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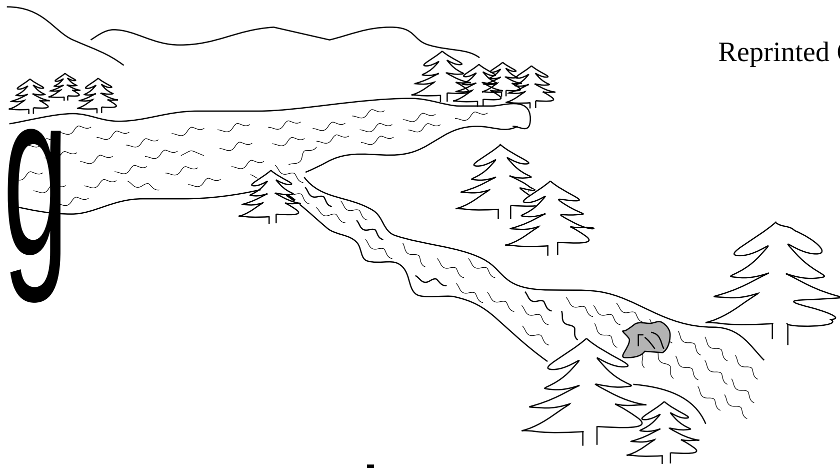

Treating Water for Sediment Removal

J.R. Miner

Lakes, ponds, and streams are important sources of water for many farms, rural camps, and households as well as for many municipalities in Oregon. Even under ideal conditions, these surface-water sources typically contain much more sediment than do groundwater sources. Under adverse conditions, such as during and after storms, surface water may contain so much sediment that it appears muddy or silt laden.

Sediment in water not only makes it unpleasant to drink or to use; sediment also harbors potentially dangerous microorganisms and protects them from the action of chlorine or other disinfectants that may be added to the water. Thus, water with more than a certain amount of sediment in it becomes unsafe for human consumption and unacceptable for use in operations such as cleaning equipment in, say, a dairy or commercial kitchen.

A filtering system is necessary to reduce sediment concentrations to desired levels. The filtered water then can be chemically treated to ensure its safety. Municipal water treatment plants typically have a system like that in Figure 1. Most of the system focuses on reducing the

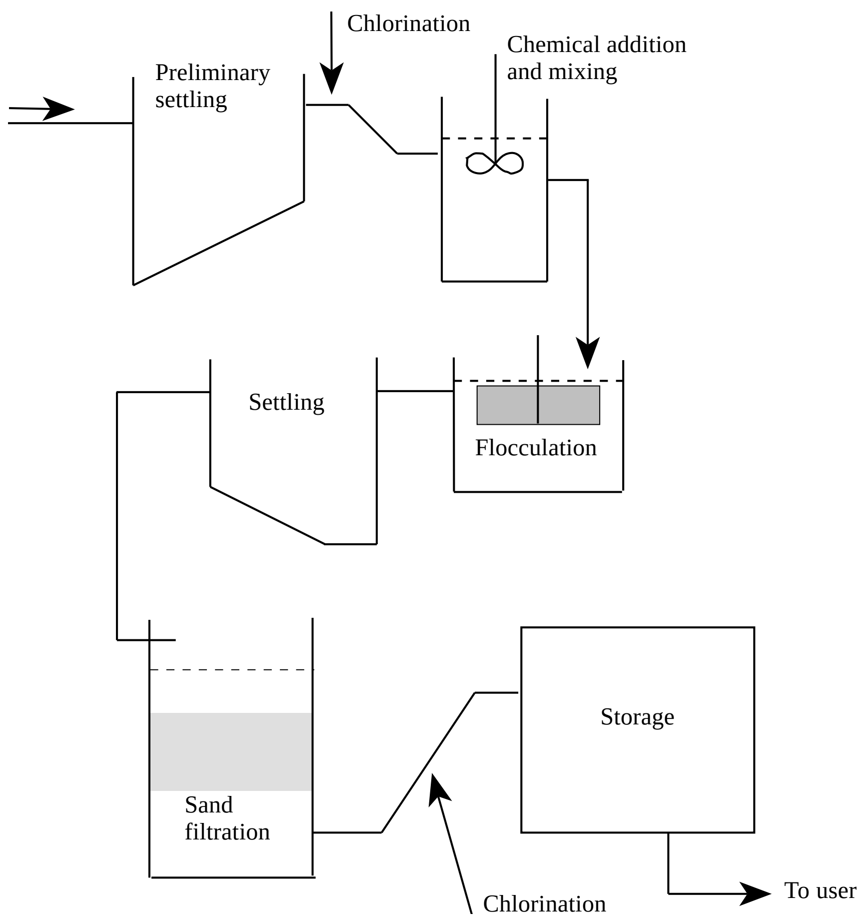

Figure 1.—Conventional municipal surface-water clarification process.

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amount of sediment in the water so that the chemical treatment phase can be more efficient, using the least amount possible of chlorine or other disinfectant.

Designing a Surface-water Filtration System

Two major factors in evaluating a lake, stream, or pond as a water source are the reliability of supply and the quality of water. Both may fluctuate over time, and water quality especially may vary greatly over a relatively short period as, for example, storms pass through. Local or other regulatory agencies may require that the water be chlorinated and filtered to remove particles larger than a certain size.

As you begin to plan a water treatment system, consider how much treated water you need both on a daily basis and at peak-use times. Generally, it is more efficient to build a smaller system and run it continuously than to build a big system just so you can meet peak needs. A smaller system still can meet peak needs if you include a storage tank to hold the appropriate amount of treated water.

With any system, you will save money and labor by running the cleanest water possible through it. The more sediment in the water at the beginning, the more it costs to remove. Reduce or eliminate the need to filter very cloudy water by building a storage tank at the front end of the system, before the filter. Ideally, the tank should hold a 2- to 3-day supply. When the surface-water quality is at its best, fill the tank. Then, when a storm roils your pond or stream, use the storage tank as your water source until the quality of the surface water improves and you can draw directly from it again.

Figure 2 shows a typical water-treatment system for a farm. Some components are optional depending on the quality of the incoming water and on any regulatory requirements for the quality of the treated water.

Filter Types

Most plumbing supply stores sell filters to remove particles of various diameters, from 5 to 50 microns. (A meter equals 1 million microns; an inch equals 25,400 microns. Table 1 gives the diameter, in microns, of several types of solids commonly found suspended in water.) Generally, a filter designed to pass larger particles will plug more slowly than a finer filter.

Table 1.—Diameter, in microns, of several types of particles commonly found in water.

Particle	Range	Average
Fine sand	20–200	50
Silt	2–20	5
Bacteria	0.3–3	1
Clay	0.2–2	1
Virus	0.01–0.1	0.05

Screening filters

In a screening filter, the filtering action takes place on a single surface of the filter, much as if you were using a screen to remove particles from a fluid.

Cartridge Filters. Cartridge filters are similar in concept and design to the oil filter on your car or tractor. Figure 3 shows a cross-section of a cartridge filter. These filters are simple to install, and the equipment required is relatively inexpensive and readily available from plumbing supply stores. The problem is that if

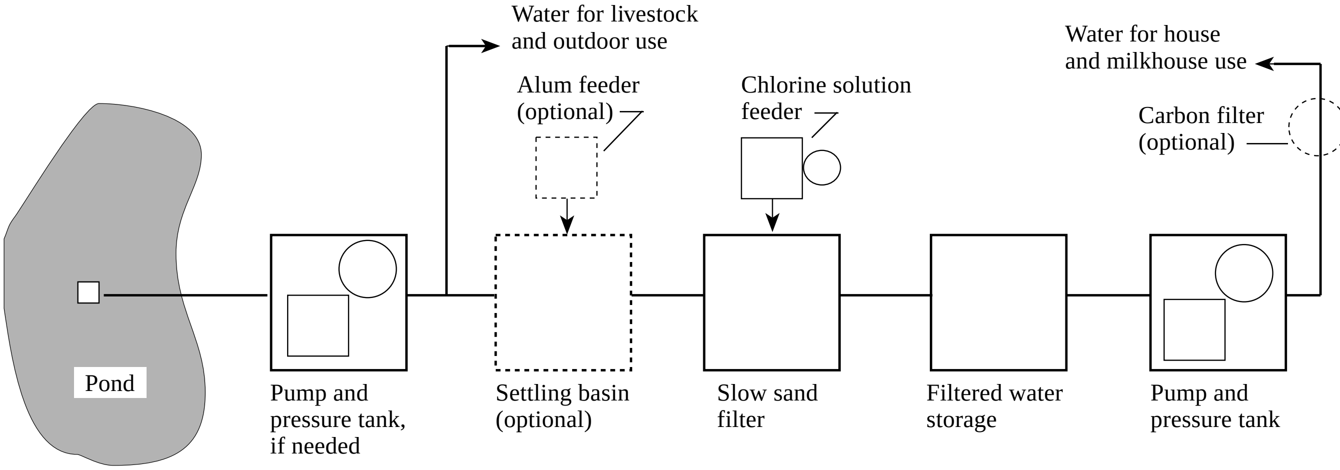

Figure 2.—A typical surface-water treatment system for a dairy farm. Note: If the water source is sufficiently clear, a commercially available filter may be used instead of a slow sand filter. Placement of the chlorination equipment and any required storage depend on local conditions and water needs.

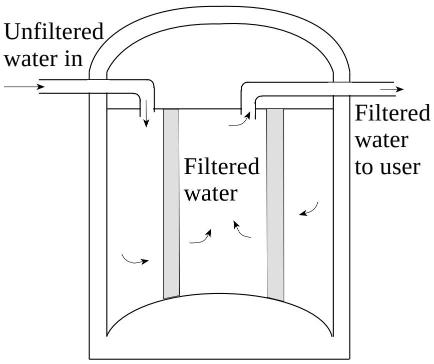

Figure 3.—Cross-section of a cartridge filter.

Table 2.—Comparison of sample cartridge filters.

Filter Unit	Unit A	Unit B	Unit C	Unit D
Overall height (in)	12	12	19.5	40
Diameter (in)	8.1	6	11	11
Construction material	Plastic	Stainless steel	Stainless steel	Stainless steel
Flow rate (clean gpm)	6–20	6	24	72
Pressure drop (psi)	3	3	3	3
Connection diameter (in)	1	0.75	1.5	2
Approximate cost ($)	100	250	1,300	1,600
Cartridge				
Number used in the unit	1	1	4	12
Height (in)	9.75	9.75	9.75	9.75
Outside diameter (in)	4.69	2.63	2.63	2.63
Approx. cost/cartridge ($)	25	9	9	9

the water supply contains quite a lot of sediment (more than 25 mg/l), the filters are likely to plug up readily. As solids accumulate on the filter's surface, the water pressure through the filter drops and so, therefore, does the flow rate. When water pressure at the faucet or other outlet drops to an unacceptable level, it's time to replace the filter cartridge.

Table 2 provides typical examples of cartridge filters available and their approximate costs.

Bag Filters. Bag filters are similar to cartridge filters except the flow is from the center of the unit toward the outside, similar to a tank-type vacuum cleaner. As water passes from the center of the bag to the outside, it leaves the captured sediment in the bag. The diameter of particles captured ranges from approximately 5 to 200 microns.

Bags can be made of natural or synthetic fiber. Polyester felt and polypropylene bags are most common.

Bag filters are generally regarded as less precise than cartridge filters, but the bags generally are less expensive than cartridges per unit of solids captured. Bags typically cost $10 to $15 each and the filter assembly with a stainless steel basket costs in the range of $1,000 to $1,500. Generally, bag filters are less readily available from local plumbing supply stores.

One option for a filter-system design is to use a bag filter as a roughing filter ahead of a more precise cartridge filter to meet the final specifications for water clarity.

Media filters

The alternative to a screening filter is a media filter, which uses the entire volume of the bed as the active filtering area (Figure 4). The filter may use either a single medium with more or less uniform density or several media of varying densities. Basically, a multilayer media filter has a layer of relatively large particles on top and layers of

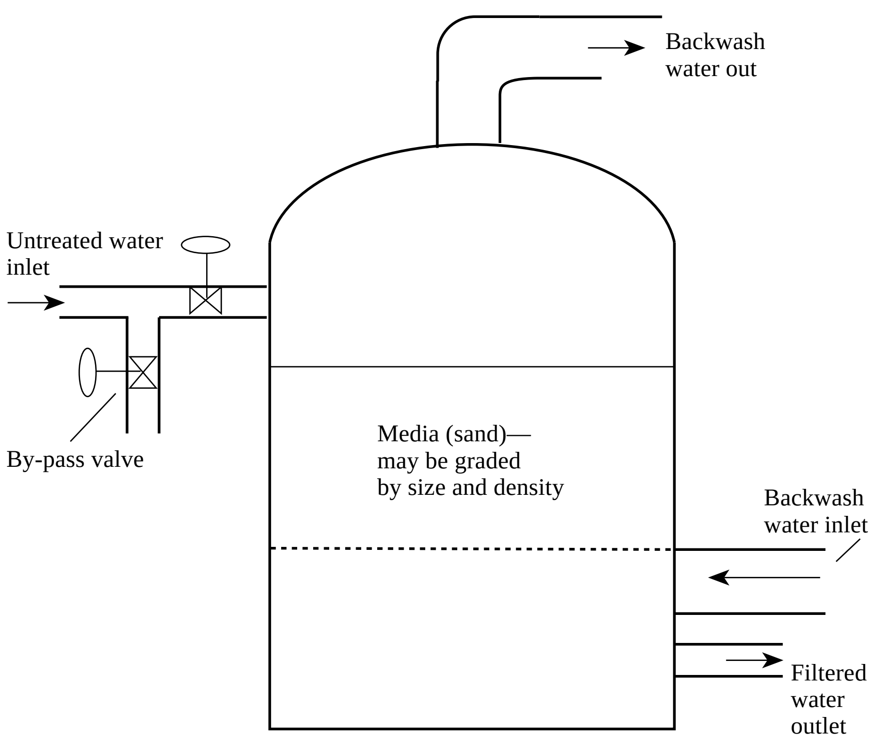

Figure 4.—Schematic view of a media filter.

successively smaller, more dense particles toward the bottom of the bed. Water containing particles moves down through the bed. When the space between the media particles becomes smaller than the sediment particle, the sediment is trapped at that point, and only the water and smaller particles will move further through the bed. Multilayer filters can remove particles down to approximately 10 microns.

Single-medium filters operate the same way as multi-density filters, except that they contain only a single medium. This type of filter typically can remove particles down to about 40 microns.

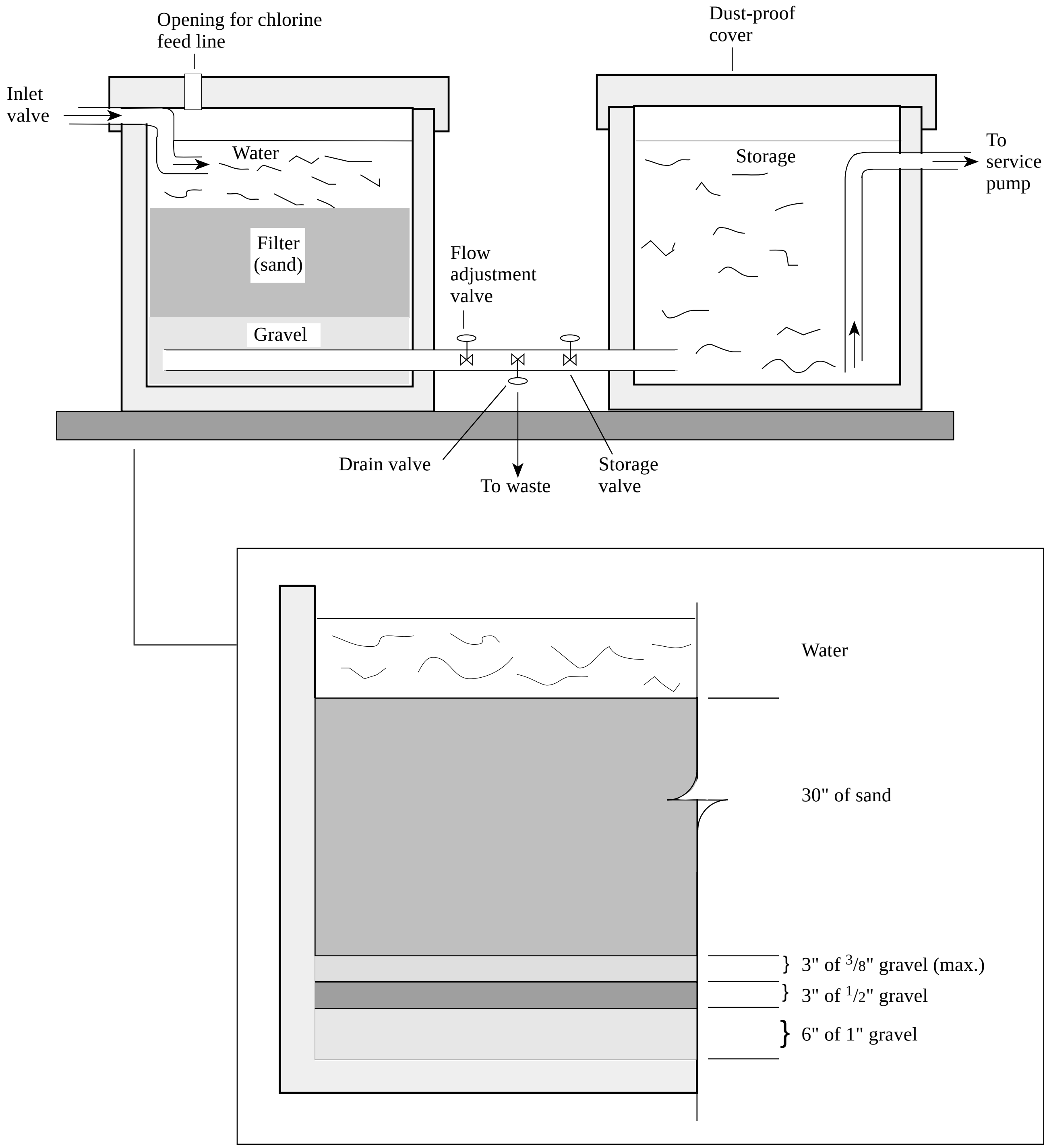

Figure 5.—An overall view (top) and a detail view of a constructed-in-place filter to clarify surface water. Based on a model in *Private Water Systems Handbook* (MWPS-14) by Midwest Plan Service, Ames, IA, 1979.

A commercial media filter usually contains manufactured media rather than natural materials such as sand and gravel. The manufactured media tend to have more uniform particle size than is typical of natural media.

With any type of media filter, over time the filter will become less permeable as the trapped sediment particles block the water's flow. At that point, the media filter must be backwashed. Media filters are backwashed by running filtered water up through the bed with sufficient force to slightly expand the bed and cause the media particles to bump into one another. The disturbance cleans the media of the sediment particles, which are flushed away.

Most municipal water treatment plants using surface water and media filters must backwash their filters periodically. The washwater and captured sediment must be managed in some way. In plants that add chemicals like lime and soda ash to improve filtering, it generally is unacceptable to discharge these solids back to the river or lake. In that case, the backwash water goes to a settling pond; when the chemicals have settled to the bottom, the improved backwash water can be piped back to the river or lake.

Media filters generally are better than screening filters in removing higher concentrations of sediment, but they are more complex, more expensive, and use clean filtered water in the backwash system. If the incoming water is relatively clear, the amount of water used in backwashing the filter is inconsequential. If, however, incoming water is very turbid, the amount of water used in backwashing may be a major fraction of the total amount treated.

A media filter typically has a by-pass valve ahead of the filter so that, if the filter becomes inoperable for some reason, water can be routed around it in an emergency.

Table 3 provides details on a few commercially available media filters.

Table 3.—Details of sample commercially available media filters.

Feature	Unit A	Unit B	Unit C
Volume of media (ft^3)	1	1.5	2
Pipe size (in)	1	1	1
Diameter (in)	10	10	12
Height (in)	44	54	48
Filtered water flow (gpm)	3	3	3
Cost of filter ($)	860	900	1,030
Cost of media/$ft.^3$ ($)	125	125	125
By-pass valve available	yes	yes	yes

Alternatives to Commercial Equipment

An alternative to using commercial equipment for the total treatment process is to use less costly components, which you can put together yourself, for part of the treatment.

Plain settling is a low-cost way to remove large particles from water. If your water source has high concentrations of suspended solids over extended periods but the solids settle rapidly, a simple settling tank or pond may reduce your overall cost. A tank that holds at least one day's water supply can be filled in the afternoon and allowed to settle overnight. Next day, the clarified water can be piped out.

A second option, mentioned earlier, is to store water from your source when the quality is good so you can avoid having to treat dirty water. If the water in your stream or pond deteriorates quickly during a storm but also recovers quickly, by having a 1- to 3-day supply in storage you may be able to avoid pumping from the source when the quality is unacceptable.

A homemade sand filter also can be a preliminary treatment device. A homemade filter tank can be constructed from any nontoxic material such as cast-in-place concrete, precast concrete culvert pipe or tanks, wooden water tanks, reinforced plastic or fiberglass, or steel. Galvanized metal tanks are not recommended because they corrode. The filter should be located away from contamination and fire hazards. If freezing is likely to be a problem, some protection will be necessary.

Your daily water use rate will determine the size of homemade sand filter you need. Table 4 can help you estimate the filter's surface area and dimensions. A filter should be 6 to 8 feet deep and generally constructed according to Figure 5. Lower flow rates allow more time between cleanings and, most likely, better sediment removal.

Sand for the filter should have an effective size of about 0.3 to 0.5 mm and a uniformity coefficient of less than 2.5.

Table 4.—Suggested dimensions for a sand filter, based on a flow rate of approximately 70 gallons per day per square foot.

Water needed (gal/day)	Filter surface area (ft^2)	Dimensions rectangular (ft)	Dimensions round (dia. ft)	Avg. flow rate (gal/hr)
200	2.9	1.5 x 2	2	8.3
400	5.7	2 x 3	3	16.7
600	8.6	3 x 3	4	25
800	11.4	3 x 4	4	33
1,000	14.3	3 x 5	5	42
1,500	21.4	4.5 x 5	6	63
2,000	28.6	5 x 6	6	83
2,500	35.7	6 x 6	7	104
3,000	42.9	6 x 8	8	125

Based on recommendations in *Private Water Systems Handbook.*

It is important to disinfect a sand filter before first use and again after adding new sand or gravel. Use 1 pint of 5 percent chlorine (laundry) bleach for every 8 square feet of filter. Continuously chlorinating immediately ahead of the sand filter tends to prevent bacteria or algae from growing on the filter. The concentration of chlorine will depend on the water's quality. A good rule of thumb is to chlorinate so there is only 1 part per million (ppm) left in the water at the end-use point.

A sand filter is simple and relatively inexpensive to build, but it does require a fair amount of maintenance, especially if you run a lot of dirty water through it. Sediment accumulates on top of the sand and eventually slows the flow to an unacceptable level. At that point—generally about twice a year, if the incoming water is not very dirty—you will need to lower the water level below the sand's surface in order to remove the sediment and the top 0.25 to 0.5 inch of sand.

Do not drain the filter completely or it is likely to become "air-bound." In that case, air that replaced water between the particles of the filter cannot escape readily when water pours back into the filter, and so the water won't run through the filter.

Putting It All Together

You have several options for achieving clear water. Trying to identify which is the best in a particular situation is not a simple matter.

The most important variable is the quality of water available from the source. At one extreme is groundwater, which is likely to be clear and contain relatively few suspended solids. The simple installation of a commercial cartridge filter would assure removal of particles larger than 5 microns and do so with little expense or effort.

On the other extreme is a river flowing through a highly erodible area and subject to dramatic changes in flow rate and in solids concentrations. A source of this kind is likely to require complex treatment such as that shown in Figures 1 or 2.

Another important consideration is the relative amount of time, labor, and money you are willing and able to invest in your system. For example, a simple sand filter is relatively inexpensive to build but requires a lot of operator attention to operate successfully. A cartridge-filter system also can do the job effectively with less maintenance but at higher cost. You also can reduce your hardware and operating costs by including water-storage tanks—before and after the filter, or both—to reduce the demands on the treatment system.

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