Do We Pay Too Much for Tap and Bottled Drinking Water?

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Civil and Environmental Engineering
Centre for Advancement of Trenchless Technologies (CATT)
July 26, 2012

WISE
WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY

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Questionnaire

When do you get a new vehicle?

- 2 years?
- 5 years?
- 10 years?
- When it is dead

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Why Upgrade Your Vehicle?

- Increase Level of Service
  - Performance
  - Comfort
  - Reliability
  - Safety
- Economics
  - Reduce operation/maintenance costs
  - Minimize replacement cost
  - Asset depreciation

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Design (Service) Life

- All cars have a design life:
  - 10 to 20 years
  - Why are leases for 2 years or 60,000kms?
  - Why are warrantees 2 years or 80,000kms
- Municipal sewer and water distribution networks also have a design life
  - Question is not if it will fail …. but when?

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Water Survey

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What is a Water Pipe Design Life?

1. 20 years (15%)
2. 50 years (50%)
3. 75 years (15%)
4. 100 years (15%)
5. 200 years (0%)

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What do you drink at home?

1. Bottled water (0%)
2. Tap water (100%)

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What is Best Quality?

1. Tap water? (60%)
2. Bottled water? (40%)

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Why Were Water Distribution Networks Constructed?

1. To provide drinking water? (20%)
2. To put out fires? (35%)
3. For internal plumbing water? (45%)
4. To cool off in a long shower (0%)

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Are 1800's Installed Water Pipes Still In Service?

1. Yes (70%)
2. No (30%)

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What costs more?

- Bottle water (2%)
- Tap water (98%)

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What is the Cost of Water?

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Cost of Bottled Water

- $1.00 to 2.00 for 500ml bottle
  = $2.00 to $4.00 per Litres
  = $2000 to $4000 per 1000 Litres

If drink 2 L per day = $730 to $1460 per year

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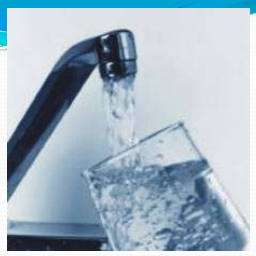
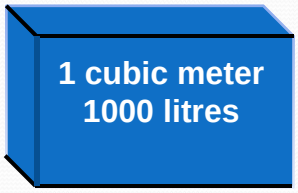
The Cost of Tap Water





$1.48

Bottled water cost = $2000 to $4000
Tap water cost = $0.00148 L not $2.00 to $4.00

For $1.00 you can fill 1351 500ml bottles from the tap

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Hidden Social and Environmental Costs of Water

- Bottled water uses twice as much water – bottle cleaned and rinsed
- Transportation = greenhouse gas emissions
  - Pump water through pipes vs truck delivery
  - Municipal storage in pipes
- not all plastic bottles recycled

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Water Quality in Ontario

Bottled Water

- Can legally contain many things we not allowed in municipal drinking water.
- Only water labelled "spring" or "mineral" are subject to higher quality standards.

Tap Water

- exceed the standards as regulated by the Ontario Ministry of the Environment and as proposed by Health Canada

Dasani = tap water from Calgary and Brampton
Aquafina = tap water from Vancouver and Mississauga

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Water Regulations in Ontario

Bottled Water

- In Canada, the Food and Drug Act.
- Water tested not to same standard as municipal water (weekly)

Tap Water

- Tap water goes through a rigorous process of cleaning, filtering and testing to ensure it is safe.
- Water tested daily numerous times

Both water sources safe and good

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Do We Pay Enough for Tap Water?

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Municipal Water Systems

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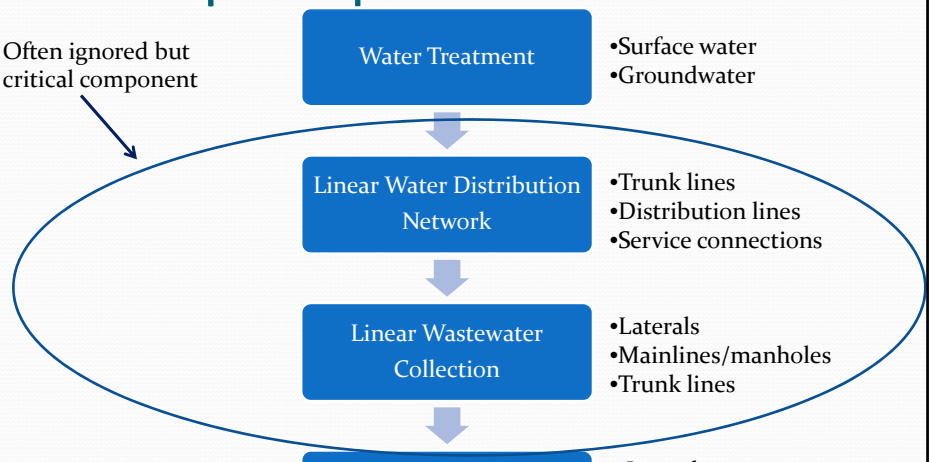
Municipal Pipelines

Often ignored but critical component



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Where Do Water Assets Fit within City Owned Assets?

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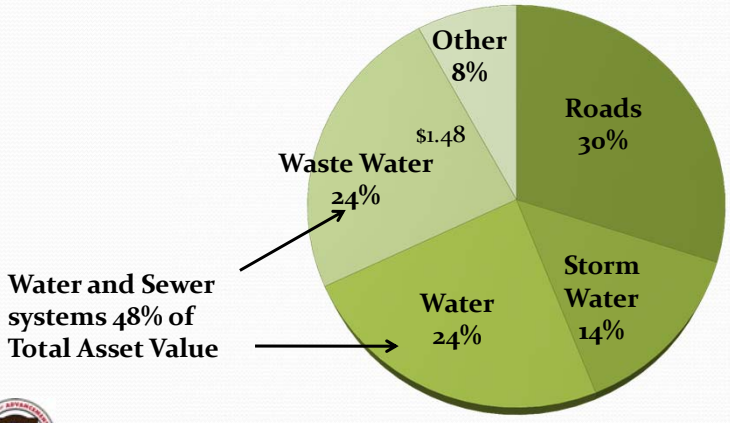
Municipal Infrastructure Assets

Asset Category	Quantity	Replacement Value	Typical Life (yrs)
Parking Lots	25	$1,522,780	20
Storm Ponds	62	$87,433,507	50
Walkways	100	$4,138,861	40
Road & Sidewalk	980 lane*km	$371,190,374	30
Bridges	24	$8,025,000	50
Culverts	61	$5,977,164	35
Dams	2	$2,000,000	50
Sewer System	480 km	$298,530,301	65
Drainage System	320 km	$185,210,195	65
Water System	490 km	$294,619,300	70
		$1,258,647,483	

Infrastructure Asset Value Distribution



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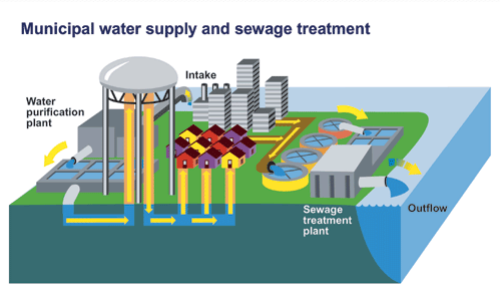
Water Infrastructure includes



- Source water wells/surface water
- Treatment plants
- Pumps and reservoirs
- Transmission and distribution pipes
- Valves and hydrants
- Service connections to houses/businesses

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Watermain Construction Materials

- Wood
- Cast Iron
- Ductile Iron
- Copper
- Asbestos cement
- High Density Polyethylene (HDPE)
- Steel
- Reinforced concrete
- Polyvinyl Chloride (PVC)

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1870 Pit Cast Iron Pipe

- Removed form City Hamilton fall 2004
- In service and no known leaks
- Manufactured in Scotland
- Left pipe was taken from the street
- Right from a boulevard

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Water Distribution Networks

- Approx. 1880's construction of water distribution networks starts
  - Toronto great fires destroyed city blocks of wood buildings
- Use as a potable water source was an after thought

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Water Distribution Design Paradigm

- Designed to meet fire flow demand
- High pressure systems (80 to 120 psi)
- Provide safe high quality drinking water by water treatment

UK Design:

- Flows must meet consumption demand
- Low pressure systems

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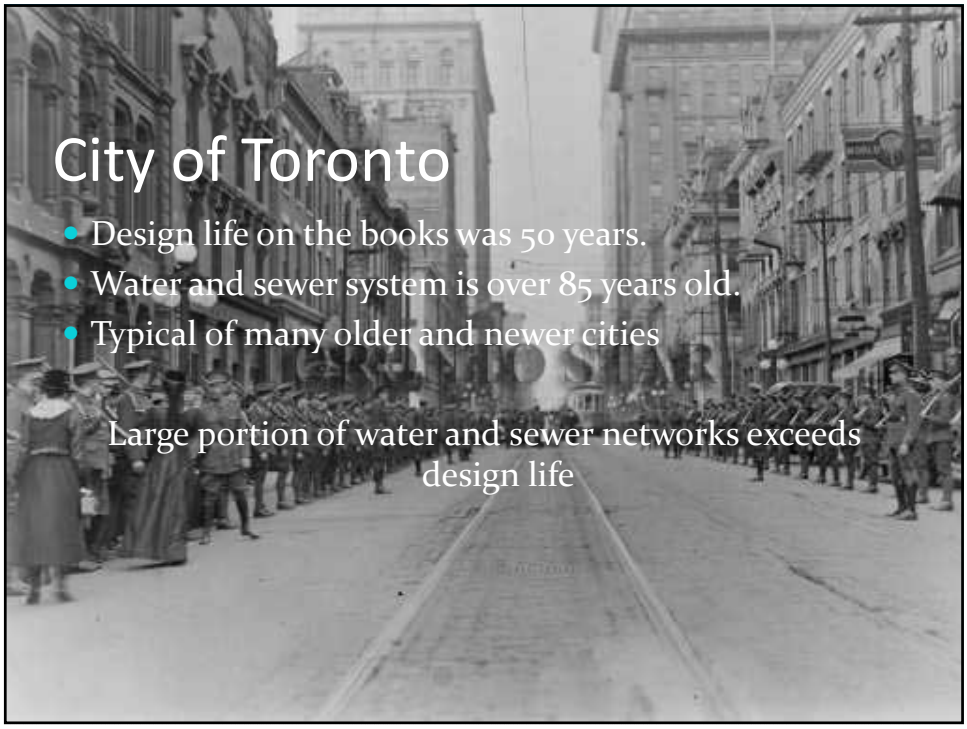

Signs of an Aging Distribution System

Material Degradation
Pipe Corrosion

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- Prince Rupert,BC
- 18in steel unlined watermain
- Age = 75 years
- George Trosky walk the pipeline from 1967 to 1993 (26 years) and install repair clamps or, more commonly, wood pegs into the pin-hole leaks .

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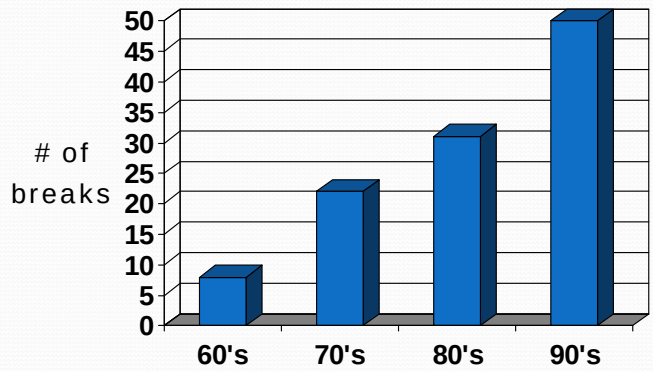
Signs of an Aging System

Material Degradation
Pressure Pipe Wire Breaks

Signs of an Aging Distribution System



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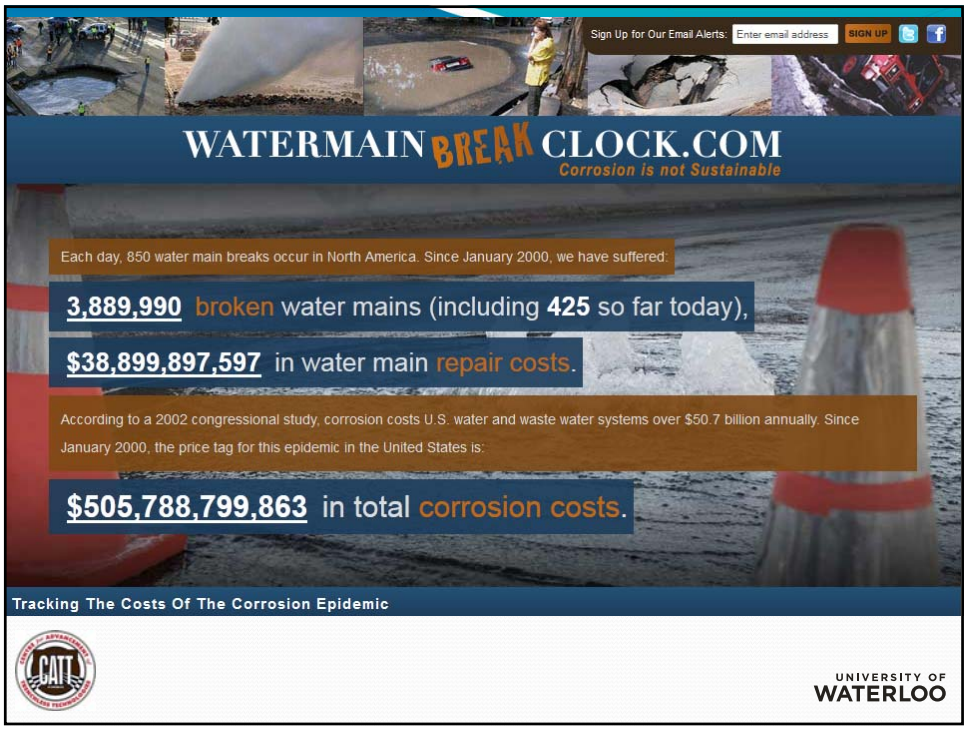

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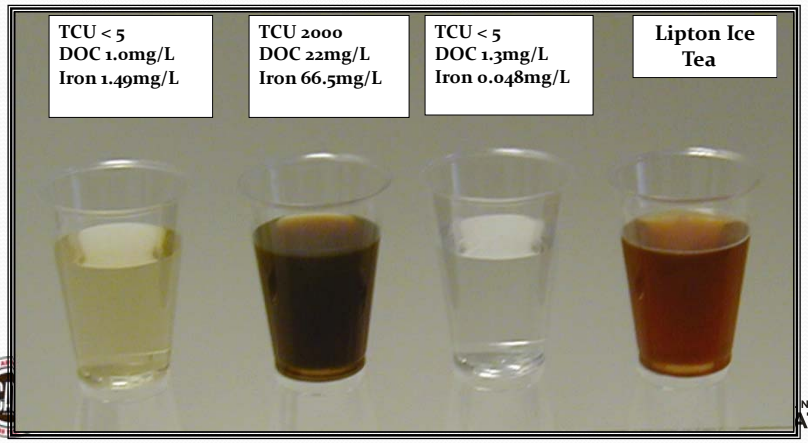
Signs of an Aging System

Internal pipe corrosion

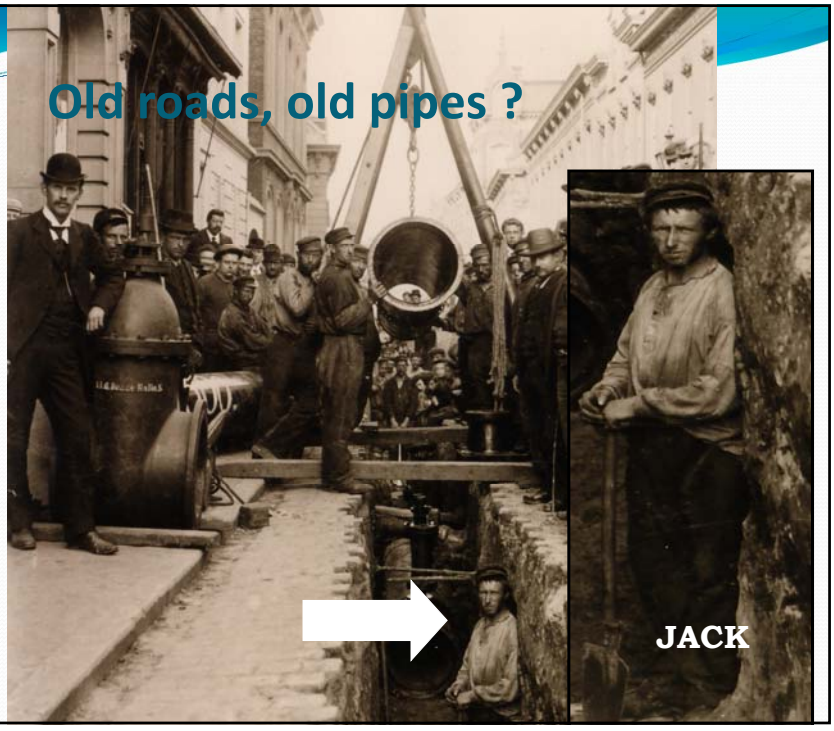
- Reduced flow capacity
- Reduced chlorine residuals
- Poor water quality

Signs of an Aging System

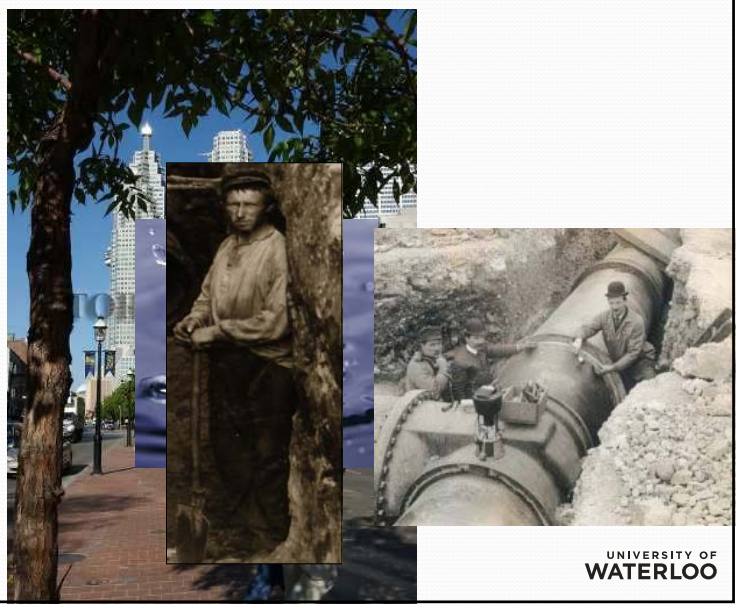
Poor Water Quality



Old roads, old pipes ?



New roads over old pipes?



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Jack Has Been Busy

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Where are those utilities?

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Jack Comes in Many Colours!

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Watermain Locators

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The Buried Infrastructure Challenge
A Complex Problem

Old water systems that needs replacement/renewal

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Mid Size Ontario Water Utility
Water and Sewer Replacement Value

- $1000/m to replace pipe using open-cut
- City of Cambridge 490km water, 480kms sewer

replacement cost

$600 to 970 million

PSAB – Historical cost = much lower

Accounting Depreciation value = much lower

Cost does not include water and wastewater treatment plants, values, manholes, service connections, laterals and operation costs

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Mid Size Ontario Water Utility
Water and Sewer Replacement

- City of Cambridge 970kms water and sewer
- If 100 year service life

Must replace 9.7 kms at cost of 9.7 million per year

- This is not possible - cost, social and environmental impacts are very large

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Jack's appearance

Jack needs to be

- Minimized or banished
  - Find other ways of rehabilitation/renovation
  - Less damage to pavement
  - Less inconvenience to customers

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Good News

- Pipes have performed extremely well
- Not all pipes bad and need replacement
  - Sewers only 15 to 20 percent in worst condition state
  - Water = ???

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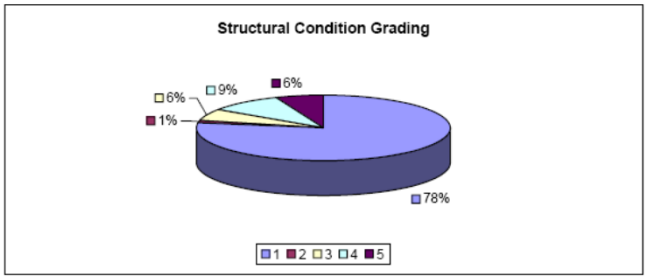
City of Niagara Falls Wastewater Pipes

		Grade					WatBAMS
		1	2	3	4	5	Total
	Material	(m)	(m)	(m)	(m)	(m)	(m)
Structural	PVC	21,099		271	220	138	
	VC	1,999	72	536	1,610	1,911	
	AC	74		68	92		
	RC	9,744	440	1,556	2,039	597	
	Total	32,916	512	2,431	3,961	2,646	43,000
	Percent	77%	1%	6%	9%	6%	

77% 7% 15%



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Good News

- We have innovative technologies to renovate/rebuild the pipes without the need to dig the up and replace
  - Minimally invasive vs open heart surgery
  - Lower cost than open cut – more work for less $$
  - Environmentally friendly – reduced GHG emissions
  - Less disruption to public and business

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Alternative to JACK

Trenchless Construction Methods

Techniques for utility line installation, replacement, rehabilitation, inspection, location and leak detection, with minimum
excavation from the ground surface.

North American Society of Trenchless Technology (NASTT)

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Key Points

- Minimal surface excavation
  - Alternative to open cut excavation
- Can have entrance and exit surface excavations –
  - JACK can not be completely
  - Banished just minimized!

- Considers pipelines usually with diameters less than 900 mm (36 inches) - non person entry

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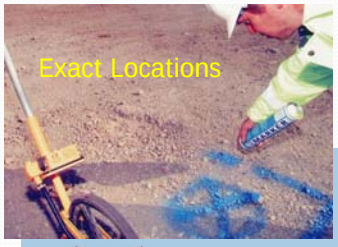
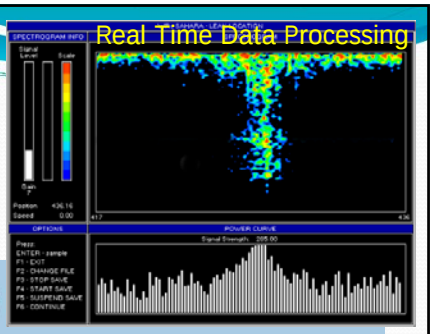
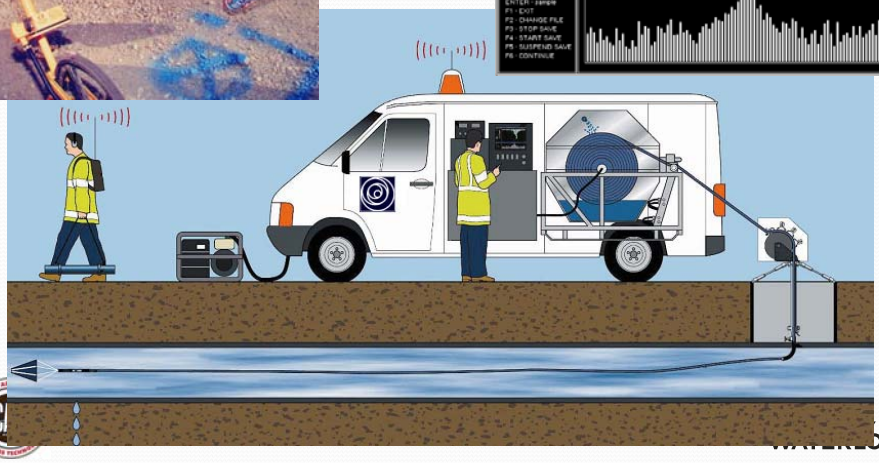
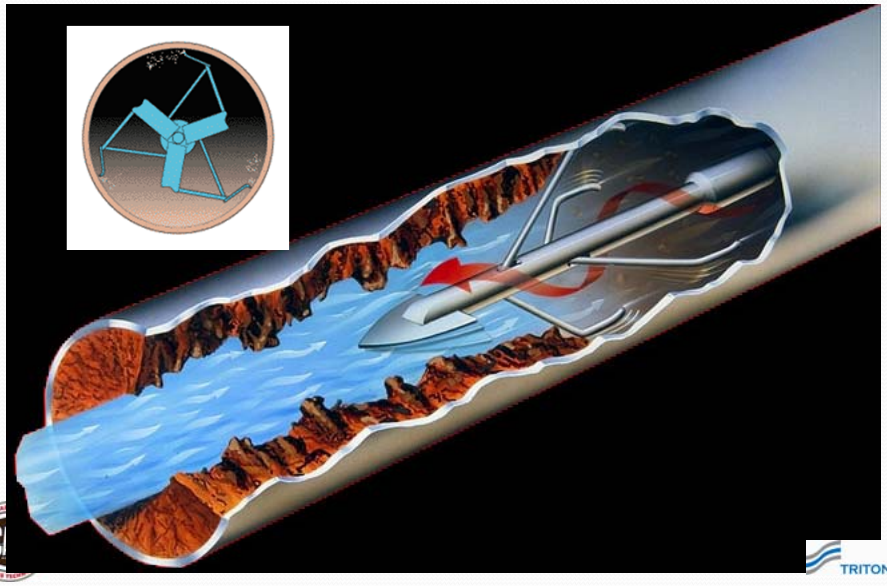
Leak Detection







Pipe Cleaning



Pipe Cleaning

Drag Scraping

Plunging

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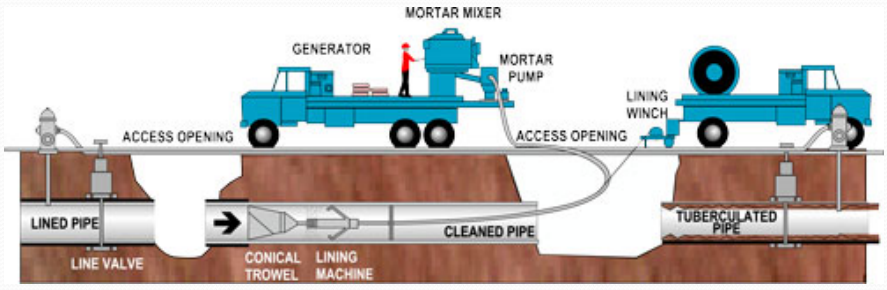
Cement Mortar Lining

Small diameter pipe



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64

Finished Product

Approx. 5mm thick

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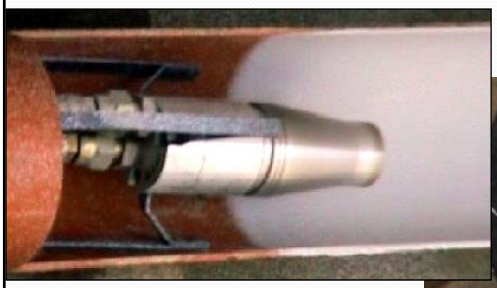
65

Spray on Lining



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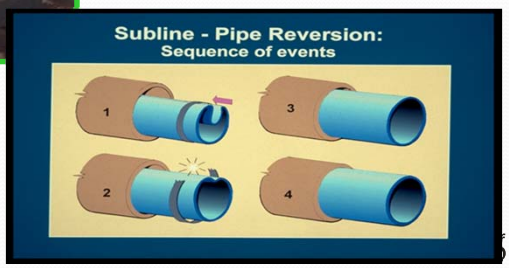
Watermain Lining

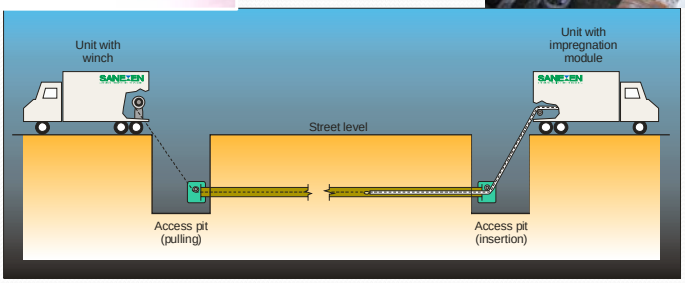
Fold and Deform Liners

Manufactured plastic pipe folded or deformed to make installation easy.

Pipe reformed in-place



Build a New Pipe Using the Old Pipe as a Form



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Trenchless Cost Water Pipe Savings

Method	Cost per Metre	Cost for 400km Network ($ millions)	Open Cut Saving ($ millions)
Open Cut Replacement	$1000	400	-
Clean and apply non-structural lining	$100 to $150	40 to 60	360 to 340
Clean and apply semi-structural Lining	$300 to $400	120 to 160	280 to 240
Clean and install Structural Lining	$800 to $1000	320 to 400	80 to 0

- For pipe installation Only
- Social and Environmental costs not included

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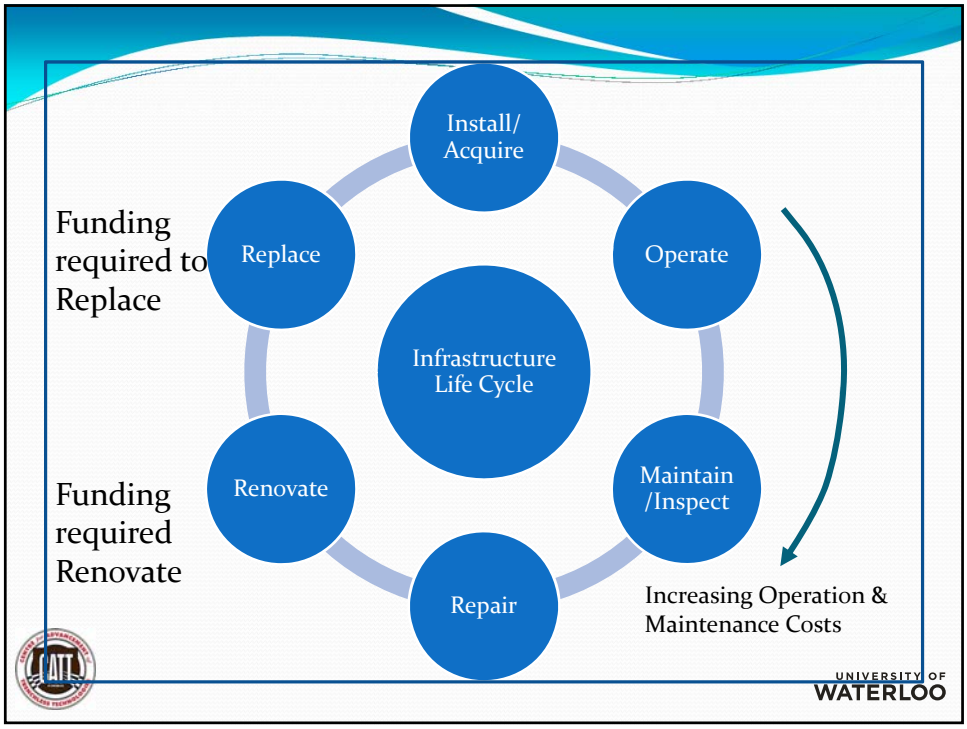

Saint John NB Bone Yard – 1912 Canada's First Incorporated City

A $200M pipe dream.
Replacing an old water system is key to Saint John's future. But is the public willing to pay?

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The Problem

- Water utilities rates have been traditionally set to cover operation costs only
- Water utilities in Ontario and across North America have a big infrastructure deficit/back log

  $80 BILLION in Ontario based on recent RBC survey

- Infrastructure deficits are growing
- No or limited funds for long-term capital works programs to remove infrastructure backlog

The Financial Problem

- Water utilities in past have relied on government grants for capital works – not full cost recovery from user fees
- Government infrastructure grants are short lived and insufficient to eliminate infrastructure deficit
  - Band-aid short-term solution
  - Does not drive long-term financial sustainability
  - Need for long-term low interest funding sources with payback periods of 15-25 years

Recent Changes in Regulations

- Public Sector Accounting Board
- Ontario Water Opportunities Act

- New Regulations set the foundation for stage 1 Asset Management
  - What do you have?
  - Where is it?
  - What is it worth?
  - What condition is it in?

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Where Does the Money Come From?

Remove large Infrastructure Backlog

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Buried Infrastructure Asset Management

the new frontier

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Asset Management Systems (AMS)

includes all activates involved in the

- planning and programming,
- design,
- construction,
- maintenance,
- rehabilitation, and
- financing

of the public portion of water and wastewater programs.

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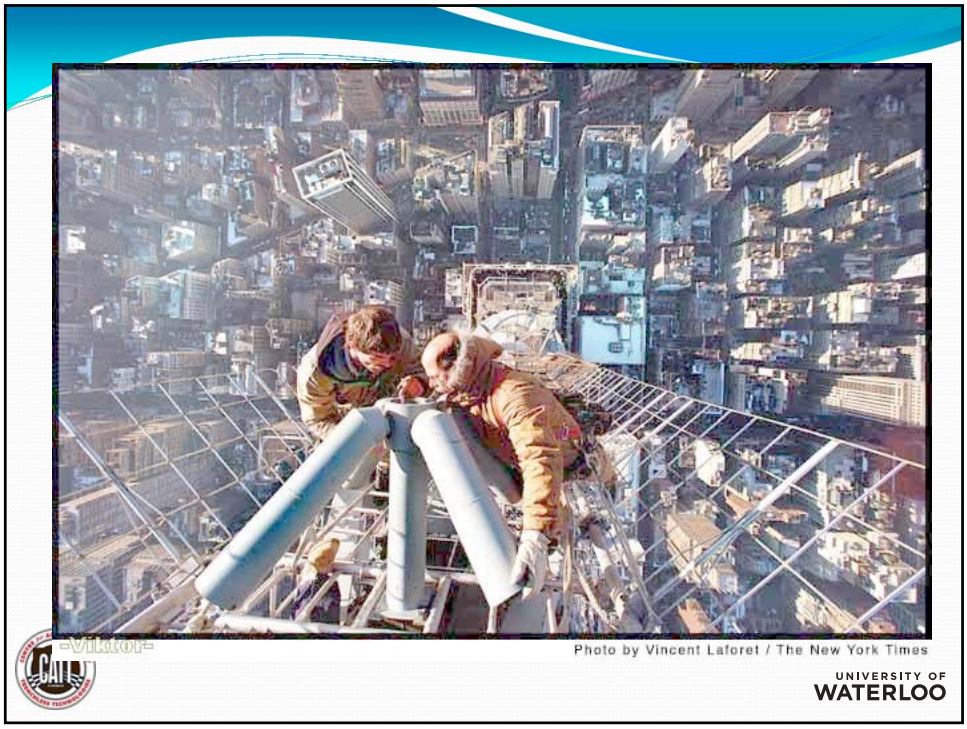
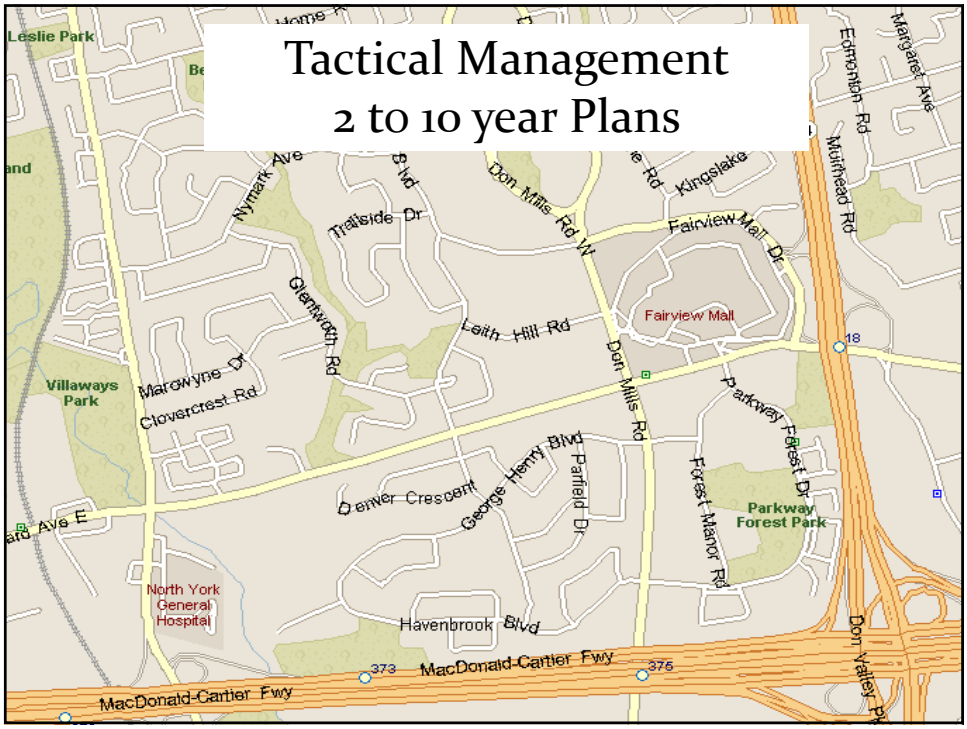


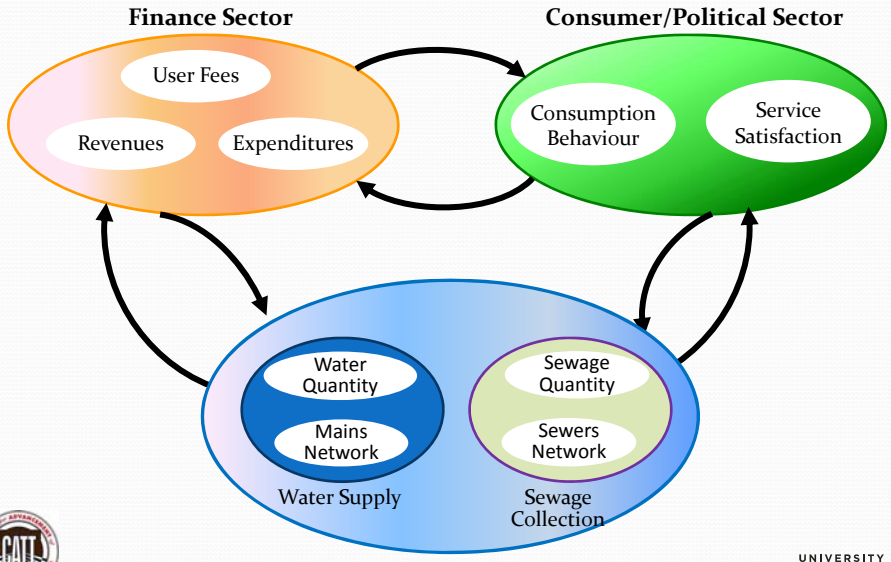
Strategic Management
20 to 100 year Plans

Tactical Management
2 to 10 year Plans



Operational Management
1 to 2 year Plans

Current AMS Gaps



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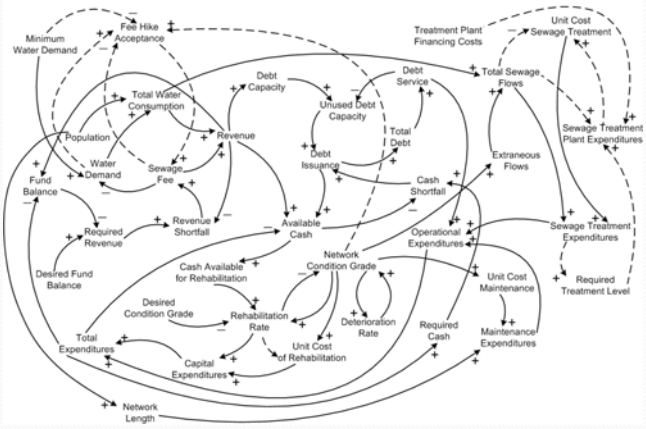
Complex System

- If the system has multiple interacting feedback loops, then it is expected to exhibit complex dynamic behaviour



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When is a System Complex?

- *System* is counterintuitive
- System resist policy changes
- System can be defeated externally when corrective actions are applied
- System often exhibits a long run response that is contrary to the short run response

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University of Waterloo Research Goal

- Develop a novel interconnected feedback loop municipal water and waste water asset management framework using **System Dynamics Modelling**

- The AMS will allow decision managers to find optimum strategies for providing and maintaining **water** and **wastewater pipes** in a **serviceable** and **sustainable condition** over the life of the assets (**50 to 100 years**).

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Application of system dynamics for developing financially self-sustaining management policies for water and wastewater systems

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Research Partners

- City of Waterloo
- City of Cambridge
- City of Niagara Falls
- NSERC
- Centre for Advancement of Trenchless Technologies

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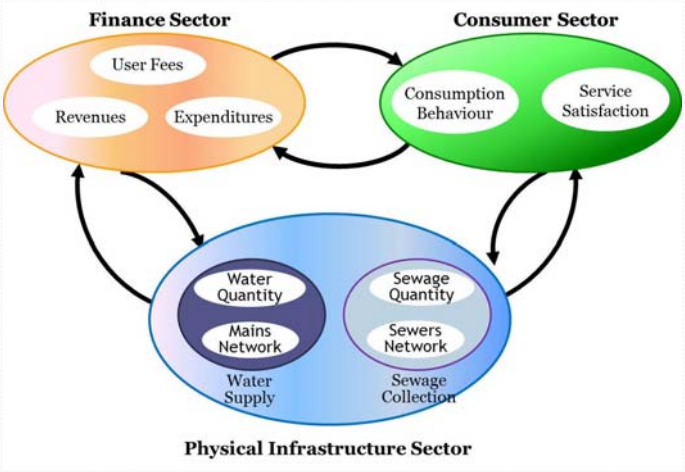
New System Dynamics Model



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Research and Findings

Scenario	Rehabilitation (% network replaced)	Price Elasticity (%/%)	Network Average Condition	Cumulative Total Expenditures (billion $)	Final User Fee ($/m³)
1A	0.00	0	97	5.57	3.75
1B					6.13
1C		-0.35			7.59
2A	1.00	0	59	4.99	3.75
2B					4.65
2C		-0.35			5.46
3A	1.18	0	53	4.99	3.75
3B					4.59
3C		-0.35			5.48

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Main Research Findings

- Borrowing for capital works can get rid of backlog in 15 to 40 years
- Interest costs very small with respect to total network value (less than 1.0 percent)
- Interest costs offset by operation and energy savings

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I have a dream…….

Safe reliable water?

Well managed water systems?

Jack retired & enjoying life?

Water Survey

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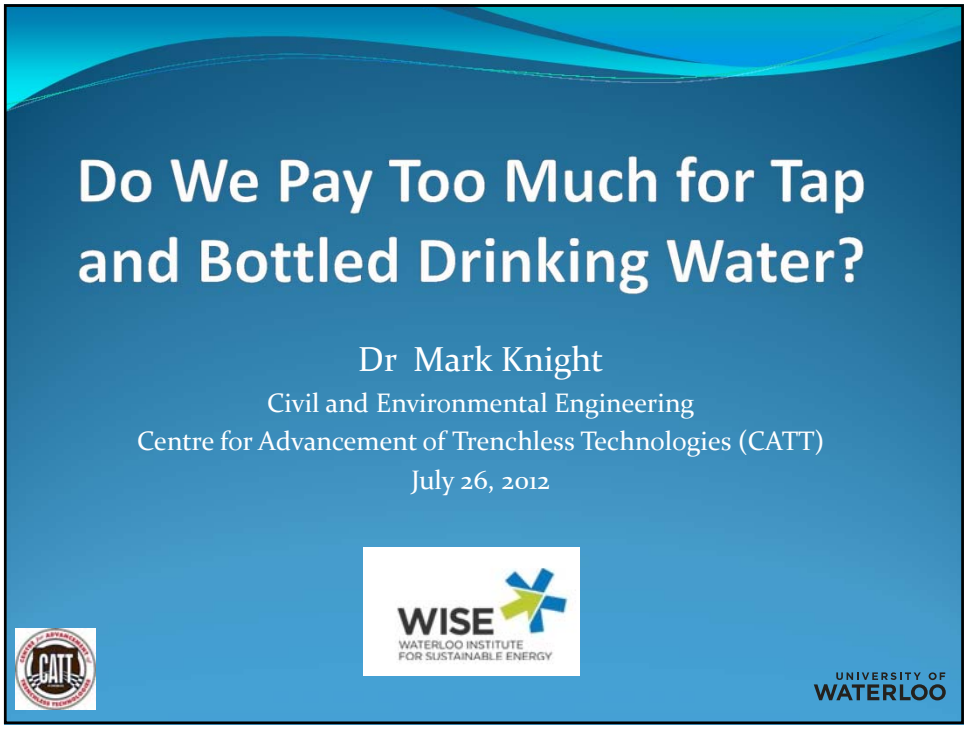
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