

Western University - Faculty of Engineering
Department of Civil and Environmental Engineering

CEE 4479/9890 - Subsurface Contamination by
Hazardous Industrial Chemicals

Course Outline 2018/2019

This course deals with subsurface contamination by hazardous industrial liquids such as PCB oils, gasoline, jet fuel, chlorinated solvents and coal tars. These compounds represent some of the most prevalent, toxic, and recalcitrant subsurface pollutants throughout the industrialized world. The fundamentals of multiphase/multicomponent flow and transport will be outlined followed by specific treatment of both denser-than-water and lighter-than-water non-aqueous phase liquids (DNAPLs and LNAPLs). The course will examine the fate of these contaminants in water, oil, and vapour phases and their subsurface distribution in both unconsolidated aquifers and fractured rock systems. Relevant analytical and numerical models are employed to better understand the concepts, their application, and the underlying mathematics. As well, the course covers field applications, including site investigation techniques as well as innovative clean-up technologies.

The objectives of the course are:

- Develop an understanding of the history, prevalence, sources, and regulatory framework surrounding industrial organic chemicals in the subsurface.
- Demonstrate knowledge of the range of compounds considered LNAPLs and DNAPLs., and the properties of the subsurface fluids (air, water, and contaminants) that influence the fate of these compounds in the subsurface.
- Recognize the differences that various subsurface environments (e.g., aquifers, aquitards, fractured bedrock) have on the fate of industrial chemicals.
- Solve mathematical relationships that describe multiphase flow in the subsurface and the partitioning of industrial liquids to other phases (vapour, soil, groundwater).
- Utilize mathematical and numerical modelling to investigate properties and problems related to the behaviour of these compounds.
- Demonstrate knowledge of established and innovative methods for site characterization and contaminant mapping and monitoring.
- Develop appreciation for a variety of established and innovative remediation techniques, both the processes that underpin them as well as their application;
- Explore how science, ethics, economics, and politics intersect to influence environmental policy and cleanup drivers.
- Appreciate the need for self-directed study and lifelong learning with respect to environmental issues and technologies.

Calendar Copy:

This course deals with soil and groundwater contamination by organic industrial liquids. Multiphase flow through porous media will be covered, linking key physics and chemistry to contaminant behaviour in the field. Relevant analytical and numerical models are employed. Practical aspects covered include site investigation techniques and innovative clean-up technologies.

Prerequisites:

For 4479 Students: CEE 3386a/b Numerical Modeling for Environmental Engineers

For 9890 Students: An upper year course in Groundwater Flow & Contaminant Transport

In exceptional circumstances, by permission of the instructor.

Corequisites:

None.

Antirequisites:

None

Note: It is the **student's responsibility** to ensure that all Prerequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the **student's responsibility** to ensure that he/she has not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards his/her degree if he/she violates the Prerequisite, Corequisite or Antirequisite conditions.

Contact Hours:

3 Lecture hours, 1 Tutorial hour

(average recommended additional personal study: 4-6 hrs/wk).

Instructor:

J.I. Gerhard, Ph.D., P.Eng.,

Canada Research Chair in Geoenvironmental Restoration Engineering

Spencer Engineering Building Room 3029

Email: jgerhard@eng.uwo.ca

Textbook:

None required. Comprehensive notes will be developed during the class. Readings will be provided.

General Learning Objectives

E=Evaluate, T=Teach, I=Introduce

Problem Analysis	E	Team Work		Ethics and Equity	T
Investigation	T	Communication	E	Economics and Project Management	
Design	T	Professionalism	I	Life-Long Learning	I
Engineering Tools	E	Impact on Society	T	Knowledge Base	E

Course Schedule:

<u>Date</u>	<u>Lecture Topic</u>
Week 1	Course outline, introduction, historical legacy
Week 2	NAPL physical properties
Week 3	NAPL chemical properties
Week 4	Capillary pressure
Week 5	Reading Week
Week 6	Relative permeability
Week 7	Phase Partitioning
Week 8	DNAPL pools and multiphase flow equations
Week 9	DNAPL modelling and field behaviour
Week 10	Site investigation and assessing DNAPL presence
Week 11	Site remediation introduction
Week 12	Remediation presentations
Week 13	Remediation presentations & Review

Assignments and Project:

Assignments will be distributed approximately every two weeks throughout the course. Tutorials will provide an opportunity to discuss tutorial questions that have been attempted in advance of the tutorial. Questions will be of a similar type to those on the midterm and exam.

All students will complete a mini project.

Graduate students will, in addition, conduct a research project and present their findings via an oral presentation to the class on a specialized topic relevant to the course.

Evaluation:

The final course mark will be determined as follows:

4479

Assignments	10%
Mini-project	20%
Midterm	20%
Final examination	50%

9890

Assignments	10%
Mini-project	15%
Project	15%
Midterm	10%
Final examination	50%

Examination and Tests

One 1.5-hr midterm. Date and Location: TBA

One 3-hr final examination. Date and location: TBA

The Midterm and Final Examinations are Closed Book. Only approved (non-programmable) calculators are allowed (see list posted outside Civil Engineering Office). No other external sources of information, including books, notes or crib sheets, are permitted. A reference list of equations will be provided with both midterm and final exams, and will be posted one week before each exam.

- Note:
- (a) **Students must pass the final examination to pass this course.** Students who fail the final examination will be assigned the aggregate mark, as determined above, or 48%, whichever is less.
 - (b) **Students must turn in all individual assignments and projects to pass this course.** Students who do not satisfy this requirement will be assigned 48% or the aggregate mark, whichever is less.
 - (c) **Students who have failed this course previously must repeat all components of the course.** No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted.
 - (d) Should any of the classes conflict with a religious holiday that a student wishes to observe, the student must inform the instructor of the conflict no later than two weeks before the scheduled class.
(For further information on Accommodations for Religious Holidays see http://www.uwo.ca/univsec/handbook/appeals/accommodation_religious.pdf)

Units:

SI units will be used in lectures and examinations.

Use of English:

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Attendance:

Any student, who, in the opinion of the instructor, is absent too frequently from class or laboratory periods in any course, will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular examination in the course.

Plagiarism:

Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage from a source, they must acknowledge that source by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).

All required papers or essay-style submissions may be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use

of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (<http://www.turnitin.com>). For numerical submissions, teaching assistants will be checking for evidence of copying; excessive similarity between assignments will be taken as evidence of plagiarism at the discretion of the course instructor.

Scholastic Offences (Cheating):

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties that might include expulsion from the program. If you are caught cheating, there will be no second warning. Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf

Attendance:

Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Accessibility:

Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

Conduct:

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Late comers may be asked to wait outside the classroom until being invited in by the Instructor. Please turn off your cell phone before coming to a class, tutorial, quiz or exam.

On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: <http://www.uwo.ca/univsec/board/code.pdf>

Sickness and Other Problems:

Students should immediately consult with the Instructor or Department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor or Department Chair regarding how best to deal with the problem. Failure to notify the Instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, please see:

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_illness.pdf

Notices:

Students are responsible for regularly checking their email, course website (<https://owl.uwo.ca>) and notices posted outside the Civil and Environmental Engineering Department Office

Consultation:

Students are encouraged to discuss problems with their teaching assistant and/or instructor in tutorial sessions. Office hours will be arranged for the students to see the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the appropriate instructor.

Accreditation (AU) Breakdown

Engineering Science = 75 %

Engineering Design = 25 %

Total AU's (57.3) = 100 %

The document "*Instruction for students unable to write tests or examinations or submit assignments as scheduled*" IS ATTACHED AND IS PART OF THIS COURSE OUTLINE