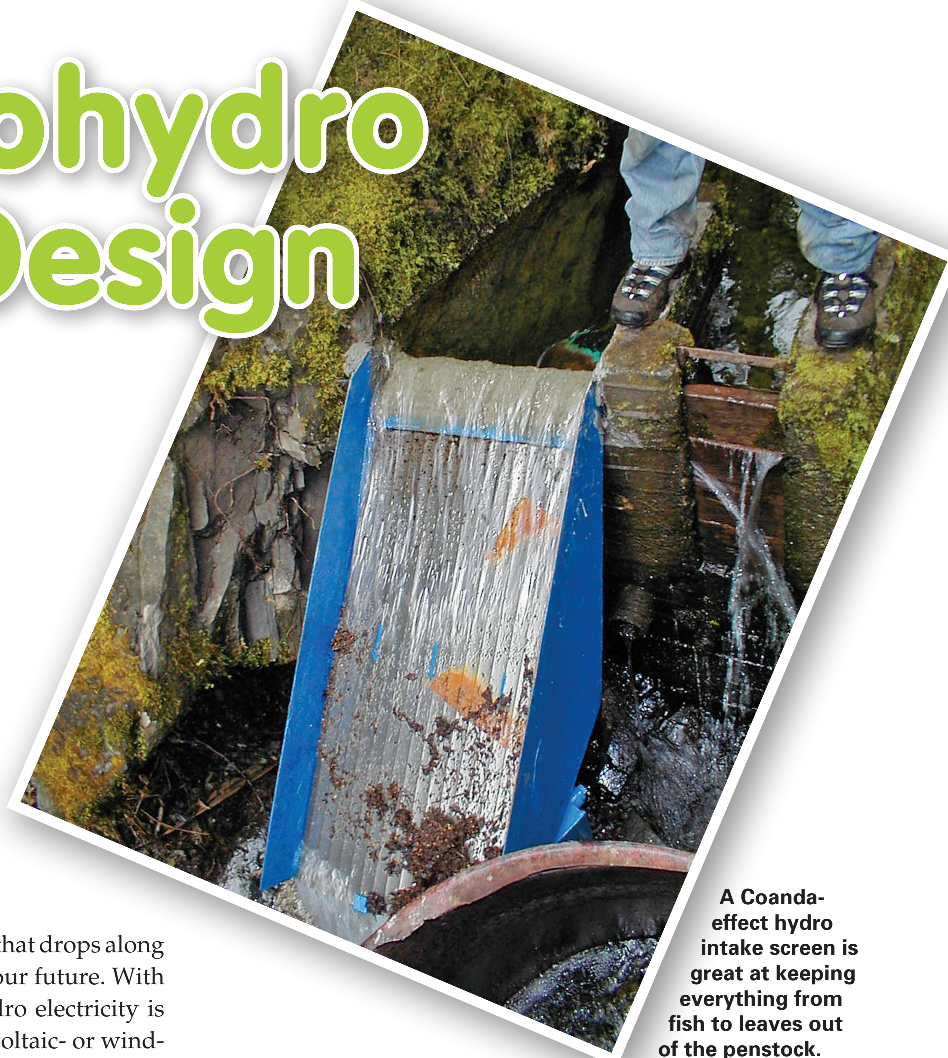
# Microhydro Intake Design

by Jerry Ostermeier



A Coanda-effect hydro intake screen is great at keeping everything from fish to leaves out of the penstock.

If you have a creek or stream on your property that drops along its course, a microhydro system could be in your future. With the right circumstances, harnessing microhydro electricity is cheaper and more constant than either photovoltaic- or wind-powered electricity, partly because a source of flowing water is available 24/7, and not vulnerable to doldrums, clouds, or the number of daylight hours.

While a microhydro system requires a more hands-on approach than PV, it is often simpler for the system owner than harnessing wind. It can also be a great do-it-yourself project—if you have the appropriate knowledge and skills. Supplying debris-free water to the hydro turbine is the first critical step in developing a low-maintenance hydro system. This article will introduce you to several methods of constructing an *intake* to do just that. Keep an eye out for additional articles that will cover penstock (the pipeline to the turbine) design, and system wiring and transmission voltage considerations for high- and medium-head microhydro systems.

## Creating a Diversion

If you follow a molecule of water through any high- or medium-head hydro-electric project, the first step is diverting it from its flowing source and into the penstock. A diversion can be a collection pond, a river-wide dam, or even a pile of rocks that backs up the water in a creek enough to cover an intake. A diversion can be simple or elaborate, inexpensive or costly—but it needs to suit your application in a mechanical sense and also in an ecological one—without disturbing fish or their habitat.

This article does not cover some aspects of water diversion, like dam or pond building, since their construction is site specific and can be quite complex, usually requiring professional design and engineering. They also often require permission and permits from government agencies, such as your state's fish and game department, and may need to include mitigation measures to protect fish and other wildlife.

Any diversion and intake needs to be robust enough to withstand the worst that winter has to offer—or it should be removable or easy to repair. Creeks can roll boulders or float trees that can damage your intake and diversion significantly. Some creeks flow evenly year-round, while others may trickle in the summer and flood in the winter. Because every site is a little different, whatever intake method you choose will need to be adapted to work at your particular location.

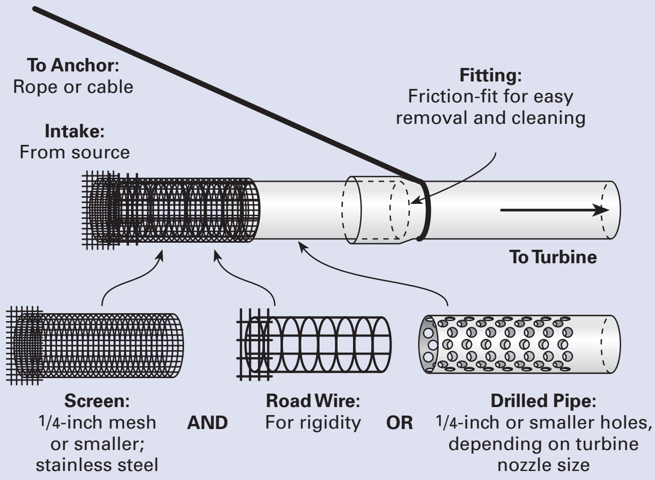
An important job of an intake is to screen out rocks and other debris, $^1/_4$-inch and larger, and anything that could lodge in the nozzles that direct the water stream onto the runner (the "wheel" in a turbine that is spun by the pressurized water). It also needs to keep out critters, like fish and other swimmers, and inhibit air bubbles from entering the pipe. For some turbine runners in high-head installations, it's also best to filter out the fines (very small particles). Included in this article are the most common intakes used for this class of hydro, with pros and cons for each. Costs will depend upon its size and the choice of materials.

## Simple Pipe with Screen

**Benefits:** Inexpensive
**Drawbacks:** Requires frequent cleaning
**Cost:** Low to moderate ($30 to $400)

The simplest microhydro diversions are variations of a screen-covered pipe stuck in a creek. However, they require frequent cleaning. During the first rains of the season in some locations, twice-daily cleanings may be necessary to remove leaves and debris from the screen.

If placed in the stream's direct flow, the intake should be situated at least 1 foot underwater for pipe diameters up to 4 inches. This can create cleaning issues, especially during high-water periods. Although most folks aren't interested in wading into icy waters to clean their intakes, on small creeks these diversions can be reasonably nuisance-free most of the year, and the needed materials are inexpensive. The simple screen can be used in many different situations.

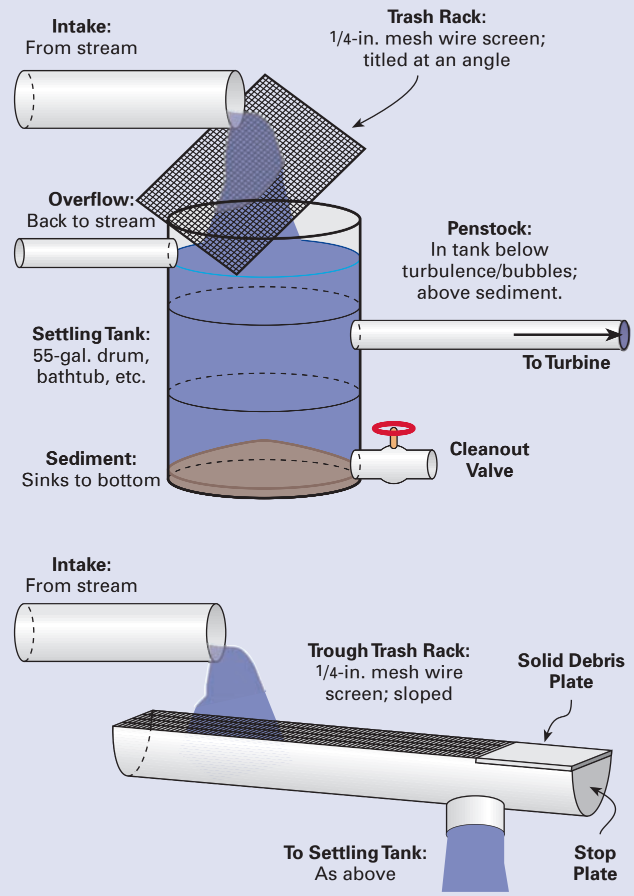



## Open-Ended Pipe or Flume, with Settling Container

**Benefits:** Easy to clean; can be set up to filter out fine particles if needed; low maintenance
**Drawbacks:** Splashing and turbulence can cause air bubbles to enter the penstock; maintenance can be high if there are a lot of leaves
**Cost:** Low to moderate ($30 to $400)

The next simplest diversion is an open pipe or flume that feeds a large vessel, such as a bathtub, 55-gallon drum, or cistern. This approach offers easier access for cleaning than the pipe-with-screen method above. A 1/4-inch wire-mesh screen is secured over the container to catch larger debris. If needed, a finer mesh can be used under the 1/4-inch screen to catch smaller particles. A cleanout can be placed at the bottom of the vessel to remove the fine sediment that makes its way through the screen.

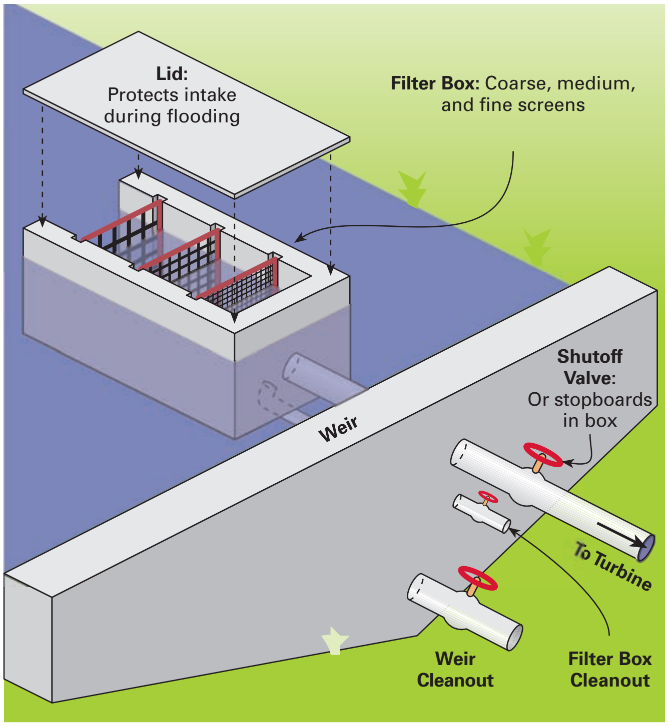
In my system, a bathtub is located under the spillway of a small dam. A disadvantage to this bathtub design is that above flows of 300 gpm, water coming over the spillway into the container tends to be turbulent and air bubbles can make their way into the penstock. This can result in lower turbine performance and also lead to early runner and bearing failure due to a water-hammer effect. Using a deeper container, like a 55-gallon drum, usually fixes this problem. Maintenance is still medium to high in the fall because of leaves but is less during the rest of the year. The bottom illustration shows a somewhat "self-cleaning" version.



## Screen Box

**Benefits:** Multiple screens catch debris of various sizes
**Drawbacks:** Moderately hard to clean because screens need to be removed from box
**Cost:** Moderate to high ($100+)

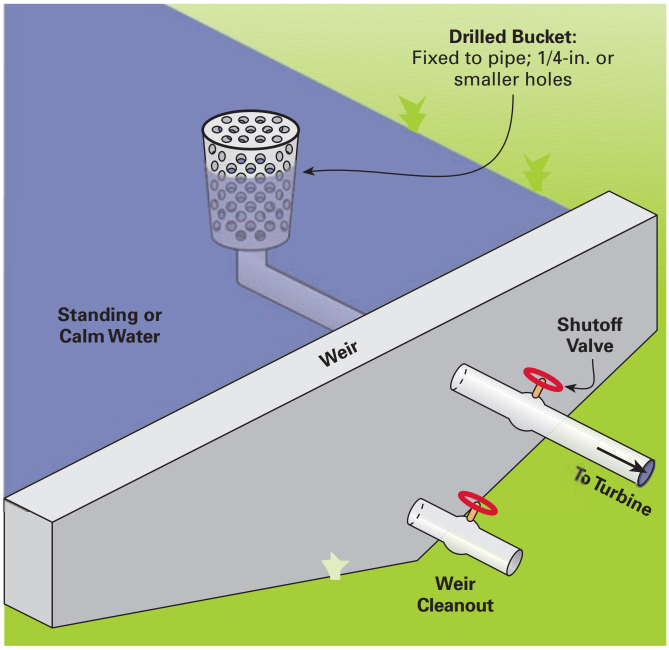
Screen boxes are the second-most common intake. They are generally constructed of concrete on-site, but can be fabricated of steel or plastic and brought in. Screen boxes are usually installed on the side of a small dam or slow-water area of a stream. They often have three screens, two valves, and a cleanout. These work about as well as the bathtub diversion, but appear less lowbrow. They are harder to clean, especially during high-water events when the water level may be above the top of the box. If constructed without an outlet shutoff, debris can enter the pipe when the screens are removed for cleaning, which defeats using the screen box in the first place.




## Pond Bucket

**Benefits:** Simple to build
**Drawbacks:** Requires slow water with a stable level, plus access by boat or walkway; doesn't screen floating debris well
**Cost:** Low ($30 to $50)

Another common method—the pond bucket—can be used close to the bank of a pond or slow-moving stream that has a fairly stable water level. With this approach, a pipe is run underground or through the dam to a screen. In a pond, the screen is often a 5-gallon bucket with many holes drilled in the sides and top. Although this intake generally does its job in slow-moving and relatively clean water, large floating debris can strike the screen or bucket, dislodging it. And access to the intake for cleanout isn't very convenient: You'll either need a plank walkway or a boat—or be prepared to swim. This diversion strategy is popular in areas with a lot of beaver activity because their dams won't impact the diversion. Pond bucket intakes can tolerate some heavy flows in the source, since pond levels can be controlled to some extent most of the time.



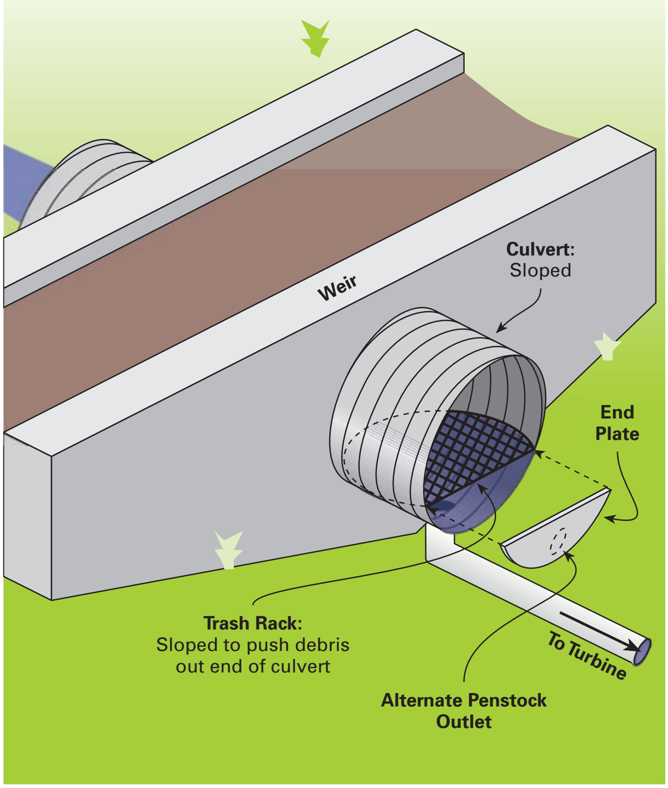

**A diversion can be simple or elaborate, inexpensive or costly—but it needs to suit your application in a mechanical sense and also in an ecological one.**

## Culvert Tap

**Benefits:** Uses an existing culvert as a diversion
**Drawbacks:** Decreases capacity of culvert; can't accommodate higher flows easily; requires fabrication skills
**Cost:** Low to moderate ($30 to $400)

This strategy taps into the bottom of a sloping culvert pipe near its lower end with a pipe adaptor to the penstock. A screen, angled low in the culvert at its upstream edge, increases in height relative to the bottom of the culvert at about 3 inches per foot. Because the slope of the culvert is still steeper than the slope of the screen within it, water can wash debris over the screen, making it somewhat self-cleaning. A wedge-shaped block at the end of the culvert and screen maintains the water level above the penstock adaptor.

Although this is a simple solution, be careful cutting or welding galvanized pipe—the fumes are toxic. Also be mindful of the maximum volume of water the pipe needs to carry during flood season. If a road washes out, you will be responsible for the damage.

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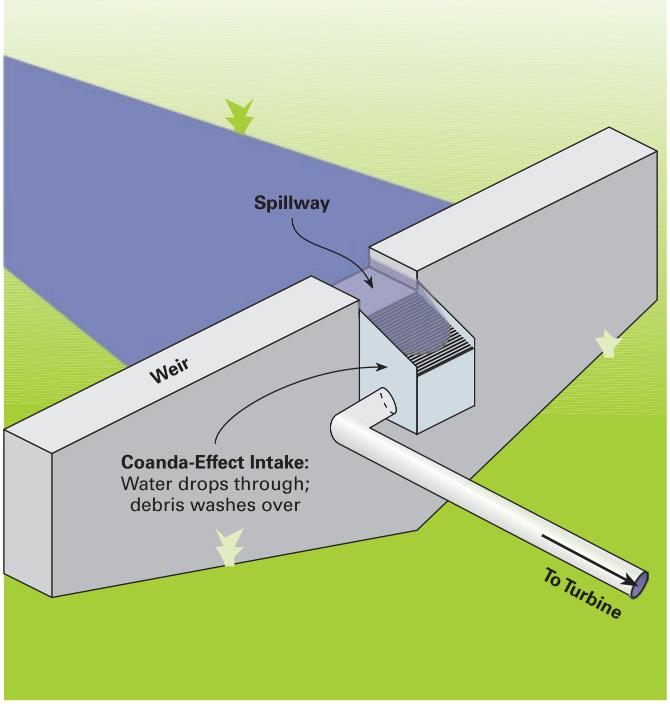
## Spillway with Coanda-Effect Screen

**Benefits:** Self-cleaning; easy to install; minimal ecological impact
**Drawbacks:** Expensive hardware; requires spillway
**Cost:** Moderate to high ($900+)

If you can construct a spillway, a Coanda-effect shear screen, which uses the surface tension of water and triangular-shaped slots to suck water through without the debris (see *HP71*), can be an effective, nearly maintenance-free solution. In warm-water areas where algae tends to grow, it will be necessary to occasionally wipe off the screen.

Although a Coanda-effect screen is pricey, its stainless steel construction helps ensure its longevity—it should last forever, barring damage from trees or boulders. Many state agencies now require this type of screen for microhydro applications because of its minimal ecological impact—almost nothing makes it past the screen, including fish.

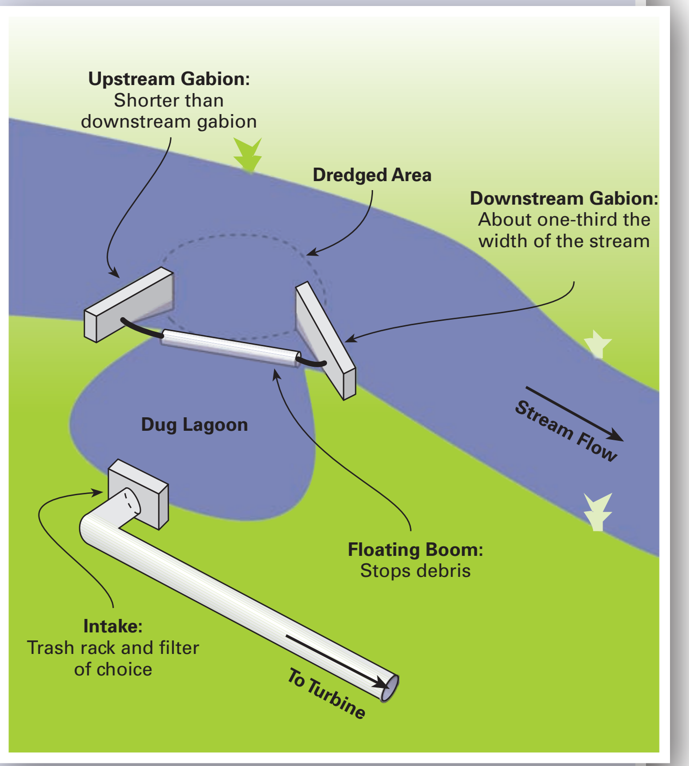


## Slow-Water Zone Diversions

**Benefits:** Good for larger streams
**Drawbacks:** Complicated and time-consuming to build; potential for stream blowouts
**Cost:** High ($1,500+)

These diversions are normally used on larger streams or rivers because of their expense, but can be used on smaller ones as well. I have built diversions in dry areas next to the stream and slightly below the existing water level, usually using concrete lagoons. When completed, simply breach the side of the creek to fill the new mini-pond. The important thing is not to redirect the stream flow out of its banks but just to pull water from it. I know of one case where the installer breached the side of the creek and accidentally redirected the creek through a neighbor's house!

Gabion (a wire-mesh cage filled with rocks) weirs can be extended from the bank to deflect the main stream flow enough to create a slow-moving (0.5 foot per second) water area to help settle debris. The deflector can also be made with rock and mortar. Gabion cages can be purchased flat from most irrigation supply stores, then assembled and filled on-site.

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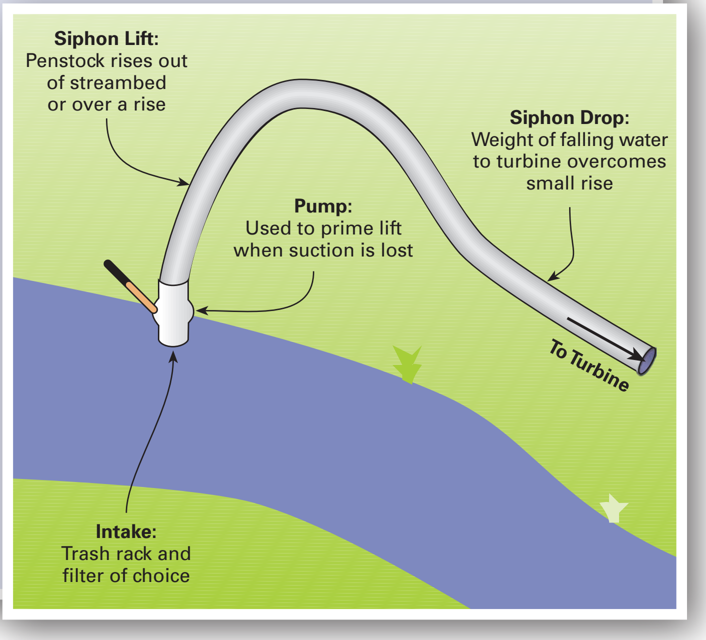
## Siphon Intake

**Benefits:** Simple to install
**Drawbacks:** Loses prime, so restarting is often needed; still needs screening
**Cost:** Low ($30 to $50)

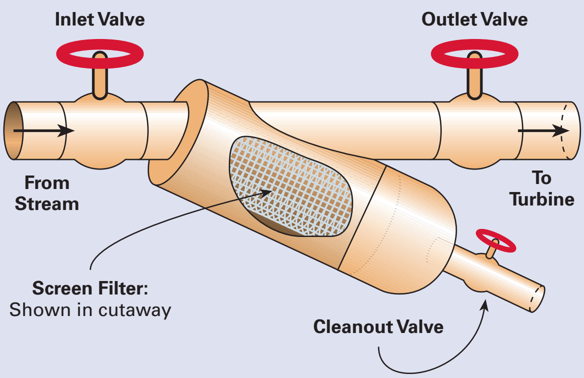
A siphon intake over a diversion works by pulling water up a short rise, using suction from the downhill-flowing pipe below it. This kind of setup can work fine for pumping water, but tends to lose the prime in a hydro application. Because of this tendency, these intakes require a foot valve and a priming process (usually a hand-operated pump) to replace the trapped air with water when suction is lost. They are used with a simple screen-type filter as part of the foot valve. Use this method if you must, but it is not advised—significant attention will be required, and you will eventually hate your microhydro system.



## In-Line Canister Filter

**Benefits:** Ready-made to bolt in-line with the penstock; easy to clean
**Drawbacks:** May require prescreening of fish and other objects; expensive hardware
**Cost:** High ($1,500+)

In-line canister-type screens can work very well but still require prescreening to keep fish and larger objects out of the pipe. They usually have a cleanout port and bolt-up flanges for connection. I have used canisters made by Amiad Filtration Systems, but you should see what is available in your area in case you ever need parts. Water filters intended for households or drinking water will *not* work because they plug up too fast.




### The Choice Is Yours

If you're lucky enough to have a creek that drops in elevation across your property, tapping into hydro-electricity is a great way to generate your own renewable energy. Properly installed systems will have minimal impact on the water source's ecosystem and its inhabitants. The range of intake and diversion types is as wide as a river. By reviewing the possibilities, you will find the right intake to fit your budget, the water source, and your personal availability for cleaning and maintaining the system.

### Access

**Jerry Ostermeier** (altpower@grantspass.com) owns Alternative Power & Machine in Grants Pass, Oregon (541-476-8916; www.apmhydro.com). He has been designing and installing microhydro and off-grid power systems since 1979. He also manufactures a user-friendly, residential-scale microhydro turbine.

Intake Equipment Manufacturers:

Amiad Filtration Systems • www.amiadusa.com • In-line screens

Hydroscreen Co. LLC • www.hydroscreen.com • Coanda-effect screens