TOWN OF MANSFIELD, MASSACHUSETTS
Engineering Department
Six Park Row, Mansfield, MA 02048

MEMORANDUM

TO: File

FROM: John D. Sullivan, Jr., Town Engineer

DATE: November 16, 2000

SUBJECT: Field Work Plan Example/Permeability Testing

I. PURPOSE

This Field Work Plan outlines procedures and methods used to determine the in-place field permeability values. This field testing is to support the design of the stormwater management system including the infiltration basins and infiltrators.

II. PROCEDURE

The permeability of the soil, at each proposed test location, shall be determined by the Falling Water Level Method or the Constant Water Level Method (depending upon field conditions). The areas of testing will include the infiltration basins and the area of proposed infiltrators. Test depths are to be predetermined, based on existing test pit information, and are to coincide with the proposed infiltration elevations.

The Falling Water Level Method consists of excavating a six-inch diameter hole with a hand shovel or post hole digger, and then inserting a four-inch PVC pipe to the depth desired to perform permeability tests. The bottom of the hole will be excavated by hand to a clean, flat, natural surface with no large rocks. The pipe is worked one to two inches into the undisturbed soil using light pressure and a rotating motion. Then, without getting bentonite chips or dust into the pipe, a bentonite seal is placed on the outside of the lower end of the pipe. The soils are then replaced outside of the pipe and packed tightly. The soil and the bentonite outside of the test pipe will be wetted during packing, so that the bentonite seal will swell before the start of the test.

The Falling Water Level Method consists of recording measurements of drop in water level, with the pipe at incremental time intervals, until less than 30% of the initial water height remains. This will provide data points beyond the 37% value required in the Basic Time Lag Method (attached).

The Constant Water Level Method is similar in preparation to the previously outlined procedure, but is used when the permeability of the ground is too great to calculate by the Falling Water Method. In the Constant Water Level Method, water is added to the PVC pipe at a rate sufficient to maintain a constant water level at or near the top of the pipe. Initially, water is added to the pipe, for a period of not less than ten (10) minutes, to ensure test conditions approach steady state conditions. Water is then added by pouring from calibrated containers over a recorded time interval or by pumping water through a water meter. The intent is to maintain the constant water level using one-gallon containers, and calculating the time it takes for each gallon of water to be infiltrated into the ground, until a virtually constant rate is obtained within 90 percent of two sequential trials.

Calculations will be based on the Basic Time Lag Method for either of the Constant or Falling Water Level Tests. The testing results will be graphed in the field to confirm steady state conditions and consistent test results. Test locations will be staked in the field and tape located onto a site plan from physical site features.

III. Schedule

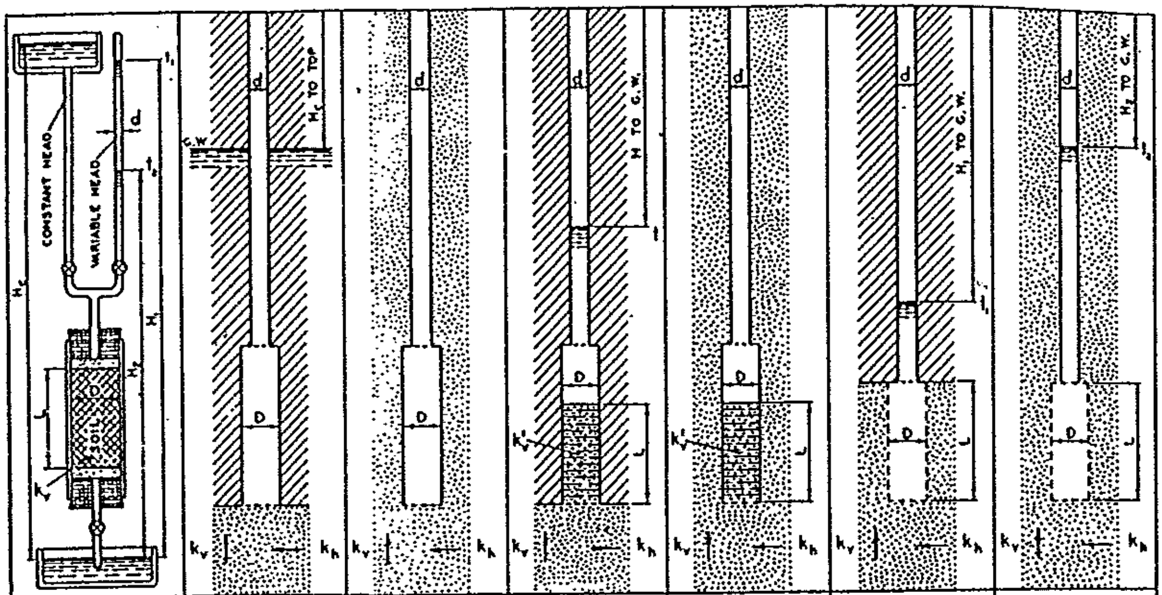
One day of permeability testing will be conducted. The Dig Safe number is

_________________________.

IV. Equipment

Gloves	Bentonite Chips	Watch or Stopwatch
Post Hole Digger	Tape Measure	Black Marking Pen
Shovel	Flagging	Pen/Pencil
Hand Auger	Semi-log Paper	4-inch PVC Pipe
Digging Bar	Regular Paper	Calculator
Stakes	Scale	Clipboard

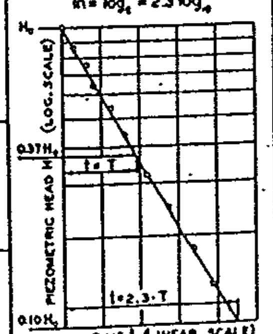
5-Gallon Filled Water Jugs (and I Gallon Jug)



CASE	CONSTANT HEAD	VARIABLE HEAD	BASIC TIME LAG
A	$k_v = \frac{4\cdot q\cdot L}{\pi\cdot D^2\cdot H_c}$	$k_v = \frac{d^2\cdot L}{D^2\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ $k_v = \frac{L}{t_2-t_1}\ln\frac{H_1}{H_2}$ FOR $d = D$	$k_v = \frac{d^2\cdot L}{D^2\cdot T}$ $k_v = \frac{L}{T}$ FOR $d = D$
B	$k_m = \frac{q}{2\cdot D\cdot H_c}$	$k_m = \frac{\pi\cdot d^2}{8\cdot D\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ $k_m = \frac{\pi\cdot D}{8\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ FOR $d = D$	$k_m = \frac{\pi d^2}{8\cdot D\cdot T}$ $k_m = \frac{\pi\cdot D}{8\cdot T}$ FOR $d = D$
C	CONSTANT HEAD $k_m = \frac{q}{2.75\cdot D\cdot H_c}$	$k_m = \frac{\pi\cdot d^2}{11\cdot D\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ $k_m = \frac{\pi\cdot D}{11\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ FOR $d = D$	FALLING HEAD $k_m = \frac{\pi\cdot d^2}{11\cdot D\cdot T}$ $k_m = \frac{\pi\cdot D}{11\cdot T}$ FOR $d = D$
D	$k'_v = \frac{4\cdot q\left[\frac{\pi}{8}\cdot\frac{k'_v}{k_v}\cdot\frac{D}{m}+L\right]}{\pi\cdot D^2\cdot H_c}$	$k'_v = \frac{d^2\cdot\left[\frac{\pi}{8}\cdot\frac{k'_v}{k_v}\cdot\frac{D}{m}+L\right]}{D^2\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ $k_v = \frac{\frac{\pi}{8}\cdot\frac{D}{m}+L}{t_2-t_1}\ln\frac{H_1}{H_2}$ FOR $k'_v = k_v$, $d = D$	$k'_v = \frac{d^2\cdot\left[\frac{\pi}{8}\cdot\frac{k'_v}{k_v}\cdot\frac{D}{m}\right]+L}{D^2\cdot T}$ $k_v = \frac{\frac{\pi}{8}\cdot\frac{D}{m}+L}{T}$ FOR $k'_v = k_v$, $d = D$
E	$k'_v = \frac{4\cdot q\cdot\left[\frac{\pi}{11}\cdot\frac{k'_v}{k_v}\cdot\frac{D}{m}+L\right]}{\pi\cdot D^2\cdot H_c}$	$k'_v = \frac{d^2\cdot\left[\frac{\pi}{11}\cdot\frac{k'_v}{k_v}\cdot\frac{D}{m}+L\right]}{D^2\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ $k_v = \frac{\frac{\pi}{11}\cdot\frac{D}{m}+L}{t_2-t_1}\ln\frac{H_1}{H_2}$ FOR $k'_v = k_v$, $d = D$	$k'_v = \frac{d^2\cdot\left[\frac{\pi}{11}\cdot\frac{k'_v}{k_v}\cdot\frac{D}{m}+L\right]}{D^2\cdot T}$ $k'_v = \frac{\frac{\pi}{11}\cdot\frac{D}{m}+L}{T}$ FOR $k'_v = k_v$, $d = D$
F	$k_h = \frac{q\cdot\ln\left[\frac{2mL}{D}+\sqrt{1+\left(\frac{2mL}{D}\right)^2}\right]}{2\cdot\pi\cdot L\cdot H_c}$	$k_h = \frac{d^2\cdot\ln\left[\frac{2mL}{D}+\sqrt{1+\left(\frac{2mL}{D}\right)^2}\right]}{8\cdot L\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ $k_h = \frac{d^2\cdot\ln\left(\frac{4mL}{D}\right)}{8\cdot L\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ FOR $\frac{2mL}{D} > 4$	$k_h = \frac{d^2\cdot\ln\left[\frac{2mL}{D}+\sqrt{1+\left(\frac{2mL}{D}\right)^2}\right]}{8\cdot L\cdot T}$ $k_h = \frac{d^2\cdot\ln\left(\frac{4mL}{D}\right)}{8\cdot L\cdot T}$ FOR $\frac{2mL}{D} > 4$
G	$k_h = \frac{q\cdot\ln\left[\frac{mL}{D}+\sqrt{1+\left(\frac{mL}{D}\right)^2}\right]}{2\cdot\pi\cdot L\cdot H_c}$	$k_h = \frac{d^2\cdot\ln\left[\frac{mL}{D}+\sqrt{1+\left(\frac{mL}{D}\right)^2}\right]}{8\cdot L\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ $k_h = \frac{d^2\cdot\ln\left(\frac{2mL}{D}\right)}{8\cdot L\cdot(t_2-t_1)}\ln\frac{H_1}{H_2}$ FOR $\frac{mL}{D} > 4$	$k_h = \frac{d^2\cdot\ln\left[\frac{mL}{D}+\sqrt{1+\left(\frac{mL}{D}\right)^2}\right]}{8\cdot L\cdot T}$ $k_h = \frac{d^2\cdot\ln\left(\frac{2mL}{D}\right)}{8\cdot L\cdot T}$ FOR $\frac{mL}{D} > 4$

NOTATION

D = DIAM. INTAKE, SAMPLE, CM
d = DIAMETER, STANDPIPE, CM
L = LENGTH, INTAKE, SAMPLE, CM
H_c = CONSTANT PIEZ. HEAD, CM
H_1 = PIEZ. HEAD FOR $t = t_1$, CM
H_2 = PIEZ. HEAD FOR $t = t_2$, CM
q = FLOW OF WATER, CM³/SEC.
t = TIME, SEC.
T = BASIC TIME LAG, SEC.
k'_v = VERT. PERM. CASING, CM/SEC.
k_v = VERT. PERM. GROUND, CM/SEC.
k_h = HORZ. PERM. GROUND, CM/SEC.
k_m = MEAN COEFF. PERM., CM/SEC.
m = TRANSFORMATION RATIO
$k_m = \sqrt{k_h\cdot k_v}$ $m = \sqrt{k_h/k_v}$
$\ln = \log_e = 2.3\log_{10}$



DETERMINATION BASIC TIME LAG T

ASSUMPTIONS

SOIL AT INTAKE, INFINITE DEPTH AND DIRECTIONAL ISOTROPY (k_v AND k_h CONSTANT) – NO DISTURBANCE, SEGREGATION, SWELLING OR CONSOLIDATION OF SOIL – NO SEDIMENTATION OR LEAKAGE – NO AIR OR GAS IN SOIL, WELL POINT, OR PIPE – HYDRAULIC LOSSES IN PIPES, WELL POINT OR FILTER NEGLIGIBLE

Fig. 1.17 Formulas for determination of permeability from seepage tests. (After Hvorslev.)

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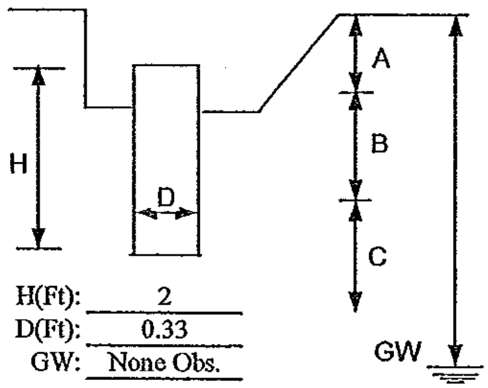
EXAMPLE

FALLING HEAD PERMEABILITY TEST

Project: Housing Authority Parking Lot

Location: Park Street/RROW 20' From first light pole and 14' from fence

By: David Field/Adam Burnett   Date: 27-Dec-01



H(Ft): 2

D(Ft): 0.33

GW: None Obs.

A Horizon: 0-10" Loam
10-14" Darker Loam

B Horizon: 14-48" Subsoil

C Horizon: 48" - 68" (Bottom of Excavation)
Med.-course sand & gravel

Test Elevation: 68"

Time (Seconds)	Depth From Top of Pipe (Ft)	% Depth From Top	% Of Water From Bottom
Trial # 1			
0	0	0%	100%
10	0.12	6%	94%
20	0.22	11%	89%
30	0.35	18%	83%
40	0.43	22%	79%
50	0.53	27%	74%
60	0.62	31%	69%
75	0.77	39%	62%
90	0.89	45%	56%
105	0.99	50%	51%
120	1.1	55%	45%
135	1.2	60%	40%
150	1.29	65%	36%
165	1.38	69%	31%
180	1.45	73%	28%
195	1.52	76%	24%
210	1.6	80%	20%
Trial #2			
0	0	0%	100%
10	0.12	6%	94%
20	0.22	11%	89%
30	0.33	17%	84%
40	0.44	22%	78%
50	0.53	27%	74%
60	0.63	32%	69%
75	0.76	38%	62%
90	0.88	44%	56%
105	1	50%	50%
120	1.1	55%	45%
135	1.2	60%	40%
150	1.29	65%	36%
165	1.37	69%	32%
180	1.44	72%	28%
195	1.52	76%	24%
210	1.59	80%	21%

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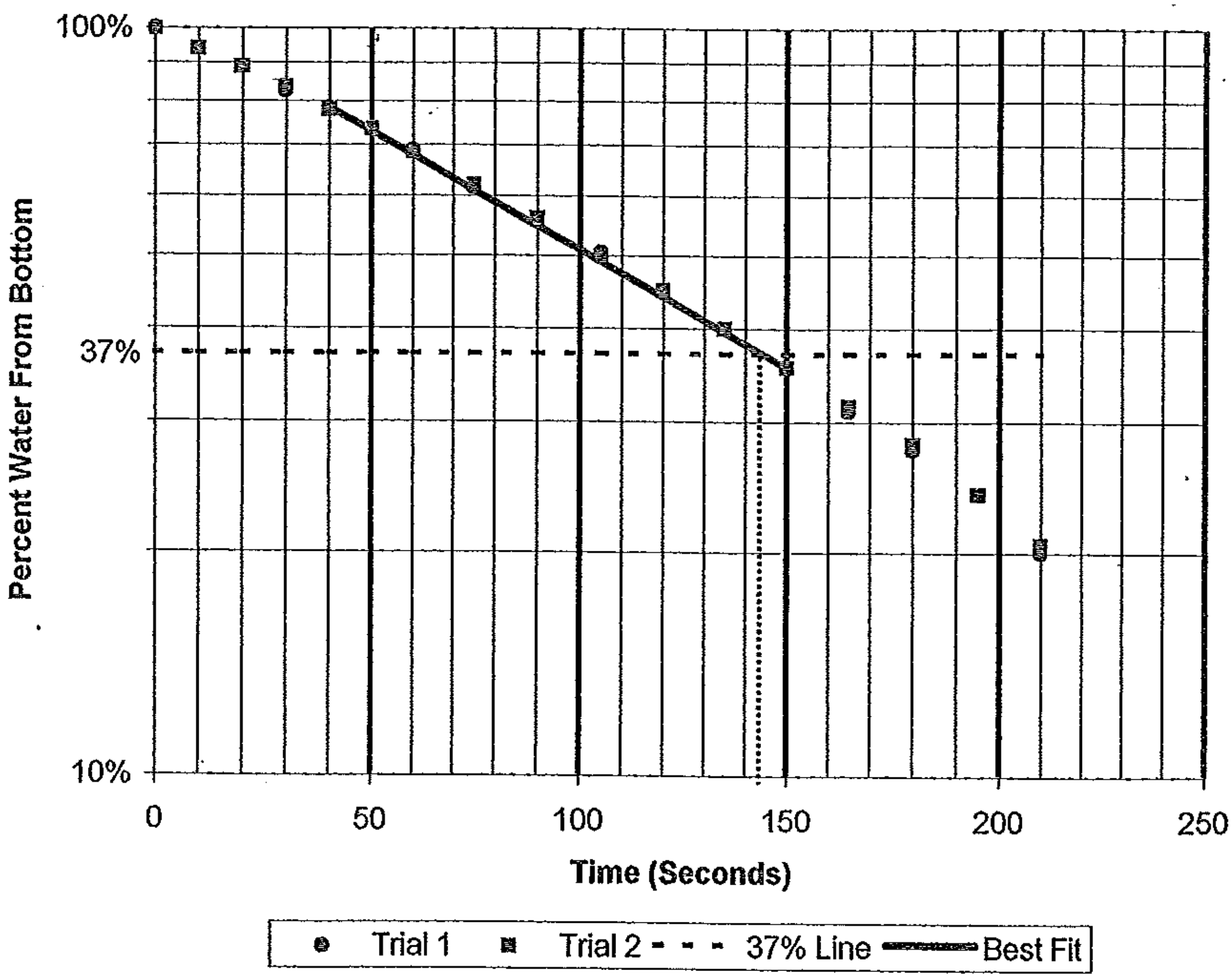
EXAMPLE

FALLING HEAD PERMEABILITY TEST



Find Permeability Km

Where: $Km = \frac{\pi (D)}{11(T)}$ and: D (ft) = 0.333; T (sec) = 143

Km = 0.0006651 ft/sec
or
6.65E-04 ft/sec

Using a Factor of Safety of: 2

Km = 3.33E-04 ft/sec