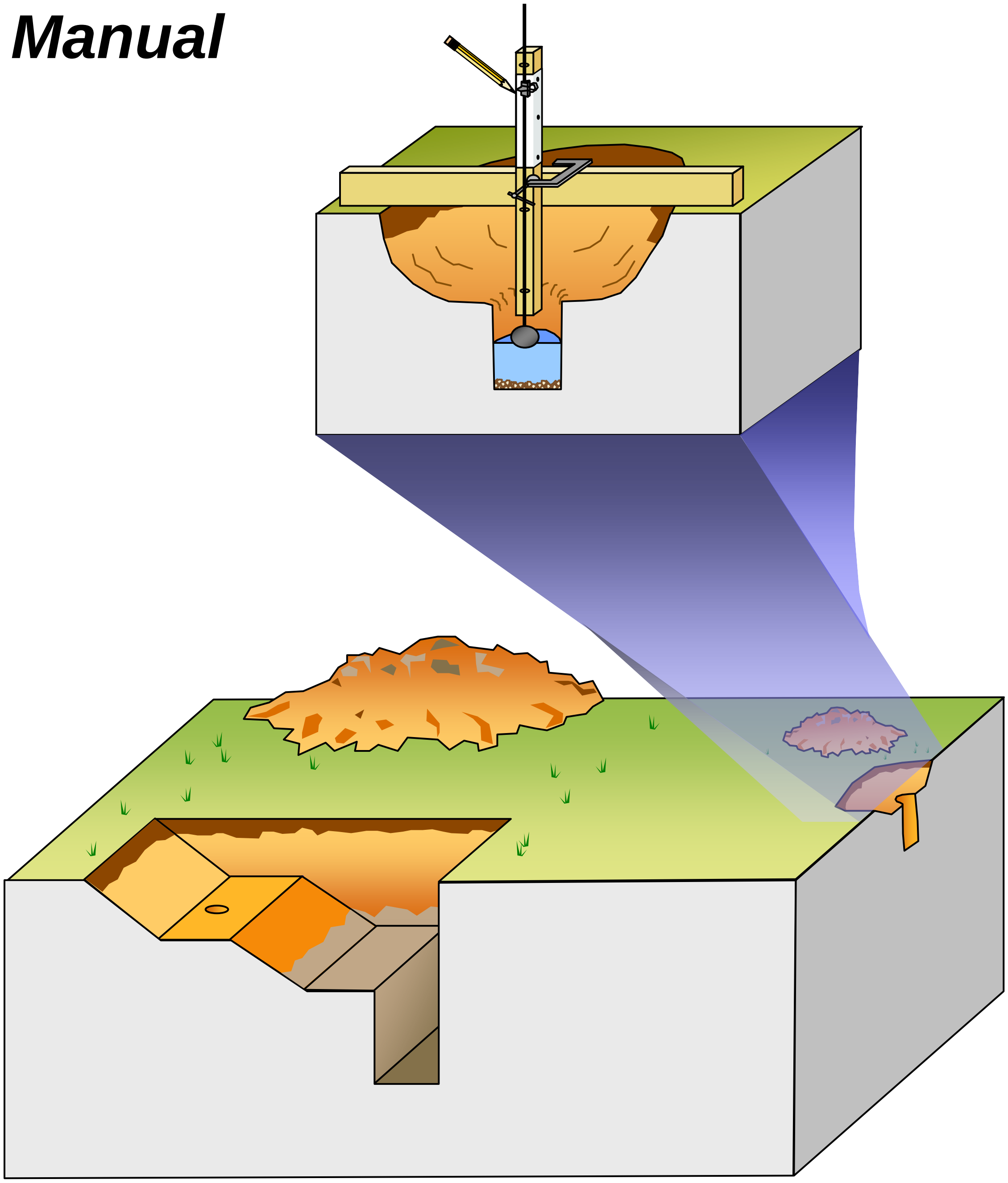
CNMI Division of Environmental Quality

Percolation Testing
Manual



August, 2007

CNMI Division of Environmental Quality, P.O. Box 501304, Saipan, MP 96950

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1. Foreword

Purpose of this manual

This manual is meant to serve as "interim" guidance to persons performing percolation tests in support of DEQ "IWDS" and "Earthmoving and Erosion Control" permit applications. "Interim" means that this manual is meant to serve as temporary guidance until such time DEQ updates its regulations and requirements, which may occur within the next few years. The procedures outlined in this manual are based primarily on the existing DEQ regulations governing the performance of percolation tests (found in Section 10 of the CNMI Wastewater Treatment and Disposal Regulations, 24 Com. Reg. 11, Nov. 27, 2002, starting at page 19800). However, in recognition of changing best practices in percolation testing, a number of changes have been made to the DEQ procedures in this document.

Over the past several years, DEQ has noted an increased lack of conformance with the procedures contained in even the original regulations. Many of the practices currently in use by persons performing percolation tests, as a paid service, result in inaccurate measurements and, increasingly, inaccurate interpretations of the test measurements themselves. These discrepancies in procedure and analysis may result in failure to properly design the system for the actual site soils and conditions. At best, such discrepancies may result in unnecessary construction costs for owners who must pay for facilities that are larger than necessary. At worst, owners as well as the general public may face excessive future costs to replace or repair inadequately sized facilities, and may be forced to suffer the inconvenience and public health consequences associated with a failed on-site wastewater or stormwater system.

It is for these reasons that DEQ is taking the preventative measure of educating and certifying soil percolation testers. As a matter of policy, all persons conducting percolation tests after the date of publication of this manual and the first DEQ-sponsored workshop will be required to learn the contents of this manual and demonstrate their competency to DEQ, through hands-on exercises and written examination.

WHAT THIS MANUAL IS NOT: This manual is not a comprehensive guide to the practice of site or soil assessment. A comprehensive site or soil assessment is meant to support a working design for an on-site wastewater treatment system or stormwater system, and involves much more than just the percolation test. DEQ intends to provide future training and potentially certification requirements for site soil evaluators.

2. Introduction

The percolation test has been the single most important input to the design of septic systems for the past 80 years, and with few refinements, has remained essentially the same since Henry Ryon introduced the test in 1924 as part of an investigation into the causes of failed subsurface disposal systems in New York State.

It has only been within the last decade or so that significant moves have been made to move away from the soil percolation test as the primary controlling factor in the design of on-site wastewater disposal systems. Many states have already adopted, or are considering adopting, design guidelines based more on the overall assessment of the site's suitability for subsurface disposal of wastewater or stormwater. In these more modern methods, the design is based on a more detailed assessment of the site soils, hydrogeology, and landscape setting. The percolation test takes a lesser role, and in some cases, is eliminated.

However, the soil percolation test is still the most practical way to obtain a quantitative indication of the hydraulic conductivity of the subsoil. As such, it will remain a significant aspect of overall site and soil assessment practices into the foreseeable future, regardless of what changes may occur in the regulations or design standards. Thus, the ability to perform a percolation test in a manner that provides accurate and repeatable results is of paramount importance for any person engaged in the practice of evaluating soils and sites for future construction or development.

This manual is intended to serve as an interim guide to the practice of performing soil percolation tests. It may be superseded in the future by changes in the regulation or guidance concerning soil evaluator certification. However, given that the percolation test has not changed much over the decades since Ryon first introduced it, it is entirely possible that this manual may simply be adopted as part of a larger program to educate and certify site soil evaluators.

Because the focus of this manual is primarily the performance and interpretation of the percolation test, much less attention is given to the other aspects of site evaluation. Do not be misled by this lack of emphasis – the soil percolation test is just one, relatively minor aspect of the overall site and soil evaluation that you should be performing as a matter of best service for your clients. Until DEQ develops more comprehensive guidance, the parts of this manual that are aimed at overall site assessment are meant purely to guide you to other, more detailed references and training opportunities.

Remember this: even the smartest, best soil evaluators and engineers are only as smart as material that they were trained on, and are only as up-to-date as their last training.

There are many resources available to learn from, and many of them are free. Chapter 9 of this manual contains a list of suggested reading materials, must-have references, and web-sites. All percolation testers should read and re-read these materials until they are intimately familiar with them.

How to use this manual

This manual may seem longer and more detailed than it needs to be. The fact is, the percolation test itself is a very simple procedure. Once you learn the procedures, you will probably not need to refer back to this manual. A quick reference sheet is provided in the appendix that summarizes the important information on one page. This can be laminated and attached to your clipboard for field use. This manual can then sit on the shelf, and be pulled down only when you have questions, or need to copy one of the forms provided in the Appendices.

The revised test procedures are designed to be flexible. In order to responsibly use this flexibility, it is helpful to keep in mind what we call the "overriding principles" of the percolation test. With these in mind, it should be easy to decide what you need to do in any given situation:

OVERRIDING PRINCIPLES

In order to obtain useful results that can be used with the soil absorption factors and other design guidelines, the following principles must be applied:

1. The test must be performed in soils that are representative of the final leaching field (or stormwater infiltrative practice).
   - *location & depth must be the same as proposed practice*

2. The test methods must be uniform & repeatable
   - *all tests must follow standardized procedures*

3. The test must be performed under simulated worst-case, saturated soil conditions.
   - *pre-soaking procedures must be followed*

4. The final reported percolation rate must represent steady-state conditions.
   - *enough measurements must be taken to show that rate of drop is steady*

References

Salvato, J.A., Nemerow, N.L., Agardy, F.J. 2003. *Environmental Engineering (Fifth Edition)*. John Wiley & Sons, Inc. Hoboken, NJ.

3. The Role of the Percolation Test

Although the percolation test remains an important factor in the sizing and design of on-site wastewater and stormwater disposal facilities, there are many other factors that influence the ultimate performance and success of these systems. Most other states in the U.S. have established "Site Assessment" or "Soil Evaluator" training, procedures, and certification requirements that minimize the importance of the percolation test, in favor of an overall assessment and evaluation of a site's soils, hydrogeology, landscape position, and wastewater treatment system capabilities.

In fact, some states have entirely removed the percolation test from their site assessment requirements in favor of selecting "Long Term Acceptance Rates" (the so-called "LTAR approach") based purely on soil texture and structure. The latest USEPA design guidance (2002) favors this approach.

Again, this manual is not meant to serve as a thorough guide to proper, overall site assessment. It is only meant to describe the procedures for conducting the percolation test. However, it is of critical importance that every percolation tester understands the role of the percolation test, and its limitations. As a professional matter, it is in your best interest to understand that a seemingly acceptable percolation rate may not, in fact, mean that a successful septic system (or "IWDS") can be built at that site.

Imagine, if you will, being hired to perform a percolation test for a client who's property is located in Susupe, Saipan, just to the east of Texas Road. You arrive on a sunny May morning, easily dig your percolation test pit to a depth of 36 inches in the silty sand soil, and obtain a promising percolation rate of 12 inches per hour. You provide this test to the engineer, who then develops the IWDS design, and both of you walk away from the project while the client builds his building.

2 weeks after construction is finished in October, you receive an angry call from your client accusing you of incompetence, because his septic tank has backed up and wastewater is flowing from the floor drains in the employees' restroom.

What happened? Seasonally high groundwater! The water table beneath the site has risen to near the depth of the leaching field due to the fact that it's now the rainy season and the Susupe wetlands are just 300 feet away. The reduced hydraulic efficiency of the leaching field has caused the effluent to "mound" up into the leaching field, and the wastewater now has nowhere to go, so it has backed up into the septic tank and the building sewer, and is causing that load of laundry from the second floor to come spewing out the floor drains on the first floor. If you have ever experienced this, you will understand why your client is so angry.

If you had dug a soil observation pit to 4 feet below the bottom of the leaching field, you might have directly observed the water table, lurking down there at its dry season depth. Or, if you had evaluated the soils even within in your percolation test pit you might have seen the mottling (redoximorphic features) that would have warned you of a seasonally high water table. And, if you had checked your USGS topographic map, NRCS Soil Survey, or even just looked around on your way to the site, the nearby wetland might have tipped you off that you might suspect a problem.

We'd like to think that we're all smarter and more experienced than that. But the fact remains that as long as we rely *only* on the percolation test, this can AND WILL happen.

So what should a thorough, comprehensive site & soil evaluation include? There are many sources of guidance available on the internet and in print, and the author of this report has read through more than you probably want to know about. For the most part, they are all pretty much the same. So, for the sake of convenience, we have decided to borrow mostly from the Massachusetts (MA) state soil evaluator training and certification program. Why? For no better reason than it is the same program that we have previously used to guide the development of DEQ's stormwater and erosion control soil tester's training materials.

By the way: try not to miss the occasional stormwater designers workshop that DEQ holds. These usually include a one-day soils workshop in which the art and science of soil evaluation is discussed in more detail.

Training materials for the MA soil evaluator's course are available on the web at this URL:

http://www.mass.gov/dep/water/compliance/traini03.htm

Additionally, our recommended methods borrow heavily from the 1980 USEPA Design Manual for Onsite Wastewater Treatment and Disposal Systems, Chapter 3:

http://www.epa.gov/owm/septic/pubs/septic_1980_osdm_all.pdf

As well as O. Benjamin Kaplan's 1987 *Septic Systems Handbook*.

The following is a brief outline of what should be included in a thorough site soil evaluation, based on a compilation of procedures contained in the MA and USEPA guidance.

RECOMMENDED SITE SOIL EVAULATION PROCEDURES:

A thorough site soil evaluation should consist of the following steps. Note that this is an outline of actions that you should be taking. This is not an outline for your final site evaluation report, which is detailed in Chapter 5:

- Client Contact
- Preliminary evaluation
- Visual survey
- Deep Observation Hole
- Percolation Test
- Reporting of results & recommendations

A brief summary of each step follows. For a more in-depth review, see the MA training materials cited above, and the references listed in Chapter 9. Of course, it must be pointed out that good practice necessitates a working knowledge of soils and hydrogeology that can only be obtained through additional study, training and experience not found in the references. In order to provide meaningful advice to your customers, there is no substitute for a deep understanding of the underlying principles and processes. Future DEQ training may provide some of this, but self-study is encouraged, starting with the references listed in Chapter 9 of this manual (many of which are available for free on the internet!)

• *Client Contact*

Before you do anything, you need to understand the specific needs of your client and their project. Is it a simple residence? Is it a dog kennel? Is it a restaurant? Is it a reverse-osmosis brine disposal field? Does you client intend to use your report to design both his stormwater systems and his septic system? The wastewater characteristics of each of these potential uses are considerably different and will affect the way in which you approach your site evaluation. Additionally, your client may have specific and long-term knowledge of the site, including previous percolation tests or geotechnical soil boring reports, and may be able to point out problems such as seasonal flooding that can focus your efforts to a particular location and save a great deal of time in the field. Ask your client where underground utilities and other potential hazards to your life and health are located.

Also, this is the time to ensure that your client fully understands the limitations of your evaluation and your needs for information and, if necessary and agreed on, the client's cooperation with entry and provision of equipment.

• *Preliminary evaluation*

This step consists of reviewing all available information on the site prior to your field visit. Sources should include USGS topographic, geologic, and hydrology maps, USDA-NRCS Soil Survey information, aerial photographs (Google Earth is now a good, free source), and other information that may be available to you, such as GIS (geographical information system) layers for public wells. The information you gather during this stage can save considerable time in the field by locating potential setbacks and estimating excavation needs (e.g., whether to expect hard limestone). This is also an excellent time to get a jump on the paperwork – the NRCS soil survey can tip you off on what to expect. Never forget: the soil survey is a general (though very useful) tool, but it is no substitute for an on-site soil investigation. As NRCS says, individual inclusions of different soil types may be found anywhere within the area mapped as one particular soil series. ***Never*** rely only on the soil survey – ***Always*** examine the site soils for yourself and make your own determination.

Experience:

They say there is no substitute for experience. This definitely holds true in the site evaluation business. A useful source of experience is the staff of DEQ – because they see every percolation test, every septic system excavation, and they receive every complaint regarding failed septic systems. Unfortunately this data is not presently compiled in any readily accessible form. However, the DEQ staff are always available to answer questions and can give you an idea of whether or not there has been an unusually high number of septic system failures in an area.

- ***Visual survey***

The goal of the visual survey is to establish landscape position, and to identify setback concerns such as wells, watercourses, or structures. The lot should be examined visually to determine the best location, if any, to locate a leaching field or stormwater disposal system, or (frequently) both. Things like depressions, rock outcrops, and vegetation indicative of wet areas should be noted on the site plan, and avoided. Elevation and slope should be taken into account. Wastewater has nothing special over water – it still flows down hill. So make sure you provide your client with a recommendation that will still allow for gravity flow from the building to the septic system, or likewise, from the developed area to the proposed stormwater treatment and disposal system.

- ***Deep Observation Hole***

The purpose of the deep observation hole is to determine the soil profile, identify restrictive horizons, and check for seasonally high groundwater. It is important to distinguish this hole from the percolation test pits, which are generally smaller and shallower. Excavation of the deep observation hole will usually require a backhoe, and a portion of the hole must go to a minimum depth equal to 3-4 feet below the bottom of the leaching field, which would therefore be about 6-7 feet. It is not necessary to excavate below the depth of the leaching field if limestone is encountered, unless a high water table is suspected. Keep in mind OSHA safety requirements – excavations deeper than 5 feet require a protective system be in place (except for excavations in competent rock). (See Chapter 4)

- ***Soil profile determination***

Using the deep observation hole, the soil profile is examined and described in detail, following the USDA field description process. This process involves identifying all soil horizons and describing the color, texture, structure and consistence within each. Proper description requires knowledge, training and experience in the USDA soil description procedures. Special attention is provided to identifying restrictive horizons (layers of low permeability clay or rock) and the signs of seasonally high groundwater. Identification of one of these restrictions can significantly impact system design.

- ***Percolation Test***

The percolation test is a simple procedure that provides a quantitative measure of how much water the site soils can absorb. The test does not provide a "true" measure of soil permeability / transmissivity. Instead, the main purpose of the test is to provide information that is then used by the designers to choose the size of the leaching field or stormwater infiltration system. The results should always be checked against the other site and soil information obtained, to make sure that realistic percolation rate has been chosen.

Chapter 6 describes the percolation test in detail.

References

Kaplan, B.O. 1987. *Septic Systems Handbook*. Lewis Publishers. Chelsea, Michigan.

Salvato, J.A., Nemerow, N.L., Agardy, F.J. 2003. *Environmental Engineering (Fifth Edition)*. John Wiley & Sons, Inc. Hoboken, NJ.

U.S. Environmental Protection Agency. 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (EPA 625/1-80-012). U.S. EPA Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH.

US Environmental Protection Agency. 2001. *Seepage Pits May Endanger Ground Water Quality* (EPA 909-F-01-001). U.S. EPA Region 9 Ground Water Office (WTR-9), San Francisco, CA.

U.S. Environmental Protection Agency. 2002. *Onsite Wastewater Treatment Systems Manual* (EPA 625/R-00/008). U.S. EPA National Risk Management Research Laboratory, Cincinnati, OH.

Oregon Department of Environmental Quality – Onsite Systems Home: http://www.deq.state.or.us/wq/onsite/onsite.htm

Massachusetts Department of Environmental Protection, Soil Evaluator Training Course:
http://www.mass.gov/dep/water/compliance/traini03.htm

4. Safety

Safety is so important that it deserves its own chapter.

What's so dangerous about percolation testing? Not so much. But once you start working in your deep observation holes, which you should be excavating to depths of 6 to 7 feet, you have entered into one of the most dangerous hazard zones recognized in the world of construction.

4.1 Trench Collapse

Many people die needlessly every year on construction sites from trench collapses. Don't think it can happen here? Think again!

Figure 4.1: An actual trench collapse accident in the Lower Base area of Saipan. The depth of the trench was about 5 feet. Soil type appears to be either backfill, or coastal alluvial sediments, which are very common along Saipan's west coast. Note the severely broken leg.

(1994, courtesy EFC Engineers & Architects)

OSHA regulations require that a "protective system" be in place for any excavation deeper than 5 feet that workers will enter. The U.S. Army Corps of Engineers requires a maximum un-shored trench depth of just 4 feet in its own test pit safety guidance. DEQ is of the opinion that entry into any pit deeper than 4 to 5 feet is unnecessary and should be avoided at all cost.

DEQ: METHOD ONE: AVOIDANCE!

If you don't have to get yourself down deeper than 4 to 5 feet, the best method is simply to not do it. Here are a couple of examples, based on ideas from the USACE and Oregon DEQ, of soil test pit "designs" that avoid the need for expensive shoring.

Safe Deep Test Pit #1:

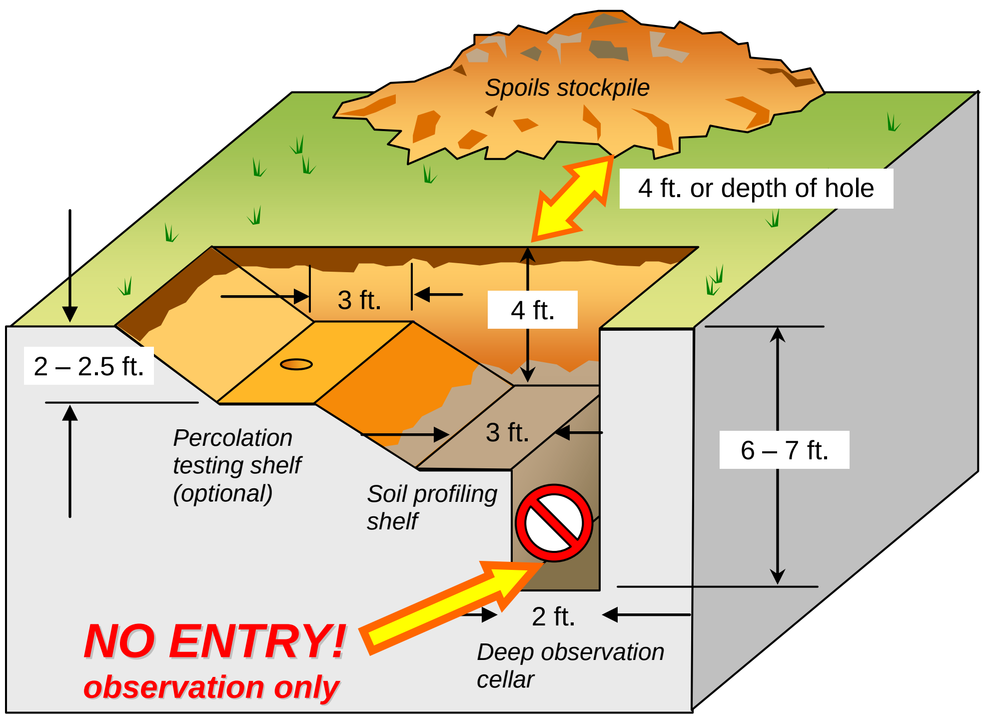


Figure 4.2: Example of a safe deep soil observation pit, making use of a 2 ft. wide "cellar" at one end for checking depth to groundwater. Personnel entry is restricted from "cellar." Hole is backfilled immediately after soil evaluation. Entry/exit ramp is sloped no steeper than 45 degrees (1:1 slope).

:

Safe Deep Test Pit #2:

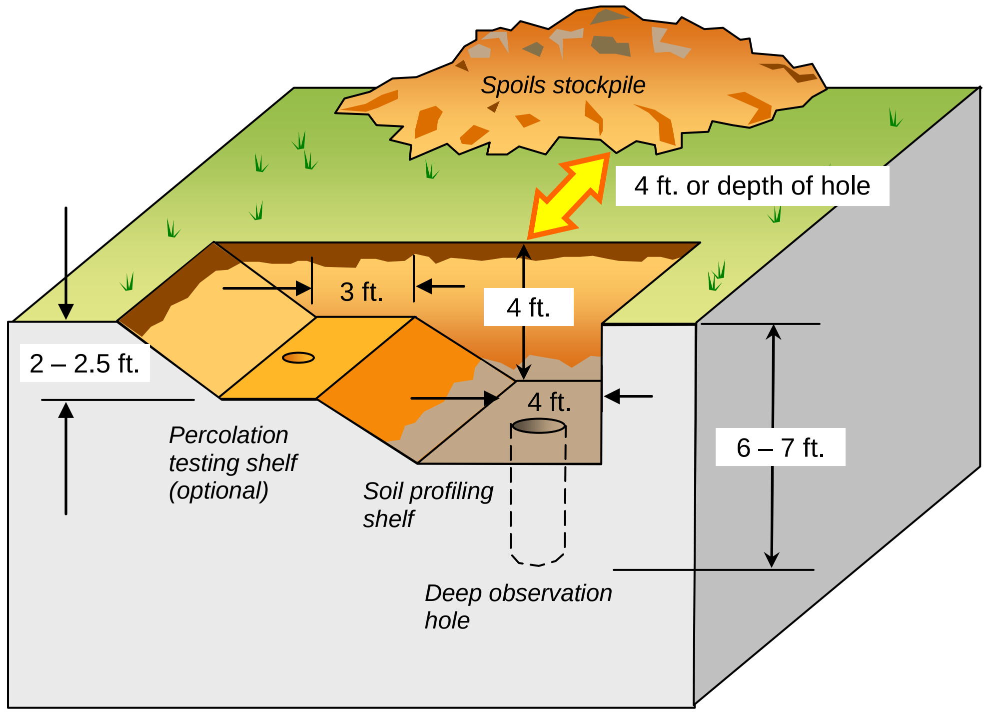


Figure 4.2: Example of a safe deep soil observation pit, making use of a hand-dug or augered hole at one end for checking depth to groundwater. Entry/exit ramp is sloped no steeper than 45 degrees (1:1 slope).

Additional Excavation Safety Rules, applicable to ALL pits:

- To prevent collapse, excavated material should be stockpiled no closer than 4 feet away from the edge of the test pit, or a distance equal to the depth of the pit; whichever is greater.
- Do not park any vehicles near the edge of your test pit. The extra weight on the soil could lead to a collapse.
- ALWAYS backfill your test pits after your work is completed. If you are leaving a deep observation pit unattended overnight, tape it off very clearly with yellow "CAUTION" tape. Smaller percolation test pits should be covered with plywood if left overnight and not covered by your soaking bottle, and also flagged with caution tape

OSHA EXCAVATION SAFETY RULES

If for some reason you cannot use one of the safe observation pit designs given above, and you or your employees must physically enter a hole deeper than 5 feet, then OSHA safety requirements for excavations will definitely apply. [See OSHA Regulations (Standards - 29 CFR), 1926.650].

Keep in mind, however, that excavations into "competent rock" do not require protective measures. This would include most limestone, but be very careful in applying this exemption – there are some instances where even an excavation into limestone can be unstable.

The following is a brief description of the OSHA requirements, reprinted from the on-line OSHA Guidance 226, located at URL:

http://www.osha.gov/Publications/osha2226.pdf

According to this OSHA document, any excavation deeper than 5 feet which workers are required to enter requires a "protective system" to be employed. The choice of protective system is up to the employer, and in general are chosen from the three following methods:

OSHA: Method 1 — Slope the sides to an angle not steeper than 1-1/2:1; for example, for every foot of depth, the trench must be excavated back 1-1/2 feet. All simple slope excavations 20 feet (6.11 meters) or less deep should have a maximum allowable slope of 1-1/2:1. These slopes must be excavated to form configurations similar to those for Type C soil, as described in Appendix B of the standard. A slope of this gradation or less is safe for any type of soil.

OSHA: Method 2 — Use tabulated data such as tables and charts approved by a registered professional engineer to design the excavation. These data must be in writing and must include enough explanatory information, including the criteria for making a selection and the limits on the use of the data, for the user to make a selection. At least one copy of the data, including the identity of the registered professional engineer who approved it, must be kept at the worksite during construction of the protective system. After the system is completed, the data may be stored away from the jobsite, but a copy must be provided upon request to the Assistant Secretary of Labor for OSHA.

OSHA: Method 3 — Use a trench box or shield designed or approved by a registered professional engineer or based on tabulated data prepared or approved by a registered professional engineer. Timber, aluminum, or other suitable materials may also be used. OSHA standards permit the use of a trench shield (also known as a welder's hut) if it provides the same level of protection or more than the appropriate shoring system.

4.2 Buried Utilities

It's not just trench collapses that can injure or kill you. Buried utilities pose a threat as well. Digging into an underground electrical conduit can end your life very fast. Digging into a water line, phone line, or sewer line might not kill you, but it can certainly ruin your day and destroy any profit you might have made on your soil evaluation, since you will be responsible for the repair costs.

It's always good practice to check with the CUC and landowner regarding the potential for buried utilities. Even though electricity may be delivered above ground, strung from poles, there may also be below-ground conduits if there are any nearby buildings. Look for electrical service connection risers as a general precaution:

Water lines are difficult to locate, and oftentimes can only be found by a knowledgeable landowner or resident. Things to look for include concrete service connection boxes and water meters, but there are many locations in the CNMI where the connection point is buried with no markings at all.

If you are performing a percolation test for a septic system, you probably don't need to worry about hitting a sewer line. If the test is for a stormwater system, and there are nearby existing buildings, then you need to look out for it. Sewer pipes can difficult to locate, but CUC can usually tell you where the main lines and laterals are. Manhole covers are an obvious indicator. Service connections from buildings can often be found by looking for ground cleanouts near the building foundation, pointing in the general direction of the pipe that connects to the main or lateral located under the street.

Phone lines are generally buried at a depth of about 6 inches, and are easy to damage. Thus, locating any potential phone lines should be a priority. Junction boxes on the street are an obvious indicator, but are not always present – you should assume that buried phone lines are present if there's a building on the property. The owner may be able to help you locate it, but if not, remember to call the phone company.

4.3 Unexploded Ordnance

Photo courtesy Bob Gavenda, NRCS

Unexploded Ordnance or "UXO" is a hazard that must be acknowledged in the Marianas. Our islands were bombarded with hundreds of thousands of projectiles during the actual battle, and a significant percentage of those rounds did not explode. After the battle, millions of rounds of explosives were stored in large facilities around the island, and when the military left, they typically did a poor job of removing them. In some parts of the island, particularly Marpi and Naftan, there are hundreds of acres that are literally peppered with UXO that was scattered by hasty and incomplete attempts to detonate the leftover ordnance in place.

Excavating a test pit in most parts of the island runs a risk of encountering UXO. Excavations in certain areas such as Marpi and Naftan run a greater risk, because those are the areas where ammunition was stored and then scattered by incomplete attempts at removal after the war. Although it is rare for UXO to detonate upon contact with excavation equipment, the risk is there. A professional UXO survey is the best way to eliminate this risk. However, it is simply not practical with small excavations such as soil test pits. Therefore, a common-sense approach is recommended.

The following UXO safety "rules of thumb" were developed by and are re-printed here with the permission of Mr. John Scott, President of Ampro, a company with considerable expertise in the detection and removal of UXO in the CNMI and Guam:

1. Encountering Unexploded Ordnance (UXO) is always a possibility when excavating in former battle sites throughout the CNMI. Construction contractors should exercise care and take precautions and protective measures whenever excavating in these areas.

2. Construction projects which involve excavation into subsurface layers run the risk of encountering UXO. Precautions must be taken to identify whether the site contains UXO or not during the initial site assessment phases of the project.

3. If UXO is not found in significant quantities based on an initial site assessment, the project may proceed without further UXO support. Occasional encounters of small numbers of UXO may be dealt with by contacting the CNMI Department of Public Safety and having their Explosive Response Team remove these items from the site.

4. If UXO is found in significant quantities the contractor will arrange for remediation of the UXO along with any other hazardous wastes at the site through

5. The Deep Observation Pit

5.2 Purpose

The new DEQ percolation test procedures require at least one "deep observation pit" per project. There are important reasons for this:

Purpose of the deep observation pit:

- to expose the soil profile for examination
- to check for "restrictive horizons"
- to check for groundwater

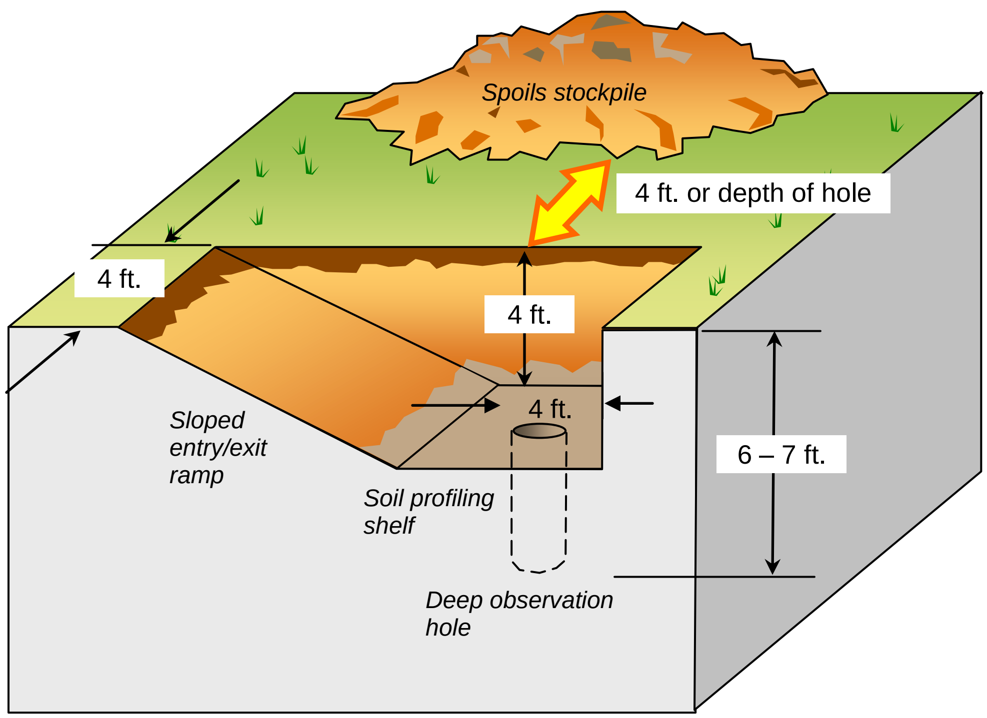


Figure 5.1: Dimensions & layout of the basic deep observation pit. Other variations are illustrated in Chapter 4 (Safety), and in the Appendix (sample instructions to excavators)

5.2 Exceptions

There are exceptions to the deep observation pit rule. In many areas of Saipan, Tinian, and Rota, the soil profile is too thin to matter and there is little chance of encountering groundwater. This is most common in areas of limestone geology. In those areas, a deep observation pit is not needed, and a percolation test is all that is required.

The Limestone Exception:

A deep observation pit may not be required if ALL of the following can be shown to apply:

- The bottom of the leaching field or other infiltrative practice will be in limestone
- Ground elevation is greater than 10 ft. above mean sea level.
- The site is not within 100 feet of:
  - an area identified as volcanic rock based on observation and/or USGS geological maps.
  - a wetland
  - a stream

Although this exception can be applied in many areas, be very careful with it:

This exception applies only to limestone, and under the conditions listed above!

If DEQ arrives and finds that your percolation test pits are located in soil, or there is a wetland or area of volcanic rock nearby, you may be required to dig a deep observation pit.

5.3 Location & Number

Only one deep observation pit is required for project sizes up to one acre, unless differing soil types are encountered at the proposed locations of leaching fields and infiltrative practices. Facilities larger than one acre may require more than one deep observation pit, but only if infiltrative practices are proposed in more than one location. The number of observation pits will depend on the number, size, and location of infiltrative practices. Keep in mind the overriding principle of representative soil types.

The deep observation pit should be excavated as near to the proposed infiltrative practice as possible, but never in the same location! The reason for this is differential settlement: after the pit is backfilled, the fill will continue to settle for some time, and cause a depression that could easily break a PVC leach line or plastic infiltrator chamber (see Fig. 5.2 & 5.3).

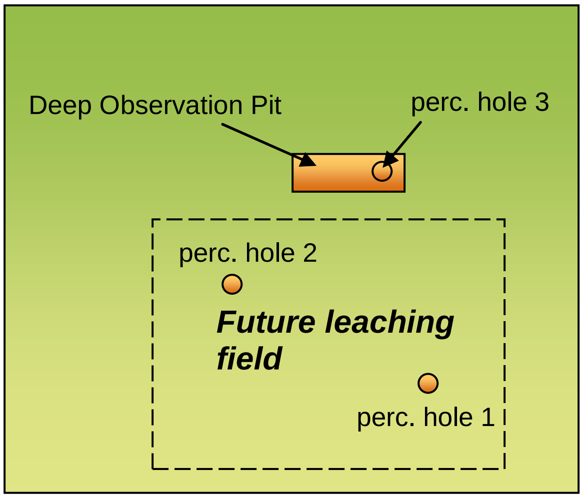


Figure 5.2: The deep observation pit should be located just outside the proposed future leaching field or stormwater infiltration system.

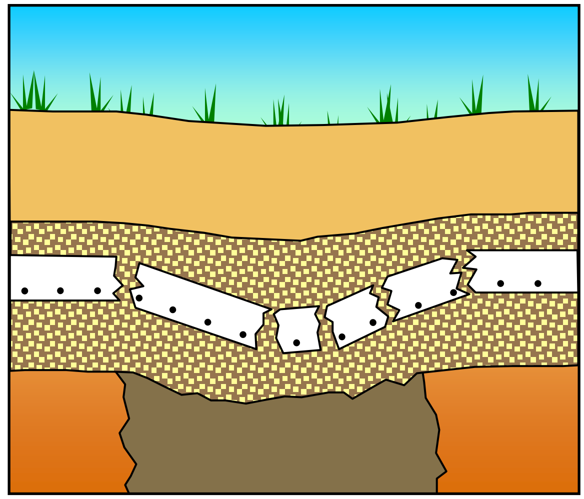


Figure 5.3: Broken drain lines are a possible consequence of locating the deep observation pit within the future leaching field. Differential settlement will occur, and can easily snap PVC pipe and degrade leaching field performance.

5.4 Soil Profile

One of the main purposes of the deep observation pit is to provide a detailed look at the soil profile. The soil profile information can be used to verify percolation test data, predict the performance of future septic systems, and especially to identify possible problems, such as restrictive horizons and seasonally high groundwater.

Since the primary purpose of this manual is percolation testing, the methods used to develop a proper soil profile description will not be detailed. Accurate soil profiling requires considerably more instruction and practice than can be provided in this manual. Accordingly, all that will be provided with this manual is a sample deep observation pit log sheet, located in Appendix 2. DEQ hopes to able to provide additional training on this subject in the future.

For now, we'll primarily focus on the identification of the potential problems of restrictive horizons, and high groundwater.

Restrictive Horizons

"Restrictive horizons" refers to layers or soil or rock that would restrict the flow of wastewater through the subsurface. An example would be a layer of impermeable (water-tight) clay, or a layer of solid volcanic rock. Such a layer would prevent the free drainage of wastewater from a leaching field, if found within a certain distance from the bottom. In most cases, a leaching field will simply not function if a restrictive horizon is found within 3 to 4 feet of its bottom. It will simply fill up with water, and then the entire septic system will fail. Thus, it is very important to identify such horizons.

In Saipan, restrictive horizons, if they are found, will usually be apparent within the first few feet of any hole. Generally, such conditions are found only in areas of volcanic geology. There are certain areas of deep clay soils, however, such as in Kagman 1, and parts of As Lito, Fina Sisu, and As Perdido, where very impermeable clays can be found from just below the surface, to a foot or two down. Failed septic systems are very common in these areas.

Groundwater

The DEQ regulations require the bottom of the leaching field to be no less than 3 feet above the highest groundwater level. The bottoms of seepage pits (which are not recommended by DEQ) are to be no less than 5 feet above groundwater. There are a couple of reasons for this. The first reason is the generally accepted rule of thumb that wastewater should pass through at least 3 feet of unsaturated *soil* (note: limestone is not soil) to provide adequate treatment and effectively remove pathogens (bacteria, viruses, etc.). The second is simple hydraulics – the wastewater will not flow as quickly out of the leaching field if groundwater is any nearer than 3 feet, for a number of reasons. In other words, leaching fields that are installed close to groundwater (within 3 feet) just don't work.

The deep boring or cellar is meant to check for the presence of groundwater. Hence the requirement that the deepest portion extend to more than 3 feet below the depth of the proposed leaching field, so that any groundwater will be visible. Be patient – allow a few hours to pass before checking. It can take time for groundwater to seep into the excavation.

However, just because you don't find groundwater in your deep observation pit doesn't mean it isn't there. "Seasonally high groundwater" (meaning groundwater levels that rise during the rainy season, for example) can occur in a number of limited areas around the islands, particularly near wetlands, streams, or in certain deep, clayey soils. If groundwater spends any amount of time in a soil it leaves its mark in the form of "redoximorphic" features, which discolor the soil and leave a "mottled" appearance, as well as other features. A trained soil evaluator will be able to distinguish these markings and make a determination of the high water level in a soil. How exactly to do this goes beyond the scope of this manual, however.

References:

Kaplan, B.O. 1987. *Septic Systems Handbook*. Lewis Publishers. Chelsea, Michigan.

U.S. Environmental Protection Agency. 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (EPA 625/1-80-012). U.S. EPA Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH.

U.S. Environmental Protection Agency. 2002. *Onsite Wastewater Treatment Systems Manual* (EPA 625/R-00/008). U.S. EPA National Risk Management Research Laboratory, Cincinnati, OH.

Oregon Department of Environmental Quality – Onsite Systems Home: http://www.deq.state.or.us/wq/onsite/onsite.htm

Massachusetts Department of Environmental Protection, Soil Evaluator Training Course:
http://www.mass.gov/dep/water/compliance/traini03.htm

6. The Percolation Test

6.1 Purpose & Principles

The old percolation test procedures covered just one page of the DEQ regulations. The new procedures aren't much longer. This chapter is considerably longer than either version of the regulations, but only because it tries to explain the new procedures in as much detail as necessary, especially the new focus on flexibility.

Yes, you heard that right: DEQ procedures that are *more flexible!* But this flexibility carries with it a requirement for more skill and responsibility on the part of the percolation tester. This chapter will try to explain as best as possible how to exercise that responsibility. However, it is not our intention to create a whole new set of requirements that must be memorized. Instead, what we want is for the percolation tester to understand the overriding principles behind the percolation test, and to be able to apply those principles to make on-the-spot decisions.

With that in mind, here are the basic, overriding principles that are to guide every decision you make as a percolation tester:

OVERRIDING PRINCIPLES

In order to obtain useful results that can be used with the soil absorption factors and other design guidelines, the following principles must be applied:

1. The test must be performed in soils that are representative of the final leaching field (or stormwater infiltrative practice).
   - *location & depth must be the same as proposed practice*

2. The test methods must be uniform & repeatable
   - *all tests must follow standardized procedures*

3. The test must be performed under simulated worst-case, saturated soil conditions.
   - *pre-soaking procedures must be followed*

4. The final reported percolation rate must represent steady-state conditions.
   - *enough measurements must be taken to show that rate of drop is steady*

6.2 The Hole

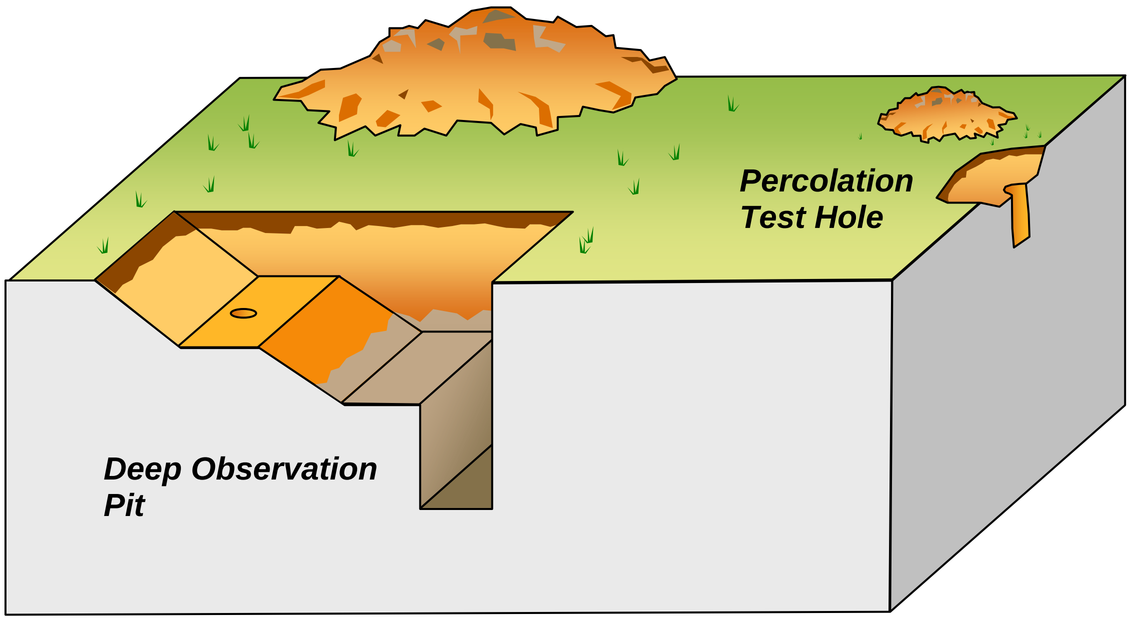


Fig. 6.1: The deep observation pit has a different purpose than the percolation test hole(s). They must be different pits.

Perc. Hole vs. Deep Observation Pit

These are not the same hole and have two entirely different purposes. The deep observation pit is meant to expose the soil profile for examination and to check for groundwater and restrictive horizons. It must be large enough for the evaluator to enter, and deep enough to expose all potential problems within 3 to 4 feet of the bottom of the proposed leaching field or stormwater infiltration practice.

On the opposite end of the spectrum, the percolation test hole is a single-purpose hole, and no one needs to physically get inside of it. So, it can be much smaller, and because of that, you can (and should) dig more than just one.

Where?

The percolation test pits should obviously be located within the area that the proposed practice is to be located, whether it be a leaching field or stormwater infiltrator. The deep observation pit should never be located within the footprint of the proposed leaching field. Why? Because when it is backfilled, the backfill material has a tendency to settle. If one part of the leaching field is settling, while the rest is not, this creates a big problem for the distribution pipes. They will either bend to the point where they don't distribute the wastewater very well anymore, or they will break.

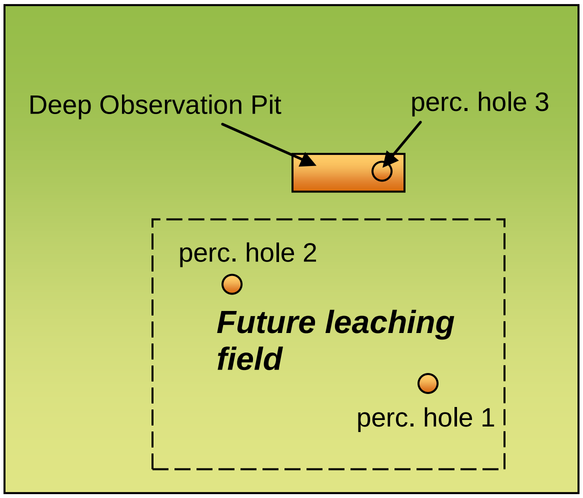


Figure 6.2: The deep observation pit should be located just outside the proposed future leaching field or stormwater infiltration system. At least two percolation tests should be performed within the proposed leach field. If three tests are performed, one may be within the deep observation pit.

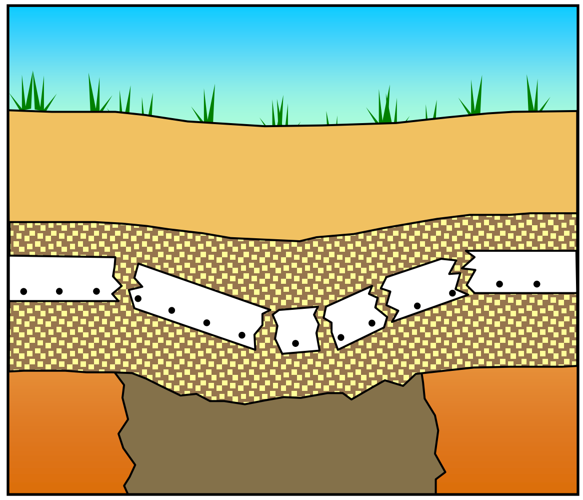


Figure 6.3: Broken drain lines are a possible consequence of locating the deep observation pit within the future leaching field. Differential settlement will occur, and can easily snap PVC pipe and degrade leaching field performance.

How many?

The old (1993) DEQ regulations require only one percolation test hole.

USEPA recommends a minimum of **three test holes**.

The final design percolation rate is then the average (arithmetic mean) of the three measured rates (with some exceptions – see the section on calculating results).
The new procedures require only one hole for residences and sites less than ½ acre, but recommends a minimum of three holes. Three holes are now required for all non-single family residence projects larger than ½ acre.

Numerous studies have determined that percolation rate can vary significantly from one hole to another, even in the same soils in the same small area. A conscientious percolation tester will take this into account and make three test holes within the proposed leaching field area. For larger facilities, or facilities with more than one leaching field or stormwater disposal practice, a larger number of tests should be performed.

Some sites in the CNMI can have huge variations in percolation rate. This happens most frequently in limestone geology, which can have a very irregular interface with the soil: One six inch pit may appear to be in a deep, silty clay loam, while a hole just a few feet away might be in clean, fast-percolating limestone (see Fig. 6.4).

Figure 6.4: Typical limestone / soil interface. 6-inch percolation test pits just a foot or two apart can give very different percolation rates. (Photo courtesy Bob Gavenda, NRCS)

How Big?

The DEQ regulations require a hole diameter between 4 inches and 12 inches. This manual requires a hole diameter of 6 inches in order to be consistent with the methods used in determining the soil absorption factors that will be used in the leach field design.

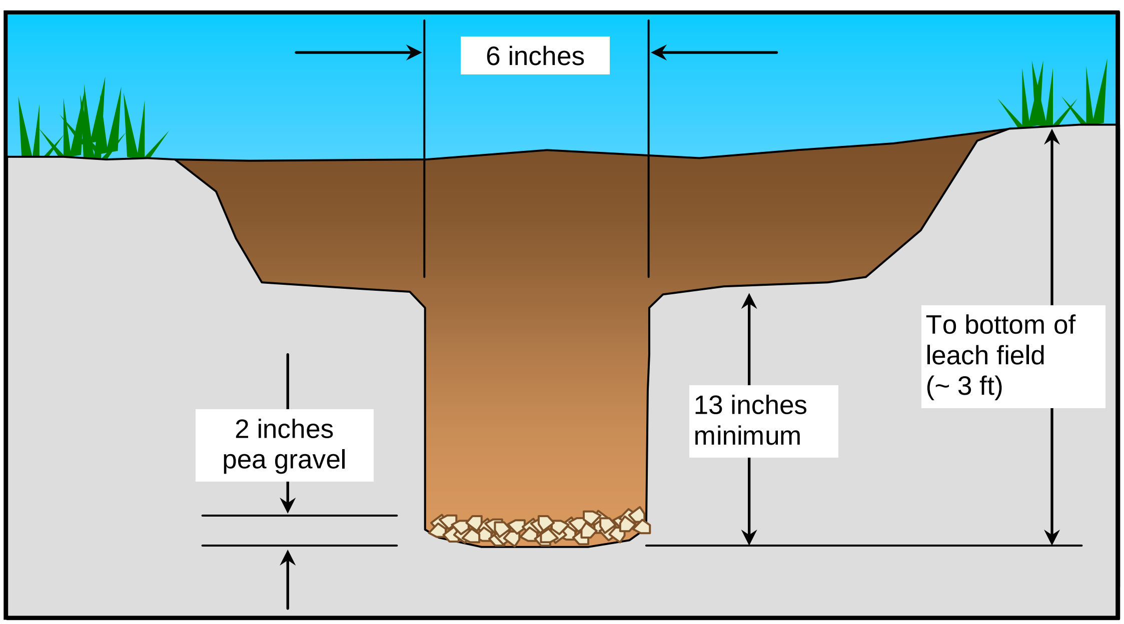


Figure 6.5: Standard percolation test pit dimensions

- diameter: 6 inches (5.5 to 6.5 inches)
- depth: to near proposed bottom of leaching field (~36 inches is adequate)

Note that since the maximum water depth for pre-soaking and testing is only 12 inches, the upper parts of the hole may be larger for ease in excavation. (See Fig. 6.5)

Can larger holes be used?

Yes. Particularly in limestone and other rocky soils, it is usually not possible to obtain a precise 6-inch diameter boring without expensive drilling equipment. Larger holes may also be used in other soils, but keep this in mind: larger diameter holes may give a slower percolation rate than found in the standard 6 inch hole. DEQ will accept this because it is more conservative – in other words, it results in a larger leaching field or infiltration system. However, this will obviously cost your client more money than may be necessary, so you will need to weigh the added convenience of digging a larger hole against the additional cost to your client. Good practice would dictate that you take every measure possible to provide the 6 inch hole specified in this method.

Limestone:

If solid limestone is reached, the depth of the percolation test pit may be reduced to provide a minimum depth of 12 inches below the limestone / soil interface. If the interface is irregular, excavate to a depth that provides 12 inches of what seems to be the best representative condition, but not to below the proposed bottom depth of the leaching field (see Figures 6.6, 6.7).

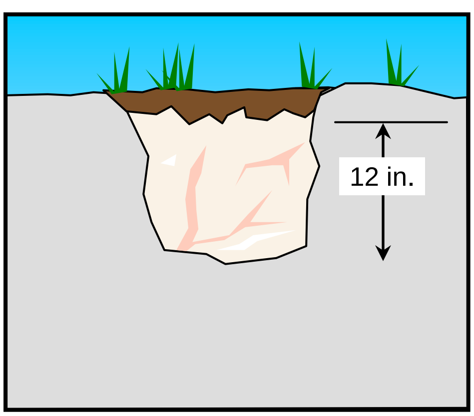


Fig. 6.6: The percolation test may be conducted at a shallower depth (but no less than 12 inches) in clean limestone.

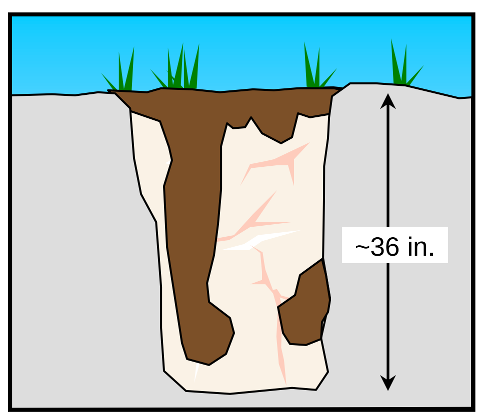


Fig. 6.7: The percolation test should be conducted at full depth if any soil inclusions are present.

"Restrictive horizons":

If a restrictive horizon is identified in the deep observation hole within 3 feet of the bottom of the leaching field (6 ft. below ground surface), the percolation test should be conducted within that soil horizon. The depth of the percolation test pit would therefore be 13 inches below the limiting horizon. Remember, by "restrictive horizon" we mean a layer of clay or other soils / rock that would have a *lower* percolation rate than the soils at the depth of the proposed leaching field. Limestone is not typically considered a restrictive layer in this sense – although it is not ideal for a number of other reasons.

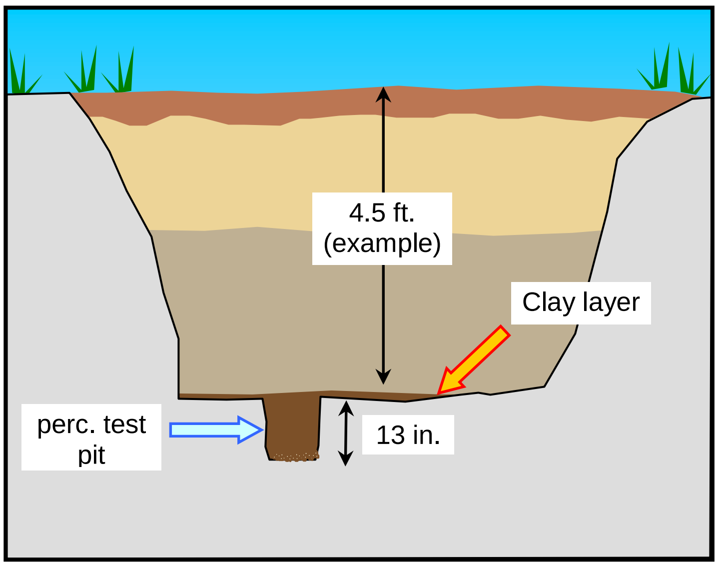


Fig. 6.8: A clay layer is found at 5 feet in the deep observation hole. Because this would be within 3 feet of the bottom of the leaching field, the percolation test must be conducted within the clay layer; NOT the overlying, more permeable soils.

Seepage pits:

Seepage pits are a special case. Seepage pits work within an entirely different hydraulic regime than leaching fields or trenches. The percolation test was not devised with seepage pits in mind.

Seepage pits are not recommended in most CNMI applications for the following reasons:

- Most soils located over limestone are very thin and the seepage pit thus discharges into the limestone, not the soil. A seepage pit located in limestone is merely an injection well, which is not an allowable method of wastewater disposal.
- As of 2001, the U.S. Environmental Protection Agency officially discourages the use of seepage pits for safety reasons and in order to protect groundwater.
- Some uses of seepage pits, including multi-residences and businesses, may be additionally regulated under USEPA injection well regulations.

- The depth of most seepage pits requires extensive shoring of the excavation to protect against collapse and meet OSHA safety requirements. The soil observation pit must be even deeper, and therefore safety requirements are even more stringent.

In the absence of any special guidance for seepage pit percolation testing methods, the percolation test shall be conducted at the proposed bottom depth of the seepage pit. This may be done within a (properly protected) deep observation hole, on a shelf located at the proposed depth (because, keep in mind, a portion of the observation hole for a seepage pit must extend to at least 6 feet below the bottom of the proposed seepage pit in order to confirm the depth of soil and check for evidence of high groundwater levels), or within a boring constructed as part of a site geotechnical investigation. Some references noted in this book (notably Kaplan) contain further guidance for conducting seepage pit tests, which may be acceptable.

Hole preparation:

In soils containing clay or fine silts, the sides of the hole should be scraped/roughened with a sharp object to eliminate any "smearing" in clayey soils. Experienced soil evaluators recommend "peeling" away the compacted layers with a nail or knife. In this respect, the hole may be bored with a standard 4-inch hand auger, and then enlarged through "peeling" to the 5.5 to 6.5 inch required diameter.

A 2-inch layer of course sand or gravel must be placed at the bottom of the hole to prevent scouring of the bottom soil while filling the hole with water.

6.3 Notifying DEQ

Greater responsibilities and trust are major components of the new rules. A certified percolation tester will have proven that he/she has the skills necessary to provide accurate percolation rates for facility design, and will understand the importance of being truthful and reliable.

Therefore, it will no longer be necessary for DEQ to witness every percolation test. However, in order to monitor the performance of certified testers, and in order to maintain the public trust, DEQ may, at any time, stop by unannounced to observe a percolation test or pre-soaking, or to observe that test pits have been backfilled after testing. Thus, for every percolation test performed, it is required that DEQ be contacted 24 hours in advance and notified of the time that pre-soaking will start, and the time that the test is expected to go forward.

NOTIFICATION RULE:

DEQ must be notified by fax or hand delivery at least 24 hours in advance of every percolation test. The notification must include a location map, the pre-soaking start time, and the estimated percolation test start time.

A sample notification form is included in Appendix 2.

How to estimate when pre-soaking will be completed:

It is possible to guess whether or not a percolation test will be conducted on the same day or the day following the pre-soak based on the site soils.

Guidelines:

Soil type	Measurement Interval
Clean limestone, sand	Same day, after 5 gallons absorbed
Clayey soils, mixed limestone	Following day

6.3 Pre-Soaking

DEQ regulations require that the hole be filled with water up to 12 inches and left to soak for at least 8 hours; and "preferably" overnight. The USEPA recommended test requires simply that the test be performed at least 15 hours after soaking, but no more than 24 hours. In other words, overnight. Kaplan suggests a slightly modified approach that requires only that the soil absorb a standard volume of water (5 gallons), or overnight; whichever comes first. DEQ has decided to adopt the Kaplan procedure:

Soaking:

Fill hole with 12 in. of clear water (10 in. above the gravel or bottom of perforated can)

a. If twice 10 in. seeps away in less than 10 min and soil is coarse-textured (sand, limestone), testing can be conducted immediately; otherwise:
b. For 6 inch diameter holes: maintain level (8-16 in.) overnight, or until 5 gallons have been absorbed.
c. For larger diameter holes: Provide enough water to maintain level (8-16 in.) overnight. This may be considerably more than 5 gallons.

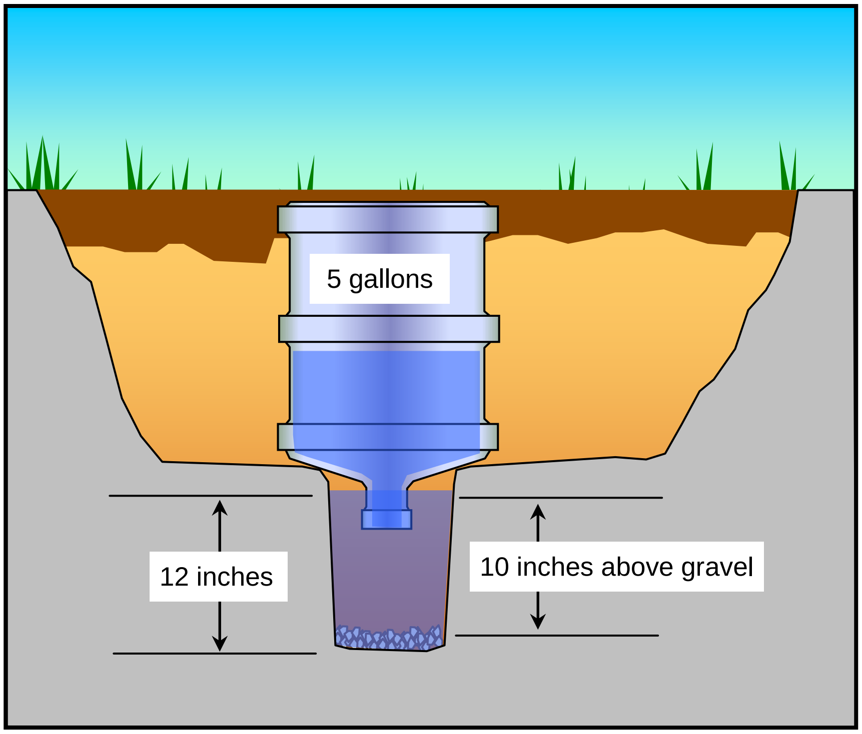


Figure 6.9: Inverting a 5-gallon water bottle over the hole is a good way to maintain the 12-inches required depth while the hole remains unattended, for example, overnight. Just make sure the bottle is securely supported so that it doesn't fall down and spill the remaining contents. Also, be careful not to scour the bottom or sides of the hole while filling in this manner. Once the bottle is inverted, the water in the hole will remain calm, just like in an office or home water dispenser.

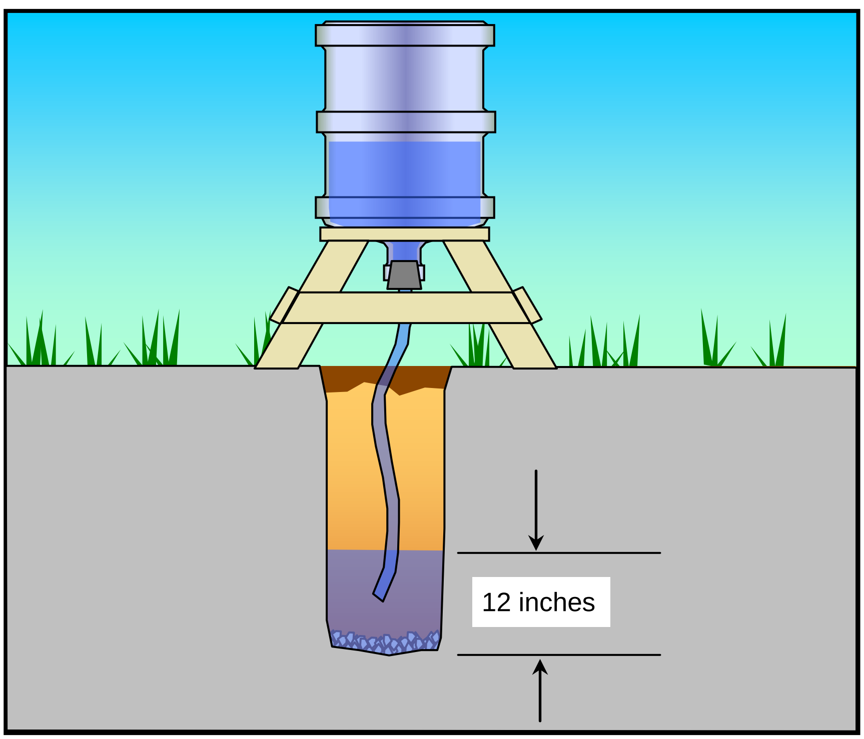


Figure 6.10: Another option for maintaining the required 12-inch depth while 5 gallons of water is absorbed. The use of a stopper and tubing allows the water bottle to be located above, or even to the side of the percolation test hole. Again, make sure the bottle is secured – a simple wooden stand would work.

Limestone:

As mentioned, in limestone or sand, or any other soil where 10 inches of water seeps away in less than 10 minutes for two consecutive re-fillings, the percolation test measurements may begin right away.

The 5-gallon rule only applies to a 6-inch test hole!

Larger holes will require more water to meet the pre-soaking rules, and there are no quick guidelines or rules of thumb for how to ensure that will happen. It is therefore in the percolation tester's best interest to use the standard 6-inch hole.

The purpose for the pre-soaking is twofold:

1. To simulate worst-case, saturated rainy-season conditions;
2. To allow full swelling of expanding clay soils to occur.

Many clays, including soils found on Saipan, expand when wet and become less permeable (giving a lower percolation rate). Some clays, in fact, can expand and seal themselves so well that they become essentially non-permeable. That is why clays are used as liners for landfills and man-made ponds. Needless to say, a clay that would make a good landfill liner would not make a good leaching field! Full expansion of clays can take several hours, and hence the overnight soaking requirement. Your client will definitely not be happy with you if you misjudge a tight, swelling clay soil.

6.4 Measurement

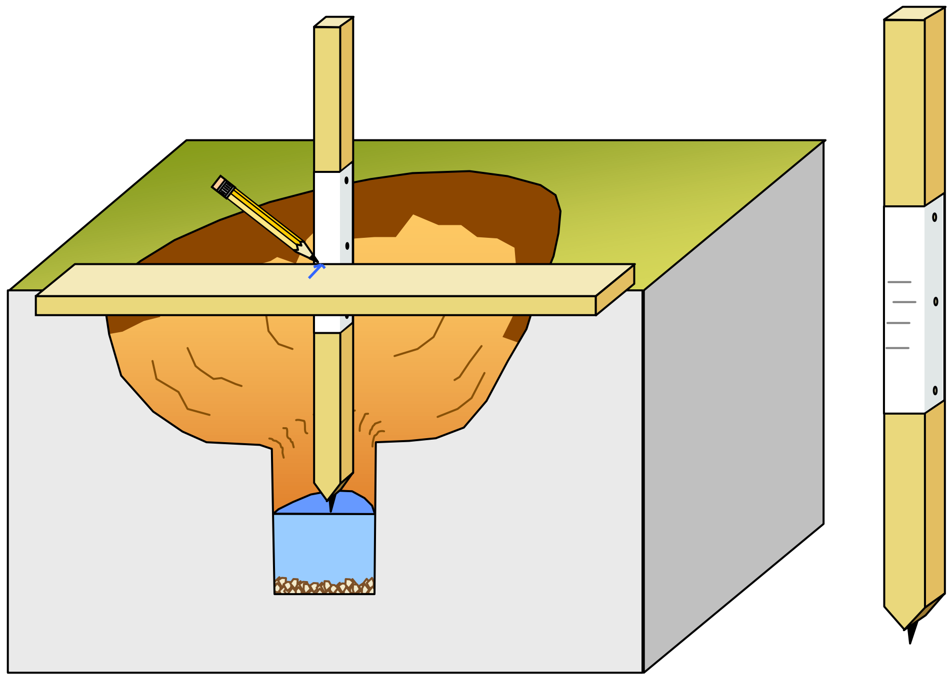


Figure 6.11: The simplest measurement apparatus is the use of a 2-by-4 cross bar and wooden measurement stick, which in this example is a ready-made stake. The stick is modified with a nail at the end to provide a more exact determination of water level in the hole. A paper is tacked to the measurement stick to provide a permanent record of the level measurements. The cross-bar is marked so that level measurements are always taken at the same point, to guard against errors caused by the cross-bar not being level.

Here's a blunt statement: measuring water levels in a hole is not rocket science! All you need is a reference to measure against, such as a two-by-four placed across the top of the pit, and a "stick" to mark water levels on.

We are providing two example measurement apparatus in this section, both taken from popular references. In the first, water level is measured in the simplest manner by lowering a pointed stick and marking the water level against a fixed cross-bar. The second example uses a float to reference the water level. Many more modifications of these designs may be possible to make the job of water level measurement easier. However, these two methods are in use around the world and are very simple to make and to use.

The cross-bar: It is very important that the cross-bar be firmly anchored to the ground! If it moves, you're going to have to start over again. At least for that particular measurement, anyway (you can just take a new reference level and re-start the 30-minute or 10-minute interval that was interrupted). Ways to stabilize the cross bar include big rocks, weights, long nails, or even tent stakes.

The cross-bar: It is also very important to make level markings at the same reference point on the cross bar. A reference mark (such as a magic-marker line or arrow) should be made, and all level marks should be made at that same point on the cross-bar. This ensures that each successive level marking is made at the same elevation, which compensates for the cross-bar not being level.

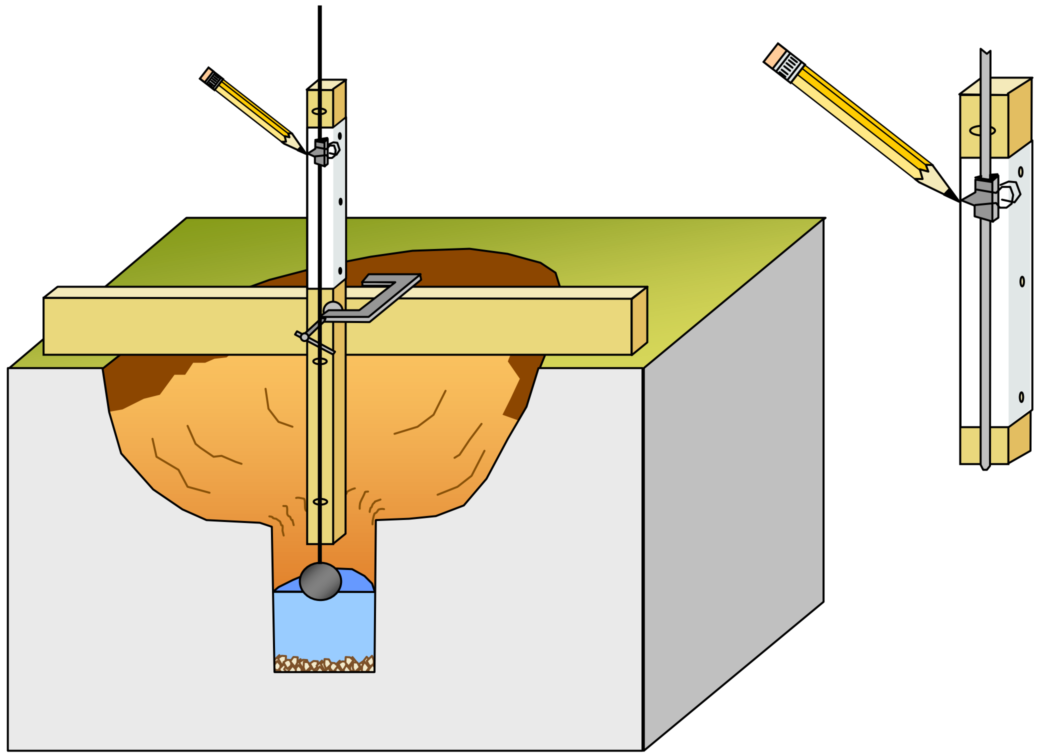


Figure 6.12: This method uses a float and rod to indicate water level. Eyelets are used to guide the float rod. A clip is attached to the moveable rod and used to mark the level on the measurement paper.

?

So why not just lower a yard stick into the water and measure the levels directly against it as the water drops? If you attended our classroom session you would know first hand why not: it is simply not possible to obtain an accurate measure of water level this way. For one, the water surface draws up around the ruler itself in a "meniscus" that makes it very difficult to judge just where the actual water level is. Secondly, it's even harder when you're trying to look 3 feet down into a 6-inch diameter hole. That's why the sharp nail works so well – as you lower the stick, the reflection of the nail and disturbance of the water surface is easy to see, and it is easy to obtain a level measurement within the 1/16th inch accuracy that is required. Similarly, a float system also provides a reliable measure of water level, once referenced to a starting point.

Depending on the soil type and initial percolation rate (which you observed while soaking the hole), you will be taking a level measurement every 30 minutes or every 10 minutes. Different measurement intervals may be used; 10 and 30 minute intervals were chosen to be consistent with the published procedures. Fast percolation rates will require shorter measurement intervals – but try to keep them at even minute intervals (example: 1 min, 5 min, etc.). Using even and uniform time intervals is crucial for knowing when to stop the test.

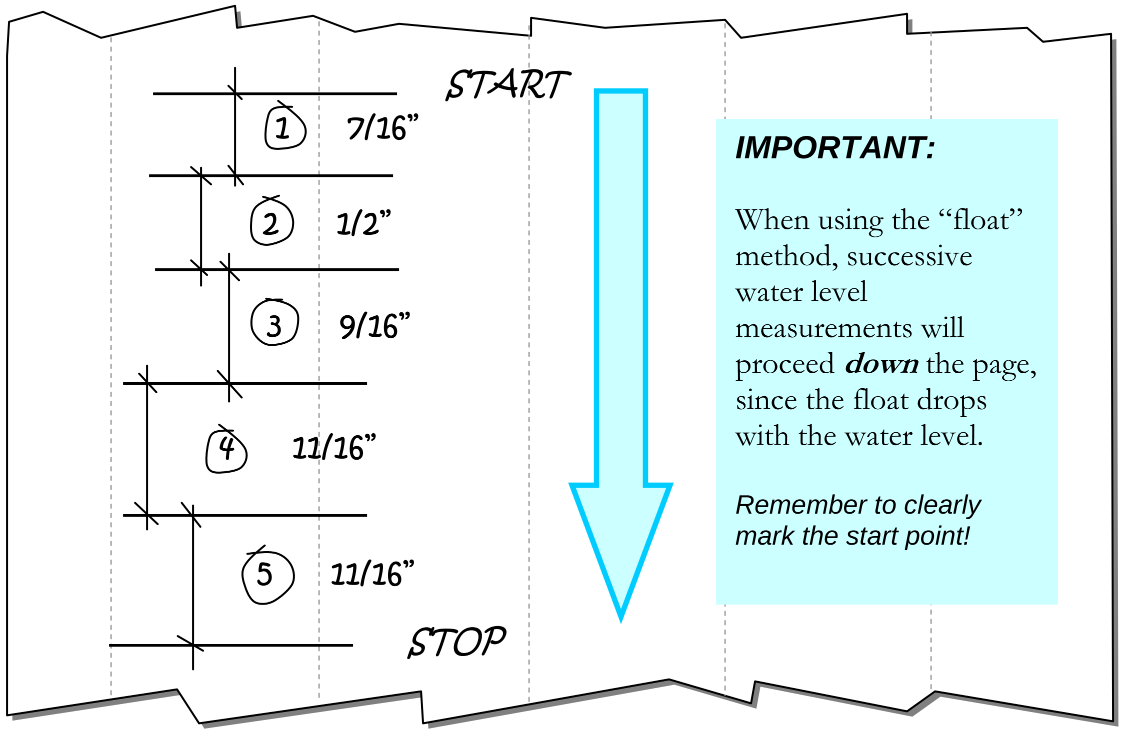
Each level measurement is referenced to the first measurement, so make sure you get the first measurement right, and do not move the cross-bar!

The Procedure:

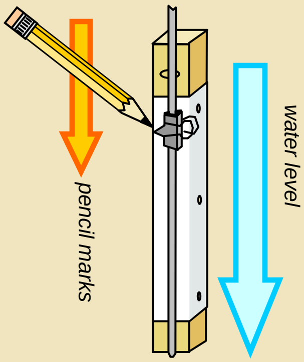
1 Starting at an initial water level 6 inches above the gravel (8 inches above the bottom of the pit), water levels are recorded either by lowering a batten (measuring stick) with a sharp tip and noting the point of contact, or with a float and rod apparatus.

To keep things simple and to provide a useful reference that can be cross-checked (by your client, by DEQ, and by yourself back at the office), we highly recommend that the levels be marked on a removable piece of paper tacked to the measurement batten. We recommend the following method of marking level measurement data (blank forms are included in the Appendix):

Figure 6.13: Example of how to mark & notate level markings using the removable measurement form. Level readings are marked as horizontal pencil marks, vertical measurement lines are drawn later to assist with measurement. Interval numbers and measurements are written in by hand.



Float Method:

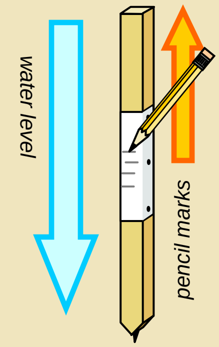


As the water level drops, so does the float. Pencil marks proceed *down* the page.

Be Careful! Depending on which method you use to make level measurements, the level markings will progress up, or down the page. If you don't carefully mark the "start" point, you run the risk of reversing the order of the measurements later in the office, and potentially using the first interval, instead of the last, for your calculations. That would be a serious error.

Always label the start point!

Stick Method:



As the water level drops, so does the stick. Pencil marks proceed *up* the page.

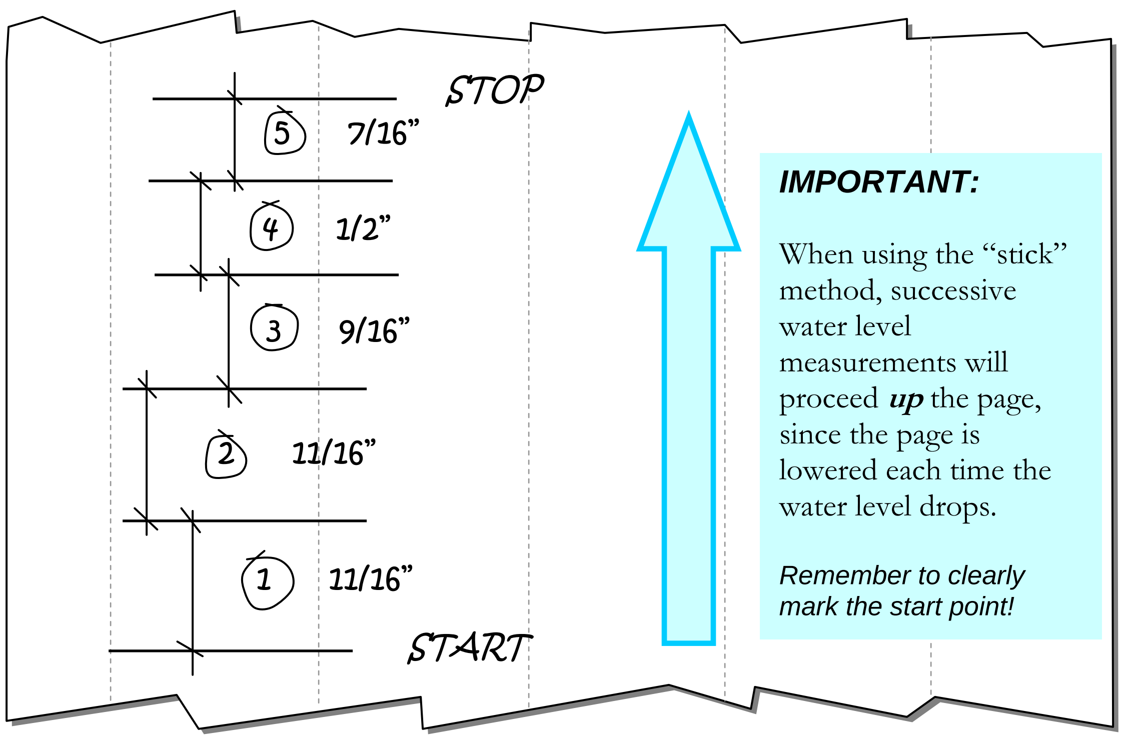


Figure 6.13: Example of how to mark & notate level markings using the removable measurement form. Level readings are marked as horizontal pencil marks, vertical measurement lines are drawn later to assist with measurement. Interval numbers and measurements are written in by hand.

2

Water levels are taken at even, uniform time intervals (30 minutes, 10 minutes, 5 minutes, 2 minutes, or 1 minute). The difference ("drop") between each water level is measured and numbered.

Choosing the measurement interval:

The appropriate time interval can be determined using a two step method involving an initial estimate based on the soil type and pre-soaking results, and observation of the first drop.

As a general guideline, the measurement interval should be chosen to provide a drop of 1 to 2 inches per interval. (a drop of less than 1 inch is unavoidable in clayey soils and other low permeability materials)

1. *Estimate:* An initial guess based on soil type will usually be correct. Based on DEQ experience with CNMI soils, the following can be considered a useful guide:

Soil type	Typical perc. rates (in./hr.)	*Measurement Interval*	Typical drop (in.)
Clayey soils	0.5 to 3.0	***30 min.***	0.25 to 1.5
Mixed limestone, alluvial sediments	4.0 to 10	***10 min.***	0.67 to 1.7
Clean limestone, silty sand	10 to 20	***5 min.***	0.83 to 1.7
Fractured limestone, sand	25 to 60	***2 min.***	0.83 to 2.0
Very fractured limestones, sands	60 +	***1 min.***	1.0 +

2. *Observation of first drop:* This can be used alone, or in conjunction with your best guess based on the above estimates. Start with the assumption that you will be using a 30 minute interval and then carefully observe the first drop. When it nears 1 to 2 inches, stop at the nearest, even minute interval.

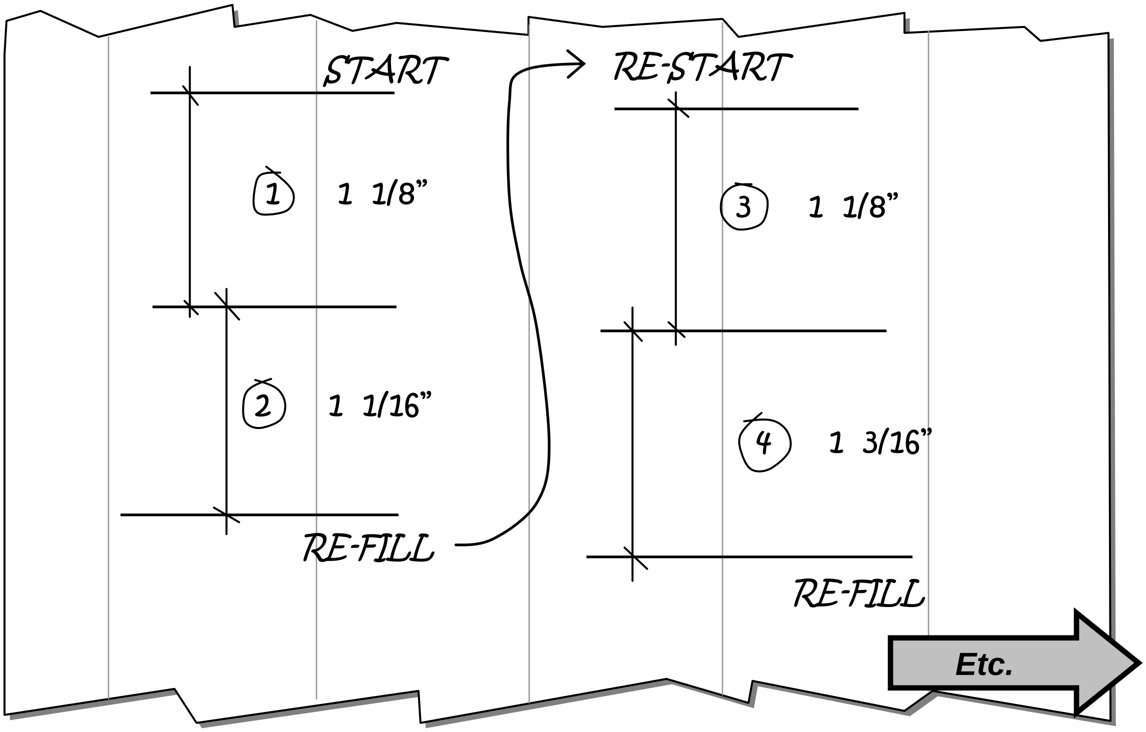


Figure 6.14: Example of how to mark & notate a re-fill during the percolation test.

Re-Filling the Hole:

It may become necessary to re-fill the hole to about 6 inches in order to complete the percolation test. Just make a note of it on your measurement paper and field data sheet so as to avoid confusion later (see Fig. 6.14).

3

The test is finished when:

1. The pre-determined minimum number of drops has been measured;

   and

2. The final three (3) drops differ by no more than a sixteenth of an inch.

   ***Or*:**

3. A maximum number of measurements has been exceeded.

HOW TO DECIDE WHEN THE TEST IS FINISHED

The procedures include rules about the minimum number of tests necessary, but they also provide for flexibility. Once again, choosing how to apply this flexibility will require good judgment on the part of the percolation tester. Overriding principles should therefore guide your decision:

OVERRIDING PRINCIPLE

4. The final reported percolation rate must represent steady-state conditions.
   - *enough measurements must be taken to show that rate of drop is steady*
   - *the final drop will be considered representative of steady-state if it differs from the previous 2 drops by no more than a sixteenth (1/16th) of an inch.*

"Steady state" means simply that the soil has reached it's maximum saturation point, at least for our level of accuracy, and the water is dropping at a constant, steady rate in the test hole. This is determined by ensuring that the same drop occurs over each uniform time interval. Because of measurement inaccuracies, "same" means within a sixteenth (1/16th) of an inch.

However, in order to make sure that good data is being obtained, good measurement practice dictates that a minimum number of drops be measured. The rule we have adopted is three measurements must be within 1/16th of an inch, and that a certain minimum number of tests shall be conducted before stopping. The minimum is determined based on measurement interval, which in turn is dictated by soil type:

Minimum number of measurements

Soil type	Measurement Interval	Minimum number of measurements (drops)
"Slow" soils	30 min.	**3** *and* *all 3 within +/- 1/16th*
'Fast" soils	10 min. or less	**6** *and* *final 3 within +/- 1/16th**

* Lower precision may be justified in very fast soils

Maximum number of measurements

Soil type	Measurement Interval	Maximum number of measurements (drops)
"Slow" soils	30 min.	**6** *(3 hours)*
"Fast" soils	10 min.	**10** *(1 hr., 40 min.)*
	5 min.	**10** *(50 min.)*
	2 min.	**10** *(20 min.)*
	1 min.	**10** *(10 min.)*

4 Once the above conditions have been met, the test is finished and the final percolation rate is determined based on the drop that occurs during the final time interval.

?

What if it rains?

Don't panic! You are simulating worst-case, rainy season conditions with your pre-soaking anyway, so there is no reason to get concerned about conducting your test during rainy weather.

Obviously, you don't want rain to directly enter you test pit, because that could easily exceed the 1/16th measurement accuracy. And if your test pit is receiving runoff, then your test should be discontinued.

General advice:

1. Carry an umbrella to protect the hole from showers.
2. Don't locate the test pit in an area where runoff will drain to.
3. Stop the test if it is obvious that runoff or excessive moisture is entering the pit.

The "Falling Head" percolation test

As a paid consultant, the professional percolation tester may want to consider following the "falling head" method of percolation testing, as described in the 1980 USEPA manual. The only difference from the above procedures is that the hole is refilled to a depth of 6 inches after every measurement. Thus, two measurements are required for each drop – a "new" starting point, and the interval drop measurement.

The main benefit to the falling head method is that it may sometimes result in a faster percolation rate, which may result in savings to your client when it comes to final construction costs. The reason for this is because the "head" or pressure of the water in the hole remains more constant. This means that you are always getting the benefit of the pressure that 6 inches of water exerts on the soil, to push the water through. In the method above, the water level continues to drop, and as it does, so does the pressure force behind the water. Theoretically, with everything else being constant, this means the percolation rate should slow down as the water level drops. The falling head method avoids this potential problem by keeping the water level constant.

It's not much harder than the method above, but it does require that you be careful in your measurement and field data keeping because you are taking a new starting level measurement for each drop.

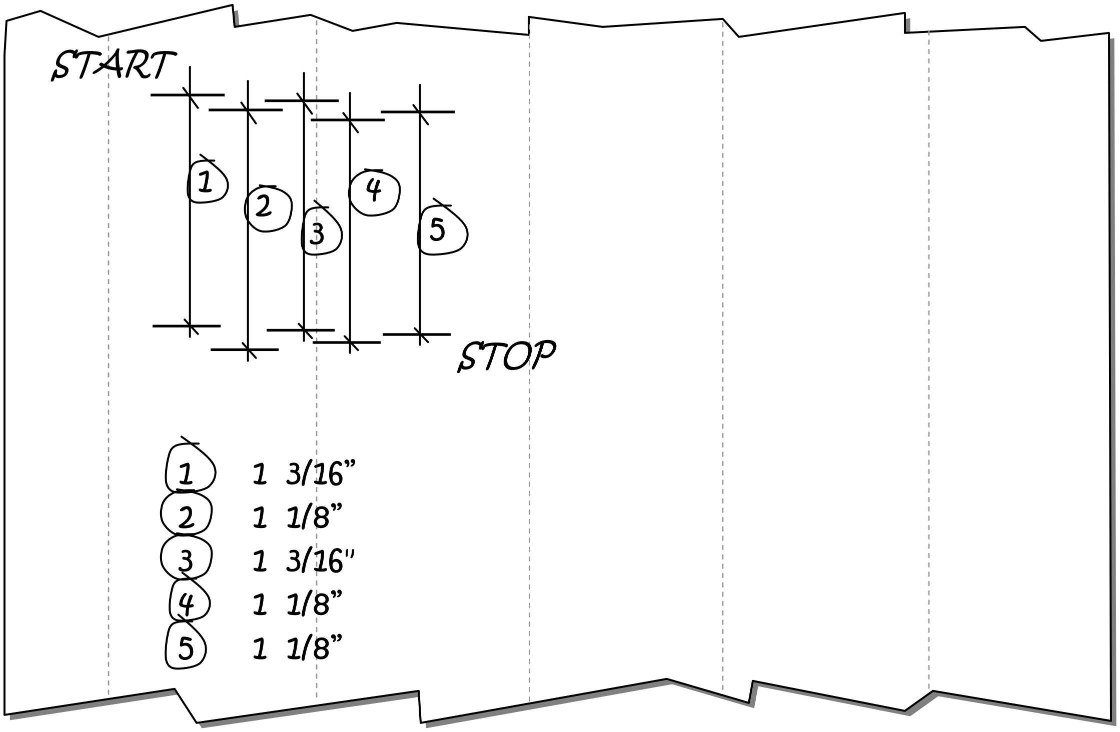


Figure 6.15: Example of how to mark & notate level markings using the "Falling Head" percolation test method, where the hole is re-filled to 6 inches between every measurement interval.

6.5 Calculation of Results

Calculating the final percolation rate is very simple, especially if you have followed the procedures above and taken level measurements at even, uniform time intervals: the final percolation rate is simply the drop that occurred during the final 30 or 10 minute interval. If shorter intervals are used, the method is the same - use the final drop that occurred.

Conversion to "inches per hour" is easy:

$$\text{percolation rate (in./hr.)} = \frac{\text{final drop (in.)}}{\text{time interval (min.)}} \times \frac{60\text{ min.}}{1\text{ hr.}}$$

Round all results to the nearest tenth of an inch (e.g. 12.1 in./hr.), except for slow percolation rates less than 2.0 inches per hour, which should be rounded to the nearest hundredth (e.g., 0.67 in./hr) for compatibility with the soil absorption factor tables.

Examples:

1. *30 min final drop of 5/16th inch:*

   [note: 5/16th inch = 5 ÷ 16 = 0.3125 inch]

$$\frac{0.3125 \text{ in.}}{30 \text{ min.}} \times \frac{60 \text{ min.}}{1 \text{ hr.}} = \underline{\mathbf{0.63 \text{ in./hr}}}$$

2. *10 min final drop of 1 3/8th inches:*

[note: 1 3/8th inches = 1 + (3 ÷ 8) = 1.375 inch]

$$\frac{1.375 \text{ in.}}{10 \text{ min.}} \times \frac{60 \text{ min.}}{1 \text{ hr.}} = \underline{\mathbf{8.3 \text{ in./hr}}}$$

3. *2 min final drop of 1 1/16th inches:*

[note: 1 1/16th inches = 1 + (1 ÷ 16) = 1.0625 inch]

$$\frac{1.0625 \text{ in.}}{2 \text{ min.}} \times \frac{60 \text{ min.}}{1 \text{ hr.}} = \underline{\mathbf{31.9 \text{ in./hr}}}$$

?

Final vs. "overall" percolation rate

The only percolation rate that needs to be reported is the final percolation rate. The so-called "overall" percolation rate is meaningless, so there is no need to compute it or report it. The only purpose of the measurements preceding the final interval is only to determine whether or not "steady state" conditions have been established, which is checked by ensuring that the previous three drops are nearly the same (within 1/16 of an inch of each other).

Averaging Multiple Percolation Rates:

If you have followed good practice as recommended by USEPA and many others, you now have three (3) or more percolation rates for your client's leaching field or stormwater practice. USEPA recommends that the final design percolation rate be the average of the three rates, unless the results are so different from each other that they indicate **variations in soil type** within the proposed leaching field area.

An average (arithmetic mean) is simply the sum of all percolation rates divided by the number of tests.

Example:

1. *Three percolation rates are measured within a proposed leaching field:*
   10.3 in./hr
   9.7 in./hr
   5.1 in/hr

Average: $\frac{(10.3 + 9.7 + 7.5)}{3}$ = **9.2 in./hr.**

When not to average: variations in soil type:

When one or more percolation rates obtained from the same area differ from the other rates by too much, it is an indication that there may be different soil types within the area, or a boundary between two soil types has been crossed. When this happens, the final percolation rate should not be the average. Common sense must be applied in determining which percolation rate to use, and which to throw out.

The method given in the 1980 USEPA manual works only for very slow percolation rates. The method given by Kaplan (1987) works for all percolation rates. Both methods rely on an arbitrarily chosen "difference" to determine what is "too" different. DEQ is choosing to adopt a more common-sense based approach.

The DEQ approach relies on using what you know about the site and the soils, and "playing it safe."

- *For very slow percolation rates* (2 inches per hour or less), take the most conservative approach possible and use the lowest measured rate if there is a wide difference between multiple test holes (say, plus or minus 1.0 inches per hour).
- *If any of the test results fall below the lowest allowable percolation rate* (0.67 inches per hour), extreme caution is urged. One low percolation rate may very well indicate that the overall site percolation rate will be lower than indicated in the holes that had more favorable rates – those rates may have been influenced by root channels. Experience with neighboring lots should be sought.
- *For all other percolation rates*, consider "throwing out" rates that are much higher than the other tests. Especially in limestone, one hole might just get "lucky" and hit a fracture or solution channel, and give a percolation rate much higher than the area as a whole. The average of the test results that are not thrown out can then be used for the design.

Example

2. *Three percolation rates are measured within a proposed leaching field:*

0.5 in./hr.
0.75 in./hr.
0.75 in/hr.

Which one do you recommend that the owner uses for the septic system design?

This is an interesting example because the average of the results comes out to 0.67 inches per hour, which is the lowest percolation rate allowable under the regulations for leaching fields. However, one of the results is below 0.67. In this case, the most conservative approach would be to report the 0.5 in./hr. figure as final, and recommend against building a septic system. Whether or not this is truly warranted would call in to play all the other observations made during the site evaluation: Could the two faster rates have been caused by root channels? Is the soil texture a clay, or silty clay? Is there a history of failed septic systems in the area? Answers of "yes" to any of these questions would support the use of the lowest figure. Use of the average should only occur with convincing evidence that the lower percolation rate was in error and is not representative of the overall site soils.

DEQ answer: *use 0.5 in./hr., unsuitable soils for septic system.*

3. *Six percolation rates are obtained at the location of a proposed beach-side hotel expansion:*

28 in./hr.
35 in./hr.
54 in/hr.
88 in./hr.
43 in./hr.
121 in/hr.

Which rate would you recommend be used for the design of the stormwater infiltrators?

This is an example of where the highest percolation rates should be "thrown out" and an average of the remaining rates used instead. While it might be tempting to include the higher rates to help support a smaller design, it could also result in a system that is too small in the long run. Remember: everything that depends on percolation rate data, whether it be leaching fields or stormwater infiltrators, is something that will clog over time. It always pays to be conservative in your design approach.

DEQ answer: discard the 88 in./hr and 121 in./hr. rates

Average the rest: $$\frac{28 + 35 + 54 + 43}{4} = 40 \text{ in./hr.}$$

(Note: a percolation rate that fast should never directly be used in any sizing calculation. Because clogging will occur over time, an appropriate factor of safety should always be used. See the CNMI / Guam Stormwater Design Manual for further information.)

References:

Kaplan, B.O. 1987. *Septic Systems Handbook*. Lewis Publishers. Chelsea, Michigan.

Salvato, J.A., Nemerow, N.L., Agardy, F.J. 2003. *Environmental Engineering (Fifth Edition)*. John Wiley & Sons, Inc. Hoboken, NJ.

U.S. Environmental Protection Agency. 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (EPA 625/1-80-012). U.S. EPA Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH.

US Environmental Protection Agency. 2001. *Seepage Pits May Endanger Ground Water Quality* (EPA 909-F-01-001). U.S. EPA Region 9 Ground Water Office (WTR-9), San Francisco, CA.

U.S. Environmental Protection Agency. 2002. *Onsite Wastewater Treatment Systems Manual* (EPA 625/R-00/008). U.S. EPA National Risk Management Research Laboratory, Cincinnati, OH.

Oregon Department of Environmental Quality – Onsite Systems Home:
http://www.deq.state.or.us/wq/onsite/onsite.htm

Massachusetts Department of Environmental Protection, Soil Evaluator Training Course:
http://www.mass.gov/dep/water/compliance/traini03.htm

7. Reporting Results

Percolation test report

First, let's draw a distinction between the percolation test report and the site evaluation: They are not the same thing! The percolation test is meant to be just one part of the overall site evaluation. Reporting should therefore be kept brief and simple.

Under present DEQ regulations, the percolation test is the primary tool used to size septic systems and stormwater infiltrators. This will change over time in favor of more thorough site and soil assessments. However, the percolation test will remain an important part of that assessment, and there will likely always be a market for the dedicated percolation tester. Thus, the following outline and forms (contained in Appendix 2) are provided as a guide for what should be included in the percolation test report. Keep in mind that this is only guidance; the percolation tester is free to modify the reporting format, as long as the necessary information is given.

In short, the percolation test report should contain the following, at a minimum:

- Client, project, location information.
- Identification and brief description of facility type(s) (e.g., "restaurant incl. septic system and stormwater infiltrator").
- Final percolation rate (include all percolation rates where more than 1, and show final calculation of average or written explanation of chosen percolation rate).
- Location map.
- Lot diagram indicating boundaries, general slopes (arrows, percent, etc.), locations of percolation test pits and observation holes, general outlines of recommended locations for infiltrative practices.
- Soil log from observation pit.
- Percolation test results:
    - Test hole # (to correspond with lot diagram)
    - Date test performed
    - Name of tester & DEQ witness
    - Size (diameter, depth) of hole
    - Brief soil description
    - Pre-soaking info (time started & stopped, volume of water absorbed)
    - Identification of time interval used
    - Log of level measurements
    - Final percolation rate (show calculation!)
    - Comments (as appropriate)

- Copy of annotated, original level measurement paper(s)

A cover sheet may be included containing specific recommendations or other site information that the tester, in his/her judgment, feels should be mentioned.

Blank reporting forms are provided in Appendix 2 to assist in following this outline.

Site Evaluation

A through site evaluation will consist of a lot more than just a percolation test. Thus, the site evaluation report will be much larger. It will also require more analysis, judgment, and interpretation. Because the purpose of this manual is to train percolation testers, it is beyond the scope of this text to provide detailed instruction in how to prepare a full site evaluation report. Instead, the reader is encouraged to look into the references provided in Chapter 9.

References:

Kaplan, B.O. 1987. *Septic Systems Handbook*. Lewis Publishers. Chelsea, Michigan.

Salvato, J.A., Nemerow, N.L., Agardy, F.J. 2003. *Environmental Engineering (Fifth Edition)*. John Wiley & Sons, Inc. Hoboken, NJ.

U.S. Environmental Protection Agency. 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (EPA 625/1-80-012). U.S. EPA Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH.

Massachusetts Department of Environmental Protection, Soil Evaluator Training Course:
http://www.mass.gov/dep/water/compliance/traini03.htm

8. Ethical Considerations

As a soil evaluator or percolation tester, you will be providing influential information that will have lasting effects not only on your client, but on the public of the CNMI as well. The septic systems and stormwater systems that are built based on your plans will either protect public health, or endanger it. It is therefore of paramount importance that the soil evaluator adhere to general principles of ethical behavior.

Duty to the public vs. duty to the client

Obviously, as a paid consultant you have a duty to provide the service that your client paid for. Generally accepted principles of ethics dictate that your duties to the public and the environment should come first. However, let's examine for a moment why it is also in your client's best interest for you to perform your job objectively and without bias.

You may be asked by a client to report a faster percolation rate than you measured. You may be told that you will not be paid unless you obtain a "good" percolation rate. You may be offered a deal that includes you only being paid if your client obtains a permit. Ignoring the fact that it goes against commonly accepted ethical rules for you to accept any of those deals, it also does nothing good for your clients, as well.

What does a client have to gain from a "faster" percolation rate? In their mind, a faster percolation test means a smaller, and therefore cheaper system. Or, in the most extreme case, it may mean the difference between being able to build a septic system, and being required to build a holding tank and paying for it to be pumped out on a weekly basis for the next 50 years. It may be tempting to cheat a little on the percolation test and report a slightly faster rate in order to benefit your client, who obviously has a lot of money at stake.

The consequences may be quite severe: a septic system that doesn't work; a source of disease that causes the owner and their children to become ill; a flooded parking lot. The possibilities are endless, and the staff of DEQ has seen all of these and will probably see more.

Your duty to your client should be the same as your duty to the public: To provide an objective and truthful evaluation of their site soils and the site's ability to absorb wastewater or stormwater. If your client does not understand, you should try to explain the consequences. If that doesn't work, then you should politely decline the job.

Engineers:

Often, you may have more than one "true" client on any job. You may have been hired directly by the owner of the property, but be preparing the report for an engineer hired by the client at a later date to design the septic or stormwater system. Licensed engineers ("P.E.s") have their own set of ethical rules to follow. An engineer relies on the percolation and soil evaluation test provided by the client to be truthful and accurate. The engineer may be liable for a failed system, and will know who provided the faulty information.

Legal Responsibilities

If general ethics are not enough, consider the penalties under the CNMI Environmental Protection Act for falsifying a percolation test. At best, a person who falsifies a percolation test will have their certification revoked. At worst, that person may face criminal penalties of up to $50,000 and one year imprisonment.

Aside from criminal penalties, falsifying a percolation test may also open the door to a civil lawsuit from the facility owner, if the falsified test resulted in "damages," for example, the cost of replacing a clogged leaching field with a holding tank & pumping costs. Or more, depending on how aggressive or good the owner's attorney is. Even if an engineer designed the failed septic system and is sued directly by the owner, you can bet the engineer, or their insurer, will come after the percolation tester if it is found that the test was falsified or otherwise in error. (And it's not hard to prove – all it takes is another percolation test, performed by another tester, to call the original test into question.)

Long story short: If does no one any good to provide false information on a percolation test.

Sample Code of Ethics:

The following is copied directly from the State of Maine "rules for site evaluators of subsurface wastewater disposal systems." All percolation testers are encouraged to read and follow these guidelines. There may come a time in the future where the CNMI adopts such rules.

(144 CMR 245 – http://www.maine.gov/dhhs/eng/plumb/documents/se_rules_2006.htm)

200. Code of Ethics

Summary : Whereas the Site Evaluators' Licensing Program was established to ensure that Site Evaluators have and hold high standards in their practice, the Department has promulgated this Code of Ethics to assist in the protection of the public welfare and to safeguard life, health, property, and environment in the practices of Site Evaluation. Each Site Evaluator is expected to place these protections and safeguards first in their consideration when practicing their profession. The Code sets forth the principles and practices necessary for the ethical conduct of Site Evaluators.

A. General Principles

1. When the profession of site evaluation is practiced, it requires professional ethical conduct and professional responsibility as well as scientific knowledge on the part of the practitioner.

2. A site evaluator shall be guided by the highest standards of ethics, personal honor, and professional conduct.

B. Relations of Site Evaluator to the Public

1. A site evaluator shall avoid and discourage sensational, exaggerated and unwarranted statements regarding their work or the product of their work.

2. A site evaluator shall not knowingly permit the publication of his or her reports, maps or other documents for any unsound or illegitimate undertaking.

3. A site evaluator having or anticipating having a beneficial interest in a property on which the site evaluator is reporting shall state in the report the existence of such interest or future interest.

4. A site evaluator having a beneficial interest in a company or concern that sells or distributes proprietary devices on which the site evaluator is reporting shall state in the report the existence of such interest.

5. A site evaluator shall not give a professional opinion or submit a report without being as thoroughly informed as what might be reasonably expected, considering the purpose for which the opinion or report is requested.

6. A site evaluator shall not engage in false or deceptive advertising, or make false, misleading or deceptive representations or claims in regard to the profession of site evaluation or in regards to others in the practice of the profession of site evaluation, or which concern his or her own professional qualifications or abilities.

7. A site evaluator shall not make a false statement or issue false information even though directed to do so by an employer or client.

C. Relation of Site Evaluators to Employer and Client

1. A site evaluator shall protect, to the fullest possible extent, the interest of his or her employer or client so far as is consistent with the law and the site evaluator's professional obligations and ethics.

2. A site evaluator who finds that his or her obligations to an employer or client conflict with his or her professional standards or ethics shall have such objectionable employment conditions corrected or terminate his/her client business.

3. A site evaluator shall not use, directly or indirectly, any employer's or client's information in any way which is competitive, adverse or detrimental to the interest of that employer or client.

4. A site evaluator retained by one client shall not accept work from a second client without the written consent of both clients', if the interest of the two clients are conflicting.

5. A site evaluator who has made an investigation for an employer or client shall not seek to profit economically from the information gained, unless written permission to do so is granted, or until it is clear that there can no longer be a conflict of interest with the original employer or client.

6. A site evaluator shall not divulge information given or obtained in confidence.

7. A site evaluator shall engage, or advise an employer or client to engage and cooperate with, other experts and specialists whenever the employer's or client's interest would be best served by such service.

8. A site evaluator shall not accept referral fees from another professional person from whom she or he is referred; however, nothing herein shall prohibit a licensee from being compensated for consultation.

9. A site evaluator shall issue professional advice primarily within the site evaluator's expertise. An employer or client shall be notified if any professional advice outside the site evaluator's expertise is needed or required.

10. A site evaluator shall not affix their signatures to any document dealing with subject matter in which they lack competence and are not duly licensed.

D. Relations of Site Evaluators to Each Other

1. A site evaluator shall not falsely or maliciously attempt to injure the reputation or business of another.

2. A site evaluator shall give credit for work done by others and shall refrain from plagiarism in oral and written communications and shall not knowingly accept credit for work performed by another.

3. A site evaluator who is an employee shall not use his or her employer's resources for private gain without the prior knowledge and consent of his or her employer.

4. A site evaluator shall cooperate with others in the profession and encourage the ethical dissemination of site evaluator knowledge.

E. Duty to the Profession of Site Evaluator

1. Every site evaluator shall seek to discourage the licensure of those who have not followed these standards of ethics, or who do not have the required education and experience.

2. It shall be the duty and professional responsibility of a site evaluator not only to uphold these standards of ethics by their conduct and example but to also encourage and advise other site evaluators to adhere to the ethical standards.

9. Suggested References & Materials

Where possible, links are provided to access the references on-line, or to an on-line order page. If you have the paper copy of this manual, it might be easier for you to access the on-line version of this manual so that you can simply click on the internet links given below, rather than manually typing them in to your browser.

This manual may be found on-line at DEQ's website:

http://www.deq.gov.mp/

Books & Publications

For books and publications that are not available on-line for free, links to the product page at Amazon.com are provided. This is not meant as an endorsement of Amazon.com, only as a convenience.

Septic Systems:

Kaplan's **"Septic Systems Handbook"** is an interesting and thorough look at traditional septic systems and percolation testing. This manual was prepared using the first edition of his book. A newer edition (1991) is available, but is very costly ($170). Considering its age, not everyone will agree that it is worth the cost – the other references listed in this section cover the material adequately enough.

Kaplan, B.O. 1987. *Septic Systems Handbook*. Lewis Publishers. Chelsea, Michigan. (2nd edition [1991] available on Amazon: http://www.amazon.com/Septic-Systems-Handbook-Second-Benjamin/dp/0873712366)

Lloyd Kahn's **"Septic System Owner's Manual"** is written for the layman, and is an easy to understand, yet surprisingly up-to-date and comprehensive look at the world of on-site wastewater treatment. You might not be able to design an entire on-site system using only this reference, but you can certainly use it to decide what kind of system you need, and you can't beat the price ($13.50)

Kahn, L. 2007. *The Septic System Owner's Manual.* Shelter Publications, Inc. Bolinas, CA. http://www.amazon.com/Septic-Systems-Owners-Manual/dp/093607020X

The **"original" USEPA (1980) manual** is still a very useful reference, and best of all, it's free:

> U.S. Environmental Protection Agency. 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (EPA 625/1-80-012). U.S. EPA Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH.
> http://www.epa.gov/owm/septic/pubs/septic_1980_osdm_all.pdf

The **"updated" USEPA (2002) manual** reads a little less like a manual and more like a report. It is, however, loaded with useful information, and if you're interested in the latest thinking on on-site wastewater system design, it's an excellent resource:

> U.S. Environmental Protection Agency. 2002. *Onsite Wastewater Treatment Systems Manual* (EPA 625/R-00/008). U.S. EPA National Risk Management Research Laboratory, Cincinnati, OH.
> http://www.epa.gov/owm/septic/pubs/septic_2002_osdm_all.pdf

Soils:

Every percolation tester and soil evaluator should possess a copy of the **CNMI Soil Survey**. Copies may be obtained from the Natural Resourced Conservation Service (NRCS) office on Beach Road, just south of Garapan. As of the date of this printing, the soil survey was not yet available on-line, or in an electronic format. However, NRCS has indicated that they are working on an electronic version of the survey, which should be available soon.

> Young, F.J., Wysocki, D.A., Burkett, D.W., Huff, T.L. 1989. *Soil Survey of the Islands of Aguijan, Rota, Saipan, and Tinian, Commonwealth of the Northern Mariana Islands.* Natural Resources Conservation Service (NRCS).

The **NRCS Field Book for Describing and Sampling Soils** is an invaluable source of detailed information. Some may consider it too detailed, and there are many more condensed or "shortcut" methods to describing soil properties such as texture, but there is still no substitute for the original material, and this author finds this to be a very useful book. A hard copy is preferable, but the manual is also available for free at URL:

> Schoeneberger, P.J., Wysocki, D.A., Benham, E.C., Broderson, W.D. 2002. *Field Book for Describing and Sampling Soils, Version 2.0.* Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.
> http://soils.usda.gov/technical/fieldbook/

Geology / hydrology:

Many USGS publications are now available on-line. Simply go to the USGS publications search page and type in "Marianas" or any island name (e.g., "Saipan") and you will be presented with a list of just about everything that the USGS has ever published about the islands. Some documents are available on in ".dvu" format, but links to free "déjà vu" viewers are available on the results page for those documents.

USGS Publications Warehouse:
http://infotrek.er.usgs.gov/pubs/

Particularly useful publications include:

Saipan: There are 2 excellent geology/hydrology resources available for Saipan, and a number of other related reports. The Carruth (2003) publication is all a site evaluator should ever need. The Cloud (1956) report is far more detailed, and is an interesting read. Other reports available on the USGS page are also worth reading, but are not mentioned here because they are not as directly applicable.

Carruth, R.L. 2003. *Ground-Water Resources of Saipan, Commonwealth of the Northern Meriana Islands:* U.S. Geological Survey Water-Resources Investigations Report 03-4178. 3 Plates.
http://water.usgs.gov/pubs/wri/wri034178/

Cloud, P. E., Jr.; Schmidt, R. G.; Burke, H. W. 1956. *Geology of Saipan, Mariana Islands; Part 1, General geology*. U.S. Geological Survey Professional Paper 280-A.
http://pubs.er.usgs.gov/usgspubs/pp/pp280A

Tinian: The one publication listed below is very useful, but unfortunately is not available on-line. However, it can be ordered for a small fee ($4.00) and mailed to the CNMI. The link provided will take you to the order page.

Gingerich, S. B.; Yeatts, D. S. 2000. *Ground-water resources of Tinian, Commonwealth of the Northern Mariana Islands.* U.S. Geological Survey Water-Resources Investigations Report 2000-4068. 2 Plates.
http://pubs.er.usgs.gov/usgspubs/wri/wri004068

Rota: Unfortunately, there are no geological maps available for the island of Rota. The following USGS report may contain useful information, and is available on-line. The University of Guam "WERI" website also contains reports about Rota geological investigations, though no island-wide descriptions or maps. However, generally speaking, the geology and groundwater environment of Rota can be considered essentially similar to Saipan and Tinian, with limestone and fresh water lens-type aquifer systems in all areas except for the upper Sabana region and its southern slopes, which is volcanic in origin.

Carruth, R.L. 2005. *Construction, geologic, and hydrologic data from five exploratory wells on Rota, Commonwealth of the Northern Mariana Islands, 1999*. U.S. Geological Survey Open-File Report 2005-1042, 40 p.
http://pubs.usgs.gov/of/2005/1042/

University of Guam, WERI document search page:
http://www.weriguam.org/reports/index.php

Websites

There is a lot of good information available for free on the internet. So much so, it could take a person several years to thoroughly read it all. The links here are to web sites that were used in the preparation of this manual and other DEQ septic system documents.

Oregon Department of Environmental Quality – Onsite Systems Home:
http://www.deq.state.or.us/wq/onsite/onsite.htm

National Small Flows Clearinghouse:
http://www.nesc.wvu.edu/nsfc/nsfc_index.htm

North Carolina Department of Environment and Natural Resources, On-site systems home:
http://www.deh.enr.state.nc.us/osww_new/new1/

Massachusetts Department of Environmental Protection, Soil Evaluator Training Course:
http://www.mass.gov/dep/water/compliance/traini03.htm

USEPA Septic Systems Home:
http://cfpub.epa.gov/owm/septic/index.cfm

The "Onsite Consortium" is a group of universities that have established a standardized curriculum for on-site wastewater designers, installers, and site evaluators. All training materials are available through their web-site, and are very comprehensive:

http://www.onsiteconsortium.org/index.cfm
Site evaluator training materials & curriculum:
http://www.onsiteconsortium.org/training/activitiesList.cfm

Supplies & Tools

Suggested Field Equipment List for the percolation tester:

- Shovel
- Post-hole digger

- Trowel, knife, or small garden shovel (for scraping / peeling soil)
- 4-inch hand-auger (see below)
- "Baretta" (heavy steel rod for breaking limestone)
- Four(4), full 5-gallon water bottles (for pre-soaking & testing)
- Water bottle stand, plug & tubing (for inverting bottle over hole)
- Water level measurement apparatus (see Chapter 6)
- Weights, stakes, large nails (for securing measurement cross-bar)
- Soil color book (Munsell - see below for ordering information)
- 12-inch ruler, with sixteenths marks
- Tape measure or folding rule
- Stop watch, or digital wristwatch with stopwatch / timer function
- Something to mark horizons and layers (large nails or golf tees)
- Soil sample tray (a plastic plate or muffin tin is acceptable)
- Spray water bottle
- Geologist's hand lens,
- Small towel to wipe hands
- Clipboard
- Soil field guide book (NRCS – see above)
- Proper field clothing including rain gear, work boots, gloves, hat, etc.
- Large (golf or beach) umbrella
- Sun block, insect repellent
- Drinking water & snacks

Links are provided to Forestry Suppliers, Inc. (http://www.forestry-suppliers.com/). This is not necessarily meant as an endorsement of Forestry Suppliers; these links are meant only as a convenience to help you find more details about the tools and supplies mentioned in this text. However, Forestry Suppliers does ship to the CNMI, and the author of this text has ordered through them on several occasions without problems. (Do make sure to at least go on-line and order their free catalog – it's an excellent resource.)

• Munsell Soil Color Charts: Order the basic book of charts only - $105.
http://www.forestry-suppliers.com/product_pages/View_Catalog_Page.asp?mi=3078

• 4-inch soil sampling hand-augers – They're expensive, but they're very convenient and in some cases can avoid the need for heavy equipment. However, with a little hard work you can probably accomplish all of your excavation needs using nothing but a shovel and baretta. This link takes you Forestry Supplier's own line of auger supplies. Other augers are available elsewhere on the same website. A complete sampling set-up might include the following:

Item 78431 – Regular Auger, 4", stainless	$ 231.00
Item 78464 – Stainless Cross Handle	$ 42.00
Item 78461 – Stainless 3' Extension	$ 88.00
Subtotal (n.i.c. shipping)	$ 361.00

Alternatively, you can get a ready-made soil sampling kit, but the kits are geared toward environmental scientists and might have more than you really need

Also, gas-powered hand augers are available that would make the whole process easier, but may or may not be able to bore into limestone. Although several models are available through Forestry Suppliers, shipping may be a problem.

Appendix 1: DEQ Percolation Test Procedures

Modified DEQ Percolation Test Procedures (July 2007)

[Adapted from Kaplan (1987) and USEPA (1980)]

Number and Location of Tests:

Deep Observation Pit

The purpose of the deep observation pit is to expose the soil column to allow for detailed soil description and to check for potentially adverse conditions including high groundwater and restrictive horizons.

a. At least one (1) deep observation pit shall be required for most sites. Additional pits may be required for large facilities (over 1 acre), facilities that include multiple leaching fields or stormwater practices, or where varying soil conditions warrant additional pits.

b. Deep observation pits are to be excavated to a minimum depth of 4 feet below the bottom of the proposed leaching field or stormwater practice. Pits deeper than 5 feet are required to meet OSHA excavation safety requirements. See percolation testing manual for safety guidance and "safety pit" designs.
   - Pits in limestone need only be excavated to a depth equal to the proposed bottom of the leaching field or stormwater practice, unless justifiable in consideration of geology (e.g., nearby interface with volcanics).
   - Shallower observation pits may also be justifiable based on information such geology and groundwater depth that would indicate no potential for adverse conditions.
   - Excavation may cease upon discovery of groundwater or a restrictive horizon within the specified depth from the bottom of the proposed infiltrative practice.

c. The deep observation pit shall not be located within the potential footprint of a future leaching field, infiltrator bed, or any other structure.

Percolation Test Holes:

The purpose of the percolation test hole(s) is only to measure percolation rate. The percolation test hole shall not be the same excavation as the deep observation pit, except as noted below.

a. A minimum of three (3) percolation test holes are *recommended* for all applications. For single-family residences, duplexes, and small commercial facilities (less than half an acre) only one percolation test hole is *required*. Larger facilities will require at least three test holes. The total number of test holes needed will depend on the size, location, and number of infiltrative practices (e.g. leaching fields, ponding basins) proposed.

b. The percolation test holes shall be located within the potential footprint of the proposed infiltrative practice.
   - If three or more percolation tests are conducted, one test may be conducted within the deep observation pit.

Percolation Test Procedures:

Excavation:

Bottom of initial excavation must be approximately 13 inches above the expected bottom of the leaching field or trench. The percolation test hole is augered or hand-dug at the bottom of the excavation.

- Where three of more percolation tests are conducted, one test may be performed within the deep observation pit on a shelf dug into the entry ramp for this purpose. The shelf shall be at least 3 feet wide, and the test hole shall be bored / dug as far back from the shelf as possible. See percolation testing manual for illustration and guidance.

Hole:

a. Final diameter is 5.5 to 6.5 inches, after scraping. Larger sizes are acceptable, as they yield slower infiltration rates.
b. Depth is 13 to 14 inches
c. Place 2 inches of pea-gravel over bottom.

Notification of DEQ:

a. DEQ must be notified at least 24 hours in advance of the start of soaking of the test pit. Notification must be by fax or hand-delivered note, and must include:
    - Directions (map) to site
    - Estimated time that soaking will start
    - Estimated time that percolation test will begin

Soaking:

Fill hole with 12 in. of clear water (10 in. above the gravel)

d. If twice 10 in. seeps away in less than 10 min and soil is coarse-textured (sand, limestone), testing can be conducted immediately; otherwise:
e. For 6 inch diameter holes: maintain level (8-16 in.) overnight, or until 5 gallons have been absorbed.
    - Invert a full 5-gallon water bottle over the 8-10in. level after ensuring the bottle is well secured and surges will not scour the sides of hole.
    - In coarse-textured soils or limestone, with percolation rates of 15 to 60 inches per hour (iph), the bottle will be empty after about 1 hour or less; in 4 iph soils, after about 7 hr; in 0.67 iph soil, the bottle will not be empty the following day.
f. For larger diameter holes: Provide enough water to maintain level (8-16 in.) overnight. This may be considerably more than 5 gallons.

Testing:

Except as noted in (a) and (b) above, begin testing after 15 hours and finish within 30 hours after beginning of soaking. Refill after each measurement. Measure from a fixed reference point.

- If there is still at least 6 inches of water in the hole (4 inches above the gravel) after 5 gallons of water have been absorbed, or after 15 hours from the start of soaking, remove the bottle, restore water level up to 8 inches (6 inches above the gravel), and make at least 2 final measurements; the interval of the measurements shall be 30 minutes , but this may be modified to keep the decline in water level within 1 to 3 inches per interval for measurement accuracy. Otherwise, follow usual procedure:

a. Fill hole to exactly 8 inches from the bottom of the hole (6 inches from the top of gravel)
b. If 6 inches is gone in 30 minutes, use 10-minute measurement intervals; otherwise, 30 minute intervals. Faster percolation rates may justify smaller time intervals (e.g., 5 min., 2 min.)
c. Measure to the nearest 1/16th inch. Lower precision may be acceptable if results justify such imprecision (e.g., very fast percolation rates).
d. Make at least six consecutive measurements until three do not vary by more than 1/16th inch. (Lower precision may be acceptable if justified.) For slower soils using 30 minute measurement intervals, the test may be stopped after the initial three intervals if all are within 1/16th of an inch. For all other soils, the test may be stopped after recording 10 measurements.
e. The final percolation rate is the final drop measured, converted to inches per hour.

Percolation Test Reporting:

Percolation test reports must be submitted in the format provided by DEQ, or in any other format containing substantially the same information. The test report must identify the final recommended percolation rate(s) to be used in the design of the infiltrative practices, along with an explanation of how the recommended rate was selected.

References

Kaplan, B.O. 1987. *Septic Systems Handbook*. Lewis Publishers. Chelsea, Michigan.

U.S. Environmental Protection Agency. 1980. *Design Manual: Onsite Wastewater Treatment and Disposal Systems* (EPA 625/1-80-012). U.S. EPA Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH.

Appendix 2: Forms

CNMI DIVISION
OF ENVIRONMENTAL
QUALITY

PERCOLATION TEST
DEQ Notification Form

Fax to: 664-8540 (Saipan) | 433-3169 (Tinian) | 532-3103 (Rota)

Or deliver by hand to: *DEQ office on island where test is located*

1. Site Location Diagram (*sketch map and/or directions*)

2. Estimated Schedule:

Pre-soaking will begin:

Date *Time*

Percolation test will begin: (estimate)

Date *Time*

3. Client Information

Owner name

Project name / type

4. Percolation Tester

Percolation tester name & signature

Date

Certification number

CNMI DIVISION OF ENVIRONMENTAL QUALITY

PERCOLATION TEST REPORT

Title Page / Summary of results

Attachments follow

1. Site Information

Owner Name

Mailing Address (P.O. Box)

Village

Island

MP

State

Zip Code

Contact person (if different from owner.)

Phone / fax number (note if cell)

2. Facility / Development Information

Facility will include:
(check which apply)

☐ On-site wastewater system
Number of systems: ________

☐ Stormwater / erosion control
Number of basins/infiltrators: ________

Project Name (if applicable)

Project type (e.g., residence, auto shop, restaurant)

3. Summary of Percolation Test Results

Field Results:

For on-site wastewater systems:			*For stormwater / erosion control:*		
Final measured rates (include all test pits)		(in./hr.)	Final measured rates (include all test pits)		(in./hr.)
test pit no.:	OS1.	________	*test pit no.:*	SW1.	________
	OS2.	________		SW2.	________
	OS3.	________		SW3.	________
	OS4.	________		SW4.	________
	OS5.	________		SW5.	________
	OS6.	________		SW6.	________

Recommended Design Rate(s):

leach field no.:	1.	________	*infiltrator/basin no.:*	1.	________
	2.	________		2.	________

Reason selected:
☐ single test ☐ average ☐ lowest

Reason selected:
☐ single test ☐ average ☐ lowest

4. Certification

Test Performed by: (print & signature)

DEQ Percolation Tester Certification Number

Witnessed by: (name of DEQ inspector)

	LOCATION MAP (SKETCH)	Owner:_________________________. Project Name: __________________________.

LOT DIAGRAM

(SKETCH)

Owner:_________________________.

Project Name: ____________________________.

CNMI DIVISION OF ENVIRONMENTAL QUALITY

DEEP OBSERVATION PIT

Soil Profile Description

TEST PIT NUMBER: ____________ ____________

Date of observation

Complete & attach one form for each deep observation pit

DEQ form version 7.19.07

1. Project Information

Owner

Hole depth: ______________________

(total – in feet, inches)

Project Name / Type

Island / village

2. Soil Profile Description

Soil Horizon/ Layer	Depth (in.)	Color (moist – Munsell)	Soil Texture (USDA)	Soil Structure		Redoximorphic features (mottles)			Other
				shape	grade	depth	color	percent	

3. Restrictions

Groundwater found? ☐ yes ☐ no shallowest depth (ft.): ________ Evidence: ☐ direct observation ☐ saturated soil ☐ redoximorphic features Comments: ________

Restrictive Horizons? ☐ yes ☐ no shallowest depth (ft.): ________ Describe: ________

3. Restrictions

Test Performed by: (print & signature)

DEQ Percolation Tester Certification Number

CNMI DIVISION OF ENVIRONMENTAL QUALITY

PERCOLATION TEST REPORT

Test Pit Results

Complete & attach one form for each percolation test, along with copy of original level measurement sheet

TEST PIT NUMBER: ______________ Examples: "OS1" for on-site wastewater system; "SW1" for stormwater infiltrators	______________ Date of measurement

1. Project Information

____
Owner Name

______________________________ ______________________________
Project Name / Type Island, Village

2. Test Pit Description

Hole Dimensions

Diameter: (in.) ______________

Bottom Depth: (in.) ______________

Pre-soaking data:

Start time / date: ______________

Volume absorbed (gal.): ______________

Soil Description: *(brief – see detailed soil profile log from deep observation pit)*

Depth (in. to in.)	Soil texture or description (e.g., silty clay loam, limestone)	Color

2. Percolation Test Data

Start time / date: ______________

*****Enter final six measurements only*****

Interval No.	Drop (in.) fractions (e.g., 1 5/16th)	Drop (in.) decimal (e.g., 1.3125")	Time Interval (min.)
1.	_______	_______	_______
2.	_______	_______	_______
3.	_______	_______	_______
4.	_______	_______	_______
5.	_______	_______	_______
6.	_______	_______	_______

3. Final Rate Calculation

final drop: ______________ (in.) X 60 ~~min.~~ = ______________ in./hr.
time: (~~min~~.) 1 hr.

3. Certification

______________________________ ______________________________
Test Performed by: (print & signature) DEQ Percolation Tester Certification Number

____
Witnessed by: (DEQ inspector signature & date)

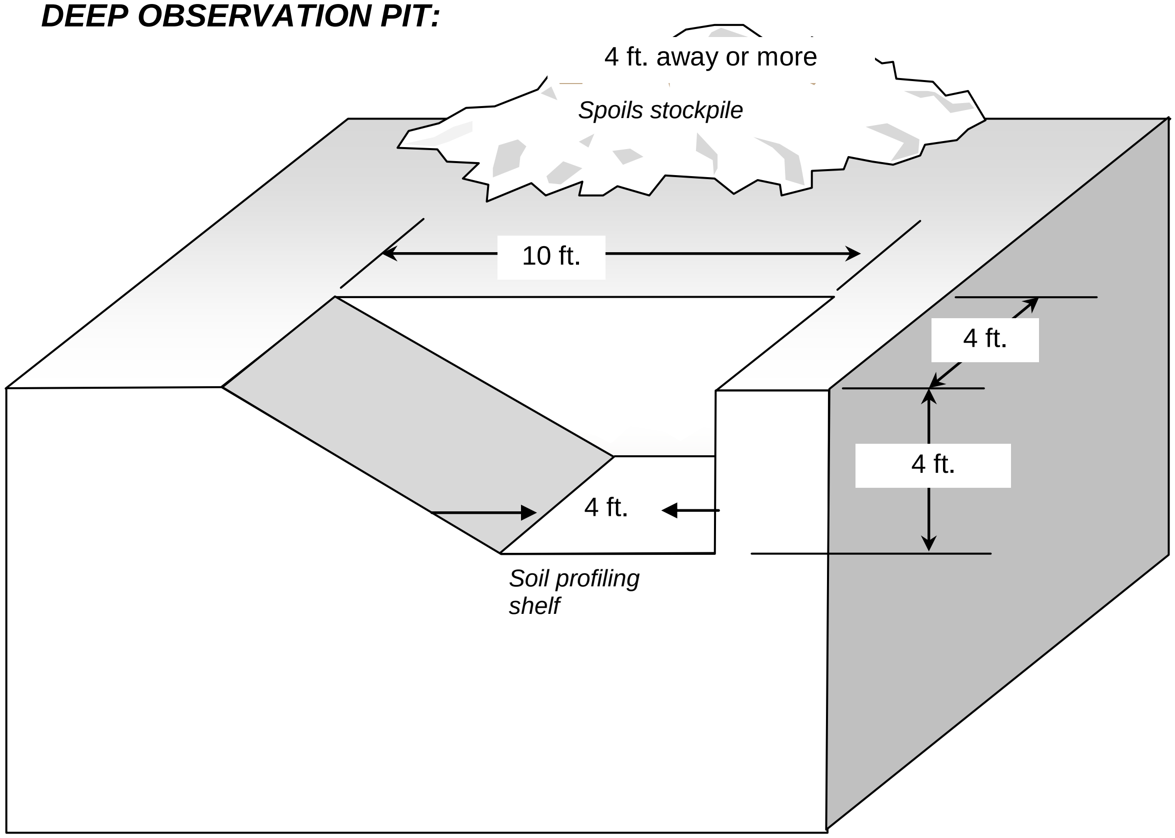
Interval:* __________ *minutes	***PERCOLATION TEST – LEVEL MEASUREMENT DATA SHEET***		
TEST HOLE #________	________ Date ________ Time	Client Name: ______________________ Project Name: ______________________ Location: ______________________	*TEST PERFORMED BY:* ______________________ *WITNESSED BY (DEQ)* ______________________

Appendix 3: Instructions to Excavator Operators

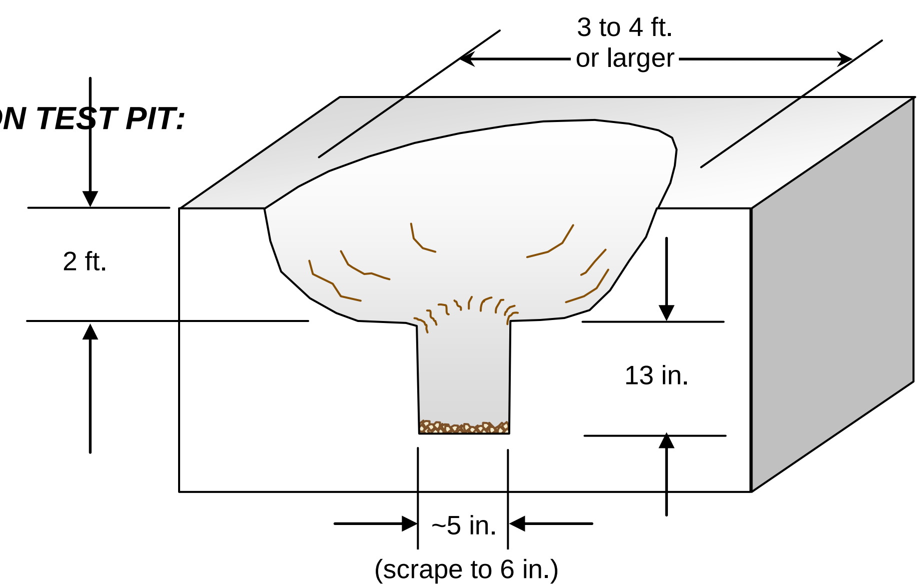
INSTRUCTIONS TO EXCAVATOR OPERATORS

Version 1

DEEP OBSERVATION PIT:



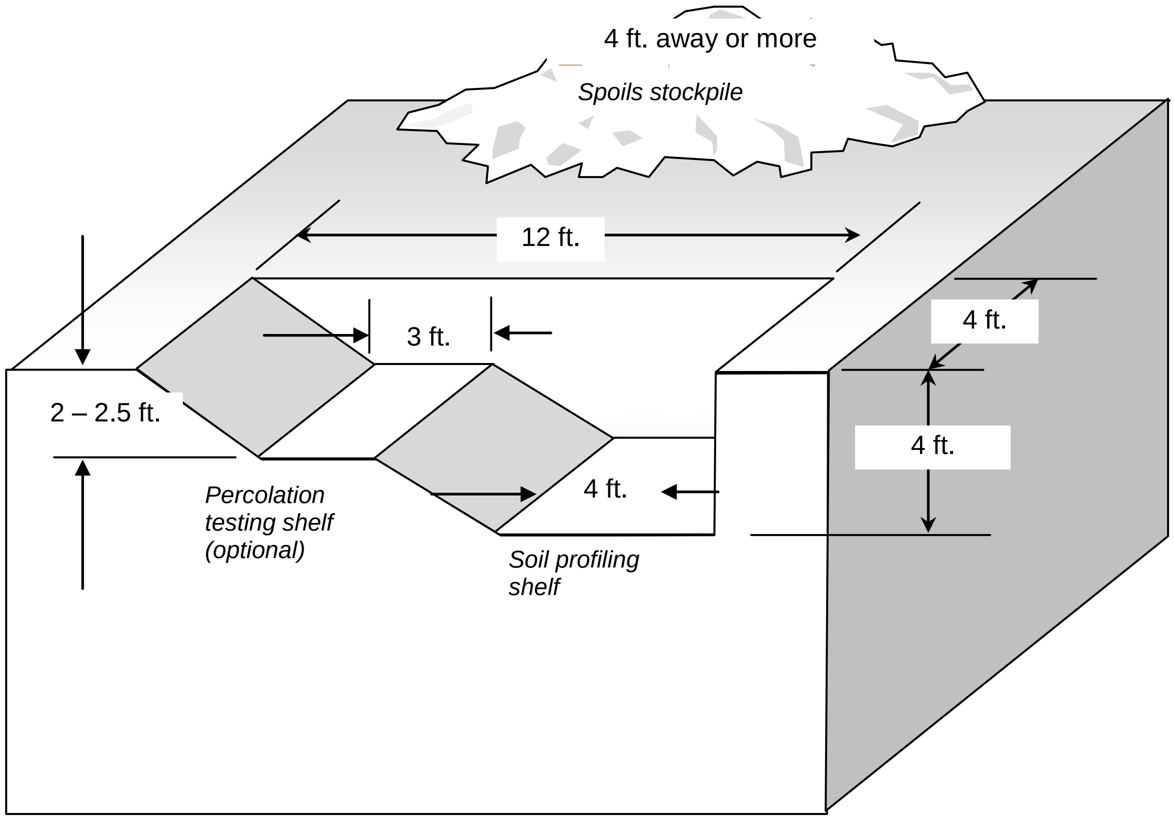
PERCOLATION TEST PIT:



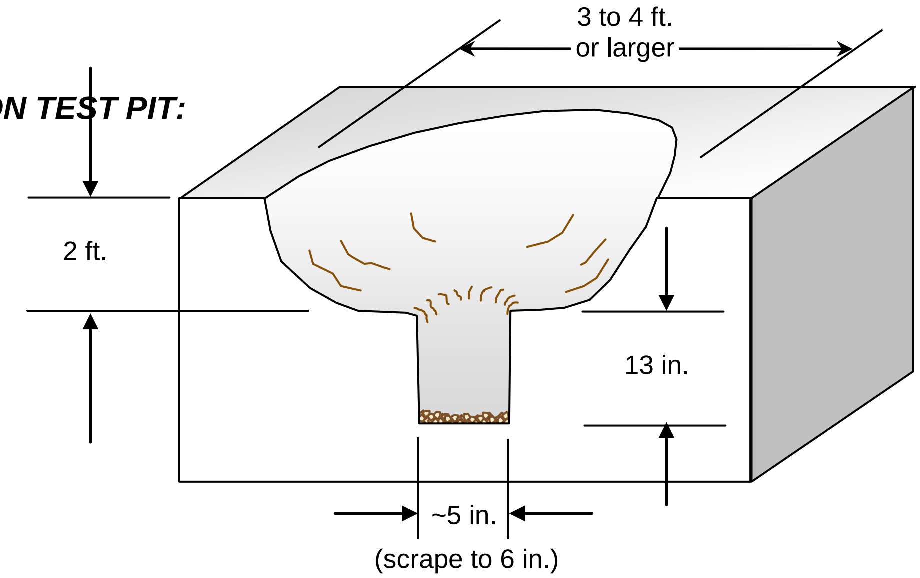
INSTRUCTIONS TO EXCAVATOR OPERATORS

Version 2

DEEP OBSERVATION PIT:



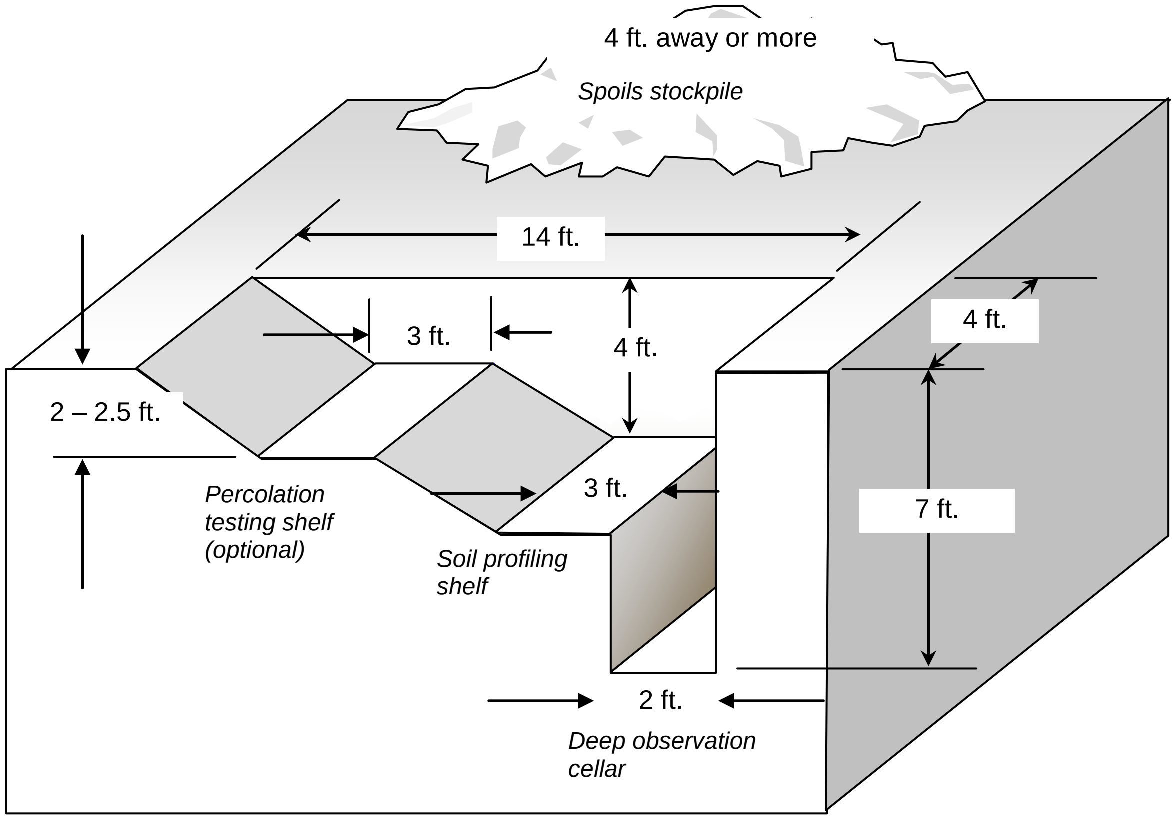
PERCOLATION TEST PIT:



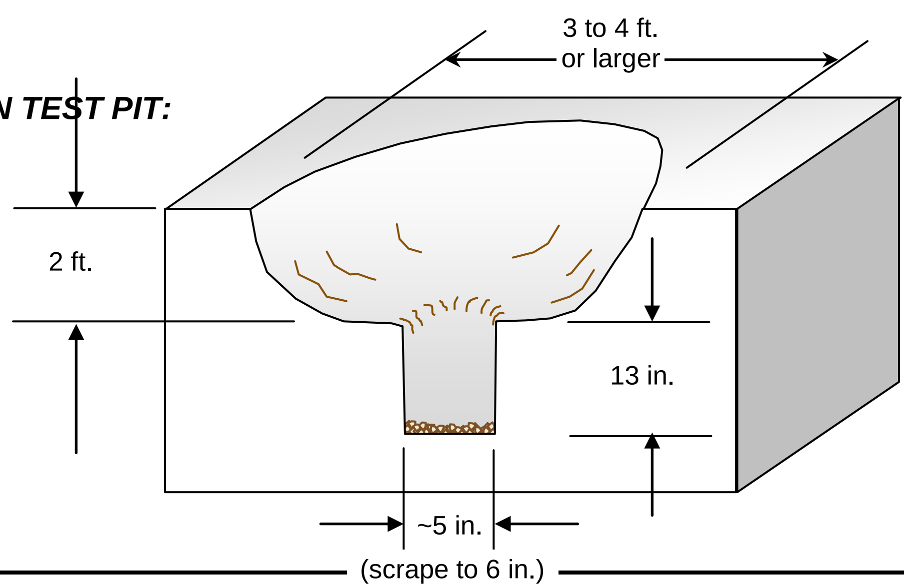
INSTRUCTIONS TO EXCAVATOR OPERATORS

Version 3

DEEP OBSERVATION PIT:



PERCOLATION TEST PIT:



Appendix 4: Sample Site Evaluation Report

(still under development)

Appendix 5: Sample Certification Exam

This is the exact same test administered during the first percolation testers training workshop on July 20, 2006. It is substantially similar to what you will see on future DEQ certification exams.

Detailed solutions are provided for your reference. If you are planning to take the exam, work through the problems first, before checking your answers. Usually, 1 hour is given in which to complete the exam.

If you print this exam from your computer's Adobe Acrobat Reader, make sure you set "Page Scaling" to "None" in the print dialogue box, so that the scale of the figures is not adjusted by your printer. Otherwise, some answers which rely on measurements may differ from the solutions provided..

CNMI Division of Environmental Quality
CNMI Percolation Testing Workshop

EXAM

July 20, 2007

1. Participant Information and Confidentiality Agreement

By taking this test, you are agreeing that you will not divulge any of the test questions to any other person, whether directly or indirectly, otherwise DEQ may invalidate your test scores, revoke your certification, and prohibit you from taking the exam again.

Name: ____
(print)

Sign your name and proceed with the examination if you agree to the above terms:

Signature: ___________________________ Date: _____________________________

1. Exam – turn page and start after reading instructions

Instructions:

1. This exam is open book.
2. You may not talk to any other test-taker during the exam
3. Circle the <u>most correct</u> answer, or write answer in the space provided.
4. Show all work on mathematical problems.
5. Read all questions <u>carefully.</u>
6. You may ask DEQ staff clarifying questions.
7. Correct answers are awarded the full point value; incorrect answers receive 0 points. No partial credit.
8. The passing "cut score" will be determined based on results & DEQ judging of difficulty of questions.
9. You will be notified of your score within 2 working days.

PART 1: 5 points for each multiple point question.

1. OSHA excavation safety rules apply to excavations deeper than:

   a. 4 feet
   b. 5 feet
   c. 6 feet
   d. 7 feet

2. If you find unexploded ordnance (UXO) while excavating your deep observation pit or percolation hole, you should:

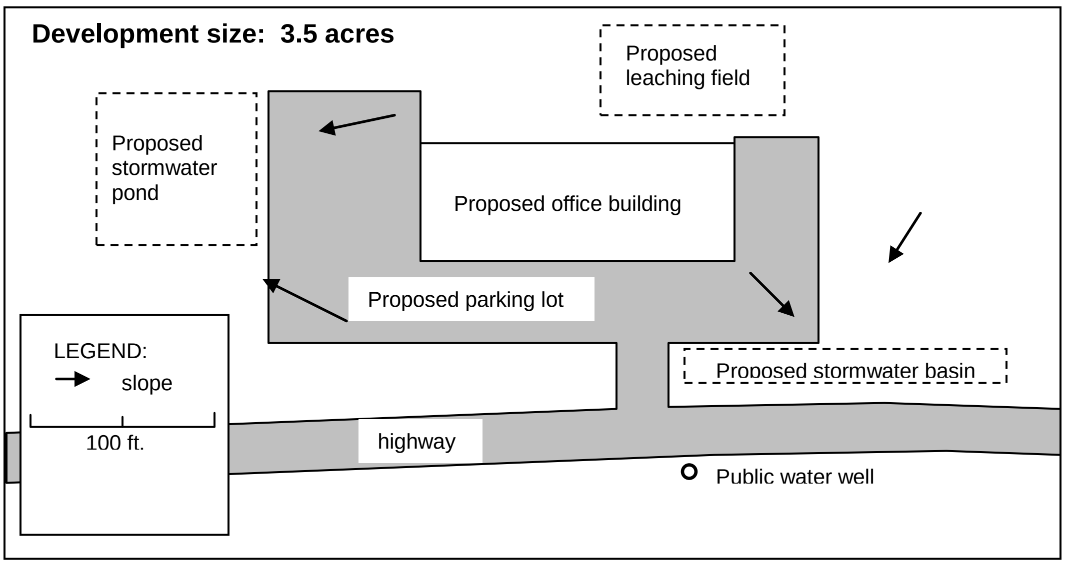
   a. Carefully move it out of the way
   b. Dig in a different location
   c. Call 911
   d. Evacuate all workers and neighbors within 300 feet.

3. Things you should do before performing the percolation test DO NOT include:

   a. Checking the soil series listed in the CNMI Soil Survey
   b. Looking at aerial imagery of the site on Google Earth
   c. Checking probably groundwater flow direction on USGS hydro. map
   d. Making a topographic survey of the lot

4. How many deep observation holes must be dug for the proposed development in the diagram below? (assume deep soil profile – no limestone)

   a. 0
   b. 1
   c. 2
   d. 3



5. For the development illustrated in problem 4 on the preceding page, how many percolation tests would you be required to perform for the proposed leaching field?

   a. 9
   b. 1
   c. 6
   d. 3

6. The purposes of the deep observation pit include:

   a. Logging soil colors
   b. Checking for impermeable layers
   c. Observing groundwater depth
   d. All of the above
   e. None of the above

7. You are pre-soaking a 13-inch deep, 6-inch diameter perc test hole dug into a silty sand. If 5 gallons of water seeps completely away in 3 hours, when can you begin the percolation test?

   a. 1 hour later
   b. The next day
   c. Right away
   d. 15 hours later

8. What is a possible consequence of using a percolation test hole with a larger than 6-inch diameter?

   a. Excessive scouring
   b. DEQ will reject the test results
   c. Faster percolation rate
   d. Slower percolation rate
   e. All of the above

9. A 10-minute measurement interval would be appropriate in which case?

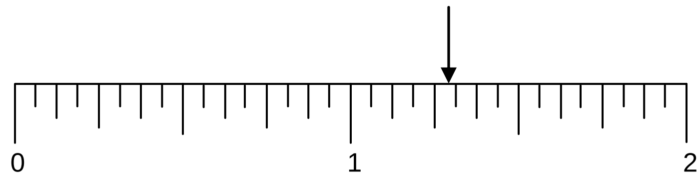
   a. 1 inch drop occurs in first 10 minutes of test
   b. Soil texture is classified as a silty clay loam
   c. 1 inch drop occurs in first 2 minutes of test
   d. Soil is a mixture of limestone and silty clay loam

10. A percolation test is performed in a silty sand. After observing the initial drop, the percolation tester decides to use a 2 minute time interval. The test is finished when:

a. 5 gallons of water is absorbed
b. 6 inches of water seeps away
c. the first 3 measurements are within 1/16th of an inch of each other
d. 10 measurements are made

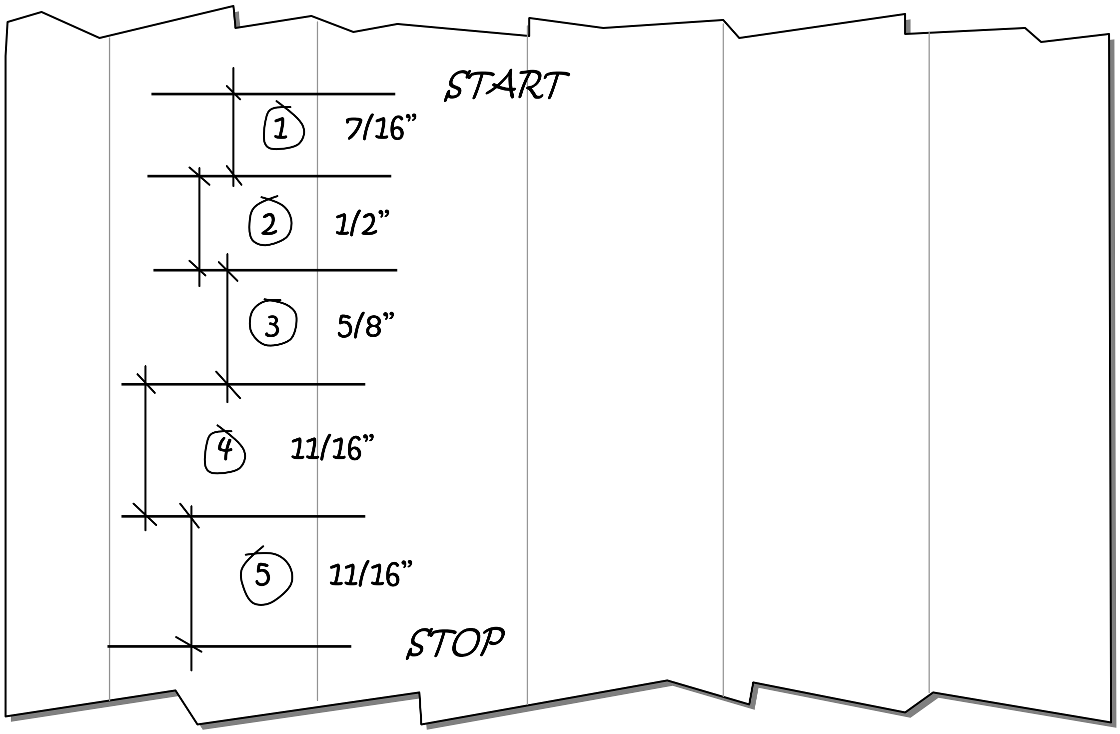
PART 2: 10 points per question

11. What ruler measurement does the following diagram represent, to the nearest sixteenth (1/16th) of an inch? (diagram not drawn to scale)

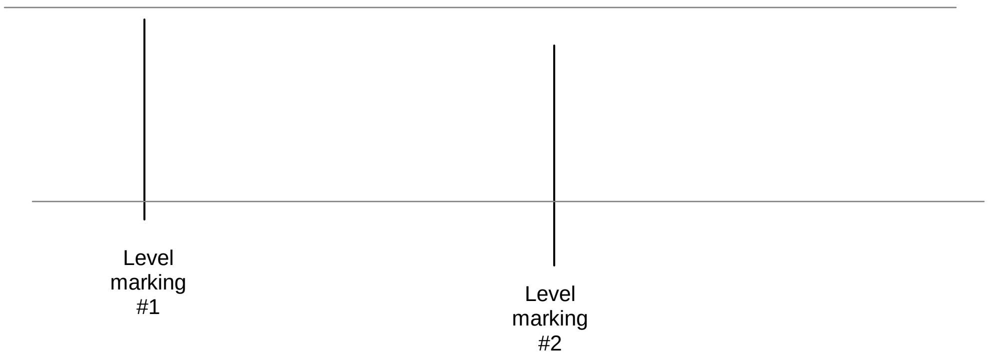


a. 5/16”
b. 1 3/8”
c. 1 5/16”
d. 1 4/16”

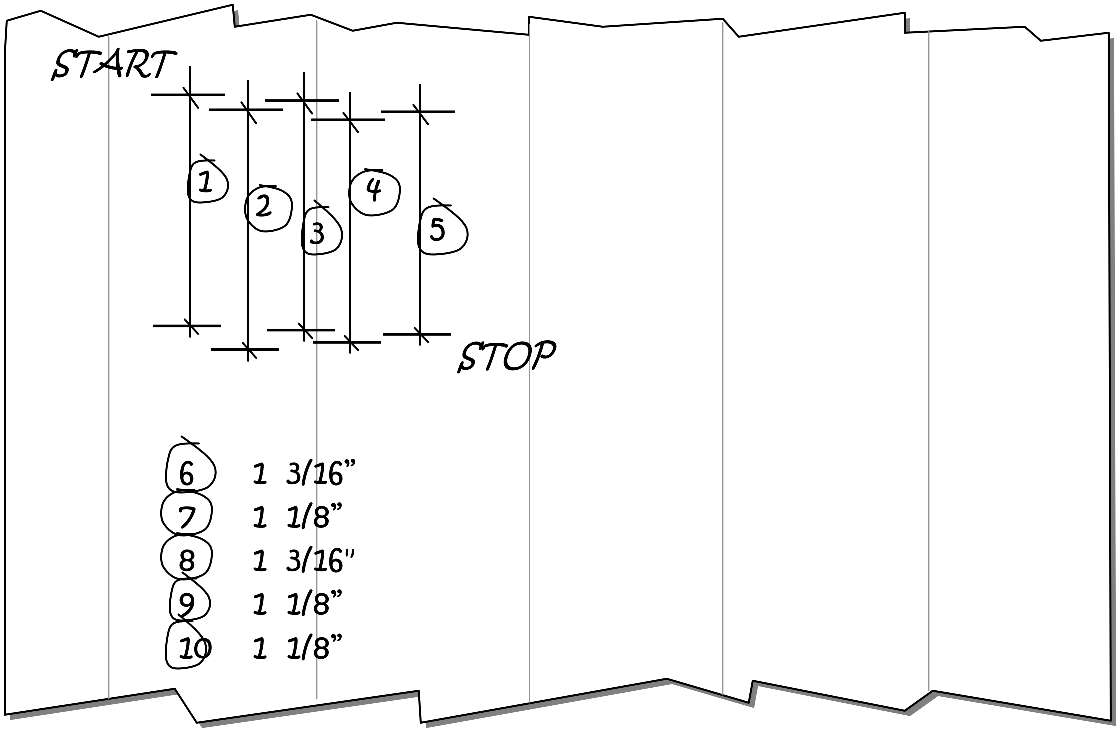
12. Compute the final percolation rate based on the following, provided measurements. Assume a 30-minute time interval was used. Show your calculations and circle your final answer.



13. Measure the drop between the following two level markings to the nearest 1/16th of an inch. Circle your measurement.



14. Compute the final percolation rate for this falling head test. A measurement interval of 5 minutes was used. Circle your answer.



15. Five percolation tests are conducted for a very large stormwater infiltration system that will be located in mixed limestone / silty clay loam soil horizon. The depth of all percolation tests was 4.5 feet. What would be the final recommended percolation rate you would report to the engineer?

Test No.	Final Rate (in./hr.)
1	15.1
2	13.2
3	12.5
4	17.0
5	8.4

SOLUTIONS:

1. b

2. c

3. d

4. d; Generally speaking, one deep observation hole should be provided near each infiltrative practice on large projects, if each practice is located in different parts of the lot from the others. Theoretically, if a stormwater practice was located close to the leaching field, the deep observation pits could be combined. But that is not the case with this example, so the answer is 3.

5. d; for larger projects such as this (larger than ½ acre), 3 percolation tests must be provided for each practice. Note that the question asks only for the number of percolation test holes required for the *proposed leaching field* – not for the entire proposed project, which would require 3 x 3 = 9 total percolation test holes. It pays to read the question carefully! Make sure you know what question is being asked!

6. d

7. c

8. d

9. a

10. d; the reason this answer is not 'c' is because of the rule for the minimum number of measurements that must be taken before stopping the test. In a "fast" soil (one where the measurement interval is 5 minutes or less), you must make at least 6 measurements before stopping. If choice 'c' had said "measurements 4, 5, and 6 are within 1/16th of an inch of each other," then choice 'c' would have been the most correct answer.

11. c; remember to estimate to the "nearest" sixteenth mark.

12. the final percolation rate is calculated using the last measurement only. Be very careful to make sure you use the last measurement in your calculation; the direction in which measurements proceed on the page will change depending on the measurement apparatus you use. The final measurement should always be easy to determine if the measurement date is correctly notated with the "start" and "stop" lines. In this case, the last measurement is 11/16th of an inch, and the calculation of the final rate is as follows:

[note: 11/16th inch = 11 ÷ 16 = 0.6875 inch – DON'T ROUND UNTIL THE END OF THE CALCULATION!]

$$\frac{0.6875 \text{ in.}}{30 \text{ min.}} \times \frac{60 \text{ min.}}{1 \text{ hr.}} = \mathbf{1.38 \text{ in./hr}}$$

13. 2 2/16th inches, or 2 1/8 inches, measured between the two vertical "level markings". (this may vary based on your printer – be sure to print with "Page scaling" set to "none" for the best chance of duplicating this answer.)

14. Again, the final percolation rate is based on only the final measured drop, which in this case is 1 1/8". There is absolutely nothing different about calculating a final percolation rate for a "falling head" percolation test than for a normal percolation test. Just be sure you use the last measured drop to base your calculation on.

[note: 1 1/8th inch = 1 + (1 ÷ 8) = 1.125 inch – DON'T ROUND UNTIL THE END OF THE CALCULATION!]

$$\frac{1.125 \text{ in.}}{5 \text{ min.}} \times \frac{60 \text{ min.}}{1 \text{ hr.}} = \mathbf{13.5 \text{ in./hr}}$$

15. Because multiple percolation tests were made for just one proposed infiltrative practice, the answer is to average the test results. First, however, the results should be checked to make sure they don't indicate a variation in soil type. In an area underlain by limestone, one should expect some variation in results. In this case, all results seem reasonable, so all results should be used in the final average calculation.

$$\text{Final (average) percolation rate} = \frac{15.1 + 13.2 + 12.5 + 17.0 + 8.4}{5} = 13.2 \text{ in./hr.}$$

But how do you know when to keep a percolation rate, or throw it out? There really is no set answer. Good judgment, based on experience, is a must. In an area underlain by limestone, what one would be most worried about is having a percolation rate that might be too high because of digging into a fracture or solution cavity by accident. In that case, you would know because the percolation rate would be extremely fast compared to the others – probably on the order of 30, 60, or even 100 inches per hour. It would definitely be a good idea to throw out any result that high, unless all other results are similarly fast, because it would bias your final percolation rate and result in a facility design that may be too small – just because a pint of water in a 6-inch hole drains that fast through a small crack, does not mean a 100' x 50' infiltration field will discharge at the same rate through even a large number of small cracks and channels.

On the other hand, if you happened to dig into a deep pocket of clay soils, it is possible to obtain a local percolation rate of 1 to 2 inches per hour. These low percolation rates should be kept and used in the final average. After all, the final system will be installed in a combination of such soils and faster-permeability limestones, and the safest design approach would be to allow the slower result to influence the final average rate you use. A conservative design approach is always advised when designing infiltrative practices. No one wants a cheaper facility if it fails after just a few years.

Appendix 6: Quick Reference Cards

If you print this exam from your computer's Adobe Acrobat Reader, make sure you set "Page Scaling" to "None" in the print dialogue box, so that the scale of the figures is not adjusted by your printer. Otherwise, some drawings and reference measurements may not be accurate.

DEQ QUICK REFERENCE CARD - PERCOLATION TESTING

v. 7-18-07

1. Location & Number

Deep Observation Pit:

Number:

- one (1) required up to 1 acre;
- larger sites may require more

Location: near (NEVER WITHIN) proposed leaching field or stormwater practice.

Percolation Test Hole:

Number:

Residences & less than half acre (22,000 sq. feet or 2,000 sq. m):

- one (1) perc. hole required;
- three (3) perc. holes recommended

Larger sites:

- depends on number of leach fields & stormwater infiltrative practices;

Location: Within proposed leaching field or stormwater practice location

Safety:

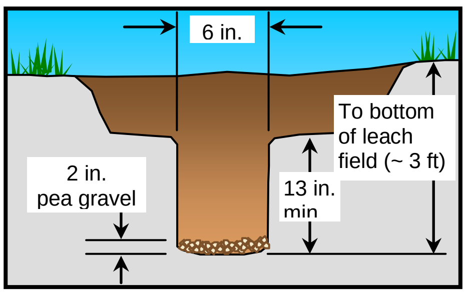
- Holes deeper than 5 feet require protection
- Beware of UXO – call DPS if found
- Check for underground utilities first!
  - Electrical
  - Water
  - Phone
  - Sewer

Limestone:

Deep observation pits are not required in areas where the bottom of the proposed percolation pit will be:

- in limestone
- at an elevation of more than 10 ft. msl
- no closer than 100 feet from a wetland, stream, or volcanic soils

2. Test Hole



1. Excavate upper hole to depth 13 inches above proposed bottom of leach field or stormwater practice. (to about 2 ft.)
2. Dig or bore perc test hole to initial diameter of 4 to 5.5 inches.
3. Scrape / "peel" to final diameter of 6 inches

Larger holes:

Holes larger than 6 inches are allowed. Keep in mind these drawbacks:

- more than 5 gallon pre-soak required
- perc rate may be lower than 6 in. hole

Limestone:

Perc holes in "clean" limestone may be as shallow as 13 inches below soil interface (*not* below surface). In limestone that has soil pockets, full depth should be used.

3. Notifying DEQ

DEQ must be notified no less than 24 hours prior to start of pre-soaking.

Hand-deliver or fax notification form to DEQ (fax: 664-8540)

Timing guidelines:

Perc test can usually begin:

- Same day in clean limestone or sand;
- Next day in mixed or clayey soils

* *These are general guidelines only! Results will vary!*

4. Pre-Soaking

6 inch holes:

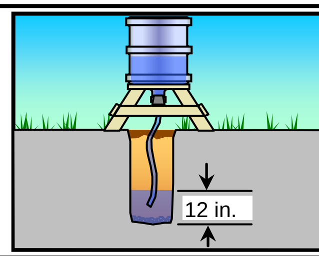
- fill to 10 inches above gravel (12 in. total)

Perc. test may start when:

- 5 gallons is absorbed; or
- overnight

Larger Holes:

- provide enough water to maintain 8-16 inch level overnight



Invert a 5-gallon bottle over the hole to maintain required depth overnight.

***Remember:** More than 5 gal. will be required for holes larger than 6 inches in diameter!*

5. Test Measurements

1. Fill hole (or reduce level) with water to 6 inches above gravel.
2. Record water levels at even time intervals:

Interval chosen based on first observed drop:
Goal: drops should be between 1 to 2 inches

"Slow" Clayey soils:	30 min.
"Fast" soils, limestone, sand:	10, 5, 2, or 1 min.

3. The test is finished when:

a. *Minimum # drops has occurred:*

3 drops:	"Slow" Clayey soils:	(30 min. intervals)
6 drops:	"Fast" soils:	(10 min. intervals or less)

AND: ***Final 3 drops are within 1/16th of an inch***
(Lower accuracy may be justified for very fast perc. rates)

OR: **b. Maximum # drops has occurred:**

6 drops:	"Slow" Clayey soils:	3 hours total time
10 drops:	"Fast" soils:	varies; 1:40 or less

6. Calculating Results

Final percolation rate:

$$= \frac{\text{final drop (in.)}}{\text{time interval (min.)}} \times \frac{60\text{ min.}}{1\text{ hr.}}$$

Averaging multiple percolation rates (r):

$$= \frac{r_1 + r_2 + r_3 + \ldots r_x}{\text{total \# samples } (x)}$$

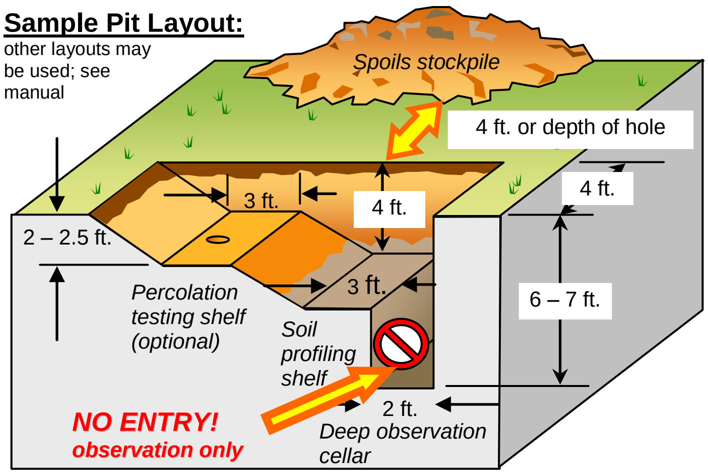
See text for guidelines on when not to use average

DEQ QUICK REFERENCE CARD – SOIL PROFILING

v. 7-19-07

Sample Pit Layout:

other layouts may be used; see manual



Safety:

- Holes deeper than 5 feet require protection
- Beware of UXO – call DPS if found
- Check for underground utilities first!
  - Electrical
  - Water
  - Phone
  - Sewer

Deep Observation Pit

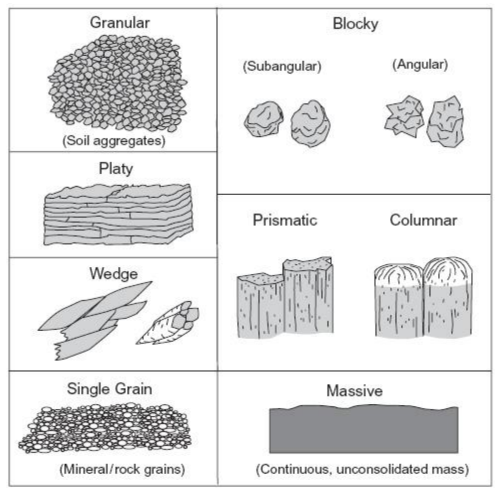
1. Soil Profiling:
   - Chip/peel section of wall 12" wide, 4 feet deep
   - Describe deeper segments by obs. & spoils
2. Check for groundwater:
   - Look for saturated soils; seepage
   - High level - redoximporhic features
3. Restrictive horizons
   - Impermeable clays or bedrock

Field Procedure for determining USDA Textural Classification

Form moist soil into ball with fingers

- • No ball • Does not stain fingers → • Does not ribbon → • Very gritty CLASSIFY AS SAND
- • Weak ball • Stains fingers slightly → • Does not ribbon → • Very gritty CLASSIFY AS LOAMY SAND
- • Fairly firm ball • Stains fingers → • Does not ribbon → • moderately gritty CLASSIFY AS SANDY LOAM
- • Firm ball • Stains fingers
  - • Does not ribbon
    - • Neither gritty or smooth CLASSIFY AS LOAM
    - • Smooth CLASSIFY AS SILT
  - • Ribbons
    - • Slight tendency to ribbon – smooth, slick, buttery feel CLASSIFY AS SILT LOAM
    - • Ribbons with some flaking <2 ½" long – very smooth, moderately sticky feel CLASSIFY AS SILTY CLAY LOAM
    - • Long ribbon >2 ½" long – sticky feel CLASSIFY AS SILTY CLAY

Examples of Soil Structure Types

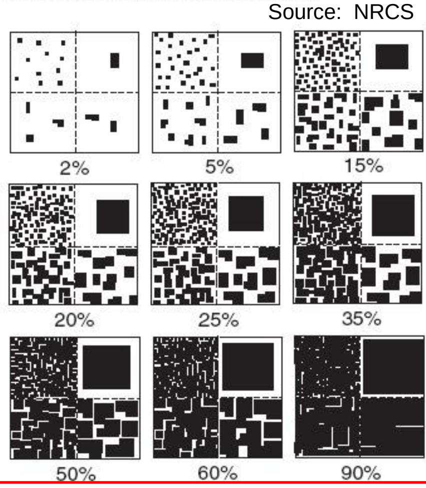


Source: NRCS

EXAMPLES OF PERCENT OF AREA COVERED

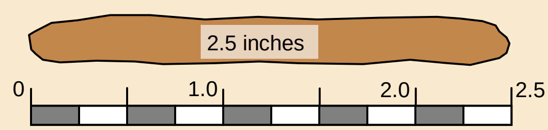
The following graphic can be used for various data elements to convey "Amount" or "Quantity." *NOTE*: Within any given box, each quadrant contains the same total area covered, just different sized objects.

Source: NRCS



Ribbon Size:

for use in textural description



GRADES OF SOIL STRUCTURE

Grade	Characteristics
Structureless	No observable aggregation
Weak	Poorly formed and difficult to see. Will not retain shape on handling.
Moderate	Evident but not distinct in undisturbed soil. Moderately durable on handling.
Strong	Visually distinct in undisturbed soil. Durable on handling.

Source: USEPA