1 INSTRUCTIONAL SUPPORT

1.1 Instructor
Instructor: Beth Parker, Ph.D.
Office: RICH 3503, ext. 53642
Email: bparker@uoguelph.ca
Office hours: TBA on CourseLink or by appointment

2 LEARNING RESOURCES

2.1 Course Website
Course material, news, announcements, and grades will be regularly posted to the ENGG*6910 CourseLink site. You are responsible for checking the site regularly.

2.2 Required Texts
There is no assigned text for this course.

2.3 Recommended Texts


2.4 Additional Resources

Lecture Notes: Lecture notes will be posted on CourseLink at least one day prior to the lecture. You are expected to have access to these for each class.

Assigned Readings: All assigned and supplementary reading material will be posted on CourseLink at least one week before each class. Students are expected to download and read each assigned paper prior to class and come prepared for a critical discussion of the papers.

3 ASSESSMENT

3.1 Dates and Grade Distribution

Class Discussion/Participation – 15%

Students are expected to have read the assigned readings for each lecture before class and participate in the discussion period that follows the lecture. For each of the assigned readings, one student will be selected at random (draw) to present the key findings and insights of one of the assigned papers. The assigned readings are listed at the end of this document and can be found electronically on the CourseLink site.

Critical Literature Reviews – 25%

Students will read the assigned literature for each lecture (typically 2-3 papers) and prepare a one to two page (double spaced) critical review. These reviews must refer to the assigned literature and are to be submitted online (on CourseLink) by midnight of the due date. This submission should include a 1-2 page review for each topic covered during the week (3 topics) for a total of 3-6 pages. Specific or general questions will be provided and posted on CourseLink along with the assigned readings. Students can bring a first draft of the review to class to aid in the discussion if they desire.

Due Dates
Lecture 1, 2, 3 - May 25, 2015
Lecture 4, 5, 6 - June 8, 2015
Lecture 7, 8, 9 - June 15, 2015
Lecture 10, 11, 12 - June 22, 2015
Lecture 13, 14, 15 - June 29, 2015

Assignments – 60%

Two assignments will be posted on CourseLink and students are expected to complete and submit the assignment online on the following dates:

Due Dates
Assignment 1 - June 10, 2015
Assignment 2 - June 24, 2015
3.2 Course Grading Policies

When You Cannot Meet a Course Requirement: When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course in writing, with your name, id#, and e-mail contact. See the graduate calendar for information on regulations and procedures for Academic Consideration:

https://www.uoguelph.ca/registrar/calendars/graduate/2014-2015/genreg/sec_d0e1810.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:

https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing Grade: In accordance with the policies of the Office of Graduate Studies, the minimum grade required to pass the course is 65%

4 Aims & Objectives

4.1 Course Description

This course will examine the nature, behavior and fate of contaminants in fractured geologic media including fractured clayey (non-indurated) deposits and bedrock. There will be emphasis on organic contaminants that are commonly found in groundwater such as chlorinated solvents, however, the principles are relevant to all groundwater contaminants. The behavior of non-aqueous phase liquids (NAPLs) will also be examined. The goal of this course is to familiarize graduate students with concepts and principles guiding our current understanding of groundwater flow and contaminant transport in fractured media. Field case studies, laboratory experiments and the scientific literature will be used to illustrate how the concepts/processes apply in the diagnosis of real site conditions and the implications for site monitoring and remediation design. The course will include: discussion of field methods and approaches, both conventional and research techniques; use of multiple working hypotheses; and how to resolve competing interpretations and examine the role of developing and testing of site conceptual models. Students should gain an appreciation of the current state of knowledge and research directions with emphasis on scales of measurement, complementary field and laboratory techniques for discerning processes most relevant to studying the field occurrence of point source contamination.

Fractured media include sedimentary bedrock such as sandstones, mudstones, shales, dolostones and limestones or crystalline rocks such as basalts, granites, gneiss and schists. Fractured media also include many low-permeability clayey or silty aquitards and insights from field studies in both clay and rock will be discussed in terms of similarities and differences in matrix and fracture characteristics. Most of the literature concerning subsurface contaminant transport and fate pertains to porous media (i.e. granular geologic deposits), however, groundwater contamination of fractured media is becoming better differentiated from porous media as these systems are becoming increasingly important in Canada and elsewhere around the globe with respect to proper design of solid, industrial and nuclear waste management options, groundwater for water supply and aquifer protection against natural and anthropogenic contaminants.
4.2 Course Aims

This course is an advanced, graduate level, course dealing with the important concepts associated with groundwater flow in fractured rock and field methods for characterizing groundwater flow and quantifying transport in fractured bedrock at both the borehole and flow system scales. The main goals of the course are (1) to develop an intuitive understanding of processes and their interactions dominating groundwater flow and transport (solute, viruses, etc.) in fractured geologic media and (2) to understand the various methods for quantifying these processes at real field sites, including standard practice and new, innovative methods and where/when/why they should be used.

4.3 Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability to:

1) Characteristics for distinct fractured rock systems (rock types) for groundwater flow, velocities and transport processes influencing contaminant mobility and fate.

2) Determine how Geology can provide insights to Hydrogeology conditions once the two data types are calibrated at a particular site.

3) Understand how hydraulic head profiles are essential for identifying hydrologic units and the flow system to inform contaminant pathways and receptors

4) Understand how single and cross-borehole logging data sets (geophysics and hydrophysics) inform 3-D fracture network connectivity and system parameters (T &S).

5) Apply the use of contaminants and other tracers for informing our interpretation of site conditions

6) Know the importance of Site Conceptual Models to integrate site data sets/interpretations and inform hydrogeology decision making.

7) Review field, laboratory and modelling (including software) tools/techniques for fractured rock characterization and monitoring.

4.4 Instructor’s Role and Responsibility to Students

The instructor’s role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on CourseLink/D2L but these are not intended to be stand-alone course notes. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and project.

4.5 Students’ Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and tutorials. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

E-mail Communication: As per university regulations, all students are required to check their <uoguelph.ca> email account regularly: e-mail is the official route of communication between the University and its students.
4.6 Relationships with other Courses

This course assumes the student has had other graduate courses on groundwater flow and contaminant transport and has a firm grasp of physical hydrogeology principles (undergraduate course in groundwater at the third or fourth year level). The complementary course offered in alternative years is focused on Aquitards (lower permeability formations) and this course focuses on fractured rock aquifers and contaminant behaviour in these systems.

5 Teaching and Learning Activities

5.1 Timetable

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Date</th>
<th>Time</th>
<th>Topic</th>
<th>Lecturer</th>
<th>Room Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tues, May 19</td>
<td>9am-12pm</td>
<td>Intro to Fractured Network Characterization Contaminant Transport PM vs. Fractured Media DNAPL Flow in Fractures &amp; Case Study</td>
<td>Parker</td>
<td>THRN 1006</td>
</tr>
<tr>
<td>2</td>
<td>Wed, May 20</td>
<td>9am-12pm</td>
<td>Use of models to build insights into solute transport in fractured rock / Craflush tutorial</td>
<td>Parker</td>
<td>THRN 1006</td>
</tr>
<tr>
<td>3</td>
<td>Thur, May 21</td>
<td>1pm-4pm</td>
<td>DFN Methods and Core DFN Hydraulic and borehole dilution testing</td>
<td>Wealthall</td>
<td>THRN 1006</td>
</tr>
<tr>
<td>4</td>
<td>Mon, May 25</td>
<td>9am-12pm</td>
<td>Hydrogeophysics Methods in Boreholes Distributed Temperature Sensing Methods in Boreholes Multi Level Systems and Flow Characterization</td>
<td>Pehme</td>
<td>THRN 1006</td>
</tr>
<tr>
<td>5</td>
<td>Tues, May 26</td>
<td>9am-12pm</td>
<td>Hydrobench/Fracman Workshop</td>
<td>Tom Doe</td>
<td>THRN 1006</td>
</tr>
<tr>
<td>6</td>
<td>Wed, May 27</td>
<td>9am-12pm</td>
<td>Nature of Fluid Flow in Fractures Remediation Technologies in Fractured Rock Flow and Transport SCM for Sed. Bedrock Aquifers</td>
<td>Dickson, Wealthall, Parker</td>
<td>THRN 1006</td>
</tr>
</tbody>
</table>

5.2 Other Important Dates

Drop Date: The last date to drop this one-semester course, without academic penalty, is Thursday, July 3rd. Refer to the Graduate Calendar for the schedule of dates: https://www.uoguelph.ca/registrar/calendars/graduate/current/sched/sched-dates-w11.shtml
6 LAB SAFETY

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

7 ACADEMIC MISCONDUCT

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community – faculty, staff, and students – to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection. The Academic Misconduct Policy is detailed in the Graduate Calendar:

https://www.uoguelph.ca/registrar/calendars/graduate/2014-2015/genreg/sec_d0e2097.shtml

7.1 Resources

A tutorial on Academic Misconduct produced by the Learning Commons can be found at:
http://www.academicintegrity.uoguelph.ca/

The School of Engineering has adopted a Code of Ethics that can be found at:
http://www.uoguelph.ca/engineering/undergrad-counselling-ethics

The Graduate Calendar is the source of information about the University of Guelph’s procedures, policies and regulations which apply to graduate programs:
http://www.uoguelph.ca/registrar/calendars/graduate/current/

8 ACCESSIBILITY

The University of Guelph is committed to creating a barrier-free environment. Providing services for students is a shared responsibility among students, faculty and administrators. This relationship is based on respect of individual rights, the dignity of the individual and the University community's shared commitment to an open and supportive learning environment. Students requiring service or accommodation, whether due to an identified, ongoing disability for a short-term disability should contact the Student Accessibility Services as soon as possible. For more information, contact SAS at 519-824-4120 ext. 56208 or email csd@uoguelph.ca or see the website: http://www.uoguelph.ca/csd/
9 RECORDING OF MATERIALS

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

10 RESOURCES

The Academic Calendars are the source of information about the University of Guelph’s procedures, policies and regulations which apply to undergraduate, graduate and diploma programs:
https://www.uoguelph.ca/registrar/calendars/graduate/current/

11 PRELIMINARY ASSIGNED READING LIST

Lecture 1 - Introduction to Fracture Network Characterization


Lecture 2 - Contaminant Transport: Porous Media vs. Fractured Media


Lecture 3 - DNAPL Flow in Fractures & Case Studies


Lecture 4 - Use of models to build insights into solute transport in fractured rock / Craflush tutorial


Lecture 5 - DFN Methods and Core DFN


Lecture 6 - Hydraulic and Borehole Dilution Testing


Lectures 7, 8, and 9 - Hydrobench/FracMan workshop
Readings TBA - Please check CourseLink for current information

Lecture 10 - Hydrogeophysical Methods in Boreholes


Lecture 11 - Distributed Temperature Sensing in Boreholes


Lecture 12 - Multilevel Systems and Flow Characterization


**Lecture 13 - Nature of Flow in Fractures**


**Lecture 14 - Remediation Technologies in Fractured Rock**

Readings TBA - Please check CourseLink for current information

**Lecture 15 - Flow and Transport SCM for Sedimentary Bedrock Aquifers**