1.	Nazwa przedmiotu/modułu w języku angielskim **Groundwater Modelling**
2.	Nazwa przedmiotu/modułu w języku polskim **Modelowanie przepływów wód podziemnych**
3.	Jednostka prowadząca przedmiot **WNZKŚ, Instytut Nauk Geologicznych, Zakład Hydrogeologii Stosowanej**
4.	Kod przedmiotu/modułu USOS
5.	Rodzaj przedmiotu/modułu **Fakultatywny otwartego wyboru**
6.	Kierunek studiów **Geologia**
7.	Poziom studiów **II stopień**
8.	Rok studiów **I lub II rok**
9.	Semestr **winter or summer**
10.	Forma zajęć i liczba godzin **lectures: 26 h** **classes in computer lab: 39 h**
11.	Imię, nazwisko, tytuł/stopień naukowy osoby prowadzącej zajęcia **lecturer: dr hab. Piotr Jacek Gurwin, prof. UWr** **coordinator: dr hab. Piotr Jacek Gurwin, prof. UWr**
12.	Wymagania wstępne w zakresie wiedzy, umiejętności i kompetencji społecznych dla przedmiotu/modułu oraz zrealizowanych przedmiotów **Knowledge and skills in hydrogeology and groundwater dynamics**
13.	Cele przedmiotu **Classes are a specializing training to enable the practical application of numerical models in hydrogeological practice.** **The lectures are aimed at understanding the theoretical basis for numerical solutions, adoption of new concepts in the field of groundwater filtration, and knowledge of the data and their processing for the model applications.** **Classes are conducted entirely in the computer lab - the aim is to provide programs for modeling filtration and practical implementation of simple models for the various hydrodynamic systems.**

14.	Zakładane efekty kształcenia	Symbole kierunkowych efektów kształcenia
	(W_1) He has in-depth knowledge about the phenomena and processes in groundwater. He can see the existing relationships and dependencies in the aquifer. He has knowledge of the science related to fluid mechanics and hydraulics.	**K2_W01, K2_W02**
	(W_2) He's able to critically analyze and make choices of hydrogeological model inputs.	**K2_W03**
	(W_3) Consistently applies the strict principles, based on empirical data to interpret phenomena and processes at a flow rate of groundwater.	**K2_W04**
	(W_4) He has expertise in the field of statistics (geostatistics) allows forecasting (modeling) phenomena and processes associated with groundwater filtration.	**K2_W05**
	(W_5) He has in-depth knowledge of the terminology in the field of hydrogeology and geo-information.	**K2_W09**
	(U_1) He's able to apply advanced techniques and research tools in the field of modeling filtration. He uses scientific literature in the field of modeling.	**K2_U01, K2_U02**
	(U_2) He can use statistical methods and specialized techniques and tools for the description of phenomena and hydrogeological data analysis	**K2_U05**
	(K_1) He understands the need for continuous learning and professional skills development. He's able to prioritize appropriately for implementation specified by himself or other tasks.	**K2_K01, K2_K03**
15.	Treści programowe **Lectures:** The idea is to highlight the broad multidisciplinary research methodology for modelling of hydrogeological processes (groundwater dynamics, hydraulics, methods of pumping test, the protection of the aquatic environment, hydrochemistry, monitoring, geoinformation). The aim is to gain theoretical and practical basis for the use of modern numerical methods across the spectrum of groundwater flow in both the local as well as regional scale. The effect of education is to understand how the numerical representation of real hydrogeological conditions is created, including knowledge of the scope of the necessary information and environmental data for the preparation of groundwater numerical solution. **Lab classes:** Implementation of the individual work in the computer lab. The aim is to introduce and teach the service of most versatile and widely	

	used modeling programs in hydrogeology. It is also important to master specialized terminology and operation interface. The primary effect of course is the possibility to prepare the necessary data and to develop a numerical model of filtration in simple hydrogeological conditions. **Modeling as the primary method of modern hydrogeology.** Definitions and basic concepts. Hydrogeological model, conceptual model and a numerical model. Outline of the history of modeling, including the method of elektrohydrodynamic analogy (AEHD) and operation mesh integrators. **Theoretical basis of numerical models of filtration.** The objectives of the model simulation. The solution for steady state and transient conditions. Methods of solutions being used in the modeling (the difference between MRS and MES methods). The solution of mathematical equations describing the filtration. Iterative methods. **Identification of the aquifer system on the model.** Aquifer system and the types of hydrostructural systems restored on the model. Boundary surfaces. Circulation and vertical seepage of water within the aquifer system. **Defining the boundary conditions.** Procedure of schematization for the implementation of the model. Discretization and mesh types. Boundary conditions and initial conditions of the model. **The issue of preparation of model inputs.** Input data, databases and digital maps. Application of GIS techniques. The problem of model scale. Specificity of the construction of models of regional aquifer systems. **The problem of schematization of hydrogeological conditions.** Geostatistical modeling. Deterministic and stochastic models. Schematization of hydrogeological conditions and simulation of the multi-aquifer structure on the model. **Numerical methods.** 2-D and 3-D spatial models. The principle of operation and application of the leading programs in the FDM method of modeling. Construction of multilayer models. Simulation of the interactions with the surface water. **Analysis of the quality of the model.** Calibration and verification of the model. Inverse modelling tasks. The types of errors that occur. **The results of model.** Analysis of the results of the model. Water balance calculations and groundwater resources in the model. Analysis of the pathlines and intake runoff area, recognition of protection zones on the model. **MODFLOW.** The MODFLOW and combined packages. Workflow and proper model documentation. **Mass transport and migration of contaminants.** Modeling of contaminant migration. Applications of the MT3D. The issue of multiphase flow in porous media. Examples of applications. Presentation of the results and the role of the Internet.
16.	Zalecana literatura (podręczniki) **Basic literature:** Anderson M., Woessner W., 1992: Applied Groundwater Modeling, Academic Press, Inc., London. Bear J., Verruijt A., 1994: Modeling Groundwater Flow and Pollution. D. Reidel Publishing Co., Dordrecht.

	Dąbrowski S., Kapuściński J., Nowicki K., Przybyłek J., Szczepański A., 2011: Metodyka modelowania matematycznego w badaniach i obliczeniach hydrogeologicznych.Warszawa. Kulma R., Zdechlik R., 2009: Modelowanie procesów filtracji. Wyd. AGH, Kraków. Macioszczyk T., Szestakow W.M., 1983: Dynamika wód podziemnych – metody obliczeń. Wyd. Geol. Warszawa. Szymanko J., 1980: Koncepcje systemu wodonośnego i metod jego modelowania. Wyd. Geol., Warszawa. Wang H.F., Anderson M.P., 1982: Introduction to Groundwater Modeling. W.H. Freeman and Co., San Francisco. **Additional literature:** Fetter C.W., 1994: Applied hydrogeology. MCPC, New York. Gurwin J., 2010: Ocena odnawialności struktur wodonośnych bloku przedsudeckiego. Integracja danych monitoringowych i GIS/RS z numerycznymi modelami filtracji . HYDROGEOLOGIA Acta Univ. Wratisl. No 3258, Wyd. U.Wr., Wrocław Gurwin J., Szczepiński J., Wąsik M., 1994: Opis programu MODFLOW wykorzystanego w regionalnych badaniach hydrogeologicznych. Mat. I Symp. Nauk.-Techn.'Bilansowanie zasobów wodnych w dorzeczu Odry'. Zesz. Nauk. Wr.A.R. nr 248, Wrocław Kresic Neven, 2006: Hydrogeology & groundwater modeling (2nd Ed.) Modelowanie przepływu wód podziemnych – wydania MPWP 1 (2004), MPWP 2 (2006), MPWP 3 (2008), MPWP 4 (2010), MPWP 5 (2012) Pinder John, 2002: Groundwater Modeling, John Wiley & Sons. ISBN: 978-0-471-08498-3 USGS: Techniques of Water-Resources Investigations Reports (TWRI), USGS Publications.	
17.	Forma zaliczenia poszczególnych komponentów przedmiotu/modułu, sposób sprawdzenia osiągnięcia zamierzonych efektów kształcenia: **Lectures:** Written exam - after completing lab exercises. positive score – at least 55% of points. **Exercises:** Score from 4 complete studies of performed numerical models of filtration. **Elementy i wagi mające wpływ na ocenę końcową**: egzamin 50 %, ćwiczenia 50%.	
18.	Język wykładowy **english**	
19.	Obciążenie pracą studenta:	
	Forma aktywności studenta	Średnia liczba godzin na zrealizowanie aktywności

	Godziny zajęć (wg planu studiów) z nauczycielem: - lectures: **26** - exercises in computer lab: **39**	**65**
	Praca własna studenta np.: - preparation for classes: **25** - study results: **10** - reading of the indicated literature: **5** - writing a report of the activities: **15** - exam preparation: **25**	**80**
	Suma godzin	**145**
	Liczba punktów ECTS	**7 ECTS**