Example on Superposition Principle (Transient State) (1/2)

Three wells are located at 75 m intervals along a straight line. Each well is 0.50 m in diameter. The coefficient of transmissibility is 2.63×10^{-3} m^2/s and the storage coefficient is 2.74×10^{-4}. Determine the drawdown at each well if each well is pumped at 4.42×10^{-2} m^3/s for 10 days.

The drawdown at each well will be the sum of the drawdown of each well pumping by itself plus the interference from each of the other two wells. Since each well is the same diameter and pumps at the same rate, we may compute one value of the term $Q/(4\pi T)$ and apply it to each well.

$$\frac{Q}{4\pi T} = \frac{4.42 \times 10^{-2}}{4(3.14)(2.63 \times 10^{-3})} = 1.34$$

In addition, since each well is identical, the individual drawdowns of the wells pumping by themselves will be equal. Thus we may compute one value of u and apply it to each well.

$$u = \frac{(0.25)^2(2.74 \times 10^{-4})}{4(2.63 \times 10^{-3})(10)(86{,}400)} = 1.88 \times 10^{-9}$$

Using $u = 1.9 \times 10^{-9}$ and referring to Table 2-7 we find $W(u) = 19.5042$. The drawdown of each individual well is then

$$s = (1.34)(19.5042) = 26.14 \text{ m}$$

Before we begin calculating interference, we should label the wells so that we can keep track of them. Let us call the two outside wells A and C and the inside well B. Let us now calculate interference of well A on well B, that is, the increase in drawdown at well B as a result of pumping well A. Because we have only pumped for 10 days, we must use the transient flow equations and calculate u at 75 m.

$$u_{75} = \frac{(75)^2(2.74 \times 10^{-4})}{4(2.63 \times 10^{-3})(10)(86{,}400)} = 1.70 \times 10^{-4}$$

From Table 2-7, $W(u) = 8.1027$. The interference of well A on B is then

$$s_{\text{A on B}} = (1.34)(8.1027) = 10.86 \text{ m}$$

In a similar fashion we calculate the interference of well A on well C.

$$u_{150} = (150)^2(3.0145 \times 10^{-8}) = 6.78 \times 10^{-4}$$

and $W(u) = 6.7169$

$$s_{\text{A on C}} = (1.34)(6.7169) = 9.00 \text{ m}$$

Since our well arrangement is symmetrical the following equalities may be used:

$$s_{\text{A on B}} = s_{\text{B on A}} = s_{\text{B on C}} = s_{\text{C on B}}$$

and

$$s_{\text{A on C}} = s_{\text{C on A}}$$

The total drawdown at each well is computed as follows:

$$s_B = s + s_{\text{B on A}} + s_{\text{C on A}}$$
$$s_A = 26.14 + 10.86 + 9.00 = 46.00 \text{ m}$$
$$s_B = s + s_{\text{A on B}} + s_{\text{C on B}}$$
$$s_B = 26.14 + 10.86 + 10.86 = 47.86 \text{ m}$$
$$s_C = s_A = 46.00 \text{ m}$$

Drawdowns are measured from the undisturbed piezometric surface. Note that if the wells are pumped at different rates, the symmetry would be destroyed and the value $Q/(4\pi T)$ would have to be calculated separately for each case. Likewise, if the distances were not symmetric then separate u values would be required. The results of these calculations have been plotted in Figure 2-31.

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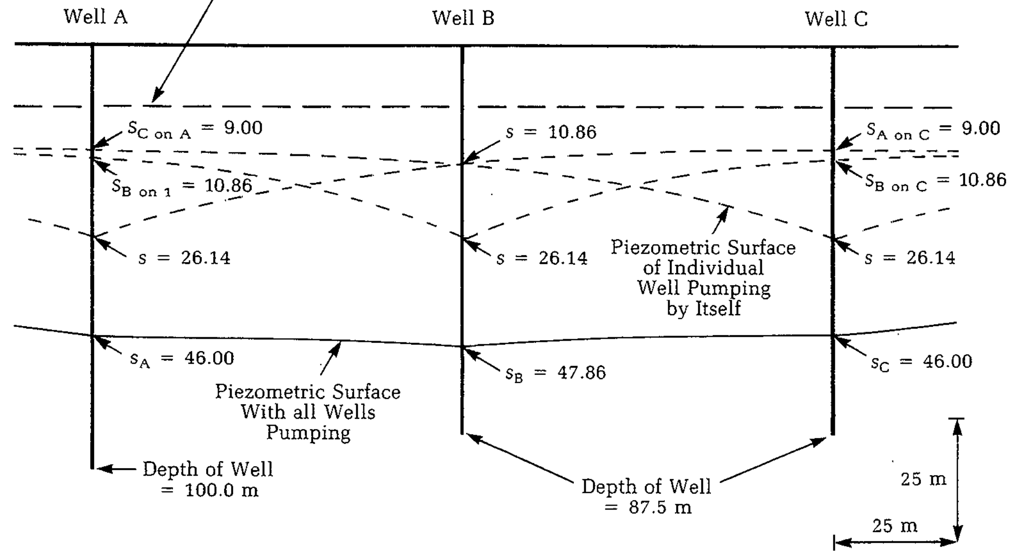

Figure 2-31 Interference drawdown of three wells

Source: M. L. Davis & D. A. Cornwell
Introduction to Environmental Engineering
PWS Engineering, 1985 pp. 84-86