Reducing the Risk of Groundwater Contamination by Improving Household Wastewater Treatment

Properly installing and maintaining a system for treating and disposing of household wastewater minimizes the impact of that system on groundwater and surface water. State and local codes specify how wastewater systems must be designed, installed and maintained. For example, Missouri Code 10CSR 20-8.021 regulates private sewage systems. The state Department of Health and Senior Services' *Onsite Wastewater Treatment Systems Owner's Manual* provides information on servicing these systems. More information is available in the Resources section. Before proceeding, also always check with the county department of health for any county regulations and limitations.

At minimum, follow the codes, but also consider whether the minimum requirements are adequate for your site.

Septic tank/soil-absorption system: The most common system

The most common form of on-site wastewater treatment is a septic tank/soil-absorption system. In this system, wastewater flows from the household sewer into an underground septic tank. Once in the tank, the system works in the following way:

- The waste components separate. The heavier solids (sludge) settle to the bottom, and the grease and fatty solids (scum) float to the top.
- Bacteria partially decompose and liquefy the solids.
- Baffles are placed in the tank to provide maximum retention of solids, prevent inlet and outlet plugging and prevent rapid flow of wastewater through the tank.
- More liquid portion (effluent) flows through an outlet to the soil-absorption field.
- The absorption field usually is a series of parallel trenches (fingers), each containing a distribution pipe or tile embedded in drainfield gravel or rock.
- The effluent leaks out through holes in the pipe or seams between tile sections, then down through the drainfield gravel or rock and into the soil.
- The soil filters out remaining minute solids and pathogens (disease-producing microorganisms), and dissolved substances slowly percolate down to groundwater.

Quantity of wastewater

Strategy: Minimize the volume of household wastewater.

Reducing the volume of wastewater entering the treatment system is important because less flow, or volume, means better treatment, longer system life and less chance of overflow. For holding tanks, less volume reduces costs by reducing the number of times the tank has to be emptied.

The quantity of water used depends on the number of people using the dwelling, how water is used and maintenance of the water supply system. Average water use in rural households is 75 gallons to 100 gallons per person every day. With low-use fixtures and individual awareness and concern, it is possible to reduce use to fewer than 50 gallons per person a day. However, even conservative use by several people may exceed the capacity of the wastewater treatment system.

Reducing the volume of water entering the system improves the treatment by increasing the time the waste spends in the system, thus providing more time for settling and aeration and more soil contact.

Consider the following ways to minimize water use:

- Eliminate nonfunctional uses, such as flushing toilets to dispose of tissues or other wastes that should be handled as solid waste. Turn off water between uses, fix plumbing-fixture leaks and try to eliminate sources of clear water and infiltration into the system. For example, divert roof drains away from the soil-absorption field.
- Consider which actions use the most water. Toilet flushing usually ranks highest. Low-flow models could decrease water use by more than half. In the United States, 35 percent to 40 percent of the population has plumbing codes that require 1.5-gallon or less toilets on all new construction. Composting toilets allow greater reductions, but they present other waste-disposal challenges.
- Bathing and clothes washing are next in order of water use. For bathing, consider installing low-flow or controlled-flow showerheads; taking shorter showers; and only using water to get wet, then soaping up without water running, then rinsing.
- For washing clothes, use a suds saver and run full loads. Front-loading washers use much less water.

When running small loads, be sure to use the reduced-water level setting.

- Run dishwashers only with a full load.
- Modern, efficient plumbing fixtures, including 0.5- to 1.5-gallon toilets, 0.5 to 2.0 gallons per minute (gpm) showerheads, faucets of 1.5 gpm or less and front-loading washing machines of 20 gallons to 27 gallons per 10- to-12-pound dry load, offer the potential of substantial reduction in residential water use and wastewater generation. These reductions commonly amount to between 30 percent and 70 percent of in-house water use (Table 1).
- In hard-water areas, the water softener may use a significant amount of water. Properly adjusting and timing the softener's regeneration mechanism reduces excessive water use.
- Keep in mind that your awareness of your family's water use and how each of you can reduce it is as important as the use of water-conservation devices.

Figure 1 shows a typical household system for wastewater generation, collection, treatment and disposal. Although systems for many farmsteads may be similar — groundwater supply, septic tank, subsurface treatment and disposal — note the lists of options below each part of the diagram. You may wish to circle the parts found in your system. The leakage, overflow, infiltration and clear water components represent possible problems with the system.

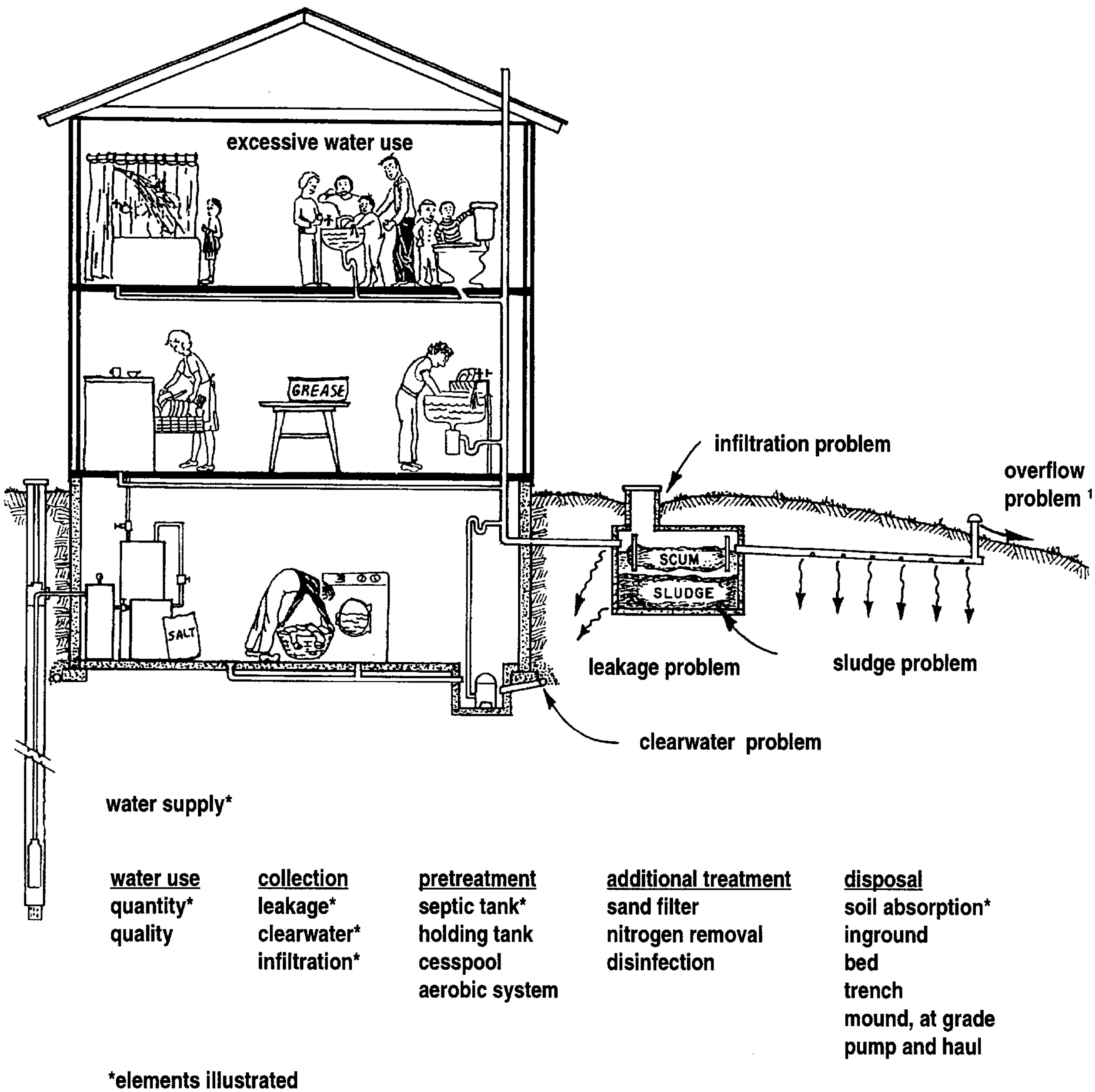

Figure 1. Typical household wastewater treatment system with problems. Illustration by Andy Hopfensperger, University of Wisconsin-Madison, Department of Agricultural Engineering.1 Overflow devices are not approved for installation in Missouri.

Unfortunately, these problems often are difficult to recognize. You may notice overflow from systems as wet spots, odors and in changes in vegetation cover. Water entry, such as infiltration and clear water, will be more difficult to detect, involving tracing where floor drains, roof drains, foundation drains and sumps are directing waters that do not need treatment into the treatment system. Leakage from the collection and treatment system — as well as infiltration of water into the system through unsealed joints, access ports and cracks — can be difficult to assess. The flow chart at the bottom of the box follows the flow of wastewater and sludge through the treatment system.

Quality of wastewater

Strategy: Minimize the amount and complexity of contaminants in the wastewater.

The quality of water refers to what is in the water, not to the water itself. Even wastewater is more than 99.44 percent pure water. Wastewater usually contains relatively small amounts of contaminants, but they make a big difference in the usefulness of the water.

Contaminants found in wastewater include:

- **Bacteria and viruses**, some of which can cause disease in humans. These microorganisms are large enough to be removed by settling or through filtration in beds or soil. Many microorganisms will die from the adverse conditions or aging in the system.
- **Suspended solids**, particles that are more or less dense (scum) than water. Most can be separated from liquid waste by allowing enough time in a relatively calm tank. Grease and fats are a part of the suspended solids. Filtration beds and absorption systems can be clogged by wastewater high in suspended solids.
- **Oxygen demand**. The microorganisms that decompose organic wastes use oxygen. The amount of oxygen required to stabilize wastewater typically is measured as biochemical and chemical oxygen demand. Wastes such as blood, milk residues and garbage grindings have high oxygen demand. Aeration and digestion processes, in the presence of oxygen and organisms, produce stable, low-odor wastewater when given enough time. Wastewater with excess oxygen demand can cause problems for soil-absorption fields, groundwater, streams and lakes by reducing oxygen levels.
- **Organic solvents** from cleaning agents and fuels may not be degraded or removed through treatment and can pass along with the wastewater back into the water supply.
- **Nutrients**. Most notable are nitrogen from human wastes and phosphorus from machine dishwashing detergents and some chemical water conditioners. Nitrate-nitrogen is a common groundwater contaminant, and phosphorus over-fertilizes surface water.

Table 1. Water use by conventional fixtures and water-saving fixtures and devices.

Conventional fixture	Gallons used	Water-saving fixture/device*	Gallons used
Toilet	4 to 6 per flush	Air-assisted toilet	0.5 per flush
Shower head	4 to 6 per minute	Low-flow shower head	2.0 per minute
Faucets: Bathroom and kitchen	4 to 6 per minute	Faucet-flow control aerators: Bathroom Kitchen	0.5 per minute 1.5 per minute
Top-loading clothes washer	40 to 55 per load	Front-loading clothes washer	22 to 33 per load

**Installation of all these water-saving devises could reduce water use by about 35 percent.*
Source: Penn State Cooperative Extension Circular 302.

Consider the following ways to improve wastewater quality:

- Cut down on your use of the garbage disposal. Using this appliance contributes a large load of suspended solids and organic matter to wastewater, and it also uses additional water.
- Do not put items down drains that may clog septic tanks (fats, grease, coffee grounds, paper towels, sanitary napkins, tampons, disposable diapers).
- Do not put toxic substances in drains that might end up in the groundwater, such as solvents, degreasers, acids, oils, paints, disinfectants and pesticides. (This does not include using bleach to disinfect laundry or to wash clothing worn for pesticide applications.)
- Do not use chemicals to clean or "sweeten" your system. They may interfere with the biological action in the tank, clog the drain field by flushing sludge and scum into the field or add toxic chemicals to groundwater.

Collection of wastewater

Strategy: Collect all wastes that need treatment. Minimize loss of untreated waste. Don't let water that doesn't need treatment or disposal infiltrate the treatment system.

Leaking piping or treatment tanks (leakage losses) allows wastewater to return to the local water supply without adequate treatment. Infiltration of clear water overloads the system and dilutes the wastes. Don't let water that doesn't need treatment — such as water from basement floor drain sumps, foundation drains, rainwater infiltration or roof drainage — add to your waste volume. Divert clear water, which doesn't require treatment, away from house, well and wastewater treatment system.

Pretreatment system

Strategy: Make wastewater more suitable for further treatment or disposal.

Septic tanks retain most of the suspended and settled solids — the sludge and scum — from wastewater. In the tank, bacteria digest and compact the sludge. The partially treated water moves on to additional treatment or disposal, for example, in a soil-absorption field.

Septic-tank design and construction influence their water tightness and effectiveness in retaining sludge and scum. Multiple tanks or chambers in a series can improve sludge and scum removal. Gas deflectors and filter screens or inclined-plate settling units help minimize solids carry-over. Tanks should be sized to accommodate at least 24 hours of wastewater flow or the minimum size, as stated earlier in this publication, while still allowing for sludge and scum retention. Pumping the tank before it is more than one-third filled with scum and sludge improves system function. When the tank is pumped, you also should check the baffles and look for tank leaks.

Aerobic (oxygen-using) biological systems (packaged systems) provide more extensive treatment of wastewater than the typical anaerobic (no oxygen) septic units, improving solids separation, releasing volatile chemicals and reducing sludge volume. However, these systems are more expensive to operate and maintain and are more subject to problems caused by changes in wastewater quality or environmental conditions.

Aerobic lagoons contain oxygen-breathing bacteria that decompose waste in a storage pond three feet to five feet deep. You can apply overflow from the system to lawns or allow it to flow through a grassed waterway. This system requires low maintenance and is inexpensive to construct.

Holding tanks collect and hold the entire wastewater flow. Disposal is generally done by a licensed contractor who spreads the waste on an approved site or hauls it to a municipal waste-treatment facility. Tank size should allow for ample capacity to accommodate pumpage and disposal at convenient and appropriate times, especially for land-spreading. When pumped, check the tank for leaks.

Alternate treatment systems

Strategy: Reduce concentration and amount of contaminants in the wastewater to expand options for appropriate disposal.

Low-pressure pipe systems use a small diameter pipe in shallow, narrow trenches in direct contact with the soil. The system is dosed under pressure using a pumping chamber after the septic tank. Typical installation uses 1.5-inch polyvinyl chloride, or PVC, with holes every 5 feet of pipe length. Costs for absorption field components and construction are reduced, but the expense of the dosing chamber and pumping systems have been added.

Drip irrigation systems are soil absorption systems that have been modified to account for sites that may have slowly permeable soils, shallow soils or steep slopes. They consist of the dosing tank, pump and controller, filter system and the drip field. The drip irrigation system uses a small diameter pipe that is buried in a shallow trench just below the surface. The dosing tank and controller can provide uniform distribution of wastewater through dosing and resting cycles. Dosing helps maintain aerobic conditions in the soil, which improves treatment of the wastewater and maintains soil permeability.

Aerobic systems, described in the previous section, may be used for additional treatment of septic-tank effluent, yielding a better quality effluent suitable for more disposal options.

Sand filters improve the quality of wastewater after septic-tank pretreatment (Figure 2). Effective treatment involves aerobic biochemical activity, as well as physical filtration. Filters consist of 2 feet to 5 feet of sand or other media in a bed equipped with a distribution and collection system. Wastewater is applied by dosing, and it may be recirculated to improve treatment.

Wetlands, or vegetated submerged beds, are designed to have one or two cells or zones of shallow excavated earthen ponds filled with up to 18 inches of rock or other granular media and planted with aquatic vegetation. Wastewater from the septic tank enters the front end of the wetlands and is spread out across the width of the bed through a perforated pipe. The wastewater is treated by bacteria and other microorganisms found in the plants and granular media in the wetlands. As wastewater is treated, it flows from the first cell to a second cell to a soil treatment system or lagoon for further treatment. Treatment of the wastewater is based on retention time in the wetland cell and granular media. During winter months when the plants use less water, the retention time should be increased.

Wastewater treated in such systems generally is lower in bacteria, nitrogen, phosphorus, oxygen demand, suspended solids and organic matter. The amount of reduction depends on design of the system. These systems must be engineered and can be costly to construct. They also must be maintained properly to operate effectively.

Additional treatment

Important considerations in designing filters include pretreatment and quality of wastewater, hydraulic loading rate, depth and type of filter media, dosing frequency, temperature and distribution, and collection systems. Maintenance includes resting, occasional raking, removing clogged and crusted surface media, filter media replacement and attention to dosing equipment.

Remove nitrogen through denitrification, the conversion of nitrate to nitrogen gas, or ion exchange. Denitrification requires anaerobic conditions in the presence of decomposable organic matter for bacteria to reduce nitrate to nitrogen gas for removal from wastewater. Denitrification and ion exchange processes are not used

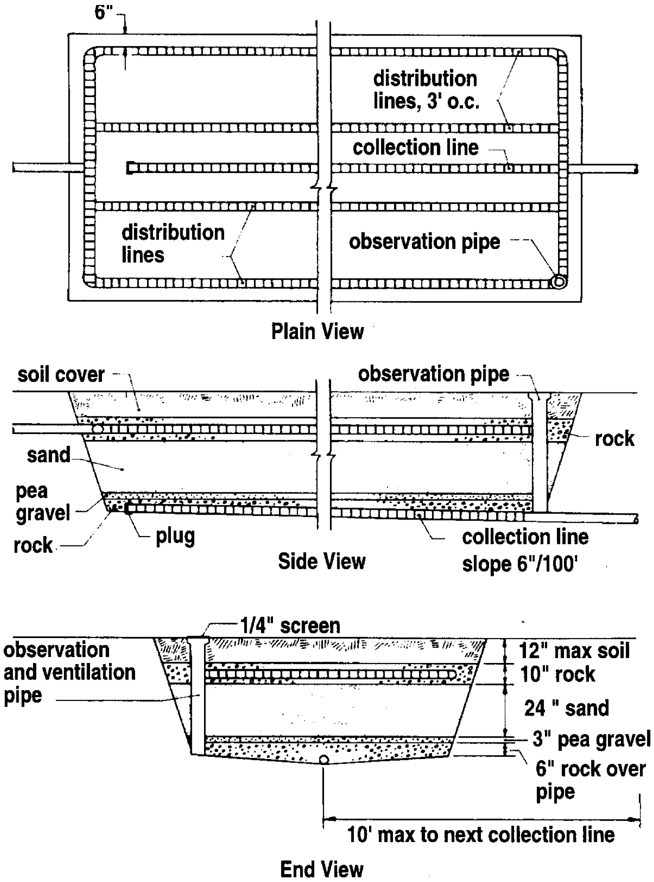

Figure 2. Buried sand filter. Source: Onsite Domestic Sewage Handbook, MWPS24, Midwest Plan Service, 1982.

extensively at this time because they are expensive to install, operate and maintain.

Disinfection systems kill disease-causing microorganisms in wastewater and are used where discharge to surface water is permitted. Chlorine, iodine, ozone and ultraviolet light systems are available for treatment of good-quality effluents, such as those from properly functioning aerobic units and sand filters.

Disinfection of holding-tank waste prior to land-spreading has been studied, but it is not in common use. Disinfection with lime is feasible.

Disposal of wastewater and pumpage

Strategy: Dissolve wastes, take advantage of additional treatment afforded by contact with soils and minimize opportunities for waste to contaminate water supplies.

Off-site disposal of wastewater, by connection to a municipal sewage system, hauling to a municipal treatment facility or land-spreading can help protect the local farmstead water supply. Discharging treated wastes to surface water from private systems is not permitted in Missouri. Improper waste management off the farm can endanger the health of others in your community.

Application of wastewater to the soil surface, though not recommended in Missouri, can provide an opportunity to recycle nutrients and to reduce the contaminant content of wastewater safely. Choose the application time so there will be no runoff, maximum use of nutrients by plants and additional reduction in microorganisms. Consider these characteristics when selecting a site: soil, land use, depth to groundwater, weather, climate and hydrogeology. Check with your local health department before considering this option.

Subsurface treatment and disposal using soil absorption (trenches, beds, at-grade and gravelless) is the common practice for household wastewater after pretreatment in a septic tank or aerobic system. There are, however, sites where soil-absorption systems are not acceptable because of high or low soil permeability, depth to bedrock or the saturated zone, or other factors. Deep, well-drained, well-developed, medium-textured soils such as silt loam and loam are desirable soil-absorption sites.

Soils and separation from the water supply are important factors. Unsaturated soils allow movement of air, keeping the wastewater aerobic. A minimum of 3 feet of unsaturated soils is recommended for bacteria removal. Finer-textured soils (clay loams and clay) retain water better, allowing plant roots to take up wastewater and nutrients and encouraging increased die-off of microorganisms. Coarse, sandy soils cause effluent to flow too quickly downward to groundwater, not providing adequate time for filtering solids and pathogens from the liquid. Disposal sites that are more distant and downslope from the well increase the isolation of your water supply from contaminated wastewater.

Disposal of pumpage from septic tanks and other treatment systems on-site should follow similar rules as for wastewater. Sludges are more concentrated than treated wastewater, so lower application rates are recommended.

Only land-apply wastewater and sludge where permitted by the Department of Natural Resources (DNR). Approved sites for land application must meet requirements found in Missouri Code of State Regulations (10CSR20.800), including requirements for soil, depth to groundwater or bedrock, slope and distance from well and residences.

Assistance with failing systems or new designs

If you suspect your household wastewater treatment system is backing up or your distribution system is clogged, first contact your plumber or treatment-system installer, who may have suggestions for extending the life of your system.

- Do not use septic-tank cleaners that contain degreasing solvents like trichloroethylene (TCE). They can contaminate groundwater.
- Do not place more soil over a surfacing soil-absorption field; this does not fix the system, and it will soon surface again.

- Do not pipe the sewage to the road ditch, storm sewer, stream or farm drain tile; this pollutes the water and creates a health hazard.
- Do not run the sewage into a sinkhole or drainage well; this pollutes the groundwater.
- Do not wait for the system to fail before pumping the septic tank. Once a system fails, it is too late to pump the tank.

A properly designed, constructed and maintained septic system can effectively treat wastewater for many years. For more information on septic systems, contact your local MU Extension specialist or local health department.

Resources

For information on design of household sewage systems, land-application requirements, contact:

- Area health department sanitarian
- Missouri Department of Health and Senior Services district offices or Missouri Department of Health, P.O. Box 570, Jefferson City, Mo. 65102, 573-751-6400
- MU College of Agricultural Engineering, 205 Agricultural Engineering Bldg., Columbia, Mo. 65211, 573-882-2731

For more information on requirements for legal land application of pumpage from holding tanks, septic tanks and other treatment systems regulated by the Missouri Code of State Regulations, Department of Natural Resources, 10CSR20.800, contact the nearest DNR, or for information on petroleum product spills, contact your local MU Extension office, or a regional DNR office listed below:

- Kansas City — 816-251-0700
- Northeast (Macon) — 660-385-8000
- Southeast (Poplar Bluff) — 573-840-9750
- Southwest (Springfield) — 417-891-4300
- St. Louis — 314-416-2960

For information on small and alternative wastewater treatment technologies:

- National Small Flows Clearinghouse, West Virginia University; P.O. Box 6893, Morgantown, WV 26506-6064, Ext. 3; 800-624-8301; ***info@mail.nesc.wvu.edu***
- Your local MU Extension office or health department sanitarian

Missouri Code of State Regulations, Title 10, Department of Natural Resources: ***http://sos.mo.gov/adrules/csr/current/10csr/10csr***

Missouri Department of Health and Senior Services, *An Onsite Wastewater Treatment System Owner's Manual: Recommended Guidelines for Operation and Maintenance*, ***http://health.mo.gov/living/environment/onsite/pdf/SystemOwnersManual.pdf***

Missouri Department of Natural Resources (DNR), *Water Protection Program*, *No-Discharge Wastewater Treatment*, ***https://dnr.mo.gov/env/wpp/no-discharge.htm***

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ALSO FROM MU EXTENSION PUBLICATIONS

EQ401 *Septic Tank/Absorption Field Systems: A Homeowner's Guide to Installation and Maintenance*

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