

HWR 535

ADVANCED SUBSURFACE HYDROLOGY

1, Flow through Heterogeneous Variably Saturated Media

SPRING 2003

INSTRUCTOR:

Tian-Chyi Jim Yeh, Professor
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LECTURE: MWF, 11:00-11:50 a.m.

Lecture Notes and References:

- 1) Lecture notes by Yeh for HWR535. Download from www.hwr.arizona.edu/yeh/hwr535.
- 2), Srivastava, R. and T.-C. J. Yeh, A three-dimensional numerical model for water flow and transport of chemically reactive solute through porous media under variably saturated conditions, *Advances in Water Resources*, 15, 275-287, 1992.
- 3)GEO-EAS (Geostatistical Environmental Assessment Software) User's Guide, EPA.
- 4) Scale Issues in Heterogeneous Vadose Zone, Yeh, 1998.
- 5) Stochastic Fusion of Information for Monitoring and Characterizing the vadose zone, Yeh, 2002.

GENERAL OUTLINE:

1. Basic concepts in flow through saturated porous media. Continuum hypothesis in fluid mechanics, continuum approach in groundwater hydrology, REV, Darcy's law, hydraulic conductivity, specific storage, specific discharge, average linear velocity, hydraulic head, homogeneity, effective parameters, heterogeneity, anisotropy concepts, and scale issues.

2. Basic concepts in flow through unsaturated porous media. Negative pressure concept, water release curves, unsaturated hydraulic conductivity, moisture capacity, water diffusivity, moisture-dependent anisotropy, and hysteresis. Pressure and moisture content behaviors in

homogenous and heterogeneous media.

3. Stochastic Representation of Heterogeneity. Probability distribution, random variable, joint distribution, moments, autocovariance, stationary processes, non-stationary processes, realization, ensemble, ergodicity. Geostatistics (variograms, kriging, and cokriging, and their applications to subsurface hydrology.

4. 3-D Governing Groundwater Flow Equations. Three-dimensional equations for flow through variably saturated porous media, boundary and initial conditions.

5. Model Calibration and Inverse Modeling. Well/ill-posed problems. Least-squares and geostatistical approaches. Strategies for model calibration for saturated and unsaturated flow in homogeneous and heterogeneous porous media.

5. Virtual Subsurface Hydrology, Introduction to the Yeh's 3-D variably saturated flow model and graphic user interface program. Introduction to Tecplot. Generation of synthetic aquifers and vadose zones. Simulations of flow in 3-D porous media. 3-D visualization and animation of simulation results.

6. Aquifer Tests. Analysis of aquifer tests. Validity of homogeneity assumption, Proper designs for heterogeneous aquifers. Hydraulic tomography.

7. Hydrogeophysics. Introduction to electrical resistivity survey, electrical resistivity tomography, Inversion, its applications to vadose zone monitoring.

ASSIGNMENT OF GRADES:

The overall grade in the course will be determined as follows: Midterms(2) 50%, Term Project, 20% (written 10% and oral 10%), homework 10%, and Final 20%.

TERM PROJECT REQUIREMENTS:

A term project is required in this course. The project involves calibration of the Yeh's model for Avra Valley alluvial aquifer in southern Arizona. The project is a group assignment (2 to 3 students as a group). **However, each student must submit his or her own final project report. The final report is due a week before the last day of the class; the report must be well-organized, carefully written, typed and concise. A maximum length of 20 type-written (double spaced) pages is suggested. An oral presentation of the project of each group is also required.**

There will be some lab sections in to assist you to run the Yeh's flow and GEO-EAS models. Many homework assignments will involve the used of the virtual model to conduct numerical experiments.