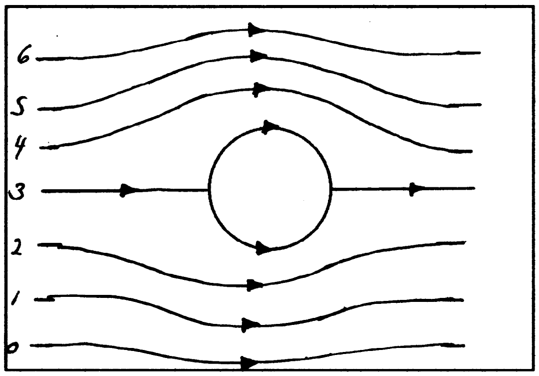
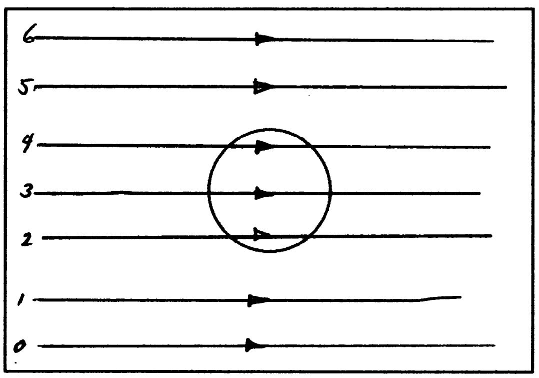
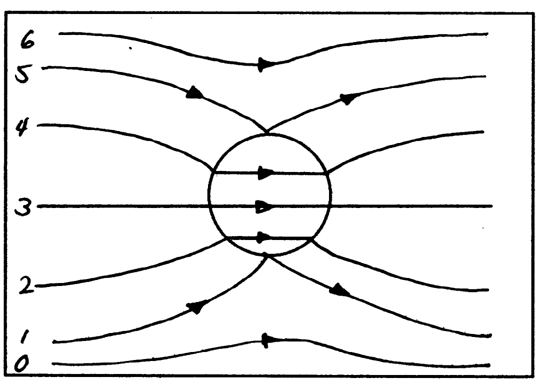
Solutions

CIVE 6361 Groundwater Hydrology   Fall 1997   Examination #2

(1) The three figures below depict streamline patterns for flow near a circular region. Explain the differences in the patterns in terms of the hydraulic conductivity within the circular region and the surrounding region.

Streamline Pattern	Explanation
	hydraulic conductivity inside circle much smaller than hydraulic conductivity outside circle
	hydraulic conductivity inside circle is equal to hydraulic conductivity outside circle
	hydraulic conductivity inside circle much greater than hydraulic conductivity outside circle

Solution

(2) A pumping test was conducted in a confined aquifer with no known recharge or no-flow boundaries. The observation well is located 250 meters from the pumped well and the pumping rate was 1.0 cubic meters/minute. The corrected data below were obtained from the test. Estimate the aquifer transmissivity and storage coefficient. A blank sheet of log-log paper and a type curve are attached.

Time (minutes)	Drawdown (meters)	t/r^2
1	0.66	1.60E-05
1.5	0.87	2.40E-05
2	0.99	3.20E-05
2.5	1.11	4.00E-05
3	1.21	4.80E-05
4	1.36	6.40E-05
5	1.49	8.00E-05
10	1.86	1.60E-04
14	2.08	2.24E-04
30	2.49	4.80E-04
60	2.88	9.60E-04
120	3.28	1.92E-03

Match point values

$u^* = 0.1$, $W(u)^* = 1.0$

$\frac{t^*}{r^2} = 7E\text{-}5$, $s^* = 0.6$

$$T = \frac{Q}{4\pi}\frac{W(u)^*}{s^*} = \frac{1\,m^3/min}{4\pi}\frac{(1.0)}{(0.6)} = 0.13\ m^2/min$$

$$S = \frac{4T\left(\frac{t}{r^2}\right)^* u^*}{~~r^2~~} = \frac{4(0.13)(7\cdot10^{-5})(0.1)}{~~0.1~~} = ~~0.0004~~\ 4\cdot10^{-6}$$

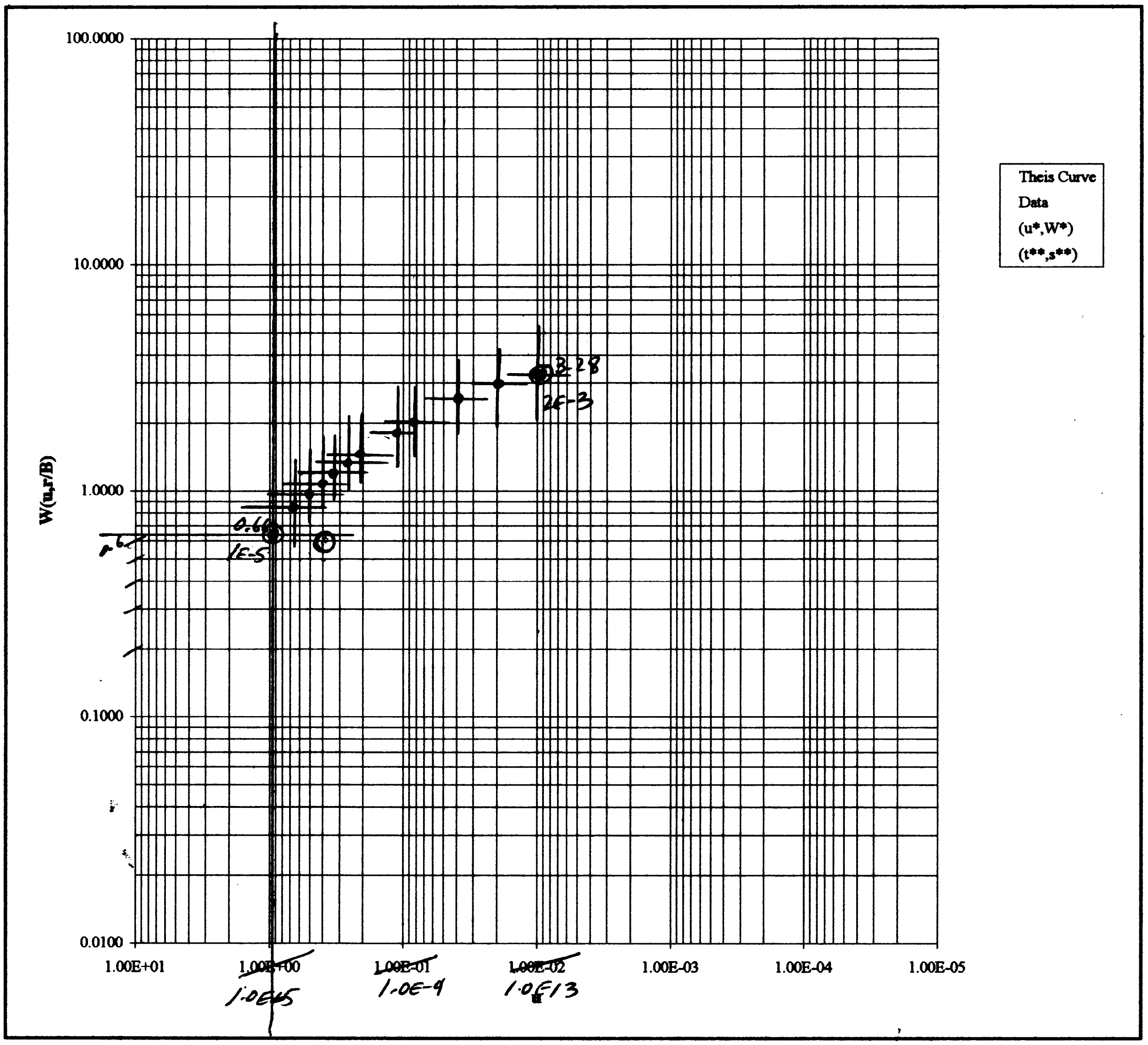
Recall

$$s^* = \frac{Q}{4\pi T}W(u)^* \qquad T = \frac{Q}{4\pi s^*}W(u^*)$$

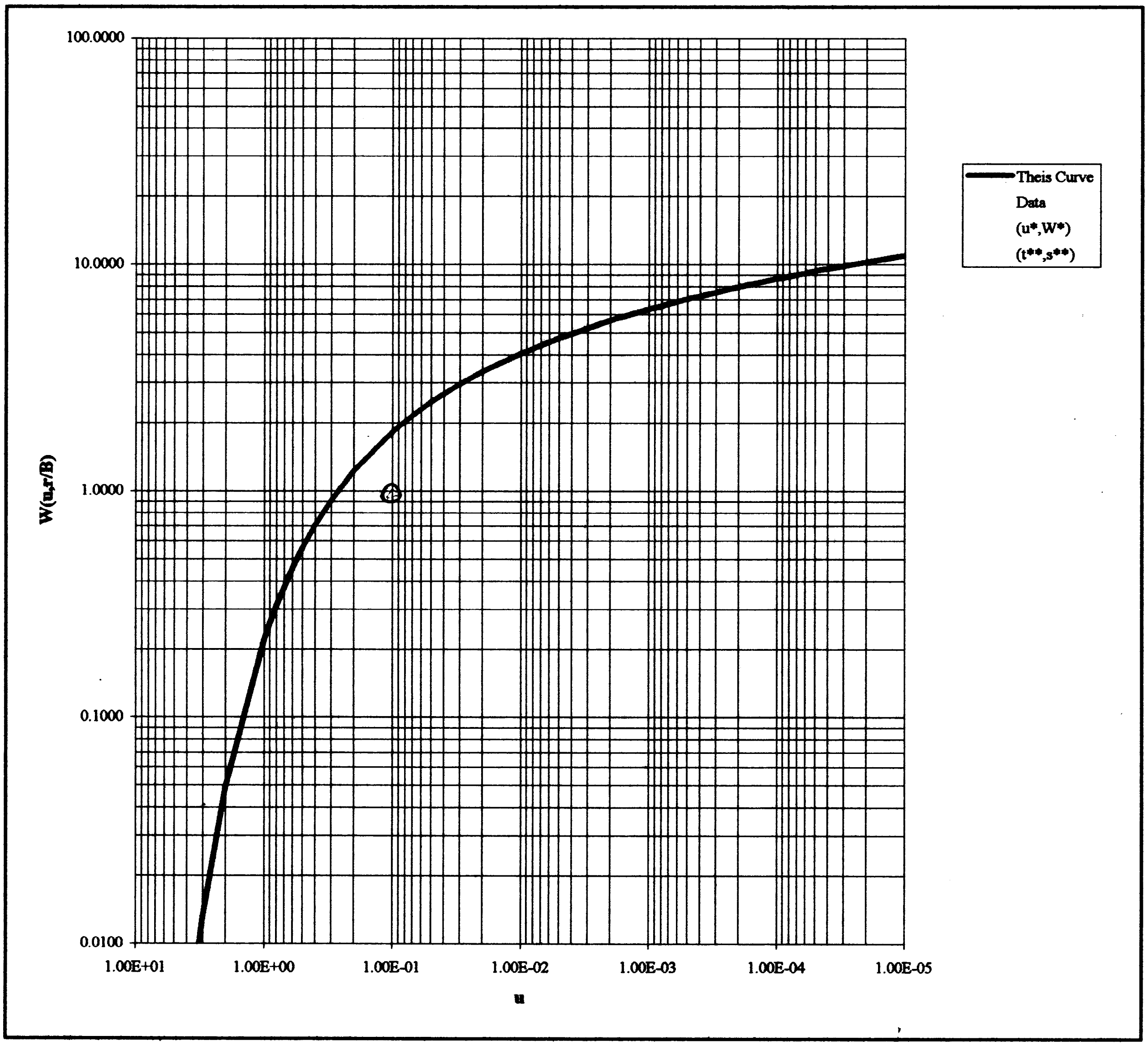
and $\Rightarrow$

$$u^* = \frac{Sr^2}{4Tt^*} \qquad \& \qquad S = u^*\frac{t^*}{r^2}4T$$

Model7 Chart 1



Model7 Chart 1



Solution

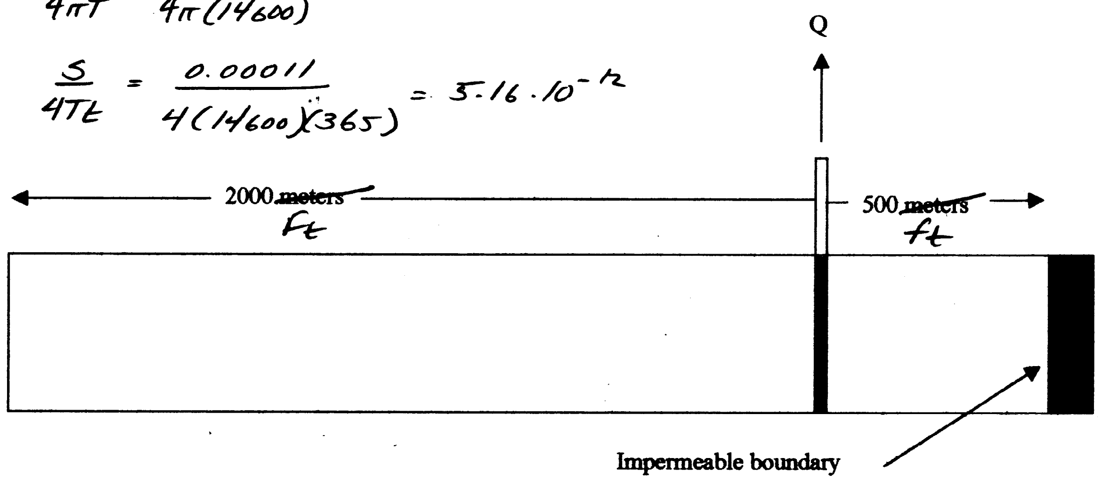
(3) Use the Cooper-Jacobs approximation to construct a sketch of the piezometric surface for the case shown below. Assume that T=14,600 ft^2/day and S=0.00011. Q= 192,000 ft^3/day and the predevelopment head is 35 feet. Plot the profile after 365 days of pumping.

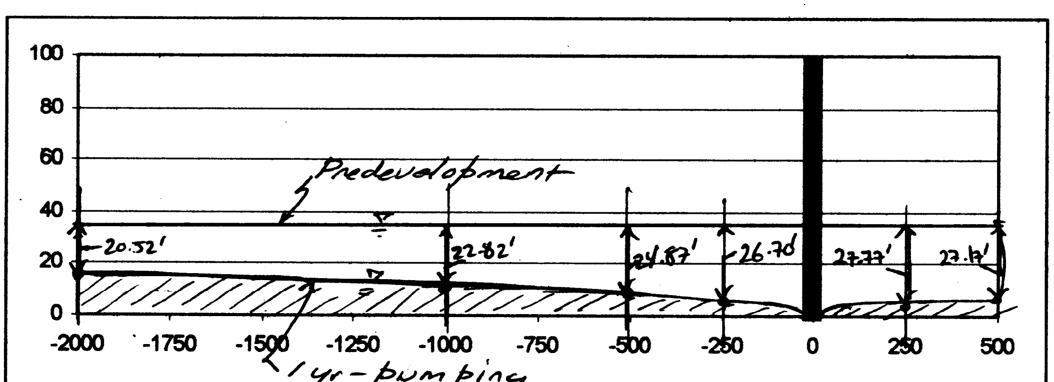
$$s(r,t)=\frac{Q}{4\pi T}[-0.57722-\ln(\frac{r^2S}{4Tt})]$$

Constants:

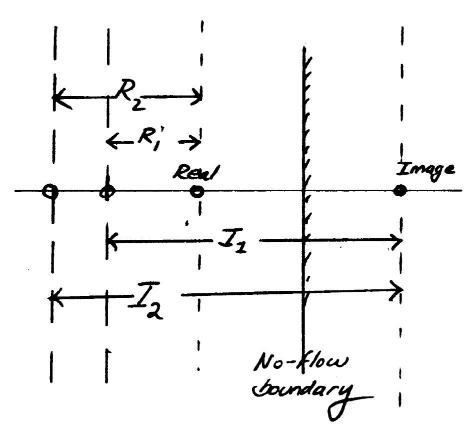
$$\frac{Q}{4\pi T}=\frac{192,000}{4\pi(14600)}=1.046$$

$$\frac{S}{4Tt}=\frac{0.00011}{4(14600)(365)}=5.16\cdot10^{-12}$$



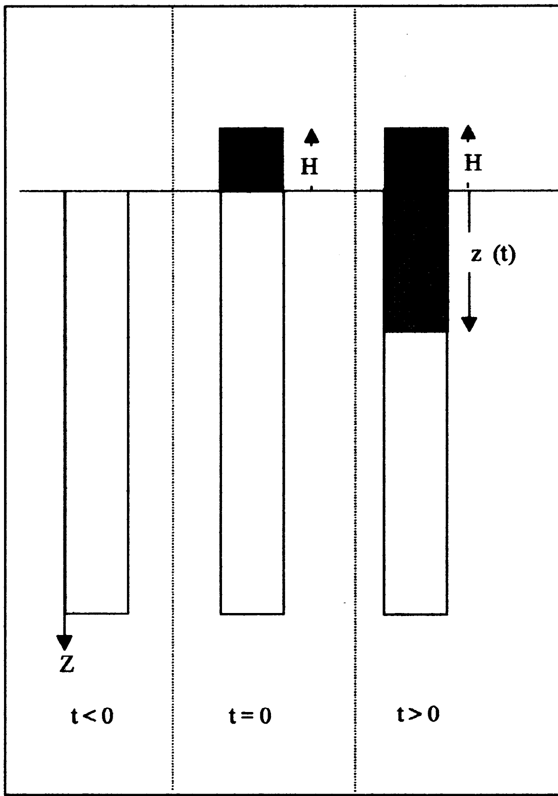


Real R	s(R,t)	Image I	s(I,t)	Real + Image	35' - R+I
-250	15.03	-1250	11.66	26.70	8.29
-500	13.58	-1500	11.28	24.87	10.12
-1000	12.13	-2000	10.68	22.82	12.17
-2000	10.68	-3000	9.83	20.52	14.47
250	15.03	750	12.73	27.27	7.73
500	13.58	500	13.58	27.17	7.82



Solution

(4) Consider the infiltration of water into a dry soil without any capillary effects as depicted in the three figures below. The hydraulic conductivity is K and the porosity is ω. Assume that the porous medium is completely saturated above the wetting front, z(t) and completely dry below.



a) What volume of water is contained in the soil at any given position of the wetting front in terms of the porosity and the front position? Assume that the area over which infiltration occurs is unity.

b) What is the total hydraulic head at the surface?

c) What is the water pressure at the wetting front?

d) What is the elevation at the wetting front?

e) What is the total hydraulic head at the wetting front?

f) What is the hydraulic gradient from the ground surface to the wetting front?

g) Express the wetting front velocity in terms of porosity, hydraulic conductivity, and hydraulic gradient. $\frac{dz}{dt} = ?$

h) After a very longtime has elapsed, what is the wetting front velocity?

a) $V_{water\ in\ soil} = \omega z(t) * \text{Area} = \omega z$

b) head at surface $= H$

c) p_w @ front $= 0$

d) elevation @ front $= -z(t)$

e) head at front $= \frac{p}{\gamma} + z_{elev.} = 0 - z(t)$

f) hydraulic gradient $= \frac{H - (-z(t))}{z(t)} = \frac{H+z}{z}$

g) $\frac{dz}{dt} = \frac{K}{\omega}\frac{H+z}{z}$

h) $t \to$ large $z \to$ large & $z \gg H$ $\Rightarrow \frac{dz}{dt} \approx \frac{K}{\omega}\frac{z}{z} = \frac{K}{\omega}$

5) Consider the non-homogeneous aquifer below. Sketch the flownet for the aquifer system. Be sure to indicate the streamlines and equipotentials (lines of constant head). Be sure that your equipotential spacing accurately reflects the non-homogeneous character of the aquifer.