Metropolitan Water Reclamation District of Greater Chicago

Welcome to the February Edition of the 2025 M&R Seminar Series

NOTES FOR SEMINAR ATTENDEES

- Remote attendees' microphones are muted at entry to minimize background noise. For attendees in the auditorium, please silence your phones.
- A question and answer (Q/A) session will follow the presentation.
- For remote attendees, please use "**Chat**" only to type questions for the presenter. For other issues, please email Pam to SlabyP@mwrd.org.
  For attendees in the auditorium, please raise your hand and wait for the microphone to ask a verbal question during the Q/A session.
- The presentation slides will be posted on the MWRD website after the seminar.
- This seminar has been approved by the ISPE for one PDH and approved by the IEPA for one TCH. Certificates will be issued only to participants who attend the entire presentation.

Ruqiao (Emma) Shen, Ph.d. Eng., Global Principal – Wastewater Energy Optimization and Sector Decarbonization Jacobs

Dr. Shen is a process engineer based in Jacobs' Toronto Office, with more than 15 years of experience in municipal wastewater treatment design, process modelling and performance assessment. She is Jacobs' Global Principal for Wastewater Energy Optimization and Sector Decarbonization, leading a global team to develop sustainable decarbonization solutions for wastewater clients, focusing on optimizing energy efficiency, maximizing energy and resource recovery, and minimizing GHG emissions from wastewater treatment, solids handling and biosolids management.

Dr. Shen currently serves as the Water Environmental Federation (WEF) GHG Focus Group chair. She holds a Ph.D. degree in Civil and Environmental Engineering from University of Toronto (Toronto, Canada), and a Bachelor's degree from Tsinghua University (Beijing, China).

Be Ambitious: Durham Region's Water and Wastewater Net-zero GHG Roadmap

Emma Shen, PhD, P.Eng, Jacobs

MWRD Chicago M&R Seminar Series

February 28, 2025

Jacobs

Challenging today.
Reinventing tomorrow.

Agenda

- Project Background
- Overall Project Methodology
- Updated Baseline GHG Inventory
- Progress Towards the Objective
- Top Opportunities
- Long-term N_2O Monitoring Study
- Roadmap to Net-Zero
- Closing Remarks
- Q&A

Jacobs

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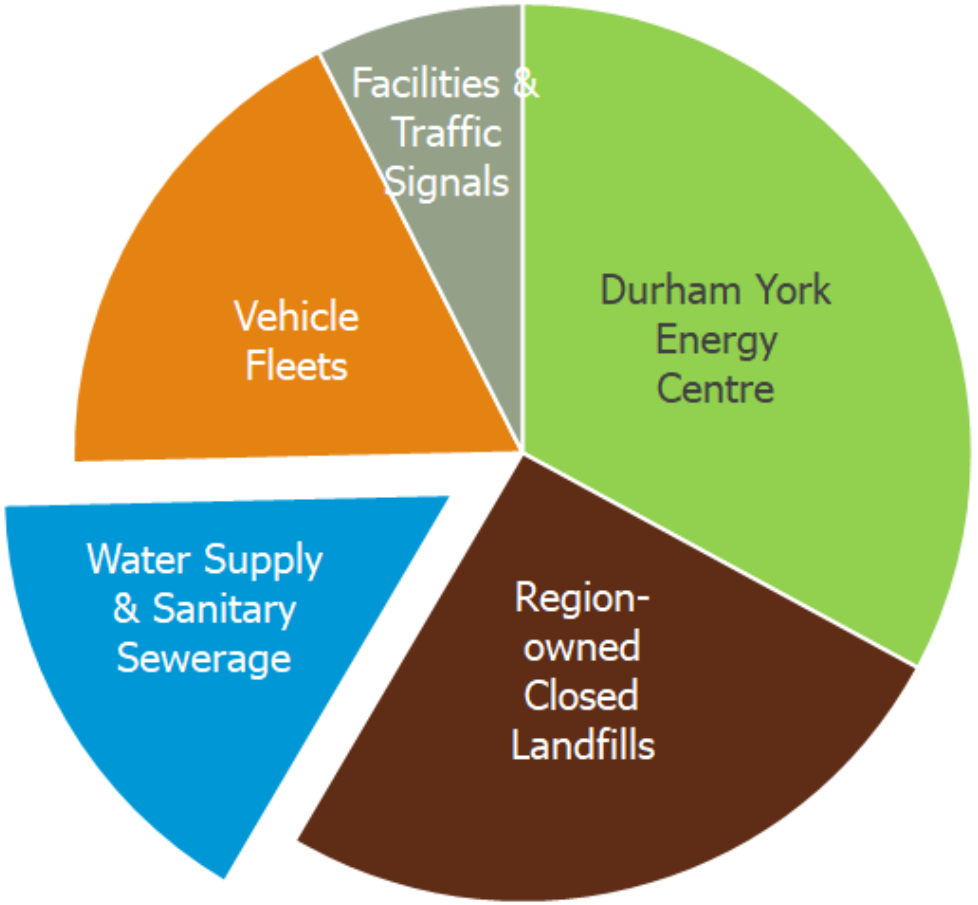
Project Background

- Durham Region, Ontario
  - Regional government with 8 municipalities
- Current population ~700,000
- Forecasted population 1,000,000 by 2041
  - One of the fastest-growing communities in Canada
- Regional Council declared a **climate emergency** on January 29, 2020

Corporate Climate Action Plan (2021)

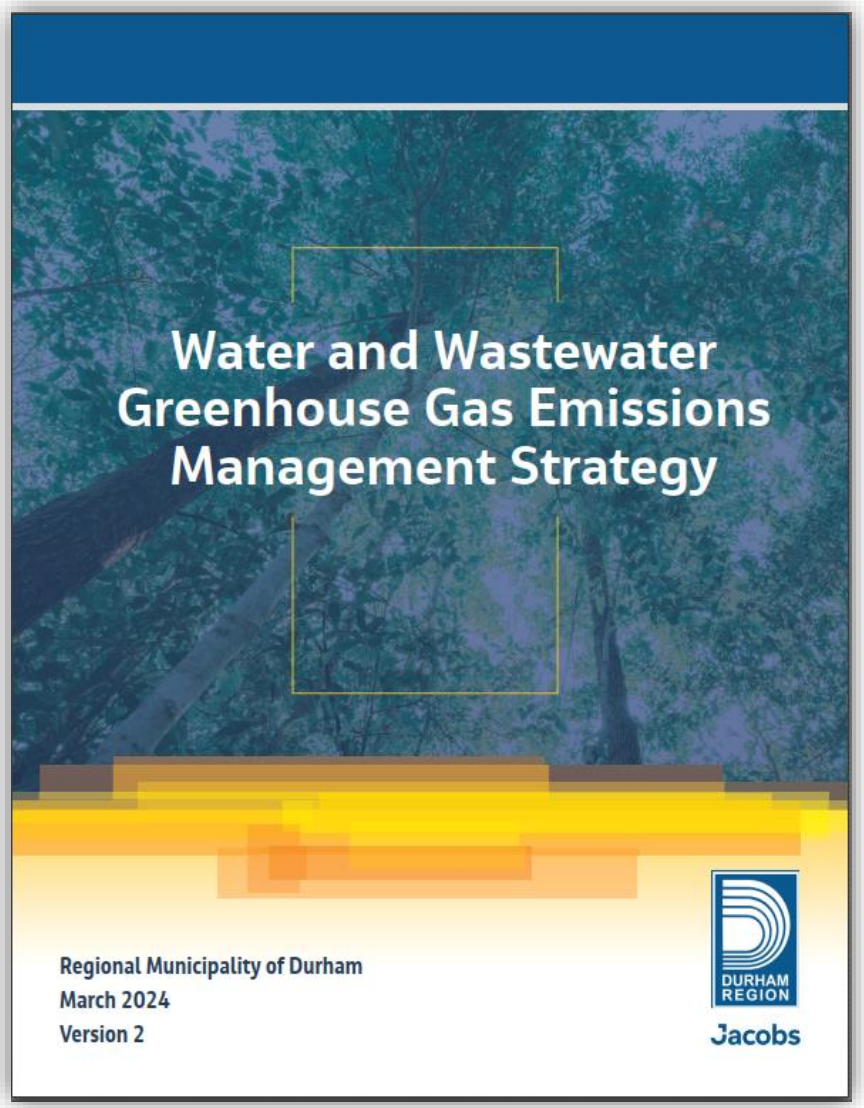
- **Corporate Climate Action Plan** (CCAP) established GHG reduction goals for corporate operations
  - 20% below 2019 levels by 2025
  - 40% below 2019 levels by 2030
  - 100% below 2019 levels by 2045



Source: https://www.durham.ca/en/resources/CAO-Office/Durham-Region-Corporate-Climate-Action-Plan.pdf

Water & Wastewater GHG Strategy (2022-24)

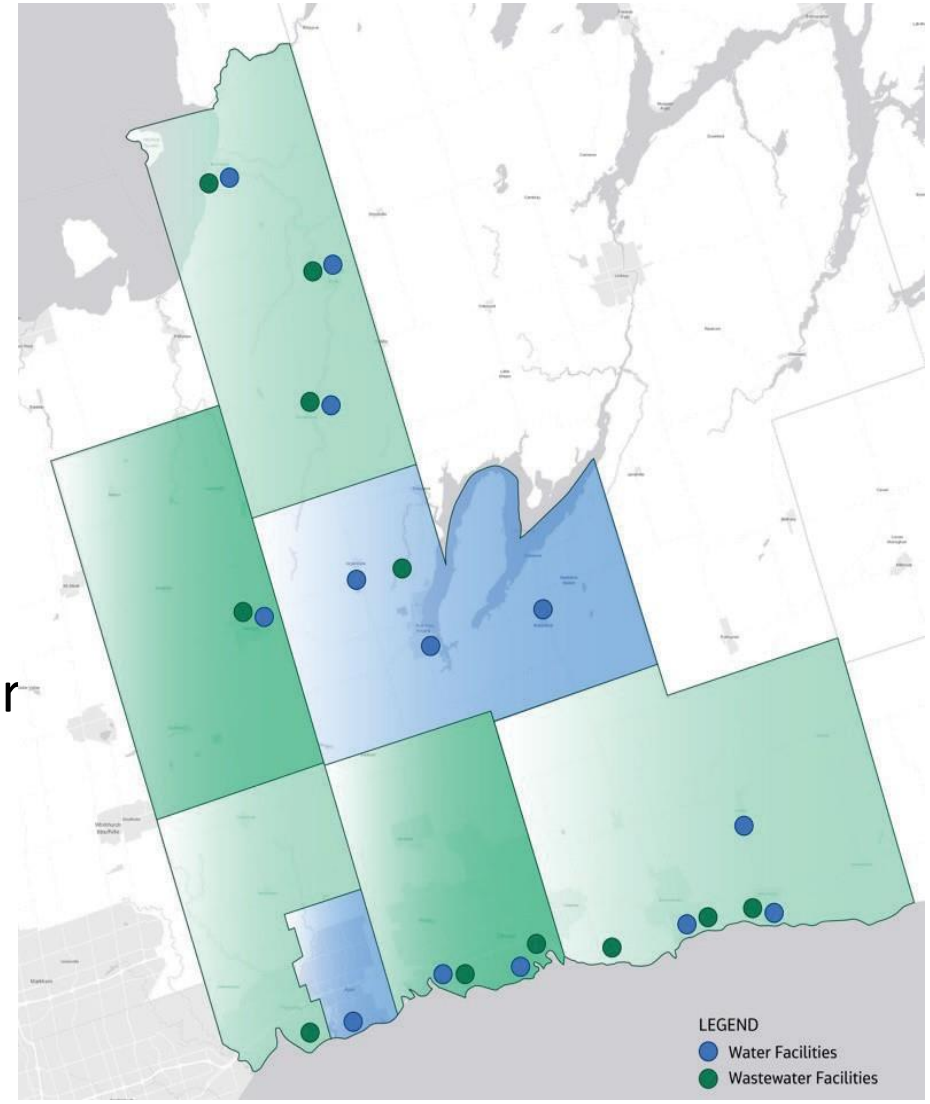
- Develop a **framework** to quantify GHG emissions at the water and wastewater facilities
- Establish the **baseline** GHG emissions
- Establish GHG **reduction targets**
- Identify **gaps** in meeting CCAP targets
- Identify the **priority areas of focus** to achieve short-, medium-, and long-term reduction targets
- Develop an **action plan**
- Identify **areas for future improvement** and roadmap to achieve the 2045 net-zero target



Durham Region's Water and Wastewater Systems

- **Wastewater collection and treatment**
  - 11 Water Pollution Control Plants (WPCPs) – total treatment capacity of 865 ML/d
  - 51 sanitary pumping stations
  - > 2,000 km of sewers
  - Serving Durham and York Regions

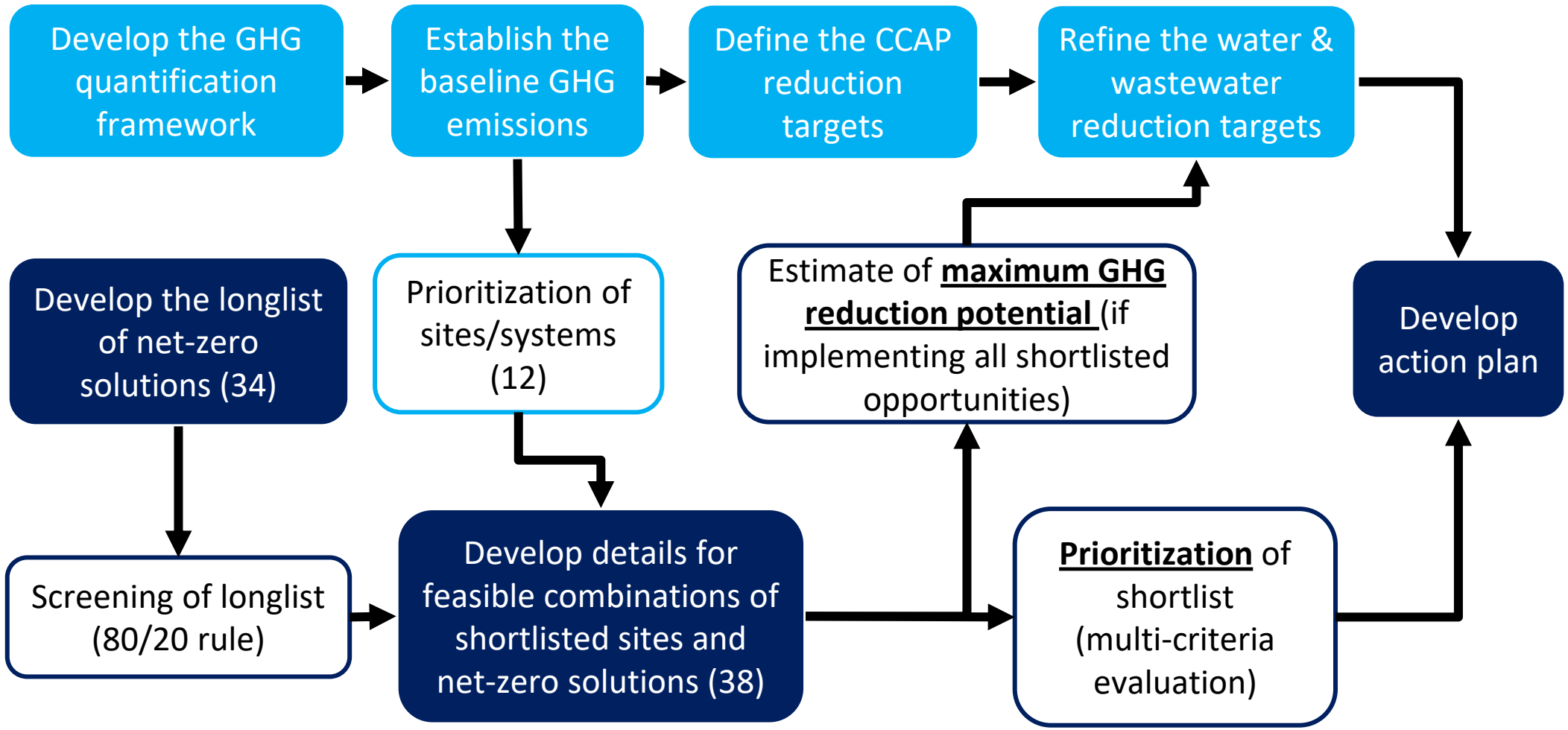
- **Water treatment and distribution**
  - 6 surface water supply plants (WSPs) and 8 groundwater well systems – total treatment capacity of 500 ML/d
  - 31 water pumping/storage facilities
  - 2,615 km of water mains



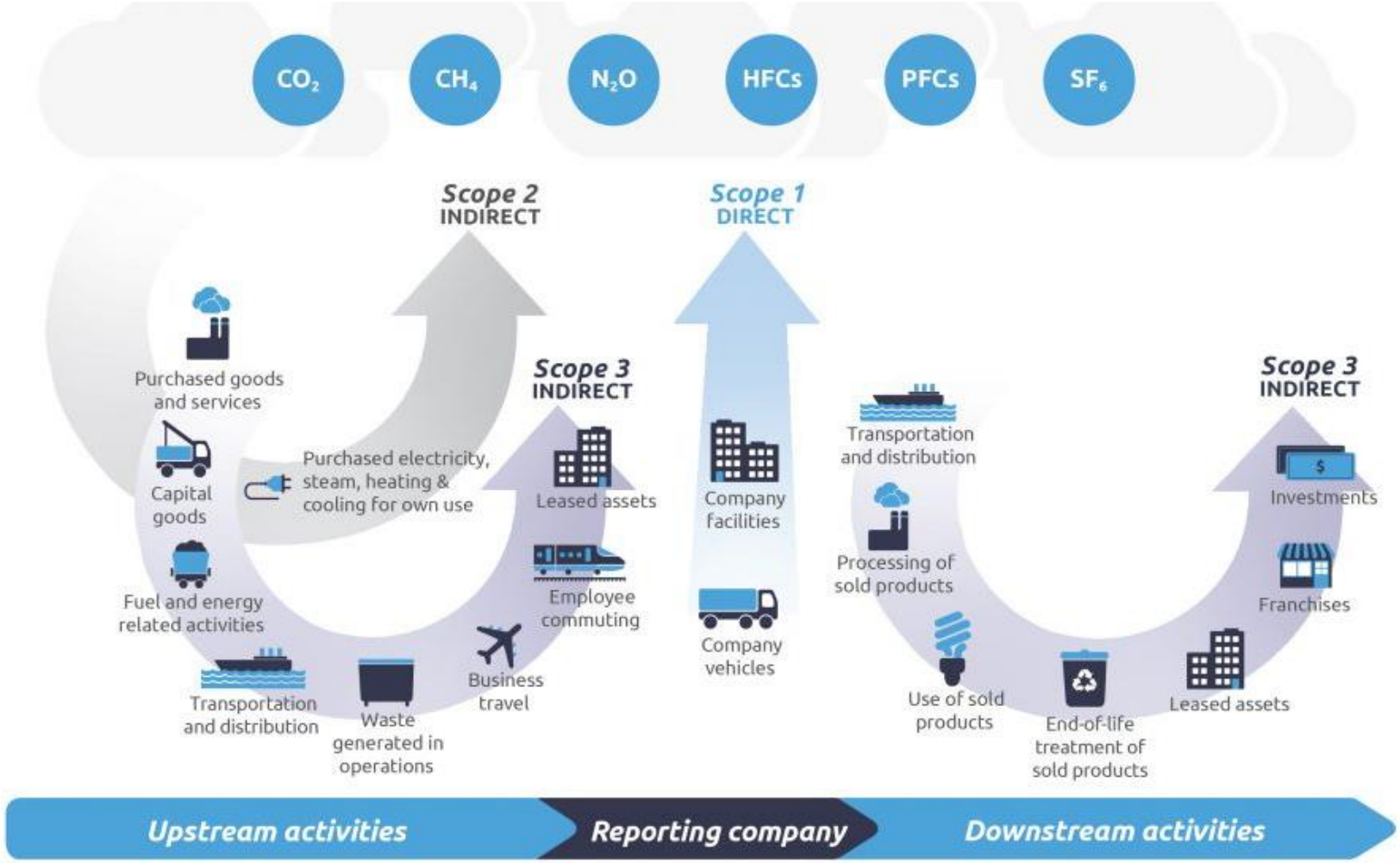
Duffin Creek Water Pollution Control Plant

- **Co-owned by Durham and York Regions**
  - Largest wastewater treatment facility
  - Total treatment capacity 630 ML/d
  - Approximately flow split 20/80 between Durham/York
  - Centralized management of Durham Region's biosolids through dewatering and incineration
  - GHG emissions presented for Duffin Creek WPCP in this study represent the **net Durham share** (i.e., ~20% of the total GHG emissions at the plant)

Overall Project Methodology



GHG Emission Scopes

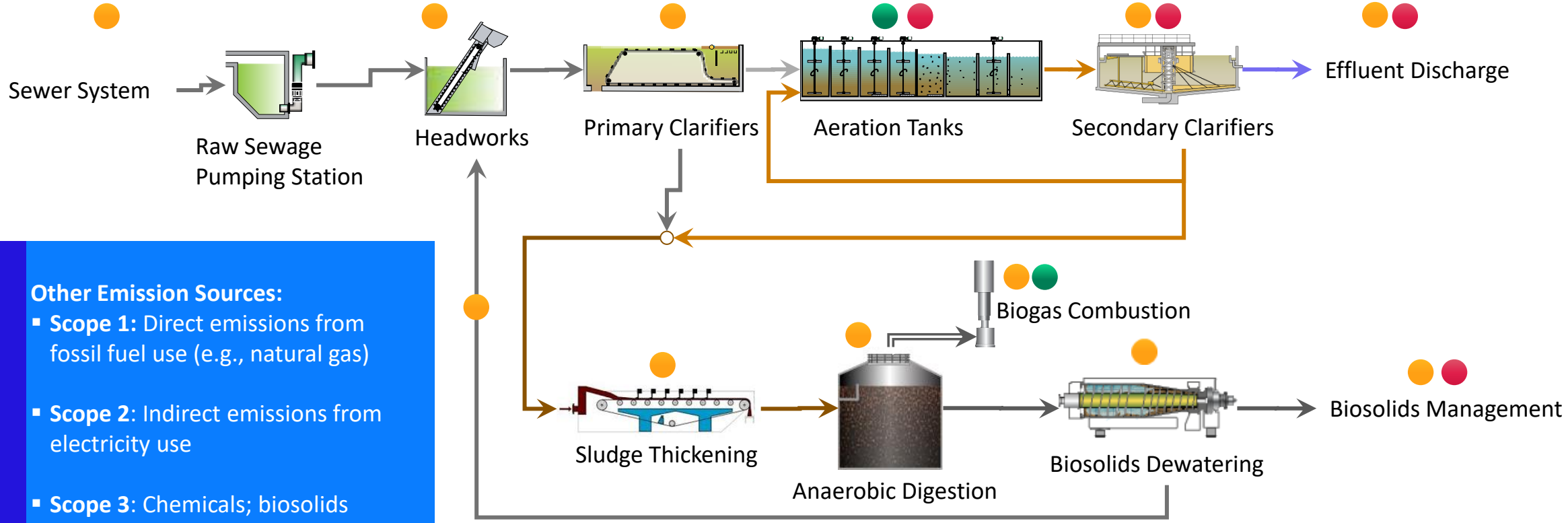


Source: Greenhouse Gas Protocol (2013)

GHG Emissions from Wastewater

Carbon dioxide (CO_2) GWP = 1 **Methane (CH_4) GWP = 28** **Nitrous Oxide (N_2O) GWP = 265**

GWP: Global Warming Potential



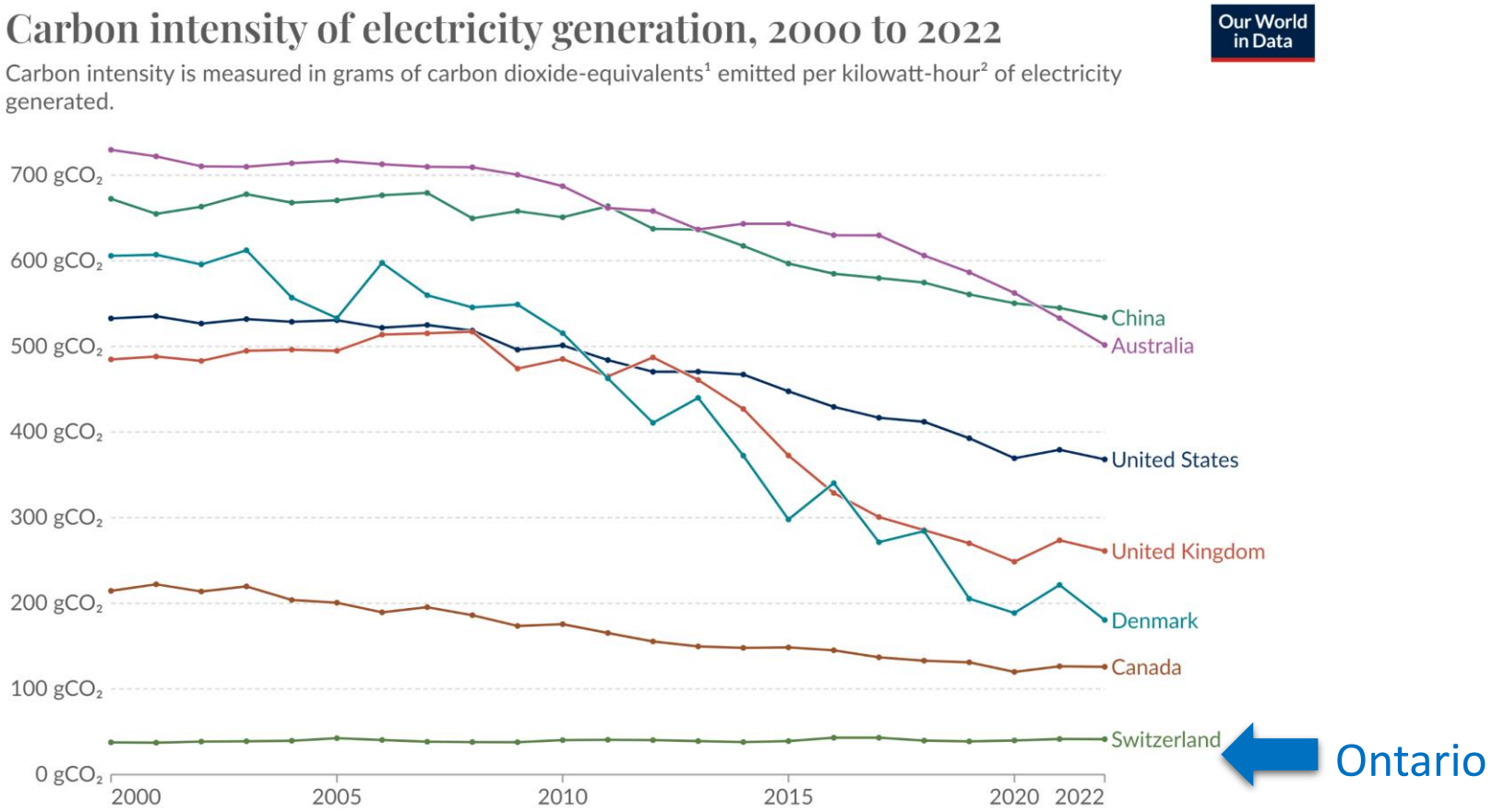
Other Emission Sources:

- **Scope 1:** Direct emissions from fossil fuel use (e.g., natural gas)
- **Scope 2**: Indirect emissions from electricity use
- **Scope 3**: Chemicals; biosolids beneficial use; 'embodied carbon' in existing (and new) infrastructure

Adopted from WEF Factsheet "GHG Sources and Sinks for WRRFs" (2021)

Unique Challenge for Ontario

Process emissions (N_2O and CH_4) dominate the wastewater GHG emissions as carbon intensity of electricity generation decreases



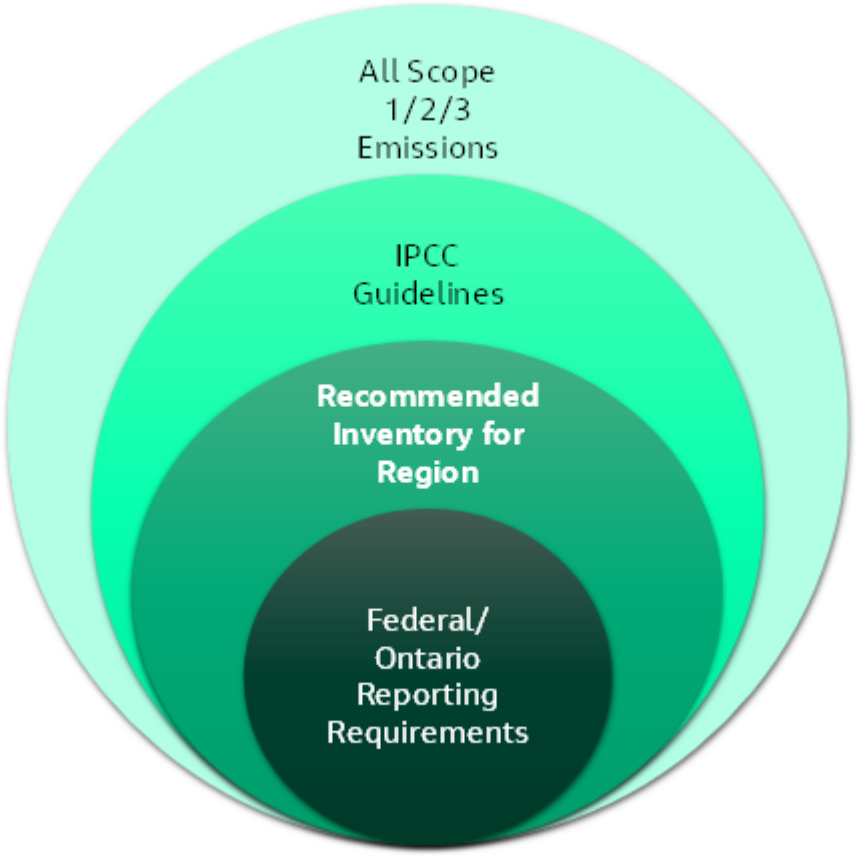
GHG Emission Sources for Durham Region

Scope	Emission Source	Applicability	Included in CCAP	Included in current project
Scope 1	N_2O – wastewater treatment	WW	√	√
Scope 1	N_2O – effluent discharge	WW	X	√
Scope 1	CH_4 – wastewater treatment	WW	X	√
Scope 1	CH_4 – effluent discharge	WW	X	√
Scope 1	CH_4 – sludge treatment	WW	X	√
Scope 1	Fossil fuel combustion	W&WW	√	√
Scope 1	Biogas combustion/flaring	WW	√	√
Scope 1	Biomass incineration	WW	√	√
Scope 2	Electricity consumption	W&WW	√	√
Scope 3	Chemicals	W&WW	X	√
Scope 3	Offsite biosolids and residuals (ash) management	WW	X	√

Inventory vs Objective Setting

- Industry best practice (e.g., 2019 IPCC Refinement)
- Availability & accuracy of quantification methods
- Level of complexity and difficulty in quantifying emissions
- Whether mitigation measures are available (such that the GHG reduction potential can be reasonably quantified)

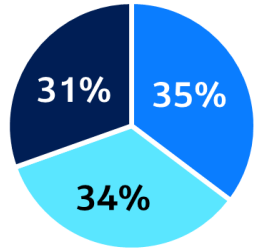
- **Recommendations for Region:**
  - Set reduction targets for **Scope 1 and 2 emissions only**
  - Track applicable Scope 3 emissions - potential for future target-setting



Updated 2019 Baseline Inventory

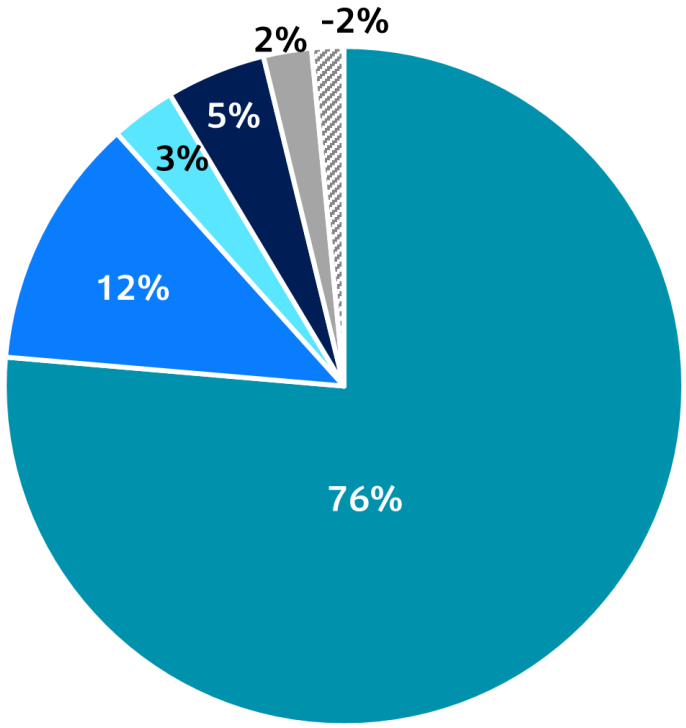
Water

Total Scope 1/2/3 emissions = 3,491 (8%)



Wastewater

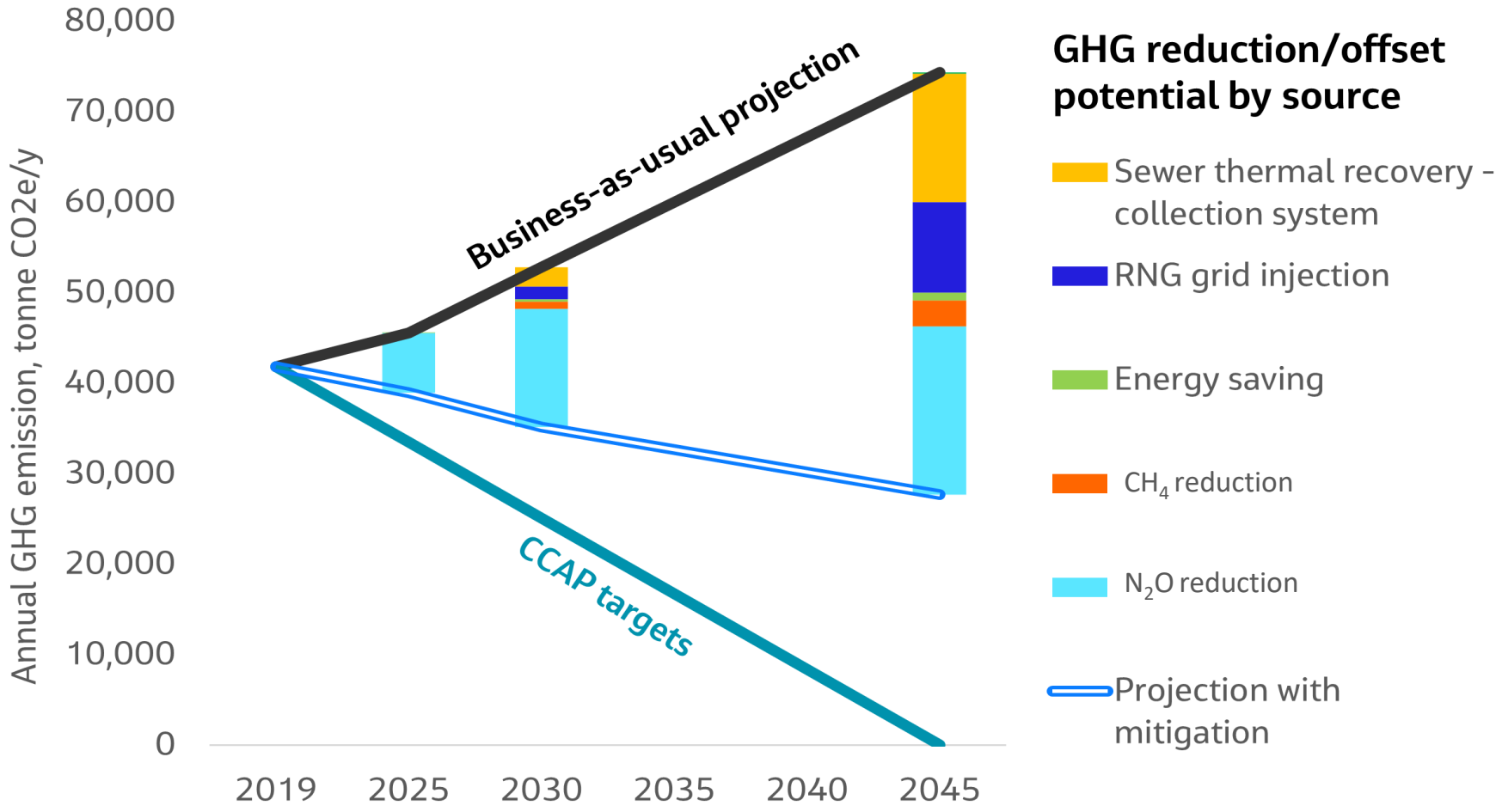
Total Scope 1/2/3 emissions = 42,422 (92%)
Total Scope 3 offset = 660



- Scope 1 Process Emissions
- Scope 1 Fossil Fuel Comsumption
- Scope 2 Electricity
- Scope 3 Chemicals
- Scope 3 Biosolids & Ash Management
- Scope 3 Biosolids Land Application & Ash Recycling (Offset)

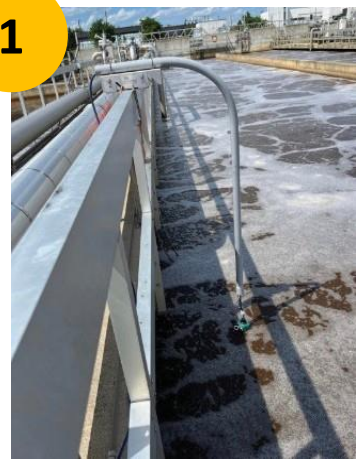
Progress Towards the Objective (Scope 1&2)

- Projected **mitigation potential** with current best practices



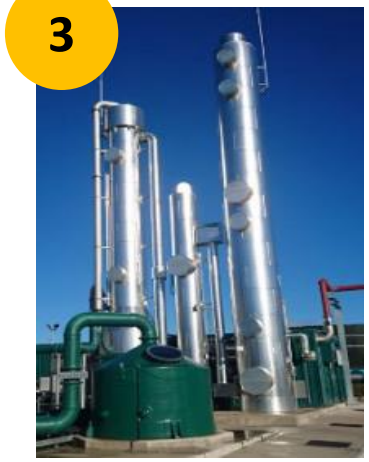
Top 3 Opportunities

1



N_2O monitoring & mitigation at WPCPs

3



Biogas upgrade to renewable natural gas

2

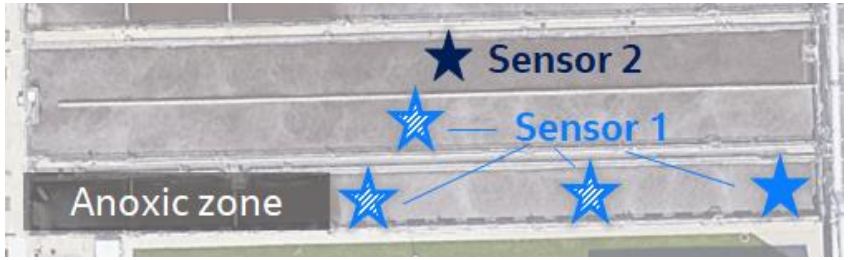
Collection system sewer thermal recovery

Science-based, cost-competitive recommendations

Project(s)	Facility/System	GHG Reduction Potential	Capital Cost	Equivalent Life-cycle Cost per Tonne of CO_{2e} Reduced	Implementation Timeline
N_2O monitoring and mitigation at WPCPs – permanent installation	Duffin Creek Courtice	🍃🍃🍃🍃🍃	$	$$	2024 to 2025
	Corbett Creek Harmony Creek Port Darlington	🍃🍃🍃🍃	$	$$	2026 to 2030
Sewer thermal recovery in the collection systems	Collection system	🍃🍃🍃🍃🍃	Project-specific	Project-specific	2026 to 2030 (selected projects) 2031 to 2045 (Region-wide)
Biogas upgrade to renewable natural gas (RNG) at anaerobic digestion facilities	Duffin Creek	🍃🍃	$$$	$	2026 to 2030
	Courtice Corbett Creek Harmony Creek Port Darlington	🍃🍃🍃	$$$	$$$	2031 to 2040

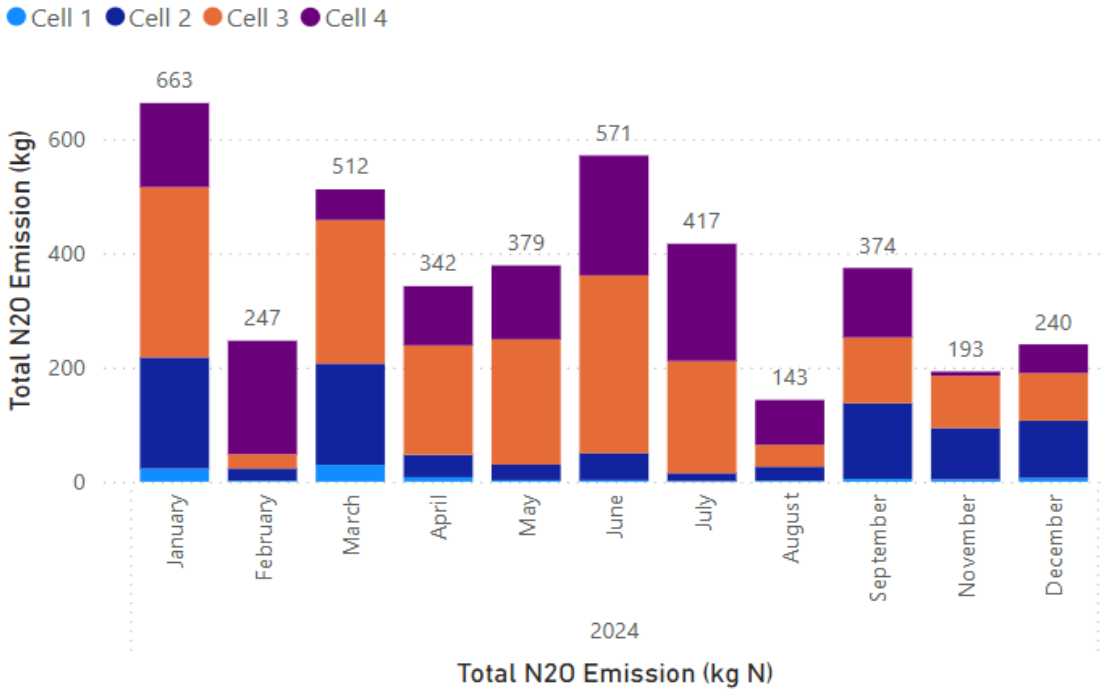
N_2O Monitoring Study at Duffin Creek WPCP

- 2-y monitoring program underway (2023-2025)
- Automated data processing & visualization (e.g., Power BI dashboard)



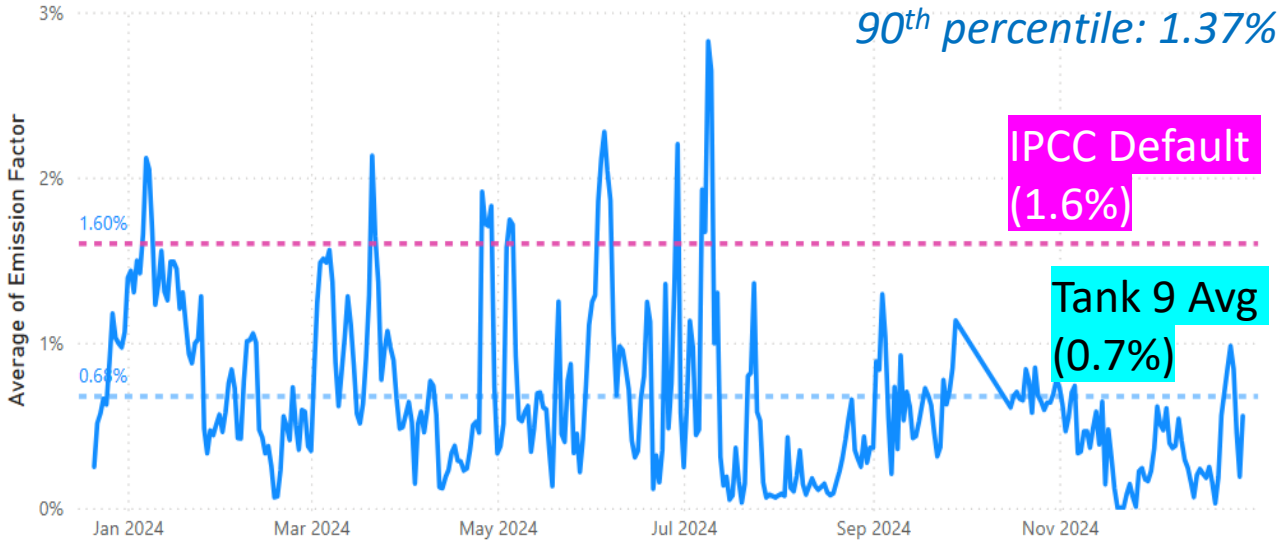
Aeration Tank #9

N_2O emissions variance – temporal and seasonal



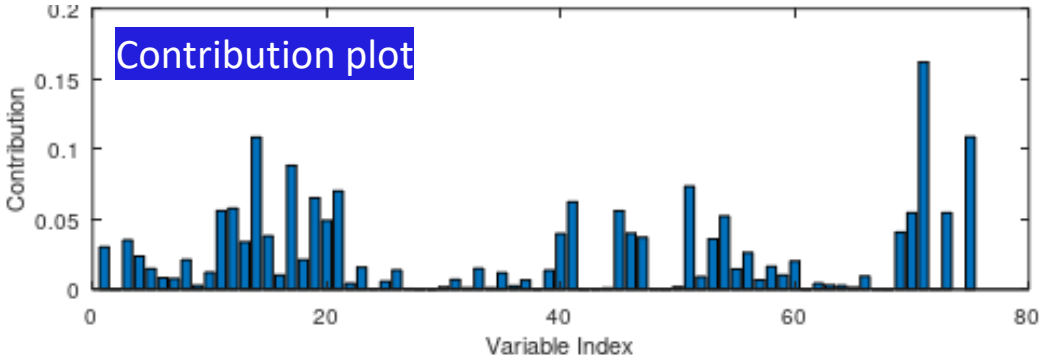
N_2O emission factor (EF) calculated as % of influent TN load to Aeration Tank 9

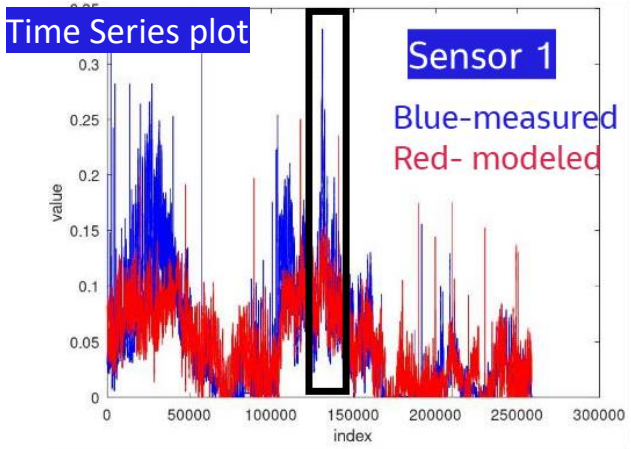
Range: 0.002% - 2.82%
90th percentile: 1.37%

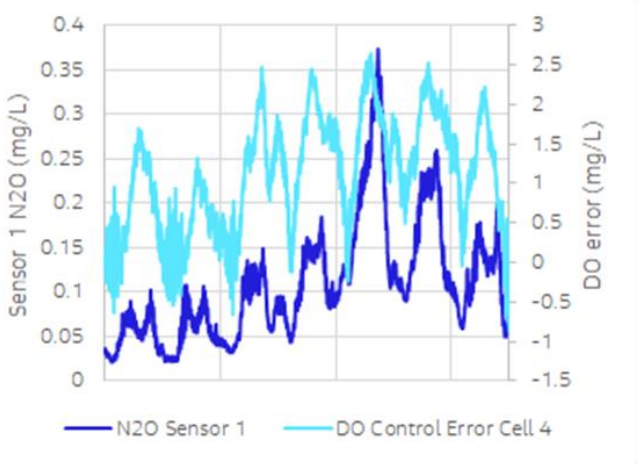


Hybrid Model for Enhanced Data Analysis and Mitigation Insights

- **Hybrid model with diagnostics** provides actionable insights on potential N_2O mitigation strategies
- Methodology enables translating operational information into data to feed the model – critical
- **Contribution plots** for event analysis – identify the most important predictors







Top predictors for N_2O peak events

Variable No.	Sensor 1 Unsorted Contributor Variable
1	Sensor 1 location
34	Stage 3 MOV
12	Effluent temperature
83	DO Control Error Cell 4
98	NHx SIM Cell 1

Based on data from late December 2023 to September 2024

Roadmap to Net-Zero

- New **Durham Standard** (and other regional initiatives) – drive the incorporation of best practices in energy and carbon efficiency during future renewals & expansions
- Federal & Provincial policies driving further decarbonization of Ontario's energy sector
- Leverage the **co-benefits** to expedite the implementation along with future planning & design projects (e.g., process performance, stability, resiliency, energy efficiency, or capacity)
- Adopt **other innovative solutions** as they become more established in the long term

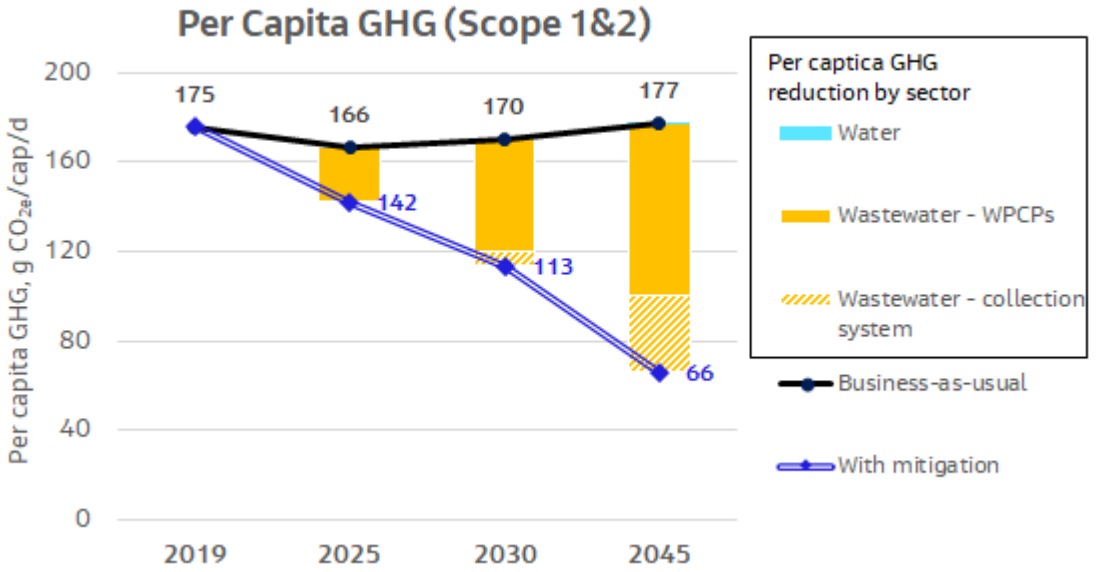
Membrane aerated biofilm reactor (MABR)

ELOVAC®
Vacuum CH_4
Extraction

Thermal conversion of biosolids (e.g., pyrolysis)

Transparent and Effective KPIs for Communication

- Reporting
  - Total GHG emissions
- Internal Tracking & Communication
  - **Per capita GHG emissions**
  - Purchased energy ($ impact)
  - GHG intensity for biogas generation & utilization (*RNG for corporate operations*)
  - Other renewable generation
  - Collection system sewer thermal recovery (*community-level contribution*)



Closing Remarks

- First project of its kind in Ontario – considering the '**possibility**' and '**reality**' of GHG mitigation in Ontario's water & wastewater sector

Timeline	2025	2030	2045
GHG reduction potential (tonne CO_{2e}/y)	4,200	8,400	16,700
% reduction from 2019 baseline	10%	20%	40%
% reduction from business-as-usual	17%	37%	66%

- Not possible to achieve net-zero cost-effectively based on what we know today
- But significant GHG reduction is possible if we act now!
- Monitoring & mitigating process emission (N_2O and CH_4) are critical!
- Monitor & adopt innovative solutions as they become more established
- GHG management strategies/goals to be updated every five years

Award and Resource

- 2023 OWWA/WEAO Climate Action Award (GHG Reduction & Mitigation Stream)

From left: Ella Murphy, Maika Pellegrino, Emma Shen, Joe Green (client), Denis Beaulne (client)

- 2024 WEFTEC paper through Access Water

Thank You!

Jacobs Global Principal – Wastewater Energy Optimization & Sector Decarbonization

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