CANADIAN ENGINEERING GRAND CHALLENGES

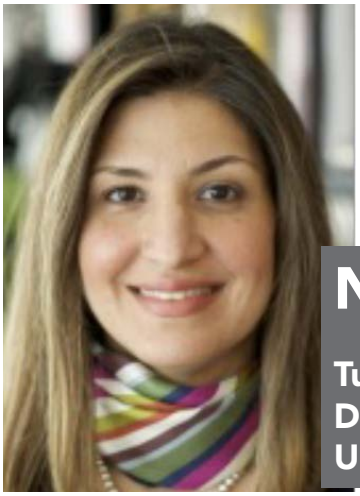
Working with You on a resilient and sustainable community

Peel Region case studies that address the Canadian Engineering Grand Challenges

Engineering Deans Canada | Doyennes et doyens d'**ingénierie** Canada

Region of Peel; A great place to live and work

What's inside



Acknowledgements

Nadine Ibrahim

**Turkstra Chair in Urban Engineering,
Department of Civil & Environmental Engineering,
University of Waterloo**

By Nadine Ibraham,

As engineers, we plan, design, and construct structures, processes and products that contribute to human growth and prosperity. We take part in transforming our natural environment in ways that influence how we live now and into the future. The obligations and responsibilities associated with our engineering activities require us to be leaders and technological stewards to safeguard people and the planet.

The Engineering Deans Canada have framed a call to action around the Canadian Engineering Grand Challenges (CEGCs) centred around the most compelling and critical issues facing Canada and Canadians today and over the next decade.

I am very grateful that this publication is an opportunity to bring the CEGCs to light and to showcase a number of projects and initiatives from Peel Region that are relevant to addressing each of the grand challenges. By raising awareness about these challenges, students will develop attributes and competencies by working in collaboration with people from other disciplines. These attributes include: the ability to design and create, the ability to integrate and solve, the understanding of business and innovation, the practice of being multicultural and diverse and the commitment to social consciousness and community.

I wish to extend many thanks and appreciation to all who contributed to this publication.

Thanks to Elise Rao, second year Environmental Engineering student at the University of Waterloo, for assisting with the design of this publication as a Legacy Project for the 2022 Douglas Wright Engineer in Residence, Kealy Dedman, in the hopes that this publication continues to be compiled for future Engineers-in-Residence representing different municipalities across Canada.

Thanks to Peel Region staff, Andrew Warren and Megan McCombe, who contributed to the, development, and design of this publication. They've made it a reality! Thanks also to all those at Peel Region who took interest in this project by reflecting on and contributing very meaningfully to each of the Canadian Engineering Grand Challenges from their areas, respectively.

Thanks to Kealy Dedman, Commissioner of Public Works at Peel Region for giving her time, energy, insight and experience to the University of Waterloo as the 2022 Douglas Wright Engineer-in-Residence.

Thanks to Engineering Deans Canada (EDC) for creating and endorsing the Canadian Engineering Grand Challenges as a framework that reflects the unique characteristics of our people, our natural landscape and the challenges we face as Canadians, which motivates and inspires our collective problem-solving sights.

Thanks to the late Carl Turkstra for his vision for establishing the Turkstra Chair in Urban Engineering that creates excitement for our future cities and for making this work possible.

Thanks to the all the readers who will find this valuable.

Kealy Dedman, 2022 Douglas Wright Engineer in Residence

Kealy Dedman provides strategic leadership and oversight of the Region of Peel Public Works Department which is responsible for delivering Transportation, Waste Management, Water and Wastewater, Operations Support, Planning and Development, and TransHelp services. Approximately 1.5 million people and over 175,000 businesses use these services within the Region. She currently oversees an annual operating budget over $850 million and a ten-year capital plan of $10 billion.

Kealy is the 2022 Douglas Wright Engineer-in-Residence for the Civil and Environmental Engineering Department at the University of Waterloo. She is the Chair of the Regional Public Works Commissioners of Ontario and the former President of the Canadian Public Works Association.

With over 25 years of progressively responsible leadership experience in the Public Works field, including the past 10 years at a senior strategic level in municipal government, she has consistently demonstrated the ability to champion sustainability and inclusivity.

Reflections from Kealy

My time as the 2022 Douglas Wright Engineer-in-Residence has been amazing. I am so happy to have had the opportunity to participate in this program at the University of Waterloo. It has been an honour to work with Dr. Nadine Ibrahim, Turkstra Chair in Urban Engineering, and exploring the intersection of theory and practice with her, as well as with Waterloo faculty and students.

The Engineer-in-Residence program has certainly demonstrated for me that the academic community and the engineering practice community can greatly benefit from closer collaboration. The program gives students an opportunity to see a career path in urban engineering and the public sector, and my many great conversations with students and faculty have broadened the scope of my own thinking around what's possible.

As the leader of a public works department in one of Canada's largest municipalities, concepts like sustainability and resiliency are top of mind. With this ebook, my hope is that we can showcase the Region's work in this regard.

It was through the Engineer-in-Residence program that I first learned of the Canadian Engineering Grand Challenges and immediately recognized it as something that provides a set of goals that both academia and those in the public works profession can embrace. The case studies that we've selected demonstrate the importance of integration across engineering disciplines and with different partners. Within a complex and varied political, social and economic environment, innovation and creativity are needed to tackle barriers to sustainable communities now and in the future. This ebook has also given us an opportunity to demonstrate the importance of telling our story in a compelling way so that decision makers can understand and endorse our initiatives.

At the Region of Peel, I believe we have been successful in achieving the important synthesis between problem solving and effective communication, and I am delighted to have this opportunity to showcase the exceptional work happening in Peel Region to address these Grand Challenges.

About the Engineering Grand Challenges 2020-2030

The United Nations' 17 Sustainable Development Goals (SDGs) are our world's call to action on the most pressing challenges and opportunities facing humanity and our natural world. Recognizing the critical role that engineers play as technological leaders and stewards, the Canadian Engineering Profession and Engineering Deans Canada believe engineers have a pressing responsibility to address these challenges with urgency.

The six Canadian Engineering Grand Challenges focus the thoughts and actions of our engineering community on the most compelling and critical issues facing Canada and Canadians today and over the next decade. More information can be found at engineeringdeans.ca.

Resilient Infrastructure

Infrastructure is key for a prosperous Canada. When fit for purpose it enables economic productivity; supports a healthy lifestyle and can address issues of social inequality. Infrastructure in Canada is most at risk due to climate change. Coastal communities rely on the management of climate risks on essential infrastructure that is reaching or exceeding its useful life. The consequence of damage and failures to infrastructure and buildings increases due to the changing stresses from climate change. When infrastructure fails it can disrupt everything from homes to businesses.

Access to affordable, reliable and sustainable energy

Energy is a critically important facet of the Canadian social and economic landscape. Due to its climactic conditions and relatively sparse landscape, Canadian residents and industries consume significant amounts of energy. contributing to over 11% of the national gross domestic product. Ensuring that future energy systems will be clean, safe, reliable, accessible and affordable for all Canadians is a key issue.

Access to safe water in all communities

Water is life. Provision of safe water is a basic human right. Issues of flooding, water scarcity, and invasive biological contaminants threaten the provision of safe water to communities and are further heightened through climate change. While Canada has an abundance of water its freshwater systems are under significant strain due to climate change, aging infrastructure and contamination. Also, the provision of safe water continues to be delivered, but there are significant challenges for small urban and Indigenous communities.

Inclusive, safe and sustainable cities

Cities are home to over 80% of Canadians – and are the arenas where many of Canada's toughest environmental and socio-economic challenges play out. Complex environmental stresses, including climate change and global biodiversity loss, among others, intersect with social challenges of widening inequality, and changing demographics. The 'design' of cities has substantial impacts on human health, linked to auto-dependent lifestyles. Addressing these challenges will necessitate changes to the ways that engineers participate in the planning of urban infrastructure and the development of urban technologies more broadly.

Inclusive and sustainable industrialization

Inclusive and sustainable industrial development depends on achieving long-term economic prosperity from industrial activities while minimizing resource use and safeguarding our natural environment. Inclusive industrialization ensures that industrial development in Canada and internationally offers equal opportunities to everyone and ensures an equitable distribution of the benefits from industrialization. Technological progress is vital in this process and can mobilize and contribute to the energy-efficiency of our industries and minimize the use of our natural resources or waste generated.

Access to affordable and inclusive stem education

Although engineering education in Canada has grown substantially over the past 165 years, female enrollment in engineering programs persists at 20 percent despite focused efforts to close the gender gap over the past decade. Also, Indigenous peoples are significantly underrepresented in Canadian engineering programs; Indigenous peoples make up 4.9 per cent of the Canadian population but only account for 1.2 per cent of total undergraduate enrollment in engineering programs. Diversity in education and the workforce would significantly contribute to economic growth; diversity of thought will benefit future innovation.

About Peel Region

The Region of Peel has a population of over 1.5 million residents and over 175,000 businesses and is an integral part of the larger economic region of the Greater Toronto and Hamilton Area.

The Region is the upper-tier government in a two-tier system that includes three municipalities: the Cities of Mississauga and Brampton, and the Town of Caledon.

The services Peel Region provides include paramedic services, health programs, long-term care and services for seniors, child care support, garbage collection and recycling, water and water treatment, road maintenance, and housing and shelter support.

Region of Peel

RESILIENT INFRASTRUCTURE

CANADIAN ENGINEERING GRAND CHALLENGES

Resilient Infrastructure through Condition Assessment & Rehabilitation (CA&R)

Infrastructure is key for a prosperous Canada. When infrastructure fails it can disrupt everything from homes to businesses. The dependency relationship between infrastructure and other areas is a key issue when it comes to risks facing Canada.

Nicholas Gan
Manager, Engineering Condition Assessment & Rehabilitation

"As our communities continue to grow, we need to make sure that our infrastructure remains in a state of good repair for reliable water supply and wastewater collection. Prioritized condition assessment and strategic rehabilitation programs, including the use of trenchless technologies, are just some of the methods that our team uses to meet this challenge."

Keeping Peel's water supply and wastewater collection safe with CA&R

Peel Region has one of the largest water and wastewater systems in the country. We currently serve 1.5 million residents in Brampton, Mississauga, and Caledon, providing 599 million litres of high-quality drinking water every day. We also remove about 500 million litres of wastewater from homes and businesses. Ensuring that this key infrastructure is safe and resilient is a top priority for the Region.

One of the ways in which we maintain this critical infrastructure is by assessing and inspecting the Region's large diameter sanitary trunk sewers and transmission watermains. Doing this provides the information we need to identify and prioritize capital rehabilitation projects, ensuring our infrastructure stays in good condition.

The Condition Assessment & Rehabilitation (CA&R) section of Public Works is responsible for inspection, assessment and rehabilitation of sanitary trunk sewers and associated maintenance holes in the wastewater collection system. These are currently inspected by third party vendors using technologies like robotic inspection and CCTV cameras. Common defects associated with this infrastructure include cracking, inflow and infiltration and corrosion.

The CA&R team is also responsible for inspection, assessment and rehabilitation of transmission watermains and associated valve chambers in the transmission system. Like the sanitary trunk sewer assets, these assets are also inspected by third party vendors using technologies such as electromagnetic inspection, personnel entry for visual and sounding inspection and robotic leak detection.

Rehabilitation is prioritized based on the condition of the infrastructure and does not typically require full replacement. Rehabilitation solutions include cured-in-place-pipe, carbon fibre reinforced polymer, slip-lining and spray lining.

Approximately 60 kilometers of trunk sewers are inspected every year, with a target to assess all 300 kilometers of trunk sewer every 5 years. Since taking on the transmission watermain program in 2021, the target is to inspect all transmission watermains within a 10-year period.

Through prioritized condition assessment and targeted rehabilitation, the Region can optimize capital expenditures by strategically rehabilitating critical assets to extend their lifespans and protect Peel's water supply and the environment. On the sanitary side, this becomes more and more important as the risk of inflow and infiltration increases with more frequent and intense storm events as a result of climate change.

Valve chamber is on its way

SAFE WATER IN OUR COMMUNITIES

CANADIAN ENGINEERING GRAND CHALLENGES

Rediscovering our Affordable and Sustainable Energy Legacy

Energy is a critically important facet of the Canadian social and economic landscape. Ensuring that future energy systems will be clean, safe, reliable, accessible and affordable for all Canadians is a key issue.

John Glass
Manager, Water & Wastewater Operations and Optimization

"The Region of Peel has recently transitioned to viewing (and officially naming) 'Wastewater Treatment Plants' as 'Water Resource Recovery Facilities'. This change reflects a shift in thinking about wastewater treatment that has led to innovative projects such as the Clarkson Cogeneration Facility, where an existing process by-product that was previously disposed of (via flares) is now recovered and converted into two separate energy sources that offset external grid demands by the facility."

Solving today's challenges with forgotten technologies

Providing clean, safe, reliable drinking water and reliable wastewater collection and treatment to Peel residents and businesses requires a lot of energy. The Region is always looking for ways to offset that energy consumption while also maintaining our high-quality water and wastewater treatment system. One of our biggest success stories in this regard has been the use of cogeneration technology to generate renewable energy from biogas produced from the wastewater treatment process at the Clarkson Water Resource Recovery Facility in Mississauga.

Cogeneration as a concept is not new. It has been around since the 19th century, when large scale plants and factories would generate heat and electricity as a by-product that would then be used to help power those same plants and factories. Unfortunately, a lot of cogeneration projects were abandoned in the mid-20th century as electricity costs decreased and it was simply cheaper to buy electricity off the grid than it was to produce in-house.

However, thinking has recently shifted back to looking at these cogeneration technologies in a more positive light as a sustainable power generation option. At the Clarkson Water Resource Recovery Facility, we use the wastewater treatment process itself to generate heat and electricity to offset the use of outside utilities. This has two impacts: it makes the plant more energy efficient and it helps to reduce carbon emissions.

This is how it works: we have five anaerobic digesters, where organic waste from wastewater is broken down by bacteria in the absence of oxygen. From this digestion process we get two main byproducts – biogas and digestate (which can be treated to make fertilizer). Biogas is comprised primarily of methane, the main component of natural gas, as well as carbon dioxide, hydrogen sulfide, water vapor, and small amounts of other gases.

The Clarkson plant produces about 8 million cubic metres of this digester gas per year. The gas is collected and used as fuel for a cogeneration engine to generate electricity to the facility's internal high voltage grid and that generates heat to keep the digestion tanks warm as well as provide heat for the buildings on site and the domestic hot water uses.

Currently, the cogeneration system produces upwards of 40 per cent of the plant's energy needs. This is the equivalent of powering 1,000 households a year! Given its success, there are plans for cogeneration to offset energy needs at the plant by a total of 85 per cent.

The combination of increased energy costs and broader environmental concerns means that building resiliency and sustainability into our infrastructure must be at the centre of our thinking. This includes trying technologies that we might have once considered outmoded. The Clarkson example demonstrates that not only is cogeneration an effective means of sustainably powering our treatment plants, it also has the advantage of being a cost-effective way to help jurisdictions reach their carbon emissions reduction targets.

Cogeneration at the Clarkson Water Resource Recovery Facility.

AFFORDABLE AND SUSTAINABLE ENERGY

CANADIAN ENGINEERING GRAND CHALLENGES

Safe water in our communities

Water is life. Provision of safe water is a basic human right. While Canada has an abundance of water, its freshwater systems are under significant strain due to climate change, aging infrastructure and contamination.

"The environment is our collective responsibility. Municipalities should continue to explore innovative and sustainable technologies to mitigate environmental impacts. This innovation will allow for more resilient, natural and sustainable infrastructure."

Syeda Banuri
Project Manager, Infrastructure Programming and Studies

Ommar Moeen
Project Manager, Major Capital Projects, Roads Design and Construction

Using Low Impact Development to keep our water supply safe and protect species at risk

Charleston Sideroad Snow Storage Facility

During the winter, as plows clear the snow off the roadways, snow accumulates on the side of the road. As the snowbanks get higher, they become a safety issue by making it harder for drivers to see and pedestrians to cross, as well as impede things like on-street parking and walking and cycling facilities. To maintain the safety and accessibility of our roads, Peel's Road Maintenance team needs to remove large snow piles from the boulevard.

The removed snow contains road contaminants such as salt, oil, grease, garbage and heavy metals. As the snow melts, that meltwater enters our watercourses, taking the contaminants with it. To improve water quality and reduce the impacts on the watercourses that feed our water supply, the Region built its first snow storage facility in 2021. The facility includes a multi-stage treatment train process to remove contaminants before release to reduce the impacts of the meltwater to receiving watercourses.

The Charleston Sideroad Snow Storage Facility uses a bioswale low Impact development system into clean the meltwater before it is discharged to the Credit River. At first glance, the site looks just like a small parking lot with a sodded area on the side of the road but there is more than the eye can see – the site has been carefully engineered to naturally filter and retain the snow melt, slowly releasing it over time to ensure there isn't a heavy load entering the river at once. A comprehensive surface and groundwater monitoring program has been put in place so the Region can ensure the site is always functioning as designed and to comply with the Environmental Compliance Approval from the Ministry of Environment, Conservation and Parks for the site.

The Region has made low impact development practices a key part of our stormwater design criteria for all capital projects. This means that any road widening project must consider low impact development practices and include them where possible.

For example, we converted a stormwater pond along Bovaird Drive in Brampton to a large infiltration facility that not only provides flood control but allows for infiltration, enhanced water quality and thermal reduction before release to protect Redside Dace, a fish species protected by the Ontario's Endangered Species Act. Projects like this and the Charleston Sideroad Snow Storage Facility demonstrate the Region's dedication to water quality and climate change adaptation.

youtube.com/watch?v=Pwl1_Murjz8

Looks can be deceiving – The Charleston Sideroad Snow Storage Facility.

SAFE AND SUSTAINABLE CITIES

CANADIAN ENGINEERING GRAND CHALLENGES

Planning for safe and sustainable cities

The 'design' of cities has substantial impacts on human health and natural systems. Addressing these challenges will necessitate changes to the ways that engineers participate in the planning of urban infrastructure and the development of urban technologies more broadly.

Mark Head
Manager, Integrated Planning

"The Scoped Subwatershed Study is unique in providing environmental planning across multiple watersheds to inform Peel's settlement expansion for growth to 2051 and direction to protect, restore and enhance natural systems. Combining land use, infrastructure and environmental planning is an innovative way to helps build resilience to a changing climate and other growth pressures."

Environmentally responsible city planning

The Peel 2051 Scoped Subwatershed Study

Historically, planning for growth has often meant treating the natural world as a constraint to be transformed and developed. However, one of the most important ways that we can build sustainable foundations into our public works practices is by designing with nature to ensure the health of our natural systems and watersheds are factored into our development plans.

With the Region of Peel planning to accommodate an additional 175,000 people and 60,000 jobs in new settlement areas over the next 30 years, managing growth and the impacts of climate change is a key priority. This means that new communities must be planned differently than in the past. A modern community needs to be more compact, sustainable and resilient.

Peel's Scoped Subwatershed Study is an integral part of this new holistic approach to planning. The study, which was one of the first regional-scale environmental studies of its kind, looked at growth across multiple subwatersheds. The integration of regional land use, infrastructure and environmental planning with guidance for managing water resources and natural heritage was a key aspect of the work.

The study has mapped the natural systems and sets targets for protecting, restoring and enhancing the systems to be resilient and sustainable in the future. This means that natural systems are fundamental building blocks for the new communities and are set before any other plans are layered on top.

Natural system resilience and the impacts of a changing climate are fully considered in the management recommendations and guidance at a regional scale across multiple watersheds. This study sets the basis for detailed further subwatershed studies and secondary plans to be completed at the local municipal level by one of Peel's lower-tier municipalities, the Town of Caledon.

This study is also an excellent example of collaboration to achieve sustainable goals, as significant contributions to the study were made across Regional departments, by the three local municipalities, the Region's conservation authorities, Provincial staff, stakeholders and the public.

For further information: peelregion.ca/officialplan/review/focus-areas/settlement-area-boundary.asp

Protecting Peel's watersheds through planning.

SUSTAINABLE INDUSTRIALIZATION

CANADIAN ENGINEERING GRAND CHALLENGES

Exploring Sustainable Industrialisation

Inclusive and sustainable industrial development depends on achieving long-term economic prosperity from industrial activities while minimizing resource use and safeguarding our natural environment.

Cindy Kambeitz
Project Manager, Water and Wastewater Optimization and Operations

"Peel's wastewater facilities produce approximately 12,000 tonnes/year of ash as a by-product of incineration processes. Incinerator ash is a versatile material that has an ever-increasing and emerging array of end uses. We have an opportunity to beneficially re-use ash in ways that help the community and avoid the environmental impacts of landfill application."

Industrial applications for waste by-products

GE Booth Incineration Ash Beneficial Re-use

Our GE Booth Resource Recovery Facility uses the process of fluidized bed incineration to manage the solids stream in the wastewater process. This means that we use a granular material, such as sand, to transfer heat directly to waste to break it down.

One of the by-products of the incineration process is ash slurry. The slurry is temporarily stored onsite in two lagoons for settling. Once a lagoon is filled, it is emptied into an onsite ash holding pond for long-term storage.

There are two main environmental concerns with storing the ash in this way. Currently, our onsite storage will be nearing capacity within the next decade, and we are running out of space to expand it. Secondly, if we can't find other uses for the ash, or expand storage capacity, the ash would eventually find its way to landfill.

To address these concerns, Peel Region staff have been investigating multiple beneficial re-use options for the ash in the private sector. Possible applications for the ash include: concrete & brick additives, fertilizer additives, and phosphorous recovery.

Preliminary testing of our ash as an additive in the manufacturing process has been positive, showing re-use as cost beneficial, and with the potential to create jobs in Peel and prolong the life of existing quarries (in the case of brick production). Before full-scale implementation, additional work needs to be done to define risk levels and determine market interest and the size of potential partners.

This project is important to the environment as our goal is to prevent this material from ever being directed to landfill given that it is a very refined and stable product for re-use in several important applications. Finding a long term and local re-use option would help us to create an environmentally and economically sustainable circular economy in ash use for the Region.

Ash ponds at the GE Booth Resource Recovery Facility.

INCLUSIVE STEM EDUCATION

CANADIAN ENGINEERING GRAND CHALLENGES

Promoting Inclusive STEM Education

Although engineering education has grown substantially over the past 15 years, there continues to be a lack of diversity in students and faculty. Encouraging diversity in education and the workforce would significantly contribute to economic growth; diversity of thought will benefit future innovation.

Kelly Sousa Dias
Manager Waste Processing and Disposal

" Processing waste involves a very complex system, and this virtual tour gives rare, behind-the-scenes access to residents of all ages in observing how machinery, technology and people all work together to manage the 570,000 tonnes of Peel's waste per year." (Kelly)

Laura Lane
Supervisor, Environmental Education

"This resource provides equitable accesss to students and residents to learn about waste sorting and processing in ways they wouldn't normally have the opportunity to do."
(Laura)

Inspiring the engineers of tomorrow

Virtual 360-degree Waste Management and Peel Curing Facilities Tour

As a public sector organization, we recognize the importance of engineering and our role in developing a diverse workforce. We are in a position to influence younger generations to consider STEM disciplines and the Region as a future workplace through educational programs and services that we provide to the local community and beyond. These programs provide young people with a window into how STEM can be applied in the 'real world' and what working for the Region as an engineer might look like.

One of our flagship educational resources is our Virtual 360-degree tour of the Peel Integrated Waste Management Facility and Peel Curing Facility. The tour gives a behind-the-scenes look at how recycling and organics are sorted and processed at the Peel's Material Recovery Facility, Organics Processing Facility and Peel Curing Facility.

This virtual tour was created with both school-aged students and their education curriculum in mind, as well as the general public, to educate about what happens to waste after it's collected, while highlighting 'how things work' with operational processes, and state-of-the-art machinery and technology. The virtual tour provides equitable access to all students and residents to learn about waste sorting and processing – removing cost and physical barriers to touring the facility.

By providing access to affordable and inclusive programs that promote STEM education, the tour, along with other education and outreach programs, help create interest in our services and perhaps aim to inspire students to pursue STEM careers in the public sector.

The Region provides a host of excellent educational resources for Peel Region schools. These include other virtual tour programs for water and wastewater treatment, student workshops on water/wastewater treatment and waste management, transportation education resources, and the Peel Children's Water Festival – a multi-day in person event that educates children about water in a fun and hands-on way.

For further information, please visit: **peelregion.ca/enviroed**

CANADIAN ENGINEERING GRAND CHALLENGES

uwaterloo.ca/urban-engineering-cities

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