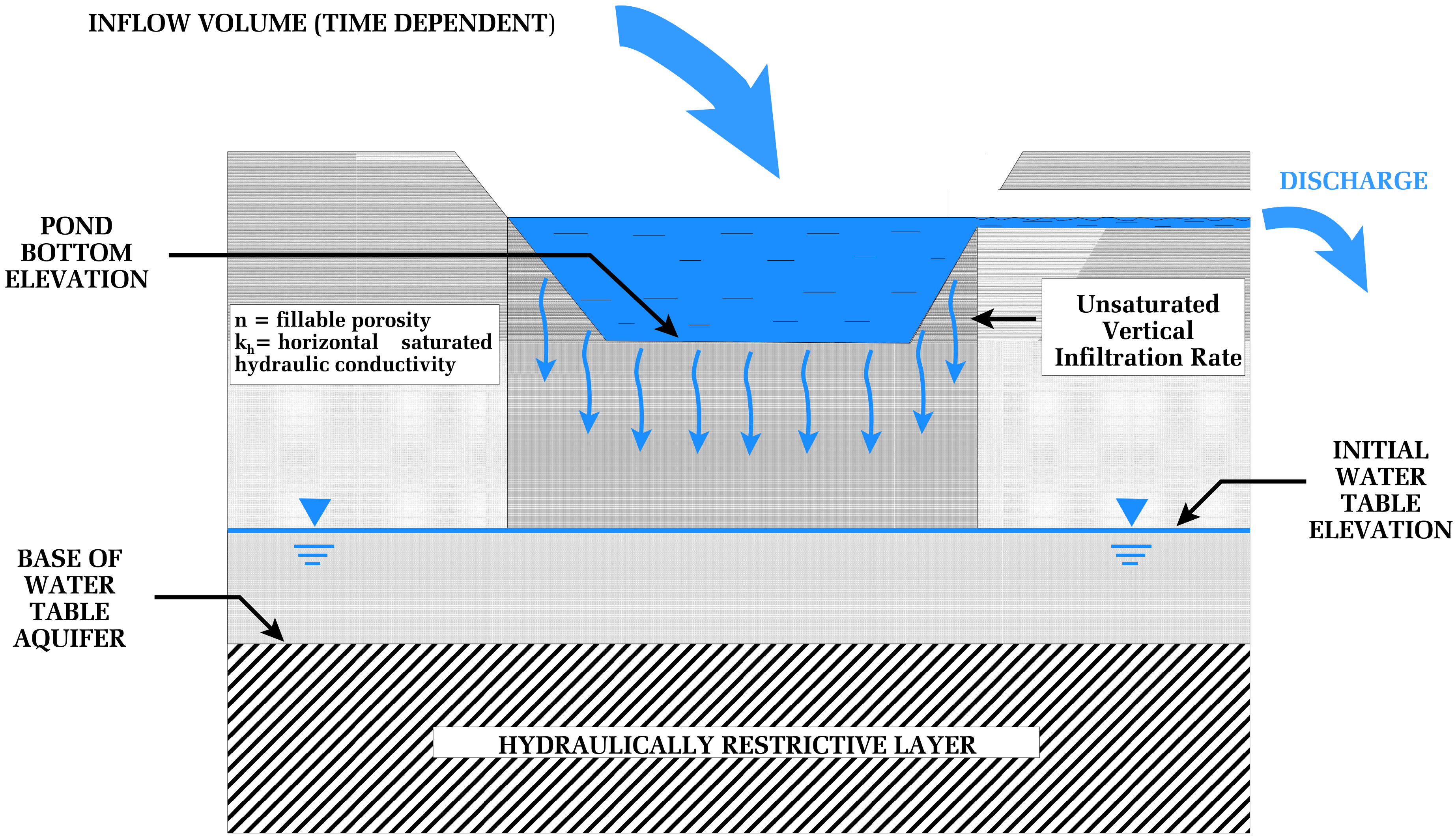
GEOTECHNICAL INVESTIGATION & ASSESSMENT TO ESTIMATE AQUIFER PARAMETERS

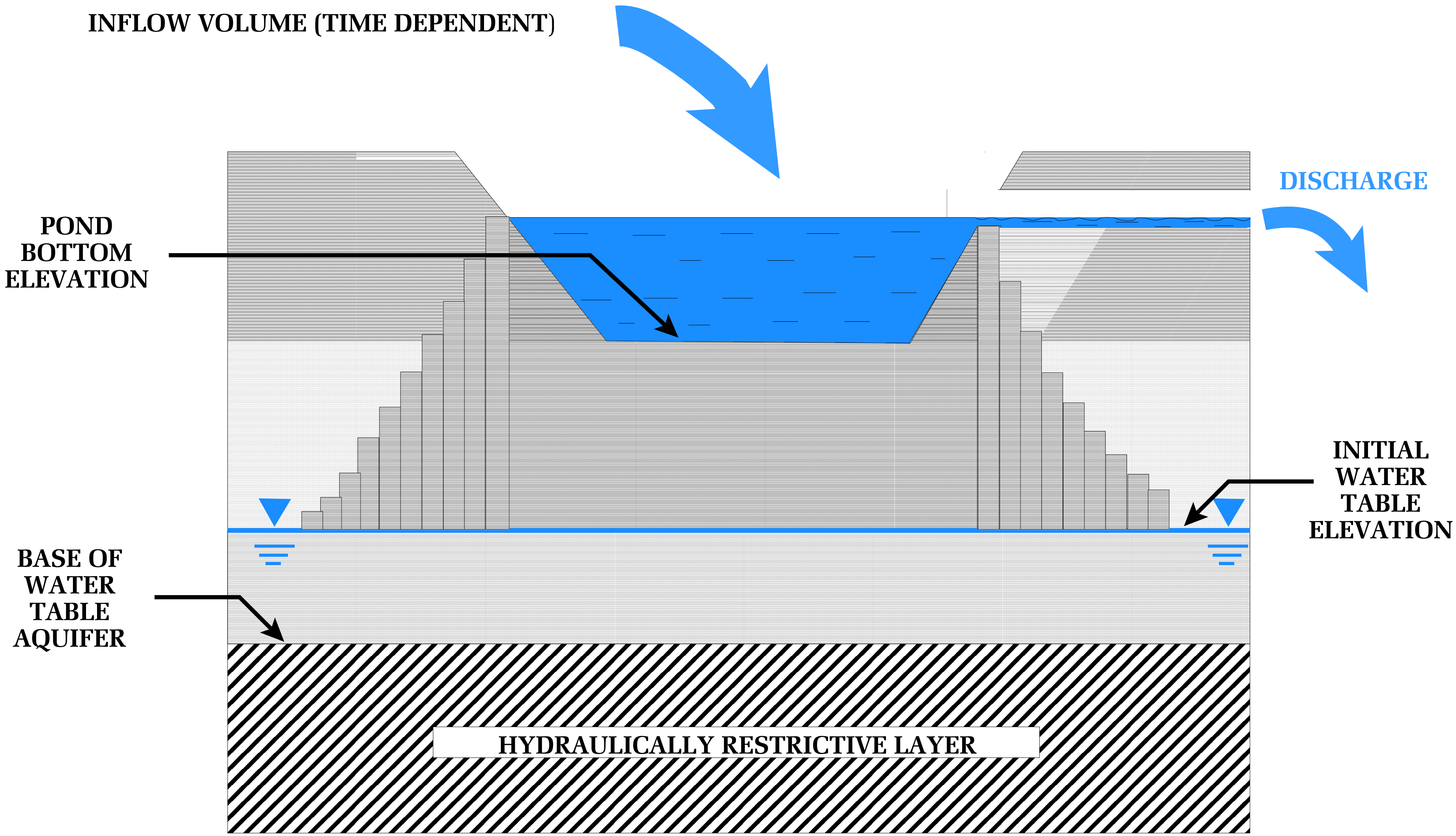
MARION COUNTY PONDS WORKSHOP

- NOTE THE WORD IS ESTIMATE & NOT DETERMINE
- MUST APPRECIATE THE CONCEPTUAL MODEL USED IN PONDS AND THE PHYSICAL MEANING OF EACH PARAMETER
- THIS TASK SHOULD BE CONDUCTED BY AN EXPERIENCED GEOTECHNICAL ENGINEER.
- REFER TO PAGE 3-7 OF THE PONDS VERSION 2.26 USER MANUAL FOR A SAMPLE REQUEST FOR SERVICES FORM

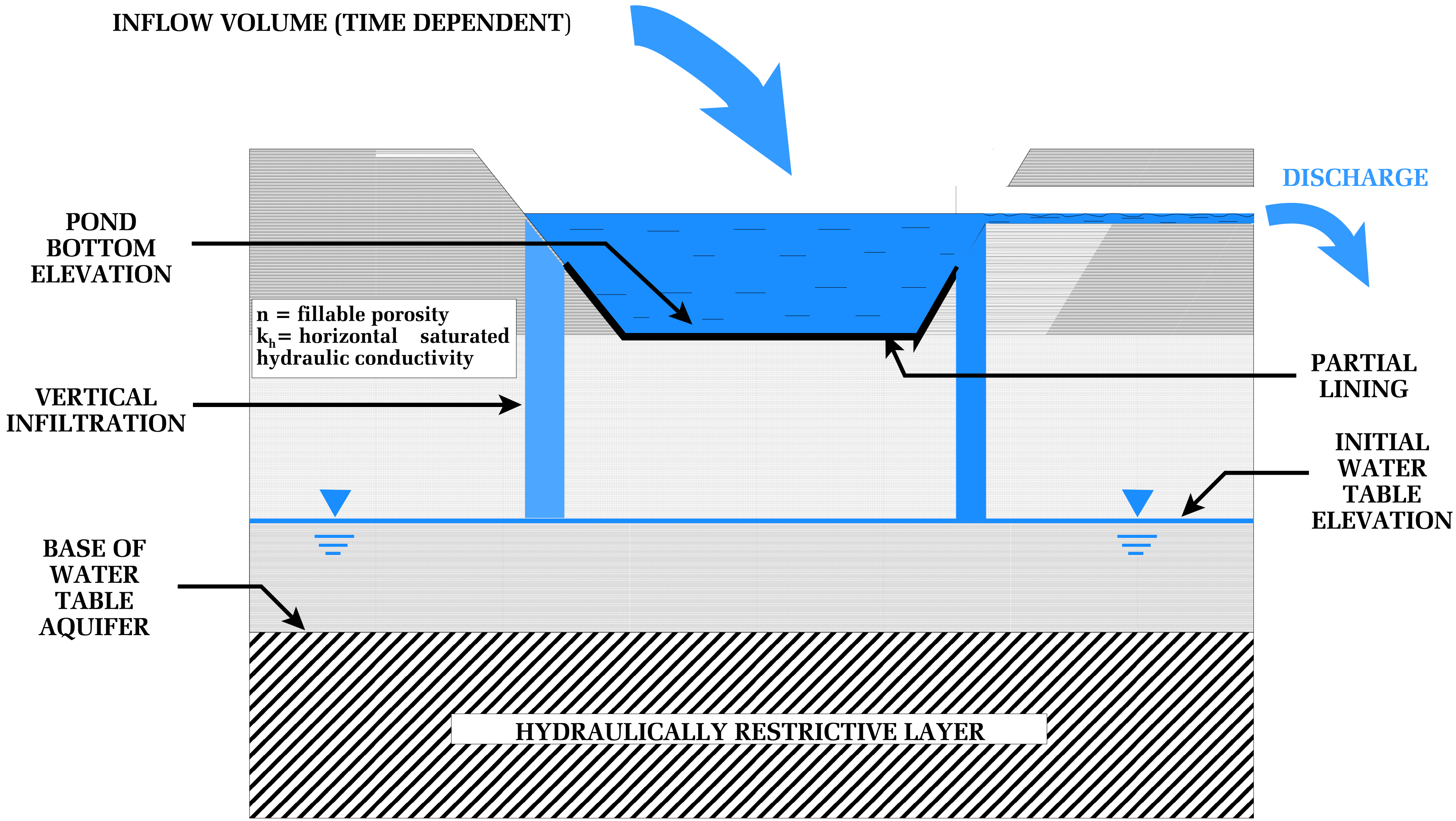
CONCEPTUAL MODEL OF STAGE I RECOVERY
UNSATURATED VERTICAL INFILTRATION ONLY



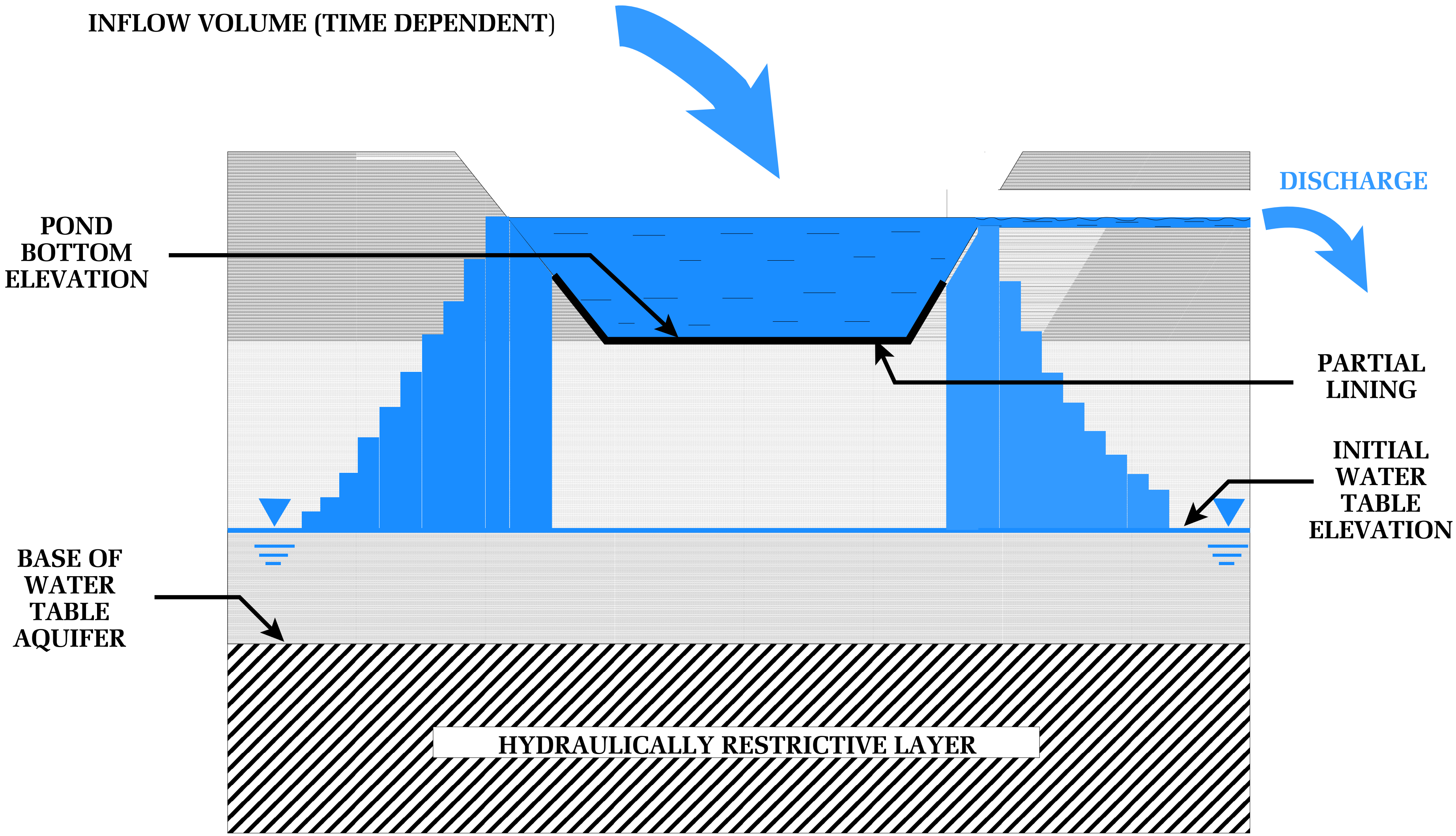
CONCEPTUAL MODEL OF STAGE II RECOVERY
SATURATED LATERAL FLOW



CONCEPTUAL MODEL OF STAGE I RECOVERY
UNSATURATED VERTICAL INFILTRATION ONLY - PARTIALLY LINED POND



CONCEPTUAL MODEL OF STAGE II RECOVERY
SATURATED LATERAL FLOW - PARTIALLY LINED POND



WHAT ARE THE AQUIFER PARAMETERS?

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- **Thickness (or base altitude) of effective water table aquifer**
- **Weighted horizontal saturated hydraulic conductivity of effective aquifer**
- **Fillable porosity of aquifer**
- **Unsaturated vertical infiltration rate**
- **Altitude of seasonal high water table**

RESPONSE TO A FREQUENTLY ASKED QUESTION

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How can the unsaturated vertical infiltration rate be greater than the weighted horizontal saturated hydraulic conductivity?

Answer:

The unsaturated vertical infiltration rate controls how fast water can enter the soil infiltrative surface and fill the unsaturated zone above the water table. This infiltration rate is usually not affected by more hydraulically restrictive soils below the water table. A minimum factor of safety of 2 is usually applied to this parameter.

The weighted horizontal hydraulic conductivity is a weighted average of the assumed thickness of the aquifer which may include clayey sands (with low permeability) in the soil profile. This parameter multiplied by the assumed aquifer thickness controls the lateral transmission of water in the soil. The recommended safety factor for this parameter is unity since it is not subject to clogging as is the unsaturated vertical infiltrative surface.

OFFICE REVIEW BEFORE WE PLAN FIELD WORK

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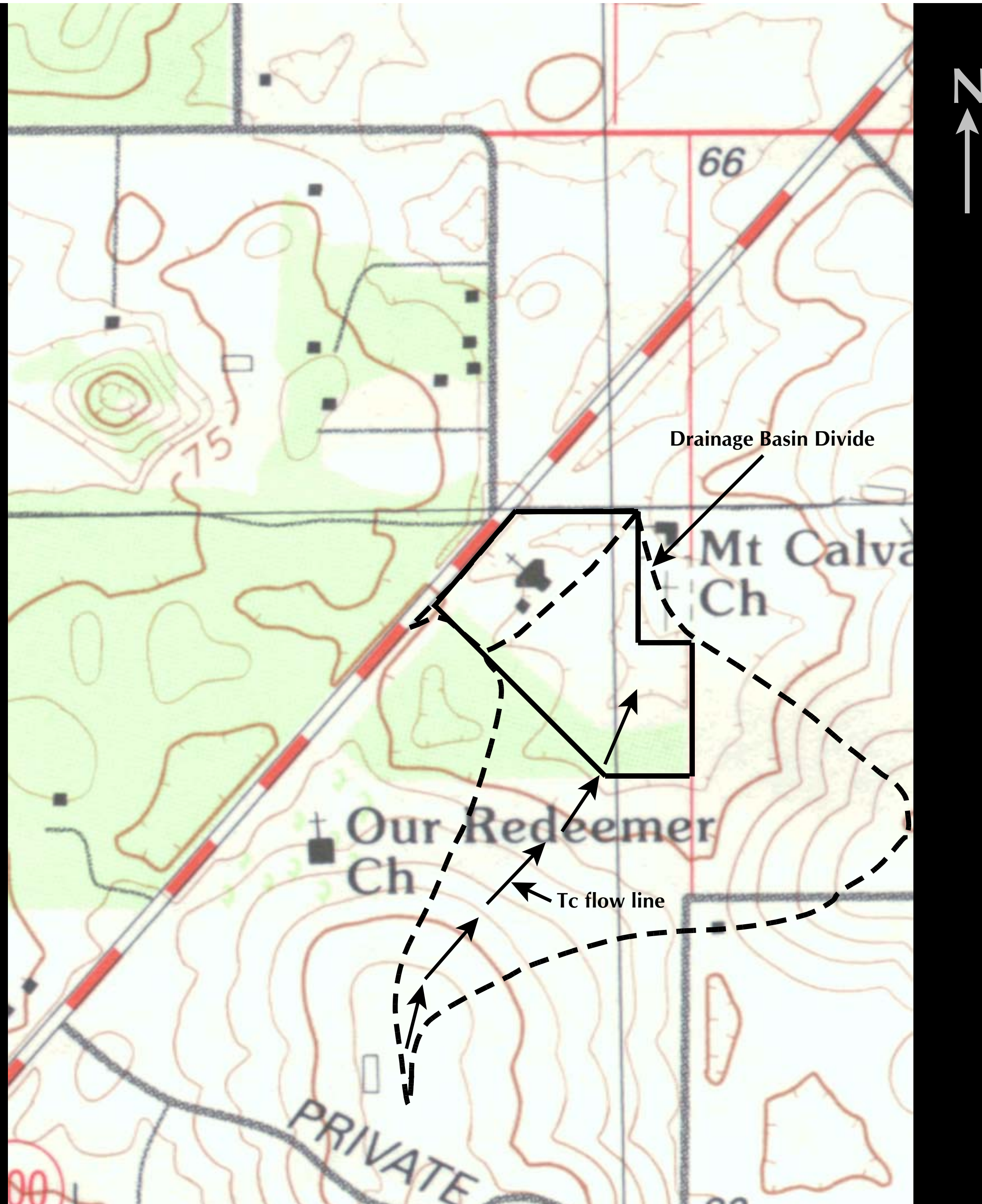
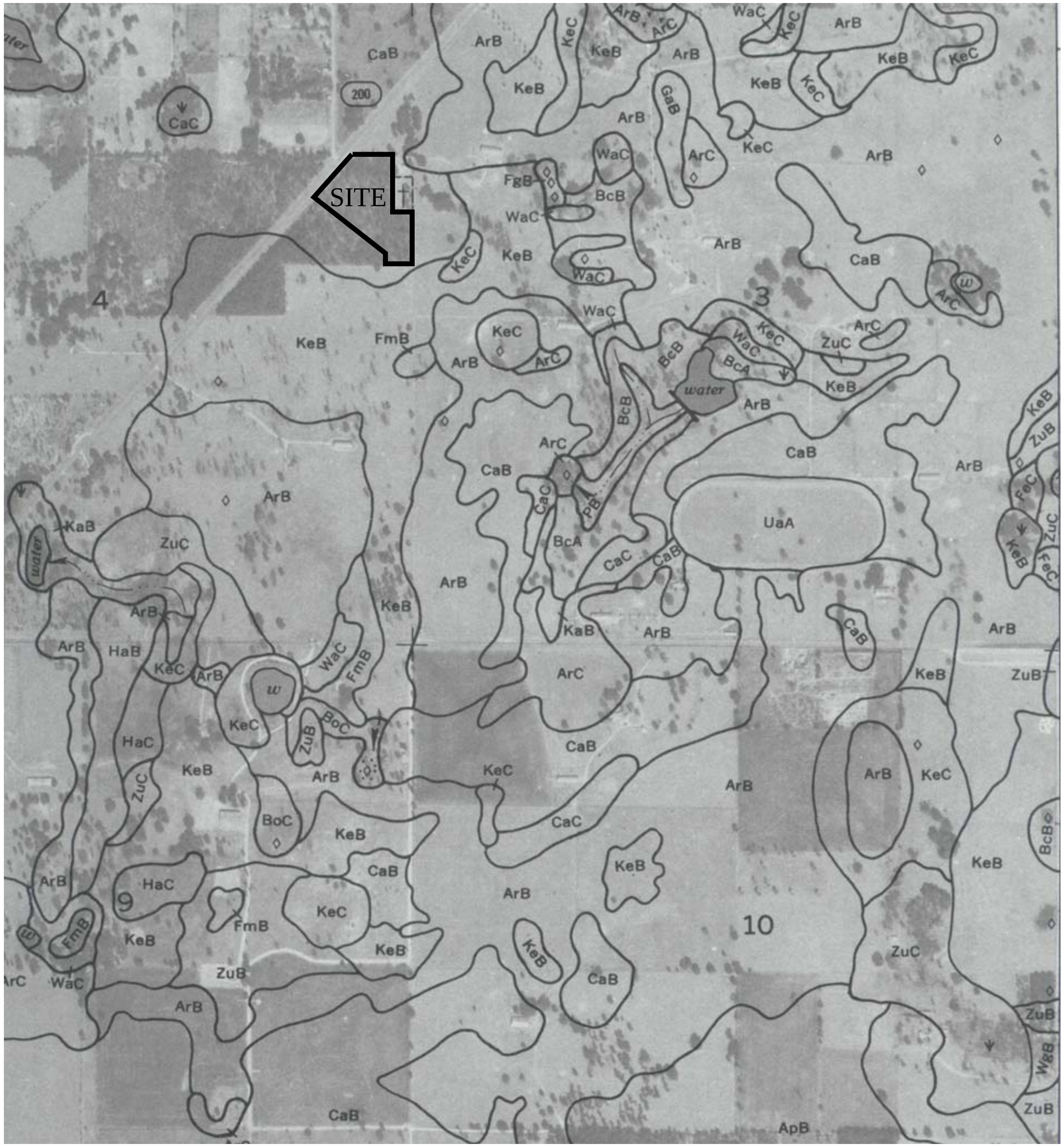
- Review USGS 7.5 minute series quadrangle map. Look at lay of the land and any closed depressions, and contributing drainage basins; should always field verify drainage basin divides.
- Review NRCS Soils Map
- Review regional map showing thickness of sediments over the limestone
- Review subregional map of potentiometric surface of Floridan aquifer and compare to land surface elevation. Water table should be at or above that elevation.

Review USGS quadrangle map





N

review NRCS soils map

Figure 3. Soil Conservation Service (SCS) Soils Map

Legend

CaB - Candler sand, 0 to 5 percent slopes

Scale: 1" = 1320 ft.

Table 3: Key SCS Characterization Data for Arredondo Sand [ArB (0-5% slopes)]

This is a nearly level to sloping, well drained soil that occurs as both large and small areas in the upland. The water table is at a depth of more than 72 inches.		
Hydrologic Soil Group (HSG)		A
REPRESENTATIVE SOIL PROFILE		
Depth	Soil Color & Texture	Permeability
0 - 7 in	dark grayish brown sand	12 to 40 ft/day
7 - 18 in	mixed yellowish brown and dark yellowish brown sand	
18 - 46 in	yellowish brown sand	
46 - 65 in	strong brown sand	
65 - 70 in	strong brown loamy sand	4 to 12 ft/day
70 - 90 in	strong brown fine sandy loam	

Official soil series descriptions can also be found at the following internet web site:

http://www.statlab.iastate.edu/cgi-bin/masoud/osd/get_osd

WHAT TYPE OF FIELD TESTS?

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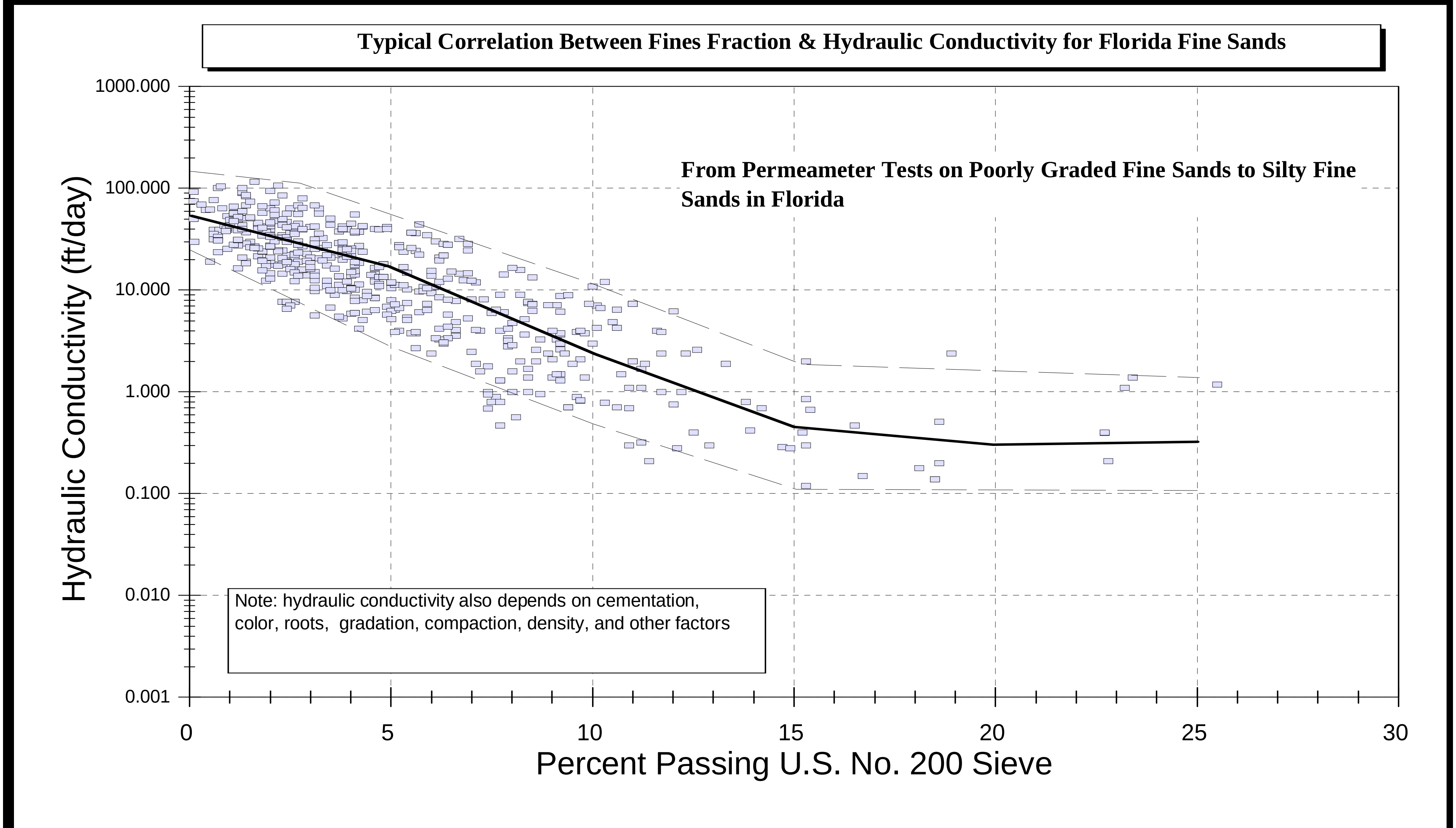
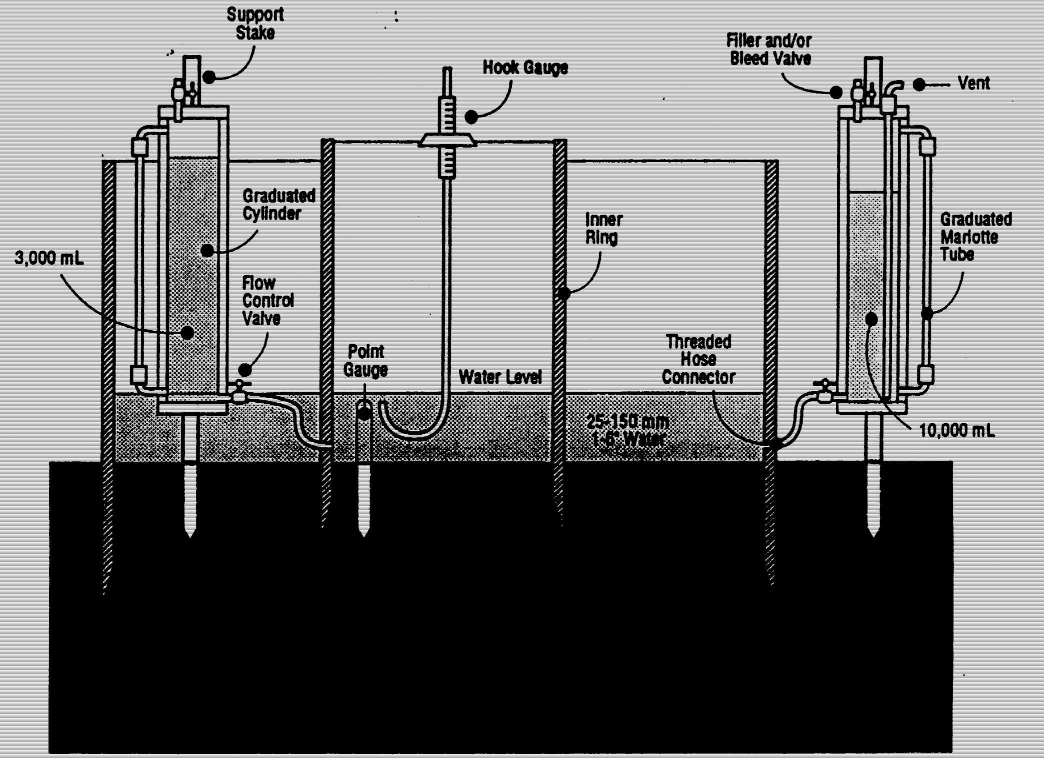
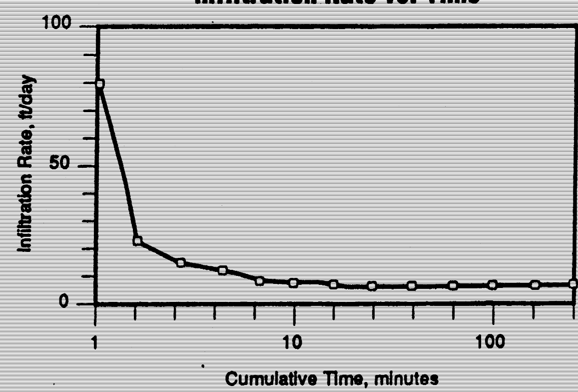
- SJRWMD Special Publication SJ93-SP10. *Get it!*
- Type of test depends on the expected conditions. Let say we assume deep water table below first clayey layer.
- If we are lucky and ponds are already excavated or there is an adjacent pond which is excavated approximately to the proposed pond bottom elevation, the most appropriate test would be a double ring infiltrometer test.
- If not, we have to use engineering judgement since there is no easy or economical way to estimate leakage through a deep layer. Range of leakage rates through the clayey soils in the Ocala area is in the range 0.2 to 4 ft/day based on my experience. Use safety factor of 2. Can also require quality control test after pond excavation to confirm value used in analysis.

WHAT TYPE OF FIELD TEST? (continued)

- If water table is above first clayey sand layer and/or relatively close to the pond bottom, then conventional field and lab testing methods apply. Conventional approach is to obtain an undisturbed permeability tube in the field, take it to the lab and run a permeameter test to measure the hydraulic conductivity.
- As an aside, note that the word hydraulic conductivity has officially replaced the word permeability (USGS).
- Also note that field testing to estimate hydraulic conductivity in wholly unsaturated soil is subject to a lot of error since the equations are empirical; perc test in some codes is meaningless
- See attached chart for range of hydraulic conductivity values based on grain size (this chart doe not apply to clayey sand in the Ocala area.


Typical Correlation Between Fines Fraction & Hydraulic Conductivity for Florida Fine Sands
From Permeameter Tests on Poorly Graded Fine Sands to Silty Fine Sands in Florida
Hydraulic Conductivity (ft/day)
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
0
5
10
15
20
25
30
Percent Passing U.S. No. 200 Sieve
Note: hydraulic conductivity also depends on cementation, color, roots, gradation, compaction, density, and other factors



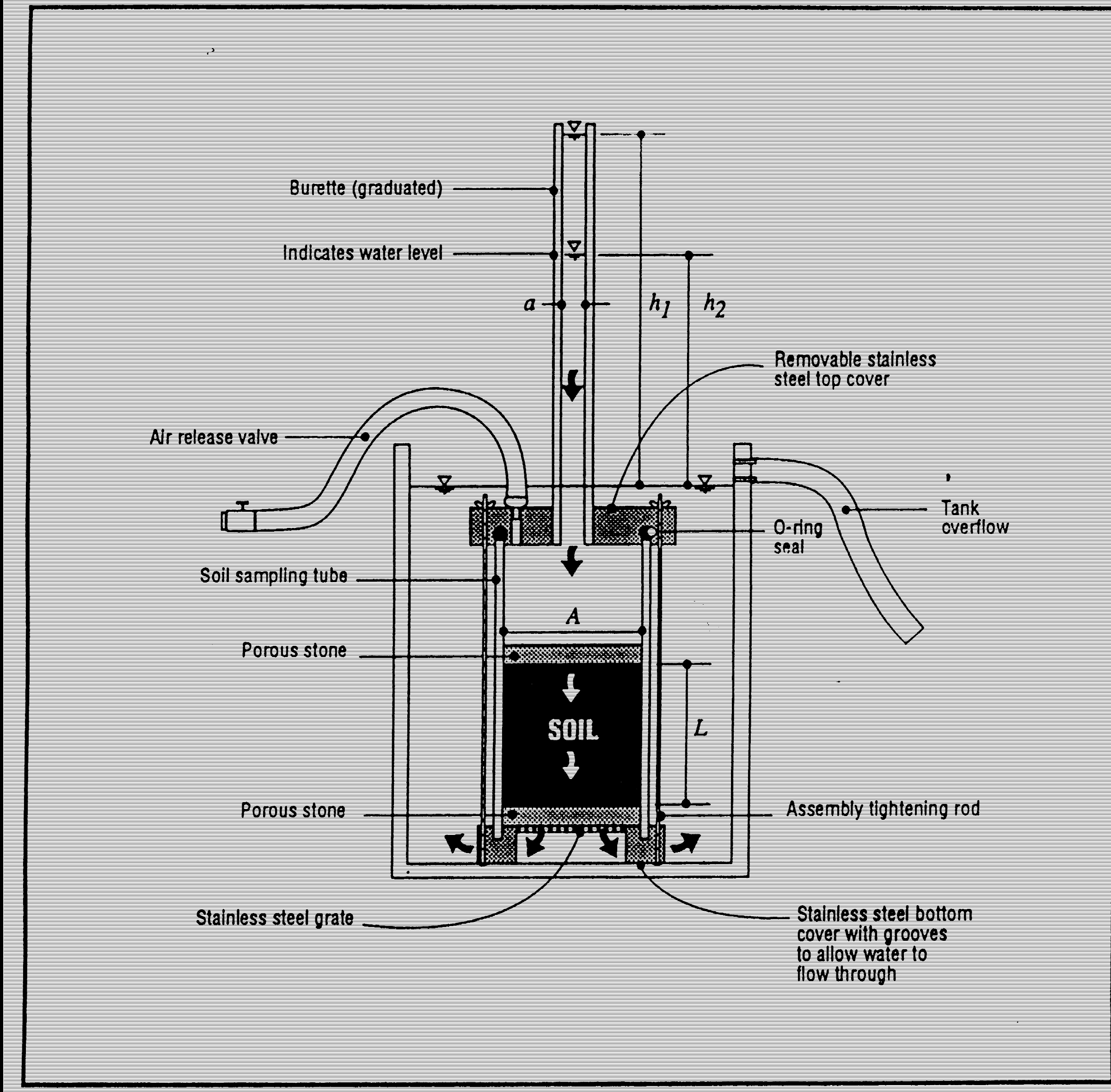


NOTE

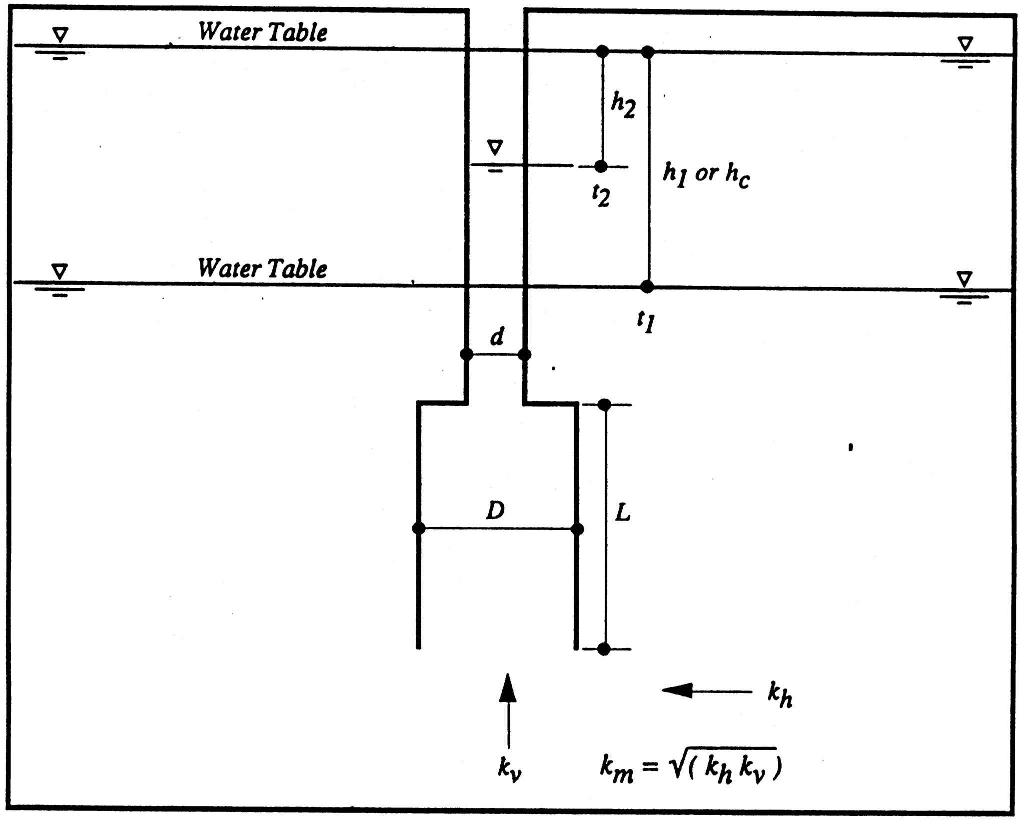
Constant-level float valves have been eliminated for simplification of the illustration

Typical Double-Ring Infiltrometer Test


4X4
4WD



Variable Head $k = \frac{a\,L}{A\,t} \ln \frac{h_1}{h_2}$



Constant Head $k_v = \dfrac{q}{2.75\, D\, h_c}$

Variable Head $k_m = \dfrac{\pi d^2}{11\, D\, (t_2 - t_1)} \ln \dfrac{h_1}{h_2}$ $\qquad k_m = \dfrac{\pi D}{11 (t_2 - t_1)} \ln \dfrac{h_1}{h_2}$ *for d=D*

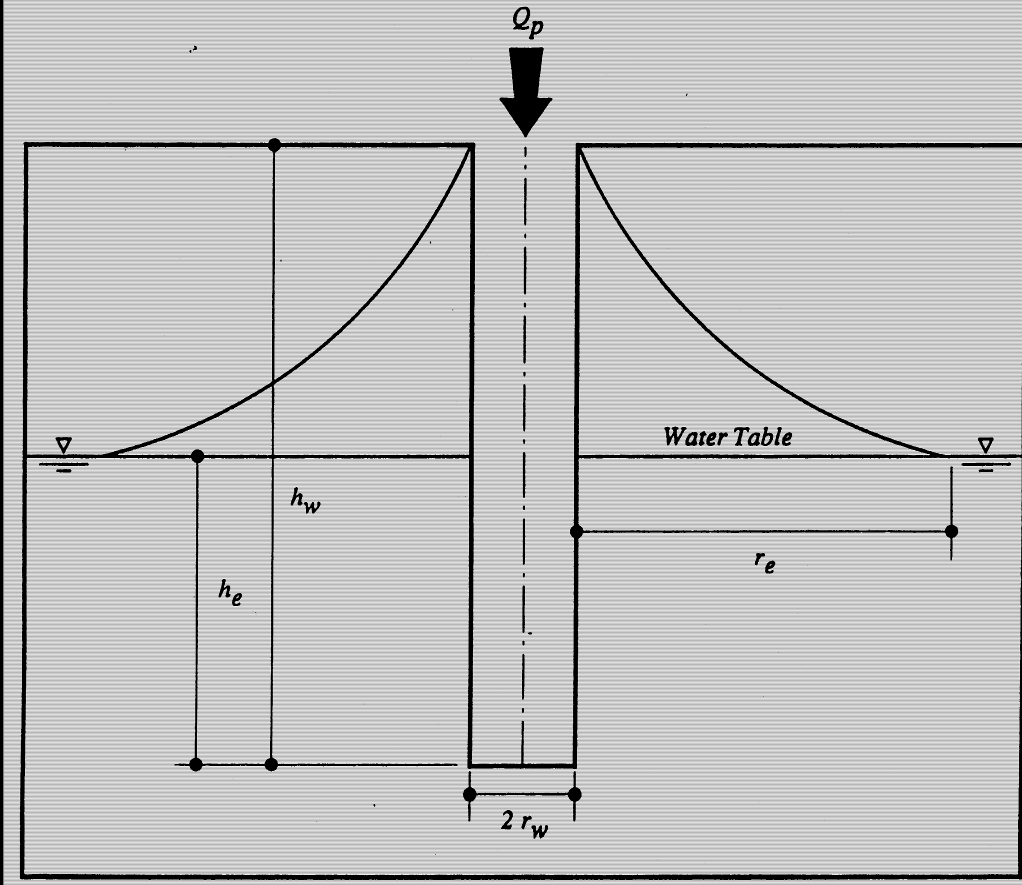
NOTE

In tests with the bottom of casing above the water table, *h* is the depth of water in hole.

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. (After Hvorslev, U. S. Corps of Engineers, W.E.S., 1951)

Field Hydraulic Conductivity Test: Cased Hole, Soil Flush with Bottom



NOTE

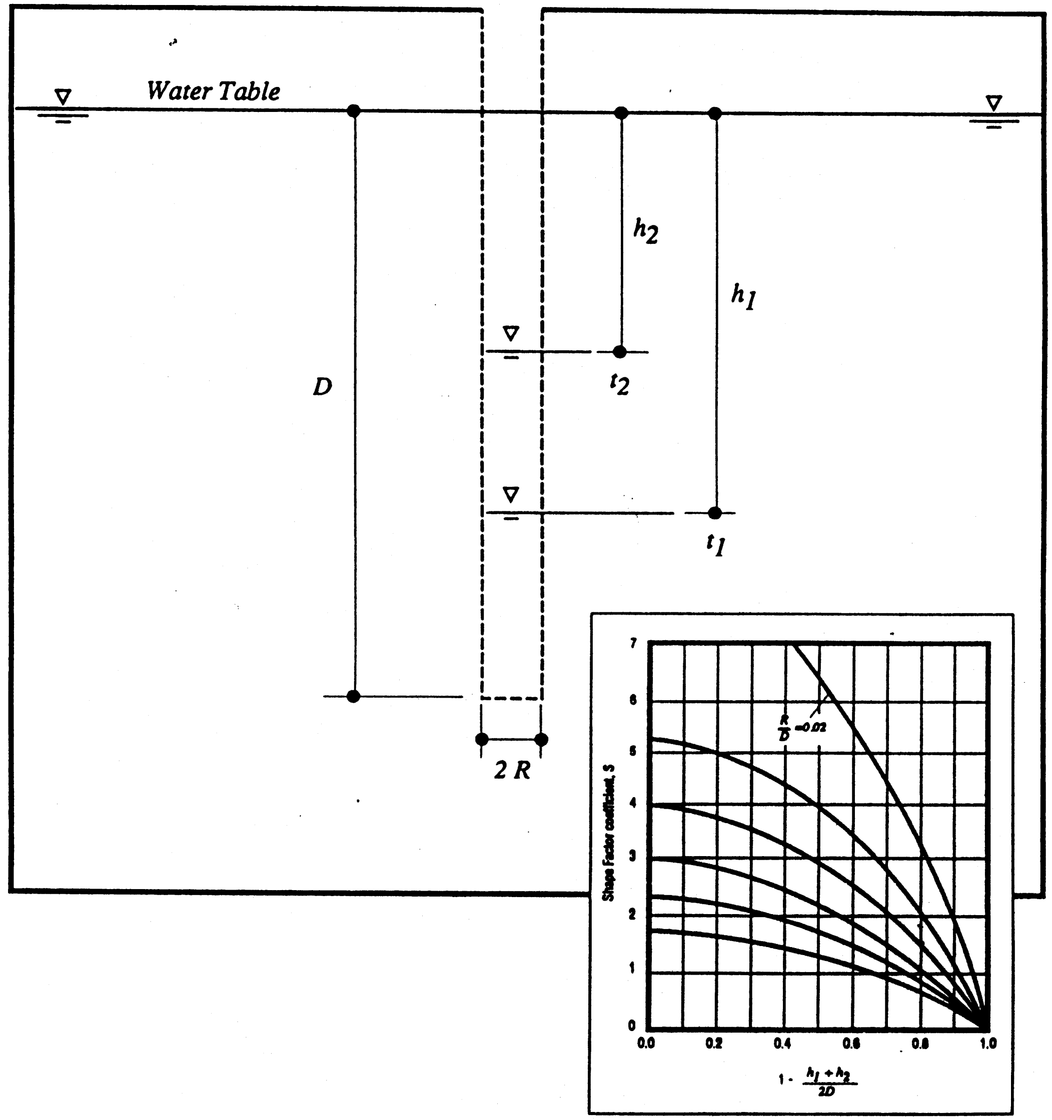
Use r_e = 20 to 25 ft.

$$K = \frac{Q_p \ln\left(\frac{r_e}{r_w}\right)}{\pi\,(h_w^2 - h_e^2)}$$

Q_p = Steady inflow rate to borehole (cfs)
K = Hydraulic conductivity (ft/sec)
r_e = Radius of influence of borehole (ft)
r_w = Radius of borehole (ft)
h_e = Depth of borehole below water table (ft)
h_w = Total depth of borehole (ft)

Source: South Florida Water Management District, 1987

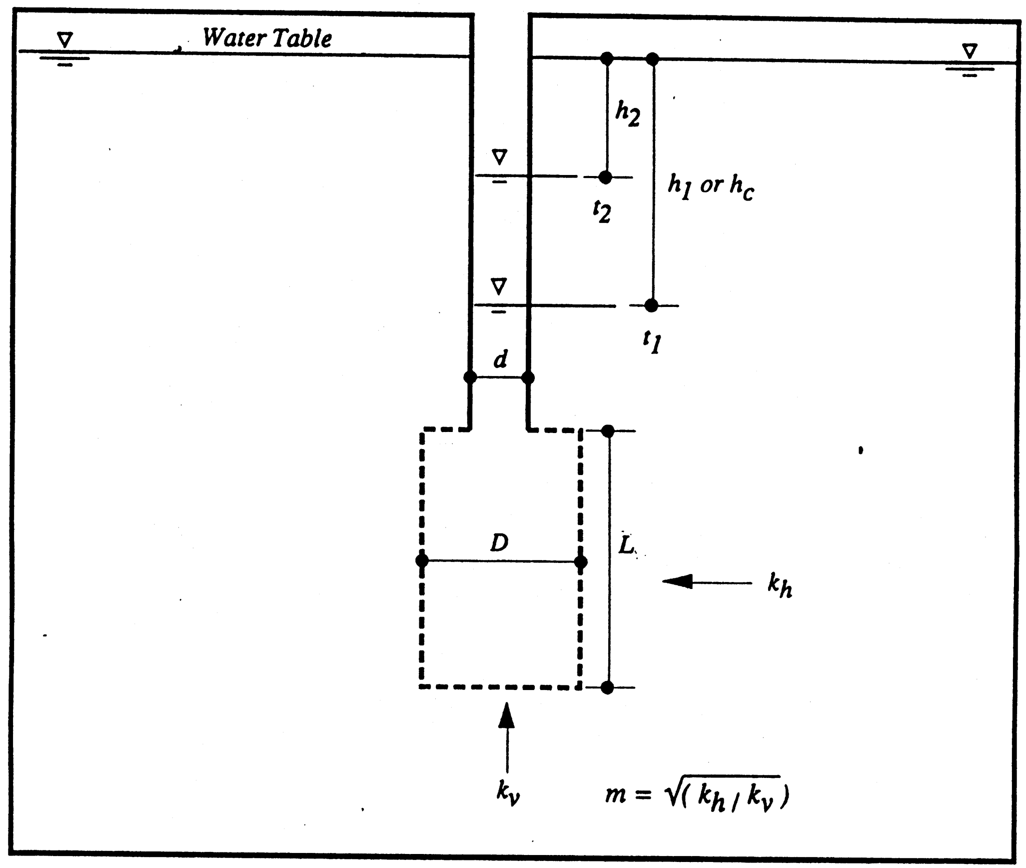
Field Hydraulic Conductivity Test: Uncased or Fully Screened Auger Hole, Constant Head



Shape Factor, F $F = 16\,\pi DSR$

Permeability, k **by variable head test** $k_h = \frac{R}{16DS} \times \frac{(h_2 - h_1)}{(t_2 - t_1)}$ *for* $\frac{D}{R} < 50$

Field Hydraulic Conductivity Test: Uncased or Fully Screened Auger Hole, Falling Head



Constant Head $k_h = \dfrac{q \ln\left[\frac{mL}{D} + \sqrt{1+\left(\frac{mL}{D}\right)^2}\right]}{2\pi L h_c}$

Variable Head $k_h = \dfrac{d^2 \ln\left[\frac{mL}{D} + \sqrt{1+\left(\frac{mL}{D}\right)^2}\right]}{8L(t_2 - t_1)} \ln\dfrac{h_1}{h_2}$ $\qquad k_h = \dfrac{d^2 \ln\left(\frac{2mL}{D}\right)}{8L(t_2 - t_1)} \ln\dfrac{h_1}{h_2}$ for $\dfrac{mL}{D} > 4$

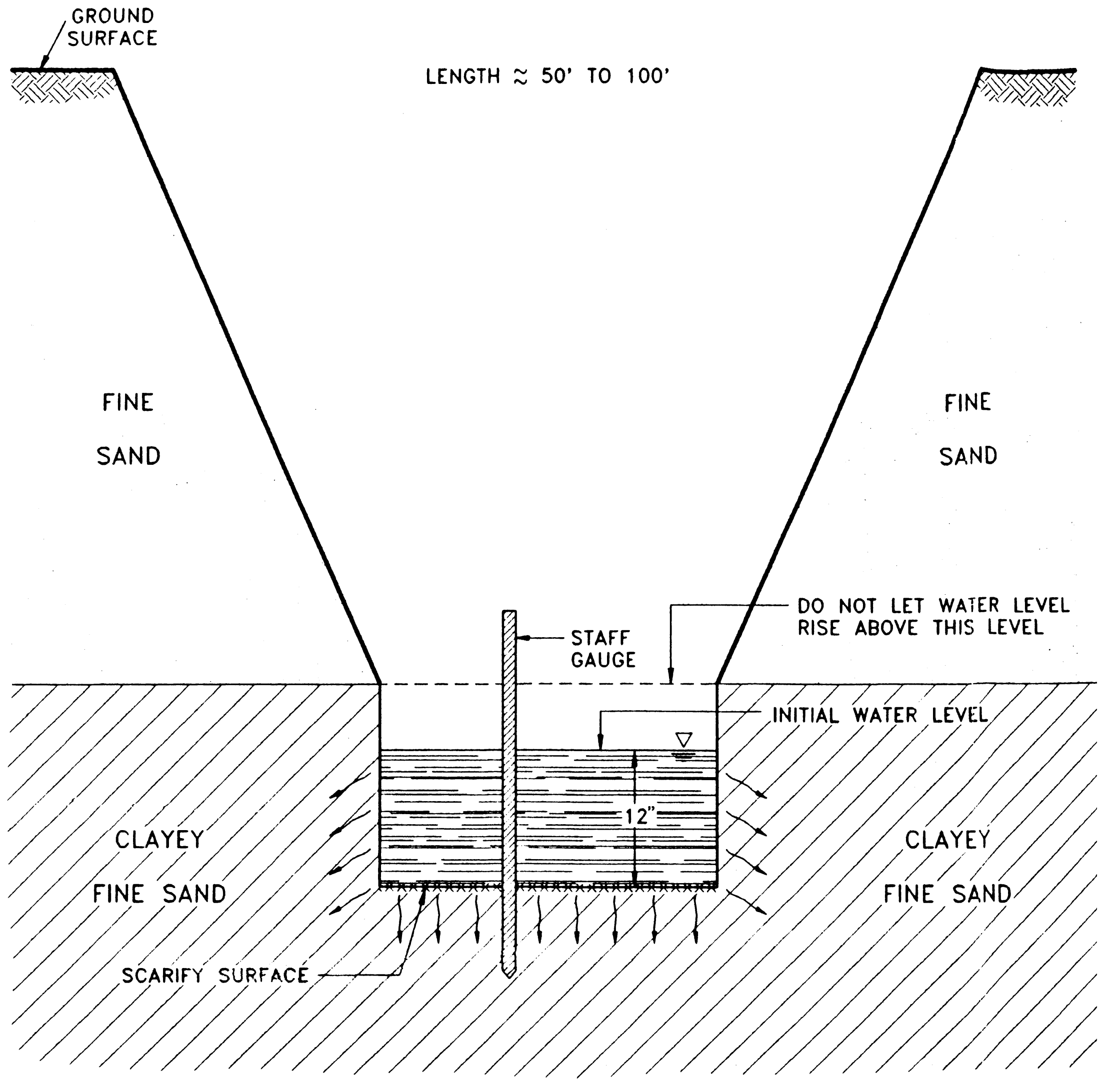
ASSUMPTIONS

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. (After Hvorslev, U. S. Corps of Engineers, W.E.S., 1951)

Field Hydraulic Conductivity Test: Cased Hole with Uncased or Screened Extension

A LITTLE MORE ABOUT VERTICAL LEAKAGE IN THESE LEAKY HYDROGEOLOGIC ENVIRONMENTS & WHAT WE HAVE TRIED TO GET A BETTER HANDLE ON THESE ESTIMATES OF VERTICAL INFILTRATION THROUGH THE SEMI-CONFINING LAYER.

THE UNCONVENTIONAL TEST I AM ABOUT TO DESCRIBE WAS ONE THAT I DEVELOPED AND WAS CONDUCTED FOR A LARGE SPRAYFIELD SITE IN COLUMBIA COUNTY (ACTUALLY FOR THE CITY OF LAKE CITY). THEY HAD A SIMILAR SITUATION IN THAT AREA WHERE VERTICAL LEAKAGE ACCOUNTS FOR A SIGNIFICANT PORTION OF PERCOLATIVE CAPACITY. REGULATORS SHOULD BEAR IN MIND THAT TYPE OF TEST IS EXPENSIVE.



TYPICAL CROSS-SECTION OF TRENCH PERCOLATION TEST TO ESTIMATE VERTICAL LEAKANCE

SCALE: 1" = 1'

PROCEDURE

- Stake the approximate centerline of trench in general accordance with location plan. Ensure that centerline of a trench generally follows a contour so that the excavated base of the trench will be fairly flat.
- Excavate trench using backhoe. Minimum trench width is 2.5 feet. Exercise caution not to mix the excavated sand with any clayey soils. Since the sand will be reused to backfill the trench.
- Depth of trench excavation to be monitored by geotech engineer's representative to determine when clayey sand stratum has been encountered.
- Excavate trench about 1.5 feet below top of clayey fine sand stratum.

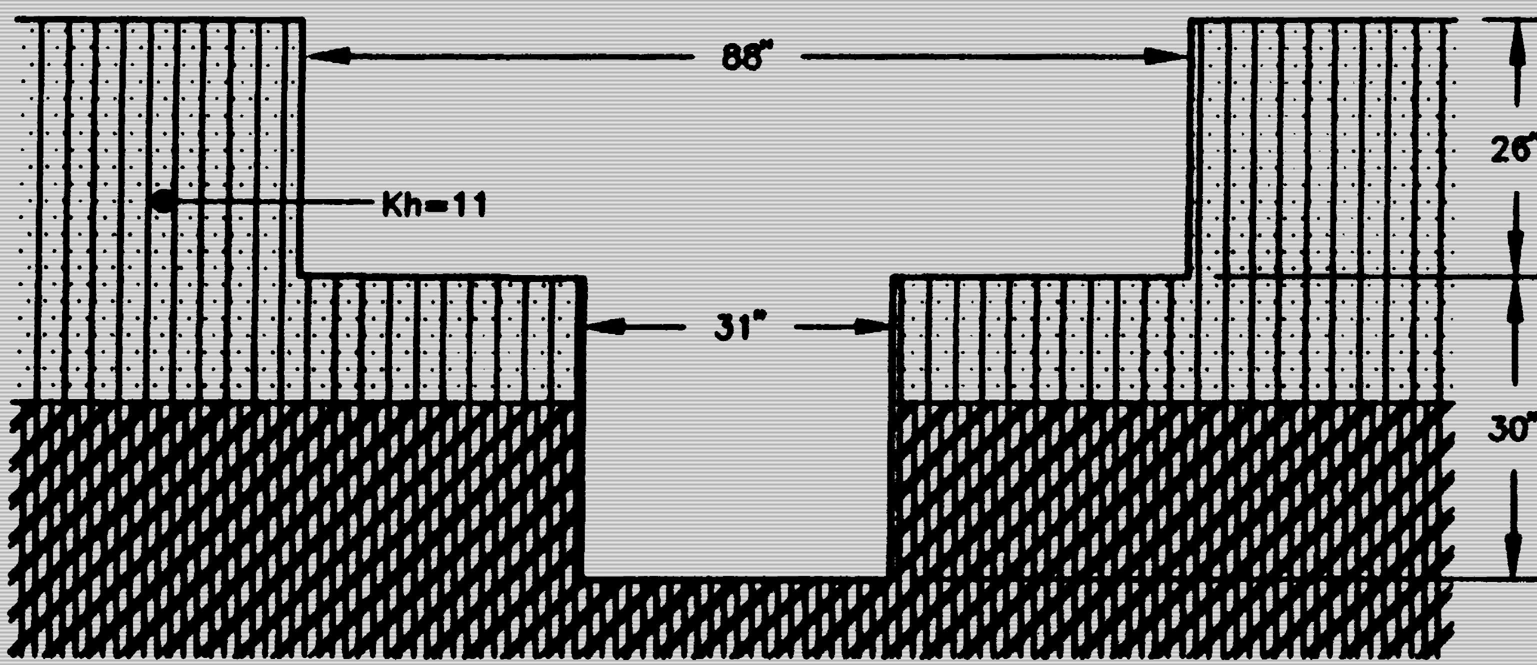
PROCEDURE (Cont'd)

- Scarify base of trench in any clayey soil to promote infiltration and open up any surface which may have been sealed by the backhoe bucket during excavation.
- Set staff gauge in trench. Use more than one staff gauge if necessary. Staff gauge graduations shall be at least at 1 inch intervals.
- Fill trench with water from water tanker until it stages approximately 1 foot above the base of the trench. Exercise caution to ensure water does not stage above the top of the clayey fine sand stratum such that some of it percolates laterally through the upper mantle of more permeable sand. Also, while an attempt shall be made to fill the trench rapidly, do not fill so rapidly that sloughing and erosion results.

PROCEDURE (Cont'd)

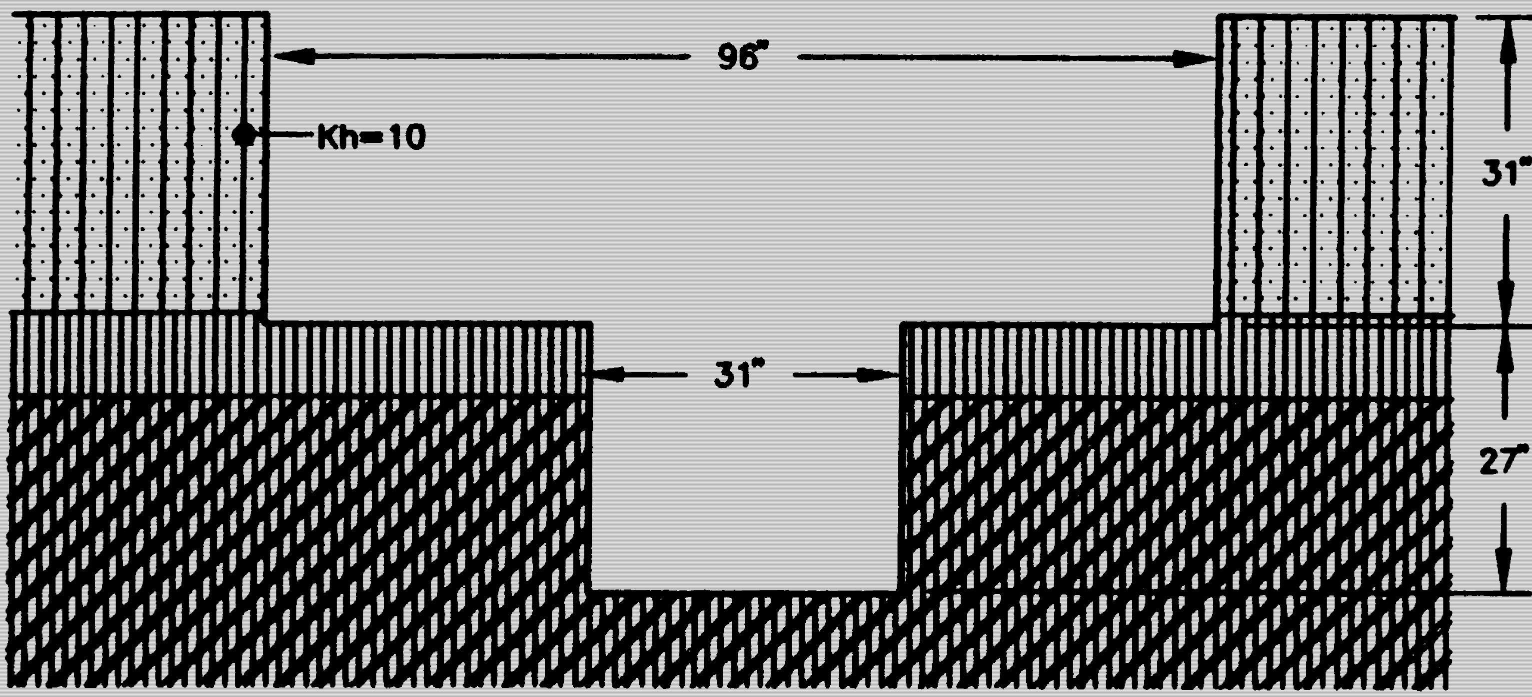
- Approximate quantities of water required to fill the trench are as follows: 50 ft (1000 gal), 75 ft (1500 gal), 100 ft (2000 gal)
- Monitor the rate of fall of the water level in the trench. The frequency of readings shall be such that the time required for each inch of percolation can be measured. This may vary from trench to trench depending on the leakance. Note any rainfall during the test. If possible also record average temperature for each day from a nearby weather station.
- Repeat the hydraulic loading as described above at least once for each test trench. However, if the recovery of the water level is negligible to very slow (less than 1 inch per week). There is no need to repeat the test.
- Upon completion of the test, backfill the trench with sand only. Discard the excavated clayey soil to a stockpile for subsequent disposalduring construction. The trench backfill material shall not be compacted.

measured rate = 37 in/wk = 0.44 ft/day



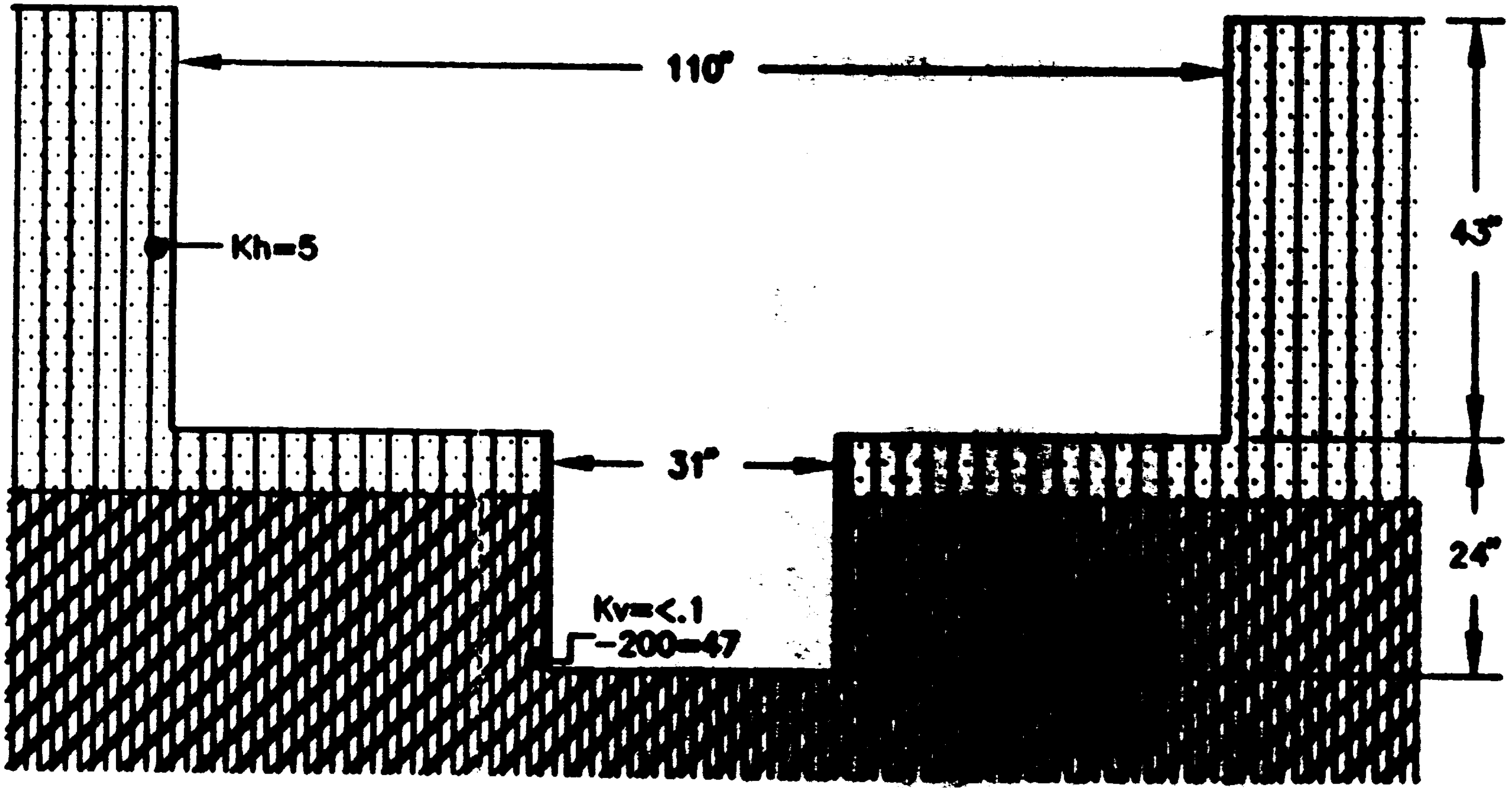
TEST PIT #1

measured rate = 19 in/wk = 0.23 ft/day



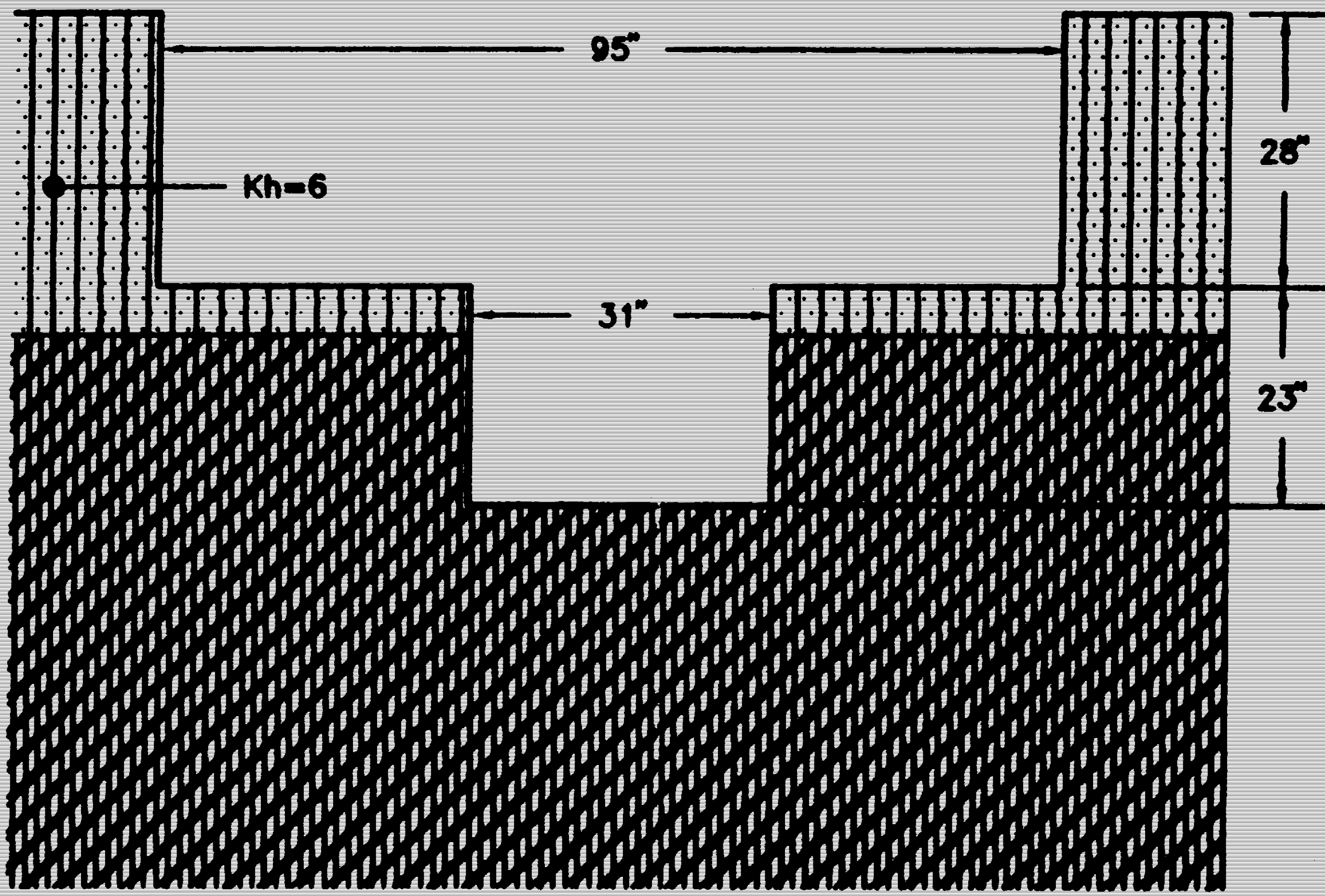
TEST PIT #3

measured rate = 140 in/wk = 1.67 ft/day



TEST PIT #5

measured rate = 32 in/wk = 0.38 ft/day



TEST PIT #7