

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

**CEE 4465a – Environmental Design for Waste Disposal**  
**- Course Outline 2023/24**

This course is an advanced course in environmental design for waste disposal and includes a complete preliminary design of a landfill facility. The objectives of the course are for the students:

- To develop an understanding of modern waste management practice and the role of landfilling in this context.
- To recognize the wide range of technical and non-technical considerations associated with site selection, approval, design, construction and operation of a modern waste management facility and understand the impact of the engineering solution in a global and societal context.
- To develop an understanding of the sources and characteristics of municipal solid waste and the chemical and biological characteristics of landfill leachate.
- To understand the professional and ethical responsibility of an engineer with respect to waste management including consideration of social, economic, environmental, worker health and safety, and legislative and other regulatory issues.
- To use state-of-the-art computer techniques for assessing the impact of proposed waste disposal sites on groundwater quality.
- To apply mathematical, scientific, and engineering knowledge to the design of the preliminary design for a landfill facility to meet specified needs and legislative requirements.
- To improve communication skills by discussing current waste disposal issues and expressing and defending opinions before their peers.
- To obtain experience working as a member of a design team and hence prepare for the engineering workplace.
- To appreciate the rapidly changing nature of knowledge and technology in this field and the need for life-long learning

**Calendar Copy:**

Consideration of properties of solid waste, landfill covers, landfill gas, leachate, techniques for disposal, regulations, liner technology, contaminant transport, and impact assessment are examined in the context of the design of solid waste disposal facilities.

**Prerequisites:**

Completion of third year of either a B.E.Sc. or B.Sc. program.

*Note:* It is the student's responsibility to ensure that all Prerequisite and Corequisite 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 they have not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Antirequisite conditions.

**Contact Hours:**

*3 lecture hours/week*

Lectures will be delivered in-person. Recommended additional personal study, including review of lecture material and self-study, is approximately 3 hours/week.

*3 design lab/tutorial hours*

A 3-hour tutorial session will be delivered in-person. Tutorials are not mandatory but students seeking assistance with weekly assignments or clarification on lecture material are strongly encouraged to attend.

**Instructor:**

Dr. Christopher Power, SEB 3039A, cpower24@uwo.ca

**Teaching Assistant:**

Aidan Haskell, @uwo.ca

**Textbook:**

Prepared class notes should be brought to each class and may be downloaded from the course website.

**Other References:**

Geotechnical Aspects of Landfill Design and Construction by Xuede Qian, Robert M. Koerner, Donald H. Gray, ISBN 0-13-012506-7. Published 2002 by Prentice-Hall, Inc. Upper Saddle River, New Jersey 07458

Ontario Regulation 232/98 (key sections in course notes). Available in the Taylor Library and also on the Web at <http://www.canlii.org/on/laws/regu/1998r.232/20040802/whole.html>.

Landfill Standards: a guideline on the regulatory and approval requirements of new or existing landfill sites, Ontario Ministry of the Environment and Energy (MOE), May 1998, Report PIBS365IE. Web link: <http://www.ene.gov.on.ca/envision/land/landfill/>

Geotechnology of Waste Management by Oweis, I.S. and Khera, 2nd Edition, PWS Publ. Co., Boston, 1998.

Solid Waste Landfill Engineering and Design by E.A. McBean, F. Rovers & G.J. Farquhar 1995.

Barrier Systems for Waste Disposal Facilities by R.K. Rowe, R.M. Quigley & J.R. Booker 2004, Chapman & Hall.

**Computing:**

Computers will be needed for the assignments and the design project.

**Units:**

SI units will be used in lectures and examinations.

**Specific Learning Objectives** [GA Indicator – **bold** denotes evaluated indicator]:

- 1) Waste Management - Diversion and Disposal. At the end of this section the student should be able to:
  - a) correctly use relevant terminology in hydrogeology and waste management [**KB4**]
  - b) incorporate the 3R's (Reduce, Reuse and Recycle) in the design of a waste management strategy and be familiar with the advantages and limitations of recycling [**KB4**]
  - c) describe alternative techniques for waste treatment (incineration and energy from waste; composting; bioconversion; waste processing and landfilling) [**KB4**]
  - d) describe the different landfilling techniques (trench method; area method) [**KB4**]
- 2) Solid Waste and Leachate Characteristics. At the end of this section the student should be able to:
  - a) describe the nature, sources and composition of solid waste [**KB4**]
  - b) describe the difference between in-place, apparent and total average density, and each of these and know when to use the different values [**KB4**]
  - c) describe the different solid waste bio-degradation processes and the characteristics of landfill leachate [**KB4**]
  - d) apply the Ontario "Reasonable Use" Guideline [**KB4**, PR1]
  - e) quantitatively estimate the contaminating life span of a landfill based on the size, infiltration and peak leachate characteristics [PA1]
- 3) Landfill Design. At the end of this section and after completion of the design project, the student should be able to:
  - a) describe the available design options for barrier systems [PA1, D2]
  - b) design barrier systems that comply with the Ontario Regulations 232 (§10) for both standard design and site-specific alternatives to the standard designs [**D3**, PR1]
  - c) design the base contours of a landfill [**D3**]
  - d) design the leachate collection system [**D3**]
  - e) describe the general characteristics of the three main groups of clay liners (re-compacted active soil; soil-bentonite mixtures; geosynthetic clay liners) and their strengths and limitations [**KB4**]
  - f) describe the main types of geomembranes and the key design considerations associated with selection of a suitable geomembrane [**KB4**, D2]
  - g) describe the typical landfill development and operations consideration [EPM2]
- 4) Environmental Impact Assessment and Regulations. After completion of this section and the design project the student should be able to:
  - a) discuss the different types of environmental regulatory systems, the requirements of a landfill approval process, and the advantages and limitations of prescriptive and performance-based regulations [PR1]
  - b) discuss the broad consideration of the Environmental Assessment Act [IESE3]
- 5) Advective-Diffusive Contaminant Transport. At the end of this section the student should be able to:
  - a) describe the key contaminant transport and retardation mechanisms (advection, diffusion, dispersion, sorption and radioactive and biological decay) [**KB4**]
  - b) describe the governing differential equations and typical boundary conditions [**KB4**]
  - c) calculate the percolation through a landfill cover, based on the water balance method and estimate leachate volumes [**KB4**, PA1]

- 6) Landfill gas. After completion of this section the student should be able to:
- estimate the quantity and composition of gas that will be generated by a MSW landfill [KB4, PA1]
  - describe and be familiar with typical gas recovery and migration control systems [KB4, PA1]
- 7) Design Project. As part of the Design Project, where students will design a landfill as part of a team, the student should be able to:
- classify the various phases of the design process and identify the key component of each phase, including the relevant legislation with which the design must comply [PA1]
  - describe the responsibility of a professional engineer with respect to long term health and safety issues and worker safety, education and training related to site investigation, construction and operation of a waste management facility [PR1]
  - describe, in general terms, what is involved in preparing for and obtaining approval of an undertaking under the Environmental Assessment Act of Ontario [PR1, IESE3]
  - describe the specific design considerations relevant to landfill design and be able to work as a member of a team that can develop a preliminary landfill design that is in compliance with Ontario Regulation 232/98, at a level that could be presented to the MOE for approval under the Environmental Protection Act of Ontario [D1, D3, D4, ITW2, ITW3, PR1, EPM2]
  - prepare well-documented and consistent design calculations, a design and operations report, preliminary design drawings and cost estimates [D3, D4, CS2]
  - provide an oral presentation of the design project and defend his/her work [CS3]

Instructor may expand or revise material presented in the course as appropriate.

### **General Learning Objectives:**

E=Evaluate, T=Teach, I=Introduce

|                   |      |                   |   |                                  |      |
|-------------------|------|-------------------|---|----------------------------------|------|
| Problem Analysis  | T    | Teamwork          | T | Ethics and Equity                | I    |
| Investigation     | I    | Communication     | T | Economics and Project Management | T    |
| Design            | E(A) | Professionalism   | T | Life-Long Learning               | I    |
| Engineering Tools | I    | Impact on Society | T | Knowledge Base                   | E(A) |

### **Course breakdown:**

Engineering Science = 86% = 39 AU's; Complementary Studies= 14% = 6.5 AU's.

### **Evaluation:**

The final course mark will be determined as follows:

|                   |      |
|-------------------|------|
| Participation     | 10%  |
| Assignments       | 15%  |
| Design Project    | 20%  |
| Quizzes           | 15%  |
| Final Examination | 40%  |
| -----             |      |
| Total             | 100% |

1. Quizzes and Examinations:

Two 50-minute quizzes will be held during lecture hours. These quizzes are tentatively scheduled for Wednesday, October 18 and Wednesday, November 15.

A three-hour written final examination will be held during the regular examination period.

2. Assignments

Four assignments will be completed during the course. Assignments are to be submitted prior to the due date to OWL. Late assignments will be assessed a penalty of 10% per day, to a maximum of 3 days, after which they will receive a mark of zero. Extensions are to be negotiated with the course instructor, not the teaching assistant.

3. Design Project

The design project is a major component of the course. You will be asked to form “design teams” of 4 or 5 students (the actual number will be specified when the number of students in the course is known). You will be assigned a site that has previously been considered for landfilling during or following an extensive EAA investigation. You will have access to key hydrogeologic data arising from these studies. The site boundaries of the area investigated will be shown on the drawing, however, you may select your own footprint subject to the requirement that the landfill must be located within the boundaries shown. You are to design the landfill subject to a number of constraints that will be specified (in addition to those arising from the Environmental Assessment Act, the Environmental Protection Act, 1998 Landfill Standard Guidelines (Ontario Regulation 232/98) MOE and MOE Guidelines for EPA Submissions and Government waste diversion targets).

Although basic information concerning the site is provided for your assistance, this information is not complete, and it will be necessary for you to obtain additional information. The submission should be sufficiently detailed such that it could be presented to the MOE for review and approval of the undertaking.

Your submission should clearly indicate the name of the individual who undertook prime responsibility for each aspect of the work and the name of the individual who reviewed that aspect of the work. All hand calculations are to be on squared paper and must be organized and presented in a neat, clear and professional manner. All pages of calculations must have the date, initials of the originator and initials of the checking engineer. All calculations are to be checked. All drawings are to be of professional quality with the name of originator and checking individual shown.

Your group will be required to make an oral presentation of your design and will be expected to defend your design (which will be reviewed by the instructor, teaching assistant, and a peer review group).

Of the marks assigned for the oral presentation and defence of your project, 10% will be assigned for your critical review of the other groups’ submissions and 80% will be assigned for the final design submission. Each student will be required to submit a written and signed assessment (with reasons) of how, in their opinion, the marks for the design project should be divided between team members (the instructor will make the final allocation after considering the opinion of all group members and reviewing the work done by each student).

#### 4. Use of English

In accordance with Senate and Faculty Policy, students may be penalised 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.

#### **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.

For more information on scholastic offenses, please see:

[http://www.uwo.ca/univsec/handbook/appeals/scholastic\\_discipline\\_undergrad.pdf](http://www.uwo.ca/univsec/handbook/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.

#### **Information regarding iClicker Cloud:**

*Classroom Polling:* We will be using iClicker Cloud, a cloud-based student response software, in class this semester. This will help me understand what you know, give everyone a chance to participate in class, and provide more interaction on concepts and example questions. We will also use this software to keep track of attendance. At the start of every class, you will register your attendance; only after you do this will you be able to answer any poll questions posted. You are required to bring a device connected to the university Wi-Fi to participate in iClicker Cloud during class, including a smartphone, tablet, laptop or iClicker remote. You will need to create an iClicker Reef Student account to participate in class.

*Creating Your iClicker Reef Student Account:* Go to [iclicker.com/students](http://iclicker.com/students) or download the iClicker Reef Student app for your Apple or Android device to sign up for a Reef account. You should use your university email address and your University ID (e.g., “cpower24” for student [cpower24@uwo.ca](mailto:cpower24@uwo.ca)) in the Student ID field. You can edit your email address, password, or student ID from your account profile. Do not create and use more than one Reef account as you will only receive credit from a single account.

You do not need to purchase anything – iClicker Cloud is fully supported by Western and is free to all its students. Make sure you choose Western University Ontario when signing up.

*Add This Course to Your Reef Account*

Institution: Western University Ontario

Course: CEE 4465A Enviro\_Design

**Use of laptop computers, tablets or smart mobile phones:**

Use of laptop computers, tablets or smart mobile phones is expected to be for the purpose of participating in the lecture explicitly. They can be used to fill in the gapped notes, participate in class polls, and to register your attendance. Students using the devices for activities not related to this class may be asked to leave.

**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. 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.

Students that are in emotional/mental distress should refer to Mental Health@Western <http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help

For more information concerning medical accommodations, please see:  
[http://www.uwo.ca/univsec/handbook/appeals/accommodation\\_medical.pdf](http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf)

**Notice:**

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 the 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 instructor.

**Masking Guidelines:**

Students will be expected to wear triple layer, non-medical, paper masks at all times in the classroom as per University policy and public health directives. Students who are unable to wear a mask must seek formal accommodation through Western Accessible Education, and present medical documentation. Students are not permitted to eat or drink while in class to ensure masks stay in place.

Students will be able to eat and drink outside of the classroom during scheduled breaks.

Students unwilling to wear a mask as stipulated by Western policy and public health directives will be referred to the Dean, and such actions will be considered a violation of the student Code of Conduct.

**Course Absences due to Daily COVID Screening Questionnaire:**

Missed assessments (e.g., presentations, essays, quizzes, tests, midterms, etc.) require formal academic considerations (typically self-reported absences and/or academic counselling).

Methods for dealing with missed work and course content are at the discretion of the instructor(s). Students should be aware that some learning outcomes cannot be easily made up and may need to be completed in a subsequent year. Your instructor will provide you with further information as to how this applies within this course.

Students who demonstrate a pattern of routinely missing coursework due to self-reported COVID symptoms, and therefore do not demonstrate mastery of the learning outcomes of the course, will not receive credit for the course.

**Contingency plan for an in-person class pivoting to 100% online learning:**

In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-to-face interaction, all remaining course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will not change. Any remaining assessments will also be conducted online as determined by the course instructor. In the event that online learning is required, a stable internet connection with working microphone and webcam will be required. As has been the case in the past, the decision to pivot to online learning will be made by Western, and not individual instructors or departments (excepting temporary online instruction in the event of instructor illness).