

6.2 Basic Flow Problems

6.2.1 Determination of Catchment Areas

Folder: \pm5\examples\basic\basic1\

Overview of the Problem

Fig. 6.14 shows a part of an unconfined aquifer. The extent of the aquifer to the North and South is assumed to be unlimited. The aquifer is homogeneous and isotropic with a measured horizontal hydraulic conductivity of 0.0005 m/s and an effective porosity of 0.1. The elevations of the aquifer top and bottom are 15 m and 0 m, respectively. The aquifer is bounded by a no-flow zone to the west. To the east exists a river, which is in direct hydraulic connection with the aquifer and can be treated as fixed-head boundary. The river width is 50 m and stage is 10m. The mean groundwater recharge rate is 8×10^{-9} m/s. A pumping well is located at a distance of 1000 m from the river.

Your task is to calculate the catchment area of the well and the 365-days-capture zone under steady-state flow conditions.

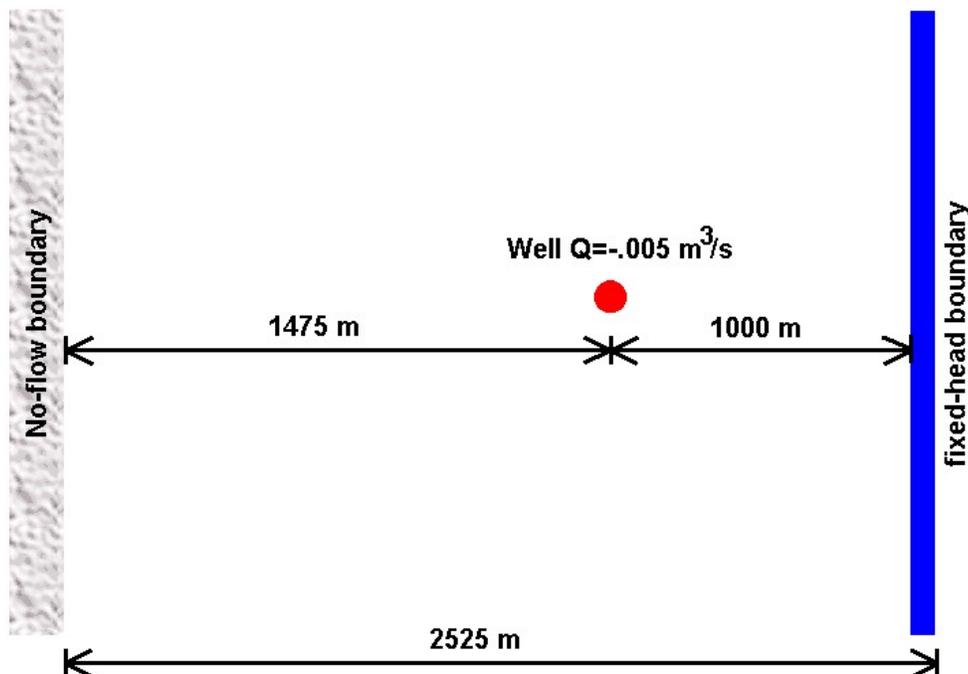


Fig. 6.14 Plan view of the model area

Modeling Approach and Simulation Results

The west boundary of the model is impervious and the river to the east is simulated by the fixed-head boundary condition (IBOUND=-1) with the initial head at 10 m. There are no natural boundaries to the South and North, so we have to use streamlines as impervious boundaries. The distance of the selected streamline from the well must be large enough, so that the hydraulic head at these boundaries are not affected by the pumping well. This is the case if the total recharge in the chosen strip is considerably larger than the pumping rate of the well. Because of the symmetry of the system, we could use one-half of the model area only. To show the whole catchment area, we decided to use the entire model area.

The aquifer is simulated using a grid of one layer, 50 rows and 51 columns. A regular grid space of 50 m is used for each column and row. The layer type is **1: unconfined**. Fig. 6.15 shows the contours, the catchment area and the 365-days-isochrones of the pumping well using a 2D-approach, where the groundwater recharge is treated as a distributed source within the model cells and 50 particles are initially placed around the pumping well in the middle of the aquifer. If the groundwater recharge is applied on the groundwater surface (refer to RCH/EVT options in chapter 4 for this option), particles will be tracked back to the groundwater surface (Fig. 6.16). We can easily imagine that the size and form of the calculated catchment area depend on the boundary condition, recharge rate and starting (vertical) position of particles and the vertical position of the well screen, if the well is only partially penetrating. A discussion about the determination of catchment areas in two and three spatial dimensions can be found in Kinzelbach et al. (1992).

To delineate the catchment area of a pumping well in a 3D flow field, we must place enough particles around and along the well screen. Fig. 6. 17 shows the catchment area calculated by PMPATH. First, 425 particles are placed around the well by using the **Add New Particles** dialog box (the settings are NI=5, NJ=5 on faces 5 and 6 and 25 particles on the circles with R=25 and NK=15 around the pumping well). Then backward tracking is applied for a duration of 100 years. Finally, the end points of the particles are saved by **File ▶ Save Particles As....** This file can be reloaded into PMPATH by **File ▶ Load Particles** to display the catchment area.

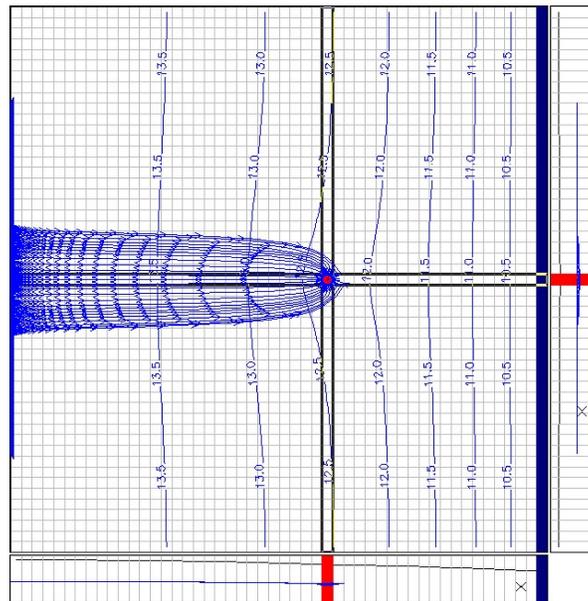


Fig. 6.15 Catchment area and 365-days isochrones of the pumping well (2D-approach: groundwater recharge is treated as distributed source within the model cells).

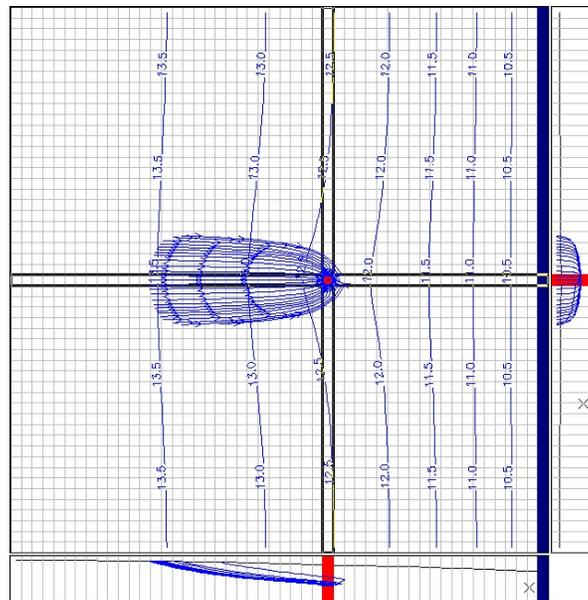


Fig. 6.16 Particles are tracked back to the groundwater surface by applying the groundwater recharge on the groundwater surface.

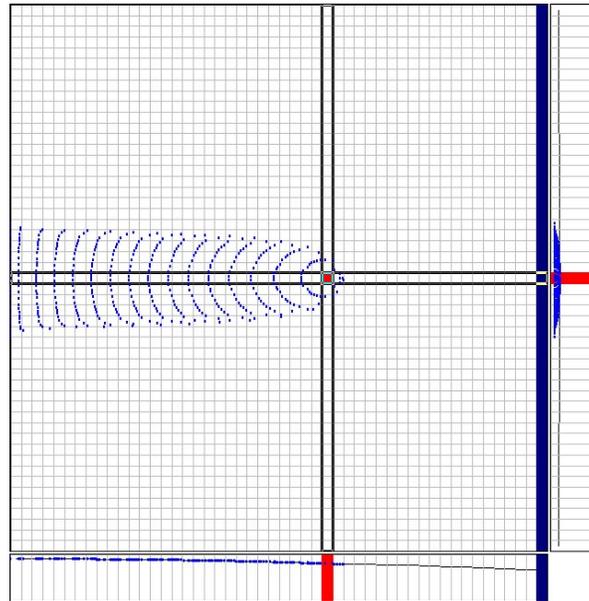


Fig. 6.17 Catchment area of the pumping well (3D-approach).