The soil characteristic used to predict draining behavior is texture. The larger the particle – coarse sands and gravels, for instance – the better the drainage. Smaller particles such as clays pack tightly together leaving no room for water to pass.

By
Paul Fisette

Many soil experts think perc results are unreliable and the rules arbitrary. So should perc tests decide the fate of building lots?

Life & Death of a Building Lot 'Subject to Perc'

The ratio of 1 in 30 is a magic number for contractors who build homes in Massachusetts. In New Hampshire the number is 1 in 60. Vermont's number is 1 in 60, or 1 in 120 for a "mound" system. Maine doesn't have a magic number. Confused? Welcome to perc-rate lotto. Percolation rates, the time it takes one inch of water to drain from a hole dug near a proposed septic system, must be determined before building permits are issued in most rural communities in the U.S. If your rate does not meet the legal minimum, then you can't build on the site.

Some states and towns have more rational regulations than others, but every state has some form of regulation for on-site sewage disposal. The purpose is to keep human waste from entering our drinking water and causing disease. For the most part the regulations work: Today's improved mortality rates and longer life-spans are in many ways attributable to environmental control of sewage.

Yet the regulations can confuse. Not only does each state follow a different set of rules, but each leaves it up to local boards of health to fine-tune the regulations to suit local conditions. States merely establish minimum standards. This leads to local regulations that are usually more stringent.

While this may sound needlessly complicated, experts agree that a universal regulation would not work. Local environments must be considered. Each community must ask itself: What are we using the aquifers for? And what is the environmental impact of building and disposing sewage near them?

The resulting patchwork of local regulations affects the roughly 23 million homes in the U.S. that process sewage on-site – including about 20%

of new homes (over 40% in northern New England and parts of the Southeast). Understanding the rules and the reasons behind them can help you negotiate through the regulatory process.

On-Site Disposal – How it Works

Most on-site septic designs have three main components: generator (house), partial treatment facility (septic tank) and final treatment facility (leaching field). An average of 45 gallons of wastewater are generated by each household inhabitant every day. Solid and liquid waste drain from the house into a watertight (usually precast concrete) septic tank. Solids enter and settle to the bottom of the tank while grease and fats rise and are trapped between baffles arranged across the top of the tank. Solids entering the tank displace liquid waste. The displaced liquid runs to the leaching field through an outlet located at the top of the opposite end of the tank. Solids left behind begin to decompose.

The liquid sewage carries suspended solids to the disposal field where the goulash percolates through the bed of stones and soil that surround the leaching drains. Wastewater is cleansed as it filters through the soil system. An organic layer, or slime mat, forms at the layer where stones meet soil. The mat is a virtual feast for millions of bacteria that break down the sewage. Infiltration of liquid into the soil is slowed as the mat thickens. And as a result the soil beneath the mat remains unsaturated. Pathogens are scrubbed from the percolating wastewater before they can reach groundwater. All this works well – as long as the leaching field is located, designed, and constructed in acceptable soil.

Soils

There are two soil concerns when it comes to septic discharge: First, if the soil in the leaching area is impermeable, the disposal system will back up into the basement or create a pond of sewage on the ground surface. Conversely, if the soil is too permeable, wastewater may rush through the soil too quickly and pollute the groundwater with phosphates and nitrates (see Figure 1 on facing page).

The soil characteristic used to predict this draining behavior is texture. The larger the particle (coarse sands and gravels, for instance), the better the drainage. Smaller particles such as clays pack tightly together leaving no room for water to pass.

This is where a soil evaluation comes in handy. A site-assessment specialist or soil scientist can take several soil borings from a proposed building lot and analyze the soil profile. It will cost a couple of hundred dollars, but it is money well spent. A preliminary soil analysis will provide you with a sense of the lot's potential before you sink serious money into the test holes required by town officials.

The other key characteristic that soils experts examine in a boring is soil mottling, which indicates the height of groundwater.

Groundwater

If the water table rises too close to the leaching field, unscrubbed sewage can enter and pollute the groundwater. Therefore groundwater levels are critical to septic design and approval.

To look for evidence of groundwater, soil scientists look at four distinct layers (or horizons) of soil: organic mat, topsoil, subsoil, and substratum. Chemical reactions color the soil (mottling) as the water table rises and falls. Mottles are irregular orange, yellow, and gray spots found in the soil profile. For any given year the high water level may be higher or lower than the average estimated by the height of mottling. But all soil experts agree that the highest point of soil mottling is a reliable indicator of average high groundwater level.

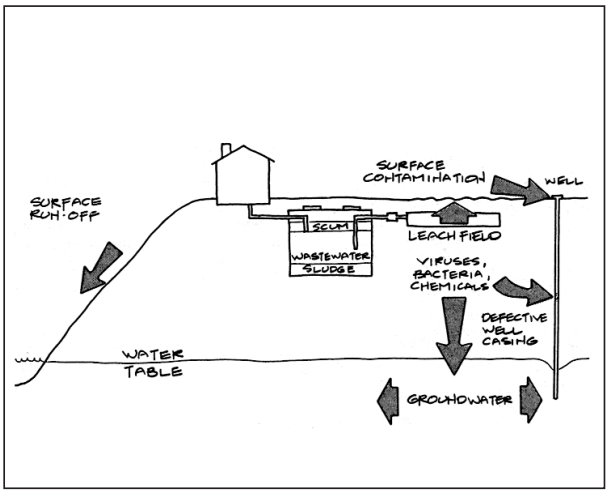


Figure 1. *A well-designed septic system removes viruses, bacteria, and other pollutants before treated wastewater reaches groundwater. However, if the soil is too impermeable the sewage will back up to the ground surface. If it's too permeable, or the water table too high, sewage byproducts can pollute wells or groundwater.*

Groundwater levels rise and fall throughout the year. Typically the water table will be lower during dry seasons and higher during wet seasons. But a very wet period during any season may elevate the water table to unusual heights.

Groundwater may collect in the bottom of an excavation, but this does not necessarily mark the water table. If you have excavated into perched water (water that is trapped between impermeable layers of soil) the water could drain from the hole. More often, the water level will rise over time as it stabilizes. For an accurate reading, therefore, it's best to wait.

Damp soil can also be a misleading clue. It does not prove that you have reached the water table. Rather, it may have been drawn up through capillary action – as much as a couple of feet depending on soil conditions. Capillary action will dampen the soil, but it won't cause water to accumulate in the hole.

Groundwater may collect in the bottom of an excavation, but this may or may not be the water table. soil located above the water table draws water up through capillary action –as much as a couple of feet depending on soil conditions. If you find water in the bottom of a test hole, just a wait a few days. The water table will seek its own level and possibly leave the hole.

Regulation and Site Evaluation

All states agree in principal that the soil around a proposed septic system must be evaluated and it must be determined that it is capable of cleansing effluent. To make this evaluation, all states require you to dig a deep observation hole in the immediate area of any proposed on-site septic system. Furthermore, most states, but not all, require that you establish soil drainage rates by running a perc test. But beyond that, various states agree little on how to determine what is a suitable site.

States do not agree on the depth and number of observation holes required for each site; the depth of permeable soil required beneath the bottom of the leaching field; the distance allowed between the top of the average high water table and the bottom of the leaching field; the size of the percolation hole and the rate water must percolate from the hole. While most regulations hold perc test results as the key criterion for septic design, some do not even require a perc test as a screening procedure.

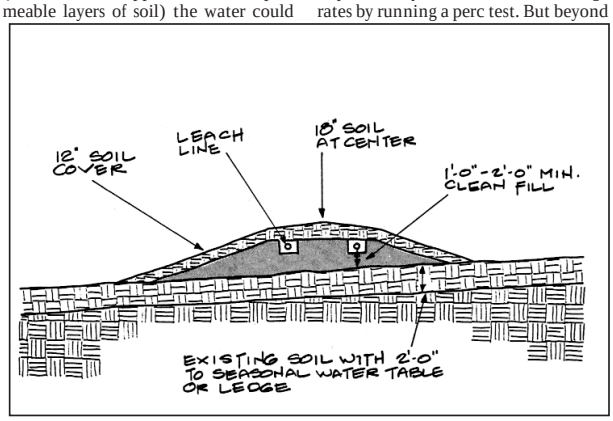


Figure 2. *In areas with high water tables, many municipalities permit "mound" systems, in which 1 to 2 feet of clean fill is built up from the existing grade.*

Deep Hole Test

An observation hole is dug so a site evaluator or engineer can look for bedrock, permeable and impermeable material, and groundwater – or signs of the average high water level. Soils are analyzed and soil horizons are inspected. The information is used to locate, size, and design the septic system.

In Massachusetts, at least two deep holes are dug and examined on each lot. They must extend 4 feet below the bottom of the leaching area and be at least 10 feet deep, unless bedrock prevents further excavation. In Massachusetts, you need 4 feet of naturally occurring permeable soil beneath the bottom of the planned leaching field or you can forget about building a disposal system. And the water table must be at least 4 feet below the system, too. But don't be mislead. You can still construct an acceptable septic system if your water table is only 3 feet below the surface as long as you build a raised or "mound" system one foot above grade on clean fill (see Figure 2).

New Hampshire's Water Supply Pollution Control (NHWSPC) regulations require that the bottom of a leaching field rests on permeable soil that is 8 feet deep. Seasonal high-water must be at least 4 feet below the system. The ruling seems rather strict, yet the state allows anyone to conduct his own soil tests and design his own system.

Vermont governs on-site sewage through subdivision regulation. Lots larger than ten acres are exempt from state regulation, but many towns control the construction of wells and septic systems with local ordinances. Lots smaller than 10 acres are considered single-lot subdivisions by the state and must be tested and approved before title of ownership can be conveyed to a new owner.

Four deep holes must be evaluated on each single-lot subdivision: two in the proposed leaching area and two more in a "reserve area," which must be available in case the primary system fails. "In Vermont, it is assumed that all septic systems will fail, so you have to prove that you have adequate area and soil conditions for two systems," says Jessanne Wyman, permit specialist with the Vermont Department of Environmental Conservation. Many states have similar provisions for reserve-area testing, according to Wyman. Vermont's observation holes must be 7 feet deep and 4 feet below the bottom of the proposed leaching field. Seasonal highwater must be 3 feet below the disposal system.

Maine, like most states, requires a licensed site evaluator to inspect soils exposed in the deep hole test. However, Maine's law seems relaxed when compared to laws of other states. Here, soil profiles are only logged to a depth of 4 feet. A soil expert describes each soil horizon in the test report, indicating: color, texture, structure, and any

restrictive layers that are found. But Joel Noel, certified soil scientist with Berwick Property Services in Berwick, Maine, explains, "We pay particularly close attention to the level of soil mottling, the level of seasonal high water, because in Maine we can locate our disposal fields just 12 inches above the water table."

Perc Testing

Perhaps the most hotly debated issue related to site evaluation is perc testing. Thomas Peragallo, certified soil scientist with Northeast Land Consultants in Lunenburg, Mass., speaks for most soil experts when he says, "Soil permeability or hydraulic conductivity is one of the most difficult criterion to estimate because there is such a wide margin of variability in results given by perc tests." Most scientists feel that perc rates should be used as a design tool, not as a build/no-build gauge for site approval.

Basically, a perc test is conducted in the following manner: A small hole, approximately 12 inches in diameter (18 inches deep in some states, 3 feet or deeper in others), is dug in the area of the proposed septic field. The perc hole is kept full of water for a period of time. Then, after the hole is "soaked," the test conductor measures the rate at which the water drains from the hole. It is measured as a ratio of 1 inch in X minutes. If your test hole drains slower than the acceptable rate, you're out of luck. Find another lot to build on. But does this restriction make sense?

Hypothetically, a landowner who owned land at the intersection of Massachusetts, New Hampshire, and Vermont could get the site approved if the water in a perc hole drained faster than: 1 inch/30 minutes in Mass., 1 inch/60 minutes in N.H., or 1 inch/120 minutes in Vt.

A hypothetical landowner who owns a tract of land at the intersection of Massachusetts, New Hampshire, and Vermont could get the site approved if the water of the perc hole drained faster than: 1 inch/30 minutes in Mass., 1 inch/60 minutes in N.H., or 1 inch/120 minutes in Vt. Why would a disposal area work in one corner of these lots but not in another?

Local regulators who require perc testing agree on one thing: the bottom of the perc hole should be dug into the least permeable soil found within the region of permeable soil that lies beneath the bottom of the proposed leaching field. But they do not agree on: where or when the holes should be tested, size and depth of the holes, how many tests should be conducted on each lot, how fast water drains from the hole, and who should administer and witness the tests.

If you are required to conduct a perc test, keep in mind that the smaller the diameter of the perc hole the better chance you have to pass the test. For example, in a hole 12 inches wide by 18 inches deep, for the level to drop one inch, about 113 cubic inches of water must pass through about 800 square inches of soil surface. If the hole were reduced to 8 inches in diameter, the level will drop an inch with 50 cubic inches of water passing through 500 square inches of soil surface – about a third less water passing through each square inch of hole surface area. So if the regulation offers you an acceptable range of hole sizes, pick the smallest one. The volume-to-surface ratio will work in your favor.

Most engineers feel they can design a perfectly safe disposal area for soils that test out within a broad range of perc tests. Scientific literature and the variability of perc results support eliminating perc as the deciding factor in site approval. The test results should be used as design ads and nothing more, says Peter Veneman, professor of soil science at the University of Massachusetts.

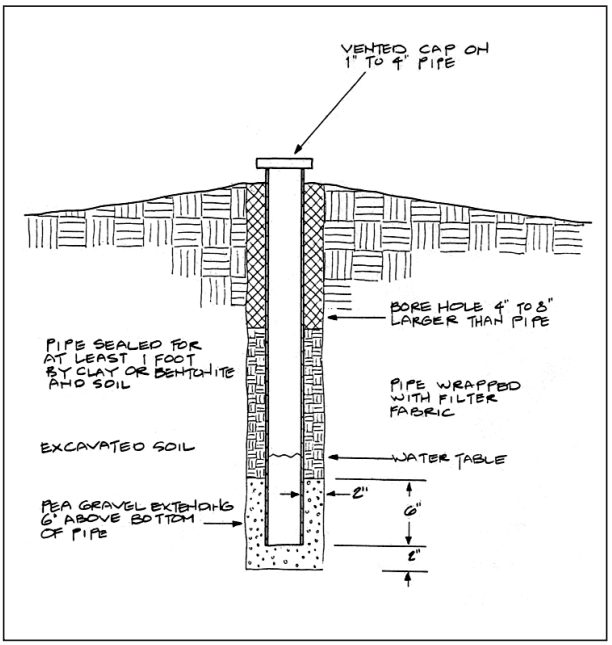


Figure 3. *A sea of PVC pipes sticking out of a farmer's field means someone is monitoring groundwater levels using "observation wells." Developers may do this to evaluate dewatering efforts on a wet site, or to clarify seasonal water levels when disputed. They are sometimes used to identify when groundwater is low enough to conduct a perc test.*

Another problem, says Veneman, is that many communities require that perc tests be conducted in the spring. This makes no sense, says Veneman, since "when you soak a hole [prior to the test], you saturate the ground. Saturated soil is saturated soil" no mater what time of year.

Furthermore, the deep hole test determines the water table, not the perc test. The perc test's purpose is to measure the soil's ability to drain water. You can't determine this if the soil is under water, so why not do it when the water table is highest. Even if that were the object, the high groundwater level may exist in March one year and in October the next.

Another pitfall is that engineers who work straight from perc-rate tables may overlook the soil's ability to cleanse sewage. A disposal system built on sandy Cape Code, for example, might need only 4 square feet of leaching area according to the perc test results because the drainage is so good. That might be true if there was only one house on every 15 acres of land. But, put a house on every quarter acre and you have created a drastically different situation. The sewage in the second case may seriously contaminate the groundwater because the effluent was not exposed to enough surface area of soil to cleanse it. In a sense, the perc rates were too good.

Observation Wells

Have you ever wondered what those white plastic pipes were that you sometimes see sticking out of the ground in the middle of a rural lot? These are called observation wells and are used to monitor the groundwater level (see Figure 3).

Many towns require deep hole tests to be run during the spring, but allow perc tests to be conducted any time of year. A deep hole dug in the spring may be full of water, but an above-grade system could still be approved if the soil were permeable. So some engineers install observation tubes into the "wet holes," fill in around the tube and wait for the water table to drop before conducting a perc test.

Observation wells are also used to monitor water-table levels while designers try to de-water a site. High groundwater can be lowered on a problem site by using various ditch-and-drain techniques. But, we are talking about a marginal lot here!

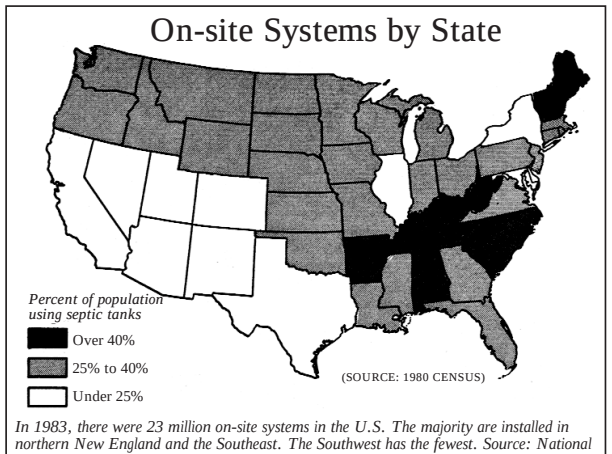
Some contractors like to test their lots in the fall so they are ready to build in the spring. They dig their deep hole in the fall, log the soil profile, run a perc test, install a couple of observation wells and close up the excavations. In the spring the board of health comes back and checks the groundwater level, the only item left to approve.

Trends

Perhaps the future success of on-site sewage disposal rests not on whether towns require perc testing, or whether we have 8 feet of permeable soil beneath our system, but rather on the professional maintenance of these systems. As Stephen Dix, of the National Small Flows Clearinghouse (see "For More Information," below) puts it, "Right now our management strategy stops as soon as we turn the disposal system over to the homeowner. That's just like running your car without a dipstick and waiting for the engine to die." There is little doubt that professionally operated systems will be with us in the future. Whether these will be administered by states, towns, or individuals is anybody's guess. The challenge is left to our communities to educate users and develop strategies that assure proper maintenance.

For More Information

For info about on-site septic design and regulation , contact the National Small Flows Clearinghouse, 617 Spruce St., P.O. Box 6064, Morgantown, WV 26506-6064; 800/624-8301. The Clearinghouse is funded by the EPA to provide information to communities and individuals. ■



In 1983, there were 23 million on-site systems in the U.S. The majority are installed in northern New England and the Southeast. The Southwest has the fewest. Source: National Small Flows Clearinghouse.

Paul Fisette is a wood technologist and director of the Building Materials Technology & Management program, at the University of Mass., in Amherst, Mass.