INTRODUCTION

Percolation tests (colloquially called a perc tests) and associated interpretations are the foundation for the design of private waste disposal systems, but are also important for investigating mine or landfill drainage. Specifically, a percolation test measures the ability of the soil to absorb liquid. In general, sandy soil will absorb more water than soil with a high concentration of clay or where the water table is close to the surface. The results of a percolation test are required to properly design a septic system.

The test could be called a field permeability test and obtained data can actually be used to determine the hydraulic parameters of the soil, such as k_f values. In short, a hole is drilled into the soil and saturated with water. Data is then collected on how quickly this known volume of water dissipates into the subsoil. In general, the rate of drop of the water level is observed by measuring the depth of the water surface below the top of the hole at 1, 2 and 5 minutes after the start of the test and at 5 minutes intervals thereafter. These observations are made until the rate of drop becomes negligible or until sufficient readings have been obtained. While every county and State will have its own laws regarding the exact calculations for the length of line, depth of pit, etc., the testing procedures usually follow the outline given above.

In general, jurisdictions are only interested in the data of a steady state condition, when water appears to percolate into the subsurface at a constant rate. This rate is expressed as MPI (minutes / inch) of drop rate and whole home waste disposal systems are designed by interpreting this number. It does work very well as a multitude of installed and functional private sewage disposal systems can attest.

As a hydrogeologist, however, a more thorough data analysis can be performed which may be used to exceed the required interpretation of a certain jurisdiction, but would be a welcomed asset for soil engineers.

YOUR ASSIGNMENT

- ☐ You may work in groups. Selected a suitable field site (someone's property) to dig percolation test holes and do the field study and measurements.
- ☐ Do the perc test. Record all data. You may share the results among your group.
- ☐ Do the computations and generate the professional report. This part must be uniquely yours. NO group work allowed!
- ☐ Turn in the report by the deadline(s) indicated for grading.

GRADING:

Writing assignments must be turned in by the deadline indicated. Read the WRITING PRIMER in detail BEFORE you submit your paper. Missed deadlines FOR ANY REASON will drop one letter grade as scheduled below with 0% F for work submitted past the final deadline.

I will read your paper until I come to the 10th fault in layout, grammar, spelling, content, concept, format, presentation, expression, design, citation, etc. (Be aware that repeat mistakes will count MORE THAN ONCE!) I will then stop reading / grading, unceremoniously return your work for revision and drop you one full letter grade. Revisions have to be returned by the next deadline and the process is repeated. You will drop one full letter grade every time I reach more than 9 mistakes or if you submit your paper PAST the indicated deadlines. Work submitted past the FINAL SUBMITTAL deadline will ALWAYS receive a 0% F. You have been warned!

NO REVIEW OF YOUR PAPER BY THE INSTRUCTOR BEFORE SUBMITTAL. PROOFREADING IS ENTIRELY YOUR JOB. YOUR GRADED SUBMITTAL WILL BE THE INSTRUCTOR'S REVIEW OF YOUR WORK!

THIS SHEET IS TO BE RETAINED & ATTACHED TO FRONT OF **EVERY** SUBMITTAL OF YOUR ASSIGNMENT
WARNING!!! NO ASSIGNMENT ACCEPTED WITHOUT THIS SHEET!!! WARNING!!!

PROJECT GRADING RUBRIC

Name:	Course section ID:
Overall FINAL Grade:	%
	/200

Your report must include the following or the indicated points will be deducted:

- ☐ (PCL) Professional Cover Letter summarizing procedure and explaining the results. Any county specific addendums should be mentioned
- ☐ (LOC) Your location, topographic and hole site MAP, including true N and scale.
- ☐ (XLD) Your EXCEL Spreadsheet MPI , K_{sat}, k_f Data Table with explanation
- ☐ (XLG) Your EXCEL Spreadsheet MPI GRAPH with explanation. Make sure the graph has a figure caption.
- ☐ (ISO) Your k_f isopleth MAP superimposed on a base map
- ☐ (SEP) Septic Field Design, calculations and recommendation

A	**1st SUBMITTAL** Comments: *Missing ☐PCL-5 ☐LOC-3 ☐XLD-5 ☐XLG-5 ☐ISO-5 ☐SEP-5* Mistakes 0 ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ 100 98 97 96 95 94 93 92 91 90 Points / Percent	Deadline to receive **A**: Copy deadline dates and times from calendar here!
B	**2nd SUBMITTAL** Comments: *Missing ☐PCL-5 ☐LOC-3 ☐XLD-5 ☐XLG-5 ☐ISO-5 ☐SEP-5* Mistakes 0 ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ 89 88 87 86 85 84 83 82 81 80 Points / Percent	Deadline to receive **B**: Copy deadline dates and times from calendar here!
C through F (>0)	**3rd & FINAL SUBMITTAL** Comments: *Missing ☐PCL-5 ☐LOC-3 ☐XLD-5 ☐XLG-5 ☐ISO-5 ☐SEP-5* 79 - number of faults = GRADE PERCENT **79 78 77 76 75 74 73 72 71 70 69 68 67 66 65 64 63 62 61 60 59 58 57 56 55 54 53 52 51 50 49 48 47 46**	Deadline to receive **C - F**(>0): Copy deadline dates and times from calendar here!

Assignments received AFTER the last deadline for ANY REASON will be counted as "missing" and will receive a 0% F!

Calculation of FINAL PROJECT GRADE:

GRADE PERCENT × 2.0 = PROJECT POINTS

	× 2.0 =	

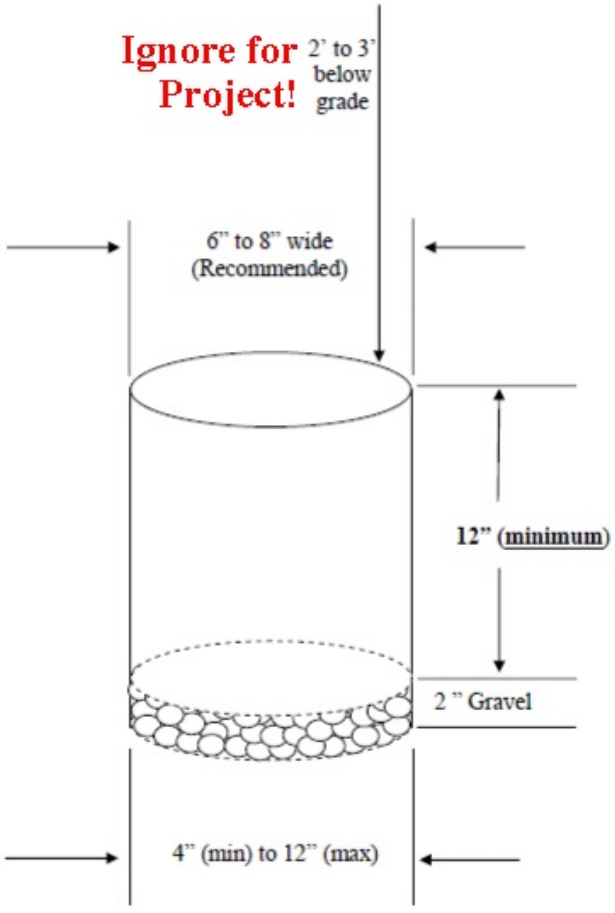
For this project you will need an open property or backyard to perform the test. You may work in groups, but remember: *"You can share the data, but NOT the write-up."* The write up must be uniquely yours.

MATERIAL LIST - In order to perform the percolation test outlined below you will need:

- Shovel &/or Posthole digger
- Field, Backyard or other property
- Bag of coarse gravel
- (3) 12" Plastic Rulers (inch markings)
- Timing Device (watch with second hand or stop watch)
- Knife
- Note Paper / Recording Table(s)
- Tape Measure
- Lots of CLEAN, CLEAR water.
- 1 ½' to 2' piece of wood
- Some screws and screw driver
- Look for additional COUNTY REQUIREMENTS

GENERAL OVERVIEW

LOCATION OF PERCOLATION TEST HOLES - The percolation(perc) test holes shall be spaced uniformly over the proposed soil absorption (leach field) site. **A minimum of three(3) test holes are required.** More than 3 are preferred. Location of holes are to be shown on a location field map.



TEST HOLE PREPARATION - Test holes that are 4 to 12 inches in diameter (6" to 8" recommended) shall be dug or bored to the proposed depth of the leach field(typical depths are 30 to 42 inches or 2' to 3' below grade). *However, for this class project we will use the surface with a perc test hole depth of 12in (1 foot). See figure.* The side walls shall be vertical and a natural soil surface (one which is not smeared from digging) shall be exposed by scraping the sides and bottom of the test hole with a sharp pointed instrument (knife). Any loose material shall be removed from the test hole and 2 inches of coarse sand or gravel placed in the bottom of the test hole in order to prevent scouring and sealing before the water is poured in. Make sure the top of the gravel layer is LEVEL since it will be the base for your water level measurements with a ruler. *See figure.*

PRESOAKING - **PRESOAKING IS ABSOLUTELY REQUIRED** in order to get valid percolation test results. The purpose of presoaking is to have the water conditions in the soil reach a stable condition similar to that which exists during continual wastewater application in a leach field. The minimum time of presoaking varies with soil type and soil conditions, but must be sufficiently long so that the water seeps away at a steady rate. Filling the hole several times during a 24 hour period and/ or overnight soaking are excellent methods. Determining the appropriate percolation test procedure will aid in ascertaining additional presoaking and hole preparation procedures.

DETERMINATION OF APPROPRIATE PERCOLATION TEST PROCEDURE

1 Fill the percolation hole with water to a depth of 12 inches over the gravel or top of the hole. Insert plastic ruler to gravel depth and record starting position.

2 Determine the time needed for the water to seep away completely. This is done by filling the presoaked test hole completely with water (as instructed under 1) and determining if the water seeps away in 10 minutes or less.

2.1 **IF** water remains in the percolation hole after 10 minutes, proceed with the (A) SLOW PERCOLATION TEST PROCEDURES.

2.2 **IF** water has completely seeped away after 10 minutes, proceed with the (B) FAST PERCOLATION TEST PROCEDURES.

(A) SLOW PERCOLATION TEST PROCEDURES

1 Make sure the test hole is properly presoaked by maintaining at least 12 inches of water over the gravel in the hole for 4 hours and then refilling the hole preferably for an overnight soaking. Let the hole sit for not less than 16 hours or more than 30 hours to allow swelling of clay systems to occur during this period. Your SLOW PERCOLATION TEST PROCEDURE must begin no sooner than 16 hours and no later than 30 hours after the end of the 4-hour soaking period.

2 To start the test, fill the percolation hole with water to a minimum depth of 12 inches or top of hole over gravel.

3 Immediately insert ruler vertically to touch gravel and record water height starting level AND starting time. *Hint: You may want to move ruler around and take a few measurements to see if your gravel is level. It might be best to anchor the ruler into a vertical position. This can be done by screwing the ruler to a perpendicular mounted 1 ½' to 2' piece of wood and laying / clamping the wood piece across the hole, keeping the ruler stationary and perfectly vertical in the test hole.*

4 Measure the drop in the level of the water at 30-minute intervals, for a total of 4 hours. If the first 6 inches of water seeps away in less than 30 minutes, the interval between measurements must be reduced to 10 minutes and the length of the test must be reduced to 1 hour. Make sure to record times and measurements.

5 Fill the hole to a maximum depth of 6 inches over the gravel as often as necessary to prevent the hole from becoming empty. Make a note in your recording.

6 The amount of the drop in the level of the water during the last interval must be used to determine the percolation rate, except that if two successive measurements do not vary more than $1/16^{th}$ of an inch, the test may be stopped and the percolation rate may be determined.

(B) FAST PERCOLATION TEST PROCEDURES

1 Make sure the hole is properly presoaked as per instructions above.

2 Fill the percolation hole with water to a level that is no more than 6 inches over the gravel. Immediately insert ruler vertically to top of gravel and record starting height and starting time. *Hint: You may anchor the ruler as per instruction 3 under Slow Percolation Test Procedure.*

3 Measure at 10-minute intervals, how much the water drops over the next 60 minutes. If 6 inches of water seeps away in less than 10 minutes, a shorter interval between measurements must be used. Don't forget to record water levels an times.

4 Refill the hole as necessary to prevent all water from seeping away. The level of the water must never exceed 6 inches in depth over the gravel. Proceed with refill and measurements until your water level drop rate is constant. If water continues to all seep away in ten (10) minutes or less, this indicates that the soil is excessively permeable and the site is unsuitable for a standard subsurface disposal system. *However, for this project, continue with the percolation test calculations as outlined anyway.*

PERC RATE CALCULATION & GRAPHING - After the water level drop rates have stabilized in all of the test holes the test is completed and you can commence with the data analysis. Use EXCEL Spread Sheet or similar software to REPORT RESULTS, do your CALCULATIONS and GRAPH RESULTS.

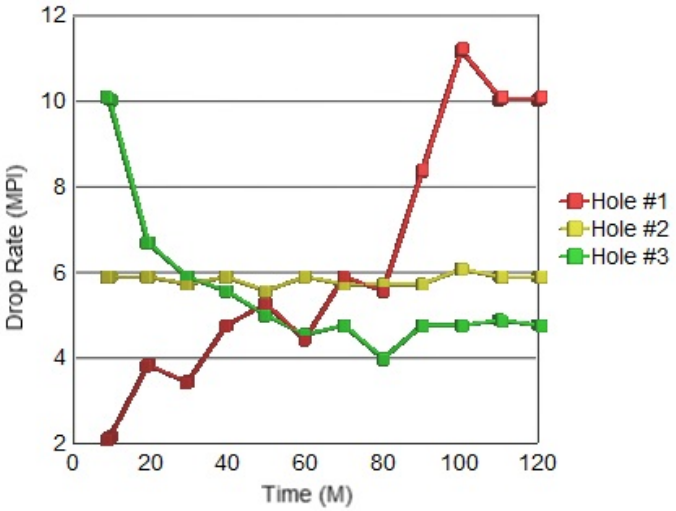
$$Perc\ Rate = \frac{Time(min)}{Drop(in)}$$ Percolation Rates are expressed in minutes per inch (MPI). To calculate the perc rate for each test hole measurement, divide the time interval by the drop in inches.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Percolation Test Calculations												
2													
3	Hole #1				Hole #2				Hole #3				
4	Time (Min)	Water Level (in)	Refill Level (in)	Drop (MPI)	Time (Min)	Water Level (in)	Refill Level (in)	Drop (MPI)	Time (Min)	Water Level (in)	Refill Level (in)	Drop (MPI)	
5	0	11.75			0	11.00			0	12.00			
6	10	7.10		2.15	10	9.30		5.88	10	11.00		10.00	
7	20	4.50	11.50	3.85	20	7.60	11.25	5.88	20	9.50	11.50	6.67	
8	30	8.60		3.45	30	9.50		5.71	30	9.80		5.88	
9	40	6.50		4.76	40	7.80		5.88	40	8.00		5.56	
10	50	4.60		5.26	50	6.00		5.56	50	6.00	12.00	5.00	
11	60	2.35	11.50	4.44	60	4.30	11.50	5.88	60	9.80		4.55	
12	70	9.80		5.88	70	9.75		5.71	70	7.70		4.76	
13	80	8.00		5.56	80	8.00		5.71	80	5.20		4.00	
14	90	6.80		8.33	90	6.25		5.71	90	3.10		4.76	
15	100	5.90		11.11	100	4.60		6.06	100	1.00	11.25	4.76	
16	110	4.90		10.00	110	2.90		5.88	110	9.20		4.88	
17	120	3.90		10.00	120	1.20		5.88	120	7.10		4.76	
18													

A sample EXCEL spreadsheet suitable for reporting results is shown here.

The perc rate is literally the inverse of the saturated hydraulic conductivity of the soil K_{sat} which would by expressed in distance/time, such as m/s. In other words, PercRate = $1/K_{sat}$ and K_{sat} = 1/PercRate

The next step is to graph your results. This is done by plotting the time since beginning of perc test on the x-axis nad the drop rates in minutes per inch (MPI) on the y-axis. Again, you should use your EXCEL software to do the graphing. Please chose XY-scatter plot from the graphing menu to arrive at your correct results. The Example given here is representative of what will be expected from you. Once the graph is completed, the perc rate can be interpreted from the plotted data. The final rate is the flat curve on the graph, where it parallels the x-axis.

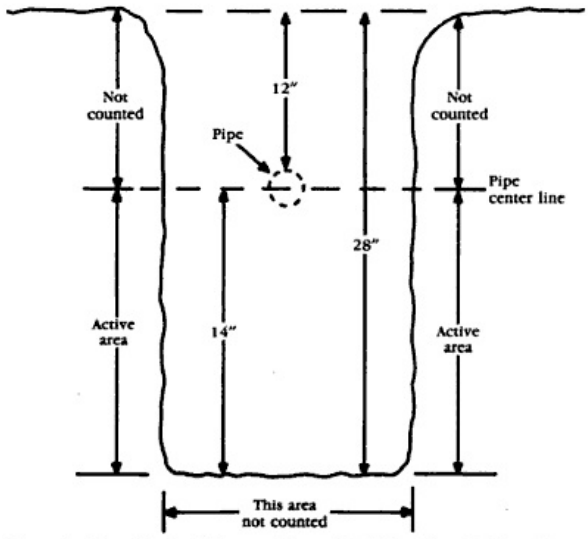


(A) Graphical Solution - Draw a straight line on the x-axis parallel to the graph, averaging the horizontal point distribution. The intersect of this line with the y-axis is your perc rate.

(B) Mathematical Solution - Use only those data points from the flat end (parallel to x-axis) of the graph and calculate the averages. In the sample graph, Hole #1 would include data from 100 - 120 minutes, Hole #2 ALL the data, and Hole #3 the 90 - 120 minute data range.

If the perc test data agrees among the test holes, the overall FIELD PERC DROP RATE can be calculated by averaging the above estimated perc rates from each hole. If perc data varies, a field map showing the various perc zones should be completed from the test data and additional holes and test might need to be performed.

SEPTIC SYSTEM DESIGN STANDARDS



Measuring the active (useful) area of the walls of a leach trench. The active area in this example is 2 times 14 inches for every foot of trench length, or 2.4 square feet per foot.

Septic System Design Standards are based on the perc rates measured. The following form from a Nevada Engineering firm will give you an idea about the requirements for designing a septic system. For our project you may chose your own house size (number of bedrooms). Follow the calculations for design standards presented on the next page.

The engineering term “effective sidewall” is defined in the graphic to the left. It is literally the depth below the drain tile multiplied by two. Usually the area is filled with gravel or river pebbles of 3/4" size. For the system you are required to design for the project, use an active sidewall depth of less than 1 foot, but greater than 4". That is, you will be filling the septic trenches in your design with a layer of gravel less than a foot thick. *Hint: The calculations on the next page already include the multiplication by 2. So don’t multiply twice!*

Calculating Size of System

NOTE: The system is sized based on tank size, perc rate and effective depth.

Number of Bedrooms	Minimum Liquid Capacity of Tank (in gallons)
3 or less	1,000
4	1,200
5 or 6	1,500
More than 6	150 gallons for each additional bedroom must be added to 1,500 gallons.

Percolation Rate	Design Application Rate (gallon/square foot)
0-10	1.6
11-15	1.3
16-20	1.1
21-25	1.0
26-30	0.9
31-40	0.8
41-50	0.7
51-60	0.6

Example of how to size your system

Step 1 – Choose tank size based on number of bedrooms.
Step 2 – Use the slower percolation rate to determine gallon/square foot design application rate.
Step 3 – The absorption area is calculated by dividing the capacity of the septic tank by the design application rate as follows:

4 bedroom house = 1,200 gallon tank
Perc rate of 23 minutes = 1
1,200 by ÷1 = 1,200 square feet

Step 4 – Multiply the effective sidewall by 2, maximum depth is 4', 4 x 2 = 8.
Step 5 – Determine the required length by dividing the required absorption area by the effective sidewall as follows:

1,200 square feet ÷ 8 (depth of trench multiplied by 2) = 150 lineal feet.

Step 6 – Maximum length of leach line is 110 feet. A minimum of two trenches, 75 feet long with 4 feet of aggregate beneath the distribution lines, is acceptable.

Enter your calculation below:

Number of Bedrooms_____Tank Size_____ Perc Rate _____

Tank Size _____ ÷ Design Application Rate_____ = _____

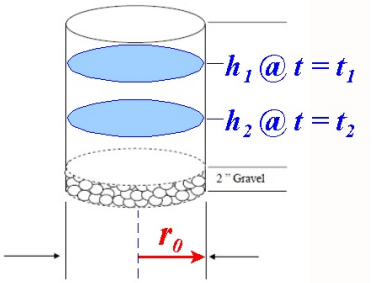
Sidewall depth X 2 = _____ Number & Length of lines _____

Or Number of Infiltrators used_____.

ADDITIONAL HYDROLOGIC INTERPRETATION

While K_{sat} can be calculated from 1/PercRate, actual k_f values can be computed as follows from the collected percolation data.

$$k_f = \frac{2.3 r_0}{5.5(t_2 - t_1)} \log \frac{h_1}{h_2}$$



Please indicate both values in your write-up. For your own understanding (NOT part of write up, try to explain why both of these values might be different)

LOCATION MAP & K_F ISOPLETHS

You are required to construct a map showing the k_f contours of the subsurface in the area of your proposed septic leach field. The map should show a topographic map of the surface with the locations of the test holes and other structures (such as houses). Make sure you provide a scale for your map. Google Maps is an excellent starting point, but remember: Your map will be a very Small Scale map probably on the order of 1" = 25ft or 1:300. You may have to enlarge the map and then redraw your section of interest. Your completed map should fit on a regular letter sized page. Do not forget to indicate true North on the map. To locate your exact test holes, use a landmark starting point and a tape measure. You should be able to transfer the test hole locations onto your map.

Superimposed on this base map are the k_f isopleths indicating changes in hydraulic conductivity, if any. Usually soils are heterogenous enough to show slight differences. Fetter (2001), section 3.12, p. 107, 108 explains isopleth construction for Hydraulic Gradients and well set-ups. You can modify the approach slightly in order to construct the k_f isopleths from your test hole data and to show hydraulic conductivity gradients.

PERCOLATION TEST REPORT

A Percolation Test Report is a professional write-up to be submitted to the health department and the client requesting the percolation test to be performed. It should include some suggestions for septic field design and sizing. It also includes all graphs and data tables. The actual report does NOT include handwritten field notes. However, since you will be graded on the whole project, please insert your hand written field notes and other supporting documents in an attached package to your official report at the end for reference.