Introduction

Currently, about 50% of practicing geotechnical engineers are involved to some extent in environmental geotechnics: the application of principles of the earth sciences to solve problems with the disposal and storage of wastes and remediation of polluted environments. This trend will certainly continue. Prior to the 1970's, however, waste related problems comprised only a small fraction of geotechnical engineering practice. It was not until the nuclear power industry bloomed and the crisis at Love Canal occurred that geotechnical engineers became entrenched in environmentally related problems. To ensure the safety of nuclear plants and to determine the magnitude of contamination at Love Canal, large subsurface explorations were needed to characterize sites. Since then, the role of the geotechnical engineer has expanded to numerous other areas including the design of earthen and synthetic containment systems, groundwater modeling, waste stabilization, vertical barrier walls, and clean-up of uncontrolled waste sites.

Purpose, Scope, and Approach

The purpose of this course is to teach students the fundamental aspects of geotechnical engineering that apply to problems of waste containment. I will focus on fundamental, long lasting, principles that can be employed in design. The focus will be on fundamental principles and their application to design, rather than step-by-step design procedures. The homework assignments will include design-oriented problems and activities. Many of these activities will be open-ended; however, this is the nature of design, and students will become more comfortable with these problems as the course proceeds.

Furthermore, I will avoid duplicating information that is contained in other courses. University of Maryland has a strong interdisciplinary program that covers many aspects of waste-related
problems. I suggest that students interested in pursuing a career in this area examine these courses as you further your education.

**Prerequisite Skills**

Permission of Instructor

**Useful Previous Coursework**

Students in ENCE 645 should understand and be able to work with basic principles of geotechnical engineering and environmental engineering as covered in ENCE340 and ENCE315. Students should have the capability to use calculus methods through basic differential equations. Also, basic chemistry principles (mass balance, partitioning, first-order kinetics) should be understood. The capability to use and program spreadsheets for use in analysis is also required.

**Objectives**

At the end of this course:

- Students should have a general idea about the characteristics of waste and waste-soil interaction.
- Students should have a general idea about the contaminant transport in the soil.
- Students should have the ability to analyze and design waste containment systems.
- Students should have the ability to design and evaluate in-situ containment walls constructed with soils and/or geosynthetics. Students should understand test methods and factors necessary when specifying testing procedures for design and evaluation of containment walls, and the ability to interpret test results and apply results to design.
- Students should be able to prepare design documents in a professional manner.
- Students should be able to write construction specifications based on results of analysis and design.
- Students should be able to apply engineering principles with realistic site information.

**Schedule and Office Hours**

The class will ordinarily meet on Mondays between 5pm and 7:30 pm. However, I do travel for the other responsibilities of my job and thus will miss some lectures. If necessary, these lectures will be made up at times that are acceptable to most students.

Regarding office hours, please note that there will inevitably be times during the semester when scheduled office hours conflict with faculty meetings, travel, etc. I will try to notify the students via e-mail about any changes ahead of time.

**Grading**

**Homework Assignments**
The due date for the homework assignment that is required for each unit will be specified by the instructor. Homework should be turned in at the beginning of the class on the assigned due date. Do not place homework in my mailbox or under my door. Assignments turned in late will receive no credit.
Students are expected to perform their homework neatly and in an organized fashion. Any homework which is sloppy, difficult to read, or difficult to understand will receive a reduced grade. Finally, it is the responsibility of the student to determine the correct solution of the problems, which contained errors. Solutions will be posted on the course web page.

**Exams**
Two take-home exams will be given during the semester. The dates for the exams will be announced during the semester. **Prior consent of the instructor or a doctor's certificate are the only satisfactory excuses from the exams and assignments.**

**Grading Scheme**
Grades will be based according to the following scheme:

*Exams, each 25%*

*Homework Assignments 50%*

It should be noted that the effort a student puts into performing and understanding the homework is often reflected in the student's performance on the exams.

**Reading Assignments**
Various journal/conference papers will be handed in during the class. Students are responsible for all material in the assigned readings. The material readings cover will not necessarily be discussed in detail in the lecture.

**Special Arrangements**
If you observe a religious holiday and would like to ask for a change in your schedule, please inform me at least a week ahead of it. Also I will make every effort to accommodate you if you need a special arrangement due to your disability.

**SCHEDULE FOR ENCE 645**

**GEOTECHNICS OF WASTE DISPOSAL**

**I. Introduction and Basic Principles**
- Containment Systems
- Lining and Capping Systems
- Clay Mineralogy

**II. Contaminant Transport**
- Basic Principles of Transport
- Advection-Diffusion, Dispersion Equations
- Transport Parameters
- Transport Through Clay and Geosynthetic Liners
III. Designing Landfill Liners

Hydraulic Conductivity of Compacted Soils
• Factors Controlling Hydraulic Conductivity
• Methods to Measure Hydraulic Conductivity in Lab
• Differences Between Lab & In Situ Hydraulic Conductivity
• Test Pads and Field Hydraulic Conductivity Measurements
• Construction Quality Assurance

Geosynthetic Liners
• Leakage, Transport, Structural Stability
• Construction

Waste Compatibility
• Factors Affecting Compatibility
• Compatibility Testing

Settlement of Landfills

IV. Leachate Collection Systems & Leak Detection Systems

Synthetic vs. Earthen Systems
• Clogging
• Filters vs. Drains

Detection Systems

V. Gas Collection Systems

Gas Generation and Composition
Types and Components
Design of Gas Collection Systems

VI. Covers and Caps

Resistive Barrier Design

Water Balance Design

Alternative Cover Design
• Backfill Design
• Stability