Course Description

Contaminant hydrogeology focuses on groundwater flow and contaminant fate and transport with the goal to assess and remediate subsurface soils and groundwater. This course relies on background knowledge in water resources engineering and contaminant transport. The course will develop conceptual and numerical skillset in contaminant hydrogeology.

Course Learning Outcomes (CLOs)

By the end of the course, you will be able to:

1. Apply the basic concepts of groundwater flow and contaminant fate and transport
2. Solve the advective velocity of contaminants in the subsurface
3. Solve the concentrations of contaminants in the subsurface under different fate and transport processes such as diffusion, dispersion, adsorption, decay, microbial degradation, etc.
4. Calculate the flow and transport processes in the unsaturated zone; estimate travel times in the unsaturated zone
5. Apply the basics of numerical modelling including the need for boundary conditions and initial conditions, and limitations of numerical modelling to model subsurface systems
6. Solve the flow and transport processes in a multiphase system in which a non-aqueous phase liquid like gasoline or a solvent is released in the subsurface
7. Evaluate the geology, hydrogeology and chemical components of a contaminated site to develop a conceptual model
8. Compare and contrast the processes and goals of different remediation technologies used to clean up contaminated sites
9. Design plans and processes to characterize and remediate contaminated sites
Graduate Attributes (GAs)
The Canadian Engineering Accreditation Board (CEAB) requires graduates of undergraduate engineering programs to possess 12 attributes. Courses in all four years of our programs evaluate students' progress towards acquiring these attributes. Aggregate data (typically, the data collected in all sections of a course during an academic year) is used for accreditation purposes and to guide improvements to our programs. Some of the assessments used to measure GAs may also contribute to final grades; however, the GA measurements for individual students are not used to determine the student's year-to-year progression through the program or eligibility to graduate. This following list provides the GAs that will be measured in this course, along with the Learning Outcomes that are intended to develop abilities related to these attributes.

GA 1.11.C Discipline-specific concept; Water Resources/Contaminant Hydrology
GA 2.1 Problem Analysis; Problem definition
GA 2.2 Problem Analysis; Approach to the problem
GA 2.3 Problem Analysis; Use of assumptions
GA 2.4 Problem Analysis; Interpreting the solution – validity of results
GA 5.1 Engineering Tools; Diagrams and engineering sketches
GA 5.3 Engineering Tools; Tools for design, experimentation, simulation, visualization and analysis
GA 5.5 Engineering Tools; Limitations of such tools and the assumptions inherent in their use

Lecture Notes
Blank lecture notes will be posted on Brightspace prior to starting a chapter. The notes are designed to supplement lectures, but do not represent the complete content of the course (for that you should attend the lectures). Some sections of the notes are left blank. We will fill them throughout lectures. Please be prepared to fill in your notes by hand, tablet, computer, or any approach you find works best for you. Completed notes will be released intermittently on the course website. Recorded lectures will NOT be provided by the instructor and students do NOT have permission to record lectures.

Course Communication
All class-wide communications will be posted on the news page of Brightspace and announced in class. You are welcome to email me with any questions, but emails should be used for important and/or time sensitive matters. Please start your email subject “ENVE 4006 F23 –” then your subject. This will ensure a more rapid response. All blank notes, assignments, PA session problems, dropboxes, etc. will be posted to Brightspace.

PA Sessions
PA sessions will be run by teaching assistants (TAs), starting Week 2 or 3 (to be announced). During these sessions, TAs will solve example problems that help you prepare for assignments and exams. The PA session will also be your TA’s office hour when they will answer your questions. Attending PA Session is not mandatory but highly recommended. I reserve the right to provide new material in PA sessions and lectures. Note, the midterm will be held during the PA session time.
### Outline of Course Topics and Progression

Please know the approximate weeks are subject to change:

<table>
<thead>
<tr>
<th>Week* (approximate)</th>
<th>Assessments</th>
<th>Lecture number</th>
<th>Anticipated Topic*</th>
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<tbody>
<tr>
<td>1</td>
<td>Biosheet bonus due</td>
<td>1</td>
<td>Welcome and Chapter 1 - Introduction</td>
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<td>2</td>
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<tr>
<td>2</td>
<td>Assignment 1 release</td>
<td>3</td>
<td>Chapter 2 - Groundwater flow and wells</td>
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<tr>
<td>3</td>
<td>Assignment 1 due</td>
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<td>Chapter 3 - Unsaturated groundwater flow</td>
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<tr>
<td>4</td>
<td>Assignment 2 release</td>
<td>7</td>
<td>Chapter 3 - Unsaturated groundwater flow</td>
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<td>8</td>
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<tr>
<td>5</td>
<td>Assignment 2 due</td>
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<td>Chapter 4 - Contaminant transport</td>
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<tr>
<td>6</td>
<td>Assignment 3 release</td>
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<td>Chapter 4 - Contaminant transport</td>
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<tr>
<td>7</td>
<td>Assignment 3 due</td>
<td>13</td>
<td>Chapter 5 – Numerical modeling</td>
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<tr>
<td>8</td>
<td>Midterm (in PA)</td>
<td>15</td>
<td>Chapter 5 – Numerical modeling</td>
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<tr>
<td>9</td>
<td>Assignment 4 release</td>
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<td>Chapter 6 - Multiphase flow and contaminants</td>
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<td>Chapter 6 - Multiphase flow and contaminants</td>
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<tr>
<td>11</td>
<td>Assignment 5 release</td>
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<td>Chapter 7 – Remediation</td>
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<tr>
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<td>Assignment 5 Due</td>
<td>23</td>
<td>Chapter 7 – Remediation</td>
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* Subject to change. I reserve the right to revise as the course progresses.

### Reference Materials (optional)

The following textbooks are good references for this course. Please note that it is **NOT** necessary to purchase these books.

- Freeze and Cherry, Groundwater, 1979, available through the Groundwater Project ([https://gw-project.org/books/groundwater/](https://gw-project.org/books/groundwater/))
- Fetter, Contaminant Hydrogeology, 1997
Assessment

**Students in ENVE 4006 (undergraduate)**

<table>
<thead>
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<th>Assessment</th>
<th>Weight</th>
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<tr>
<td>2. Midterm</td>
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<tr>
<td>3. Final exam</td>
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<tr>
<td>Bonus Biosheet</td>
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**Students in ENVE 5301 (graduate)**

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<tbody>
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</tr>
<tr>
<td>2. Midterm</td>
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<tr>
<td>3. Final exam</td>
<td>45%</td>
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<tr>
<td>4. Final project</td>
<td>15%</td>
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</table>

**Brief descriptions:**

**Assignments:**
To aid your mastery of the course concepts, problems will be assigned as 5 assignments. Doing the assignments will help prepare you for exams. Marks are awarded for a complete and proper writing of the solution (including units, assumptions, conclusion statements, etc.), not just the right answer. Assignments should be submitted on Brightspace in 1 file in acceptable format (PDF). If excel or coding software is used, you must include the files, but all the information must be found in the PDF. If not, the TA will not give you marks.

**Midterm:**
A midterm will be held during the term (approximately Week 6 or 7 during PA sessions). It will be a closed book (formula sheet will be provided). Midterm will be proctored by the teaching team. Marks are awarded for a complete and proper writing of the solution (including units, assumptions, conclusion statements, etc.), not just the right answer. All students must achieve a mark of 35% or higher to pass the course and be eligible to write the final exam.

**Final Exam:**
This course has a three-hour final exam (to be scheduled in final exam period) which will be an individual, closed-book test on all chapters. Marks are awarded for a complete and proper writing of the solution (including units, assumptions, conclusion statements, etc.), not just the right answer. Please note:

i) Final exams are for evaluation purpose and will not be returned to students.

ii) Students who are unable to write the final examination because of a serious illness/emergency or other circumstance beyond their control may apply for accommodation by contacting the Registrar’s office. Consult the Section 4.3 of the University Calendar. Distance exams are not approved by the instructor.
Biosheet Bonus (for undergraduate student only in ENVE 4006):
Provide a one-page Biosheet with the following components:

- A photo of yourself
- Your name and preferred name (if applicable)
- Hometown
- Favorite course
- Reason for choosing your discipline of engineering
- Work experience (it’s okay, if you don’t have much. You could also talk about interesting projects you’ve done in school)
- Career Aspiration once graduated

The format is up to you. Please note, the biosheet must be submitted by the detailed due date or you will not receive the bonus marks. Pass/fail basis.

Final Project (only for graduate students in ENVE 5301):
Graduate students in ENVE 5301 will also be required to submit a project; details will be provided at a later date. Project will be due on the last day of classes.

Missed Term Work
Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for alternate arrangements with the instructor and in all cases, this must occur no later than three (3) calendar days after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. The accommodation provided will be shifting the weight to the final exam, only if a self-declaration form has been received within 3 calendar days. To request academic consideration for a missed assessment, please submit a “Self-Declaration Form” (found here) to me with 3 calendar days. Consult Section 4.4 of the University Calendar.

Late Submission Policy
Without a valid or recognized accommodation or if no self-declaration form is submitted within 3 calendar days, a penalty of 10% per day will be given for all assessments (this, of course, does not apply to the midterm and final exam which are given 0 if missed). For assignments, late submissions are not accepted after the solution set is posted and will result in a grade of zero, unless appropriate documentation is provided.

Appeals
Please bring any grading appeals to my attention within 5 calendar days of grades being posted. Please write a brief description of your concern and submit to me. I will then review and discuss with you, if needed. Teaching Assistants will not change any marks. These concerns must be directed to the instructor.
Course Material Copyright

Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors, guest lecturers and students, are copyright protected and remain the intellectual property of their respective author(s). All course materials, including notes, outlines, recordings, and other materials, are also protected by copyright and remain the intellectual property of their respective author(s).

Students registered in the course may take notes and make copies of course materials for their own educational use only. Students are not permitted to record lectures on their own. Students are not permitted to reproduce or distribute lecture notes, recordings, and course materials publicly for commercial or non-commercial purposes without express written consent from the copyright holder(s).

Academic dates

Students should be aware of the academic dates (e.g., last day for academic withdrawal) posted on the Registrar's office web site [https://carleton.ca/registrar/registration/dates/academic-dates/](https://carleton.ca/registrar/registration/dates/academic-dates/)

Academic Integrity

The University Academic Integrity Policy defines plagiarism as “presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one’s own.” This includes reproducing or paraphrasing portions of someone else’s published or unpublished material, regardless of the source, and presenting these as one’s own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, art works, laboratory reports, research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet and/or conversations.

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another’s data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one’s own; and
- failing to acknowledge sources through the use of proper citations when using another’s work and/or failing to use quotations marks.

Plagiarism is a serious offence that cannot be resolved directly by the course’s instructor. The Associate Dean of the Faculty conducts a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They can include a final grade of “F” for the course or even suspension or expulsion from the University.
Final Grades
Standing in a course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean.

Course Completion
Please take careful note of Section 5.1 of the Academic Regulations in the Undergraduate Calendar (https://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/grading/#credit): “To obtain credit in a course, students must satisfy the course requirements as published in the course outline.”

Addressing Human Rights Concerns
The University and all members of the University community share responsibility for ensuring that the University’s educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the Department of Equity and Inclusive Communities at equity@carleton.ca.

We will strive to create an environment of mutual respect for all through equity, diversity, and inclusion within this course. The space which we work in will be safe for everyone. Please be considerate of everyone’s personal beliefs, choices, and opinions.

Academic Accommodation
Students with diverse learning styles and needs are welcome in this course. You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows. For more information, please consult: http://students.carleton.ca/course-outline

  Pregnancy Obligation
  Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please consult: http://students.carleton.ca/course-outline

  Religious Obligation
  Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please consult: http://students.carleton.ca/course-outline

  Accommodations for Students with Disabilities
  The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity
Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). Requests made within two weeks will be reviewed on a case-by-case basis. After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (http://www.carleton.ca/pmc) for the deadline to request accommodations for the formally scheduled exam (if applicable).

Survivors of Sexual Violence
As a community, Carleton University is committed to maintaining a positive learning, working, and living environment where sexual violence will not be tolerated, and survivors are supported through academic accommodations as per Carleton’s Sexual Violence Policy. For more information about the services available and to obtain information about sexual violence and/or support, please visit: http://www.carleton.ca/sexual-violence-support

Accommodation for Student Activities
Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more information, please consult: http://students.carleton.ca/course-outline

Engineering Academic Advising
The Engineering Academic Support Service assists undergraduate engineering students with course selection, registration, and learning support from first year through to graduation. Academic Advisors Contact can be found here: https://carleton.ca/engineering-design/current-students/undergrad-academic-support/undergraduate-advisors/.

Mental Wellness
If you find yourself suffering during this or any other term from anxiety, stress, or issues related to mental health, this is nothing to be ashamed of. It is highly recommended that you seek help; refer to Counselling Services. You are also welcome to reach out to me to discuss on-campus resources.

If you need to talk to someone from the department for more information and support with connecting to resources, you can contact the following faculty members, depending on your program. Or contact the department at or CEEUGChair@cunet.carleton.ca.

ACSE: Prof. Scott Bucking
Email: scott.bucking@carleton.ca, Office: 5209 Canal Building
Here is a list of on-campus and off-campus resources:

1. **Carleton’s Health and Counselling Services**: To book an appointment contact the main clinic by calling (613) 520-6674. If urgent, let the Patient Care Coordinator know or go in person to the main clinic (2500 Carleton Technology and Training Centre Building) and indicate that they are in crisis and need to speak to someone right away. For more information, please see https://carleton.ca/health/

2. **Emergencies and Crisis and Emergency Numbers**

3. **Good2Talk (1-866-925-5454)**: Good2Talk is a free, confidential helpline providing professional counselling and information and referrals for mental health, addictions and well-being to post-secondary students in Ontario, 24/7/36 https://good2talk.ca/

4. **Empower Me**: Undergraduate students have access to free counselling services in the community through Empower Me, either in person, by telephone, video-counselling or e-counselling. This free service is accessible 24/7, 365 days per year. Call 1-844-741-6389 (toll free) to make an appointment with a counsellor in the community. More information is available https://students.carleton.ca/services/empower-me-counselling-services/

5. **The Walk-In Counselling Clinic (off-campus community resource)**: The walk-in Counselling Clinic have offices in various locations across Ottawa and the greater Champlain region that are open 7 days a week. Individuals will be assisted, with no appointment, on a first-come, first-serve basis during the Walk-in Counselling Clinic hours. The Walk-in Counselling Clinic offers services in many languages and is free and confidential. More information can be found at: https://walkincounselling.com/


7. **Distress and Crisis Ontario, Available for chat 2 pm – 2 am EST.** https://www.dcontario.org/

8. **BounceBack Ontario (Toll-Free: 1-866-345-0224)** is a free skill-building program managed by the Canadian Mental Health Association (CMHA). It is designed to help adults and youth 15+ manage low mood, mild to moderate depression and anxiety, stress or worry. Delivered over the phone with a coach and through online videos, you will get access to tools that will support you on your path to mental wellness. https://bouncebackontario.ca/.