipe. This design should minimise the likelihood of the pipe blocking with sediment. In the unlikely event that it does block it may be cleaned using commercial sewer cleaning equipment. Contact a contractor.

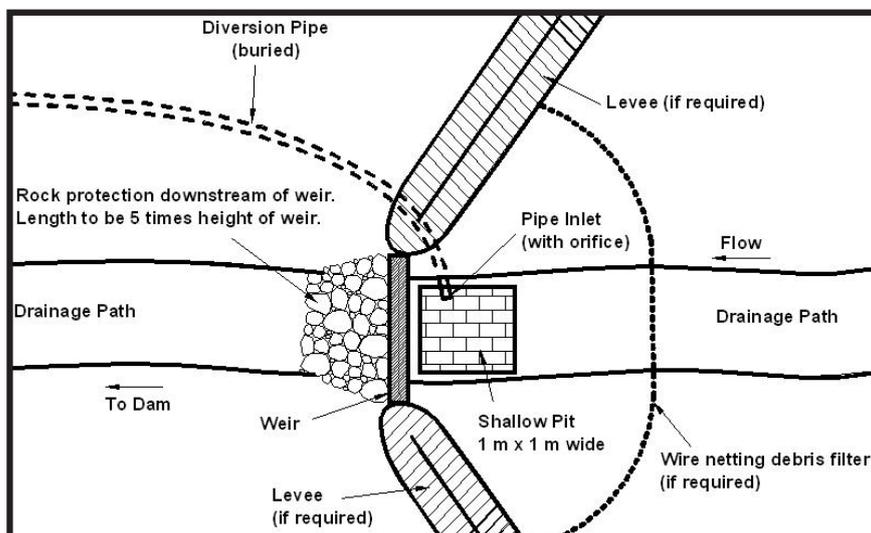


Figure 7: Layout of small weir, shallow pit, levees and pipe inlet