

## MODULE INFORMATION SHEET

<b>Name of Module Unit</b>	<b>Groundwater Protection</b>
Name in polish language	Ochrona wód podziemnych
Module type	compulsory
Form of studying	full-time day courses
Level of study	graduate course (M.Sc. level)
Type of study ( for extra-mural courses)	-
Programme	Environmental Engineering
Speciality	Environment Protection Engineering
Responsible department	Chair of Environmental Protection and Management
Responsible persons	dr inż. Grzegorz Sinicyn

Semester	Lectures(E)	Tutorials	Laboratory	Computer Exercises	Projects	ECTS
2	15E				30	3

### Learning outcomes (knowledge, skills, competencies)

The module will consist of elements of groundwater flow and mass transport theory. Variables and parameters used in hydrogeology will be introduced and their physical interpretation explained. The groundwater flow equation in 3D will be presented. Also simplified model of horizontal groundwater flow will be introduced for steady state and transitional groundwater flow. Groundwater pollution transport theory will contain description of principle transport mechanisms of mass in groundwater like advection, diffusion and dispersion. The principles, legal aspects and technical methods of groundwater protection will be presented. Knowledge on designing of protection zones and monitoring systems in the vicinity of groundwater intakes will be passed to students. Particular methods of protecting groundwater from leakage from waste disposal sites (mechanical and hydraulic isolation) will be detailed. Methods of polluted groundwater remediation will be presented.

Project exercises will be based on use of numerical models of flow and mass transport in subsoil. Three projects concerning the groundwater pollution will be discussed.

1. Assessment of impact waste disposal site on groundwater.
2. Hydraulic isolation of waste disposal site.
3. Inverse trajectories detection of pollutant .

The projects will aim towards developing practical skills of students in groundwater protection.

### Prerequisites

Hydrology. Engineering Hydrology and Hydrogeology. Water Protection. Water Management.

### Rules for integrated grade setting

40% of exam results + 60% of mark for guided project

### Recommended readings

Appelo., C.A.J., D. Postma, 2005. Geochemistry, Groundwater and Pollution, A.A. Balkema Publishers, Leiden.

Wood, E.F., R.A. Ferrara, W.G.Grey and G.F.Pinder, 1984. Groundwater contaminations from hazardous wastes. Prentice-Hall, Inc., Englewood Cliffs, NJ, 163 p.

Shwartz F.W. (at al), Ground Water Models. Scientific and Regulatory Applications. National Academy Press, Washington, D.C., 1990  
 Gorelick S.M, Freeze R.A., Donohue D., Keely J.F., Groundwater Contamination. Optimal Capture and Containment, Lewis Publishers, USA, 1993

### Contents of lectures (syllabus)

	Topics	Time (hrs.)	Scope (S / Ex)
1	Definitions. Variables and parameters used in hydrogeology and their physical interpretation. Importance of groundwater. Impact of human activities on groundwater resources. Sources of groundwater pollution.	2	S
2	The groundwater flow equation in 3D. Simplified model of horizontal groundwater flow for steady state and transitional groundwater flow.	4	S
3	Groundwater pollution transport theory – principle transport mechanisms of mass in groundwater like advection, diffusion and dispersion, equilibrium chemistry of aquatic subsurface systems	3	S
4	Water resources protection. Groundwater balance. Protection zones in the vicinity of groundwater intakes.	2	S
5	Groundwater remediation methods. Techniques of WDS isolation (mechanical and hydraulic isolation).	2	S
6	Case studies.	2	S
<b>Total</b>		<b>15</b>	<b>hours</b>

S – topics listed in the legal study programme standards from 12.07.2007  
 Ex – extended topics

### Lecturers

dr inż. Grzegorz Sinicyn

### Assessment method

Written test.

## Contents of guided projects

	Topics	Time (hrs.)	Scope (S / Ex)
1	Basics of groundwater modelling. Software tutorial. Examples of groundwater flow models (MODFLOW code). Examples of groundwater pollution transport models (MT3D code).	6	S / Ex
2	Project 1. Preparation a conceptual model for groundwater flow simulations. Preparation and run the flow model: calculation the groundwater heads within the model area, calculation the velocity field, calculation the groundwater budget. Calculation and designing a wellhead protection area for water intakes.	6	S / Ex
3	Project 1. Preparation and run the transport model. Calculation the concentration distribution. Simulation of remediation action (based on 'pump-and-treat' or 'hydraulic barrier' methods) which avoid the contamination of wells.	6	S / Ex
4	The calculation skills (analytic solutions): seepage to/from the aquifer with simple models, equivalent hydraulic conductivity, horizontal flow model, inverse depression cone problem, dewatering of the excavation, drawdown caused by galleries of abstracting wells.	12	S / Ex
<b>Total</b>		<b>30</b>	<b>hours</b>

S – topics listed in the legal study programme standards from 12.07.2007

Ex – extended topics

### Persons responsible for guided projects

dr inż. Grzegorz Sinicyn, mgr inż. Maria Grodzka-Łukaszewska

### Assessment method for guided projects

Assessment of projects delivered by students and defence of the project by students.