

# Building a Homemade Ram Pump

Scott Lee

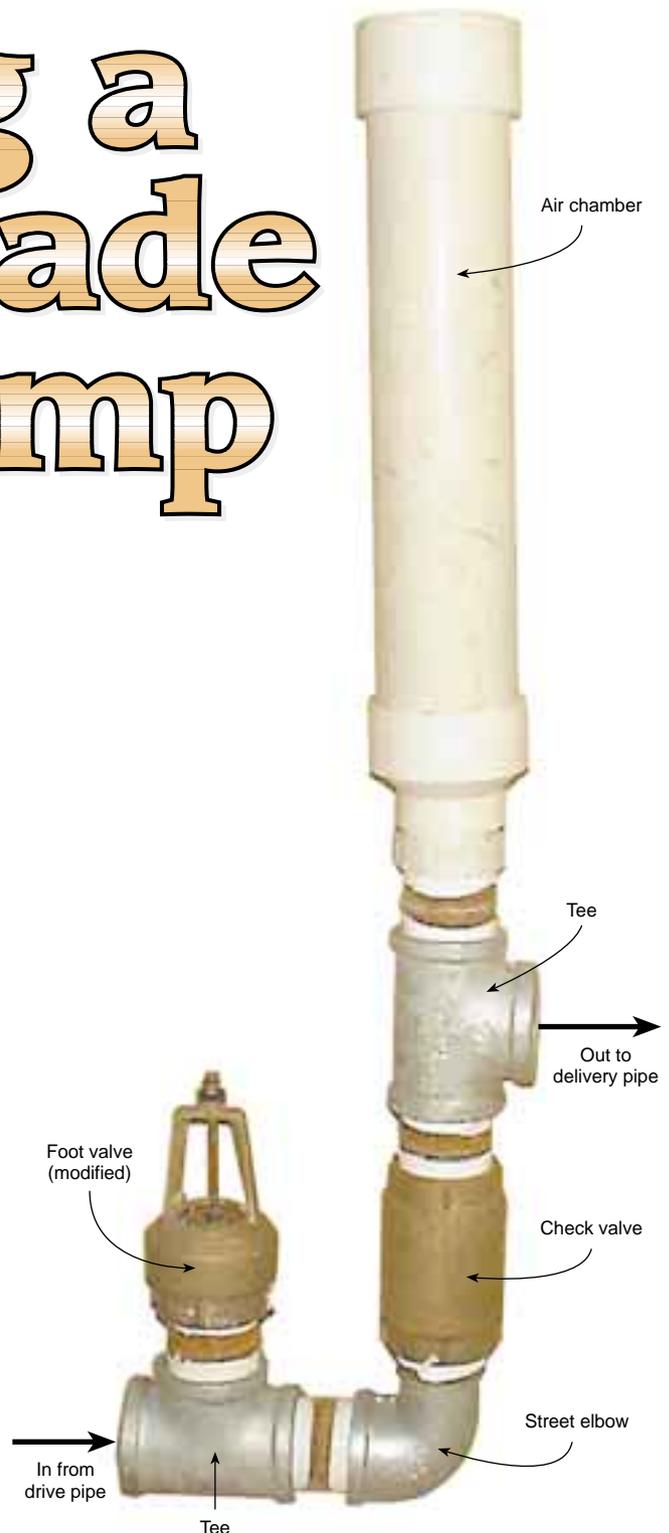
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**D**uring the mid 1970s, I first encountered the hydraulic ram water pump. A friend of mine was interested in a water pump for irrigating a garden. I had also purchased some land with a stream and a nice garden spot, but no electrical service. The combination of a stream below my garden spot and no electrical power seemed to be a perfect situation for a hydraulic ram.

## Three Tries

The manufactured rams back in the '70s were fairly expensive—US\$250 and up. Some publications had home-built designs. One in particular was by an organization called VITA (Volunteers in Technical Assistance). Based on the cost of the manufactured rams, I set out to construct a home-built ram pump. The first two versions of my ram were based loosely on VITA's descriptions and plans. They weren't followed

Scott Lee's ram pump in operation.



exactly, due to the difficulty in obtaining some of the parts that were mentioned.

I recently went to the local hardware store to check out the cost of these parts. The 2 inch version of my homebrew ram will cost about US\$130 (see parts list). A 1 inch ram will be cheaper, and might cost a little more than half that amount. The cost of the pipes needed to hook up the ram may exceed the cost of the ram itself.

## Ram Pump Parts List

Qty	Item
1	2 inch foot valve (brass)
1	2 inch check valve (brass)
2	2 inch tees (galvanized)
6	2 inch close nipples (galvanized)
1	2 inch street elbow (galvanized)
1	2 by 1 inch bushing (galvanized)
1	1 inch close nipple (galvanized)
1	3 inch pipe cap (PVC)
1	3 inch pipe, 18 inches long (PVC)
1	3 by 2 inch reducer (PVC)
1	2 inch PVC to IPT adapter (PVC)
1	1/4 inch threaded rod (stainless)
6	1/4 inch nuts (stainless)
2	1/4 inch washers (stainless)
1	Faucet washer
1	14 gauge copper wire, 2 inches

The first version of my ram was built entirely out of galvanized steel pipe and fittings. The waste (or impetus) valve proved to be the hardest to construct. The first version's valve was constructed from a 1 1/2 by 1 inch bushing. While this valve worked after a fashion, it was very leaky. I figured that the ram would perform better if this valve would seal tightly. My second version had a valve that was constructed from a 1 1/2 inch pipe plug. The plug was bored with a 1 inch hole, and had the inside surface of the plug machined smooth. This resulted in better ram performance.

I never used the first two versions in working applications, though I did test them. Shortly after the second one was operational, an article appeared in *The Mother Earth News* (May/June 1979, #57, page 120) with instructions on how to build a ram mainly out of PVC pipe fittings. Using this design as a guide, I developed a third version. This version was also built from galvanized steel pipe fittings, with the exception of the air chamber, which was constructed from PVC pipe

and fittings. This version still required machining of a sort—cutting threads on the outside of a 1 1/2 inch hose barb, so that it would thread into a 2 by 1 inch bushing.

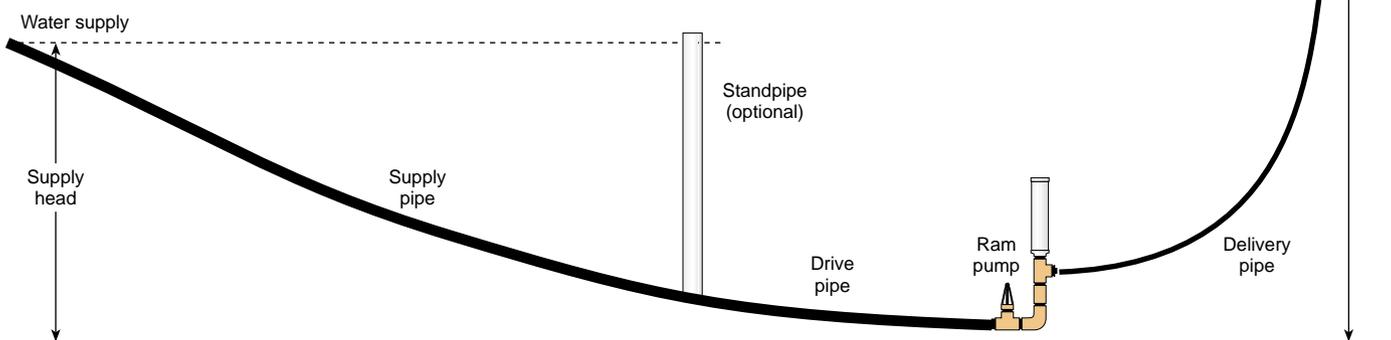
Although this was a workable system for constructing the waste valve, it still was not as simple as I wanted. For a time, this ram was used to pump water to my garden. The water was also used to provide showers, with the use of 200 feet (60 m) of 3/4 inch black poly pipe for a solar water heater. This pump was installed with a 4 foot (1.2 m) fall (head) to the ram, developed over the distance of 100 feet (30 m). It had a delivery lift of 30 feet (9 m) to a 3 by 12 foot (0.9 x 3.7 m) pool used as a storage tank. The point of use was 15 feet (4.5 m) lower than this storage pool.

## Standpipe

When the ram was first put into service, it operated very slowly—about 15 to 20 cycles per minute. Everything that I'd read stated that rams of this size should operate at about 45 to 60 cycles per minute. I fabricated a standpipe and inserted it in the drive line about 30 feet (9 m) from the ram. This is within the recommended 5–10 times ratio of head to drive pipe length. This allowed the ram to operate in the 45 to 60 cycles per minute range. The flow of water delivered to the tank increased from 0.25 to 0.75 gallons (0.9 to 2.8 l) per minute.

Ideally, the length of the drive pipe should be in the range of 5 to 10 times the head. So for a head of 3 feet (0.9 m), the length of the drive pipe should be in the range of 15 to 30 feet (4.5–9 m).

If the drive pipe is too long, the cycle frequency that the ram can operate at will be limited to some low value. The standpipe provides a closer location for the ram pump's supply. This means that there is less resistance in the drive pipe, and the flow can reach full velocity more



## How a Ram Pump Works

The energy required to make a ram lift water to a higher elevation comes from water falling downhill due to gravity, as in all other water-powered devices. But unlike a water wheel or turbine, the ram uses the inertia of moving water rather than water pressure, and operates in a cycle.

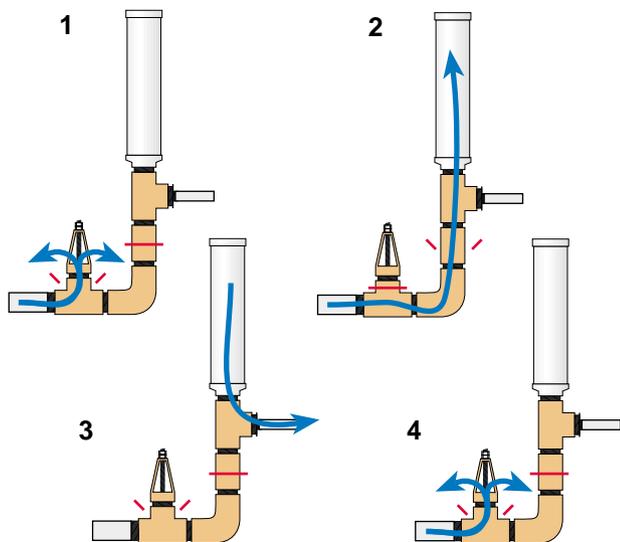
1. When the waste valve is opened, water flows from the source, through the water inlet (drive) pipe, and out the waste valve.
2. After a short time, the velocity of the flow is high enough to force the waste valve closed. The water, due to its inertia, wants to continue moving past the valve. The pressure inside the ram will rapidly increase enough to force the check valve open. This forces some water into the air chamber, compressing the chamber's air bubble. The pressurized bubble forces that water through the delivery pipe to the point of use.

For a ram pumping one gallon (3.8 l) per minute, and cycling 60 times per minute, each cycle pumps one-sixtieth of a gallon—about two ounces (60 ml). The compressed air in the air chamber helps smooth out the flow on the delivery side of the ram, so the flow tends to be more continuous, rather than a small spurt during each cycle of the ram.

3. Soon after the check valve has opened, the pressure surge (generated by the waste valve closing) is spent. Flow will try to start backwards, but the check valve will close, preventing this from happening.

4. At about this time, the pressure in the drive pipe will be low enough so that the waste valve can open, allowing water to start flowing from the source to the ram, beginning a new cycle.

The cycle that the ram goes through can occur 30 to 120 times per minute, depending upon conditions such as head, flow, and the size of the ram.



quickly than without the standpipe. Basically, a standpipe allows the ram to operate as if it had a shorter drive pipe.

The diagram on page 43 shows a standpipe inserted between the supply pipe and the drive pipe. The critical distance is now only the distance between the standpipe and the ram, not the total distance to the source of supply.

A standpipe can easily be constructed out of PVC pipe and fittings. The pipe needs to be long enough so that it is a few inches higher, in its installed location, than the elevation of the water source. Consider screening the top of the standpipe to keep out birds, insects, and detritus if you are pumping potable water.

The standpipe is usually inserted at a distance from the ram that is 5 to 10 times the supply head. This will vary from installation to installation. Since my installation had 3 feet (0.9 m) of supply head, I inserted the standpipe 30 feet (9 m) from the ram. This allows the ram to cycle properly, which results in more water pumped.

It's also important to consider the diameter of pipe on long drive runs, to minimize flow loss due to pipe friction. When in doubt, go up in size. It's recommended that the standpipe be at least two full pipe sizes larger than the drive pipe. I've used 4 inch standpipes with 2 inch rams, and 2 inch standpipes with 1 inch rams. It's also recommended that the pipe from the supply to the standpipe be one full pipe size larger than the drive pipe. This will insure that the flow to the standpipe will be able to keep up with the ram pump's usage.

### Drive Pipe

This configuration operated for about six months, after which it was dismantled for the winter. It was later installed at a new location with 3 feet (0.9 m) of head and 12 feet (3.7 m) of lift. Most of the time it supplied garden soaker hoses, with an old 52 gallon (200 l) hot water tank being used for a small storage volume, operated as a pressure tank.

One day, we were operating the ram with the discharge valve shut, and we noticed that the 2 inch black poly drive pipe was actually expanding visibly with each closing of the waste valve. We concluded that a portion of the energy was being wasted expanding the drive pipe, rather than pumping water. We also noticed that the max discharge pressure was 21 psi.

So I replaced the 30 feet (9 m) of black poly pipe between the standpipe and the ram with schedule 40 PVC pipe. With this pipe in place, I noted that the maximum discharge pressure was now 57 psi. This meant an almost threefold increase in the amount of water delivered. With a 12 foot (3.7 m) lift, we

measured the flow at 2 gpm after the installation of the PVC drive pipe.

Based on these observations, I suggest that you don't use black poly pipe or other flexible pipe for the drive pipe. If you are using a standpipe, the pipe from the standpipe to the ram is the only section that needs to be rigid. The supply pipe from the source to the standpipe can be flexible. If your drive head is higher than a few feet, steel drive pipe is recommended, since high pressures can blow out plastic pipe joints.

#### Versions Four & Five

Although this ram was successful, it still was not completely satisfactory. The waste valve needed a lot of maintenance, and also required a pipe threading machine to make it.

In light of these shortcomings, a fourth version was built using a standard plumbing check valve for the basis of the waste valve. This worked well, but required a lot of work to cut discharge ports into the check valve.

In a matter of days after version four was put in operation, it was discovered that a foot valve would serve the purpose as well as a check valve, with very little work required to convert. This valve was built and put into operation successfully and performed well. The fifth version is still in use. I think that it was first used in 1980 or '81. This ram continues to provide irrigation for a garden, and water for keeping a compost pile moist enough for proper decomposition.

It should be noted that this is not a year-round installation. Before winter weather starts, the ram and standpipe are removed from the stream to prevent freezing. They are reinstalled the following spring. This has worked well, since there is no demand for the water during the winter.

I built and installed another ram of this size for a neighbor, to supply water from a spring to two houses. This ram was a slightly improved version. The main differences were that I used a larger check valve and foot valve, which improved the performance slightly. This ram was supplied by 4 feet (1.2 m) of head and lifted the water 30 feet (9 m) to a 1,500 gallon (5,700 l) storage tank about 1,400 feet (425 m) away.

At the storage tank, separate centrifugal pumps and pressure tanks were used to supply water to both



The foot valve on its way to becoming the waste valve—the stem is cut off the valve disc and the lower crosspiece has been cut away from the casting.

houses. The ram delivers almost 1 gpm to the storage tank, which has proved to be plenty of water for all normal household uses. This ram installation is freeze-proof, with the delivery line buried and the ram in an enclosure. The ram has proved to be superior to trekking to the spring and running a gasoline engine-driven pump every two to three days to fill the storage tank.

#### How to Build The Ram

All of the parts for the ram were obtained from a local hardware store's plumbing section. The foot and check valves were Simmons brand, but any other good quality valves should work as long as they are of the same general configuration.

Begin the fabrication of the waste valve by removing the screen that is supplied as part of the foot valve. Then use wrenches to remove the valve disc from the foot valve, and cut off the supplied stem from the valve.

Now take the disc and drill a 1/4 inch (6 mm) hole in the center of it.

Use extreme care in drilling this hole to make sure that it is straight and centered. Use a drill press if you can. It is possible to get this right by hand if you are careful.

Now cut a 6 inch (15 cm) piece of 1/4 inch (6 mm) threaded stainless steel rod for the new valve stem. Thread on one of the 1/4 inch nuts, far enough to allow the valve disc to be placed on the threaded rod with room for another 1/4 inch nut. Lock the disc to the threaded rod by tightening both nuts against the disc.



The valve disc is reassembled with a 6 inch long piece of 0.25 inch stainless steel threaded rod, and locked in place with nuts top and bottom.

Now take the valve body and enlarge the threaded hole in the top crosspiece to 1/4 inch with a drill. Again, use care to get this hole straight. Using a hacksaw, remove the lower crosspiece.

After these modifications have been made, take the modified valve disc and insert it up through the valve body. After you have inserted it, put on a 1/4 inch washer, a faucet washer with its hole enlarged to 1/4 inch, and another 1/4 inch washer. The faucet washer provides some cushion to help quiet the waste valve when it falls open. Then thread on two 1/4 inch nuts, adjusting them so that they allow about 1/2 inch (13 mm) of movement of the valve disc and stem within the body. This is a good starting point—further adjustments can be made later, after the ram is operating. Your assembled valve should look like the diagram at right.

### Air Sniffer

The next step is to modify the 2 inch check valve by adding an air sniffer hole. This hole will allow a little air to be taken in on each stroke of the ram, replacing air in the air chamber that has dissolved in the water and gone up the delivery pipe. Loss of all the air in the air chamber can result in something breaking. I once saw the bonnet of a 2 inch PVC valve blow off. This valve was used to isolate the ram from the drive pipe. If you choose not to use an air sniffer, you must shut down the

ram every few days and drain some water from the air chamber.

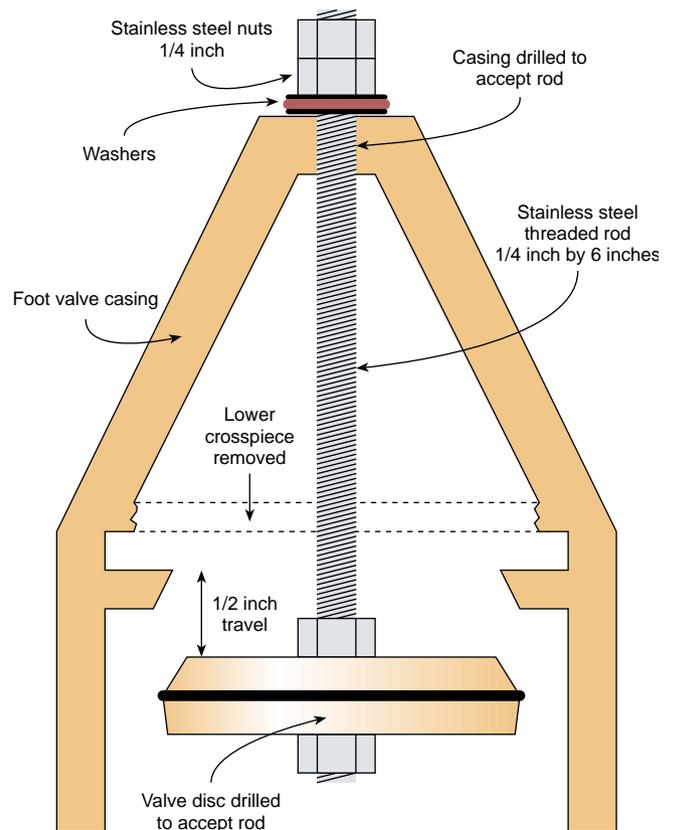
Begin the construction of the air sniffer by stripping the insulation from a piece of #14 (2 mm<sup>2</sup>) copper wire. Select a drill bit that is just slightly larger than this wire. Use this bit to drill a hole in the check valve as shown in the next sketch.

Make sure that you drill this hole on the correct side of the valve seat, as shown on page 47. After you have drilled this hole, twist a small loop in one end of the wire you have stripped. Insert the straight end of this wire into the hole, and twist another small loop in the wire on the inside of the check valve. If you are building the ram for a low-head installation, you may want to remove the spring from the check valve at this time. Otherwise it can be left in place.

### Air Chamber

The air chamber is the last piece you will need to assemble before the ram can be completely finished. A 4 inch diameter air chamber should be okay for up to 10 feet (3 m), while a 6 inch chamber should work for about 15 feet (4.5 m). When in doubt, it's probably better to err on the large side. The air chambers are usually about 18 inches (46 cm) plus the length of the fittings, but could be made longer if necessary.

### Assembled Waste Valve Detail





**The modified foot valve ready to assemble onto the ram.**

To assemble the air chamber, glue a cap to one end of the 3 inch PVC pipe. Then glue the 3 by 2 inch reducer to the other end of the pipe. After these are complete, glue in the PVC to IPT adapter. The air chamber should now be complete, and the final assembly of the ram can proceed.

#### **Assembly**

Screw a 2 inch close nipple into one of the end branches, and another into the side branch, of a 2 inch tee. Teflon tape should be used on all of the threaded connections. This will aid in any disassembly that may be required in the future. Screw your waste valve onto the nipple on the tee's side branch.

Screw the street bend onto the nipple on the end branch. Screw the check valve onto the end of the street bend. The flow directional arrow should point away from the street bend. Screw a 2 inch close nipple into the check valve. Screw an end branch of the other 2 inch tee onto the close nipple.

Screw another close nipple into the other end branch of the 2 inch tee. Screw your air chamber onto this nipple. Screw the 2 by 1 inch bushing into the side branch of

the tee. Screw the 1 inch close nipple into this bushing. Go back to the first 2 inch tee and screw in the last 2 inch close nipple.

Your completed ram should look approximately like the photo on page 42. The 3 inch air chamber size on this ram should be adequate for supply heads of up to 5 feet (1.5 m). If the head is greater than this, the air chamber should be larger.

#### **Installation**

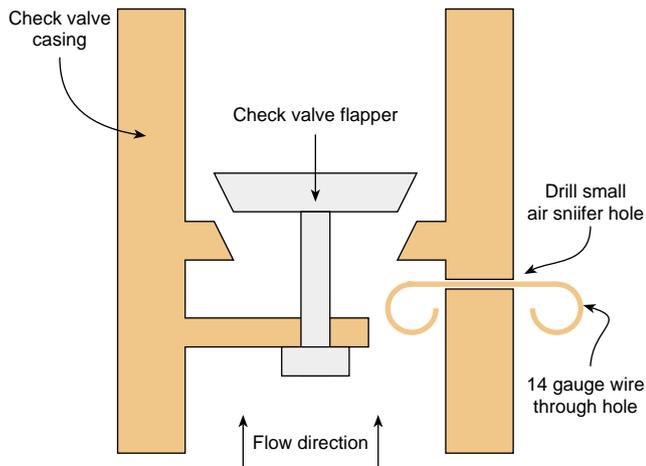
This completes the ram pump construction, but you may find that this is the easiest part of the job. As much or more depends on a good installation. I recommend that you use a union on either end of the ram. A gate valve on both the drive and discharge lines will also facilitate any maintenance that is required on the ram itself. The diagram on page 43 is a typical ram installation, showing head, lift, supply, delivery, and the length of the drive pipe.

To calculate how much a ram will deliver, divide the head by the lift, multiply by the flow, and finally multiply by 0.6. It takes at least 5 gpm to run this ram, with at least 2 feet (0.6 m) of head. In general it is easier to pump more water with more head, so run more drive pipe to get the head you need.

**The check valve with the wire poking out of the air sniffer hole.**



### Check Valve Cutaway



Using this equation, a site with 3 feet (0.9 m) of head, 20 feet (6 m) of lift, and a supply flow of 10 gpm would deliver 0.9 gpm. The same flow and lift, with 4 feet (1.2 m) of head, would result in 1.2 gpm delivered to the point of use. Or the same delivery could be accomplished with less supply flow. The delivered flow of 0.9 gpm could be achieved with 7.5 gpm of supply flow, using 4 feet (1.2 m) of head.

Maintenance on this ram is not very demanding. I've had to replace the faucet washer a couple of times per year. Otherwise the ram is noisy, and tends to wear the metal parts more. The O-rings on the valves will have to be replaced about every five years. The wire in the air sniffer will last two to four years.

### Consider a Ram

Hydraulic rams can be very useful in providing a supply of water from a lower to a higher elevation. They can pump in a remote location, with no other energy required besides the falling water. Don't be discouraged about the small flow of water delivered by a ram, since they can pump 24 hours a day. Remember that one gallon per minute times 1,440 minutes per day will be 1,440 gallons per day delivered to wherever it is needed. It can also be used year-round if the ram and piping are protected from freezing.

The most important step in deciding if a ram is for you is a site survey. This will ensure that you have the flow and head required to operate a ram. Once this has been determined, build a ram to supply the water. Rams are inexpensive, easy to construct, and dependable, so there's no reason not to use one, if you have a location that meets the requirements.

### Access

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Other *Home Power* articles on ram pumps:

*Hydraulic Ram Pump*, by Kurt Janke & Louise Finger, *HP41*, page 74.

*Things that Work!* on the Folk Ram Pump, by Michael Welch, *HP40*, page 44.

