

## Graduate Program in Groundwater Engineering Science at the University of Guelph



The Morwick G360 Groundwater Research Institute (MG360) at the University of Guelph is a field-focused groundwater research center, conducting research in three main areas: aged contaminated industrial sites; groundwater resource protection for drinking water supplies; and potential impacts to surface water and groundwater from upstream unconventional oil and gas development. MG360's research strategy is to collect high-resolution data to quantify flow system properties improving the conceptual and numerical models used to make decisions.

MG360 provides students with a dynamic learning environment based on hands-on approach that combines rigorous coursework with practical research opportunities. Collaborative projects and access to state-of-the-art facilities enable students to develop essential skills for real-world water management issues. This guide highlights groundwater-focused and complementary courses offered at the University of Guelph, designed to equip graduate students with the knowledge needed to excel in the field.

## Table of Contents

<b>Groundwater Focused Graduate Courses</b> .....	4
ENGG 6720 Groundwater Contamination and Remediation .....	4
ENGG 6740 Introduction to Groundwater Modelling .....	4
ENGG 6760 Groundwater Flow Systems .....	5
ENGG 6790 Special Topics: Sensors and Field Methods in Hydrogeology .....	6
ENGG 6790 Special Topics: Tracers in Hydrogeology .....	6
<b>Complementary Graduate Courses</b> .....	8
ENVS 6190 Environmental Microbiology Technology .....	8
ENGG 6260 Colloids, Interfaces and Emulsions: Concepts and Practical Applications .....	8
ENVS 6440 Field Sampling Strategies and Geostatistics .....	9
ENVS 6460 Environmental Remediation .....	9
ENGG 6610 Urban Stormwater Management.....	10
ENVS 6470 The Science and Management of Multiple Stressors in the Great Lakes .....	10
ENVS 6501 Integrating Science and Policy in Environmental Science.....	10
ENVS 6720 Geology of Groundwater Systems .....	11
ENGG 6790 Special Topics: Environmental Engineering: Geochemical Modeling for Engineering Applications .....	12
ENGG 6840 Open Channel Hydraulics .....	13
ENVS 6882 Environmental Toxicology, Risk Assessment and Risk Communication .....	13
<b>Undergraduate Foundational Courses</b> .....	14
ENVS 3060 Groundwater.....	14
ENGG 3650 Hydrology .....	14
ENGG 4240 Site Remediation .....	15
ENGG 4250 Watershed Systems Design.....	15
ENGG 4510 Assessment and Management of Risk .....	15
<b>About the Professors</b> .....	17
Groundwater Focused Faculty.....	17
Dr. Beth Parker .....	17
Dr. Jana Levison.....	17
Dr. Jonathan Munn.....	18
Dr. Ferdinando Manna .....	18
Water Quality, Wastewater and Surface Water Focused Faculty.....	18
Dr. Andrea Bradford .....	18
Dr. Andrew Binns.....	19
Dr. Asim Biswas .....	19
Dr. Cameron Farrow .....	19
Dr. David McCarthy .....	20
Dr. Erica Pensini.....	20

Dr. Loren Knopper .....	20
Dr. Rafael Santos .....	21
Environmental Sciences Focused Faculty .....	21
Dr. Emmanuelle Arnaud .....	21
Dr. James Longstaffe .....	22
Dr. Kari Dunfield .....	22
Dr. Ryan Prosser .....	22
Dr. Thomas Graham .....	23
Risk Assessment Focused Faculty .....	23
Dr. Paul Sibley.....	23

## Groundwater Focused Graduate Courses

These core courses are designed specifically for students focused on groundwater studies. They complement each other, providing a comprehensive overview of various groundwater topics, including physical hydrogeology, use of isotope and tracers, contaminant transport and fate, field methods, sensor technology, and numerical modeling.

### ENGG 6720 Groundwater Contamination and Remediation

**Professor:** Dr. Beth Parker

**Offered:** Winter 2026

**Course Description:** Despite recent progress, characterization and remediation of fractured rock aquifers remains a technical challenge. This course offers an in-depth exploration of the key concepts and cutting-edge field methods used to characterize and quantify groundwater flow and contaminant transport in bedrock groundwater, informing remediation technology designs and performance using several field study sites as case examples. From the borehole to larger flow systems, you'll gain hands-on experience with field data set interpretations and technical expertise essential for solving complex environmental and engineering challenges. Fractured rock hydrology plays a crucial role in a wide range of industries and global issues, including mining, waste containment, oil and gas extraction, geothermal energy, water supply, and watershed management. By mastering these concepts seeing data from field studies, you'll gain insights on field methods used for characterization and designing monitoring systems that inform groundwater transport and fate that positions yourself to work in the contaminant hydrogeology profession for developing effective work plans and develop sustainable solutions for these pressing challenges

**Learning Objectives:**

1. Distinguish characteristics for flow and transport in granular aquifers, different rock types and aquitards influencing contaminant mobility and fate.
2. Determine how Geology provides key insights to Hydrogeology conditions once the two data types are calibrated at a particular site.
3. Understand how various source zone conditions and contaminant types exhibit distinct mobility and fate behaviours and why.
4. Know the importance of Site Conceptual Models to integrate site data sets/interpretations and inform contaminant hydrogeology decision making, including risk to receptors, mitigation strategies and remediation technology evaluations best suited.
5. Review field, laboratory and modelling (including software) tools/techniques for granular aquifer, clayey aquitard and fractured rock characterization and monitoring.

### ENGG 6740 Introduction to Groundwater Modelling

**Professor:** Dr. Jana Levison

**Offered:** Fall 2024

**Course Description:** Introduction to current groundwater issues, definition of terms, review of fundamental equations describing fluid and contaminant transport in saturated groundwater zones. Mathematical techniques (analytical, FE and FD) for the solution of the fundamental equations.

Application of numerical groundwater models to a variety of situations. Case studies. Review of groundwater models used in industry. The goal of this course is to introduce students to the basics of groundwater modelling as it is currently practiced. Primary topics will include an introduction to groundwater issues, definition of pertinent terms as well as an introduction to the fundamental equations describing fluid flow and contaminant transport in the saturated zone. Before proceeding to the use of already existing (e.g., commercial) groundwater models, the various mathematical techniques for the solution of the fundamental equations will be introduced and their advantages and shortcomings covered. The course will finish with the application of the models to a variety of situations. Finally, groundwater models commonly used in industry are covered.

**Learning Objectives:**

1. Know the basis for the fundamental equations for groundwater movement for steady and unsteady flow for fully saturated conditions.
2. Understand the basic parameters used in groundwater systems to describe the transport mechanisms of fluid and dissolved contaminants.
3. Be familiar with the transformation of the fundamental partial differential equations into approximate linear equations for the purposes of numerical modelling.
4. Understand the capabilities and limitations of numerical modelling for groundwater systems.
5. Develop and apply a commercial grade groundwater model to a variety of situations including those for which an analytical solution exists.
6. Calibrate a groundwater model for fluid flow and contaminant transport problems.

## ENGG 6760 Groundwater Flow Systems

**Professor:** Dr. Beth Parker

**Offered:** Winter 2025

**Course Description:** Groundwater flow systems connect water recharged from rainfall and snowmelt through the ground and discharging at surface waters or wetlands, sustaining ecosystems and water supplies for communities, whether taken from wells or from surface water. Groundwater represents more than 97% of our available freshwater, sustaining surface water flows throughout the seasons and resilience to climate variability, however, groundwater systems are spatially complex and dynamic. Unlike the majority of 'groundwater flow system' courses that focus on the most transmissive zones (aquifers), this course also focuses on aquitards that play a key role in directing groundwater flow paths and rates and infrastructure support. This course provides an in-depth exploration of real-world groundwater systems using field studies conducted in a range of geologic environments and climates, offering students the opportunity to examine diverse data sets and measurement tools used by the profession to understand system conditions and quantify parameters needed to inform models. Familiarity with field/lab measurement techniques and data analysis methods prepares the engineer or scientist to address some of society's most pressing challenges: managing legacy contaminated sites, protecting source water, building resilient cities with reliable underground infrastructure, reducing impacts from mining and energy extraction operations (i.e. geothermal, oil/gas) and effective waste disposal/isolation.

**Learning Objectives:**

1. Describe groundwater flow systems and explain the role of aquitards in these systems.

2. Describe aquitard integrity and be able to characterize concerning design concepts and monitoring of waste disposal sites, hazardous waste landfills and deep radioactive waste repositories.
3. Critically review technical literature related to Groundwater resource protection and waste management.
4. Develop critical and creative thinking skills and recognize best practices in professional and ethical behaviour in groundwater resources use and monitoring.
5. Recognize and build a global understanding of environmental threats from deep sedimentary rock aquitards targeted for unconventional oil and gas extraction, coal and mining.

## ENGG 6790 Special Topics: Sensors and Field Methods in Hydrogeology

**Professor:** Dr. Jonathan Munn

**Offered:** Fall 2024

**Course Description:** As a field-based research Institute, field methods and use of sensors represent a central component of our training. This course covers a wide range of cutting-edge sensors and field methods, giving you hands-on experience in studying and characterizing aquifer systems—an essential skill set for anyone pursuing a career in water resource management, environmental consulting, or hydrogeological research. The course alternates between classroom sessions, where you'll learn the theory behind modern tools and methods, and exciting field lectures, where you'll put that knowledge to the test. You'll interact with industry-standard sensors and instruments, apply various field techniques, and collect real data to use in your assignments—gaining firsthand experience in the process.

### **Learning Objectives:**

1. Collect and interpret high quality field data from a variety of sensors to support hydrological/hydrogeological site investigations.
2. Interpret and utilize various borehole geophysical and hydrophysical logs to inform aquifer properties.
3. Make informed selections on the type of sensors (point, distributed, etc.) to best achieve project goals objectives.
4. Understand the limitations of measurements made in open boreholes or long screened wells, and how to reduce these limitations if possible.
5. Apply thermal tests and sensors to assess hydraulically active groundwater flow and groundwater surface interaction.
6. Collect robust field notes and understand data storage and management as key aspects of field data collection
7. Capture and interpret information from continuous rock core using modern field logging methods and sensor measurements
8. Present technical information and results in a professional manner

## ENGG 6790 Special Topics: Tracers in Hydrogeology

**Professor:** Dr. Ferdinando Manna

**Offered:** Winter 2025

**Course Description:** Curious about how water moves through the Earth's critical zone, tracking rainfall infiltration through unsaturated zone and recharging shallow and deep groundwater? This course focuses on the use of tracers as powerful tools to understand water flow and transport through porous media and fractured aquifers. By using tracers, you'll gain the ability to track, quantify, and better understand water movement in the unsaturated zone, assess groundwater recharge, and uncover how these processes inform groundwater quality and quantity, which in turn impact ecosystems and drinking water supplies. Moreover, this course dives into today's most pressing global challenges related to groundwater. You'll explore how climate change influences groundwater systems, assess the growing risks associated with groundwater depletion, and develop strategies for the sustainable management and protection of this vital resource.

**Learning Objectives:**

1. Recognize the different hydrological processes and their chemical and isotopic signature.
2. Understand unsaturated zone flow mechanisms and the influence of preferential flow pathways on flow and transport processes.
3. Develop conceptual models of recharge to explain where, when and how recharge occurs.
4. Critically select and apply different methods to constrain recharge in function of their temporal and spatial scale.
5. Understand the relationship between groundwater use and global environmental issues.
6. Understand the impact of climate change on groundwater systems.
7. Present technical information and results in a professional manner.

## Complementary Graduate Courses

Although not specifically focused on groundwater, these courses may be relevant to students depending on their individual research or thesis interests.

### ENVS 6190 Environmental Microbiology Technology

**Professor:** Dr. Kari Dunfield

**Offered:** Winter 2024

**Course Description:** Current topics in selected areas of environmental microbial technology. An emphasis will be placed on the physiology and genetics of microorganisms useful in environmental biotechnology. The course involves extensive use of current journal articles. An undergraduate degree in microbiology or related discipline is recommended prior to registering in this course. The graduate course in Environmental Microbial Technology will provide an interactive forum for students to participate in an advanced discussion on current techniques and research in environmental microbiology. Using a combination of oral presentations by students, written assignments, and laboratory demonstrations, students will be given the opportunity to discuss and debate current issues in environmental microbiology.

**Learning Objectives:**

1. Provide students with an advanced understanding of targeted issues in environmental microbiology and key concepts therein
2. To expose students to a broad range of techniques in environmental microbiology
3. To provide students with an opportunity to develop critical thinking and communication skills in order to better communicate the essential elements of environmental microbiology in public and political arenas

### ENGG 6260 Colloids, Interfaces and Emulsions: Concepts and Practical Applications

**Professor:** Dr. Erica Pensini

**Offered:** Winter 2026

**Course Description:** This course focuses on the theory and applications of colloid and interface science in diverse sectors, relevant to engineers, physicists and chemists. Major topics include the forces of interactions between colloids, the stabilization and destabilization of emulsions and foams, and polymeric fluids and gels. This course aims to teach basic concepts related to colloid and interface science, and to elucidate the multifaceted applications of this science.

**Learning Objectives:**

1. Write: research project reports
2. Orally present (a project)
3. Successfully complete (creatively discuss scientific ideas, demonstrate knowledge, identify how fundamental science can be used to find solutions to real problems): midterms suitable for a graduate level course
4. Demonstrate your knowledge during: an oral exam/questioning period

## ENVS 6440 Field Sampling Strategies and Geostatistics

**Professor:** Dr. Asim Biswas

**Offered:** Winter 2026

**Course Description:** Concepts and practical aspects of collecting, synthesizing and interpreting data from spatially and temporally variable and/or correlated fields. Hands-on experience in describing spatial structure of large data sets (supplied by student or instructor) using available software.

**Learning Objectives:**

1. Critical review skills on spatial data analysis literature
2. Understand various field sampling strategies (sampling designs) and develop sampling protocols
3. Understand and apply basic geostatistical methods to spatial data.
4. Analyze spatial data using R and ArcGIS

## ENVS 6460 Environmental Remediation

**Professor:** Dr. Thomas Graham

**Offered:** Winter

**Course Description:** This course discusses environmental remediation/bioremediation topics including, but not limited to, phytoremediation, bioremediation, mycoremediation, and physical and chemical remediation to improve air, water and soil quality. For example, this course may explore the use of plants to take up and accumulate toxins from contaminated soils, use of bacteria to degrade groundwater contaminants, and physical/chemical processes to remove contaminated substrates or break down contaminants in those substrates. Environmental remediation is, by nature, multidisciplinary, involving chemistry, physics, biology, engineering, landscape design, etc. Numerous guest lectures from academic and commercial experts serve to explore this diverse field.

**Learning Objectives:**

1. Develop a baseline understanding of, and appreciation for, the various challenges and potential benefits of Environmental Remediation
2. Identify an area of interest, within the context of Environmental Remediation, to study and explore by attending lectures, group discussions, critiques of current scientific journal articles, professional interviews and group work.
3. Demonstrate enhanced critical thinking skills through critiquing current scientific journal articles (both high- and low-quality articles) and critiquing other students' presentations.
4. Demonstrate enhanced communication skills (both oral and written) through written assignments, and an in-class presentation (on a student selected topic).
5. Exhibit improved professional and ethical behavior towards diverse scientific ideas and academic opinions through presentations, group discussions and critiquing presentations by fellow students
6. Develop a better understanding of career options and requirements of the field by conducting an interview with an Environmental Remediation professional (commercial, academic, government)

## ENGG 6610 Urban Stormwater Management

**Professor:** Dr. Andrea Bradford

**Offered:** Winter 2025

**Course Description:** The course addresses stormwater management system design to minimize the effects of urbanization on flooding, channel geomorphology, groundwater recharge and quality, receiving water quality and aquatic communities. The importance of integrating low impact development and source controls in a management strategy is stressed. Students design traditional minor system components, lot-level and conveyance systems (including infiltration practices, vegetated swales, bioretention), and an extended detention wet pond. The course is delivered using lectures, discussions of journal articles, student presentations, guest lecturers and field trips. An oral exam, a paper on a topic of choice and a design project are the major course evaluation components.

**Learning Objectives:**

## ENVS 6470 The Science and Management of Multiple Stressors in the Great Lakes

**Professor:** Dr. Paul Sibley

**Offered:** Fall

**Course Description:**

This course focuses on the issue of multiple stressors and cumulative effects in the Great Lakes basin, which includes both the lakes and their surrounding watersheds. The course will consist of two integrated learning components: 1) a lecture-based learning environment, featuring lectures by the course instructor and occasionally guest lecturers that will focus on fundamental science and policy concepts required to understand the issue of multiple stressors and cumulative effects in the Great Lakes; 2) in-course and field-based activities (a full-day field trip to a local stream) to provide students with hands-on experience that will help to better understand the issues faced by the Great Lakes and its surrounding basin (e.g., designed to reinforce material and concepts taught in lecture). On the field trip, students will gain an understanding of the basis and nature of monitoring designs; practice methods for collecting and processing samples for monitoring different environmental compartments.

**Learning Objectives:**

1. Explain the concept of Areas of Concerns pertaining to contaminants in the Great Lakes.
2. Explain basic concepts in risk assessment and conceptual site models.
3. Understand how to manage multiple stressors, including chemical stressors such as pesticides, using the Bow-tie risk assessment method.
4. Explain the concept and impact of eutrophication and nutrient pollution using a Scenario Analysis
5. Explain the history and current status of various invasive species and the role of policy in science.

## ENVS 6501 Integrating Science and Policy in Environmental Science

**Professor:** Dr. James Longstaffe and Dr. Ryan Prosser

**Offered:** Fall

**Course Description:** A case-study approach, based on current and historical issues, and involving presentations from faculty, professionals and students, will be used to develop an advanced understanding of current issues in the environmental sciences, including examination of the underlying science and management of the issues, and the effectiveness of associated policies.

**Learning Objectives:**

1. Professional and Ethical Behaviour. You will be exposed to group work, where professional and ethical behavior should prevail while delivering the course requirements.
2. Communicating. You will be challenged to communicate complex ideas in written, oral and multimedia platforms
3. Literacy. The students will continue to develop their literacy skills through reading policy - related paper to understand global issues. You will continue to develop your literacy skills through the preparation of short discussion papers that will require research and communication skills. ENVS\*6501 01: Integrating Science and Policy in Environmental Science - 2
4. Critical and Creative Thinking. This learning outcome will be addressed through the written work and students' independent ability to think and develop problem solving frameworks in order to inform policy.
5. Global Understanding. Throughout the course, you will be challenged to think about environmental and policy problems that span the globe.

## ENVS 6720 Geology of Groundwater Systems

**Professor:** Dr. Emmanuelle Arnaud

**Offered:** Winter 2025

**Course Description:** Geology often plays an important role in groundwater flow systems, influencing recharge to aquifers as well as contaminant fate and transport. This course will explore the relationship between geology and groundwater through selected readings and assignments. Students will gain a better understanding of subsurface heterogeneity in previously glaciated settings, the role of tectonics and sea level change over geologic time in determining the nature of sedimentary rock successions, and the effect of secondary processes on the nature of the materials through which groundwater and contaminants flow. The course will include several guest speakers from industry and government agencies.

**Learning Objectives:**

1. Explain what depositional and post depositional processes influence the characteristics of different glaciated settings/deposits that would affect groundwater flow and/or contaminant transport.
2. Explain what depositional and post depositional processes influence the characteristics of different sedimentary rock types that would affect groundwater flow and/or contaminant transport.
3. Create a conceptual model of their own through a literature review that synthesizes the geological conditions at multiple scales that would impact groundwater or on the fate and transport of a contaminant in a particular geological setting.
4. Explain the types of geological data sets needed to inform ground water site investigations through case study analysis.

5. Identify and describe sediments and sedimentary rock types using standard sedimentological techniques through logging both Quaternary and sedimentary rock core.

## ENGG 6790 Special Topics: Environmental Engineering: Geochemical Modeling for Engineering Applications

**Professor:** Dr. Rafael Santos

**Offered:** Fall 2024

**Course Description:** Geochemical modeling is a technique that enables understanding of geochemical phenomena based on fundamental principles of geochemistry coupled to physical observations and measurements. It can be used to predict the behavior of materials, fluids and solutions, the extent of chemical reactions and the reaction path that is followed, as well as to explain observed phenomena and to describe complex multi-phase elemental speciation and distribution. Geochemical modeling has traditionally been applied to systems in equilibrium, but has now extended to include kinetic modeling, biological modeling and transport modeling. Consequently, geochemical modeling has become a powerful tool in a number of research fields where geochemistry governs a natural process or is applied to produce a desired result. This course will explore the thermodynamic underpinning of geochemical modeling, the inner workings of geochemical models, and will enable students to perform geochemical modeling of various systems and phenomena. Students will learn to use, and make use in projects, of the modeling software Visual MINTEQ and The Geochemist's Workbench. This course will demonstrate the application of geochemical modeling for the study of several natural and engineered systems, including: water supply and treatment, groundwater flow and extraction, waste injection wells, recovery of oil from reservoirs, formation, dissolution and alteration of minerals, biodegradation, and microbial populations. It will also cover several aspects of geochemistry (equilibrium and redox reactions, reaction kinetics, phase diagrams, surface complexation, activity and fugacity, the first and second laws of thermodynamics) and mineralogy (weathering, ageing, Ostwald ripening, leaching, polymorphs). With the knowledge and skills gained in this course, students will be able to apply geochemical modeling in diverse engineering fields, such as Water and Wastewater Treatment, Groundwater Management, Oil and Gas Extraction, Solid Waste Storage, Site Remediation, Carbon Capture and Storage, (Bio)Hydrometallurgy, Chemistry of Building Materials, Fouling and Scaling, Geothermometry, and the Fate of Pollutants.

### **Learning Objectives:**

1. Selectively search and critically review scientific literature on a geochemical modeling topic of their choice.
2. Collect and analyze relevant information to perform geochemical modeling of a problem of their choice.
3. Knowledgeably use geochemical modeling software to correctly model a geochemical process under equilibrium and non-equilibrium conditions.
4. Comprehend the fundamentals of geochemistry, mineralogy and thermodynamics behind geochemical models.
5. Critique applications of geochemical modeling to various Engineering, Environmental Sciences and Earth Sciences applications.
6. Communicate the rationale used to construct and how to operate a geochemical model.

## ENGG 6840 Open Channel Hydraulics

**Professor:** Dr. Andrew Binns

**Offered:** Winter 2025

**Course Description:** Basic concepts, energy principle; momentum principle; flow resistance; non-uniform flow; channel controls and transitions; unsteady flow; flood routing. This course is an advanced, graduate level, course dealing with the important concepts associated with open channel flows in natural and altered environments. The main goals of the course are (1) cover the fundamental calculations and problems with open channel situations for both natural and altered channels; and (2) apply state of the science approaches and models to actual open channel problems.

**Learning Objectives:**

1. Apply the basic flow resistance equations used in open channel flows to a variety of situations.
2. Apply knowledge of non-uniform flows and their calculations to determine water surface profiles in natural channels.
3. Use knowledge of basic flow characteristics in rivers to provide designs for bridges, control structures and river protection works.
4. Apply basic principles and knowledge of unsteady flow to analyze the attenuation of flood waves in open channels.
5. Understand natural channel design concepts for the purpose of river and stream restoration.
6. Apply and understand sediment transport relations to predict bed-load and suspended-load transport in alluvial channels.
7. Assess the effect of ice on open channel hydraulics in rivers and streams.
8. Understand the influence of anthropogenic activities on hydraulic, hydrologic and morphologic processes in rivers.
9. Concisely and articulately communicate the results of an in-depth assessment of an open channel flow problem and solution to colleagues in a professional manner.

## ENVS 6882 Environmental Toxicology, Risk Assessment and Risk Communication

**Professor:** Dr. Loren Knopper

**Offered:** Winter

**Course Description:** The goal of Human Health in the Environment is to provide students with the opportunity to learn about and discuss current day issues related to environmental contaminants and how they can affect (or be perceived to affect) human health. The course will be a mix of lecture (by instructor and guests), presentations by students (group or individual depending on class size), and reading/critiquing published scientific literature related to specific weekly topics. Topics to be covered include, but are not limited to: wind turbines, methylmercury, diesel exhaust, electromagnetic fields, and poly- and perfluoroalkyl substances (PFAS).

**Learning Objectives:**

1. The objective of the course is to let students gain a technical and practical understanding of toxicology, risk assessment and risk communication.

# Undergraduate Foundational Courses

## ENVS 3060 Groundwater

**Professor:** Dr. Asim Biswas

**Offered:** Winter 2025

**Course Description:** This course provides a general understanding of the physical and chemical processes that operate in the groundwater zone under natural and human-induced conditions. The interrelations between the groundwater regime and the other components of the hydrological cycle are studied. Considerable emphasis is placed on the applied aspects of topics such as exploration, testing and development of aquifers for water supply, the chemical quality of groundwater, and the hydrogeological aspects of waste disposal.

**Learning Objectives:**

1. Define physical properties that control flow, storage of water, and contaminant transport in the unsaturated (soil) and groundwater zones.
2. Apply knowledge of these physical properties to understand unsaturated and groundwater flow (with some examples of contaminant transport problems).
3. Resolve the importance and application of geology in defining groundwater flow.
4. Brief introduction to the importance of modeling as a tool in describing water flow and contaminant transport in unsaturated and groundwater zones.
5. Solve soil water and groundwater flow problems (e.g., unsaturated flow in root zone to saturated flow in groundwater, slug, and pumping test problems to identify potential aquifers).
6. Knowing basis for groundwater well construction. 7. Introduction to various instruments used in measuring soil and groundwater properties and flow and storage of water in the unsaturated zone.

## ENGG 3650 Hydrology

**Professor:** Dr. Andrew Binns

**Offered:** Winter 2025

**Course Description:** Quantitative study of natural water circulation systems with emphasis on basic physical principles and interrelationships among major processes; characteristics of mass and energy; inputs to and output from watersheds; factors governing precipitation occurrence, evaporation rates, soil-water storage changes, groundwater recharge and discharge, run-off generation; methods of streamflow analysis; mathematical modeling.

**Learning Objectives:**

1. Recognize and quantify basic hydrologic processes, such as runoff generation, infiltration and evaporation, in order to perform analyses of the hydrologic functioning of a watershed.
2. Describe commonly-used methods of measuring quantities which are important in hydrologic calculations.
3. Select and apply methods of calculation to obtain quantitative estimates of the response of a watershed to atmospheric inputs.
4. Apply statistical methods to assess the relative frequency of hydrologic events and determine the risk associated with the selection of specific hydrologic design values for inputs and/or outputs from watersheds.

5. Apply a representative hydrologic model and describe its attributes, strengths and weaknesses.
6. Apply stream gauging techniques to measure the velocity and compute the discharge in a river.
7. Understand the effect of natural and anthropogenic impacts on hydrologic processes occurring in watersheds

## ENGG 4240 Site Remediation

**Professor:** Dr. Erica Pensini

**Offered:** Fall 2024

**Course Description:** Remediation of contaminated sites is done to mitigate impacts to the environment and public health. The course will: review the applicable legislation; identify the important soil, water, air and chemical interactions; review the steps of an environmental risk assessment so that contaminated sites can be identified and evaluated to see if remediation is required; and evaluate and appraise various remediation technologies to complete the soil and groundwater remediation.

**Learning Objectives:**

1. Selectively search and critically review scientific literature on a site remediation topic of their choice
2. Collect and analyze relevant information for a target site to complete Phase I and II Environmental Site Assessments
3. Complete a risk assessment on the target site to evaluate whether site remediation is needed
4. Knowledgeably select an appropriate remediation technology, and design an effective, feasible and safe remediation plan for the target site.

## ENGG 4250 Watershed Systems Design

**Professor:** Dr. Andrew Binns

**Offered:** Winter 2025

**Course Description:** This course is a hydrological analysis of watershed systems including stream flow for design of structures and channels, flood warning, flood plain mapping and low-flow characteristics. Hydraulic analysis is applied to the design of dams, reservoirs, control structures, energy dissipation structures, bridges and culverts. An analysis of steady flow profiles, flood waves, and sediment transport is applied in the design of natural and constructed channels and protective works for rivers to achieve environmentally sustainable land use in watershed systems.

**Learning Objectives:**

1. Apply hydrological techniques to obtain flow rates for the design of conveyance and storage systems.
2. Apply the laws of conservation of mass, energy and momentum to the analysis of hydraulic conditions in conveyance structures and storage facilities.
3. Translate water-related needs into system performance criteria for design purposes.
4. Design open channel networks for water conveyance and storage.
5. Employ standard software in the solution of flow problems and in design calculations.

## ENGG 4510 Assessment and Management of Risk

**Professor:** Dr. Cameron Farrow

**Offered:** Winter 2025

**Course Description:** This course will develop the bases by which risk to human health and the environment can be assessed. Issues of hazardous waste cleanups, permitting of water and air discharges, food safety, flood protection, as examples, are addressed. The course also examines how decisions are made to manage the risks to acceptable levels.

**Learning Objectives:**

1. Use the knowledge of everyday risks in society, to establish the context of risk assessment and management of engineering risk, as it pertains to human health and the environment.
2. Assemble, interpret, and analyze environmental data as a basis from which risk assessments can be developed, including fate and transport concerns associated with engineering risk.
3. Identify strategies which can be used to determine if the collection of additional data are warranted.
4. Understand how to access various data sources from epidemiology and toxicology as inputs to engineering risk assessments.
5. Develop plans for appropriate engineering risk assessment and management, reflecting legal, economic, and socioeconomic considerations.

# About the Professors

## Groundwater Focused Faculty

### Dr. Beth Parker

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Dr. Beth Parker is a Professor in the School of Engineering, College of Engineering and Physical Sciences at the University of Guelph, Director of Morwick G360 Groundwater Research Institute, and Director of the University Consortium for Field-Focused Groundwater Research. She completed her PhD in Earth Sciences at the University of Waterloo in 1996 and her MSc in Civil and Environmental Engineering from Duke University, in 1983. Since 2007, she has held a Senior Industrial Research Chair in Groundwater Contamination in Fractured Media from NSERC. She specializes in high-resolution field methods for groundwater system characterization and uses innovative characterization methods to improve monitoring system design, contaminant detection, and prediction of transport mechanisms in complex flow systems including fractured rock.



### Dr. Jana Levison

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Jana K. Levison has a bachelor's degree in Civil Engineering (environmental option) and a Ph.D. in Civil Engineering (focus: anthropogenic impacts on fractured bedrock aquifers). She is an Assistant Professor in the School of Engineering in the Water Resources Engineering group at the University of Guelph. Previously she was a postdoctoral fellow at the Université du Québec à Montréal, working on multidisciplinary ecohydrological modeling related to climate change. In 2009-2010 she led engineering and public policy initiatives as the Junior Fellow and Acting Executive Director of the Ontario Centre for Engineering and Public Policy at Professional Engineers Ontario. She has also worked at the Cataraqui Region Conservation Authority on the Drinking Water Source Protection team. At the University of Guelph Dr. Levison is conducting novel research related to agricultural and climate change impacts on groundwater quality and quantity, with a focus on fractured bedrock aquifers. Other areas of research interest include: source water protection; appropriate potable water technologies for marginalized communities; renewable energy production (ground-source heating and cooling); and fostering engineering and technological input into public discourse.



## Dr. Jonathan Munn

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Jonathan Munn is an Assistant Professor in the School of Engineering at the University of Guelph. His research focuses on advancing sensor-based technologies for measuring active fracture flow, and refining lithostratigraphy and hydrostratigraphy using high-resolution field datasets. He has extensive experience working in the Silurian dolostone aquifer in the Guelph region and has conducted field research at over a dozen field sites across 3 countries collaborating with private and public sector partners. His research has practical applications for contaminated site investigations and municipal source water protection.



## Dr. Ferdinando Manna

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Ferdinando Manna, PhD is an Assistant Professor in the School of Engineering at the University of Guelph. His research focuses on understanding unsaturated zone processes and quantifying spatial and temporal variability of groundwater recharge rates using multiple approaches including groundwater tracers, head measurements and numerical modeling.



## Water Quality, Wastewater and Surface Water Focused Faculty

### Dr. Andrea Bradford

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Andrea Bradford received her PhD from Queen's University in Kingston, Ontario. Her dissertation addressed the hydroecological relationships and water balance of Minesing Swamp, a wetland of international importance under the Ramsar Convention. She gained five years experience in environmental consulting and two years experience at Ontario's Ministry of Environment, Water Policy Branch, before joining University of Guelph, in 2002. She has provided expert testimony related to protection of aquatic ecosystems and the livelihoods and well-being of the people who depend upon them. Bradford's research explores the water needs within aquatic ecosystems—particularly wetlands and streams. She studies and applies green infrastructure design for urban stormwater management



## Dr. Andrew Binns

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Andrew Binns received his PhD from Queen’s University in 2012. He then held a position as a postdoctoral fellow in the Department of Integrative Biology at the University of Guelph and a position as an Assistant Professor in the Department of Civil and Environmental Engineering at the University of Western Ontario. He joined the School of Engineering at the University of Guelph in 2015 where he is an Associate Professor and a Principal Investigator for the G360 Institute for Groundwater Research. He is a registered professional engineer in the province of Ontario. Binns’s research focuses on water resources engineering and environmental hydraulics and is concerned with the sustainability and resiliency of surface water environments. This includes examination of the fundamental processes related to surface water hydraulics and watershed hydrology and the development of tools and approaches to predict this behaviour and the response to natural and anthropogenic stressors.



## Dr. Asim Biswas

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Asim Biswas obtained his BSc in Agriculture from Bidhan Chandra Krishi Viswasvidyalaya in 2004 and went on to earn an MSc in Soil Science from the University of Agricultural Sciences in Bangalore, India, in 2006. Asim's dedication to soil research led him to the University of Saskatchewan in Canada, where he pursued further studies and research on soil and its spatial variability. In 2011, he successfully completed his PhD in Soil Physics. Driven by his passion for exploration, Asim accepted a position as an environmental research scientist and post-doctoral fellow at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia. In 2013, he joined McGill University's Department of Natural Resource Sciences as an Assistant Professor, and later in 2016, he moved to the University of Guelph. Today, Asim is a renowned scientist specializing in data-driven sustainable soil management. He focuses on enhancing the productivity and resilience of land-based agri-food production systems in an environmentally sustainable manner. His work revolves around utilizing scientific data to inform soil management practices, aiming to optimize agricultural outcomes while minimizing negative environmental impacts.



## Dr. Cameron Farrow

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Cameron Farrow received his PhD from the University of Guelph in 2016. He was a postdoctoral researcher and lecturer with the University of Guelph, School of Engineering from 2016 – 2018. Dr. Farrow then joined the School of Engineering in 2018 as an Assistant Professor. Dr Farrow’s interdisciplinary background, encompassing environmental and biological systems, potable water treatment technologies, and engineering education provides a unique research vision. His research is primarily focused on the following areas: Potable Water Supply and Risk Analysis: Design and analysis of effective water treatment technologies. Assessment of risks associated with contamination of potable water supplies and risk management approaches. Engineering Education and Pedagogy: Engineering design education, the evolution of engineering education to address future challenges, and the importance of interdisciplinary design education.



## Dr. David McCarthy

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David McCarthy received his BSc in mathematics and physics and his BEng in Civil Engineering, and his PhD from Monash University. His PhD focused on modelling microorganisms in urban stormwater. David is a world-renowned environmental engineer focusing on the biosurveillance of pathogens in urban water systems and the development of methodologies to monitor and manage these to protect human health. His research spans health-related water microbiology, risk assessments, pathogen fate and transport, urban hydrology, stormwater management, green water treatment technologies, and novel IoT devices for the monitoring and sampling of water quality. David's work has significantly impacted industry practices, including the development of novel stormwater treatment systems and real-time monitoring and control technologies for urban water systems.



## Dr. Erica Pensini

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Erica Pensini received her BEng and MAsc in Environmental Engineering at Politecnico di Milano in Italy, and her PhD in Environmental Engineering at the University of Toronto. Her current research focuses on the development of new energy-efficient water treatment technologies, that enable water reuse and restoration of polluted aquifers.



## Dr. Loren Knopper

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Loren Knopper is a Senior Principal and the Senior Technical Advisor for Research, Environmental Services, at Stantec Consulting Ltd., and an internationally recognized environmental health professional with close to 25 years of academic and consulting experience. Over the course of his career Loren has followed a collaborative and multidisciplinary approach that has combined his experiences in biology, zoology, physiology, toxicology, risk assessment, public health, public communication, project management and business development. Loren is a discipline and inspiration driven, outcome focused, big picture thinker. He has successfully led and managed projects of various levels of complexity for a diverse set of sectors that include agrochemical, renewable energy, commercial, private, and government. In addition to the technical (e.g., human health and ecological risk assessments of contaminants in air, soil, water and sediment for birds, mammals, bees, plants and aquatic receptors; registration of agrichemical products) and project management (proposal writing, financial scoping, team leadership, business development) aspects of his work, a core component of what Loren does as a senior professional deals with communication. Whether as a facilitator of professional development courses, an expert witness at legal hearings, a subject matter expert at public open houses and town hall meetings, a university lecturer, a real-time consultant to his clients, or as an author of scientific



manuscripts (>40) and plain language reports, Loren communicates with purpose, understanding and empathy, all of which stem from his broad based experience. This is where his innovation and expertise in the field stands out from others. At present, Loren is Senior Technical Advisor for Research for Environmental Services at Stantec and teaches two graduate level courses in the School of Environmental Science.

## Dr. Rafael Santos

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Rafael Santos received his PhD from the KU Leuven, Belgium, in 2013. He has worked at Zenon Environmental, Vale Inco, and Sheridan College Institute of Technology and Advanced Learning. Santos is a registered Professional Engineer of Ontario. He joined the University of Guelph's School of Engineering in 2017 where he is now an Associate Professor. Santos's main area of research is in the areas of water and solid waste treatment, environmental remediation, applied mineralogy and geochemistry, and carbon dioxide sequestration. He works to transform waste materials into valuable products and carbon sinks. Some examples of his work include turning steelmaking slags into paper fillers, turning incineration ashes into adsorbents, and turning carbon dioxide into building material. His aim is to reduce the environmental impact of industrial activities while contributing to the sustainable development of society. He is also interested in developing new reactor technologies and processing routes that consume less energy, use less hazardous substances, and are safer to operate. Santos has experimented with the use of ultrasound to speed up reactions, with tubular reactors to better control product properties, and with hot-stage reactions to take advantage of energy that is normally wasted.



## Environmental Sciences Focused Faculty

### Dr. Emmanuelle Arnaud

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Emmanuelle Arnaud holds a Masters degree in Geography and a Ph.D. in Geology. She is a glacial geologist with expertise in the field-based analysis of glacial sediments and sedimentary rocks in Canada, Norway, Scotland, and Alaska. Her research is focused on identifying physical sedimentary characteristics to reconstruct past glaciations and to document and predict the nature and extent of these glacial deposits for various environmental and resource management applications. Dr. Arnaud has been a leader of multidisciplinary and multi-institutional projects that combine various proxies to reconstruct past environmental changes in glaciated regions. She also leads a study on subsurface heterogeneity of glacial sediments and its impact on groundwater recharge and contaminant transport as well as a study related to non-point source pollution of groundwater (specifically nitrate and pathogens) in agricultural settings. Dr. Arnaud is currently an Associate Professor in the School of Environmental Sciences and provides research direction to MG360 at UoG.



## Dr. James Longstaffe

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James Longstaffe earned his BSc in the Department of Chemistry at the University of Western Ontario, earned his MSc in Chemistry at Dalhousie University and his PhD in Chemistry at the University of Toronto. His research focuses on the behaviour of chemical contaminants in the environment. Contamination of the environment with anthropogenic chemical agents is recognized as one of the leading factors contributing to global environmental change. The complex relationships between the chemical, physical, and biological processes that occur in the heterogeneous mixture of air, water, soil, and biology in the near-surface environment plays an important role in governing the behaviour of contamination in the global environment, including their persistence, degradation, transport, and ecotoxicity. A key part of my research involves developing applying novel analytical methods to provide new insight into the natural processes that remove or reduce the impact of environmental contamination.



## Dr. Kari Dunfield

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Kari Dunfield received her BSc in Cellular Molecular Microbial Ecology at the University of Calgary, and earned her MSc in Plant Science and PhD in Soil Science at the University of Saskatchewan. Since joining the University of Guelph in 2004, she has been performing innovative research in environmental microbiology. Dr. Dunfield uses molecular techniques to study the impacts of human activities on soil microbial communities, and the resulting effect on soil function and health. Her work is often multi-disciplinary and in collaboration with various scientists and university partners (UBC, University of Saskatchewan, Algoma University and Nova Scotia Agricultural College). Dr. Dunfield's current research focuses on two major issues of importance to Ontario and Canada. The first examines the impact of agricultural practices (tillage and growing crops for biofuels) on soil microbial communities associated with greenhouse gas emissions and carbon sequestration. The second involves the survival and transport of human pathogens in soils, surface and subsurface waters. Dr. Dunfield is looking at application methods of manure and sewage biosolids that minimize the survival of pathogenic microorganisms in the environment



## Dr. Ryan Prosser

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Ryan Prosser earned his BSc at Queens University, BEd at the University of Wollongong in Australia, and another BSc at the University of Guelph. He went on to earn his PhD in Environmental Toxicology. Growing up, Ryan always loved being outside and near the water. From family camping trips, canoe trips and summer camps, he always had a love for the environment. He chose to study biology in university not quite knowing where it would take him. After completing teacher's college, Ryan taught chemistry to grade 11 and 12 students in Kuwait, but always had the idea of research in the back of his mind. When he returned to Canada he chose to pursue grad school and was able to find a topic that combined his interest in biology and chemistry, with his love of the outdoors - environmental toxicology. Today Ryan's research looks at the impact of chemicals or the mixture of chemicals on aquatic and terrestrial ecosystems.



## Dr. Thomas Graham

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Thomas grew up in rural Southwestern Ontario, which helped shape and foster his interest in the natural sciences at an early age. Thomas gravitated towards the plant sciences in particular and that, combined with his concern with the environmental issues of the day, lead him to the University of Guelph for his undergrad (and eventually his MSc and PhD as well). Towards the end of his undergraduate degree, Thomas took his love of plant sciences to new heights as he became involved in the use of plants as bioregenerative life-support systems for human space exploration; the ultimate manifestation of Controlled Environment Agriculture (CEA), a field in which Thomas has since developed substantial expertise. After completing a NASA Post-Doctoral Fellowship at Kennedy Space Center, Thomas returned to the University of Guelph as the R&D Manager for the Controlled Environment Systems Research Facility (CESRF). Thomas continues to build and develop a diverse research program around all aspects of Controlled Environment Agriculture in his position as the PhytoGro Research Chair in Controlled Environment Systems.



## Risk Assessment Focused Faculty

### Dr. Paul Sibley

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Paul Sibley earned his BSc and MSc at the University of Guelph and his PhD at the University of Waterloo. His research is designed to better understand the relative risks that environmental stressors may pose to the biota of aquatic and terrestrial ecosystems with the goal of improving scientific and public understanding of those risks. His research interests focus on issues of water quality and its management including invertebrate and sediment toxicological assessments of novel, priority, and/or emerging chemicals, the use of aquatic invertebrates and fish as indicators of ecosystem health, assessment of ecosystem-level responses to contaminants using model aquatic ecosystems, lab-to-field extrapolation, development of risk assessment methodologies, understanding risk perception, and risk communication.

