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5.1
Modelling as a tool of groundwater assessment

title: **Numerical model conceptualization utilizing advanced geoinformatic techniques in investigations of complex multi-aquifer systems of MGWB in Poland**

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INTRODUCTION

The aim of the paper is to provide an overview of existing research studies and methodology of developing numerical models of the Major Groundwater Basins (MGWB) characterized by complex multi-layered conditions. The MGWBs were documented as regions with good groundwater quality and the most beneficial exploitation conditions in Poland and after the verification the quantity of 163 out of 190 MGWBs was finally accepted (Herbich et al., 2009). Model investigations for three different types of MGWBs: Nº 302, Nº 321 and Nº 326 (Fig. 1) were documented to show how important is GIS-based developing of the model structure including DTM creation and proper boundary conditions setting.

Figure 1. Location of models of the developed MGWBs.

Considering aspects of establishing a flow system, groundwater resources and protection zone identification a 3-D models were built using MODFLOW (McDonald, Harbaugh, 1988; Harbaugh et al., 2000) application in integration with other geoinformatic techniques especially advanced GIS tools (Gurwin, Lubczynski, 2005; Gurwin, Serafin, 2007, 2008). A highly complicated hydrogeological conditions are found as well within Quaternary/Neogene (Fig. 2) as Mesozoic MGWBs that were studied. The examples of different type and varying scale were selected to show crucial steps of conceptualization.

CONCEPTUALIZING MODELS OF COMPLEX QUATERNARY/NEOGENE AQUIFER SYSTEMS

Gathering appropriate data from hundreds of boreholes, utilizing GIS and advanced geostatistical analysis a 3-D representation of hydrostratigraphic unit interfaces is developed. Afterwards using fully GIS integrated modelling environments like GMS and VISTAS the structure of the aquifer system is transferred to the grid of numerical model. The boundary conditions of such a large-scale regional models should be consistent with natural hydraulic boundaries, that's why an extent of the entire model domain is usually far much wider than MGWB itself (Fig. 2).

Considering numerical models of deeper aquifers a special attention should be paid on semipervious layers, which determine distribution of recharge from above-lying shallow Quaternary aquifers. Then the parameters of thickness and vertical conductivity are crucial and GIS layers should be prepared utilizing geostatistically approved data analysis, as it is shown in map of the aquifer bottom in the Figure 3.

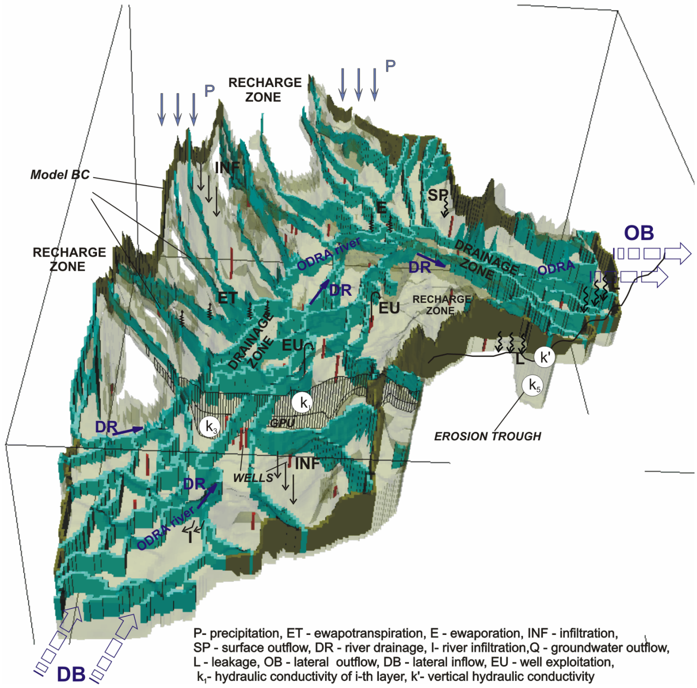

Figure 2. Conceptualisation of groundwater flow system within complex Quaternary MGWB No 302 on 3-D numerical model.

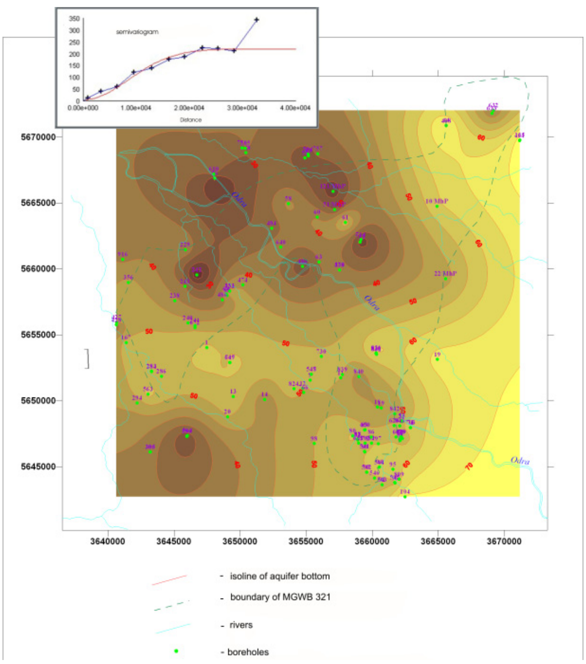

Figure 3. Contour map of bottom of the Neogene aquifer within the MGWB 321.

A composition of the top/bottom GIS layers together with hydrogeological parameters allowed to prepare a 3-D grid representation of the MGWB 321 in the GMS Modflow environment (Fig. 4).

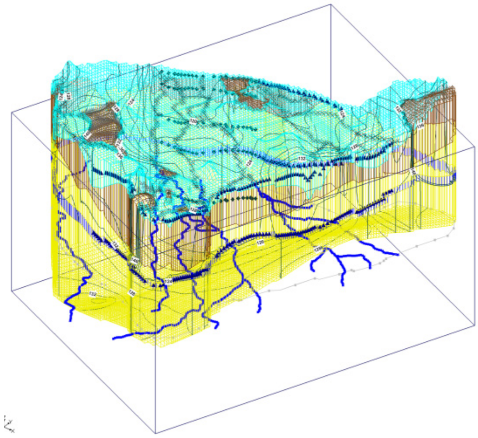

Figure 4. Scheme of the MODFLOW numerical model of groundwater flow system within the Neogene MGWB 321 with calculated hydroizohypses (Gurwin, 2008).

The results of the model are presented on the sets of numerical maps and diagrams, but full 3D model (Figure 2, Figure 4) gives also opportunity of pathlines analysis which is a basis for MGWB protection zone determination (Figure 5).

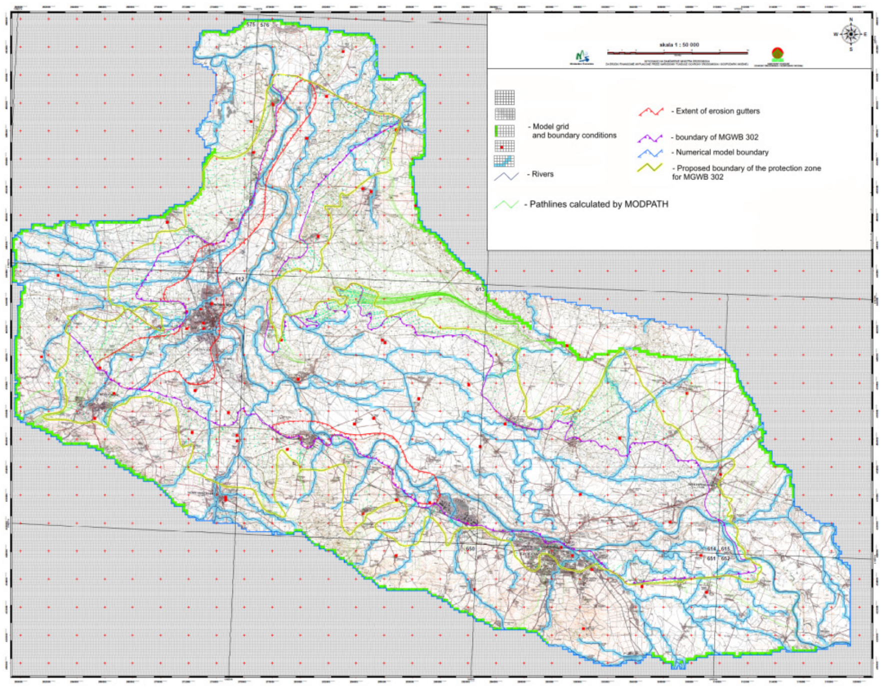

Figure 5. Results of protection zone evaluation for MGWB No 302 according to the numerical MODFLOW/MODPATH model.

A particle tracking method with forward advective pathline simulation is used to evaluate velocity vectors and to establish the isochrones of 25-year fluxes. But the final protection zone was delimited considering the time of seepage through an unsaturated zone as well (Gurwin, Serafin, 2010).

DEVELOPING OF A LARGE-SCALE MODEL OF MEZOZOIC AQUIFERS — MGWB Nº 326

As an example of extremely large-scale modelling can be taken a numerical model developed for MGWB Nº 326 which covers a big part of the central Poland (Fig. 1) — an active area of the model is 7 thousand of sq. km. A complicated structure of the Jurassic/Cretaceous fissured massif was evaluated with GIS support and next the nine-layer finite difference model was created (Fig. 6). Having finally calibrated model a water balance was calculated as a basis of groundwater resources analysis.

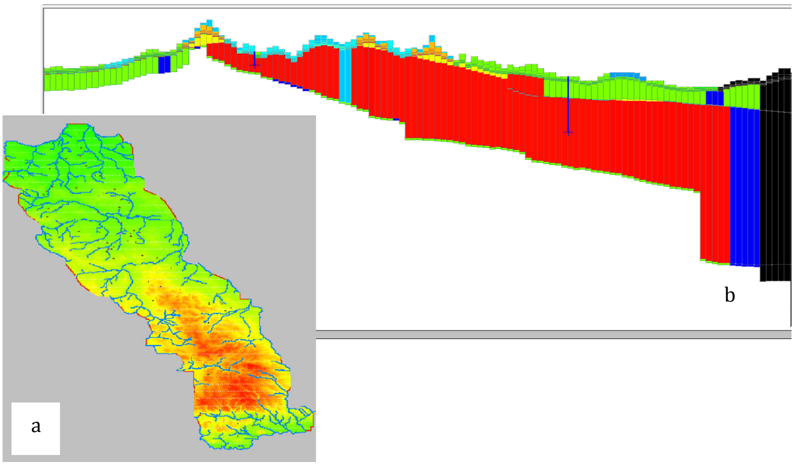

Figure 6. DTM in a finite difference projection (a) and spatial differentiation of the numerical model layers with respect to tectonics of the Mezozoic massif of MGWB No 326 (cross section W-E) (b).

CONCLUSIONS

So far investigations carried out for establishing water balance components, groundwater resources and protection zones in several MGWBs in Poland have proved that full model control from a GIS platform is necessary to fulfill all these tasks. Developing a 3-D numerical flow model gives opportunity of detailed analysis of complex Quaternary/Neogene aquifer systems. Setting of boundary conditions is much more credible using GIS, especially considering river BC and spatial recharge input data.

An extremely large-scale modeling within intensively tectonically engaged systems is also feasible to be done when thousands of records of data can be quickly analyzed in GIS tools including advanced geostatistical calculations.

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REFERENCES

Gurwin J., Lubczyński M., 2005: *Modeling of complex multi-aquifer systems for groundwater resources evaluation-Swidnica study case (Poland).* Hydrogeol. J. vol. 13, no. 4, pp. 627–639.

Gurwin J., Serafin R., 2007: *Numeryczny model filtracji systemu wodonośnego GZWP 322 Oleśnica. (Numerical Groundwater Flow Model of the MGWB no 322 Aquifer System).* (In:) Współczesne problemy hydrogeologii, T.XIII, wyd. AGH Kraków, pp. 655–666.

Gurwin J., 2008: *Numeryczny model filtracji systemu wodonośnego wschodniej części GZWP nr 321. (Numerical Model of Groundwater Flow System of the Eastern Part of the MGWB 321).* (in:) Modelowanie procesów hydrologicznych CMPH 2008 (ed. B. Namysłowska-Wilczyńska), Oficyna Wyd. Polit. Wr., Wrocław, pp. 293–314.

Gurwin J., Serafin R., 2008: *Budowa przestrzennych modeli koncepcyjnych GZWP w systemach GIS zintegrowanych z MODFLOW.(Design of 3D Conceptual Models of MGWBs Using GIS Integrating in MODFLOW).* Biul. PIG HYDROGEOLOGIA nr 431, pp. 49–59.

Gurwin J., Serafin R., 2010: *Zastosowanie numerycznego modelu filtracji i systemów geoinformatycznych GIS jako narzędzi wspomagających wyznaczanie stref ochronnych GZWP (Application of Numerical Modelling and Geoinformatic Systems GIS as Support Tools in Assessments of MGWB Protection Zones).* Biul. PIG HYDROGEOLOGIA (in print).

Harbaugh A.W., Banta E.R., Hill M.C., McDonald M.G., 2000: *MODFLOW-2000 The US Geological Survey modular ground-water model-user guide to modularization concepts and the groundwater flow process.* US Geol. Surv. Rep.

Herbich P., Kapuściński J., Nowicki K., Prażak J., Skrzypczyk L., 2009: *Metodyka wyznaczania obszarów ochronnych głównych zbiorników wód podziemnych dla potrzeb planowania i gospodarowania wodami w obszarach dorzeczy (Methodology of Protection Zone Determination of the Major Groundwater Basins for Planning and Management Water in the Basin Area).* Ministry of the Environment, Warszawa.

McDonald M.G., Harbaugh A.W., 1988: *A Modular Three-Dimensional Finite-Dfference Ground-Water Flow Model.* U.S. Geological Survey Open-File Report, Washington.

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