ICLR and Norton: Working together to Diagnose and Reduce Basement Flooding in Existing and New Homes

Dan Sandink, MA, MSc (Pl)
Institute for Catastrophic Loss Reduction
dsandink@iclr.org
www.iclr.org

Barbara A. Robinson, MASc, P.Eng.
Norton Engineering Inc.
nortonengineeringinc@gmail.com
www.nortonengineeringinc.ca

Institute for Catastrophic Loss Reduction
Building resilient communities

NORTON ENGINEERING

Inflow and Infiltration (I/I) is Clean Water Entering Sewers

- I/I is **clean water** that gets into the sanitary sewer that should not be there
- A small amount of I/I is expected in new systems; but we keep exceeding that
- I/I **directly contributes to flooding** by filling up pipes with water, using up capacity that could convey larger storms
- I/I is occurring equally on both **public and private property**

Ongoing Engineering-Related Projects

(ICLR & Norton Engineering)

- I/I in New Subdivisions (2005 to present): a colossal waste of capacity
- I/I in all Existing Sewer Systems
- Relationship between I/I and Flooding 
- Societal Costs of I/I: enormous
- I/I and how the Ontario Building Code (OBC) does not do enough to prevent it
- CSA Guideline for Basement Flood Protection (to specify construction requirements)
- Flood Risk and Engineering Data (Research): how can insurers use the data engineering departments already have to price risk 
- ICLR Municipal Advisory Committee (to inform all of our work)
- Durham Region New Homes Standard (ICLR)

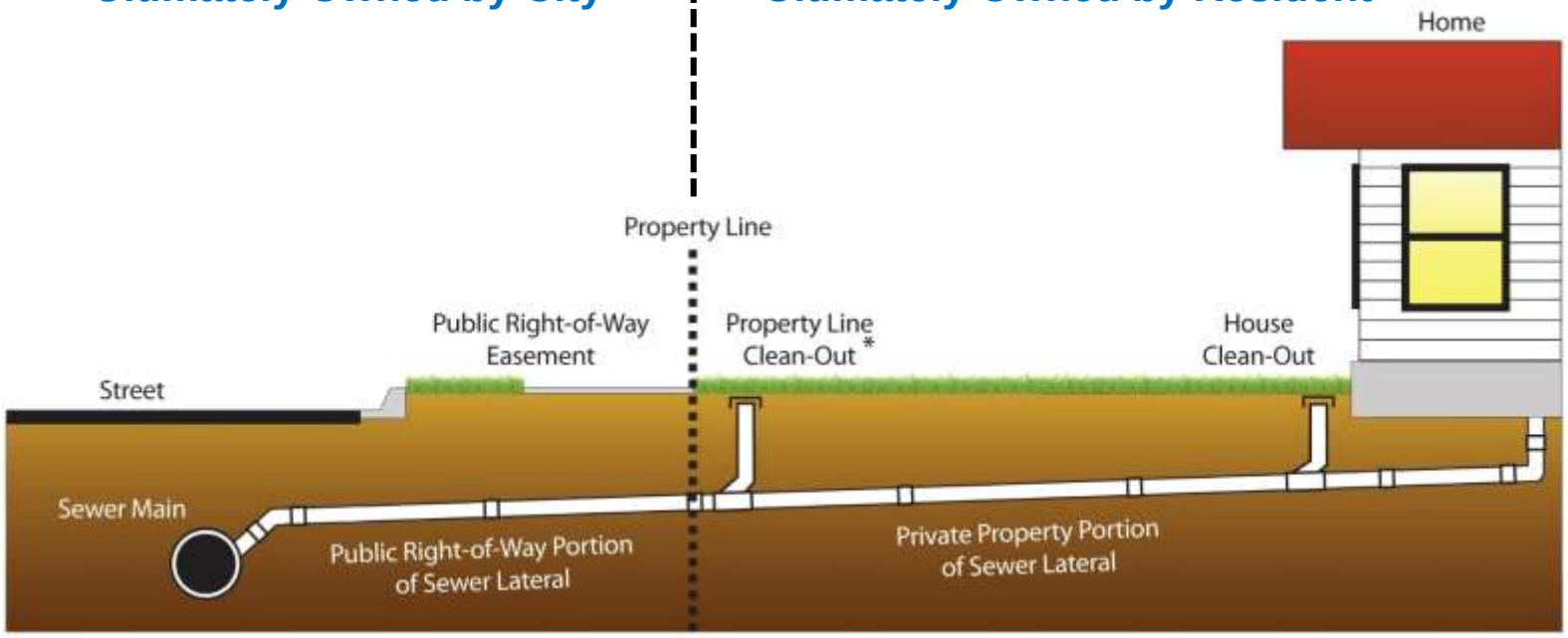
*** I/I is Clean Water**

Public Side and Private Side Sewer Systems are Distinct & Under different Rules

(New Subdivisions)

Under the Jurisdiction of Engineering Departments (Ontario Standards)
Ultimately Owned by City

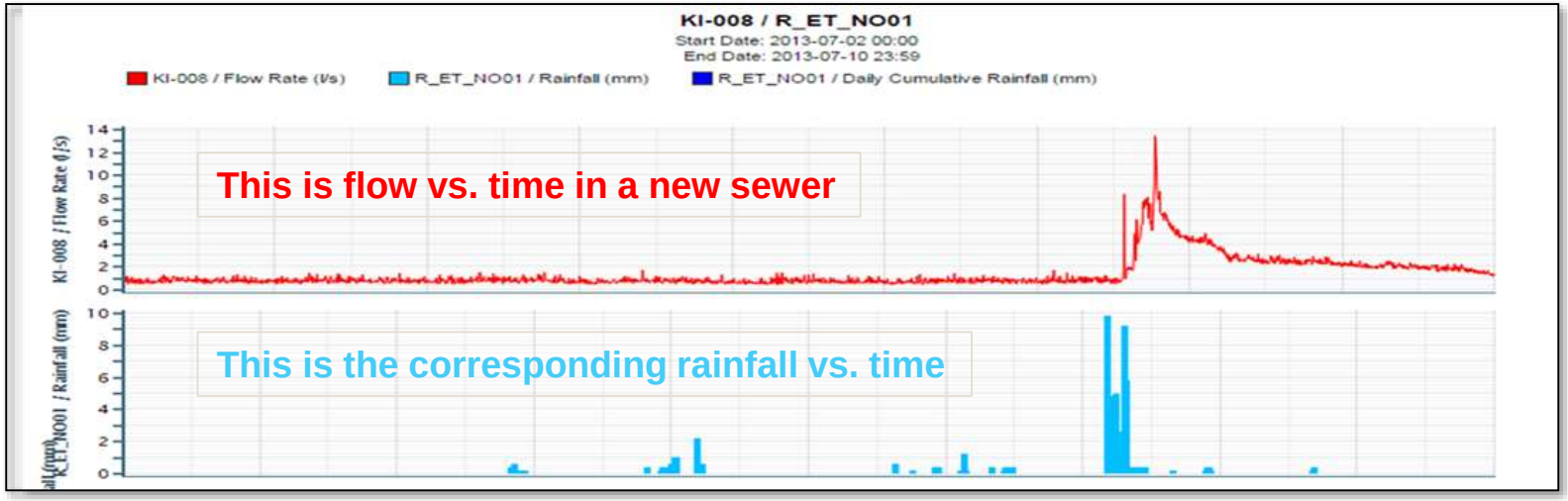
Under the Jurisdiction of Building Departments (Ontario Building Code (OBC))
Ultimately Owned by Resident



* Not standard on all properties.

I/I in New Subdivisions: a Colossal waste of Capacity

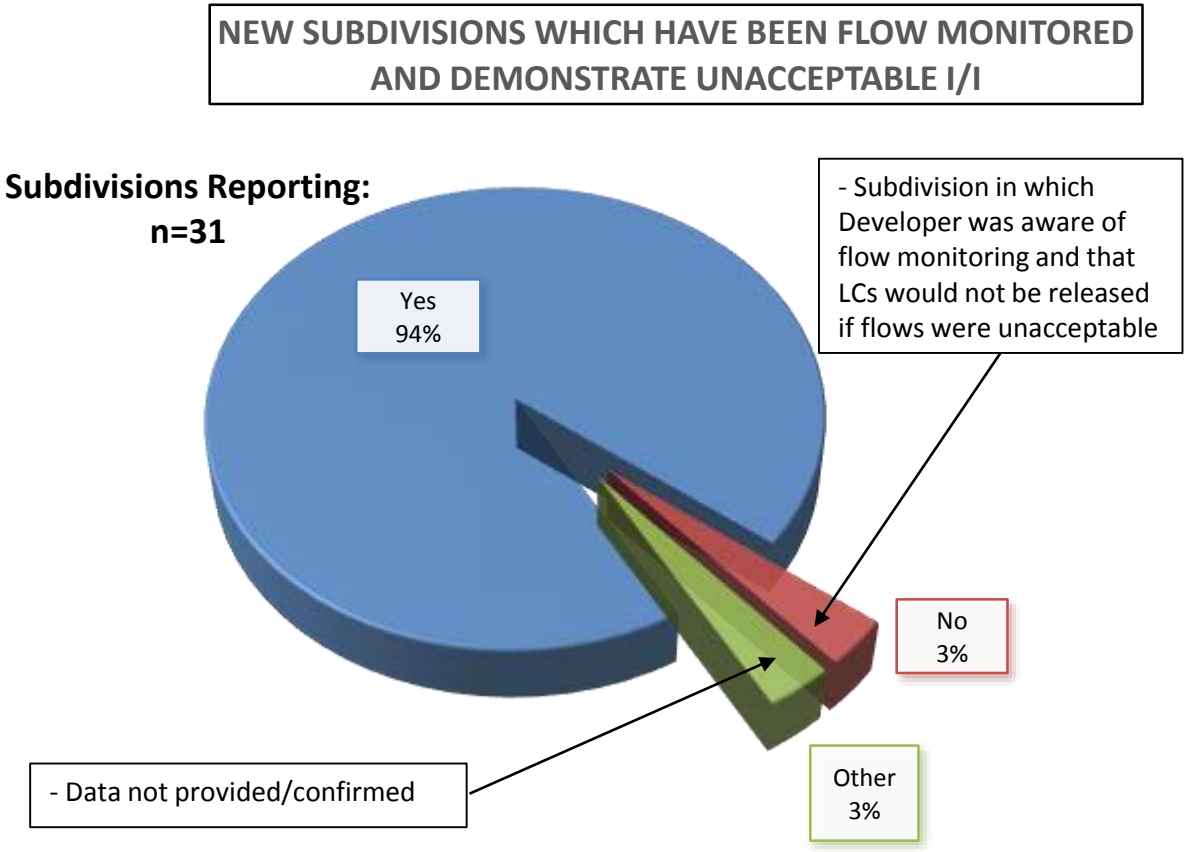
- Engineers have been flow monitoring in existing sanitary sewers for decades
- Only recently have we started to flow monitor downstream of new subdivisions
- Results are disastrous: see typical sample below



*** I/I is Clean Water**

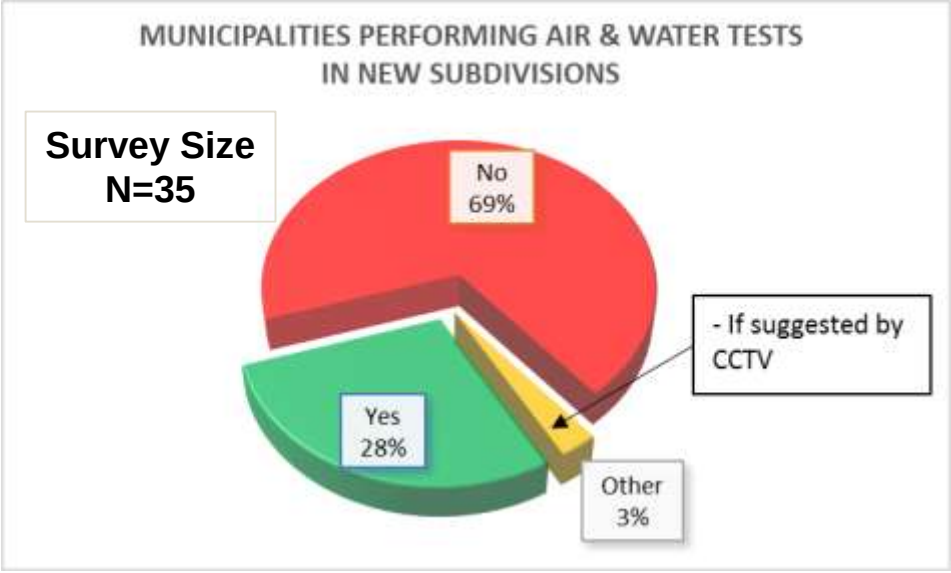
I/I in New Subdivisions: How Many are Leaking?

- Project started with a request for data in 2015: results are appalling



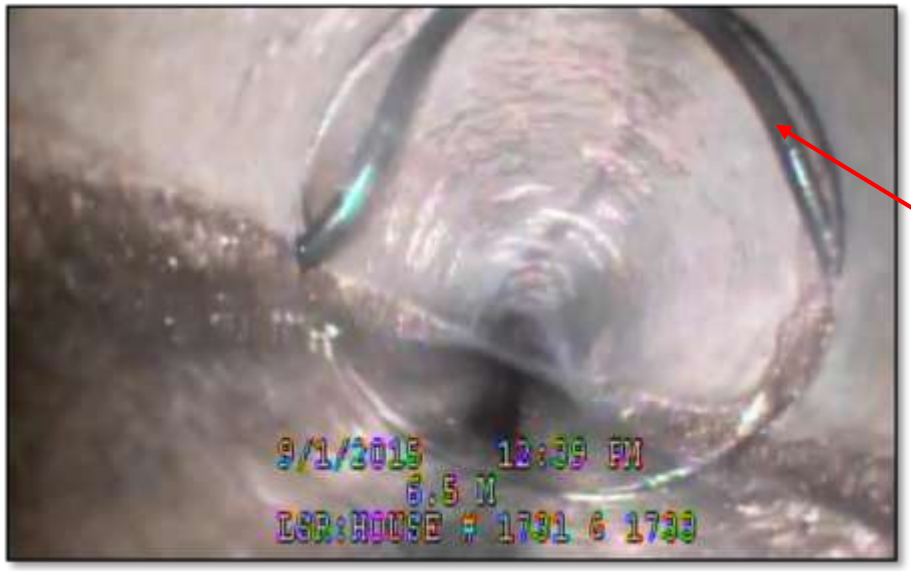
I/I in New Subdivisions: Why are Sewers Leaking on the Public Side?

- In 2016, we surveyed 30+ municipalities to identify the causes and conditions contributing to this observed I/I
- In the public side sewers, it is reported that the ***specified*** testing and acceptance procedures for new sewers are not being followed



I/I in New Subdivisions:
Public Side Installation - One Issue

- Pipe sections are connected using a rubber gasket to provide a tight seal.
- When we run a CCTV camera through sewers, we often find unseated gaskets. These pipes will leak. Forever.

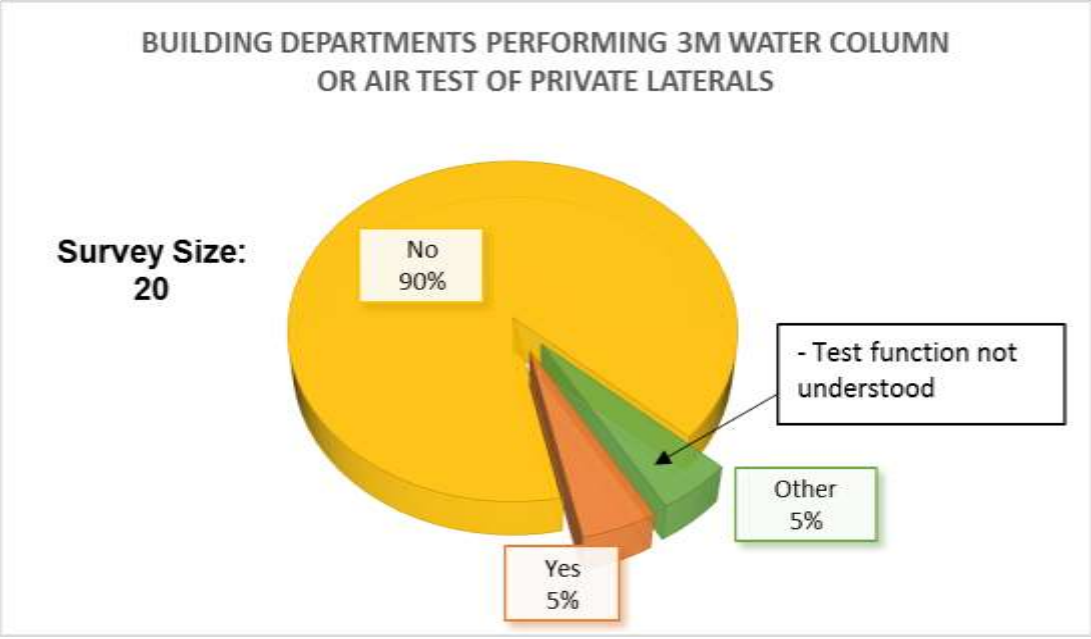


Gasket not installed properly:

Leakage is inevitable

I/I in New Subdivisions: Why are Sewers Leaking on the Private Side?

- In the private side laterals, it is reported that the ***required*** testing and acceptance procedures for laterals* are not being followed
- One example of an Ontario Building Code (OBC) mandated test:



*** Remember that we test to ensure pipes are watertight and don't allow clean water to enter sewers**

I/I in New Subdivisions: Private Side – One Issue

- Plastic pipe must be properly laid in the ground with bottom & side bedding (Granular B (type of gravel)), else it may fail/crack
- Typical example of observed installation (bedding requirements are specified in OBC but rarely observed):

I/I in New Subdivisions: Issue at Property Line

OPSS 410 (Construction Specification for Pipe Sewer Installation in Open Cut – November 2012), e.g. **Public Side Requirement** is very clear regarding the installation of new sanitary sewers:

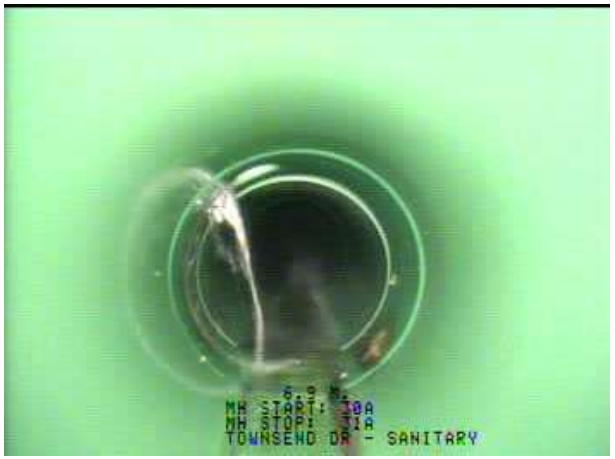
"Installation of factory made tees or wyes, strap-on-saddles or other approved saddles to connect service connections to the main pipe sewer (less than 450mm)"

Alas, this is rarely observed and affects the ability of the building department to test the private side lateral.

I/I in New Subdivisions: Connection at Property Line

The connection at the Property Line provides ample opportunity for I/I to develop (differential settlement)

The OBC does not currently call for an inspection of this connection. It should.



CCTV of Lateral to Property Line may identify this. Only 14% of surveyed municipalities are insisting on this CCTV inspection of the lateral (all through Push Camera launch from house basement)

Other Issues we are finding

- There are **significant variations** in practices, both in Policies and Procedures in place, and in actual application of these during reviews and in the field.
- Most Cities/Regions have guidelines, checklists, manuals to assist their staff and developers, but follow up/follow through of items is **not always getting done**
- Planning/Development groups are often doing things differently than engineering/capital works groups.
- **Coordination** between Departments and Codes/Regulations is a significant challenge (Jurisdictional issues)
- Construction industry and workforce practices (public and private) are often **careless**
- **Pressure**s to approve Developments quickly
- **Price**- (versus qualification-) based selection

See also: Kesik, T. (2015), ICLR.

I/I in all Existing Sewer Systems: Ubiquitous

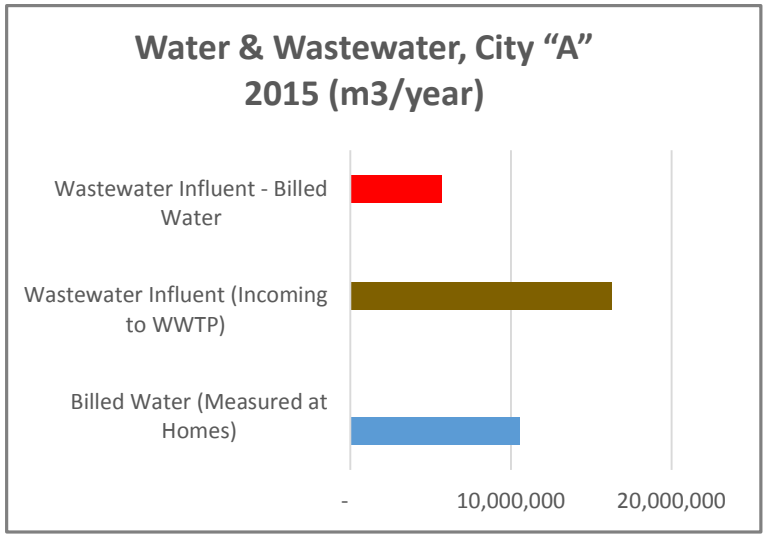
- **“Significant”** I/I exists in all sewer systems in Ontario (separated as well as combined).

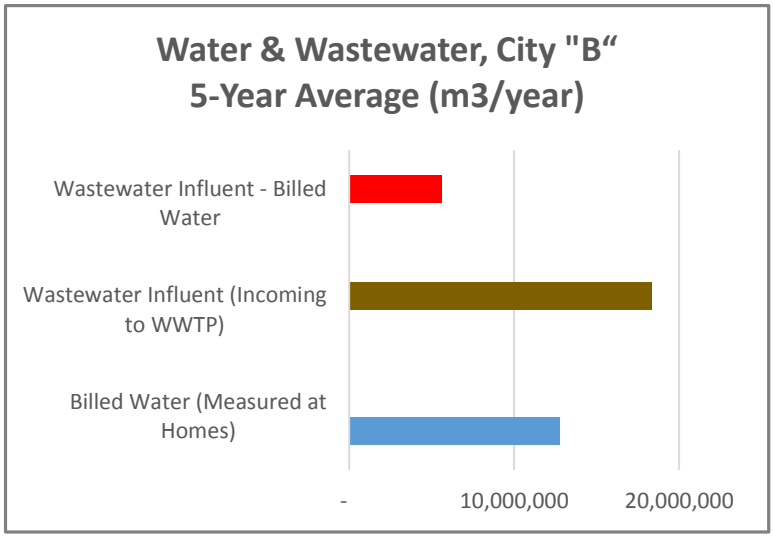
- ICLR and Norton have been working on a project to calculate actual societal costs of I/I. Premise of work was to collect data for 75% of the population of Ontario to develop a broad estimate of what I/I is costing taxpayers.

- Water data across Ontario is mandated by the Province to be made public. **Sewer data is not (why not?)**. This is a significant finding!

*** I/I is Clean Water**

I/I in all Existing Sewer Systems: A Tale of Two Cities





City “A” treats 5,730,000 m^3 and City “B” 5,590,000 m^3 of I/I per year. At $2.75 per m^3 (very low estimate), this costs $15.8 million and $15.4 million **per year** for treatment alone.

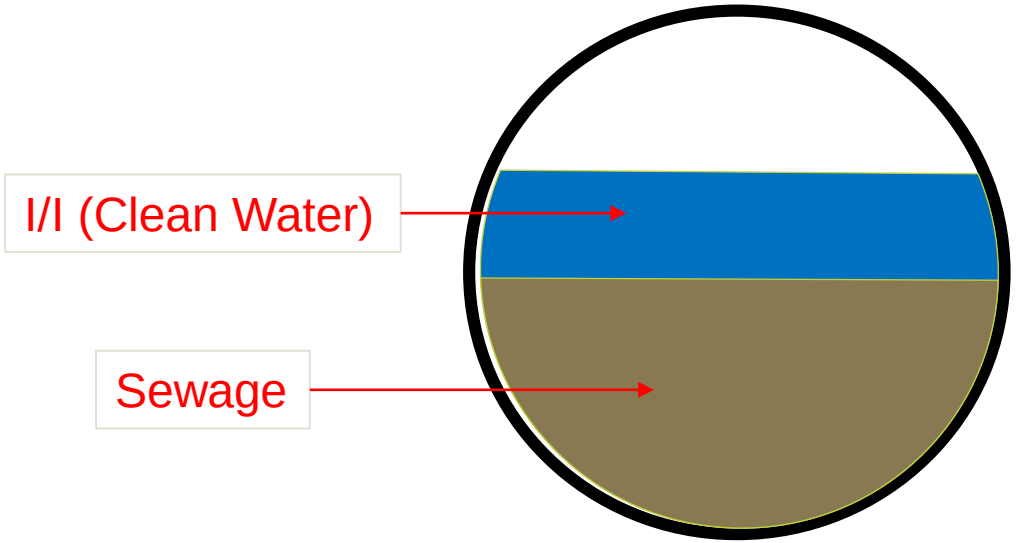
What are the Costs of I/I (Treatment Alone)

The present value of **1 L/s** of I/I, over a **40 year** asset life cycle (before scheduled rehabilitation of a sewer) is **$1,000,000** (@ $1.50/$m^3$ and 3%), for **treatment costs alone!**

There is a Direct Relationship between I/I and Flooding

- Every drop of I/I that enters a municipal sewer system will ultimately contribute to a flooding event, by using up capacity that would otherwise be available to convey additional flow.
- Every drop of I/I that enters that sanitary system on the private side lateral puts individual homes at higher risk of flooding.
- There is probably no “engineering” way to quantitatively predict this direct relationship, but it absolutely exists.

What does a Clean Water in a Sewer Look Like?



This capacity could be used to:

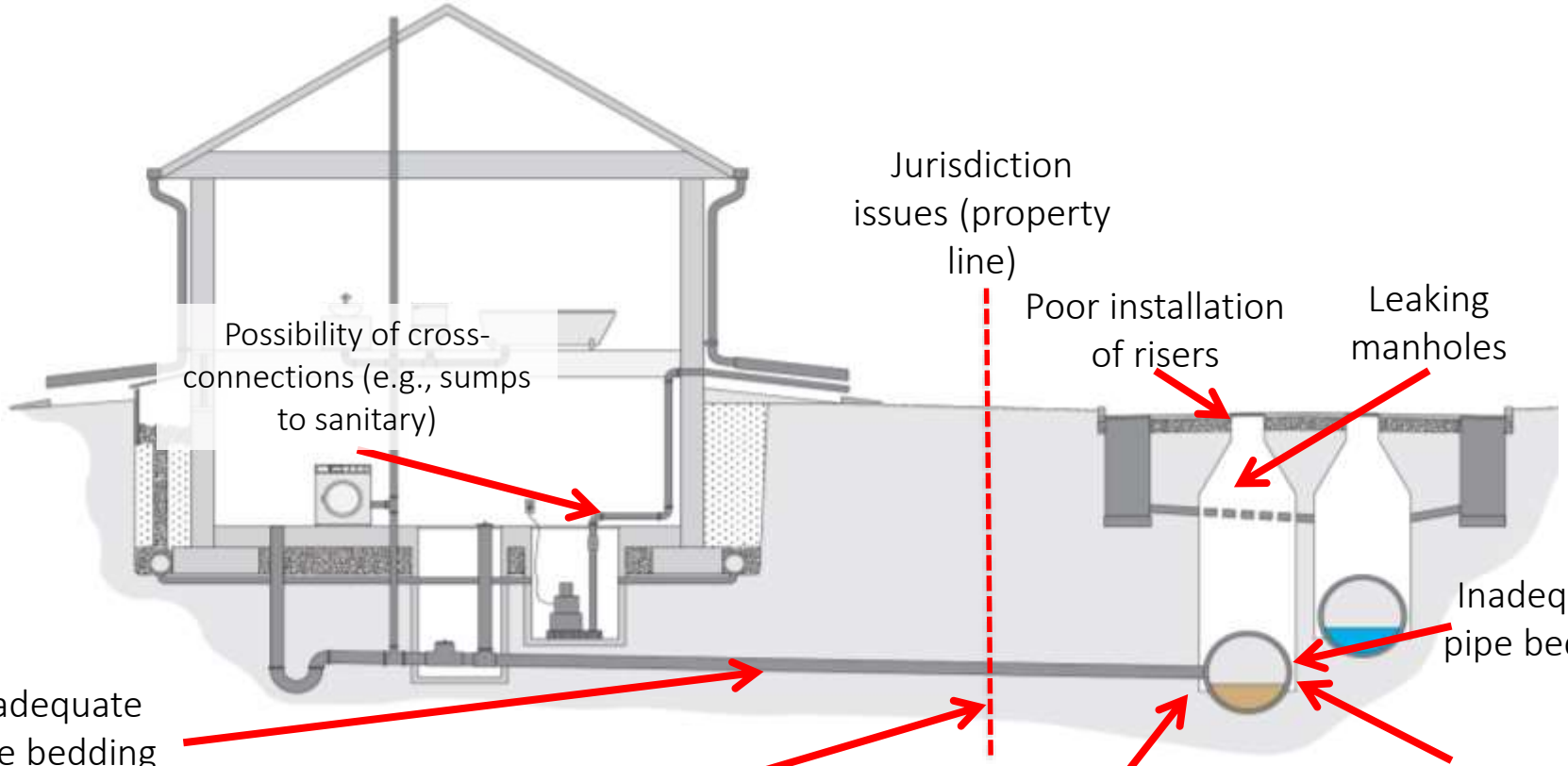
- Allow new development
- Provide capacity to reduce routine flooding
- Provide extra capacity to convey larger rainfall events (e.g. mitigate effects of climate change)

Flood Risk and Engineering Data: Can our Industries work together?

- Insurers (particularly larger ones) know a great deal about flood risk
- Engineering departments/Cities know a great deal about their sanitary sewer systems through experience, modeling, resident complaints, etc.
- Generally these two data sets are never compared
- We are looking at a way to combine these two data sets to the mutual benefit of both:
  - Cities will be able to better manage their systems to avoid flooding
  - Insurers will be better able to accurately price risk

Relationship between I/I and Flooding

Common sources of Leaks



Source: Sandink et al, 2017, via Robinson et al

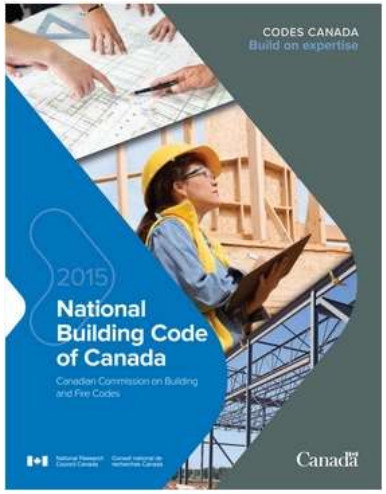
I/I in Existing Sewer Systems:
Sample Calculation: City of Hamilton (2014)

Without regard for who is paying, the actual annual costs of allowing roof leaders to be **illegally connected** to Hamilton's sewer systems are enormous.

We included the following costs: treatment, City administration, insurance claims, lost opportunity, and compassionate grant (upsizing of trunk sewers and uninsured, unrecoverable costs not included):

- Total Actual Costs of 773 Known Roof Leaders Connected to Sewer System:
  - Low estimate: $4,455,185 per year, or **$5,700 per house per year**
  - High estimate: $8,779,906 per year, or **$11,400 per house per year**
- Cities cannot afford to not address this issue
- Let's address this "soft" I/I now (I/I that doesn't require additional digging)

I/I and the OBC*/NBC* (ICLR & Norton, 2016 to present)



- Norton is working with ICLR to develop a summary of OBC (NBC) requirements that are inadequate to prevent I/I
- The OBC is contradictory on numerous I/I related items, and is being interpreted differently by different municipalities and indeed, staff at different levels within the same municipality.
- We will summarize & share this information with engineering and building departments across Ontario (and NBC across Canada).

- **OBC: Ontario Building Code**
- **NBC: National Building Code**

The OBC: Not Protecting Against I/I?

Under the Category of "Health – Sanitation", OH2.1 states that:

"An **objective** of this Code is to limit the probability that as a result of the design or construction of a building, a person in or adjacent to the building will be exposed to an unacceptable risk of illness due to unsanitary conditions caused by exposure to human or domestic waste."

7.4.5.3. Connection of Subsoil Drainage Pipe to a Sanitary Drainage System

(2) Where a *storm drainage system* is not available or *soil* conditions prevent drainage to a culvert or dry well, a foundation drain or *subsoil drainage pipe* may connect to a *sanitary drainage system*.

9.14.5.1. Drainage Disposal

(1) *Foundation* drains shall drain to a sewer, drainage ditch or dry well.

9.14.6.1. Surface Drainage

(1) The *building* shall be located or the *building* site graded so that water will not accumulate at or near the *building* and will not adversely affect adjacent properties.

9.26.18.2. Downspouts

(1) Where downspouts are provided and are not connected to a sewer, extensions shall be provided to carry rainwater away from the *building* in a manner that will prevent *soil* erosion.

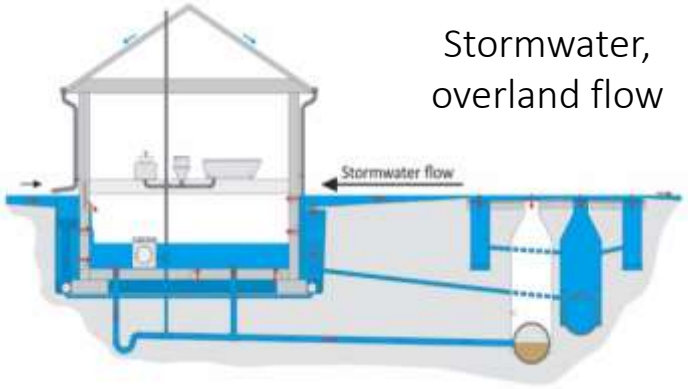
CSA Guideline for Basement Flood Protection Background

- Project began in April 2017
- New Guideline is being developed by CSA as part of a group of standards being updated with funding by the National Research Council (NRC) around **Climate Change Adaptation** (CCA)
- Guideline looks at the **mandatory implementation** of protective plumbing measures & other lot level measures in both new and existing infrastructure
- The CSA Guideline will ultimately be a Standard referenced in the OBC and NBC)
- Seed (Draft) document developed by D. Sandink
- Chair/Vice Chair

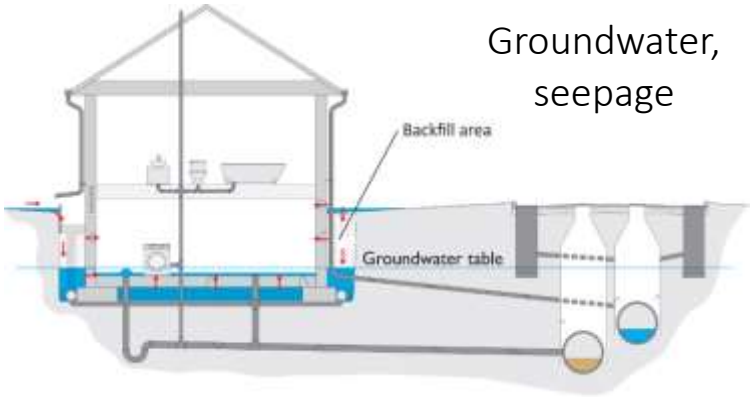
CSA Group

CSA Guideline for Basement Flood Protection
Addressing Flooding and Buildings in a Changing Climate

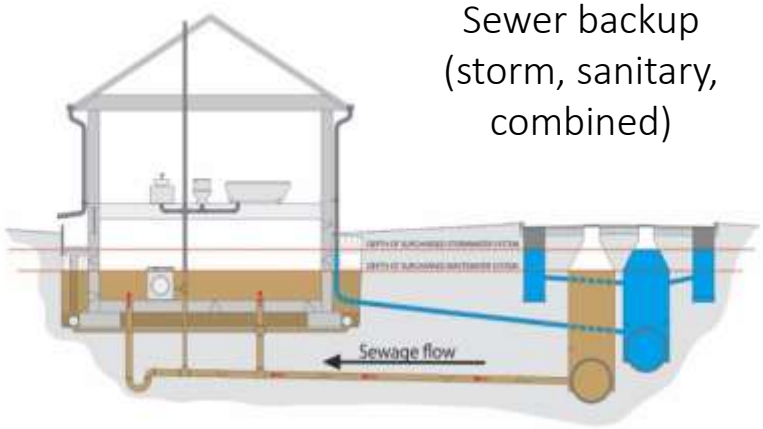
Stormwater, overland flow



Groundwater, seepage



Sewer backup (storm, sanitary, combined)



- Other major household flood causes:
  - Sump/pump failure
  - Failure of building sewers, drains (e.g., root blockage, collapse)
  - *Etc.*

Sandink, ICLR, 2017)

CSA Guideline for Basement Flood Protection Sample Content

6. Dry floodproofing

6.1 Site grading and drainage

6.2. Eavestroughs and downspouts

6.3. Seal cracks in foundation walls and basement floors

6.4. Overland flood entry points

6.5. Ventilation systems

6.6. Foundation drainage, sump system

6.7. Sewer connection maintenance, replacement

6.8. Sewer backwater protection

CSA Group

Addressing Flooding and Buildings in a Changing Climate
Durham Climate Change Resilience (ICLR)

The 18 proposed programs in this Plan are:	
Cross-Sectoral programs:	• Protect Our Outside Workers • Social Infrastructure for Emergency Resilience
Building Sector programs:	• The Durham Climate Resilience Standard for New Buildings • Building Retrofit for Climate Resilience
Electrical Sector programs:	• Asset Protection Against Flooding • Vegetation Management • Asset Design and Service Life Management program
Flooding Sector programs:	• Address Urban Flooding • Redefine Flood Hazards Considering Climate Change • Improve Flood Forecasting, Warning and Emergency Response • Address Riverine Flooding
Human Health Sector programs:	• Extreme Weather Alert and Response (EWAR) System • Property Standards By-laws for Maximum Temperature Allowed in Apartments • "Cool Durham" Heat Reduction program
Roads Sector programs:	• Resilient Asphalt program • Road Embankment program • Adaptive Culverts and Bridges
Natural Environment Sector program:	• Achieving Climate Change Resilience in the Natural Environment

Inflow and Infiltration (I/I) is Clean Water Entering Sewers

- I/I is not going away
- I/I **directly contributes to flooding**
- I/I is occurring equally on both **public and private property**
- **Municipalities**, **insurers** and **the public** will benefit from removing/preventing this I/I
- **ICLR** has initiated or is contributing to numerous projects to address I/I from all angles!

Questions?