CVEN 674: Groundwater Engineering
Spring Semester 2013
Tuesdays and Thursdays
2:20 p.m. to 3:35 p.m.
Civil Engineering Building Room 219

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Course Description and Outcomes:

Welcome to Groundwater Engineering! Managing water below the surface of the earth presents a unique engineering challenge. Not only are we working with natural systems, which are always subject to a higher degree of uncertainty than man-made ones, but we also have to work wearing a blindfold. We can never truly, deterministically characterize a hydrogeologic system, because in order to do so, we would need to drill so many wells that there would be no more "ground" to contain the water! It can be daunting to consider, but we wouldn't be engineers and scientists if we didn't enjoy a challenge, now would we?

In this course, we will first survey the fundamental science of hydrogeology, the study of the distribution and movement of water through geologic formations, i.e. soil, sediments, and rocks. We will then explore, in depth, the mathematical models of fluid flow in porous media and methods for solving these equations. They are derived from physical principles like conservation of mass and are used to describe all groundwater flow. These equations have been solved analytically for some common flow situations, like pumping wells, but we must use numerical methods to tackle complex, multidimensional ones. We also need to use statistics to quantitatively describe the uncertainty associated with the subsurface. Finally, we will use all of these tools to address practical groundwater engineering problems: characterizing the subsurface using aquifer tests, transport and remediation of contaminant, and others (as time permits).

After successfully completing this course, you should be able to accomplish the following types of engineering tasks:

- Create a conceptual model of an area's hydrogeology that can be used to guide a site investigation or engineering design project.
- Compare methods for solving groundwater flow equations under a variety of situations, selecting the most appropriate modeling techniques based on an engineering project's goals and evaluating how their weaknesses may impact the final conclusions.
- Develop a preliminary consulting report for a groundwater development or remediation project.

The TAMU course catalog has a slightly more abbreviated description. It reads, "Groundwater Engineering (3-0). Credit 3. Groundwater hydrology, theory of groundwater movement, steady-state

flow, potential flow, mechanics of well flow, multiple-phase flow, salt water intrusion, artificial recharge, groundwater contamination and models."

Course Resources:

Required Text: Todd, D. K., and Mays, L. (2005). *Groundwater Hydrology*, 3rd Edition. Wiley Interscience: Hoboken, NJ. ISBN 0-471-05937-4.

Optional Reference: Pinder, G. F. and Celia, M. A. (2006). *Subsurface Hydrology*. Wiley Interscience: Hoboken, NJ. ISBN-13: 978-0-471-74243-2. Available for free as an electronic, pdf text from the TAMU Library.

Website: Course materials will be posted on the TAMU eLearning website at http://elearning.tamu.edu. All enrolled students should have access to the site, using your Howdy logon. Auditors may request permission from me to access the site.

Prerequisites: Fluid Dynamics at the undergraduate level is required (CVEN 311 or its equivalent), unless you have my prior approval. A good foundation in calculus is also recommended, since most groundwater flow equations use differentials. Computer programming skills or some previous coursework on hydrogeology will certainly be helpful, but are not required. Please feel free to contact me if you are uncertain about your preparation for this course.

Course Grading and Policies:

Unlike sediment deposition, your success in this class is not based on a random process! The same good behavior that helped you excel in your undergraduate studies should also be applied here. Please attend lectures and actively participate in discussions, turn homework and other assignments in on-time, and keep up with the reading assignments. I will uphold my end of this implicit student-teacher contract by providing relevant and timely feedback on your completed work, attempting to give lively and interesting lectures, and leaving plenty of time for questions.

Homework will be 15% of your grade and is designed to give you practical experience handling hydrogeologic measurements and flow calculations. It will, when possible, be based on actual data sets found in the literature. Homework should be turned in during class or to my mailbox (205 WERC) by 5:00 p.m. on the day it is due (typically Fridays). Late homework will be accepted any time prior to last class of the semester, for a maximum of half-credit. Your written work should be your own, but you may consult me or your student colleagues if you are having difficulty solving a problem.

The class will visit the TAMU Hydrogeology site at a date to be determined. We will collect a number of data points, and you will be asked to analyze the results and create a brief consulting report. This report will be 10% of your grade. It may be completed individually or in a group.

One 75-minute midterm and one 120-minute final examination are scheduled, for 25% each. Makeup exams will only be given for excused absences. Another 25% of your grade will be based on your term project, which will consist of a paper and oral presentation on a groundwater related topic of your choosing.

Task	Percentage of Grade

Homework	15%
Field Report	10%
Project	20% written, 5% oral
Exam 1	25%
Exam 2	25%

Academic Integrity Statement:

"An Aggie does not lie, cheat, or steal or tolerate those who do."

As engineers, we have a strong code of ethics that we must follow, in order to ensure the safety of the public. The same is true for us in our capacity as scientists and researchers. While the results of ethical failures in research are generally less dramatic than those in engineering, they can have just as grave an impact on those involved. Texas A&M students, as part of their professional training, are expected to understand and follow the Aggie honor code, which may be found at *www.tamu.edu/aggiehonor*. The Dean of Faculties asks us to remind you that, "Upon accepting admission to Texas A&M University, a student immediately assumes a commitment to uphold the Honor Code, to accept responsibility for learning, and to follow the philosophy and rules of the Honor System. Students will be required to state their commitment on examinations, research papers, and other academic work. Ignorance of the rules does not exclude any member of the TAMU community from the requirements of the processes of the Honor System."

One common, and often unintentional, breach of the honor code occurs when students fail to understand the proper way to cite sources of text and ideas in research papers. To help prevent this, you are required to read the library tutorial on "Academic Integrity and Plagiarism" before beginning your projects (http://library.tamu.edu/help/help-yourself/using-materials-services/online-tutorials/library-tutorials/page4/). Proof of completion of the associated quiz will be required before I grade your project proposal.

ADA Statement:

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Cain Hall or call 845-1637. Students already registered with Disability Services are encouraged to contact me as soon as possible, to make appropriate arrangements.

Course Outline and Objectives:

Topics and Assigned Readings	**Learning Outcomes**
I) Understanding Hydrogeology a. Introduction: Ch 1 b. Describing aquifers: Suppl. 1 c. Fundamentals of fluids in porous media: Ch 2, Ch 3.1 - 3.5 d. Groundwater flow concepts: Ch 3.6-3.10	• Explain significance of groundwater to hydrologic cycle and engineering projects • Define properties of porous media • Solve Darcy's law for simple flow geometries • Relate properties to geologic formations
II) Mathematics of Groundwater Flow a. Mathematical formulations of flow: Suppl. 2, Ch 4.1 b. Equations for well hydraulics: Ch 4.2 - 4.10 c. Equations for aquifer testing: Ch 5	• Describe origin, function, utility, and assumptions behind equations of flow in porous media • Apply the appropriate equations and their analytical solutions to a variety of flow situations • Perform and analyze data from common aquifer tests
III) Applied Groundwater Concepts a. Numerical modeling of complex flows: Ch 9 b. Contaminant transport: Suppl. 3 c. Remediation: Ch 8 d. Topic to be decided	• Derive and use forward and backward finite difference equations for saturated flow • Simulate common groundwater flows using numerical modeling software • Predict contaminant migration and concentration in simple flow geometries • Suggest and compare methods of remediation for common situations

Course Schedule:

1/24 Project Topic Due
1/31 Homework 1 Due
2/14 Homework 2 Due
2/28 Homework 3 Due
____ Hydrogeology Site Visit
3/7 Exam 1, in class
3/11 Spring Break
3/21 Homework 4 Due
3/28 Project Drafts Due
4/4 "Consulting" Report Due
4/18 Homework 5 Due
4/23 Presentations
4/25 Presentations
____ Presentations
____ Project Final Version Due
5/8 Exam 2, 1:00 p.m. – 3:00 p.m.