RECALIBRATION OF HYDRODYNAMIC MODEL DEPOSITS DRMNO IN KOSTOLAC COAL BASEN

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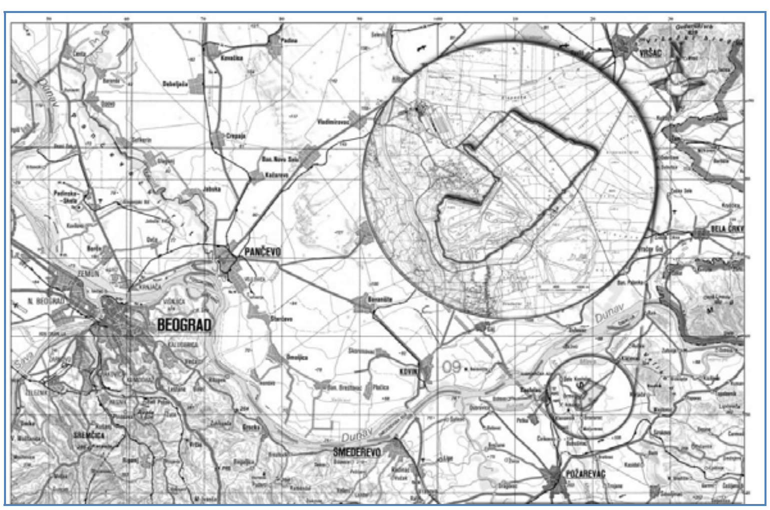
Abstract

The deposit Drmno is located in Kostolac coal basin, where coal mining is performed by surface excavation. Quality drenage is very important for coal mining. Creating a hydrodynamic model of deposit is very important as a starting sentence for successful system design to protect the mine from groundwater.

Keywords: Drmno, hydrodynamic model, coal

1. INTRODUCTION

Coal deposit Drmno covers land area of about 52 km^2. Open pit mine Drmno is located northeast of the village of Drmno (Picture 1). East of Belgrade open pit mine Drmno is about 100 km away. Border deposits represents the Danube River in the north and the west of the river Mlava.



Picture 1. Geographical position of open pit Drmno

For protection of open pit Drmno from surface water, apply standard object of protection: bench channels, water-collectors, pump stations and pressure pipelines. The system of protection of groundwater in the open pit Drmno the combined type, and consists of drainage wells, sealing wall, bench channels, water collector and pump stations. The base consists of lines of wells that are set by the contours of the mining field.

Hydrodynamic calculations for purposes of determine the number of wells, their mutual distances and individual capacities as well as to forecast the effects of the defense system of underground water were realized on a hydrodynamic model of the groundwater regime in wider zone of the open pit Drmno.

Hydrodynamic model of deposits Drmno was conceived and designed as multilayered model, with a total of six layers, viewed in a vertical profile. Each of these layers corresponds to a particular real-layer, schematic and separated based on knowledge of the terrain and the results of the analysis of extensive field research works. Starting from the ground surface, correspondent model and terrain layers are:

first aquifer	roof alluvial and loess sediments
second aquifer	mostly gravel aquifer
third aquifer	sands and clay layer above roof of the second (II) coal seam, which laterally (eastward) becomes sand layer above roof of third (III) coal seam
fourth combined isolator -	Second (II) coal seam (isolator) laterally (east) becomes
aquifer	roof sand layer above third (III) coal seam
fifth aquifer	sandy layer that lies above the roof of third (III) coal seam. In the western part of the field lies on (model layer) sixth aquifer
sixth aquifer	silty-sandy layer, which lies abowe roof of third (III) coal seam. In the part of the field where he is absent, sand is above roof of third (III) coal seam. The fifth aquifer is represented by sands.

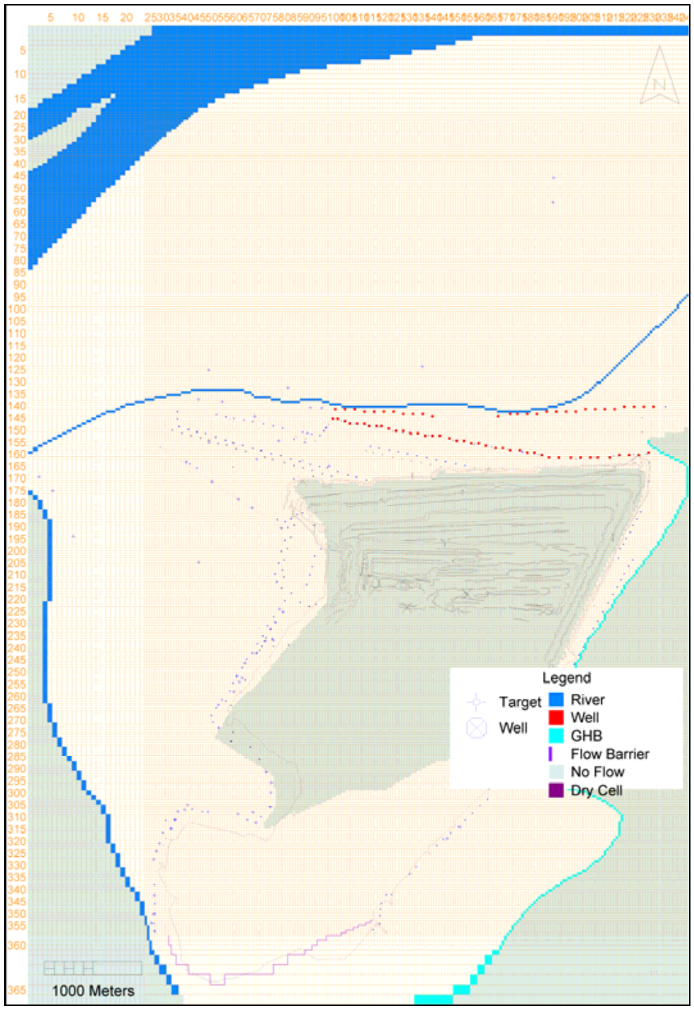
Beneath the floor of the fifth or sixth layer (depending on position) is third III coal seam, which by its hydrogeological and hydraulic mechanism represents an isolator, or limit flow surface. The area covered by the model has dimensions of 6.720 * 10.320 m. As noted, the model consists of 6 schematic layers, with a total of 726.520 active cells. Discretization flow area with fields, measuring 10 * 10 to 80 * 80 m. Smaller fields are located in the zones of greater interest (barrage of wells), while the bigger fields are located at more distant parts of the terrain.

Movement of groundwater is based on the model and simulated as well as real movement under pressure, or unconfined, in each discretized field individually, where the conditions of aquifer flow over time altered in model accordance with the real conditions. Data used to recalibrate the hydrodynamic model Drmno deposits are collected and used for the period January 2015 - December 2015, the observation of groundwater regime, the work of drainage wells, water levels of the Danube and Mlava, and the value of rainfall.

2. RECALIBRATION OF HYDRODYNAMIC MODEL

The original multilayered hydrodynamic model Drmno (Pušić, Polomčić, 1999) due progress over time, due to the inclusion and exclusion of a large number of wells, and consideration of developing open pit mine within the appropriate technical documentation, changed certain baseline characteristics. First, increasing the area around the coal deposits covered by the model (dimensions 6.720 * 5.550 m from 1999 to 6720*10.320 in 2008 year), and then executed detailed discretization of flow area, which resulted in an increase in number of model cells (from 80.851 in 1999 to 726.520 active cells, starting from 2008 year). Also, there was a conversion of part of boundary conditions in more complex, and some are first entered into the model, with the main purpose of the simulation as close to real conditions on the field (Picture 2).

Hydrodynamic model created in 1999 underwent several times recalibration, (2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014), in accordance with the progress of mining operations, results new geological research, development of the system for protecting mine from ground water, new data observation of groundwater regime, as well as specific tasks related to implementation of the existing mathematical model. In the first two recalibration of models were made some major changes in terms of the distribution zone of hydrogeological parameters and their values (coefficients of filtration and specific capacity of aquifers) than the original model. Also, in certain parts of the model, adjustments were made in elevation of gometry individual layers, according to recent results of geological and hydrogeological exploration works. In the third model recalibration performed less intervention on changes in local values of filtration coefficients in a gravelly and sandy aquifer.



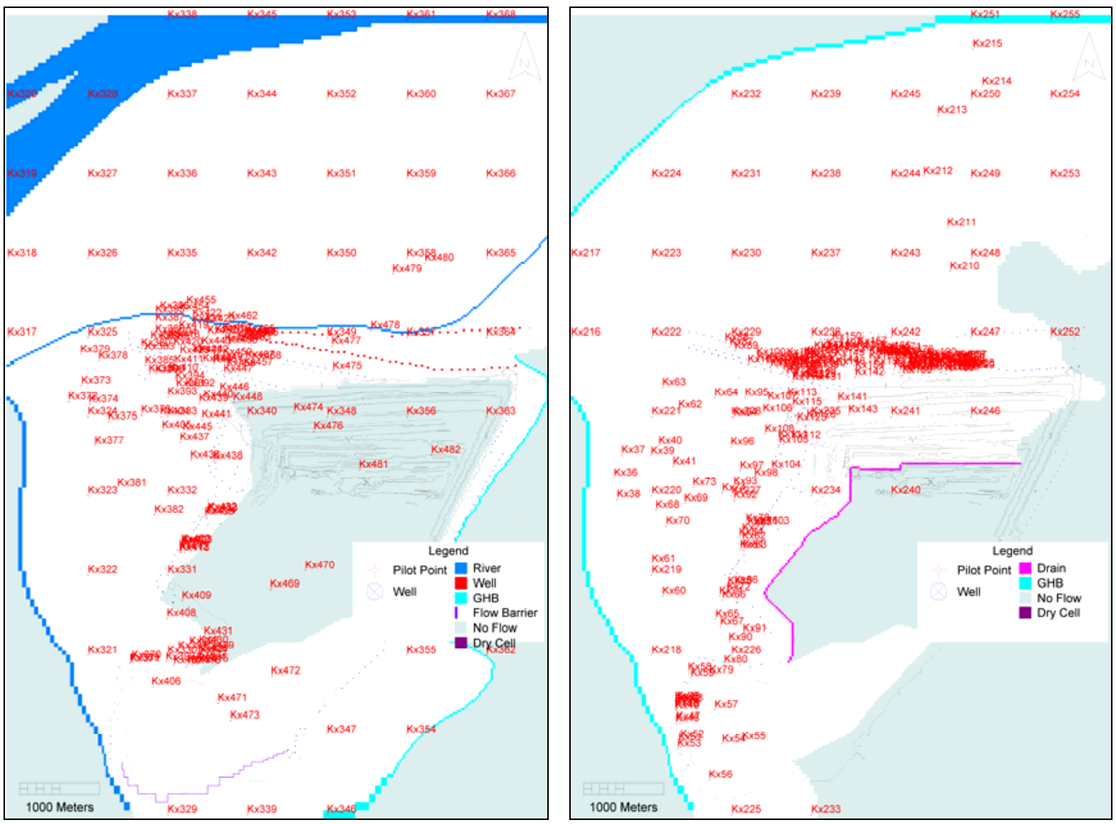
Picture 2. Discretization covered by model

Recalibration models from 2008 was performed for the needs of the Main mining project (Faculty of mining and geology). On occasion, the current model has been extended to the south, south of the existing sealing wall, and north to the Danube. During 2009, 2010 and 2011 was made three more model recalibration, this time in the existing boundaries of the area covered by the model in 2008, but with new boundary of mine and new information about the work of the drainage system, registered piezometric levels, and new information related to rainfall and water levels of surface flows. The same was done in 2012, 2013 and 2014 when recalibration is performed following the model of the current state of mining operations and entering into the model with new information about the spatial position represented lithological parts with infliction of new registered value of the groundwater regime, and all for the purpose of locating wells in the drainage lines LC-XIV (formerly LC-XIV ') and LC-XV (formerly LC-XIV), and assess the effects of their work.

New recalibration is done with the data of the groundwater regime from 2015. It also made certain corrections and refinements of existing models concerning the placing of more complex boundary conditions and adding new ones in the lower layers of the model. On the east is underground inflow fom the higher parts of the terrain which is simulated with boundary condition piezometrical general level. With this boundary condition underground inflow from west and north in sands and above roof of third (III) coal seam are simulated.

Hydrodynamic calculations were implemented in unsteady regim of flow. Period of time covered by recalibrating the model corresponds to the period of regime observations on the mine Drmno (January 2015 - December 2015). The main calculation step was one day, which is on the lower level of iterations divided into 10 parts, of unequal duration (factor 1.2). Recalibration of the model was done manually and automatically with help of program PEST with regularization, which involves placing, respectively control points in the process of model calibration allows assigning heterogeneous zone in terms of the value of certain field parameters.

Picture 3 shows a second layer of model (sand sediments) and the fifth layer of model (sandy sediments abow the roof of the third coal seam) in which they are given control points for the horizontal component of filtration coefficient (K_x). Control points determine the spatial distribution of horizontal (K_x = K_y), vertical (K_z) filtration components ratios, and specific storage. Total number of control points is 530 with a horizontal component and 320 control points with a vertical component of the coefficient of filtration, while the default for a specific storage 340 control points. The way of assigning control points depended on the hydrogeological nature of certain sediments and the number and arrangement of piezometers in the aquifers. For less permeable sediments assign the homogeneous network control points for each separate lithological member (first and third layer of a model). On the other hand, the water-bearing bed in which there are piezometers wich refer to inflict control-points through the so-called, triangulation between the piezometers with an additional control point in the center of each triangle consisting of three adjacent piezometers. Then they carried thickening in areas that are not there, like default, control points. Control points that determine the distribution of the value of the vertical component of filtration coefficient shifted in relation to horizontal component of $\Delta x = \Delta y = 10$ m.



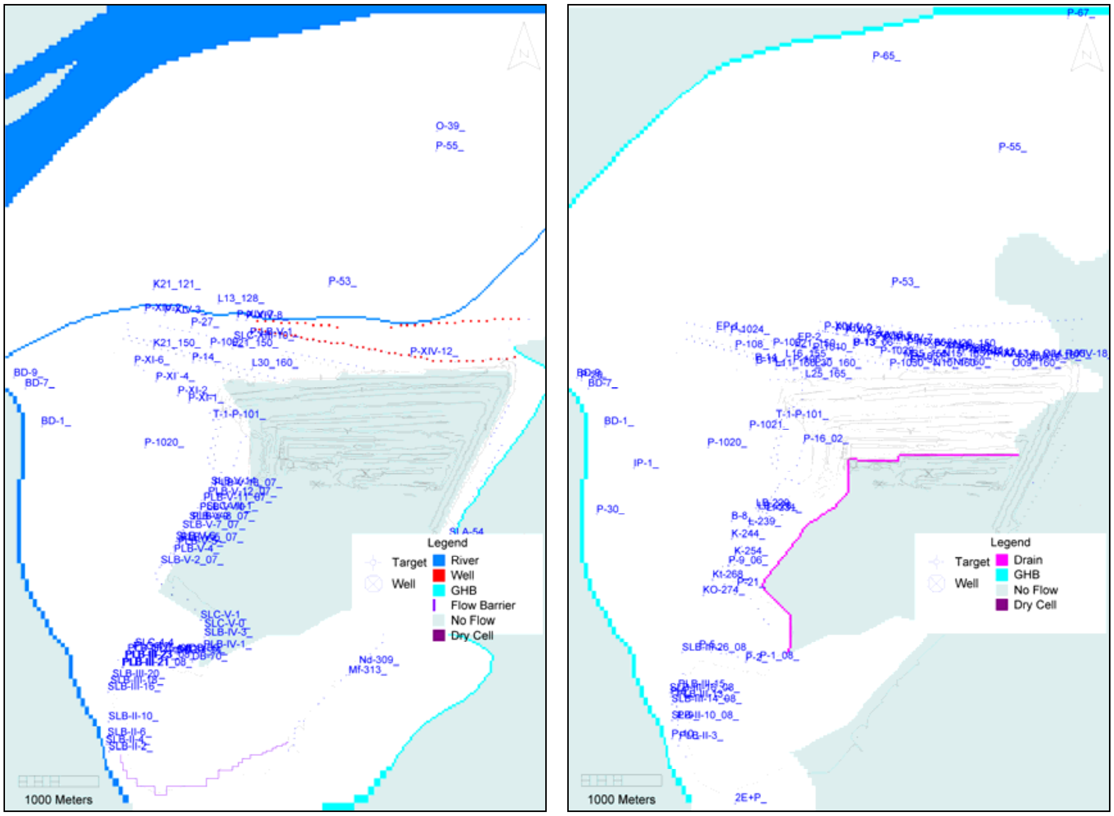
a) *b)*

Figure 3. Distribution of control points for automatic calibration model – a) alluvial gravels, b) sand abowe third (III) coal seam

Picture 4 shows the locations of surveillance objects in the area covered by hydrodynamic model of mine, which were used for the implementation of non-stationary model recalibration.

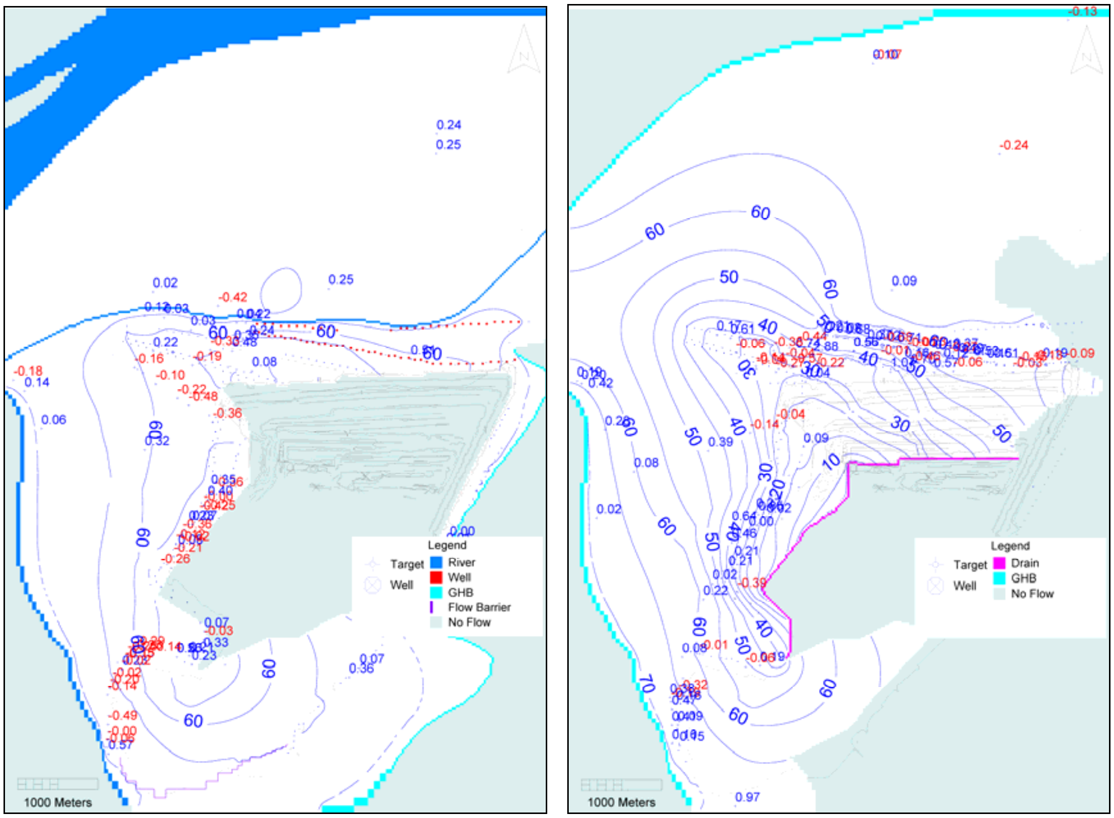
Picture 5 shows the distribution of piezometer levels in gravelly and sandy aquifer above the roof of third (III) coal seam, obtained by simulating the groundwater regime with the situation that referd to the end of recalibration model period - December 2015.

In order to assess the quality of derived recalibration hydrodynamic model deposits Drmno prospecting was carried out statistical analysis of simulation results of the groundwater regime. Table 1 shows the basic statistical indicators related to residuals, or differences registered and calculated values piezometer levels in a total of 219 observation of the object, while Picture 6 shows the value of residuals. The present statistical indicators point to good compliance registered and calculated values of piezometrical levels in observation objects.



a) *b)*

Picture 4. Position of observation objects on the OP 'Drmno (December 2015) and the boundary conditions - a) sand sediments, b) sands above roof third (III) coal seam



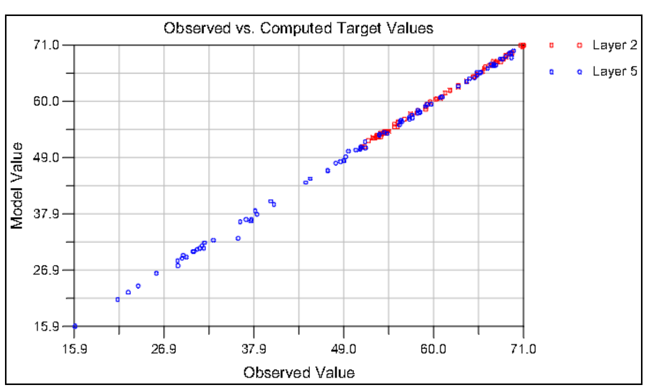
a) *b)*

Picture 5. Positions of piezometrical levels in a) - gravelly b) - sandy layer above the third (III) coal seam at the end of the period for which is carried out recalibration model (December 2015)

Table 1. Statistical indicators of residuals

(Difference between registered and calculated values piezometrical levels)

The mean value of the residual	0,08
Standard deviation	0,36
Absolute mean value	0,27
The sum of squares	11,60
Mean square error	0,40
The minimum value of residuals	-0,68
The maximum value of residuals	2,88



Picture 6. Values of the residuals at the end of the time period for which the model is recalibrated

3. CONCLUSION

Sistem protection of groundwater in the open pit Drmno is combined type, and consists of drainage wells, sealing wall, bench channels, water collector and pump stations. Hydrodynamic calculations for purposes of sizing the number of wells, their mutual distances and individual capacities as well as forecast the effects of the defense system of underground water were realized on a hydrodynamic model of the groundwater regime wider zone of open pit Drmno, which was created as multilayered model (6 layers) .

The first model hydrodynamic bearings Drmno was created in 1999, and its recalibration is done on several occasions: 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014. The latest recalibration was done in 2015 and made certain corrections and refinements of existing models concerning the placing of more complex boundary conditions and adding new ones in the lower layers of the model. Recalibration of the model was done manually and automatically using PEST program with regularization, which involves placing control points whitch in the process of model calibration allows assigning heterogeneous zone in terms of the value of certain environmental parameters.

In order to assess the quality of derived hydrodynamic model recalibration deposits Drmno performed a statistical analysis of the results of simulation of groundwater regime. Statistical figures indicate good compliance registered and calculated values piezometrical levels in observation objects.

4. LITERATURE

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