Pumping Near An Impervious Boundary

The drawdown due to pumping will be greater near the boundary when a confined aquifer is bounded on one side by a straight-line impermeable boundary (Figure 1.).

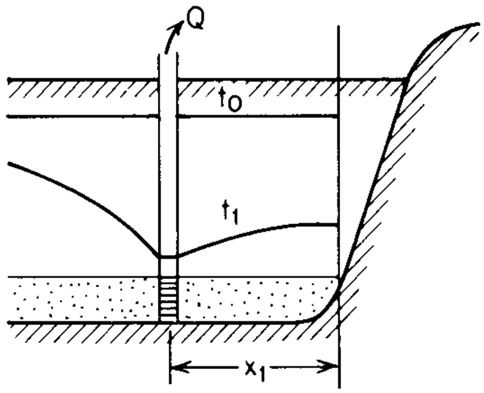

Figure 1. Drawdown near an impervious boundary (Freeze and Cherry 1979)

Analytical Solution

The analytical solution for drawdown near an impervious boundary as a function of time and space is given by (Ferris et al., 1962)

$$h_0 - h(x, y, t) = \frac{Q}{4\pi T}[W(u_r) + W(u_i)] \qquad (1)$$

Where

$$u_r = \frac{[(x-a)^2 + y^2]S}{4Tt} \qquad (2)$$

$$u_i = \frac{[(x+a)^2 + y^2]S}{4Tt} \qquad (3)$$

$$W(u) = \int_u^\infty \frac{e^{-u}du}{u} \qquad (4)$$

and

$x, y =$ rectilinear coordinates relative to the pumping well, [m]
$a =$ is the distance of pumping well from constant head boundary, [m]
$S =$ is the aquifer storage coefficient, [-]
$T =$ is the aquifer transmissivity, [L^2/T]
$t =$ is the time, [T]
$h_0 =$ is the initial head in the boundaries before pumping,[L]
$Q =$ is the constant flow rate abstracted from the well, [L^3/T]
W(u) = is the Well function

IGW Numerical Solution

IGW is applied to solve a flow problem for the following situation (figure 2):

Given Physical parameters:

$Q = 1000$ m^3/day
$h_0 = 20$ m
$S = 0.0002$
$t = 0.00175$ day = 151.2 sec
$T = 1000$ m^2/day = $K_x \cdot$ Thickness = 50 m/day $\cdot$ 20 m
$a = 50$ m

Given Numerical Parameters:

$\Delta x = 5.5$ m
$\Delta y = 5.5$ m
$\Delta t = 1.0368$ sec

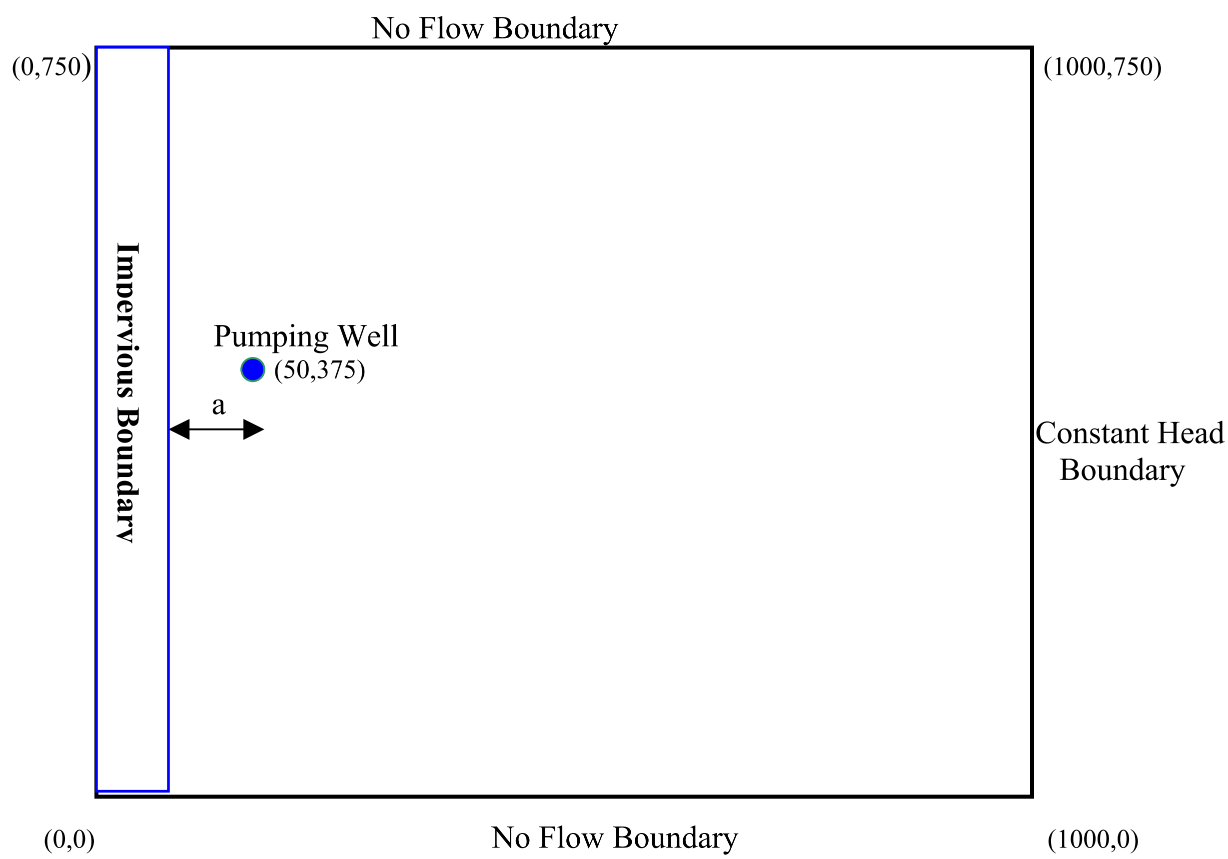

Fig 2. Plan view of IGW model set up for comparison to the Analytical Solution

Analytical Solution versus IGW

The IGW solution is compared with the exact solution and presented in Figures 3 and 4. .

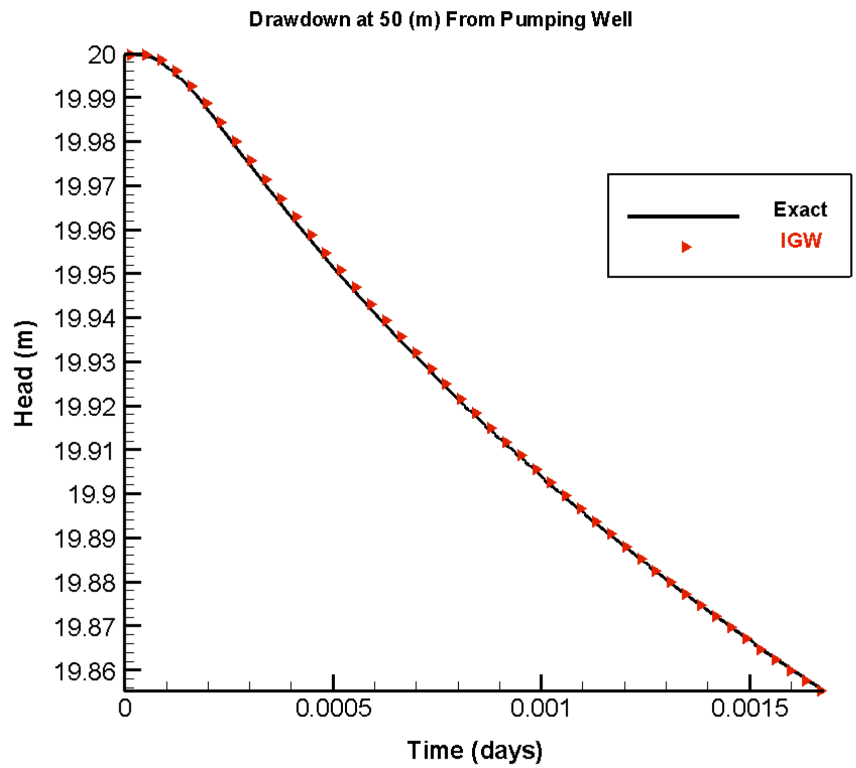

Fig 3. Transient Comparison between the analytical solution and IGW (monitoring well at 50 meters from the pumping well).

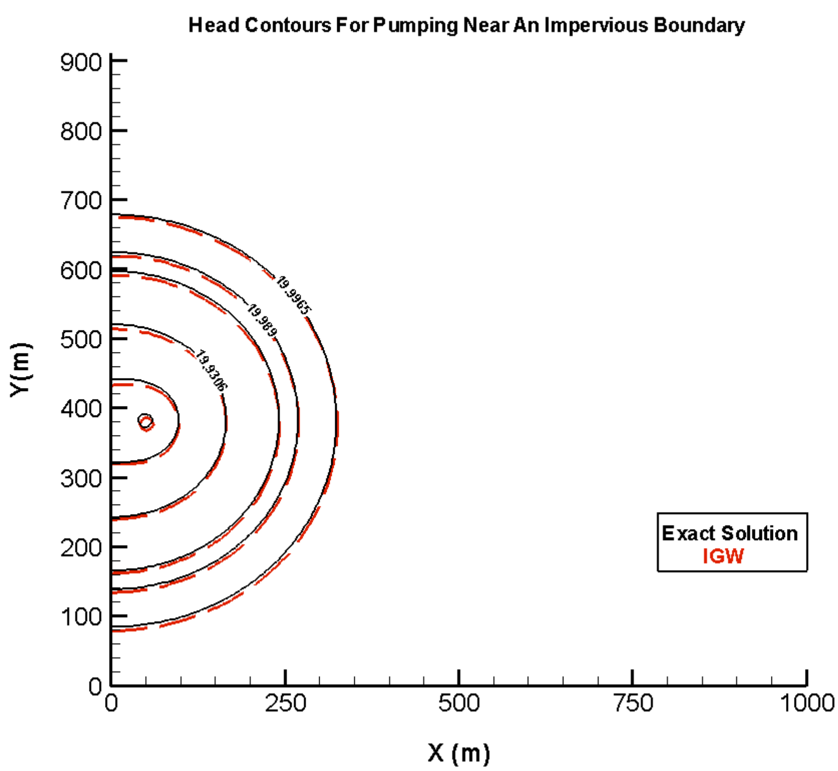

Fig 4. Comparison of the analytical solution with IGW at 151.37 seconds

The numerical solution is graphically indistinguishable from the exact until the drawdown influence begin to reach the boundaries.

The cone of depression is also plotted in 3D in Figure 5.

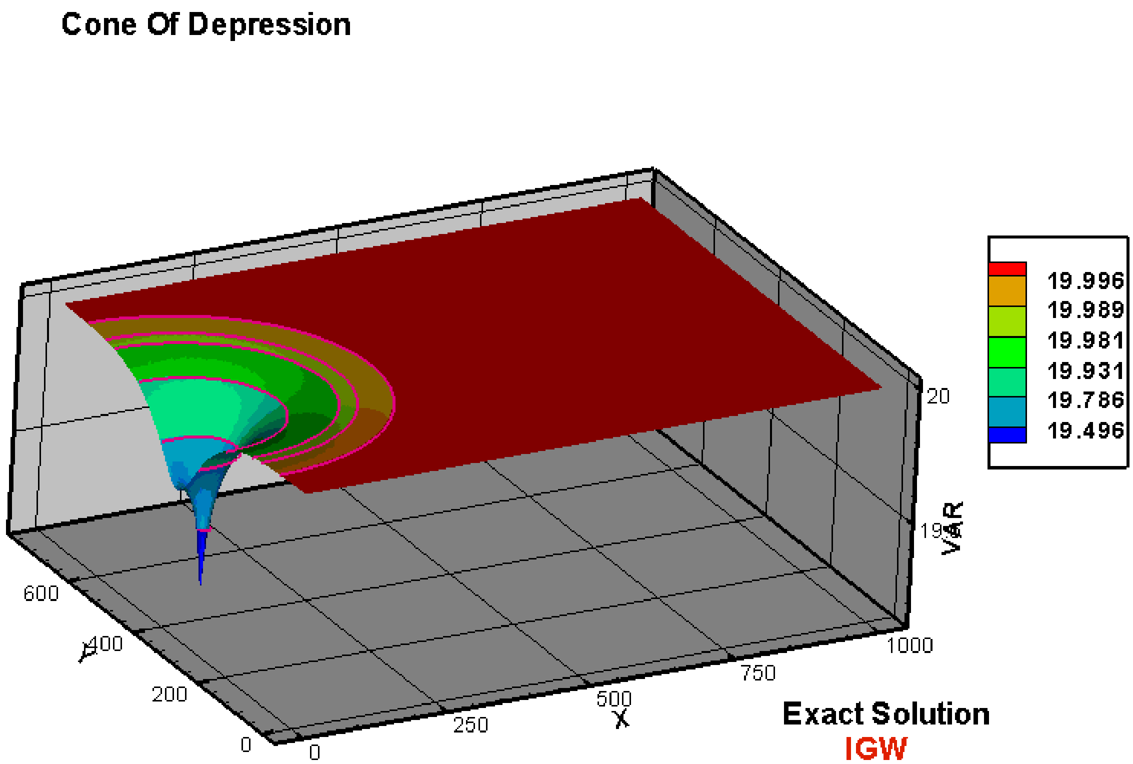

Figure 5. The Cone of Depression in Pumping Near An Impervious Boundary