STEP 5

YOUR PLUMBING FIXTURES AND WATER SYSTEMS

Water is both a necessity and a luxury. If necessary, you can survive in a healthy way with only minimal water for drinking, cooking, bathing, and sanitation. On the other hand, if you water your lawn extravagantly or if you like to take long showers or if you have a swimming pool, you will use a vastly greater amount of water.

No matter how you plan to use water, we will make your water system as efficient as possible. In the U.S., water heating accounts for 24% of the natural gas used in homes, and 11% of the electricity. This makes water heating the third largest user of energy in U.S. homes. In your super-efficient home, where heating and cooling costs have been cut drastically, water heating may be your largest or second largest energy cost.

In this Step, we will start by selecting plumbing fixtures that use as little cold and hot water as possible. Then, we will maximize the efficiency of your hot water heating system. We will install filtering and other treatment that may be needed to get pure water from a contaminated local water supply. We will lay out your water pipes to avoid annoying problems, and we will minimize the risk of flooding by a failure in your water system. Throughout, we will exploit opportunities to enhance convenience, comfort, safety, and elegance.

Most of the features in this Step apply equally to a new house or to an existing house. Most of the equipment and system improvements can be installed in an existing house fairly easily. Exploit every repair as an opportunity to upgrade your water system.

Efficient and Luxurious Plumbing Fixtures

Water systems involve two big costs, the cost of the water itself and cost of energy for heating it. In turn, the biggest factor in water heating cost is the amount of water that you use. (See the sidebar.) This makes it doubly important to design a water system that uses as little water as possible for whatever you want to do, whether it is filling a pot of water for cooking or taking a long, luxuriant shower.

Minimizing your water consumption is a matter of selecting the most efficient water using fixtures and appliances. So, we will begin by selecting your plumbing fixtures. (We will select your water using appliances in Step 7.)

U.S. Residential Water Consumption

The U.S. Geological Survey estimated the following average household water use per individual in the United States, in gallons per day (liters per day):

toilets:	**27**	**(100)**	**cold water only**
laundry:	**17**	**(60)**	**mixed hot & cold**
showers:	**14**	**(50)**	**mixed hot & cold**
baths:	**8**	**(30)**	**mixed hot & cold**
faucets:	**10**	**(38)**	**mixed hot & cold**
dishwashing:	**2**	**(8)**	**hot water only**

These quantities vary widely among individuals, depending on gender, age, employment, social factors, and geographic location.

Homes also use a lot of water outdoors, mostly for lawns, shrubbery, and gardens. Outdoor water usage is seasonal. Variation among households is even greater than for indoor usage. Drier regions use the most outdoor water. For example, outdoor use accounts for 44% of average household water use in California, but only 7% in Pennsylvania.

SHOWER FIXTURES

In Step 1, we designed the layout of your showers. Now, let's install the faucets and shower heads.

Shower Faucets: Simplest is Best

The most efficient faucets for showers are the ordinary kind, one for hot water, one for cold water, and a diverter valve in the middle to select whether to send the water to the shower head or to a spigot near the floor. Figure 5-1 is an example. Get the kind of faucets that screw clockwise to close, and use round knobs. They are the most obvious to use. They are reliable and easy to repair. And, they are inexpensive.

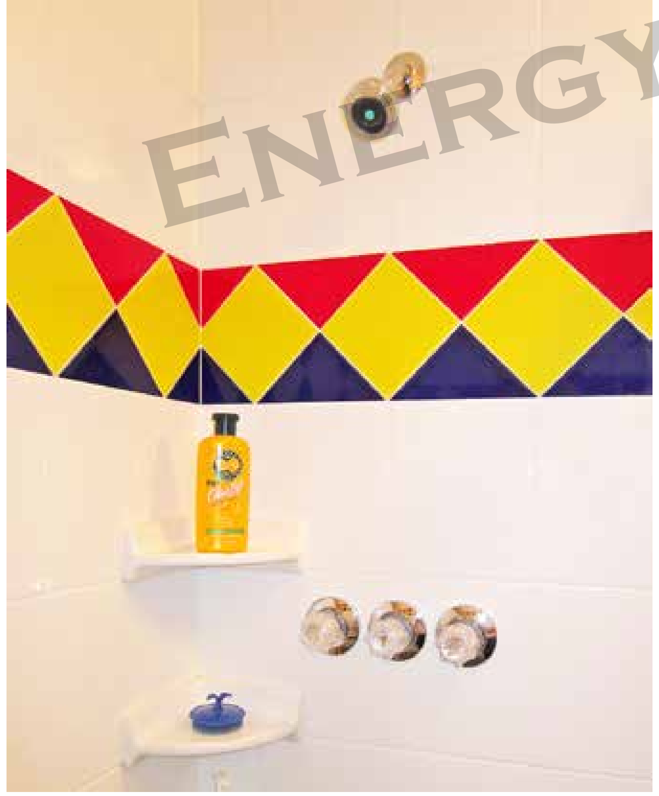

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Figure 5-1. This classic arrangement of shower faucets, hot and cold with the diverter valve between them, usually is best. However, there are benefits in not locating the faucets under the shower head.

Alternatively, install a single-lever faucet that controls both the temperature and water volume. Figure 5-2 is an example. The position of the lever provides a visual indication of the water temperature, but only after the hot water has flowed long enough to warm the pipes to the shower head. This kind of faucet is convenient, but it is more expensive to repair than individual faucets.

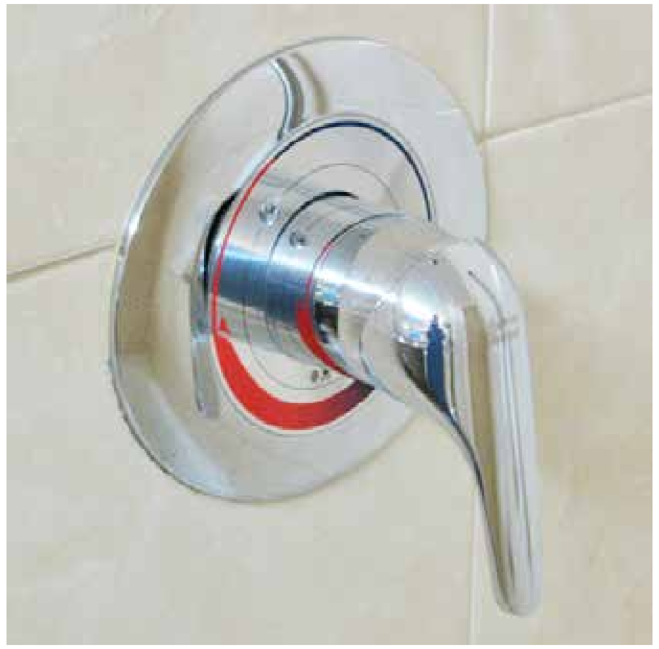

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Figure 5-2. If you want a single-lever shower faucet, this is the right kind. Turning it right or left adjusts the temperature. Pulling the lever in or out adjusts the flow rate. A lever gives you better control than pulling a round knob in or out. You need a separate diverter valve to send the water to a low spigot, if you have one.

More complex faucets provide no advantages, and most of them have serious disadvantages. All non-standard types of faucets force the bather to fiddle with the faucet to adjust the temperature or the flow rate. As the bather fiddles, water is being wasted. Also, odd faucets cause the bather to select a higher flow rate than he would use with a familiar faucet.

Avoid full-flow shower faucets, which must be the stupidest idea in the history of plumbing. They have a single knob that turns on the water to full flow before allowing the bather to select the water temperature. They waste an enormous amount of water. Even with a recirculating hot water system (explained later), this kind of faucet first dumps cold water on the bather, and then adds the risk of scalding while the bather struggles to set the temperature.

Don't use thermostatic shower faucets, no matter how appealing they may seem. The first slug of water coming from the hot water supply will be cold. If a thermostatic faucet is adjusted to a high temperature by a previous user, the cold water will be followed by scalding water. And, the thermostatic element will eventually fail, leaving you without a usable shower until it is repaired. Anyway, you don't need thermostatic control of your shower water because we will design your water pipes to avoid annoying fluctuations in temperature.

Shower Heads: a Compromise

Selecting your shower heads involves compromises between pleasure, convenience, water conservation, and health. Fortunately, shower heads are inexpensive and easy to replace. If you don't like one, unscrew it and try another. If you make the shower space large enough to install two shower heads, you can install two different kinds.

Expect to negotiate with your spouse about the esthetics of the water spray. Some people prefer a needle-like spray, while others want the sensation of standing under a waterfall. Unless water conservation is your overriding concern, get shower heads that allow the bather to select different spray patterns. Most adjustable shower heads adjust the spray pattern by changing the orifices or by varying the sizes of the orifices. Water consumption will vary with the setting. Figure 5-3 shows a typical adjustable unit.

Some shower heads include a pulsing spray as one of the settings. This is an esthetic feature that does not save water.

For those of European taste, shower heads are available in "telephone" style, which are installed on flexible hoses. Some people love them, others find them annoying. They are useful for parents bathing small children.

You will save water and energy if the shower head is easy to adjust. The easiest adjustment is a large butterfly knob on the side of the shower head. An adjustment ring around the perimeter of the head may be difficult to turn with wet hands. Avoid cheap units that have a knob in the center of the nozzle plate, forcing the user to reach through the spray to adjust it.

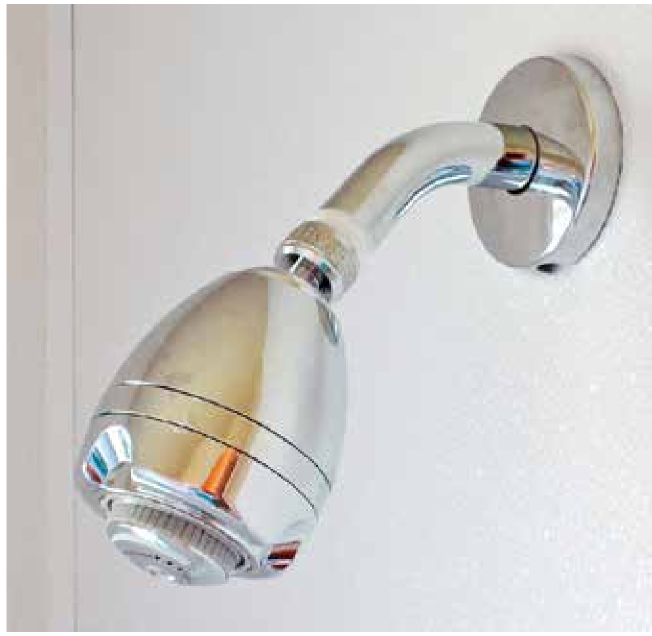

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Figure 5-3. An adjustable shower head that is advertised as "water saving." Many shower heads make this claim. Select a unit that makes it easy to adjust the spray pattern with wet fingers. Make sure that the connecting pipe, or "gooseneck," is long enough to keep the shower head from dripping on the faucets below.

THE BEST HOT WATER TEMPERATURE

Water heaters allow you to adjust the water temperature over a wide range. For most households, 120 °F (49 °C) is a good compromise. It is warm enough for dishwashing, clothes washing, and hot showers, and it is low enough to avoid the risk of scalding. Avoiding the risk of scalding is a dominant issue if children or elderly people live in the house. On the other hand, higher water temperature provides more effective clothes washing and dishwashing.

A lower temperature setting reduces heat loss from the tank. The effect of water temperature on efficiency is small if you select a water heater with a high "energy factor" rating. However, if you install a hot water recirculation system, keep the temperature as low as possible to minimize the continuous heat loss from the hot water pipes.

Lowering the water temperature reduces the effective storage capacity of your water heater. So, buy a water heater that is big enough for your needs at the lowest temperature setting that you expect to use.

Water temperature above approximately 140 °F (60 °C) suppresses the growth of dangerous microorganisms that occur in water systems, such as the bacteria that cause Legionnaires' Disease. Unfortunately, the hazard of scalding begins at a lower temperature, in the range of 120 to 140 °F (49 to 60 °C).

All water heaters accumulate debris at the bottom of the tank that enters with the water supply. Microorganisms can feed and proliferate in this debris. In conventional fuel-fired water heaters, the flame plays on the bottom of the tank, so the water in the debris layer may be hot enough to keep it sterilized even if the water temperature is set fairly low.

However, there has been concern that electric water heaters may act as a breeding site for dangerous organisms because the heating element is located above the bottom of the tank, and stratification keeps the water in the debris layer relatively cool. How serious is this risk? Perhaps nobody really knows.

If infection from an electric water heater is a concern, you can deal with it by filtering the hot water with a type of filter that is effective for hot water. Or, install "tankless" electric water heaters for applications, such as showers, where bacteria may be a health hazard.

When you vacate the house for a few days or longer, save energy by turning the water heater off. You should always do this when you turn off the main water valve, to avoid burning out a water heater that runs dry.

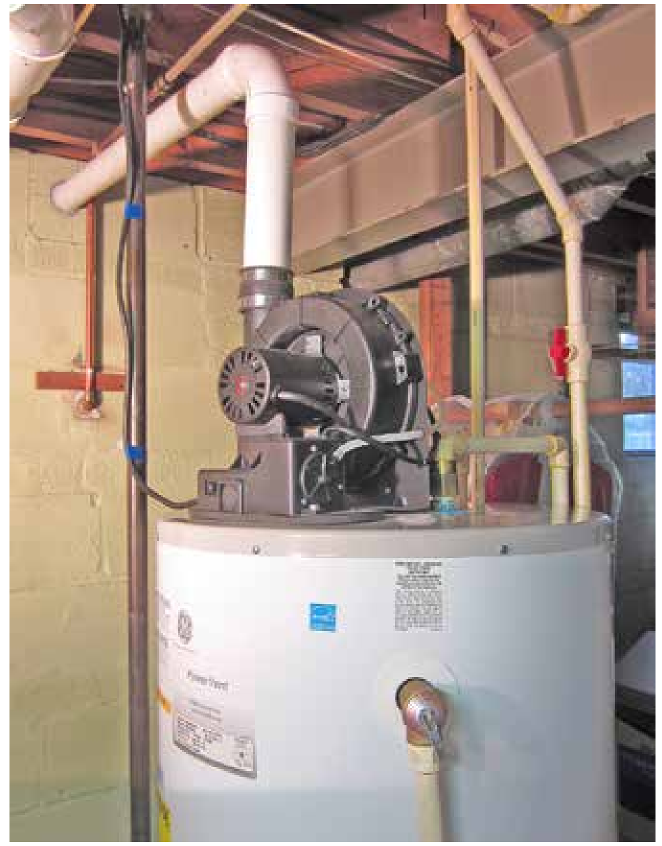

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Figure 5-16. A direct-vent water heater. The fan at the top of the heater draws the combustion gas through the heater and discharges it to the outside through a side wall. The exhaust gas is cool enough to be discharged through a plastic pipe.

To exploit this benefit, you need a "direct-vent" water heater. This kind of gas-fired water heater has a fan that draws the combustion gas through the heater and discharges it through an adjacent wall. Figure 5-16 shows a typical direct-venting water heater. Figure 4-26, in Step 4, shows the small outside exhaust fitting.

A direct-vent heater greatly reduces convection heat loss because it requires a fan to force the gas flow through the central heat exchanger. The fan turns off when the flame is not burning.

A direct-vent water heater cannot create a carbon monoxide hazard within the house. However, most models draw their combustion air from inside the house, in common with conventional gas-fired and oil-fired water heaters. The amount of combustion air is relatively small, but make provision for it. We covered this issue in Step 4, under the heading, *Eliminating the Danger of Carbon Monoxide*.

With present models of direct-vent water heaters, the fan makes a significant amount of noise, both inside the house and at the outside vent. The noise occurs only when the flame is burning. If the heater is located in an unoccupied space, the sound in the rest of the house is muted.

Turning the Water Heater On and Off

Turn off the water heater whenever you turn off the main water valve, which you should do whenever you vacate the house for an extended period. This is to protect the tank or the heater element from burning out if there is a leak in the house water system that empties the water heater. Also, a fire that starts in the water heater could burn down the house.

Turning off the water heater when the house is vacant also saves energy.

Most modern fuel-fired water heaters have an electric igniter that you can turn on and off with the flip of a switch. This is an important convenience.

A "pilot light" is an older kind of igniter for fuel-fired water heaters. It is a small, continuous flame that ignites the main flame. Restarting a pilot light after turning off the water heater is a tedious process that requires you to crouch down in front of the heater with a long match or a barbecue lighter. This can be almost impossible for a person who has limited mobility.

However, a water heater with a pilot light has one significant advantage: it requires no electricity. If your home loses electrical power for an extended period, a fuel-fired water heater with a pilot light will provide hot water as long as the fuel supply lasts.

Minimize Heat Loss from the Tank to the Pipes

During times when no hot water is being used, a water heater may waste energy if the hot water can escape from the tank by convection. This occurs if either the cold water supply pipe or the hot water discharge pipe is higher than the top of the water heater.

In the cold water supply pipe, the denser cold water falls into the tank, while the warmer water in the tank rises through the same pipe. This convection continues indefinitely as the escaping hot water cools in the inlet pipe. The same thing happens at the tank outlet when the water in the hot water pipes sits still and cools.

Simple pipe loops at the water heater inlet and outlet prevent heat loss from the water heater by convection.

A simple, reliable way to avoid this energy waste is to install short descending legs in the tank's inlet and outlet pipes. The lighter hot water at the top of the tank cannot drop into the denser cold water in the descending legs. As a result, the hot water cannot move by convection into the surrounding pipes.

Figure 5-17 shows how pipe loops are installed. The descending legs can be short because the lighter hot water remains at the top. A drop of about 6" (15 cm) is ample. Pigtail loops in the inlet and outlet pipes have been used for the same purpose, and they probably work as well.

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Figure 5-17. Installing descending loops at the tank inlet and outlet is a simple, foolproof method of preventing convection heat loss to the surrounding water pipes. Only the pipe near the top of the tank needs to be insulated, in most cases.

Many plumbers don't understand how these legs work, so make sure that they are installed properly. Unfortunately, the engineers who write some plumbing codes also don't understand them, so codes may require "check valves" in water heater installations. Tell your plumber to omit the check valves, and use descending pipe legs instead. See the sidebar on the next page.

HEAT PUMP WATER HEATERS (FOR WARMER CLIMATES)

A heat pump water heater is similar to a conventional storage water heater, except that it uses a heat pump as the heat source. The heat pump takes heat from the air in the surrounding space, and transfers that heat to the water in the tank. The heat pump usually is mounted on top of the tank, as in Figure 5-19.

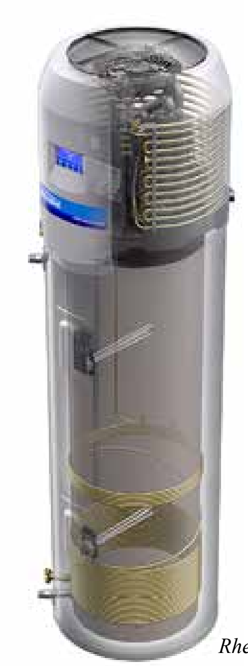

Figure 5-19. Heat pump water heater. The heat pump on top of the tank has coils that extract heat from the surrounding air. The heat is sent to coils in the bottom of the tank. This unit also has two electric resistance heating elements, which supplement the heat pump when the air temperature is too low.

Rheem Water Heating

Beware that filters coming from some countries make false claims of NSF certification and protection ability. Your best defense against false claims is to buy from well established manufacturers and vendors.

Sediment Filters

"Sediment" filters act as a simple sieve, rather than by molecular attraction or chemical action. They are available with pore sizes as small as 5 microns. They are desirable if your water supply contains a significant amount of miscellaneous dirt. They are cheaper for dirt removal than other kinds of filters.

Sediment filters are commonly used with private wells. They are also used as pre-filters for other types of water treatment that are easily clogged, such as reverse osmosis.

Inexpensive sediment filters are commonly made of tightly wound string. This material is vulnerable to channeling at high flow rates. A newer material that resists channeling is made of polypropylene fibers that are partially melted together.

There are two designs of sediment filters, "surface" filters and "depth" filters. Surface filters are simple filters that have a single pore size. Depth filters are made in layers having different pore sizes. The largest pore size is on the upstream size and deeper layers have progressively smaller pore sizes. Depth filters are intended to provide longer life when the debris in the water supply has a range of particle sizes.

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Figure 5-25. Water softener. In the metal cylinder on the right, common salt replaces hardness minerals with sodium compounds. The plastic bin on the left contains salt for replenishing the unit. The sodium that is added to the water may aggravate heart disease.

Water Softeners

A "water softener" is a chemical treatment process that is designed specifically to remove "hardness" minerals from your water supply. These minerals are calcium and magnesium compounds. If they are concentrated in your water, they deposit a hard, tenacious scale or scum on your water fixtures and in your water pipes. When hard water is heated for dishwashing and laundry, the minerals precipitate in quantities that make laundry grey and stiff, and they waste detergent. The minerals make bathing unpleasant, and they also give a bad taste to hot beverages.

Water softeners are larger, more complicated, and more expensive than water filters. The apparatus typically requires about as much space as a water heater. Figure 5-25 shows a typical unit.

Most home water softeners employ a principle called "ion exchange." This process replaces the calcium or magnesium with sodium. Usually, the "hard" water is circulated through a tank of ordinary salt (sodium chloride) to convert the calcium and magnesium compounds into sodium compounds, which are much more soluble. The salt must be replenished periodically.

This method of softening water is the most common because salt is cheap. However, it is believed that increasing the amount of sodium in the water supply increases the risk of heart disease. If you use this kind of water softener, it may be prudent to install a reverse osmosis filter to remove the sodium from your drinking water.

Another disadvantage of salt-based water softeners is that they may make the water somewhat corrosive. Correcting this, if necessary, requires additional chemical treatment.

"Precipitation" is a more expensive method of softening water that avoids the problem of using salt. A combination of chemical processes is used to convert the calcium and magnesium compounds into solids that can be filtered out. The most common of these methods is the "soda-lime" process.

If you soften water for laundry, you may not want to soften the water for showers, bathing, and hand washing unless the water is very hard. Oddly, water that has been "softened" imparts a soapy feel to your skin that persists until your skin is dry.

Hardness is a matter of degree. If the hardness of your water causes only minor trouble, there are less expensive methods of dealing with it. To improve your laundry, use a detergent that contains a water softening additive, such as "aluminosilicate." Or, add packaged water softeners (which may be called "water conditioners") at the beginning of the wash and rinse cycles.

To remove superficial mineral deposits on water fixtures, wipe them with vinegar (acetic acid), lemon juice (citric acid), or a commercial cleaner for hard water deposits. If the hardness in the water makes your hot beverages taste bad, you can use bottled water to make your hot beverages.

Reverse Osmosis

Reverse osmosis uses a membrane that has extremely small pores, the size of molecules. The membrane allows water molecules to pass through, but not certain atoms or molecules, or particles of much larger size. The pore size typically is smaller than 0.001 micron.

Some of the atoms removed by reverse osmosis include sodium, fluoride, arsenic, copper, mercury, and lead. However, reverse osmosis does not block chlorine or radon. Reverse osmosis removes some larger molecules, but not all. For example, some pesticides are not blocked.

The filtering of the reverse osmosis membrane is not absolute, because microscopic flaws in the membrane allow a fraction of contaminants to pass through. Therefore, the membrane itself does not provide reliable protection against viruses, bacteria, or protozoa.

A complete reverse osmosis system includes other types of filters, so it removes most hazards from the water supply. But, reverse osmosis also removes healthful minerals and fluoride. The minerals probably are available in the foods you usually consume. You may be able to replace the fluorine by using fluoridated toothpaste.

If the water supply contains a large concentration of "hardness" minerals, reverse osmosis will remove these minerals, but they will clog the membrane quickly. If you install a water softener to remove minerals from the house water supply, a reverse osmosis filter for your drinking and cooking water will remove the harmful sodium that is added by the water softener.

To keep the membrane from becoming clogged, the filter system flushes the upstream side of the membrane. This requires additional water, which is dumped to the sewer. Typically, the flushing action requires several units of water for each unit of water that is filtered.

Significant pressure is needed to force water through the reverse osmosis membrane. In residential systems, this pressure comes from the water supply system. Typically, this pressure is barely high enough to filter a useful amount of water. Under typical conditions, a residential system may produce 10 to 50 gallons (40 to 200 liters) per day. Therefore, reverse osmosis is limited primarily to providing water for drinking and cooking. The slow trickle from the reverse osmosis membrane is stored in a small tank, typically having a capacity of about 4 gallons (16 liters).

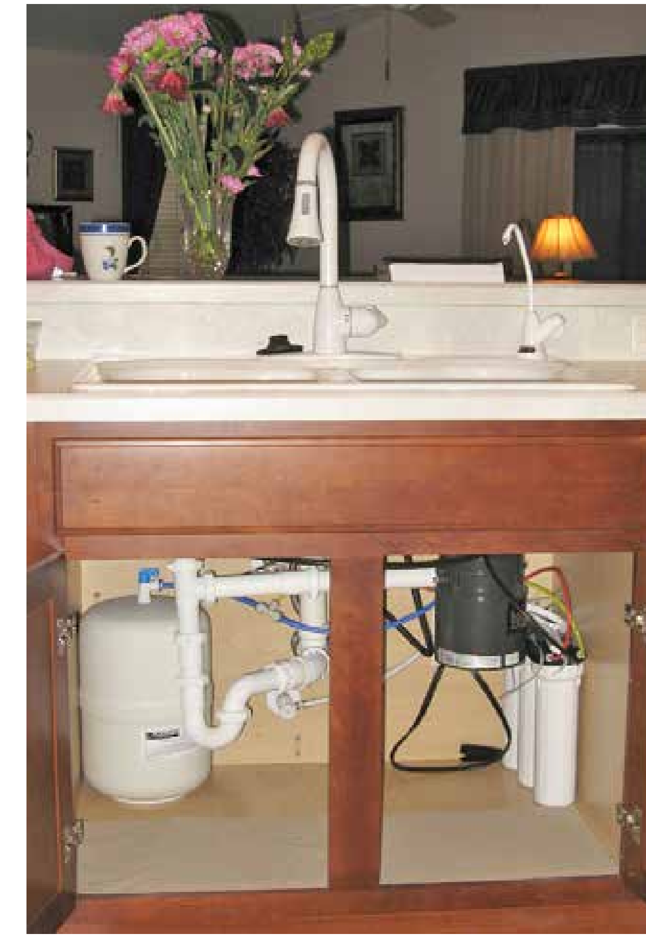

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Figure 5-26. Reverse osmosis water filter under a kitchen sink. The filter membrane and two auxiliary filters are on the right in the rear of the cabinet. The storage tank is on the left. The dark item in front of the filters is a garbage grinder. This common installation makes it awkward to replace the filters. It would be better to install the filters in a cabinet above the counter.

Reverse osmosis is combined with other filters. One or two pre-filters are installed ahead of the membrane to keep the small pores of the membrane from being clogged, and typically at least one carbon filter is installed downstream to trap chlorine and organic compounds that pass through the membrane.

The membrane of the reverse osmosis system typically lasts one or two years. The other filters in the system typically need replacement every six months. Replacing all these elements is an expensive maintenance burden.

The tank and the filters usually are installed under the kitchen sink, along with the sink drains and garbage disposer, as in Figure 5-26. This makes maintenance awkward, especially for older residents. For that reason, Step 1 recommends installing kitchen water treatment equipment in a separate accessible cabinet that is located at a convenient height.