CONSTANT HEAD BOREHOLE PERMEAMETER TEST PROCEDURE

Use the following instructions to conduct a constant-head borehole permeameter test using a Pask (constant head borehole) Permeameter. Other borehole permeameters may be used; however, these instructions relate only to the Pask permeameter. This information is based on Appendix C of the Nova Scotia Sewage Disposal Guideline that can be found at the following web site:

http://www.gov.ns.ca/nse/wastewater/sewagedisposalguide.asp

The permeameter test measures the permeability (also called hydraulic conductivity) of the soil at the bottom of a borehole, above the water table. The test measures the hydraulic conductivity by temporarily saturating the soil at the bottom of the borehole. It measures the ïfield-saturated hydraulic conductivityò, which is commonly abbreviated as Kfs.

The first step is to make or buy a permeameter. See the Nova Scotia Guideline for instructions on building a permeameter. This is a simple device to make, but the clear plastic tube (pipe) may be expensive or difficult to source. To avoid the clear plastic pipe, common white PVC pipe may be used with a sight gauge constructed from clear plastic tubing (Tygon or similar). Many permeameters have a screw cap rather than a rubber stopper at the bottom. Some permeameters have a ball valve on the lower tube; this is useful but not necessary. There are companies that make and sell permeameters and suitable soil augers.

The upper clear plastic tube or pipe is a small water reservoir. Convenient dimensions are 9-10 cm inside diameter and 60 cm length, but this reservoir can be different diameters or lengths. A smaller diameter reservoir is more accurate for low-permeability soils and uses less water. You will need to know the inside diameter of the tube in order to calculate the volume of water draining into the borehole.

Equipment and supplies:

MANDATORY:

- Permeameter.
- Supply of water. The test uses about 4 liters per test, if using a 10 cm diameter permeameter. A 5-cm permeameter uses about one liter per test. Water is usually supplied by garden hose or Gerry cans.
- Hand auger. A commonly used auger has a 7 cm auger bit, but you can use augers of different diameters.
- Wristwatch with second hand, or other timer with minutes and seconds.
- Pre-printed forms. See the following pages for a blank form and an example completed form.

OPTIONAL:

- Wire brush, or length of pipe with protruding screws, or similar device to roughen smeared soils.
- Tripod, sawhorse, or other method to hold the permeameter vertical during the test. This can be useful for shallow auger holes, or if conducting two of more tests at the same time.
- Digging bar or steel probe. This is useful for gravelly or stony soils.

Test procedure:

Select the locations and depths for the auger holes. A common layout is to auger four holes, one at each corner of the proposed dispersal area. Testing in the receiving area may also be needed, and testing of deeper soil layers may also be useful or needed.

Holes should be augered to the same depth as the planned depth of the infiltration surface. For sand mounds and at-grade beds, the auger hole depth should be 25 to 35 cm. When augering the hole, do not use excessive downward pressure on the auger and in general it is best to remove the auger after maximum two turns to remove soil, this is intended to reduce soil compaction.

- At each location, auger a hole to the required depth. In stony soil, it may help to probe using a digging bar or steel rod, to find a suitable location to auger a hole.
    - If the sides of the auger hole are smeared, gouge, pick or roughen the side walls with a wire brush, ice pick or other sharp object. Important: If you roughen or gouge the side walls of the auger hole, you will also need to take equal care to prepare the bottom and side walls (the infiltration surface) of the dispersal system.
- Measure and record the diameter of the auger hole.
- Complete the top part of the permeameter form.
- Write down the soil texture and structure.
- Turn the permeameter upside down, remove the plug, fill with water up to the ñair inlet holeò, and then replace the plug.
- Fill the auger hole to a water depth of about 25 cm.
- Place the permeameter in the auger hole, with the ñwater drain slotsòat the bottom of the hole.
- Watch the clear plastic tube for large bubbles rising from the bottom.
- As soon as the large bubbles appear, start taking readings of the height of water in the clear plastic tube (in millimeters), taking one reading every minute. If the rate of fall is very fast, you can take one reading every 30 seconds. If the rate of fall is very slow, you can take one reading every two minutes or more.
- During the test, record the rate of fall of the water level in mm per minute.
- When the rate of fall stabilizes, the test is complete. The rate of fall is stable if the fall is nearly equal for three consecutive readings. With most soils, this takes 4 to 20 minutes.
- After the test, if a flow restrictive horizon is suspected close to the base of the hole, then auger or probe to this horizon and measure the depth.
- Repeat for the remaining auger holes.
- Calculate the Kfs for each of the test holes, using the calculation method below.

Calculation Method:

- Write down the final stable rate of fall in the water level, in millimetres per minute.
- Calculate the Flow Rate (Q) by multiplying the rate of fall by the volume Conversion Factor. 0 shows the factor for permeameters of various diameters.

Permeameter calculation factors

INSIDE DIAMETER OF THE RESERVOIR (CM)	FACTOR
10.23	8.22
10.16	8.10
5.25	2.17

- For other sizes of permeameters, the conversion factor may be calculated as follows:
  - R = Radius in cm = Inside Diameter ÷ 2.
  - Conversion Factor = 0.3142 x R x R.
- Write the flow rate on the form, in mL / minute.
- Use the chart (at the bottom of the page) to select the Soil Factor (F), based on the type of soil and the diameter of the auger hole.
- Calculate the Kfs. This is the Flow Rate (Q) multiplied by the Soil Factor (F), Kfs = Q x F.
- Write this in the space at the bottom left part of the form.
- If the highest measured Kfs is more than 10 times higher than the lowest, then the minimum allowable number of tests is six. *This is because of the high variability of the soil*.
- Select the Kfs to be used for sizing of the dispersal area. This will be the median or middle value from all the tests conducted.

Mathematical-minded APs may want to set up a spreadsheet to calculate Kfs from the measured rate of fall, using the formulas in the referenced web site and other technical papers.

Special Situations:

Site with a very shallow flow-restrictive horizon:

If the flow-restrictive horizon is within about 30 cm of the bottom of the auger hole, then the calculated Kfs may be lower than the true Kfs. If it is important to calculate a more accurate Kfs, then one option is to use the modified Glover formula, as outlined in the Permeameter Appendix (below).

Testing in hot weather:

If the temperature of the water used for the permeameter test is above 25 degrees Celsius, then the test results should be adjusted according to the procedure on pages C-2 and C-3 of the following reference:

http://www.gov.ns.ca/nse/water/docs/OSTG_11-Section11-TechGuideAppendix.pdf

Troubleshooting:

Water level falls too fast:

If the reservoir water level falls too fast to measure, then it is only practical to estimate the lower limit of the soil permeability. The Kfs should be reported as: ñgreater than 30,000 mm/dayò In this situation, conduct at least eight permeameter tests.

A rapidly falling water level could also be caused by a large pore, such as an old root channel. In this case the problem can be noted and further tests done to confirm the soil permeability.

Water level is static; does not change:

In soils of very low permeability, if the auger hole fills with water to above the air hole, the water will drain slowly, delaying the start of the test. Gently remove some water from the auger hole to expose the air hole and start the test. If the reservoir still does not drain, this indicates soil of very low permeability, and the Kfs should be reported as ñless than 10 mm/dayò

The soil can be re-tested using a smaller diameter permeameter and a larger diameter auger hole.

It may help to try permeameter tests at different depths or at different locations. Testing at different depths and locations will help in selecting the best location for the dispersal system and the best depth for the infiltration surface.

Water level drops very slowly:

In soils of low permeability, the permeameter water level may drop very slowly, about one millimeter per minute. Potential strategies for low permeability soils include: (1) re-test at different locations on the property; (2) re-test at different depths; (3) roughen or scarify the side walls of the auger hole; (4) re-test using a smaller diameter permeameter and larger diameter auger hole; (5) use an alternate permeability test method, such as a ring infiltrometer.

Permeameter test form on next page…

Location (address):		File #:
Auger hole #:	AH location:	
AH depth:	AH diameter (at bottom of hole): cm	Date:
Height of air hole: 20 cm	Permeameter inside diameter: cm	Tested by:

Constant Head Borehole Permeameter Test Results

Time of day	Total elapsed time *min*	Interim time *min*	Water level reading *Mm*	Drop in level *mm*	Rate of fall *mm/min*	Remarks or Observations
	0					Start of test
						Soil texture:
						Structure:
Stable rate of fall in mm / minute =						

For small (5.25 cm) permeameter: Flow rate (Q) = (Rate of fall) x 2.17 = ... mL / min

For large (10.23 cm) permeameter: Flow rate (Q) = (Rate of fall) x 8.22 = ... mL / min

Calculations

Reference: Mooers, J.D., and D.H. Waller, 1993.

Soil factor (F) as a function of auger hole diameter and soil type:

AH diameter	7 cm	8 cm	9 cm	10 cm	11 cm	12 cm	18 cm	20 cm	22 cm
Gravelly sand and coarse sand	8.9	8.1	7.5	7.0	6.6	6.2	4.5	4.2	3.9
Fine-medium sand, loamy sand, sandy loam, structured soils	7.2	6.6	6.1	5.7	5.3	5.0	3.7	3.4	3.2
Massive clays and silts	4.4	4.1	3.8	3.6	3.4	3.2	2.5	2.3	2.1

Kfs = Q x F = x = mm/d

Example of a completed permeameter test form:

Location (address): Lot 11, Any Road, No Town, BC		File #: PLS-3
Auger hole #: 2	AH location: 5 m east of test pit TP-3	
AH depth: 60 cm	AH diameter (at bottom of hole): 18 cm	Date: 22 July 2008
Height of air hole: 20 cm	Permeameter inside diam: 10.23 cm (4")	Tested by: JPL

Constant Head Borehole Permeameter Test Results

Time of day	Total elapsed time *min*	Interim time *min*	Water level reading *Mm*	Drop in level *mm*	Rate of fall *mm/min*	Remarks or Observations
09:41	0	1.0	155			Start of test
	1		140	15		
	2		125	15		
	3		110	15		
	4		98	12		
	5		82	16		
	6		70	12		
	7		55	15		Soil texture: Sandy loam.
						Structure: ABK 2
						Angular blocky ï moderate
Stable rate of fall in mm / minute =					15	

For small (5.25 cm) permeameter: Flow rate (Q) = (Rate of fall) x 2.17 = N/A mL / min

For large (10.23 cm) permeameter: Flow rate (Q) = (Rate of fall) x 8.22 = 123 mL / min

Calculations

Reference: Mooers, J.D., and D.H. Waller, 1993.

Soil factor (F) as a function of auger hole diameter and soil type:

AH diameter	7 cm	8 cm	9 cm	10 cm	11 cm	12 cm	18 cm	20 cm	22 cm
Gravelly sand and coarse sand	8.9	8.1	7.5	7.0	6.6	6.2	4.5	4.2	3.9
Fine-medium sand, loamy sand, sandy loam, structured soils	7.2	6.6	6.1	5.7	5.3	5.0	**3.7**	3.4	3.2
Massive clays and silts	4.4	4.1	3.8	3.6	3.4	3.2	2.5	2.3	2.1

Kfs = Q x F = 123 x 3.7 = 455 mm/d

Comment: The Kfs can be rounded off to 460 mm/d.