MODULE DESCRIPTION FORM 2021/2022

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

CL951 Groundwater Flow Modelling

Module Registrar: Dr. Yannick Kremer **Yannick.kremer@strath.ac.uk**	**Taught To (Course): MSc Hydrology**		
Other Lecturers Involved:	**Credit Weighting: 10**	**Semester: 2**	
Assumed Prerequisites: Groundwater hydrology, Mathematics (including basic differential equations)	**Compulsory/ optional/ elective class**	**Academic Level: 5**	**Suitable for Exchange: Y**

Module Format and Delivery (HOURS i.e. 1 credit = 10hrs of study):

Lecture	Tutorial	Laboratory	Groupwork	External	Online	Project	Assignments	Private Study	**Total**
10	20					40		50	100

Educational Aim

This class aims to guide the student

- To gain an understanding of Groundwater Flow Modelling as a discipline and to understand the role of modelling in hydrological research, groundwater management and environmental protection.
- To understand the key equations required for modelling groundwater flow and solute transport.
- To understand how a finite difference approach can be used to solve partial differential equations such as the groundwater flow equation, in a spatiotemporal domain.
- To provide an introduction to MODFLOW, an industry standard numerical code for groundwater flow modelling.
- To provide an introduction to MT3D, an industry standard groundwater solute transport simulator.
- To provide an introduction to FloPy (a Python interface to MODFLOW) and demonstrate the use of Python notebooks for interactive modelling and reporting.
- To develop groundwater flow modelling skills and understand how groundwater models can be used to refine and understand conceptual models, and to understand the limitations inherent to numerical modelling.

Learning Outcomes

On completion of the module the student is expected to be able to

LO1 The role of groundwater flow modelling within hydrogeology and consequently water resources management

LO2 The mathematical basis of groundwater flow models (Darcy's law, conservation of mass/energy, finite difference maths)

LO3 The key components of groundwater flow models and the typical workflow of groundwater flow modelling, with emphasis on application using MODFLOW.

LO4 Interpretation of groundwater flow models in a water resource management context

Syllabus

The course will be taught using a combination of (online) lectures, computer practicals and case studies. The following topics will be covered in the lectures and practicals:

- Key equations for groundwater flow modelling and contaminant transport
- Case studies applied hydrology
- Numerical modelling
- Finite difference and finite element models
- Conceptual models
- Groundwater flow models
- MODFLOW and FloPy
- Model parameter calibration and sensitivity
- Upscaling
- An introduction to Python and related tools. No prior knowledge of programming or Python is required.

N.B. the class runs over nine weeks. The class will be delivered via online/blended learning. A typical week will consist of:

- 2 to 4 mini lecture videos (10 minutes each)
- Independent reading (1-2 hours)
- Practical (2-4 hours)
- MyPlace quiz 5-10 minutes

Assessment is based on the MyPlace quizzes and independent coursework

Assessment of Learning Outcomes

Criteria

For each of the Module Learning Outcomes the following criteria will be used to make judgements on student learning:

LO1 The role of groundwater flow modelling within hydrogeology and consequently water resources management
C1 Theory of groundwater flow modelling
C2 Ability to translate conceptual model to numerical model

LO2 The mathematical basis of groundwater flow models (Darcy's law, conservation of mass/energy, finite difference maths)
C1 Implementation of finite difference scheme in spreadsheet software
C2 Demonstrate understanding of model basis in written reports

LO3 Groundwater flow modelling using MODFLOW
C1 Document the functioning and implementation of groundwater flow models using MODFLOW in written reports
C2 Successful completion of weekly assignments using MODFLOW, assessed using MyPlace quizzes

LO4 Interpretation of groundwater flow models in a water resource management context
C1 Written reports on Groundwater Flow models, interpreting case studies.
C2 MyPlace quizzes on theory and applications

The standards set for each criterion per Module Learning Outcome to achieve a pass grade are indicated on the assessment sheet for all assessment.

Principles of Assessment and Feedback

(within Assessment and Feedback Policy at: https://www.strath.ac.uk/staff/policies/academic/)

MyPlace quizzes are designed to reinforce key concepts of groundwater flow modelling and evaluate the weekly practical. The quizzes are worth 20% of the total marks and should be attempted before the deadlines indicated on MyPlace. The student will complete two written reports on applied groundwater flow modelling, this constitutes 80% of the final mark.

Assessment Method(s) Including Percentage Breakdown and Duration of Exams

	Examinations				Courseworks		Projects	
	Number	Month(s)	Duration	***Weighting***	Number	***Weighting***	Number	***Weighting***
	8 MyPlace quizzes			20%			2 written reports	80%
L/Outcomes	LO1, LO2, LO3, LO4						LO1, LO2, LO3, LO4	

Indicate which learning outcomes (LO1, LO2 etc) are to be assessed by exam/coursework/project as required.

Coursework / Submissions deadlines (*academic weeks*):
Week 8 Literature review of case studies on key topics in hydrogeology involving groundwater flow modelling.
Week 11 Report on MODFLOW model for the Dumfries basin. The model itself is created largely during the practical sessions.

Resit Assessment Procedures:
---Submission of coursework(s) prior to commencement of the August exam diet.

PLEASE NOTE:
Students must gain a summative mark of 50% to pass the module. Students who fail the module at the first attempt will be re-examined during the August diet. This re-examination will consist entirely of coursework. No marks from any previous attempts will be transferred to a new resit attempt.

Recommended Reading

*****Purchase recommended   **Highly recommended reading   *For reference**

*** Anderson, Mary P., William W. Woessner, and Randall J. Hunt. Applied groundwater modeling: simulation of flow and advective transport. Academic press, 2015. (Available online via Strathclyde Library)

Additional Student Feedback
(Please specify details of when additional feedback will be provided)

Date	Time	Room No
To be determined based on demand and lockdown measures in place		Zoom session or on Campus meeting room

Session:

Approved:

Course Director Signature:

Date of Last Modifications:

ASSESSMENT TIMETABLE

Module Code	CL951	Module Title	Groundwater Flow Modelling

Indicate in the tables below the Hand-Out (H), Submission (S) and Feedback (F) week number for each assignment (lab report/coursework/project etc) and the timing of each Exam (E), Class Test (CT) or Quiz (Q)

Semester 1

Assessment type & title	LOs	Weight (%)	Individual or Group	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period

Semester 2

Assessment type & title	LOs	Weight (%)	Individual or Group	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9	WK10	WK11	Exam Period
Weekly MyPlace quiizzes		20%		HSF	HSF	HSF	HSF	HSF	HSF	HSF	HSF	HSF			
Report 1: Literature		40%									S		F		
Report 2: MODFLOW		40%												S	F

Appendix

Mapping Module Learning Outcomes to AHEP

Assessment Title	**Engineering Council AHEP competencies**
Report 1 and 2	A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies • Graduates must have developed transferable skills, additional to those set out in the other learning outcomes, that will be of value in a wide range of situations, including the ability to: • Apply their skills in problem solving, communication, working with others, information retrieval and the effective use of general IT facilities • Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem including production, operation, maintenance and disposal • Work with information that may be incomplete or uncertain, quantify the effect of this on the design and, where appropriate, use theory or experimental research to mitigate deficiencies

Programme Threads

	Assessment Title		
Thread	**Primary**	**Secondary**	**Contributory**
Design	**X**		
Health, Safety & Risk Assessment			
Sustainability		**X**	
Professionalism, Ethics, Diversity and Inclusion		**X**	
Application of Maths to solve engineering problems	**X**		
Industrial Engagement & Site Visits			**X**
Digital Technologies	**X**		