Sprawozdanie z udziału w konferencji:
International FEFLOW Conference, Berlin 2015

W dniach 16 – 25 września 2015r., dr Sławomir Sitek, pracownik Wydziału Nauk o Ziemi wziął udział w międzynarodowej konferencji FEFLOW 2015, w Berlinie. Udział w tym wydarzeniu był możliwy dzięki dofinansowaniu uzyskanemu ze środków Centrum Studiów Polarnych KNOW (Krajowy Naukowy Ośrodek Wiodący).

Cała konferencja była poświęcona zagadnieniom związanym z wykorzystaniem modelowania numerycznego do odwzorowania przepływu wód, migracji zanieczyszczeń czy procesów związanych z płytką i głęboką geotermią. W jednej z sesji dotyczącej modelownia wyżej wymienionych procesów w obszarach górniczych miałem przyjemność zaprezentowania własnych wyników badań (Sitek, Kowalczyk; Impact of urban and post ore mining area on the hydrogeological system. A case study of the Tarnowskie Góry town, southern Poland). Referat ten dotyczył wpływu urbanizacji i obszarów pogórniczych w rejonie Tarnowskich Gór na system wodonośny i formowanie się zasobów wód podziemnych.

Dodatkowo w sesji posterowej byłem także współautorem posteru dotyczącego zastosowania modelowania do określenia interakcji pomiędzy wodami podziemnymi i powierzchniowymi w zlewni bezpośredniej dla zbiornika Goczałkowice (Czekaj, Sitek, Witkowski; Groundwater modelling of the quaternary aquifer and Goczałkowice dammed reservoir interaction).

Konferencja zgromadziła wielu użytkowników z różnych stron świata co było świetną okazją do wymiany doświadczeń. Udział w konferencji przyczynił się do poznania najnowszych trendów rozwoju tego typu modelowania oraz do podniesienia własnych umiejętności budowy modeli dzięki możliwości udziału warsztatach. Odbywały się one zarówno przed jak i po konferencji. Szkolenia dotyczył między innym automatycznej kalibracji, metod budowy modeli w kopalniach odkrywkowych i podziemnych, oraz poznania modelowania hydrologicznego z wykorzystaniem oprogramowania MIKE SHE i MIKE 11.


MIKE
Powered by DHI
FEFLOW 2015


FEFLOW

GROUNDWATER MODELLING OF THE QUATERNARY AQUIFER AND GOCZAŁKOWICE DAMMED RESERVOIR INTERACTION. A CASE STUDY FROM SOUTHERN POLAND

JOANNA CZEKAJ[1*] SŁAWOMIR SITEK[1] ANDRZEJ J. WITKOWSKI[1]

[1] University of Silesia, Faculty of Earth Science, Department of Hydrogeology and Engineering Geology, Będzińska 60, Sosnowiec, Poland, *corresponding author: joanna.czekaj@us.edu.pl

INTRODUCTION

Interaction between groundwater and surface water is an essential issue in hydrogeology and water resources management. Determination of the interaction corresponds with the Water Framework Directive, which emphasized its importance in context of achievement of a good status of water and dependent ecosystems.

This work presents preliminary results of modelling of the groundwater – surface water interaction in the area of drinking water reservoir using FEFLOW .

METHODS

The study, conducted between 2011 and 2013, combines a multi-scale hydrogeological survey of the Quaternary aquifer with groundwater modelling, which was focused on evaluating aquifer – surface water interaction, at direct reservoir catchment scale.

Three – dimensional (3D) steady-state numerical model, set up in FEFLOW simulator (Diersch, 1998), was developed to represent groundwater flow in the study area, evaluate aquifer – reservoir interaction, define groundwater flow path and estimate water budget (Czekaj, Witkowski, 2014).

RESEARCH AREA

Research area is the direct catchment of the Goczałkowice reservoir (64.7 km²). The reservoir was built on the Vistula River (fig. 1). Its principal functions are: (a) flood control in the Upper Vistula River catchment and (b) water supply of the Upper Silesian Industrial Region (Southern Poland).

Study area is located in Polish Carpathian Foredeep. Useful aquifer – Quaternary aquifer, is comprised of mainly alluvial sediments. Beyond the areas of the river valleys Quaternary aquifer is associated with the accumulation of glacial and fluvioglacial sediments (fig. 2).

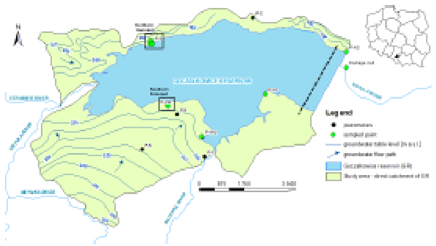

Fig. 1. Localization of the study area with sampling points marked. 3 groundwater and surface water samples were taken from the Northern transect area, 2 groundwater samples were taken from the Southern transect.

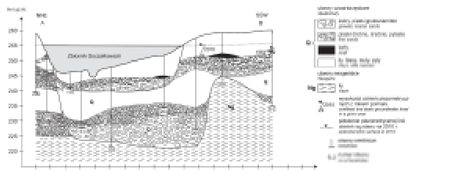

Fig. 2. Hydrogeological cross-section of the study area (Sołtysiak et al., 2011). Groundwater table is mainly confined, it is unconfined within alluvials. Hydraulic conductivity, ranges from 5.36·10⁻⁸ to 6.5·10⁻³ m/s (Czekaj, Witkowski, 2012). Groundwater recharge in this area is difficult due to aquifer capping (5 m thick aquitard).

MODELLING

Conceptual model of groundwater – surface water interaction in the area of Goczałkowice reservoir was set basing on archive data and monitoring data (Czekaj, Witkowski, 2014) (fig. 3).

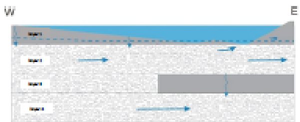

Fig. 3. Conceptual model groundwater – surface water interaction in the area of Goczałkowice reservoir. The model assumed high seepage coefficient through the reservoir bottom and direct exchange in the area of the deepest part of the reservoir.

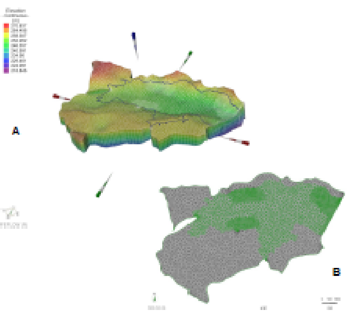

Fig. 4. The groundwater flow model settings. A 4-layered groundwater flow model was developed to evaluate aquifer – reservoir interaction, determine groundwater flow paths and estimate water budget (A). Goczałkowice reservoir was featured using Fluid – transfer boundary condition (B). The Cauchy type boundary condition was also applied on the model boundaries.

A 4-layered groundwater flow model was developed to evaluate aquifer – reservoir interaction, determine groundwater flow paths and estimate water budget. The model was set up in steady-state condition using FEFLOW 6.2 (tab. 1).

Recharge	3 – 6 %
Hydraulic conductivity	$2 \times 10^{-8} - 6 \times 10^{-3}$ m/s (I aquifer) $5 \times 10^{-8} - 9.5 \times 10^{-4}$ m/s (II aquifer)
Seepage coefficient	3×10^{-7} m/s
Surface water stage (GR)	254.7 m asl

Tab. 1. Hydrogeological properties using as an input data.

Goczałkowice reservoir was featured using *Fluid – transfer* boundary condition. The model was calibrated using trial-and-error methods against hydraulic head and surface water level.

Model results show (fig. 5): (1) difference in groundwater dynamic between southern and northern part of the catchment, (2) potential zones of GW-SW exchange. The interaction is mainly dependent to pressure on the first aquifer (fig. 6).

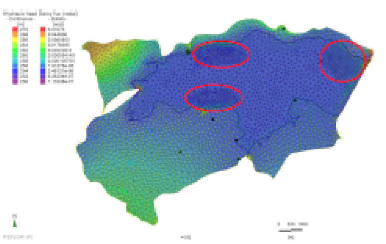

Fig 5. Results of groundwater flow modelling. General groundwater flow is directed towards Goczałkowice reservoir. Groundwater flow modelling in steady state indicates groundwater drainage in local scale. The mesh was rebuilt (bigger density) in the potential direct GW-SW exchange area (red circles).

The water budget indicates groundwater drainage (tab. 2). Model was validate to water balance of the reservoir (fig. 6).

Cauchy BC (as GR representation)	
$- 1.99 \times 10^5$ [m³/d]	$+ 7.1 \times 10^4$ [m³/d]

Tab. 2. Selected elements of the model domain water balance. Dominated value of „losses" indicates draining character of Goczałkowice reservoir which is also seemed to be confirmed by reservoir water balance (fig.6).

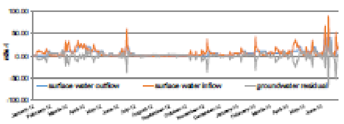

Fig. 6. Groundwater residual, due to water balance calculations, between 01.01.2012 – 30.06.2013. Water balance calculations (Hood et al., 2006) show a high seasonal variation of GW – SW relation in the study area. In may 2012 (time spot for the model calibration) positive value for groundwater residual is observed which suggests groundwater drainage.

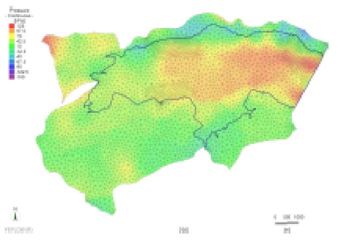

Fig 6. Hydraulic pressure applied on the first aquifer. The GW – SW interaction in the area of Goczałkowice reservoir seems to be mainly depended to pressure on the aquifer.

CONCLUSIONS

- ✓ Groundwater – surface water interaction was evaluated using groundwater flow modelling.
- ✓ Preliminary results of groundwater flow modelling in steady state, using FEFLOW, shows significant difference in groundwater dynamic between southern and northern part of the catchment. The model indicates mainly groundwater drainage.
- ✓ The GW - SW interaction is observed mainly in local scale, dependent to hydraulic pressure.
- ✓ Basing on water balance analysis seasonal and water-management-dependent interaction was noticed.
- ✓ Further simulations, using different scenarios, are needed to more reliable evaluation the GW – SW interaction in the study area.

ACKNOWLEDGEMENT

Research was conducted as a part of strategic research project: POIG 01.01.02-24-078/09: *Integrated system supporting management and protection of dammed reservoir (ZiZOZap)*, co-fund by European Funds Programme and Ministry of Science and Higher Education of Poland.

REFERENCES

CZEKAJ J., WITKOWSKI A.J., 2012: Structural model of Quaternary aquifer in area of Goczałkowice reservoir [in polish]. Bulletin of Polish Geological Survey. 451

CZEKAJ J., WITKOWSKI A.J., 2014: Hydrodynamic modelling as an evaluation tool of groundwater – surface water interaction in the area of dammed reservoir. Goczałkowice reservoir case study. [in :] Krawiec A. and Jamorska I. (Eds.): Mathematical models in hydrogeology. Publishing House of Nicolaus Copernicus University, Toruń [in polish];

DIERSCH, H.-J. G., 1998: Interactive, Graphics-based Finite Element Simulation System FEFLOW for Modelling Groundwater Flow, Contaminant Mass and Heat Transport Processes, User's Manual. WAS Y Ltd, Berlin, Germany

HOOD, J. L., ROY J. W., HAYASHI M., 2006: Importance of groundwater in the water balance of an alpine headwater lake. Geophysical Research Letters 33, L13405,

SOŁTYSIAK M., WITKOWSKI A., KAŹMIERCZAK J., 2011: Hydrogeological aspects of strategic research project Integrated system supporting management and protection of dammed reservoir (ZiZOZap) (Goczałkowice reservoir). [in polish]. Bulletin of Polish Geological Survey. 451