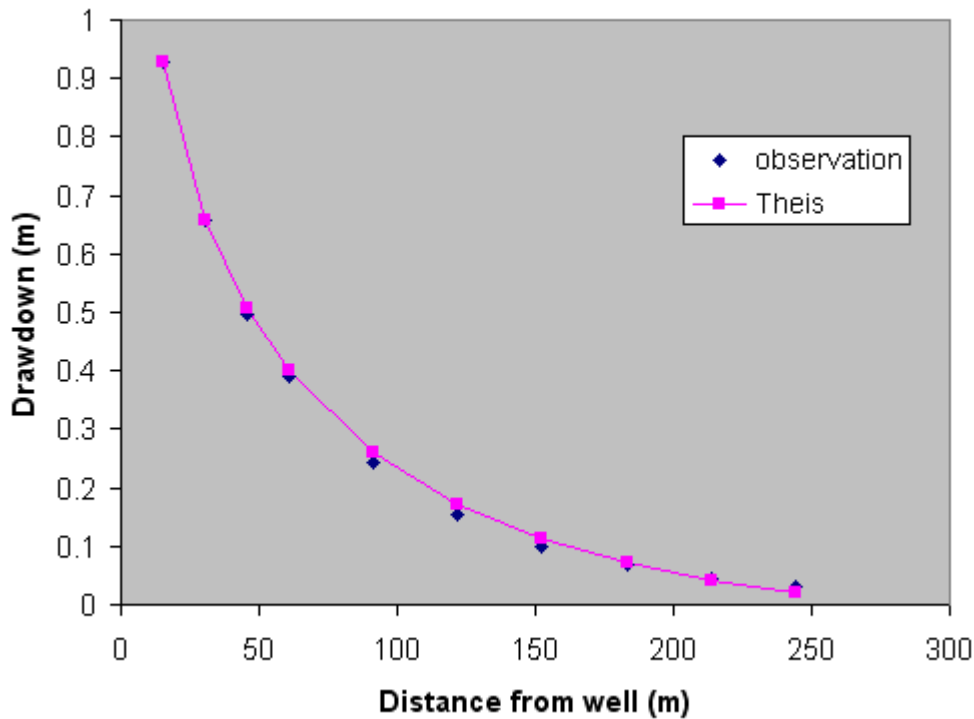


**1. Pumping Test Analysis, Computer Procedure**

By adjusting the transmissivity (T) and storativity (S) in the workbook Theis.xls on the spreadsheet Parameters, one may obtain the best fit to the observations with the prescribed pumping rate. The resulting fitted values are listed in the following table with the observations, using a transmissivity of  $1200 \text{ m}^3/\text{day}$  and a storativity of  $1.4 \times 10^{-4}$ .

	observation	Theis' solution	difference
distance (m)	s (m)	s' (m)	(m)
15.25	0.9272	9.27E-01	-2.72E-04
30.5	0.6588	6.59E-01	4.16E-04
45.75	0.49715	5.06E-01	8.49E-03
61	0.3904	4.00E-01	9.42E-03
91.5	0.244	2.59E-01	1.54E-02
122	0.15555	1.71E-01	1.52E-02
152.5	0.10065	1.12E-01	1.09E-02
183	0.0671	7.11E-02	3.96E-03
213.5	0.04575	4.27E-02	-3.01E-03
244	0.0305	2.21E-02	-8.41E-03

The values calculated by the Theis' solution is plotted against the observation as follows:



**2. Pumping Test Analysis, Graphical Procedure**

With the type curve and the drawdown-time charts, we may read from the chart the following numbers:

```
> t := 10; s := 1; Wu := 5.6; Ou := 43.0; u := 1/Ou;
```

```

t := 10
s := 1
Wu := 5.6
Ou := 43.0
u := 0.02325581395

```

Given a pumping rate of  $Q = 1.43 \times 10^3 \text{ m}^3/\text{day}$ , one may estimate the transmissivity using the

equation  $s = \frac{Q}{4 \pi T} W(u)$  as follows:

```

> Q := 1.43e3/(24*60); T := Q*Wu/(4*3.14159*s); T[m^2/day] :=
T*24*60;

```

```

Q := 0.9930555556
T := 0.4425395350
T
m^2
day := 637.2569304

```

with a unit of  $\text{m}^2/\text{min}$ . The storativity may thus be estimated, using the equation,  $u = \frac{r^2 S}{4 T t}$ , as follows:

```

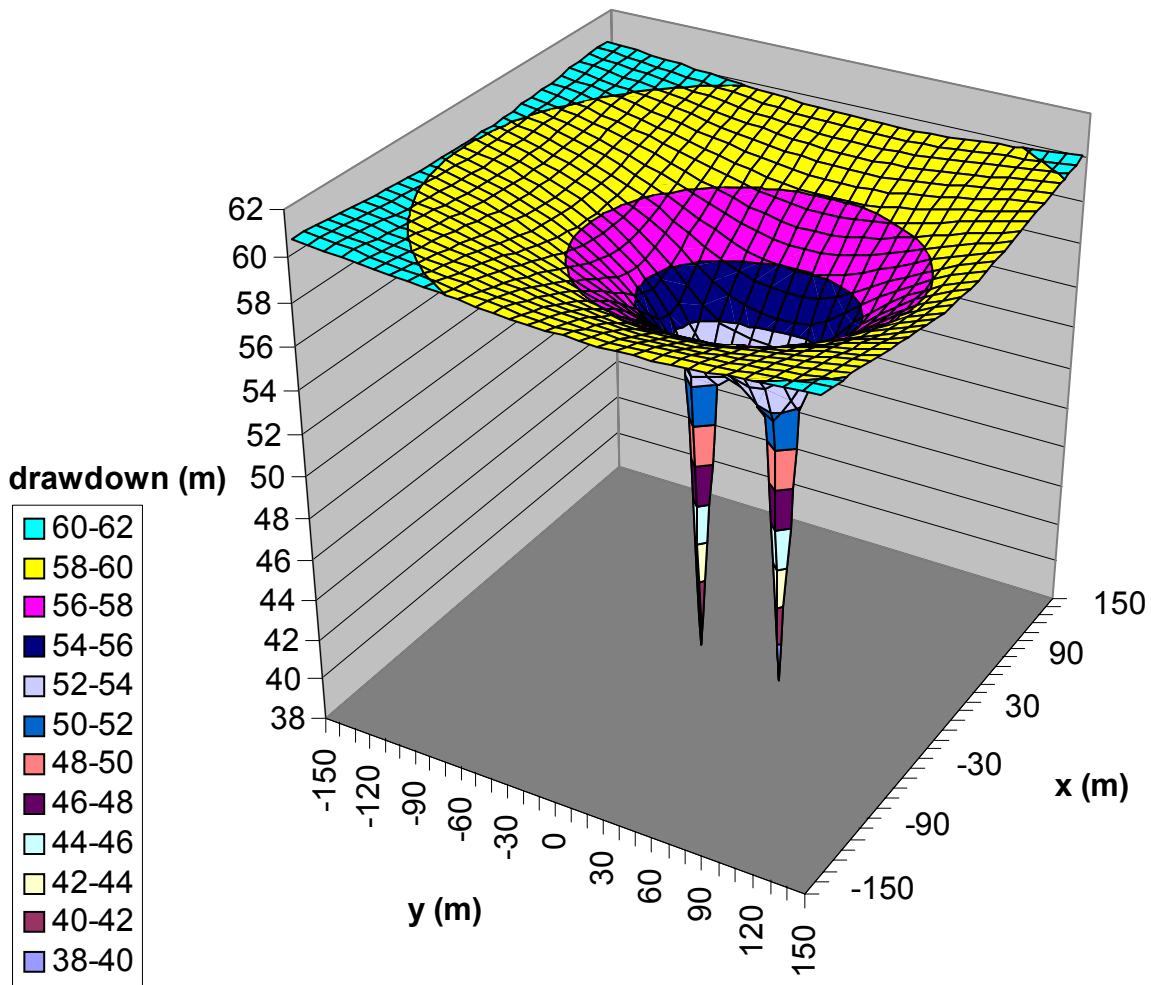
> r := 60; S := u*4*T*t/r^2;
r := 60
S := 0.0001143513010

```

### 3. Two pumping wells

Using the workbook *Theis.xls*, the following steps are taken to calculate the drawdowns as results of the two pumping wells:

- Calculate the equipotential surface as a result of the first well, pumping at  $1500 \text{ m}^3/\text{day}$ .
- Convert the values obtained above to drawdowns.
- Reset the pumping rate  $Q$  and repeat steps a and b above. Because the pumping rate at the second well turns out to be higher than the first one, the drawdown at 10 m from the second well is thus used as the criterion to determine the maximum allowable pumping rate at the second well. After a few trial and error, the maximum allowable pumping rate at the second is approximately at  $2000 \text{ m}^3/\text{day}$ . The following figure shows the equipotential surface with the two computations above juxtaposed. Note the slightly lower equipotential on the right half of the figure, where the second well is located.



#### 4. Asymptotic Behavior of a Well and Well Efficiency

Given the following measurements:

```
> s[1] := 0.6; r[1] := 97.5; s[2] := 1.1; r[2] := 33.5; Q := 5.43e3; t := 24/24;
```

$$s_1 := 0.6$$

$$r_1 := 97.5$$

$$s_2 := 1.1$$

$$r_2 := 33.5$$

$$Q := 5430.$$

$$t := 1$$

one may use the following equation to estimate the transmissivity of the aquifer:

$$s_1 - s_2 = \frac{2.3 Q}{2 \pi T} \log_{10} \left( \frac{r_2}{r_1} \right), \text{ or } T = \frac{2.3 Q}{2 \pi (s_1 - s_2)} \log_{10} \left( \frac{r_2}{r_1} \right)$$

```

> T := 2.3*Q/(2*3.14159*(s[1]-s[2]))*log10(r[2]/r[1]);
      T := 1844.414468

```

with a unit of  $cm^2/day$ . The storativity may be estimated through the following equation:

$$s_1 = \frac{2.3 Q}{4 \pi T} \log_{10} \left( \frac{2.25 T t}{r_1^2 S} \right), \text{ or } S = 10^{\left( -\frac{s_1 4 \pi T}{2.3 Q} \right) \frac{2.25 T t}{r_1^2}}$$

```

> S := 2.25*T*t/r[1]^2*10.0^(-s[1]*4*3.14159*T/(2.3*Q));
      S := 0.03361462463

```

Using the workbook Theis.xls, the well function  $W(u)$  at  $r = 0.3$  m is calculated at 14.13. The theoretical drawdown, in the unit of m, at the pumping well is thus:

```

> Wu := 14.13; s[0.3] := Q/(4*3.14159*T)*Wu;
      Wu := 14.13
      s_0.3 := 3.310350459

```

Given the well efficiency of 60% or 0.6, the total drawdown at the wellbore is thus:

```

> s[total] := s[0.3]/0.6;
      s_total := 5.517250766

```

Well loss and the well loss constant may thus be determined as follows:

```

> s[w] := s[total] - s[0.3]; C := s[w]/Q^1.98;
      s_w := 2.206900307
      C := 0.8889535171 10^-7

```

If the pumping rate is doubled, the theoretical drawdown will be doubled as well. However, the well loss is almost quadrupled. The well efficiency may thus be determined as follows:

```

> s[w] := C*(2*Q)^1.98; s[total] := s[w] + 2*s[0.3]; E[p] :=
  2*s[0.3]/s[total];
      s_w := 8.706069033
      s_total := 15.32676995
      E_p := 0.4319697458

```

The well efficiency is in fact reduced to about 43% from 60%.