beta	erf(beta)
1.00E-07	1.13E-07
1.00E-06	1.13E-06
1.00E-05	1.13E-05
1.00E-04	0.000113
1.00E-03	0.001128
1.00E-02	0.011283
0.1	0.112463
1	0.842701
2	0.995322
3	0.999978
4	1
5	1
6	1
10	1

Capture Zone in an **Unconfined Aquifer:**

Maximum Width:

$$y_{max} = \frac{\pm QL}{K\left(h_1^2 - h_2^2\right)}$$

L = distance between pre-pumping up&down gradient heads h_1 and h_2

substitute smaller y values to find x location of various widths

$$x = \frac{-y}{\tan\left(\frac{\pi K\left(h_1^2 - h_2^2\right)y}{QL}\right)}$$

NOTE: tangent is for angle in radians

down gradient distance to stagnation point

$$x_p = \frac{-QL}{\pi K\left(h_1^2 - h_2^2\right)}$$

Confined

$$y_{max} = \frac{\pm Q}{2Kbi}$$

$$x = \frac{-y}{\tan\left(\frac{2\pi Kbiy}{Q}\right)}$$

$$x_p = \frac{-Q}{2\pi Kbi}$$

Unconfined

$$y_{max} = \frac{\pm QL}{K\left(h_1^2 - h_2^2\right)}$$

$$x = \frac{-y}{\tan\left(\frac{\pi K\left(h_1^2 - h_2^2\right)y}{QL}\right)}$$

$$x_p = \frac{-QL}{\pi K\left(h_1^2 - h_2^2\right)}$$

Let's explore this

K = 0.01 m/sec effective porosity = 0.26

b = 20 m

i = 0.001

plume ~300m across ~1200m long

What rate do we need to pump to collect this plume?

Confined

$$y_{max} = \frac{\pm Q}{2Kbi}$$

$$x_p = \frac{-Q}{2\pi Kbi}$$

$$x = \frac{-y}{\tan\left(\frac{2\pi Kbiy}{Q}\right)}$$

Unconfined

$$y_{max} = \frac{\pm QL}{K\left(h_1^2 - h_2^2\right)}$$

$$x_p = \frac{-QL}{\pi K\left(h_1^2 - h_2^2\right)}$$

$$x = \frac{-y}{\tan\left(\frac{\pi K\left(h_1^2 - h_2^2\right)y}{QL}\right)}$$

Let's explore this

K = 0.01 m/sec effective porosity = 0.26

b = 20 m

i = 0.001

plume ~300m across ~1200m long

What rate do we need to pump to collect this plume?

$Q = y_{max}\ 2\ K\ b\ i = 150m\ 2\ 0.01\frac{m}{s}\ 20m\ 0.001 = 0.06\ \frac{m^3}{s}\ \frac{264Gal}{m^3}\ \frac{60s}{min} = 950GPM$

$Xp = \frac{-0.06\ m^3/s}{2\quad 3.14\quad 0.01\frac{m}{s}\quad 20m\quad 0.001} = -47.75m$

For unconfined conditions, same result, if $2bi = (h_1^2-h_2^2)/L$

$Q = ymax\ K\ \frac{(h1^2-h2^2)}{L} = 150m\ 0.01\frac{m}{s}\ \frac{(21*21-19*19)}{2000} = 0.06\ \frac{m^3}{s}\ \frac{264Gal}{m^3}\ \frac{60s}{min} = 950GPM$

$Xp = \frac{-0.06\ m^3/s\ \ 2000m}{3.14\quad 0.01\frac{m}{s}\ (21*21-19*19)} = -47.75m$

Confined

$$y_{max} = \frac{\pm Q}{2Kbi} \qquad x_p = \frac{-Q}{2\pi Kbi} \qquad x = \frac{-y}{\tan\left(\frac{2\pi Kbiy}{Q}\right)}$$

Unconfined

$$y_{max} = \frac{\pm QL}{K\left(h_1^2 - h_2^2\right)} \qquad x_p = \frac{-QL}{\pi K\left(h_1^2 - h_2^2\right)} \qquad x = \frac{-y}{\tan\left(\frac{\pi K\left(h_1^2 - h_2^2\right)y}{QL}\right)}$$

K = 0.01 m/sec   effective porosity = 0.26
b = 20 m
i = 0.001
plume ~300m across ~1200m long

Where should we put the well? Let's just consider the unconfined case:
We will need a higher Q to over-capture for safety, say +20% width=360m

$$x = \frac{-y}{\tan\left(\frac{\pi K\left(h_1^2 - h_2^2\right)y}{QL}\right)}$$

$$X = \frac{-150\text{ m}}{\tan\left(\frac{3.14\ 0.01\text{m/s}\ (21\text{m}*21\text{m}-19\text{m}*19\text{m})150\text{m}}{0.072\text{ m}^3\text{/s}\quad 2000\text{m}}\right)} = 260\text{m} \quad \text{for } Y = 150\text{m}$$

If you need to work in degrees, recall there are 2 π radians in a 360° circle, so degrees = radians*180/π

for Y = 175m	**X = 2000m**
for Y = 160m	**X = 440m**
for Y = 100m	**X = 18m**
for Y = 50m	**X = -42m**
for Y = 25m	**X = -53m**
for Y = 0.1m	**X = -57m**

Draw that out
For this increased Q Xp=-57

Confined

$$y_{max} = \frac{\pm Q}{2Kbi} \qquad x_p = \frac{-Q}{2\pi Kbi}$$

Unconfined

$$y_{max} = \frac{\pm QL}{K\left(h_1^2 - h_2^2\right)} \qquad x_p = \frac{-QL}{\pi K\left(h_1^2 - h_2^2\right)}$$

Let's explore this
K = 0.01 m/sec   effective porosity = 0.26
b = 20 m
i = 0.001
plume ~300m across ~1200m long

volume of water currently contaminated is the minimum volume to be collected
minimum volume to be collected = 300m * 1200m * 20m * 0.26 = $1.9\text{x}10^6$ m^3
Time to pump that volume = Volume / Q
Time to pump that volume at Q = 0.072 $\frac{\text{m}^3}{\text{s}}$ = $3.1\text{x}10^7$ sec ~ 301 days

Can we support that pumping rate? What will the drawdown be?
Removal of one volume will not capture all, estimate drawdown near well at 2 years

$$s = \frac{Q}{4\pi T} W((r^2S)/(4Tt)) = \frac{0.072\text{m}^3\text{/s}}{4\ 3.14\ 0.2\text{m}^2\text{/s}} W[((0.1\text{m})^2\ 0.26) / (4\ 0.2\text{m}^2\text{/s}\ 365\text{d}\ 2\text{y}\ 86400\text{s})] =$$

$$= 0.029\text{m } W(5.15\text{x}10^{-11}) = 0.029\text{m } 23.1 = 0.67\text{m}$$

(in the confined case W(u) ~ 33.2 s ~ 1m)

What could we do if this drawdown were too large?