IEG Technical Briefing Note No.22

Calculating the Radius of Influence of a IEG - Groundwater Circulation Well (GCW)

The capture zone and the sphere of influence of the circulation cell can be calculated for a IEG-GCW system to be installed at a site using equations and graphical solutions developed by Dr. Bruno Herrling (1992) and Dr. Jürgen Stamm (1997) University of Karlsruhe, Germany.

Based on the aquifer parameters the upstream and downstream stagnation points, the capture zones at the top (Bt) and bottom (Bb, well spacing and circulation times can be calculated.

Development of recirculating flow is strongly influenced by vertical hydraulic conductivity (Kv) and by anisotropy (ratio of Kv to Kh). In coarse sands and gravel with a low anisotropy, high recirculation rate can be achieved. Fine sands decrease the recirculation rate but increased the width of the capture zone.

Based on a horizontal hydraulic conductivity Kh (m/sec) 5,0 x 10-4 and the following parameters an exemplary calculation for the GCW parameters is shown below:

Parameters	Data
■ Thickness of impacted upper sand aquifer (m)	10,00
■ BTEX max. Concentration in groundwater (mg/l)	57
■ MTBE max. Concentration in groundwater (mg/l)	23
■ Discharge through GCW-Q (m^3/h); Estimated base on site hydrogeology	4,00
■ Porosity %	0,25
■ Hydraulic Gradient -I (m/m) (pumping well on or off)	0,002
■ Horizontal hydraulic conductivity -Kh (m/sec)	3,0x10-4
■ Vertical hydraulic conductivity Kv (m/sec), Assumed Kh/Kv = 10	3,0x10-5
■ Groundwater velocity - Va (m/d)	0,36
■ Average Depth to Groundwater below surface	20

The flow field around a GCW is composed of capture zone, release zone and circulation cell. The stagnation point, the capture zone widths and the circulation time are presented in the table below:

GCW Type	GCW Reverse Flow
■ Recirculation Flow Q (m^3/h)	4
■ Stagnation Point S (m)	18
■ Capture Zone top width (Bt; m)	58
■ Capture Zone bottom width (Bb; m)	12
■ Circulation time at 18m distance (days)	58

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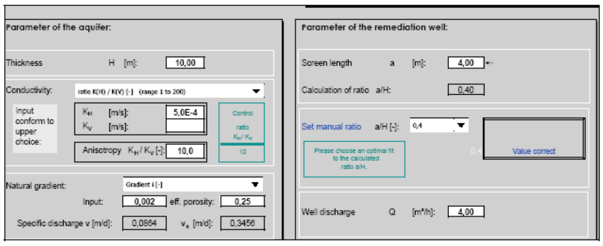
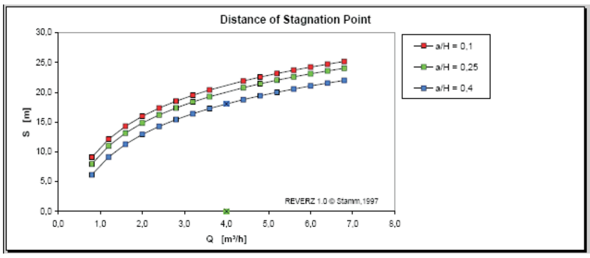
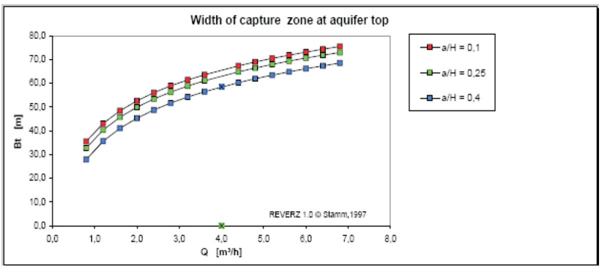
The distances of the up-gradient and down-gradient stagnation point is S = 18 m. When operating in a reverse flow mode (water entering the GCW well from the upper screen interval and exiting at the bottom), the width of the bottom of the capture zone (Bb) is about 12 m and the width of the top of the capture zone (Bt) is 58 m. Circulation time is defined as the amount of time required for a unit volume of water to move from the upper, outflow zone of the well through the zone of influence of the GCW system, and back into the lower, inflow zone of the well. This calculation of circulation time does not take into account the varying groundwater velocity during a given molecule's circulation path, because accelerated flow takes place closer to the well. Within 58 days of operation, one complete flush of one pore volume will occur at the stagnation point. The circulation times decrease with the distance to the GCW. The circulation time at the distance of the stagnation point is about 58 days.

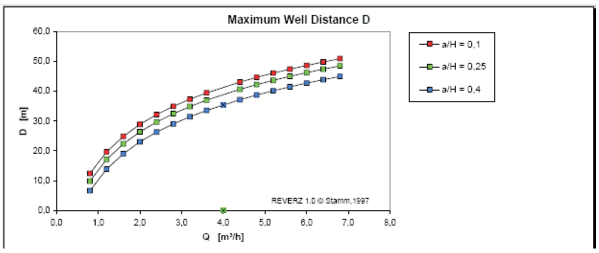
In the following the original print-outs for the distance of stagnation point, Width of capture zone at the top of the aquifer, width of capture zone at the bottom of the aquifer, maximum well distance d and curve of circulation time (Stamm, 1997) are displayed:

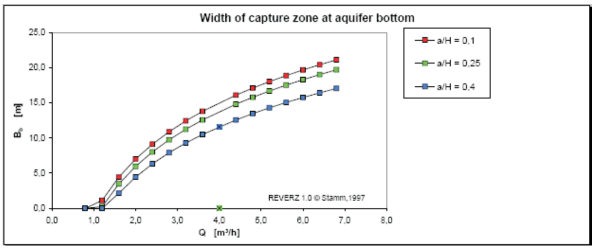
GCW Dimensioning with the Hydraulic Conductivity of KH 5x10E- 04 (m/s)

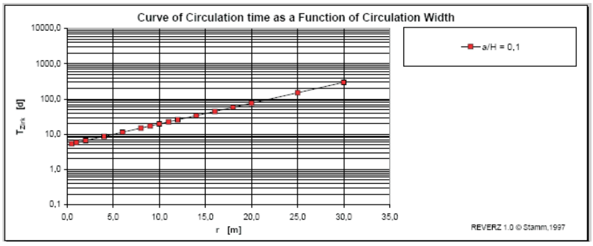












The subsequent conclusions can be made from the site-specific calculations:

The size of the contaminated area of the gas station requires two GCWs with a well distance of 36 m. For an efficient remediation one pore volume will be flushed in a distance of 18 m from the GCW in about 58 days. The correct positioning of the GCWs is important to prevent the release of untreated contaminated water.

For two wells of the same flow directions a stronger up-ward vertical flow between the wells will be induced which can particulary improve the treatment of LNAPL contaminated aquifer zones.

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