WATER RESEARCH

UNIVERSITY OF TORONTO | Engineering

WATER RESEARCH AT U of T ENGINEERING

Fresh water, salt water, wastewater, industrial water, drinking water: all water on Earth is part of the same cycle — and every drop matters. Yet around the world, water supply and quality are under increasing pressure from growing populations, industrial development and climate change.

U of T Engineering researchers are leading the way in addressing the global water crisis. From taps, to toilets, to tailings, our faculty members have deep expertise in established and emerging areas of water research, as well as the transdisciplinary mindset necessary to create robust and resilient solutions. We are leveraging ancient microorganisms to make mining and other water-intensive industries more sustainable, and to remediate sites contaminated by past activity. We are also ensuring that drinking water and wastewater processes remain safe and cost-effective for those who have them, and addressing the challenges of the nearly two billion people who still do not.

Water is crucial for life. Together with our industry partners, we are ensuring that people around the world have access to safe, clean water for generations to come.

SELECTED AREAS OF EXPERTISE IN WATER RESEARCH AT U of T ENGINEERING

- Bioremediation
- Drinking water
- Commercialization
- Energy-from-waste
- Industrial water
- Municipal wastewater
- Remote development
- Stormwater
- Water accessibility
- Water accountability

SPECIALIZED EDUCATIONAL OFFERINGS IN WATER

Our Master of Engineering students can choose from technical specializations in Advanced Water Technologies and Engineering & Globalization, both of which address local and global water challenges through engineering design and research.

RESEARCH CENTRES & INSTITUTES

2017 — INSTITUTE FOR WATER INNOVATION (IWI)

An interdisciplinary group of researchers dedicated to sustainable water management, IWI is establishing fundamental understanding, developing innovative technologies, and educating future engineering leaders.

2011 — BIOZONE

This multidisciplinary team of renowned researchers works at the interface of biology and engineering to address urgent needs in energy, environment and health.

2009 — CENTRE FOR GLOBAL ENGINEERING (CGEN)

Through courses, co-curricular activities and research, CGEN facilitates creative solutions to global challenges in sanitation, alternative energy, health care and clean water.

1995 — LASSONDE INSTITUTE OF MINING

This world-leading interdisciplinary institute brings together researchers from across the spectrum of mining activities, from exploration and extraction to processing and metallurgy.

1987 — PULP & PAPER CENTRE

Close collaborations with industry enable this research centre to develop new ways to treat and recover value from biomass, as well as the wastewater associated with wood processing.

RESEARCH IMPACT

"Working with companies on these challenges is exciting, because so much of what we're learning is new to science. When we truly understand how these natural systems work, we're going to be able to work in harmony with them. That's sustainability."

PROFESSOR LESLEY WARREN
Claudette MacKay-Lassonde Chair in Mineral Engineering;
Director, Lassonde Institute of Mining

LOCALLY ADAPTED WATER SOLUTIONS

In Pedro Arauz, Nicaragua, the six-month-long dry season takes a brutal toll on local agriculture. Though the area has plenty of groundwater, a lack of infrastructure and difficulties with importing goods mean that irrigation technologies are out of reach for most farmers.

A team of students supervised by mechanical and industrial engineering professor **AMY BILTON** has been travelling to Pedro Arauz for nearly three years. Working closely with community members and charities, they've designed and built a wind pump — using locally available materials — that can provide irrigation much more efficiently than the hand pumps that are currently in widespread use. One of Bilton's graduate students also designed an electricity-free device that senses how wet or dry the soil is and regulates the water's flow accordingly.

As the head of the Water and Energy Research Laboratory, Bilton and her team specialize in designing simple and sustainable technologies to address challenges unique to specific areas of the developing world. They recently partnered with an international consortium to pilot an electricity-free, solar-powered device that circulates the water in fish farms in Bangladesh. They are also in the process of developing a similar system based on wind power.

Fish are a major source of inexpensive protein and an economic driver in the south Asian country. Better water circulation increases the level of dissolved oxygen, which can increase farm productivity.

PARTNERING FOR NEXT-GENERATION DRINKING WATER TREATMENT

In developed countries, people expect clean, safe drinking water whenever they turn on their taps, but professors **BOB ANDREWS**, **SUSAN ANDREWS** and **RON HOFMANN** in the Department of Civil & Mineral Engineering know that this cannot be taken for granted. As members of U of T Engineering's Drinking Water Research Group (DWRG) and the Institute for Water Innovation, they work closely with industry and local municipalities to ensure the integrity of drinking water supplies for decades to come.

Professors Bob Andrews and Ron Hofmann both hold NSERC Industrial Research Chairs with partners including the City of Toronto and a number of other municipalities in and around the Greater Toronto Area, which serve millions of consumers. Their work offers municipalities a window on the future by testing new drinking water treatment processes and assessing their impact for a given community. Their analysis enables local governments to make smarter investments that can save millions of dollars.

A key aspect of the DWRG's work is that much of it is done on site, with graduate students working either in pilot plants run by the municipalities or in full-scale drinking water treatment plants. This provides rich opportunities for students to get to know their future employers, while enabling operators and municipal engineers to gain new perspectives and learn about the latest advances in their fields.

MICROBES IN WATER AND MINING

Globally, the mining industry is second only to power generation in water usage. Every year mines use 7 to 9 billion cubic metres of water to extract desired elements from raw ore, resulting in large volumes of tailings — a combined water-particle waste slurry that is stored on site in tailings ponds. Tailings ponds are often black boxes containing largely undescribed bacteria and other microorganisms that thrive on mineral wastes and drive chemical reactions that can lead to acidification, toxicity and oxygen consumption. Uncovering the roles of these microbes offers new opportunities to better manage tailings and prevent potential environmental impacts for mines across all extractive resource industries.

Professor **LESLEY WARREN** (left) has spent decades working with the extractive resources sector, including Syncrude Canada, Glencore, Vale, Hudbay, Rambler as well as the Ontario Mining Association, NRCan and the Mining Association of Canada to shed light on the drivers of these reactions. As the director of the Lassonde Institute of Mining and the Claudette MacKay-Lassonde Chair in Mineral Engineering, she and her team study the genes and behaviour of the organisms that live in mine waste contexts. Armed with this knowledge, mines could ensure conditions that encourage the growth of organisms that break down toxic compounds, or prevent the growth of organisms that produce those toxic compounds in the first place.

With access to unparalleled facilities in the new Mining, Water and Environment Laboratory at U of T Engineering, Warren's research is leading the way toward new wastewater management solutions that will be more sustainable, efficient and cost effective.

Photo courtesy of Lesley Warren

THE INVISIBLE CLEANUP CREW

From former gas stations to oil refineries, thousands of sites host a legacy of toxic chemicals. Benzene, toluene, ethylbenzene and xylene, collectively known as BTEX, are often among them, and their removal from soil and wastewater can be expensive and time consuming. Chemical engineering professor **ELIZABETH EDWARDS** (right) has a new solution: a team of microorganisms that consumes and destroys BTEX chemicals.

Edwards, Canada Research Chair in Anaerobic Biotechnology, was awarded the 2016 Killam Prize in Engineering for her research on the naturally occurring microbes that thrive in contaminated sites. By growing these organisms in the lab and feeding them increasing concentrations of BTEX, Edwards and her team leverage the power of evolution to develop cultures ideally suited to breaking down particular contaminants. When these enriched cultures are added back to the soil, they can speed up the natural process of degradation.

Through a partnership with SiREM, an environmental consulting company, Edwards translates her research from the lab to the marketplace. The company already sells KB-1, a culture Edwards developed for degrading chlorinated compounds such as those formerly used in dry cleaning, to help remediate sites worldwide. They are now looking to do the same with the BTEX cultures.

As the director of BioZone, Edwards heads a multidisciplinary team of researchers who are leveraging the power of microorganisms in many other ways as well. For example, some may be able to transform forestry or agricultural waste into new products, from bio-based plastics to fuels.

THE FUTURE OF WATER RESEARCH

THE NEXT GENERATION OF REMEDIATION EXPERTS

At thousands of former industrial sites across Canada — from rail yards to chemical plants — barrels of hazardous chemicals are buried in the ground. What happens when those barrels start to rust, disintegrate and eventually leak?

Since 2014, professor **BRENT SLEEP** in the Department of Civil and Mineral Engineering has headed the Remediation Education Network (RENEW), which provides rich experiential learning opportunities for graduate students working on the hydrogeology, chemistry and microbiology of contaminated sites. The project, funded by a Collaborative Research and Training Experience (CREATE) grant from NSERC, yields highly qualified personnel equipped to understand the spread of pollution from these sites, and develop new approaches for containing or destroying it.

GOING WITH THE FLOW

A strong storm over a city the size of Toronto can empty enough water to fill more than 10,000 Olympic-sized swimming pools in less than a day. This water picks up trash, dirt, oil and other debris and then travels into storm sewers, quickly overwhelming the city's wastewater treatment plants and pouring directly into local rivers and lakes.

Professor **JENNIFER DRAKE** in the Department of Civil & Mineral Engineering believes there is a better way. She is a leading expert on low-impact development solutions — also known as green infrastructure — that can restore a more natural flow pattern to our built environment. Drake and her team focus on monitoring and modelling the performance of technologies like water-permeable pavement and green roofs, determining whether or not they work over the long term. This insight helps civil engineers, architects, urban planners and others design cities that work with nature, rather than against it, keeping local water bodies cleaner and more sustainable.

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

LEADING INNOVATION STARTS HERE

Connect with us to discuss how a partnership with U of T Engineering can benefit your organization:

OFFICE OF THE VICE-DEAN, RESEARCH
44 St. George Street, Toronto, Ontario
engineering.partnerships@utoronto.ca | 416-978-7890

www.uoft.me/leadinginnovationstartshere

STATEMENT OF ACKNOWLEDGEMENT OF TRADITIONAL LAND
We wish to acknowledge this land on which the University of Toronto operates. For thousands of years it has been the traditional land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people and we are grateful to have the opportunity to work on this land.

V2-18.11