

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE
Department of Geological Sciences
GROUNDWATER MODELING

Geology 578 -
Time: 1800-2100 Thursday
Room: Science 1231
Text: Applied Groundwater Modeling
(Anderson and Woessner, 1992)

Instructor: Dr. Tabidian
Office: Science 1232
Telephone: 677-2536
Office Hours: 0800-0930 T.Th.

A MODULAR THREE-DIMENSIONAL FINITE-DIFFERENCE GROUND-WATER FLOW MODEL (Michael McDonald and Arlen Harbaugh, 1988)

COURSE OBJECTIVES:

The primary objective of this course is to discuss the principals of finite difference methods and their applications in groundwater modeling. The emphasis of the class lectures is on the theoretical aspects of numerical modeling (finite difference method). Steps involved in simulation of groundwater systems under various initial/boundary conditions and management schemes will be practiced. The emphasis of the student presentations will be based on published papers concerning the applied aspects of groundwater computer modeling utilizing finite difference and analytical computer models.

GRADING:

Homework	20%	96-100	A	71-75	C
Seminars	40%	91-95	A-	60-70	D
MODFLOW project	20%	86-90	B+		
Final exam	20%	81-85	B		
		76-80	B-		

CONTENT OF THE COURSE

- Matrix theory
 - Definitions and principals
 - General mathematical operations
 - Thomas Algorithm for Tridiagonal Matrix
- Ordinary and partial differential equations
- Initial and boundary value problems
- Bernoulli, Continuity, and Laplace equations
- Groundwater flow equations
- Analytical versus numerical solutions
- Finite difference equations
- Explicit difference equation
- Implicit difference equation
- Crank-Nicolson equation
- Alternating-Direction-Implicit Method
- Iterative methods
- Direct methods

HOMEWORK/PRESENTATIONS:

On the average one student presentation every three weeks and one homework assignment every two weeks. A few of these homework assignments will require several hours of manual calculations. All the homework assignments will be collected, checked, and **selected ones will be graded.**

The topics of the student presentations will cover the current models/topics and published research papers in the area of application of numerical and analytical methods in groundwater and other geologic-system modeling.

SEMINAR TOPICS:

- Analytical Models
- Numerical Models
- MODFLOW (published papers)
- MODFLOW Project

Each presentation should include (depending on model): mathematical basis of the model, solution scheme, type or types of physical systems which can be simulated, required input data, required hardware/software, output results and format, advantages, limitations, examples/published papers, references, etc. Prepare a handout for each class member.

MODFLOW:

Steady state and transient simulation of a groundwater system using MODFLOW.

PRESENTATIONS

Week

ANALYTICAL MODELS:

Analytical Equations, System Type (Confined, Unconfined, etc.), Assumptions, Usefulness, Case Studies, Model Updates, Cost, Hardware/Software Requirements, etc.

4	George, Mark, Colleen
5	Joe, Rana, Eric
6	Robert, Andrew, Kevin

TWO MODFLOW PAPERS/PROJECTS:

Objective(s), Grid Design, Boundary/Initial Conditions, Hydrogeology, Inputs/Outputs, Results, Model Shortfalls, Possible Improvements, etc.

7	George, Mark, Colleen
8	Joe, Rana, Eric
9	Robert, Andrew, Kevin

NUMERICAL MODELS:

Numerical Equations/Methods, System Type (Confined, Unconfined, etc.), Assumptions, Usefulness, Case Studies, Model Updates, Cost, Hardware/Software Requirements, etc.

10	George, Mark, Colleen
11	Joe, Rana, Eric
12	Robert, Andrew, Kevin

MODFLOW PROJECT:

13	George, Mark, Colleen
14	Joe, Rana, Eric
15	Robert, Andrew, Kevin

REFERENCES

- **Anderson, M. P., and W. W. Woessner, 1992. Applied Groundwater Modeling, Academic Press.
- Appel, C. A., and T. E. Reilly, 1988. Selected Reports that Include Computer Programs Produced by the U. S. Geological Survey for Simulation of Groundwater Flow and Quantity, Water Resources Investigations Report 87-4271, 64 pp.
- Aral, M. M., 1990. Ground Water Modeling in Multilayered Aquifers (Volume I, Steady Flow and Volume II, Unsteady Flow), Lewis Publishers, Inc, 128 pp and 152 pp.
- Ayres, F., 1962. Theory and Problems of Matrices, McGraw-Hill Book Company, 219 pp.
- **Bachmat, Y. and Others, 1978. Utilization of Numerical Groundwater Models For Water Resource Management, EPA-600/8-78-012, U.S. EPA, Ada, Oklahoma.
- **Bear, J., and A. Verruijt, 1987. Modeling Groundwater Flow and Pollution, D. Reidel Publishing Company, 414 pp.
- **Gerald, C. F., 1978. Applied Numerical Analysis, Addison-Wesley Publishing Company, 518 pp.
- Ghadiri, H., 1992. Modeling Chemical Transport in Soils: Natural and Applied Contaminants, Lewis Publishers.
- Hurst, C. J., 1992. Modeling the Metabolic and Physiologic Activities of Microorganisms, John Wiley & Sons, Inc.
- **Istok, J., 1989. Groundwater Modeling by the Finite Element Method, American Geophysical Union, 495 pp.
- James, A., 1993. Introduction to Water Quality Modeling, John Wiley & Sons, Inc.
- Kazda, I., 1990. Finite Element Techniques in Groundwater Flow Studies, with Applications in Hydraulic and Geotechnical Engineering, Elsevier Science Publishing Company.
- Luckner, L. K., and W. M. Schestakow, 1991. Migration Processes in the Soil and Groundwater Zone, Lewis Publishers, Inc.
- **McDonald, M. G., and A. W. Harbaugh, 1988. A Modular Three-Dimensional Groundwater Flow Model, Book 6, Chapter A1, U.S.G.S.
- **Mercer, J. W., and C. R. Faust, 1981. Groundwater Modeling, National Water Well Association, 60 pp.
- **National Research Council, 1990. Ground Water Models, Scientific and Regulatory Applications, National Academy Press, 303 pp.
- **Pinder, G. F., and W. G. Gray, 1977. Finite Element Simulation in Surface and Subsurface Hydrology, Academic Press, 295 pp.
- **Prickett, T. A., and C. G. Lonquist, 1971. Selected Digital Computer Techniques for Groundwater Resource Evaluation, Illinois State Water Survey Division, 62 pp.

- Prickett, T. A., 1975. **Modeling Techniques for Groundwater Evaluation**, Illinois State Water Survey, 141 pp.
- **Remson, I., G. M. Hornberger, and F. J. Molz, 1971. **Numerical Methods in Subsurface Hydrology**, John Wiley & Sons, Inc., 389 pp.
- **Rosenberg, D. U., 1969. **Methods for the Numerical Solution of Partial Differential Equations**, American Elsevier Publishing Company, Inc., 125 pp.
- Scheid, F., 1968. **Theory and Problems of Numerical Analysis**, McGraw-Hill Book Company, 422 PP.
- **Unesco, 1969. **The Use of Analog and Digital Computers in Hydrology**, International Association of Scientific Hydrology and Unesco, Belgium.
- **Van der Heijde, P. and Others, 1985. **Groundwater Management: the use of numerical models**, American Geophysical Union, Water Resources Monograph 5.
- **Walton, W. C., 1989. **Numerical Groundwater Modeling, Flow and Contaminant**, Lewis Publishers, Inc.
- **Walton, W. C., 1992. **Groundwater Modeling Utilities**, Lewis Publishers, Inc.
- **Wang, H. F., and M. P. Anderson, 1982. **Introduction to Groundwater Modeling**, W. H. Freeman and Company, 237 pp.
- Willis, R., and W. W. Yeh, 1987. **Groundwater Systems Planning and Management**, Prentice-Hall, Inc., 416 pp.