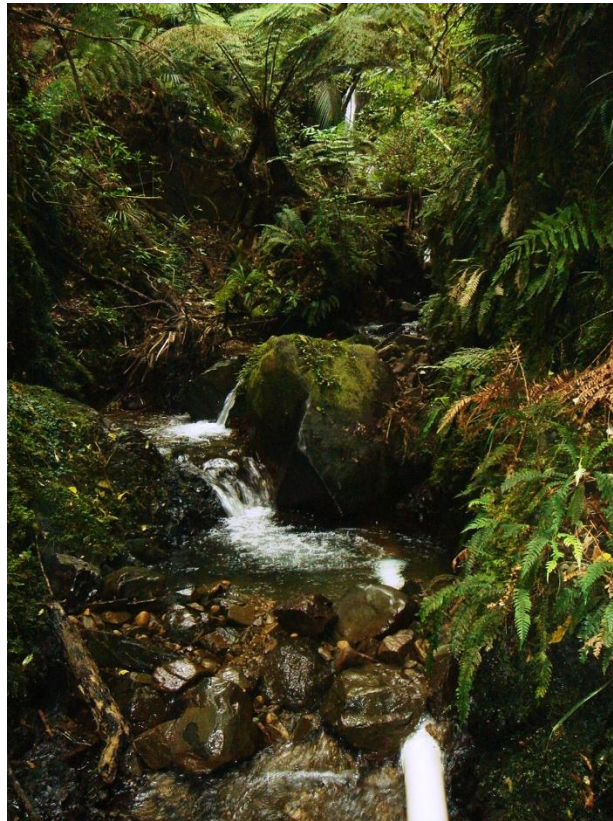




PowerSpout Intake Guide



CONTENTS

Introduction 3

 1.1. Functions of the intake 3

 1.2. Should I build a big dam? 3

 1.3. Scour pipe 4

 1.4. Valve and Vent pipe 4

2. Environmental measures 5

 2.1. "Hands off flow" 5

 2.2. Exemptions 5

3. Submerged filter intake 6

4. Wash-over or "self cleaning" filter screens 8

5. Forebay tank sited out of the stream 12

6. Types of screen 14

 6.1. Aquashear coanda-effect screens 14

 6.2. Choosing the right size of screen 15



Introduction

The intake for the water that feeds your turbine is the part of the hydro system that is most likely to cause you trouble if you get it wrong. A blocked intake is by far the most common problem, and cleaning the intake is the most frequent maintenance task on many sites. We hope that this document will help you to find a suitable intake design for your situation.

2018 Update – from the middle of 2018 PowerSpout will be offering a stainless steel Coanda intake screen to complement our range of hydro turbines that in many instances can freight with your turbine. Refer to our web site to locate the latest information on this new product.

1.1. Functions of the intake

- Divert the water into a pipe (or "penstock") leading to the turbine
- Remove floating vegetation, aquatic life forms, small stones and bubbles from the flow
- Do no harm to the local ecology
- Survive flood conditions
- Avoid becoming an eyesore :-)

1.2. Should I build a big dam?

Hydropower is associated with the construction of dams, but there is no necessity for a big dam project in most cases. All you need to do is divert the water into a pipe and return it to the stream below the turbine. This may entail a low weir or whatever it takes to create a small pool of water. Sometimes you can catch the flow of water as it falls out of a culvert pipe or over a rock ledge and then you do not need any sort of dam.

It is unlikely that you will benefit much from storing a large volume of water. The power of your turbine is not enhanced by the weight of water behind the dam. Pressure (head) depends only on the difference in height between the intake and the turbine. A dam is unlikely to make a big difference to this height.

If you do have access to a large pool of water, this is useful because it helps to settle out silt and bubbles. Another advantage of a reservoir is that it gives you breathing space when the flow is dwindling. If you monitor the overflow daily, and notice it has stopped overflowing, then the body of water behind the dam gives you a bit of time to adjust your turbine (close a valve or change a jet) to use less flow, before the penstock starts to draw in air.

Having said all that, most sites will only require a modest weir. The main thing is to have sufficient depth of water that you can submerge the mouth of the pipe. Beware of using a small pipe at a shallow depth because the water velocity will create a vortex that draws air into the pipe. It may be possible to fix this issue retrospectively with a horizontal baffle or raft above the pipe mouth but it's better to make sure the pipe is deep enough and large enough that the water flows in quietly.

Remember, you can use a few metres of oversized pipe and reduce the diameter a few metres further down the run. A low velocity in a larger pipe will allow any air bubbles time to rise and escape backwards out of the pipe.

1.3. Scour pipe

It's a good idea to have a scour pipe built into the structure of your dam or weir at the lowest point, so that you can drain the pool, and flush out the silt and stones from time to time as they build up. This is also useful whilst constructing and for maintaining the filter screen and penstock.

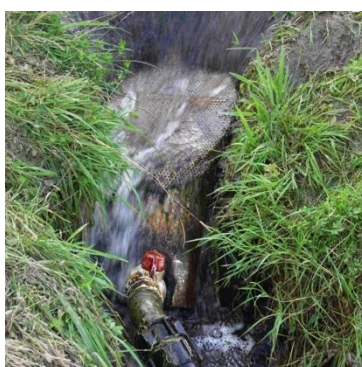
A simple way to block the scour pipe and fill the pool is to place a cap on the inner end of the pipe, with a rope attached, so you can yank the cap off to drain the pool. Or push it open from below with a long pole.



1.4. Valve and Vent pipe

The penstock leaving the intake may need a valve and/or a vent.

It is not essential to fit a valve at the top of the penstock. It may be useful if your penstock is vulnerable to damage and if leakage could then cause flooding problems.



If a blocked filter or a closed valve interrupts the flow then the water already in the pipe will create suction. The most negative pressure you can get is one atmosphere, which is created by ten metres of head pulling on the top end of the penstock. Your pipe then has a partial vacuum in it. This could crumple your filter, or even crush your pipe. Having said that, most pipes can withstand atmospheric pressure quite comfortably.

It's a good idea to fit a vent pipe which rises above the water level in the pool. This admits air so the pipe can safely drain without creating a vacuum. If the vent is positioned a few metres down the run, it will also assist air to escape that has become entrained with the water entering the penstock mouth during normal operation.

Take care that the vent **does not draw air in** though! The filter will create a bit of a pressure drop in normal use. If in doubt as to where to put the vent pipe, do the following test. Drill a small hole, and verify that water comes out of it at all times, even when your filter is partially blocked.



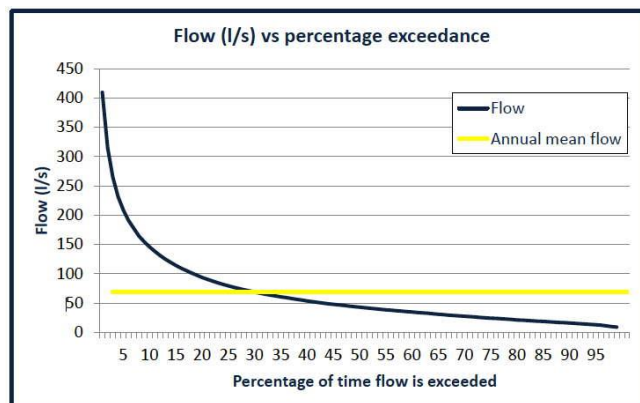
If water stops coming out then any vent at this location will draw air in, which is not normally helpful. In this situation you may have to locate the vent pipe further down the slope where the pressure has built up due to the extra head.

2. Environmental measures

Different environment agencies in different countries will have different requirements. For example there may be a constraint on how large the holes can be in your intake filter screen. Large holes can be a danger to fish and other creatures.

2.1. "Hands off flow"

In the UK it is normal for the Environment Protection Agency to stipulate a minimum flow that must be left in the stream. To establish this "hands off" flow you will need to pay for a computer study (LowFlows report) which produces a "flow duration curve" predicting how much of the time the flow will exceed any particular value. Here is an example.



The most important figure on this curve is the "Q90" which is the flow that is exceeded for 90% of the time. In the above this would be 15 l/s. To satisfy the Agency you will need to make arrangements to leave this much flow in the watercourse **at all times**. If the report is accurate and the system is compliant this will mean no water for 10% of the time and insufficient water to be able to run the system for a larger percentage.

The "hands off flow" is created in practice by building a deliberate leak into your water collection system. Often this will be a notch, or an orifice, that releases the Q90 flow all the time and prevents the penstock from taking any water unless this flow is exceeded. In order to be compliant and receive permissions and feed in tariffs and so forth, you will need to pay for the flow report, pay for an application to the Agency, and then build an intake with a substantial leak in it. In this way you ensure that you will not impact on any life forms dependent on the water you are using.

2.2. Exemptions

- In situations where a vertical waterfall exists and hence there is and no natural fish passage and the water diversion distance is short (length of water fall) then rules are often relaxed on a case-by-case basis. As many domestic-scale hydro schemes exploit small local waterfalls this situation is surprisingly common.
- In some jurisdictions where the stream completely dries in summer, then this may mean that the stream is not a legal waterway and no consent may be needed, but always check first.

The fact that it dries up need not be a big problem so long as you have a hybrid system with solar PV as well as hydro generating capacity. Domestic scale hydro for wet weather support to larger off-grid solar PV systems is becoming very common.

- Streams that disappear underground through porous bedrock or into a cave system may also have no legal status, and consent may not be required, but again it is best to check.

2.3. Impacts of construction

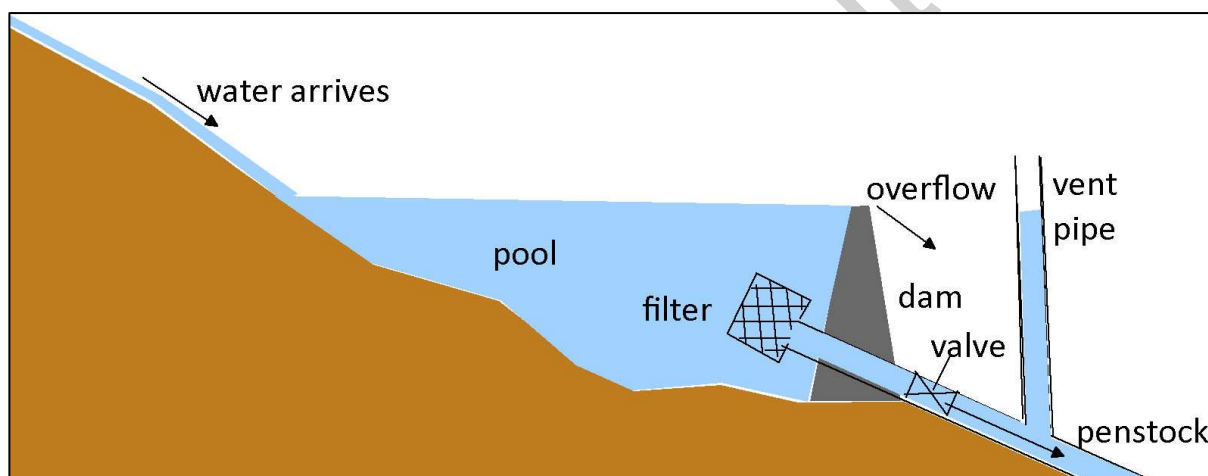
- All structures that are in, on or over the bed of the stream should be precast or pre-constructed so that physical works do not occur over the stream. The consent holder shall take all practicable steps to minimise the disturbance of the streambed during the construction activities and to minimise the release of sediment.
- Any sections of the stream bank or its adjacent surfaces which are disturbed during construction of the intake or discharge structures shall be immediately stabilised upon completion of works to prevent erosion.

3. Submerged filter intake

The obvious intake for a beginner is to dump the end of the pipe in a pool of water.

You may need to bury the pipe within the dam or weir, or a pile of stones that obstructs the flow and creates the pool.

Syphon intakes are also doable, but best avoided where possible, so as to keep life simple.



Some kind of filter is advisable. A frog will probably not pass through your turbine jets gracefully and the impact of its arrival could burst the pipework.



On the left you can see a trash rack that will block larger items such as tree branches and rocks.

From an environmental point of view the requirements are likely to be:

- that the holes in the screen are small enough to exclude most aquatic life forms
- and intake approach velocity is no more than 0.3 m/s

A low water velocity toward the screen allows fish to swim away and escape entrapment. A large screen area (in relation to flow) will help to fulfill this requirement.

The crude system shown right is to make multiple cuts in the pipe with a saw, and blank off the end.

Cylindrical filters built from wire mesh (or perforated plate) are another solution that we often see.

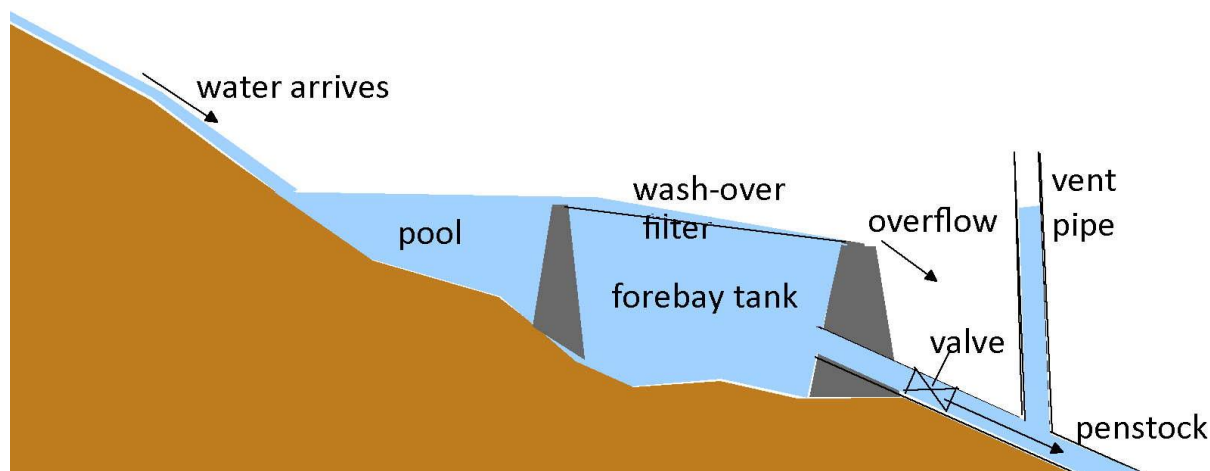
The next photo right shows a filter made from perforated sheet metal. This is a good material for filtering the flow, but **a bad situation for a filter**. Any debris will remain adhering to the filter until it is removed. It's a dead end.

You will need to develop a technique for conveniently cleaning this at frequent intervals. A special brush perhaps. Or a technique for fishing the end of the pipe out of the pool so you don't have to go swimming.

The filter should be well below the surface and above the bottom of the pool to avoid sucking in debris that floats or sinks. But wherever you put it, it will attract vegetation in the latter part of the year.



4. Wash-over or "self cleaning" filter screens



A much better arrangement for filtering the intake is to arrange the overflow water to wash over the filter and clean off the debris. Essentially the intake is a "forebay" tank with a perforated lid. This tank can be positioned in the path of the flowing water in a variety of ways, depending on the layout of the intake site. The tank can be made from concrete, stainless steel, plywood, timber, plastic, etc... as befits the site and the budget.

The design of this and every aspect of the intake must take account of the worst flood conditions. Either you have to build strong enough to withstand the flood or be prepared to rebuild afterwards.

The filter screen is often sloped so as to assist the cleaning action. It needs to be large enough and the slope gentle enough that the water does not simply shoot across it, or fly over it, and pass on. It's helpful to have raised edges (wing walls) at each side to prevent the water sliding off the sides.

There is some headloss associated with this slope, as the water surface in the sump below is usually at or slightly above the bottom edge of the screen. When there is surplus flow, you will see water entering and then overflowing out from the same screen, top and bottom.



These photos below show screen boxes built into various sorts of dams. Water flows over the lowest part of the lip of the dam/weir and down the filter screen. In the event of a flood there is a wider spillway available for the flow.

The example on the bottom left has a plywood gate inserted. This suggests that the size of screen and the holes in the screen were insufficient. The plywood gate captures the flow, but it somewhat defeats the self-cleaning action.





Sometimes the tank can be buried in the stream bed, so that there is no need for any sort of dam or weir structure. All you need are a few stones on each side to direct the flow over the screen.



If there is a natural waterfall that is tall enough, you can simply put your screened tank underneath. These pictures show prefabricated screen boxes positioned under water that falls out of culvert pipes and over ledges.



In this example above you can easily see the shut-off valve and the vent pipe. However they are somewhat inaccessible in the event of flooding, and it is actually likely that the vent pipe would be damaged by debris flying out of the culvert.

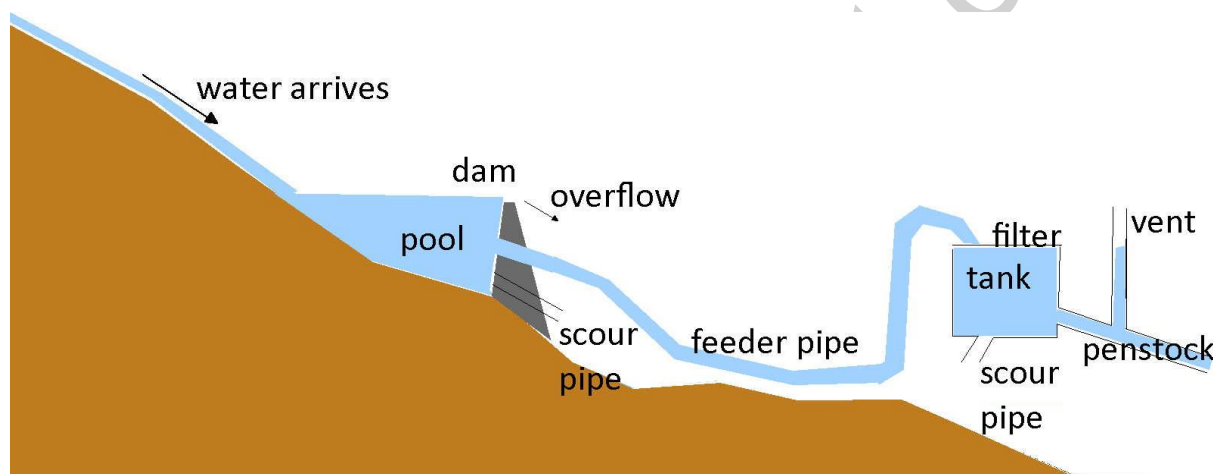


5. Forebay tank sited out of the stream

The above examples are inaccessible during floods. It may be difficult to unblock or repair the filter screen or to operate the valve. A good solution is to install the forebay tank at a more accessible location, almost level with the pool but further up the bank at a lower point in the stream. A feeder pipe is used to bring the required flow to the tank, at a fairly steady rate. The level of the tank is critically important in obtaining the correct flow.

The pipe discharges over a filter screen on top of the tank, and the surplus runs back into the stream below. The design of the washover screen can be similar to the previous ones. But the situation well above the stream level makes it much easier to route the penstock downward with a good initial gradient from the tank toward the turbine. It is usually possible to take a piece of the main penstock pipe and use it as the feeder pipe. The longer the feeder pipe is, the shorter the penstock needs to be.

Arrange the gradient of the feeder pipe downward and back up so that there is no danger of air getting trapped in any high spots along the route.



There is no need for any filter on the mouth of the feeder pipe itself. It can be situated below the surface of the pool (if one is available), so that it avoids sucking in floating debris. The forebay tank does need a filter. It can also be equipped with a scour pipe to remove sediment. The penstock can have a vent but there is probably no need for a valve. Flow can usually be interrupted by deflecting the feeder pipe.

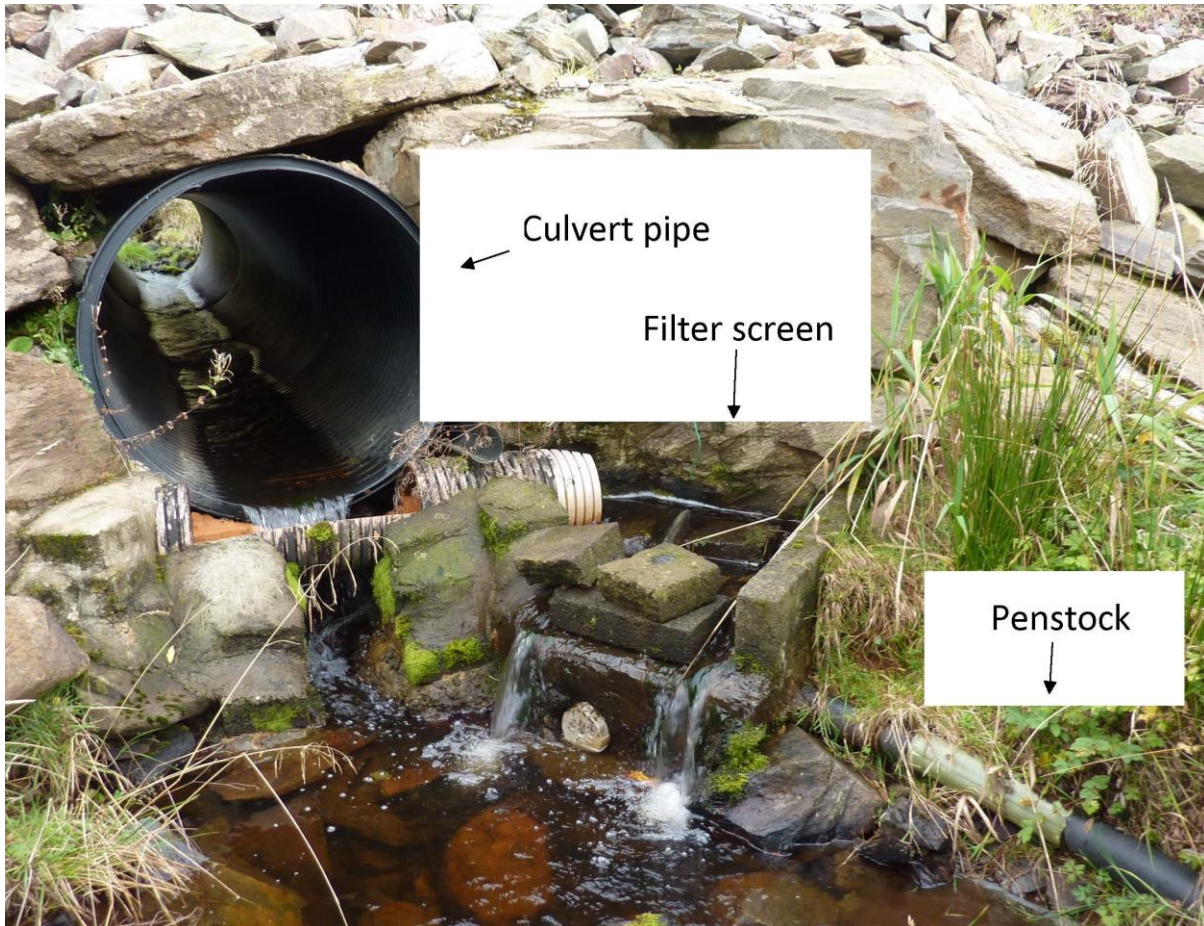
It's important to make sure that the overflow path back into the stream is environmentally friendly. Make sure that all aquatic life sucked into the feeder pipe is passed on down the overflow path and the water does not cause erosion and fill the stream with mud.

The photo on the right shows a blue plastic barrel used as a forebay tank. Penstock take-off is on the left. Feeder pipe is on the right. To set things in motion the feeder pipe is lifted onto the wooden shelf so that it discharges through the perforated screen and into the barrel. Surplus/overflow water runs down an existing gully below.



This blue plastic barrel is not a thing of beauty but it functions well as an intake. A means of scouring the silt out of the barrel would be a useful addition. There is room for improvement in the way the overflow is handled, though. It would be best to collect the overflowing water and pipe is safely back into the stream along with any fish that may be carried along.

Below is another example of a well-functioning system where the flow is captured from a culvert pipe and diverted over a screen above a tank.



Again, the screen is a little undersized for free flow to work, so the water overflow has been restricted using concrete blocks. There is still a vigorous flushing action.

In floods the bulk of the flow comes flying out of the culvert and bypasses everything, leaving the screen accessible for cleaning.



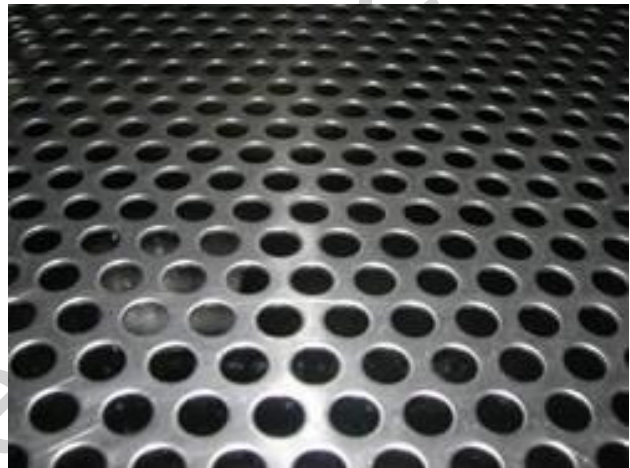
6. Types of screen

You can use a variety of materials for the filter screen, but the best is stainless steel. To avoid blockages, the hole size should be less than half the diameter of your smallest jet. To prevent danger to aquatic life the holes should be very small - around 1-3 mm diameter.

The galvanised wire mesh in the example on the right is probably a false economy. The holes are quite large and the mesh is weak and poorly supported so it will probably collapse in a flood.



A better choice is perforated stainless steel plate. A smooth plate is good for shedding vegetation such as leaves, that tend to plaster themselves over the surface of the screen. You can buy stainless sheet (try eBay for example) with holes in a range of sizes right down to one millimetre, and the smaller the better. Small holes will be better at excluding rubbish and also small aquatic creatures. Grass and leaves are less likely to get lodged in a small hole. In the summer algae may grow on the metal, so it will need a scrub with a bristle brush a few times each year.



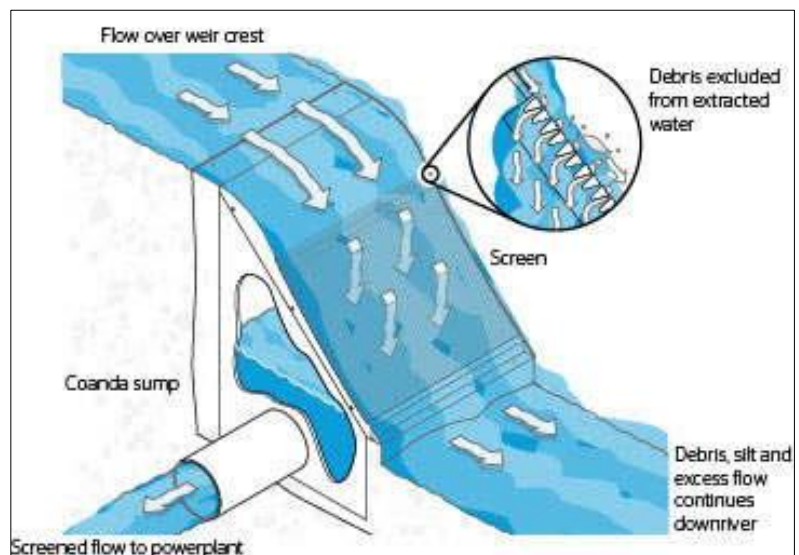
Make sure the hole size is 1.2-1.5 times larger than a bristle on a "typical" brush you will use for cleaning.

Support the screen material on sturdy bars. Ideally these should be stainless too but provided they are thick and strong it does not matter so much if they are galvanised or rusty steel. It's all down to how much you want to spend, in relation to the life expectancy.

6.1. Aquashear coanda-effect screens

The best solution of all is probably "Aquashear" screen material (see right) that has been specially developed to separate water from particles, using surface tension.

To get the best from this material it should be installed according to the manufacturer's instructions.



All too often we see it used on submerged filters where its special properties are completely irrelevant.

Install it in a wash-over design as shown right, with a curved acceleration plate above it. That's how it was designed to work. The flow velocity should be slow. A flume that brings the water to the top of the screen at speed can cause problems with this type of filter.

Aquashear is rated for 90 litres/second per metre of surface area. Other screen materials may need larger areas and it is always better to be generous with the area of screen in case it blocks or underperforms.



6.2. Choosing the right size of screen

As a rule, the bigger your screen wetted area is, the better it will work. Every situation is different (in terms of water velocity, depth etc.) and there is no simple formula that will be accurate. You need to take account of the ratio between the area of the holes and the total area of the screen.

As a rule of thumb we recommend that:

The minimum total area of your **holes** should be 1/100 square metre for every 1 l/s flow.

Say for example you are designing for 10 l/s flow.
You would need $10/100 = 1/10$ th square metre of holes.

Say the holes represent 1/4 of your screen area.
Then you need **roughly** 4/10 square metres of wetted screen material.
This could for example be 100 x 40 cm or 70 x 60 cm.

Bigger will always be better, and it pays to do it right at the outset.