Permeameter Customer FAQ

- **What is the applicable permeability range for the ETC Pask Permeameters?**

For the **ETC Standard Pask Permeameter**, the applicable Kfs range would be:

10-8 m/sec to 10-4 m/sec

The estimated applicable Kfs range for the **ETC Slow Soils Pask Permeameter** would be:

10-9 m/sec to 10-6 m/sec.

- **What is the difference between the Standard ETC Pask Permeameter and the Slow Soils Pask Permeameter which is included in the Comprehensive Pask Permeameter Kit?**

The **Slow Soils (SS) Pask Permeameter** (which comes in the **ETC Comprehensive Pask Permeameter Kit**), is a variation of the ETC Standard Pask Permeameter. It is better suited for testing very slowly permeable soils such as: clay, silt, silt loam, clay loam, loam, sandy silt, etc. It is also ideal for engineering consultants and others who conduct quality control testing in the field on compacted clay liners for lagoons, stormwater ponds and landfills.

The Slow Soils permeameter (SS) has a much smaller reservoir diameter than the Standard Pask Permeameter. For every milliliter (ounce) of water which flows out of the well hole into the soil, there will be a larger drop on the smaller diameter SS reservoir compared to the Standard Pask Permeameter. This makes it more accurate at the lower (slower) end of the Kfs range because it is easier to detect drops for small volumes of water on the scale of the Slow Soil Permeameter reservoir. So for testing very slowly permeable soils, the results obtained with the SS permeameter will be more accurate, and it also won't take as long to run a test (to reach steady state conditions).

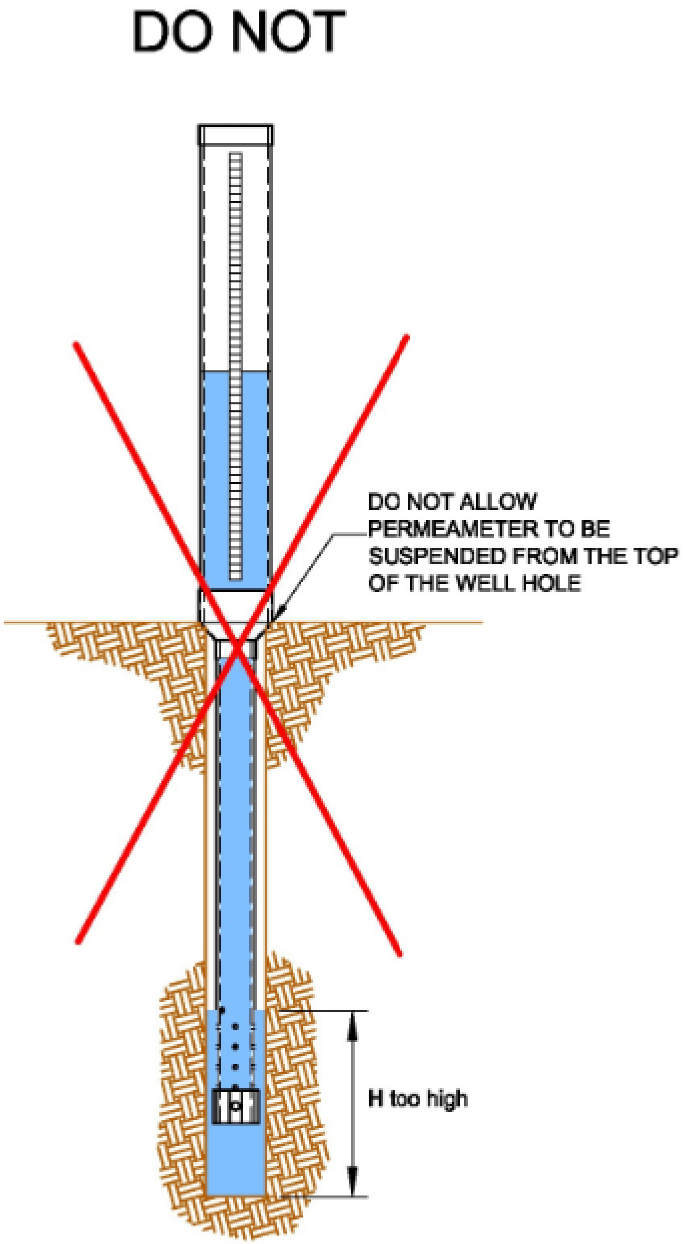
- **What is the difference between the ETC Simplified Falling Head Permeameter Kit and ETC Pask Permeameter Kits (Standard, Comprehensive or Slow Soils)?**

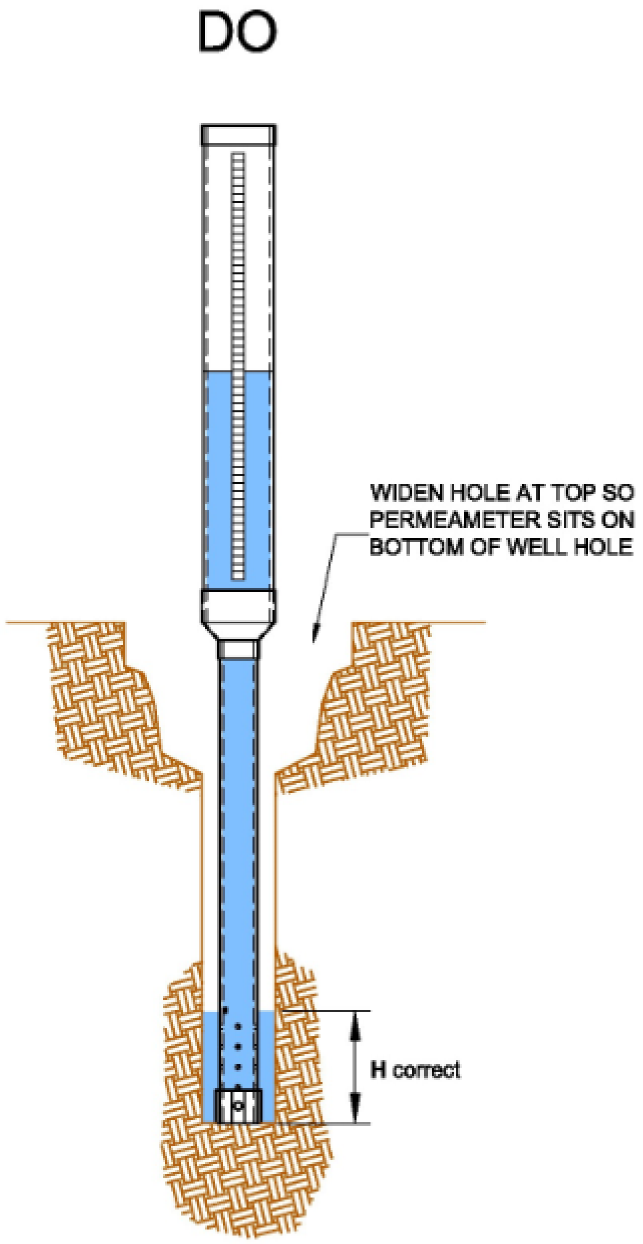
Our ETC Simplified Falling Head Permeameter Kit is for testing disturbed samples of very clean, sandy soil or fill with a low fines (silt + clay) content. It can be used to conduct a test in a laboratory or office or in the field, at a job site, or at a sand stockpile. A test on a clean, fast sand can typically be completed in 15min to 60min. This kit is NOT for testing natural soil or sand deposits *in situ* (in-place) or for testing soils with more than 10% silt+clay content. Use our Standard Pask Permeameter Kit instead.

- **What is the maximum depth to which you can measure with the Pask Permeameter? Do you offer extension tubes to go deeper?**

Our device is meant to be simple and fast to use and economical to purchase, but that means there are some limitations compared to other more expensive instruments. We do not offer extensions to the permeameter to test at greater depths.

However, many of our satisfied customers conduct tests with the Standard Pask to depths of 90cm and even to 180cm below ground surface. This can be done simply by removing some soil at the ground surface so the Permeameter will sit on the bottom of the well hole. See the image below which is from our User Guide (get updated one from Cathy) and also refer to the short video at this link: https://youtu.be/el886-mIcyc





Without removing any of the upper soil layer with a shovel or machine, the practical maximum depth of a test using the **Standard Pask Permeameter** is about 60 cm below ground surface. Users could test to a greater depth (approx. 80cm) with the **Slow Soils Pask Permeameter**, without removing any extra soil.

- **How often should you take readings with the Pask Permeameter? Is there a particular time interval that should be used?**

Since the readings taken with the Permeameter are used to calculate the steady state rate of fall on the reservoir, there is no requirement to take readings at a constant interval or at any particular interval. If it is feasible to dedicate a technician to the instrument while conducting tests, then using a constant time interval between readings may be convenient and simplify the rate-of-fall calculations. Users may find it easier to determine when steady state flow conditions have occurred if readings are taken at a constant interval such as 1 minute, 10 minutes, 30 minutes, etc.

If the soil being tested is a permeable sand, then taking readings at a constant interval of 1 minute may be convenient and appropriate, as the reservoir levels are likely going to drop relatively fast.

However, for fine grained, silty and clayey soils, which are often slowly permeable, a 1 minute interval between readings is probably too short, as the drop in water level between readings may only be a few millimeters. Very small drops between readings are more difficult for technicians to discern, and could lead to a loss of accuracy. Therefore, when testing slowly permeable soils, it is recommended to use a time interval sufficiently long enough to result in a significant, discernable drop (e.g. > 1 cm) between readings. A time interval of 1 hour or more between readings may be appropriate.

If you have purchased the **Comprehensive Pask Permeameter Kit**, then it is recommended to use the ***Slow Soil Pask Permeameter*** included with that kit when testing slowly permeable soils. The smaller diameter reservoir will result in a larger drop between readings than with the Standard Pask Permeameter.

Again, it is not necessary to use a constant time interval between readings. It is also not a problem to miss some planned readings if you choose to take them at a constant time interval. Simply take the missed reading as soon as you can, noting the actual time when the reading was taken, and calculate the rate of fall for the larger time interval. Alternatively, just skip the missed reading and resume constant readings at the next planned interval.

It is also not a problem to start with one time interval and change to a different interval during the test. What is most important is that the test runs long enough so that steady state flow conditions are achieved. As discussed in the User Guide, steady state flow can be assumed after getting three to five consecutive rate-of-fall readings which are the same.

- **I want to use my own auger which has a different diameter than the auger that comes with the ETC Pask Permeameter Kits. How do I determine the diameter of the well hole that my auger will produce so that I can use your Quick Field Reference Tables to determine Kfs?**

Most augers will create a slightly larger hole than the nominal diameter of the auger. We have already done the work to figure this out by making and measuring concrete casts of auger well holes. We found that the 2-3/4" (7cm) Riverside auger that comes with our kit results in a typical **well hole diameter of 8.3cm**. If your augers will result in a different diameter hole, you will need to measure this and let us know. We need this information to prepare ***custom*** *quick field reference tables* which will be appropriate for use with your augers. Many busy consulting firms find this is not worth the hassle for $150, which is another reason why most order the complete kit.

- **How do we know when the test has run long enough to achieve steady state conditions?**

Users of the constant head well permeameter method can conclude that steady state conditions have been achieved when the flow rate into the soil (rate of fall on the reservoir) is approximately constant for a minimum of three to five successive readings.

In more specific mathematical terms, steady state equilibrium has been achieved when the change in discharge rate is less than 10% of the *median value* for three consecutive discharge readings.

Alternatively, when the flow rate reaches quasi-steady state conditions it varies around an average value. To determine this average, plot the rate of fall on the reservoir (or the calculated Kfs values) against the time and pass a smooth curve through them using a manually or mathematically best-fitting curve. Steady state flow is reached if the tail end of this curve is nearly horizontal and does not indicate an upwards or downwards trend.

From paper by Laurence Gill and Joanne Mac Mahon (reference)

- **How should the final steady state rate of fall value be determined?**

The geometric mean infiltration volume (rate of fall on the reservoir) for the last three measurements after steady state has been reached is used to calculate Kfs. Kfs is not normally distributed and so the geometric mean of steady state flow rate measurements should be used for calculations.

For example, the geometric mean of the number set {1.80, 1.50, 1.43} would be as follows: √3 1.80 x 1.50 x 1.43 = 1.57

Whereas the arithmetic mean of the same number set would be as follows: (1.80 + 1.50 + 1.43) / 3 = 1.58

- **What is the applicable range for borehole (wellhole) radius, a, ponded water head, H, and H/a?**

According to the work of Elrick and Reynolds, the C value (shape factor) relationships given in Equation 1 on page 2 of our User Guide, have been calibrated for approximately:

$1\text{cm} \le a \le 5\text{cm}$,
$0.5\text{cm} \le H \le 20$ cm; and
$0.25 \le H/a \le 20$

If a, H or H/a values are substantially outside of these ranges, it is recommended that new C values be calculated using the procedures outlined in Reynolds and Elrick (1987).

Reynolds, W.D., and D.E. Elrick, 1987. A laboratory and numerical assessment of the Guelph permeameter method. Soil Sci. 144:282-299.

- **Can the Glover analysis be used to calculate Kfs from ETC Pask Permeameter readings?**

It can, however, we recommend using the "constant head well permeameter" (CHWP) method developed by Elrick and Reynolds (1986) as it represents a significant improvement over previous borehole techniques. The CHWP method addresses all three components of borehole flow, namely:

1) flow due to the hydrostatic pressure of the ponded water;
2) gravity-driven infiltration out through the base of the test hole; and
3) infiltration due to the capillary suction or "capillarity" of the surrounding unsaturated soil.

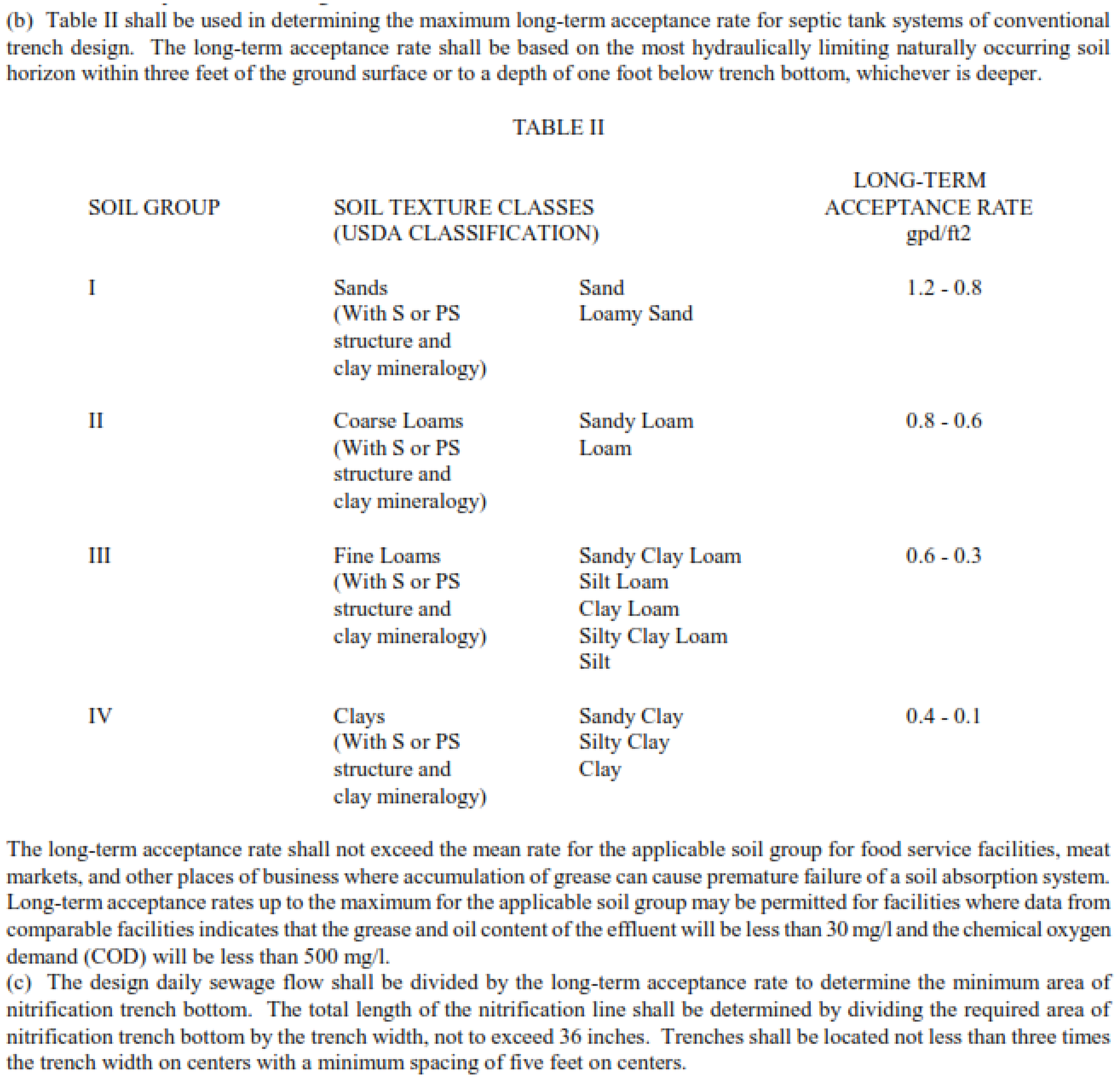
The *extended single-head* CHWP analysis is used in the same way as the Glover analysis (e.g. one head, one steady flow rate), but **the single-head CHWP analysis accounts for gravity-driven as well as capillary suction infiltration out of the well hole, whereas the Glover analysis does not**. As a result, the CHWP analysis gives more accurate estimates of Kfs than the Glover analysis. Under some conditions (e.g. a small ponded head in dry, fine-textured soil), the Glover analysis can overestimate the true soil Kfs by an order of magnitude or more.

This 1992 peer-reviewed paper by Elrick and Reynolds describes the improvements of the CHWP method and the limitations and potential inaccuracies of the outdated Glover solution.

- **Can Long Term (Effluent) Application Rate (LTAR) be correlated with Kfs?**

North Carolina (see emails from Alan Clapp) recommends that septic tank effluent LTARs do not exceed 10% of the average measured Ksat values or 25% for treated effluent.

North Carolina is another jurisdiction which takes a dual approach to determining long term acceptance rates (LTARs). The NC Dept. of Public Health has published this document: RECOMMENDED GUIDANCE FOR IN-SITU MEASUREMENT OF SATURATED HYDRAULIC CONDUCTIVITY BY THE CONSTANT HEAD WELL PERMEAMETER METHOD AND FOR REPORTING RESULTS. A detailed field evaluation of the soil and site are first performed. A LTAR is then **assigned** based on soil group and landscape as per the following table:



(b) Table II shall be used in determining the maximum long-term acceptance rate for septic tank systems of conventional trench design. The long-term acceptance rate shall be based on the most hydraulically limiting naturally occurring soil horizon within three feet of the ground surface or to a depth of one foot below trench bottom, whichever is deeper.

TABLE II

SOIL GROUP	SOIL TEXTURE CLASSES (USDA CLASSIFICATION)		LONG-TERM ACCEPTANCE RATE gpd/ft2
I	Sands (With S or PS structure and clay mineralogy)	Sand Loamy Sand	1.2 - 0.8
II	Coarse Loams (With S or PS structure and clay mineralogy)	Sandy Loam Loam	0.8 - 0.6
III	Fine Loams (With S or PS structure and clay mineralogy)	Sandy Clay Loam Silt Loam Clay Loam Silty Clay Loam Silt	0.6 - 0.3
IV	Clays (With S or PS structure and clay mineralogy)	Sandy Clay Silty Clay Clay	0.4 - 0.1

The long-term acceptance rate shall not exceed the mean rate for the applicable soil group for food service facilities, meat markets, and other places of business where accumulation of grease can cause premature failure of a soil absorption system. Long-term acceptance rates up to the maximum for the applicable soil group may be permitted for facilities where data from comparable facilities indicates that the grease and oil content of the effluent will be less than 30 mg/l and the chemical oxygen demand (COD) will be less than 500 mg/l.

(c) The design daily sewage flow shall be divided by the long-term acceptance rate to determine the minimum area of nitrification trench bottom. The total length of the nitrification line shall be determined by dividing the required area of nitrification trench bottom by the trench width, not to exceed 36 inches. Trenches shall be located not less than three times the trench width on centers with a minimum spacing of five feet on centers.

In situ permeability testing must then be performed to support the rate **assigned** from the soil assessment. Ksat (Kfs) is measured and expressed in units of gpd/sq.ft. For untreated effluent (i.e. primary septic tank effluent), the department recommends LTARs that do not exceed 10% of the average measured Ksat values. LTARs for treated effluent should not exceed 25% of Ksat. If the LTAR based on the percentage of the average Ksat is **higher** than the assigned LTAR from the soil assessment, then practitioners/designers are deemed to have "justified" the soil assessment based LTAR. This is also subject to a subsequent lateral flow analysis which shows water will move away from the drain field, off the site, after moving through the soil treatment zone. However, if the measured Ksat based LTAR is **lower** than the soil assessment assigned LTAR, then its "back to the drawing board" according to a soil scientist contact of mine.

So in summary, practitioners must measure Ksat values in order to support a proposed long term acceptance rate (LTAR) based on soil group type. However, Ksat measurements cannot be used as a means to **validate unsuitable soils**.

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Kfs (m/sec) x 2,120,462 = Kfs (gpd/sq.ft) (type "convert inches/hour to gallons per day per square foot" into google)
or
Kfs (inches/hour) x 14.961 = Kfs (gpd/sq.ft) (type "convert inches/hour to gallons per day per square foot" into google)

My concern with adding a column to our Quick Field Reference Tables with Kfs values in gpd/sq.ft, is that some people may assume that Kfs equals LTAR without taking into account the chemical and biological differences and clogging potential of effluent compared to clean water and without taking into account the clogging potential as it relates to soil texture and structure. Clearly the NC Guideline document does recognize this somewhat as indicated by the limitation they place on LTARs as a percentage of the average measured Ksat values.

With respect to stormwater system design, the Minnesota stormwater manual (online wiki), states:

"*The measured infiltration rate shall be divided by a safety factor of 2. The safety factor of 2 adjusts the measured infiltration rates for the occurrence of less permeable soil horizons below the surface and the potential variability in the subsurface soil horizons throughout the infiltration site. This safety factor also accounts for the long-term infiltration capacity of the stormwater management facility.*"
(https://stormwater.pca.state.mn.us/index.php?title=Design_criteria_for_infiltration&oldid=35583
see **Step 5. Determine infiltration type and size practice)**

NC allows a 1:1 relationship, no FOS required.

- **Can in situ permeability testing eliminate the need for detailed test pit evaluation of the soil profile?**

Constant head permeability testing (not a percolation test) is recommended for sizing of soil absorption systems (SAS) which will be installed in **native (in situ) soils**. This testing is recommended as a supplement to (but not a replacement for) the soil morphology based assessment (texture, structure, consistence, etc.)

Many states used to size septic fields based only on Perc Times, without any need for detailed test pit evaluations. Some still do. Atlantic Canada has been using permeability testing for many years, however, in my opinion they place too much emphasis on it, letting the Kfs results overrule and ignore potential red flags with soil texture, structure, consistence from the test pit evaluation. Some states moved completely away from Perc Testing and now rely entirely on a soil morphology based set of sizing criteria. When I give presentations at septic industry conferences in the USA, I often get strong reactions from soil scientists working in these jurisdictions who worry that "permeameter advocates" are trying to replace a thorough site and test pit assessment with permeability tests. I explain that is NOT what I am advocating as I favour a two-pronged approach like in BC.

There are definite challenges with doing a proper assessment of soil texture, structure for septic industry practitioners with minimal education and training in soil/site assessment. Based on hand texturing methods (not lab grain size testing) even a reasonably experienced soil scientist can have difficulty discerning between, say, a sandy loam with a high proportion of **fine** sand, and a sandy loam with mostly medium size sand. Yet the Kfs and short and long term effluent infiltration rates will be significantly lower for the fine sandy loam. That is just one situation where I find permeability testing to be very helpful as a check on the soils evaluation.

For example, here in PEI we have a lot of compact, sandy loam glacial till soil. Based on the soil type from BC's Table II-22, a lot of our sites would result in an HLR in the 23-27 Lpd/sq.m range. Depending on the relative density and proportion of fine and very fine sand, in situ permeability tests in this soil are typically in the range of 90 to 200 mm/day, which according to BC's Table II-23, would indicate a maximum HLR of 12 to 15 Lpd/sq.m for septic tank effluent. So if we were following the BC approach, the permeability test HLR criteria would provide a more conservative HLR for drain field sizing. However, our PEI regulations allow an HLR of 24 to 32 Lpd/sq.m for these soil conditions and permeability. Not very sustainable in my opinion, but the politicians are reluctant to change the rules.

I further note that Table 12 from the CAN CSA B65-12 standard (screenshot excerpt pasted below) would indicate HLRs in the 8 to 12 Lpd/sq.m range for fine sandy loams having a Kfs in the 30 to 125 mm/day range, which is an even more conservative HLR than BC. Table 12 was based in part on the work of Dr. Jerry Tyler (formerly of the University of Wisconsin).

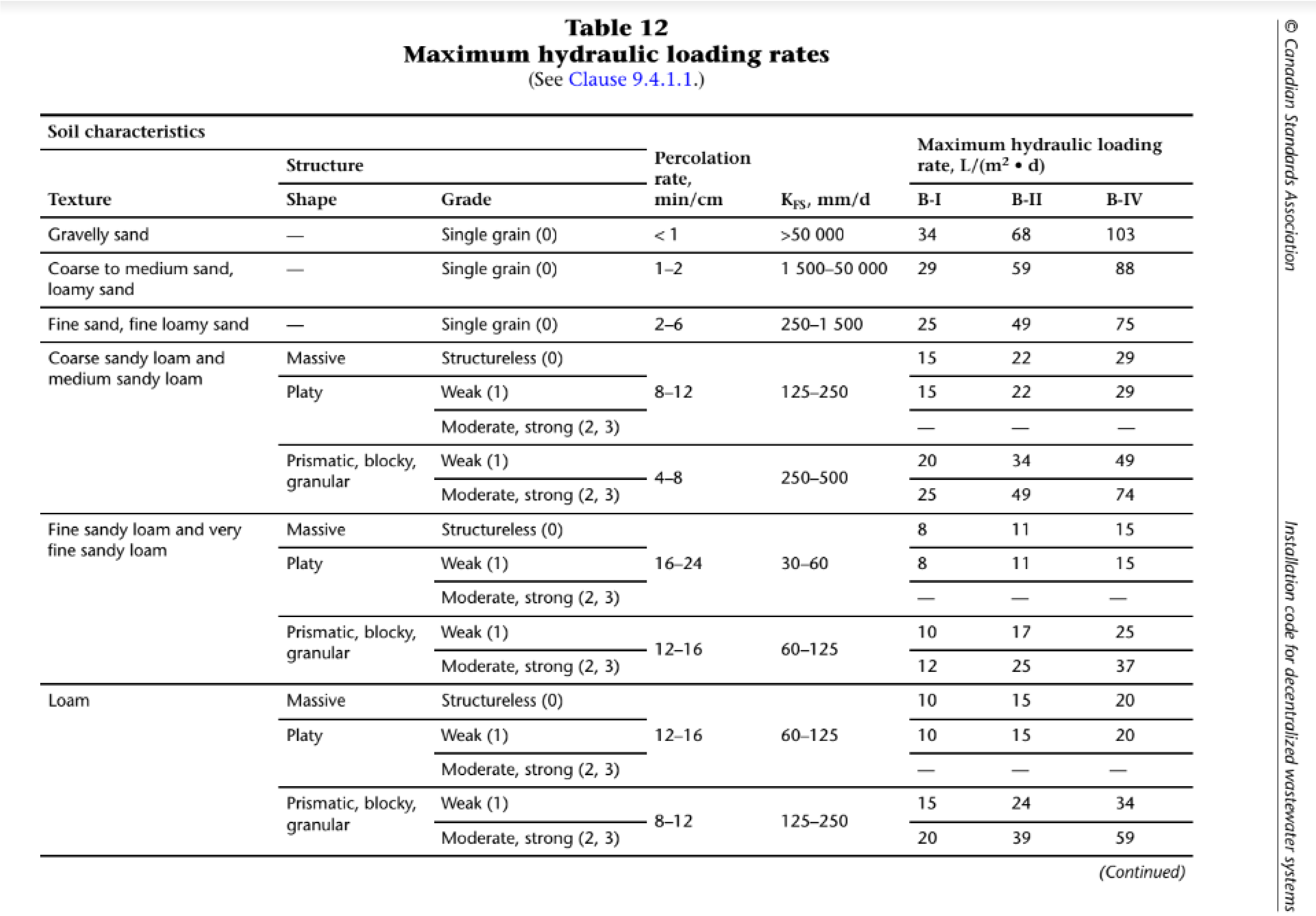

Table 12
Maximum hydraulic loading rates
(See Clause 9.4.1.1.)

Soil characteristics			Percolation rate, min/cm	K_{FS}, mm/d	Maximum hydraulic loading rate, $L/(m^2 \bullet d)$		
	Structure						
Texture	Shape	Grade			B-I	B-II	B-IV
Gravelly sand	—	Single grain (0)	< 1	>50 000	34	68	103
Coarse to medium sand, loamy sand	—	Single grain (0)	1–2	1 500–50 000	29	59	88
Fine sand, fine loamy sand	—	Single grain (0)	2–6	250–1 500	25	49	75
Coarse sandy loam and medium sandy loam	Massive	Structureless (0)	8–12	125–250	15	22	29
	Platy	Weak (1)			15	22	29
		Moderate, strong (2, 3)			—	—	—
	Prismatic, blocky, granular	Weak (1)	4–8	250–500	20	34	49
		Moderate, strong (2, 3)			25	49	74
Fine sandy loam and very fine sandy loam	Massive	Structureless (0)	16–24	30–60	8	11	15
	Platy	Weak (1)			8	11	15
		Moderate, strong (2, 3)			—	—	—
	Prismatic, blocky, granular	Weak (1)	12–16	60–125	10	17	25
		Moderate, strong (2, 3)			12	25	37
Loam	Massive	Structureless (0)	12–16	60–125	10	15	20
	Platy	Weak (1)			10	15	20
		Moderate, strong (2, 3)			—	—	—
	Prismatic, blocky, granular	Weak (1)	8–12	125–250	15	24	34
		Moderate, strong (2, 3)			20	39	59

(Continued)

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Installation code for decentralized wastewater systems

In conclusion, in my opinion, Kfs measurements should not be used as a means to validate unsuitable soils or to justify a higher LTAR than indicated by soil texture, structure and consistence.

- **Can practitioners without post secondary education or extensive training in soil science be taught to carry out a proper in situ permeability test using the ETC Pask Permeameter and the extended single ponded height method?**

I have taught several short courses (3-5 days duration) on behalf of the provinces of PEI and NB which involved classroom instruction and teaching hand texturing (texture by feel) in the lab and in the field (test pit evaluation) to septic industry practitioners. Our goal is to teach them to be able to classify soils into one of the 12 main textural classes for which anything in the silt, clay loam or clay categories would all be lumped together (generally regarded as unsuitable for the in-ground installation of a drain field in our region). So practically speaking, that means there are only six soil texture classifications or groups (i.e. sand, loamy sand, sandy loam, Loam, silt loam and clay loams/clays) that we want practitioners to be able to discern between. Even after only a few days of training, most of the students in my courses were able to arrive at the correct classification, or very close.

We also teach in situ permeability testing using the Pask Constant Head Well Permeameter, single-ponded height method. The single ponded height method requires that practitioners select an appropriate soil texture-structure (capillarity) category, α^* from one of the four options indicated below.

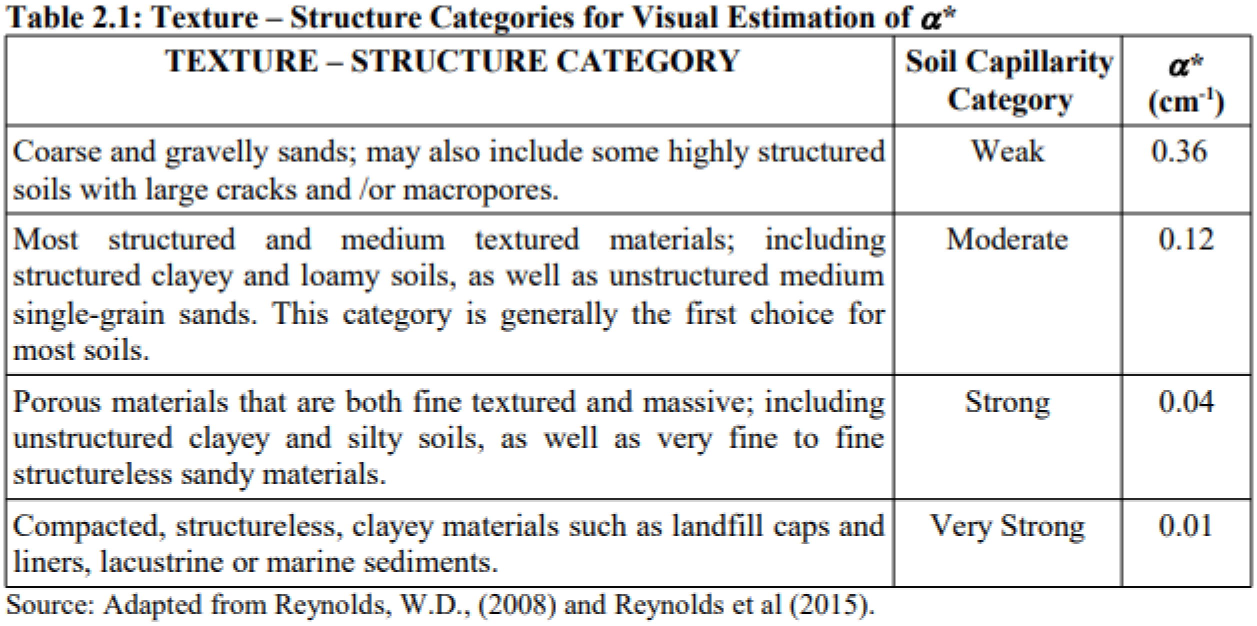

Table 2.1: Texture – Structure Categories for Visual Estimation of α^*

TEXTURE – STRUCTURE CATEGORY	Soil Capillarity Category	α^* (cm^{-1})
Coarse and gravelly sands; may also include some highly structured soils with large cracks and /or macropores.	Weak	0.36
Most structured and medium textured materials; including structured clayey and loamy soils, as well as unstructured medium single-grain sands. This category is generally the first choice for most soils.	Moderate	0.12
Porous materials that are both fine textured and massive; including unstructured clayey and silty soils, as well as very fine to fine structureless sandy materials.	Strong	0.04
Compacted, structureless, clayey materials such as landfill caps and liners, lacustrine or marine sediments.	Very Strong	0.01

Source: Adapted from Reynolds, W.D., (2008) and Reynolds et al (2015).

It is really only the first three texture-structure categories which are relevant in septic soil assessment applications. Again, after basic training, most practitioners, even many with no post-secondary education, were able to estimate an appropriate soil texture-structure category or were off by, at most, one category. Fortunately, as explained by Reynolds (2008) the potential error due to improper selection of α^* is not excessive and can be mitigated by using a ponded well height (H) that is relatively large. We use a default H = 15cm with our Pask permeameter kits, but will supply them with alternative H values upon request.

Complex formulas and calculations definitely intimidate practitioners without post-secondary education which presents an obstacle to the widespread use and adoption of permeameter testing. To address this concern, we developed these ***Quick Field Reference Tables*** for each of the soil texture-structure categories for our permeameter kits. These tables are specific to the internal permeameter reservoir dimensions, well height and the typical borehole diameter created by the auger included in our kits. To obtain the Kfs value, practitioners need only consult the appropriate soil category table and read off the Kfs value corresponding to the steady state rate of fall they have calculated. In our site assessment courses most students have demonstrated the ability to understand the method and execute this relatively basic level of math required.

Here in Atlantic Canada, it is standard practice to express Kfs in scientific notation. However, this is not well understood by practitioners other than engineers, soil scientists, and others with post secondary STEM education. It therefore presents another obstacle which reduces understanding and acceptance. Therefore, a further simplification would be to follow the lead of BC, CSA B-65 standard and others and express Kfs in units of mm/day (or inches/hour for those using imperial units). I will likely be revising our Quick Field Reference Tables in the near future to change our tables to mm/day.

- **Can ETC Pask Permeameter Kits be transported on airlines as checked baggage?**

Yes, if you trust the airlines not to lose it! The carry case is extremely rugged and the contents are well protected inside with EPE foam. There are wheels on one end of the case and two handles to facilitate transport. Just be aware that the case weighs about 36 lbs with all the parts inside, so you will likely want to use a cart if you have other checked bags to manage. The outer dimensions of the case are 51" x 16" x 6.5" (136 x 42 x 16 cm) so the total linear dimension is 74" (194 cm). This may result in an oversize checked bag fee depending on the airline's policy.

- What are the main differences between a ***permeability test*** conducted using an ETC Pask Constant Head Permeameter (PP) and an ***infiltration test*** conducted using a Double Ring Infiltrometer (DRI)?

What is measured?

PP - measures (field saturated) hydraulic conductivity (Kfs) which is a **true soil property**. Kfs is calculated using the peer reviewed and widely accepted, constant head well permeameter (CHWP), single ponded height method. It is based on three dimensional flow of water from one point to the other within the soil mass.

DRI - measures infiltration rate, which is **not a true soil property**. It is calculated based on the entry of water at the soil-atmosphere boundary assuming one-dimensional flow into the subsurface. This can be affected by many things such as the condition of the soil surface, moisture content or degree of saturation of the soil, head of water applied, temperature of the liquid, and diameter and depth of embedment of the rings. Thus, tests made at the same site are not likely to give identical results and the rate measured by the test method described in the ASTM D3385 standard is primarily for comparative use.

Repeatability & seasonal variability:

PP - Excellent repeatability of tests. Seasonal variability is insignificant**.

DRI - Infiltrometers showed poor or inconsistent test results for different seasons and/or soil moisture contents**.

Physical effort to conduct a test?

PP - Low to moderate physical effort depending on soil density, prevalence of gravel. The permeameter itself is light-weight, weighing less than 3kg. See this video showing how easy it is to carry out a test with the PP: https://youtu.be/dx7O2ubKfJ8

DRI - Very cumbersome procedure requiring a lot of physical effort to insert the rings which weigh 22.7kg**. Testing (insertion of the rings) in moderately stiff (dense) or gravelly soil is very difficult, requires considerable effort and can cause considerable disturbance to stiff soil)**. See this video showing how difficult and time consuming it is to carry out a test with the DRI:
https://youtu.be/LayNjNKZmzc

Amount of water required to conduct a test?

PP - Very little water required. For most soils, 4 Litres of water is sufficient to conduct a test.

DRI - Test requires a lot of water**. ASTM D3385 standard recommends a 200 Litre barrel for the main water supply to fill the two calibrated head tanks which are used for measurement of liquid during the test. The ASTM standard says "Capacities of about 50 Litres (13 gal) would not be uncommon" for these head tanks, especially if a test has to continue overnight.

Minimum time required to conduct a test?

PP - Tests on most moderately permeable soils can be completed in less than 1 hour.

DRI - Very time intensive.** The ASTM D3385 standard says to run the test for a minimum of 6 hours.

Education & training required?

PP - Practitioners with basic education and training can learn to conduct a test properly. Dynamic Monitor's *Quick Field Reference Tables* make determining the Kfs value from the test data very easy, in 10 seconds or less.

DRI - Intermediate to advanced education and training required to learn how to conduct a test properly and calculate results reliably.

Testing depth?

PP - Can accommodate a range of testing depths. Testing from 20cm to 90cm below ground surface is routine. Testing at greater depths (up to 210cm) can be done with the assistance of a machine to excavate a small hole, (max 120cm deep) so the technician could auger the well hole from the bottom.

DRI - Can only be used to test the surface soil layer A horizon (i.e. to approx. 20cm depth). Testing at greater depths is possible, but more difficult. It would require excavation of a large pit to allow enough room for swinging a sledge hammer to drive the rings into the soil.

Cost

Here in Canada, the DRI sells for approximately double the cost of our Pask Permeameter Kit (purchased from Hoskin Scientific). Regardless, even if the DRI was half the cost of the PP, given the cost savings in personnel time for training and to conduct tests, I believe your customer would recover any cost difference after using it on just one or two projects.

**Reference:
B. Ghosh, S. Pekkat, and S. Yamsani, “Evaluation of Infiltrometers and Permeameters for Measuring Hydraulic Conductivity,” Advances in Civil Engineering Materials 8, no. 1 (2019): 308–321, https://doi.org/10.1520/ACEM20180056