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Civil Engineering

SUSTAINABLE Queen's

Engage | Act | Inspire

The Civil Engineering Department is extensively engaged in addressing 10 of the 17 UN Sustainable Development Goals as detailed in the following table. The work addresses the goals through research and by extensive interaction with both industry and government to find ways of addressing 60 different sustainability issues relevant to 21 of the UN Targets as described in https://www.un.org/sustainabledevelopment/ .

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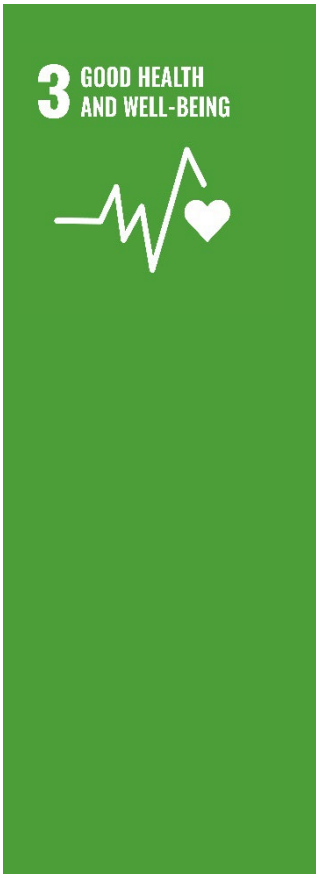
UN Goal	Faculty members and their research contributions
	**Dr. Mark Green and Dr. Katerina Genikomsou** are engaging and partnering with First Nations and other Indigenous communities to develop better community resilience against the effects of wildfires **(Target 1.5)**.
	**Dr. Sarah Jane Payne** is working on wastewater-based epidemiology as part of an early warning network for the arrival of respiratory viruses in communities by creating low-cost, low-tech sample collection tools that could be adopted in resource-constrained communities **(Target 3.9)**.
	Dr. Sarah Jane Payne and Dr. Yves Filion are working to reduce human health risk from toxic metals that can accumulate or be released from water pipes and plumbing materials. They are finding ways to improve water quality management and maintenance strategies. **(Target 3.9)**.
	Dr. Kevin Mumford and Dr. Kerry Rowe are working to reduce the movements of per- and polyfluoroalkyl substances (PFAS) from landfills and contaminated sites into groundwater and consequently the drinking water supply and the food supply to reduce the number of illnesses and deaths arising from these ubiquitous chemicals **(Target 3.9)**.

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6 CLEAN WATER AND SANITATION

Dr. Richard Brachman and Dr. Kerry Rowe
are evaluating the performance of bentonite to be used to seal around canisters containing radioactive waste in proposed deep underground facilitates and are considering the effects of high bedrock salinity and temperature of potential contaminant transport by flow and diffusion through the compacted bentonite to ensure negligible impact on water-related ecosystems **(Target 6.6)**.

Dr. Élise Devoie
is considering the issues of water security in remote Northern communities impacted by permafrost thaw, assessing the risks of thaw and potential contaminant transport from landfills and industrial activities to groundwater and surface water resources used for drinking water supply or for traditional food harvesting **(Target 6.3).**

Dr. Ian Moore and Dr. Neil Hoult
are investigating the behaviour of new, deteriorated, and rehabilitated water, storm and wastewater pipes using both laboratory and field monitoring data, and have led to a greater understanding of how to design, assess, and repair these critical assets. Outcomes in this area include: (a) Design code recommendations for improved ways to design reinforced concrete sewer pipes, (b) Recommendations for Canadian municipalities and consultants on the performance of liners for the repair of cast iron water pipes, and (c) New equations for the design of stormwater culverts that address significant limitations in current approaches **(Target 6.3).**

Dr. Ian Moore
is working to understand how pipe joints resist leakage, and to develop improved joint design methods for circumstances where the joint is subject to rotation and shear force. Past projects explain the behaviour of buried thermoplastic, corrugated steel, fibreglass, and steel-thermoplastic composite sewer and stormwater pipes, and underpin design methods for these structures internationally **(Target 6.3).**

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6 CLEAN WATER AND SANITATION

Dr. Kevin Mumford
seeks to understand the behaviour of contaminants in subsurface environments and use that understanding to protect and remediate groundwater resources. His team is using a combination of laboratory experiments and numerical models, to develop and improve site investigation strategies and remediation technologies for contaminants including petroleum fuels, chlorinated solvents and per- and polyfluoroalkyl substances (PFAS) that are often present at current and former industrial sites and pose a risk to human health and the environment. **(Target 6.3).**

Dr. Jason Olsthoorn
is determining how contaminants are transported within our surface and groundwater reservoirs **(Target 6.3).**

Dr. Sarah Jane Payne
is developing ways to simultaneously reduce water consumption, while delivering high-quality drinking water at the tap. Her team is examining the impact of increased water stagnation and hold times on the release and accumulation of toxic metals in plumbing as well as the accumulation of microplastics and nanomaterials **(Target 6.3).**

Dr. Fady Abdelaal and Dr. Kerry Rowe
are improving the design and construction of potable water reservoirs to ensure safe storage of clean water resources, particularly in communities facing water scarcity. **(Target 6.4 and 6.B).**

Dr. Kerry Rowe
is improving the design and construction of sewage and freshwater retention lagoons in small northern communities thereby restoring and protecting water-related ecosystems **(Target 6.6)**; is working on developing designs for the effective containment of per- and polyfluoroalkyl substances (PFAS) and micro and nanoplastics in municipal solid waste and construction and demolition waste landfills and monofills for contaminated soil **(Target 6.3).**

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6 CLEAN WATER AND SANITATION

Dr. Kerry Rowe and Dr. Fady Abdelaal
are improving the design and construction of many forms of waste containment facilities including municipal solid waste landfills, low-level radioactive waste storage facilities, and mine waste facilities together with lagoons used for the storage of sewage and other fluids that could have an acceptable escape the environment. Their work is addressing **(Target 6.6)** on five continents.

Dr. Stephanie Wright
Is working with Northern Indigenous communities to assess groundwater vulnerability and develop source water protection plans to ensure access to safe drinking water supplies **(Target 6.3).**

Dr. Xiaying Xin
is developing novel and innovative technologies for emerging microbial and chemical contaminant removal to provide high quality drinking water. The technologies are being designed to be sustainable, cost-saving, energy-efficient, and eco-friendly, which may facilitate the technology application in small and remote communities in developing countries, to achieve universal access to the safe water supply **(Target 6.3).**

Dr. Ryan Mulligan
is investigating transport of contaminants in coastal regions of lakes and oceans **(Target 6.3)**, and is the Director of the Beaty Water Research Centre (BWRC) at Queen's.

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7 AFFORDABLE AND CLEAN ENERGY

Dr. Mark Green and Amir Fam
are working on the development of concrete-filled fibre reinforced polymer tubes (CFFTs) specifically designed for wind turbine towers **(Target 7.2).**

Dr. Kevin Mumford
is working to improve understanding of the role of background dissolved gases and gas mixtures on the fate of hydrogen-related to underground hydrogen storage (UHS) and approaches to monitor storage sites for potential leakage to facilitate decarbonization efforts on the path to net-zero. **(Target 7.2).**

Dr. Kerry Rowe
is working on improving the design and construction of pumped storage schemes for storing wind and solar energy until is needed in peak periods and hydroelectric schemes for clean energy addressing both the need to improve the global percentage of renewable energy **(Target 7.2)** and improvement in energy efficiency **(Target 7.3).**

Dr. Kerry Rowe and Dr. Fady Abdelaal
are working on the safe storage of long-lived low level waste thereby aiding potential use of small modular reactors for small communities and providing access to modern energy in remote locations **(Target 7.1).**

Dr. Ryan Mulligan
is working towards evaluating impacts of marine renewable energy on the coastal environment **(Target 7.2).**

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9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Dr. Amir Fam
is developing new designs for new construction and retrofitting of existing structures in order to enhance their longevity **(Target 9.1).**

Dr. Amir Fam and Dr. Mark Green
are studying an innovative new biopolymer for reducing the cement (and hence carbon) content of concrete structures as well as investigating the biopolymer as a coating material to reduce corrosion of reinforced steel and hence increase the durability and resiliency of infrastructure **(Target 9.1)**; are developing new insulated wall panels systems incorporating ultra high-performance concrete to enhance the energy efficiency of construction **(Target 9.4).**

Dr. Neil Hoult, Dr. Ian Moore, Dr. Andy Take, and Dr. Josh Woods
are developing a better understanding of the performance of linear infrastructure assets (i.e., pipes, railways, and bridges) subjected to regular loading, ongoing deterioration, and extreme events. Outcomes: (a) Development of a robotic system that installs fibre optic sensors on linear infrastructure assets, (b) First of its kind data on the performance of bridges and rail tracks under vehicle and long-term environmental loading (e.g., the response of rail tracks to thermal loading, which is likely to be increasingly important with the rise of global temperatures), and (c) Advanced assessments of a bridge's reserve capacity allowing it to survive extreme events **(Target 9.1).**

Dr. Ian Moore
is developing new pipe products and methods for pipe repair, by explaining the mechanics of these pipe and lined-pipe systems, and developing design methods for use by consultants; has developed methods used internationally by contractors who install pipes using Horizontal Directional Drilling to mitigate the risk of inadvertently losing drilling fluids into the environment **(Target 9.1).**

Dr. Kerry Rowe and Dr. Fady Abdelaal
are working with industry to show the effectiveness of new materials that provide more sustainable and resilient infrastructure **(Target 9.1).**

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Dr. Andy Take
is assessing the impact of climate change on critical transportation corridors serving residents of the northern and Indigenous communities and developing new strategies to reduce climate-driven damage to railway bridges along critical corridor **(Target 9.1).**

Dr. Élise Devoie
is considering the issues of water security in remote Northern communities impacted by permafrost thaw, as well as the impacts of frost action on infrastructure through the development of new monitoring techniques **(Target 11.3).**

Dr. Amir Fam
is using (a) rapid construction methods such as corrosion-resistant fiber-reinforced polymer stay-in-place structural forms for concrete construction, and (b) low-carbon construction materials for the development of energy-efficient buildings **(Target 11.3).**

Dr. Mark Green and Dr. Katerina Genikomsou
are engaging and partnering with First Nations and other Indigenous communities to develop better community resilience against the effects of wildfires **(Target 11.5).**

Dr. Neil Hoult and Dr. Josh Woods
are developing improved approaches to design and assessment making new structures more sustainable and existing structures more resilient by (a) developing low carbon-reinforced concrete design and construction techniques that will reduce CO2 emissions associated with concrete construction. (b) using high-quality sensor data to provide better tools for understanding how existing structures behave and hence allow engineers to take advantage of this additional capacity as extreme events become more frequent and the need to repurpose rather than replace existing buildings to amortize their carbon footprint over a longer period becomes necessary **(Target 11.3).**

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11 SUSTAINABLE CITIES AND COMMUNITIES

Dr. Ian Moore
is developing pipe repair methods to provide more sustainable solutions than conventional cut-and-cover pipe replacement **(Target 11.3).**

Dr. Fady Abdelaal and Dr. Kerry Rowe
are improving solid waste management and in so doing reducing the environmental impact of cities **(Target 11.6).**

Dr. Kerry Rowe
addresses disaster risk reduction through a better understanding of piping through holes in liners for tailings dams and development of improved design approaches **(Target 11.3).**

Dr. Andy Take
is working on disaster risk reduction through: 1- better understanding of dam breach and, in particular, the failure of dams storing mine waste (tailings); and 2- better understanding of the linkage between rainfall intensity and the mobility of landslides (i.e. how fast and how far the debris will travel) essential to manage these risks in the context of a changing climate **(Target 11.3).**

Dr. Ryan Mulligan
is working to design nature-based solutions for coastal protection, and to improve infrastructure resilience to reduce the impacts of disasters caused by hurricanes and tropical storms **(Target 11.5).**

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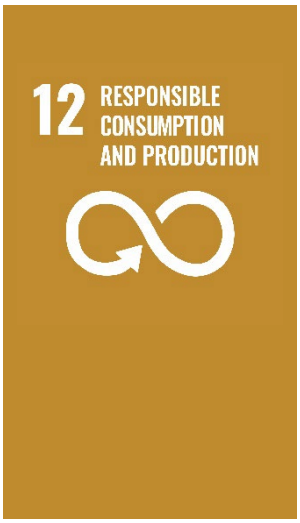

Dr. Amir Fam
is using ultra-high-performance concrete (UHPC) which is 3 to 4 times stronger than normal strength concrete, thereby significantly reducing the volume of material required in a structure and the associated deadweight used in design **(Target 12.2).**

Dr. Ian Moore
is contributing to the development of methods of pipe repair that represent a much lower consumption of resources **(Target 12.1)** and generation of waste **(Target 12.5).**

Dr. Ana Maria da Silva
is working to understand the physical and environmental impacts on river ecosystems of altered flow regimes caused by climate change, land-use changes, and water exploitation by deepening the understanding of river behaviour and developing models for the prediction and simulation of river response to a range of stressors **(Target 13.1.).**

Dr. Élise Devoie
is working to understand the impacts of climate change on permafrost, groundwater, and surface water resources, assessing current rates of thaw, and producing predictions of future conditions and challenges posed by changes in climate and development of and adaptation measures **(Target 13.1.).**

Dr. Amir Fam
is developing sustainable, durable, and high-performance structures to tackle the challenges posed by climate change and adverse environmental conditions in highway bridges, buildings and other structures **(Target 13.1.).**

Dr. Mark Green and Dr. Katerina Genikomsou
are engaging and partnering with First Nations and other Indigenous communities to reduce the incidence of wildfires and to develop better community resilience against the effects of wildfires **(Targets 13.1 and 13.3).**

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13 CLIMATE ACTION

Dr. Neil Hoult and Dr. Josh Woods
are reducing the carbon footprint of new and existing infrastructure and making infrastructure more resilient against future extreme events through innovative approaches to design, material selection, and construction; and developing novel techniques for infrastructure monitoring that allow structures to (a) remain in service longer thus amortizing their carbon footprint over a longer service life. (b) evaluate the condition of the infrastructure before and after extreme events to evaluate the resilience of the asset and the system, and (c) enable more effective design by optimizing the use of materials and infrastructure **(Target 13.1).**

Dr. Kevin Mumford
is improving understanding of methane leakage from oil and gas wells, which are an important contributor to greenhouse gas (GHG) emissions. **(Target 13.2).**

Dr. Jason Olsthoorn
is working to describe how lakes are changing due to climate change and develop adaptive strategies to minimize the impact on Canadians **(Target 13.1.).**

Dr. Kerry Rowe and Dr. Fady Abdelaal
are addressing mitigate the impact of the huge increase in mining required to provide batteries for electric vehicles being introduced to address climate change and develop techniques for minimising environmental hazards due to this increased mining **(Target 13.1.).**

Dr. Stephanie Wright
is working to understand the impact of climate change on surface water and groundwater resources in cold regions that are severely impacted by a warming cryosphere. This work aims to support water resource professionals in managing and protecting vulnerable freshwater supplies in the face of climate change **(Target 13.1.).**

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13 CLIMATE ACTION	**Dr. Xiaying Xin** is working on harmful cyanobacterial algal bloom control for both in-situ and in-vitro treatment to reduce the effects of global warming on water quality **(Target 13.1.).**
	Dr. Ryan Mulligan is leading research efforts to simulate the impacts of changing atmospheric conditions on coastal regions of lakes and oceans **(Target 13.1).**
	Department of Civil Engineering has courses explicitly building knowledge and capacity to meet climate change **(Target 13.3.).**
14 LIFE BELOW WATER	**Dr. Ryan Mulligan** is conducting research on ocean waves and currents, to improve management and protect coastal ecosystems to avoid significant adverse impacts, and strengthening resilience **(Target 14.2).**
	Dr. Jason Olsthoorn is investigating how heat, nutrients, and plastics move around in the world's lakes and oceans and developing measures to significantly reduce pollution **(Target 14.1).**
	Dr. Stephanie Wright is conducting interdisciplinary research with First Nations in the Yukon, Canada and fish biologists to understand how permafrost thaw is changing groundwater discharge to streams, which is critical to maintaining winter flows and fish habitat. The results aim to inform adaptation measures needed to protect salmon populations that are critical to the region's traditional ways of life, food security, and local economy **(Target 14.2).**

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Dr. Mark Green and Dr. Katerina Genikomsou
are engaging and partnering with First Nations and other Indigenous communities to reduce the incidence of wildfires **(Targets 15.1 and 15.2).**

Dr. Ryan Mulligan
is investigating flooding and inundation of the land surface that, driven by tsunamis, storms and sea-level rise **(Target 15.3).**

Dr. Kerry Rowe
works on the cleanup of contaminated soil is aiding in the restoration of damaged ecosystems from the Artic to the Antarctic **(Target 15.1).**

Dr. Kerry Rowe and Dr. Fady Abdelaal
are helping conserve and restore terrestrial and freshwater ecosystems by minimizing the escape of contaminated fluids from waste containment facilities including municipal solid waste landfills, low-level radioactive waste storage facilities, and mine waste facilities together with lagoons **(Target 15.1).**

Dr. Kerry Rowe, Dr. Richard Brachman and, Dr. Jamie Van Gulck
are seeking to mitigate the impacts of contaminated water escaping from old mine waste and oil and gas waste disposal sites on terrestrial and freshwater ecosystems **(Target 15.1).**

Dr. Stephanie Wright
is working to understand how contaminants migrate from thawing drilling waste stored in Arctic permafrost. Findings aim to inform remediation of contaminated land and to develop site management strategies needed to limit negative environmental impacts to the land **(Target 15.1).**

Dr. Ana Maria da Silva
is working to develop methods and guidelines to be used as foundation in river restoration and re-naturalization projects **(Target 15.1).**