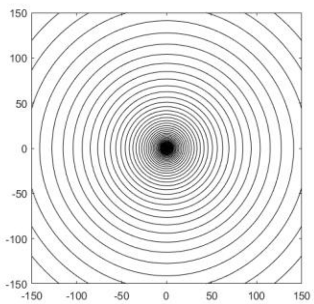
Case 1, no uniform flow

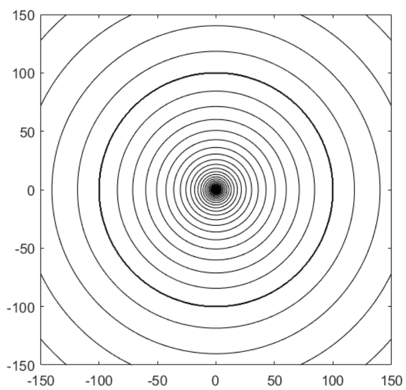
	Q_max, m/d
K = k1	1.27 * 10^3
K1 = 10* k	5.31* 10^4
K= 10* k1	72

Potential contours:

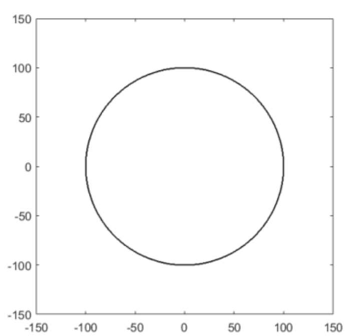
K=k1



K1>k



k>k1



2.

For k1>>k

	Q max, m/d
Zw=0	5.31* 10^4
Zw=50	4.84 * 10^3
Zw=75	4.14 * 10^4

For k1 << k

	Q max, m/d
Zw=0	72
Zw=50	73
Zw=75	75

The maximum discharge decreases slightly as the well is placed further from the center of the inhomogeity.

3.

For k1>k

Radius of gravel pack, m	Qmax, m/d
.5	2.19 * 10^4
1	2.37 * 10^4
1.5	2.49 * 10^4
3	2.73 * 10^4
5	2.94 * 10^4

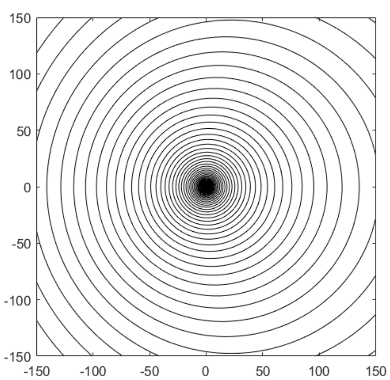
The maximum discharge of the well increases somewhat as the size of the gravel pack around it increases.

Case 2, uniform flow left to right

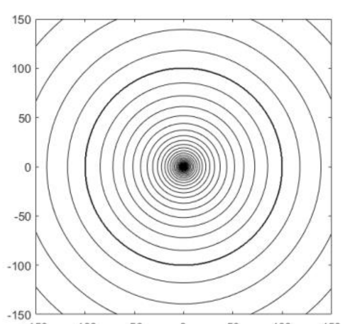
	Q_max, m/d
K = k1	1.27 * 10^3
K1 = 10* k	5.79 * 10^4
K= 10* k1	6.79

Head contours:

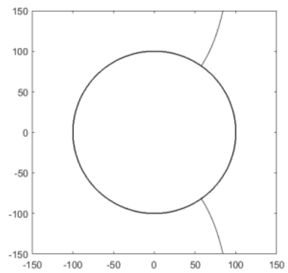
K=k1



K1>k



k>k1



2.

For k1>>k

	Q max, m/d
Zw=0	5.79 * 10^4
Zw=50	5.25 * 10^4
Zw=75	4.48 * 10^4

For k1 << k

	Q max, m/d
Zw=0	6.79
Zw=50	6.19
Zw=75	6.0

3.

For k1>k

Radius of gravel pack, m	Qmax, m/d
.5	2.39 * 10^4
1	2.59 * 10^4
1.5	2.72 * 10^4
3	2.92* 10^4
5	3.212 * 10^4

Code:

Main.m:

```
%case 1: no uniform flow

    %Parameters
    k = 10;
    k1= 10; %m/d
    zw =0;
    rw = 0.05;
    R = 100; %m
    Rinf = 10*R;
    Qx0 = 0; %No uniform flow
    PhiInf = .5 * k * 20*20;
    z = zw+rw;
    %calculate maximum discharge
    Q_max = ((Qx0*(z))*(2*k1/(k1+k))+ (-Qx0* (Rinf -(k1-
k)*R*R/((k1+k)*Rinf)))- (k1/k)*real(PhiInf))/
real((1/(2*pi))*log(z-zw)+ ((k1-k)/(k1+k))*(1/(2*pi)) *
log((conj(zw)*(z)/-R) + R)  - (2*k/(k1+k))* (1/(2*pi))*log(Rinf
- zw) -((k1-k)/(k1+k))*(1/(2*pi))*log(Rinf/R));
    %calculate constant
    c = real(PhiInf +  (2*k/(k1+k))* (Q/(2*pi))*log(Rinf - zw)
+((k1-k)/(k1+k))*(Q/(2*pi))*log(Rinf/R)+ Qx0* (Rinf -(k1-
k)*R*R/((k1+k)*Rinf)));


    %Calculate Q max if there was no inhomogeneity
    Q_noInhomogeneity = -PhiInf  /real(   (1/(2*pi))*(log(zw+rw-
zw) -log(Rinf - zw))  );
```

```
    %Contour the real potential
    ContourMe_R_int(-150,150,500, -150,150,500,
@(z)real(Omega_total(Qx0, z, k1,k,R, c,Q_max,zw)),60);




%Case 2, uniform flow


    %Parameters
    k = 10;
    k1= 100; %m/d
    zw =0;
    rw = 0.05;
    R = 5; %m
    Rinf = -10*R;
    Qx0= .5*k*(21*21 - 19*19)/(2 * abs(Rinf)) ;%with uniform
flow
    PhiInf = .5 * k * 21*21;
    z = zw+rw;

    Q_max = ((Qx0*(z))*(2*k1/(k1+k))+ (-Qx0* (Rinf -(k1-
k)*R*R/((k1+k)*Rinf)))- (k1/k)*real(PhiInf))/
real((1/(2*pi))*log(z-zw)+ ((k1-k)/(k1+k))*(1/(2*pi)) *
log((conj(zw)*(z)/-R) + R)  - (2*k/(k1+k))* (1/(2*pi))*log(Rinf
- zw) -((k1-k)/(k1+k))*(1/(2*pi))*log(Rinf/R))

    c = real(PhiInf +  (2*k/(k1+k))* (Q/(2*pi))*log(Rinf - zw)
+((k1-k)/(k1+k))*(Q/(2*pi))*log(Rinf/R)+ Qx0* (Rinf -(k1-
k)*R*R/((k1+k)*Rinf)));




    ContourMe_R_int(-150,150,500, -150,150,500,
@(z)real(Omega_total(Qx0, z, k1,k,R, c,Q_max,zw)),60);
```

```
function [ Omega ] = Omega_total(Qx0, z, k1,k,R,C,Q,zw )
%UNTITLED4 Summary of this function goes here
%   Detailed explanation goes here

rsq=(z)*conj(z);
if rsq>R^2
    Omega = Omega_outside(Qx0, z, k1,k,R, C,Q,zw);
else
    Omega = Omega_inside(Qx0, z, k1,k,R, C,Q,zw);

end
```

```
function [ Omega ] = Omega_outside(Qx0, z, k1,k,R,C,Q ,zw)
%UNTITLED Summary of this function goes here
%   Detailed explanation goes here
Omega = -Qx0*(z-((k1-k)/(k1 +k))*(R*R)/z) +
(2*k/(k1+k))*(Q/(2*pi))*log(z-zw) + ((k1-
k)/(k1+k))*(Q/(2*pi))*log(z/R) + real(C);
end
```

```
function [ Omega ] = Omega_inside(Qx0, z, k1,k,R,C,Q,zw )
%UNTITLED2 Summary of this function goes here
%   Detailed explanation goes here

Omega =( -2*k1/(k1 + k))*Qx0*z +(Q/(2*pi))*log(z-zw)+ ((k1-
k)/(k1+k))*(Q/(2*pi)) * log(R - z* conj(zw)/R)
+(k1/k)*real(C);
end
```

ContourMe_R_int.m

```
function [Grid] = ContourMe_R_int(xfrom, xto, Nx, yfrom, yto,
Ny, func,nint)
%================================================================
===========
% ContourMe(xfrom, xto, Nx, yfrom, yto, Ny, func)
(01.23.09)
%
%   Contour the real part of the specified complex function.
%
```

```
% Arguments:
%
%   xfrom   starting x-value for the domain
%   xto     ending x-value for the domain
%   Nx      number of grid columns
%
%   yfrom   starting y-value for the domain
%   yto     ending y-value for the domain
%   Ny      number of grid rows
%
%   func    function to contour;  must take one complex
argument.
%
% Returns:
%
%   Grid    Ny x Nx matrix of values of func at the rid nodes.
%
% Example Usage:
%
%   G = ContourMe(1,2,11,1,2,11,@(z)Omega(1,-1,z));
%===============================================================
===========

Grid = zeros(Ny,Nx);

X = linspace(xfrom, xto, Nx);
Y = linspace(yfrom, yto, Ny);

for row = 1:Ny
    for col = 1:Nx
        Grid(row,col) = func( complex( X(col), Y(row) ) );
    end
end
contour(X, Y, real(Grid),nint, 'k');
axis equal
```