Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions

York Region

London CANADA

THE CITY OF WINDSOR ONTARIO, CANADA

Institute for Catastrophic Loss Reduction
Building resilient communities

Region of Peel
working with you

Phase 1 Final Report 2015 to 2017

September 2017

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NORTON ENGINEERING

Table of Contents

Table of Tables

Table of Figures

1 Introduction

Inflow and Infiltration (I/I) together refer to clean water that enters sanitary sewer systems. Inflow includes sources of direct flow of excess water into sanitary sewer systems, including downspout connections, cross connections from storm systems leakage through maintenance covers, among other sources. Infiltration includes indirect sources of excess water entering sanitary sewer systems, including pipe defects, loose joints, cracks, etc. and is influenced by the height of the groundwater table. During short duration, high intensity (SDHI) rainfall events, inflow/infiltration may result in overloading and surcharge of sanitary sewer systems, causing sanitary sewer backup.[1]

Allowing excessive I/I into sanitary sewer systems limits capacity for additional development, limits capacity to mitigate expected increased flows associated with climate change, affects the design life of the sewers, and is costly to treat (particularly if the costs of expanding wastewater treatment plants - WWTPs) is considered.

In a 2010 Climate Change Position Paper, the Association of Municipalities of Ontario (AMO)[2] stated that

> "changing averages and extremes present challenges to municipal planning and infrastructure, and as we begin to experience more significant climate change effects, our communities will become increasingly vulnerable. These changes represent a significant threat to Ontario municipalities' natural and built capital, which will have repercussions on our economic, environmental and social sustainability."[3]

The issue of excessive ("unacceptable") Inflow and Infiltration (I/I) in new subdivisions has come to the attention of our industry. The engineering community do not currently have a definition of "unacceptable" I/I, although it is frequently identified as such. This issue is discussed in Section 2.2 of this report.

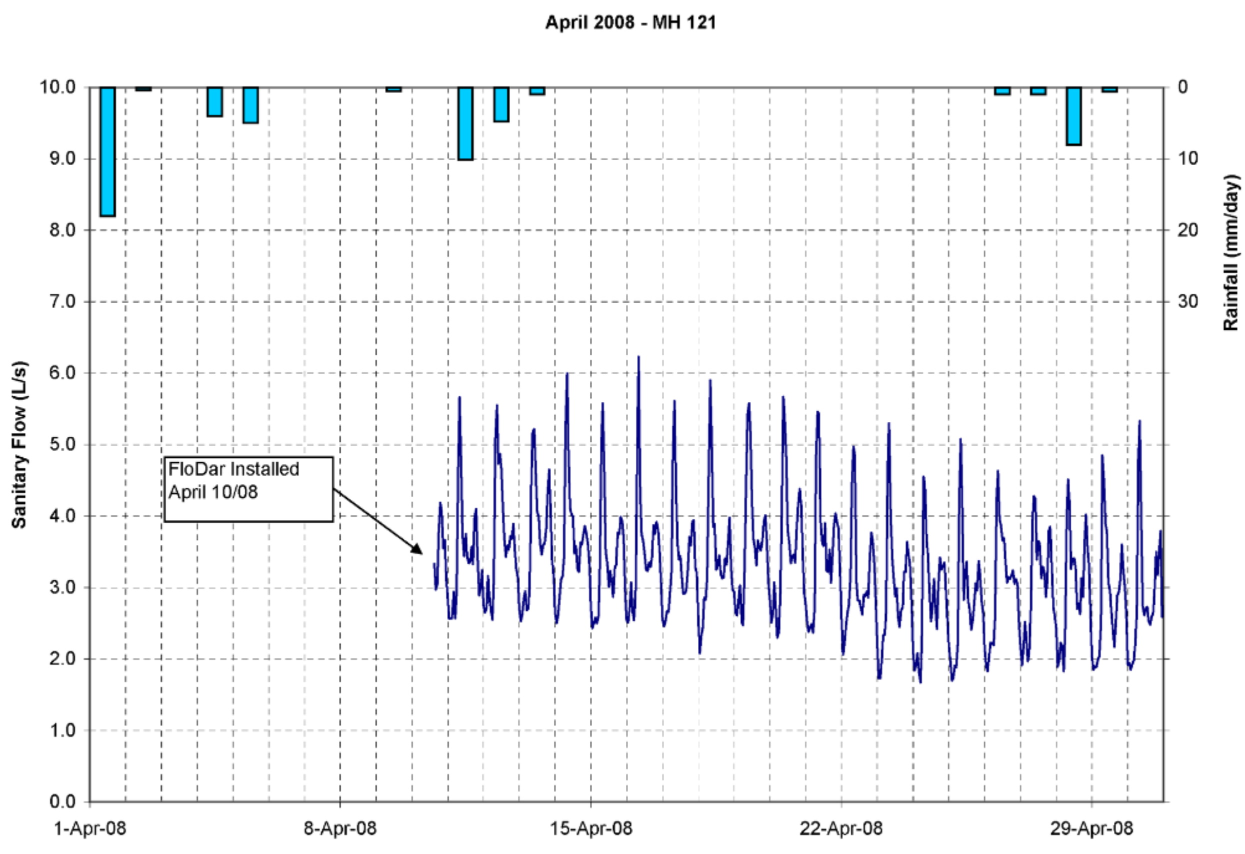
In 2005, a new subdivision in St. Jacobs, Ontario, (Township of Woolwich - Woolwich) demonstrated substantial baseflows, as captured inadvertently at a downstream flow monitor. Follow-up investigation and a variety of temporary flow monitors revealed that these flows originated from a new subdivision.

Figure 1 illustrates a sample of the flows observed downstream of the subdivision in 2008. As shown in Figure 1, there is significant, unacceptable baseflow originating from this subdivision of 120 homes. The source of the baseflow was determined to be at the property line, where disparate pipe sizes were not connected by fittings, and were leaking badly. The deficiency was subsequently corrected by the contractor. This subdivision does not show a response to rainfall ("inflow").

Following this first discovery, the Woolwich initiated flow monitoring downstream of all new subdivisions to ensure that they were not also demonstrating unacceptable levels of I/I.

In 2010, a paper was presented at Water Environment Association of Ontario (WEAO)[4] that identified the issue of I/I originating in new subdivisions in Woolwich. Although there was some awareness of this issue across Ontario at the time, particularly with Operations staff, it was not yet widely known. Since then, Woolwich has continued to monitor all new subdivisions and has found a wide variety of additional deficiencies introducing unacceptable I/I into their sewer systems. An additional paper with more detailed information on the variety of I/I sources discovered in Woolwich was presented at Water Environment Federation (WEF) in 2012[5].

FIGURE 1: FLOW MONITORING RESULTS DOWNSTREAM OF ST. JACOBS NEW SUBDIVISION[6]



Recognizing that the issue of unacceptable I/I in new subdivisions was likely prevalent across Ontario, Norton Engineering Inc. initiated a project in 2015 to examine the problem in more detail, to identify the underlying causes and conditions, and to develop feasible and cost-effective solutions for municipalities, regulators and elected officials.

A Steering Committee for this project was established in June 2015. The founding Steering Committee was composed of representatives from funding municipalities (who represent a good cross section of sewer system types and size/layout of municipality), as well as experts in the consulting, engineering, and insurance industries. They included:

Anthony Parente, P.Eng.
Director, Wastewater
Region of Peel – Public Works

Chris Smith
Project Manager, Business Strategy and Improvement
Region of Peel – Public Works

Dan Sandink, MA, MSc (Pl)
Director of Research, **Institute for Catastrophic Loss Reduction**

Rosa D'Amico, MCIP, RPP
Manager, System Sustainability Management (A), Infrastructure Asset Management, Environmental Services, **Regional Municipality of York**

Tom Copeland, P.Eng.
Environmental Services Engineer, Wastewater and Drainage Engineering, **City of London**

Chris Manzon, M.A.Sc., P.Eng. Senior Manager Pollution Control
Pollution Control Division, Public Works
City of Windsor

Christine Hill, M.A.Sc., P.Eng.
Business Development Leader, Infrastructure Planning
Cole Engineering

This report summarizes Phase 1 of this project, presents recommendations, and suggests next steps. Phase 1 took place from 2015 to 2017 and involved collecting data from across Ontario to determine the prevalence of the phenomenon. A detailed survey of municipal staff and other stakeholders followed, to determine why this phenomenon exists. In addition, this report provides a variety of actions that municipalities can take in increasingly complex steps to immediately begin to address this issue.

Phase 2 continues in 2017/2018.

The Steering Committee for Phase 2 includes the original funding partners from Phase 1, as well as new funding partners, including:

John Duong, P.Eng.
Manager of Manager of Systems Planning & Customer Service
Water & Wastewater System Services, **Halton Region**

James Etienne, P. Eng.
City Engineer, **City of Cambridge**

Jason Alexander
Manager of Wastewater Operations, **City of Cambridge**

Trevor Brown, P.Eng.
Manager, Engineering and Wastewater Programs
Water Division, **Regional Municipality of Waterloo**

Heather McGinnity, P.Eng.
Manager of Environmental Services
Public Works, **Town of Orangeville**

This work is being performed under the broad direction of The Regional Public Works Commissions of Ontario (RPWCO) Water & Wastewater Subcommittee, and the supervision of Peel Region.

2 Collection of New Subdivision Flow Monitoring Data

2.1 Collection of Flow Monitoring Data from New Subdivisions Across Ontario

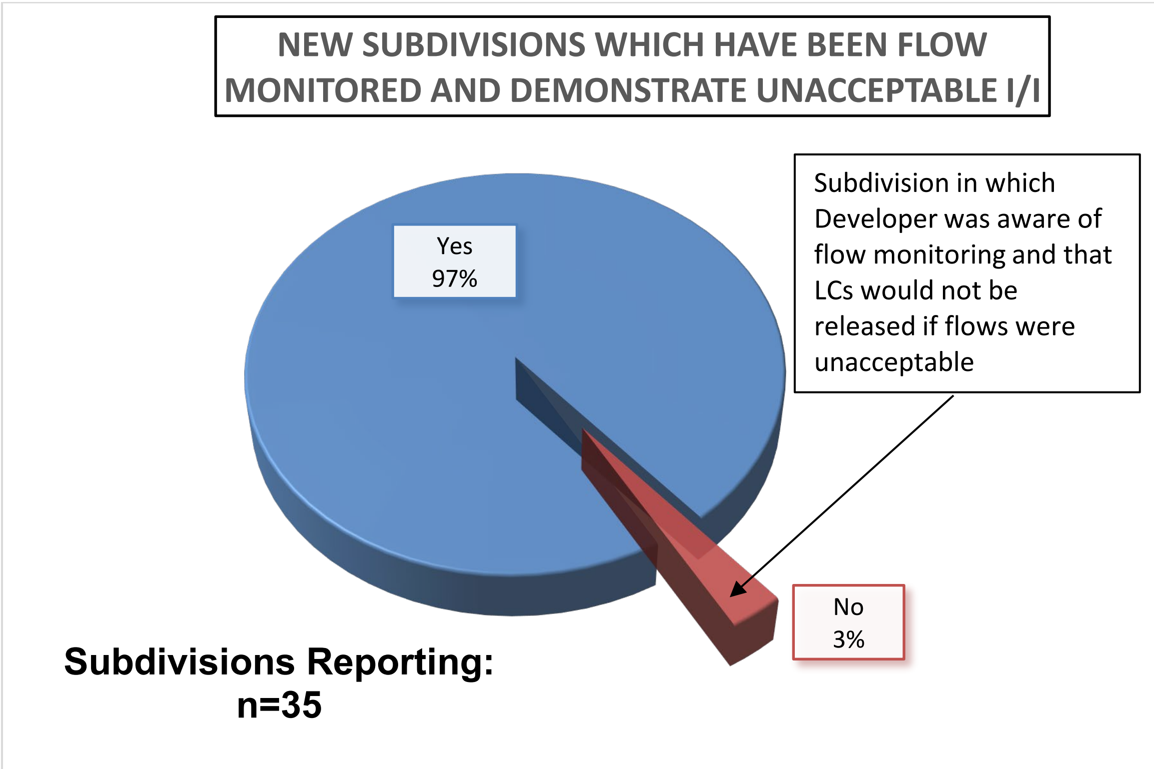
The first step in this project was to determine whether the flow monitoring results in new subdivisions in Woolwich were observed elsewhere in Ontario. A data collection effort was undertaken to examine new subdivision data collected by others, to determine the nature and extent of the problem across Ontario. Using existing industry resources and contacts [e.g. Water Environment Association of Ontario (WEAO), Ontario Public Works Association (OPWA), Municipal Engineers Association (MEA) forums, Water Environment Federation (WEF), RPWCO, Steering Committee member personal contacts, etc.], existing flow monitoring data from new subdivisions was gathered.

Contributing municipalities and agencies were promised confidentiality to encourage as many jurisdictions/developers as possible to provide flow monitoring data. No QA/QC was performed by Norton Engineering on the data received; it was assumed that this step was undertaken by the authority collecting the data, and the data was accepted as correct. Results of this work were presented at WEAO in 2016.[7]

As of September 2017, flow monitoring data (both in-sewer and at sewage pumping stations) had been collected downstream of thirty-five subdivisions across Ontario. As illustrated in Figure 2, 97% of the subdivisions for which flow monitoring information was provided to the study team had unacceptable high levels of I/I.

Only one subdivision in the dataset, located in Woolwich, had acceptable I/I. This finding can be attributed to the fact that Woolwich has been flow monitoring all new subdivisions since the first discovery of unacceptable I/I in 2005. Woolwich has been using flow monitoring results to assist them in determining whether to accept new sewer systems. Where subdivisions demonstrate unacceptable flows, the Township holds Letters of Credit (LCs: deposits made by developers as part of their Subdivision Agreement). Local developers and their consultants are aware of this fact and have had monies held back in the past. The consultant responsible for inspection of this subdivision confirmed that they advised the developer, contractors and builders that this subdivision was being flow-monitored, and monies would be held back from all parties if the sewer system was not constructed to specification. This would appear to be the reason for this well-functioning system.

FIGURE 2: PERCENTAGE OF SUBDIVISIONS REPORTING UNACCEPTABLE I/I (N=35)



2.2 Context of Allowable I/I

The typical peak I/I allowance used in sewer system design in Ontario is based on the 1985 Ministry of Environment Guidelines which are out of date but are the most recent Guideline to identify a range for peak long term I/I. They specify an allowable I/I for sanitary sewers of 0.10 to 0.28 L/s/ha[8]. Because sewers are sized based on this value, it is intended to provide for peak long term I/I. Most Ontario municipalities have traditionally used the higher end of this range in sanitary sewer design sheets that are included with approval applications for new sewers.

The updated MOECC Design Guidelines for Sewage Works (2008) stated that “an allowance should be made for the leakage of groundwater into the sewers and building sewer connections (infiltration) and for other extraneous water entering the sewers from sources such as maintenance covers (inflow)”. It later states that “an allowance should be made in the design sewage flows to cover this flow component”, but does not provide a value.

Table 1 depicts a typical sanitary sewer design sheet. The sanitary sewer design sheet contains two components of peak flow. The areas in yellow shown in Table 1 are (cumulative) domestic peak flow. The areas in green are peak I/I flow. They are added together to give the total peak flow, highlighted in pink. This total peak flow is used to size new sanitary sewers (proposed sewer design, heading in orange).

TABLE 1: PORTIONS OF A TYPICAL SANITARY SEWER DESIGN SHEET

City of XXX
Sanitary Sewer Design

Location: Trunk Sewer		Design Flow Factor, F=	0.00417 L/s (equivalent to 360 Lpcd)
Project #: Consulting Engineer		Infiltration Factor, F_i=	0.28 L/s/ha
Checked by: ABC		Maximum Allowable Flow=	100 % of sewer's design capacity
Computed b DEF		Maximum Velocity=	3.0 m/s
Date: xxx		Minimum Velocity=	0.6 m/s

Location		Area Number	From MH	To MH	Pop Density (pers/ha)	Area (ha)		Population		Peaking Factor	Sanitary Flow (L/s)		Peak I/I Flow (L/s)	Additional Flow (L/s)	Total Flow (L/s)	Proposed Sewer Design			
						Incr.	Cum.	Incr.	Cum.		Average	Peak				Dia. (mm)	Velocity (m/s)	Qd Full (L/s)	% Capacity
1	A	AM11	PS02	L002	0	0.001	0.00	0	0	5.00	0.00	0.00	0.00	60.80	60.80	200	0.90	28.43	214
2	B	AN10	A002	A001	62	10.53	10.53	653	653	5.00	2.72	13.61	2.95	0.00	77.36	250	1.15	56.46	137
3	"	AN10	A001	A001	62	0.96	11.49	60	712	5.00	2.97	14.85	3.22	0.00	78.87	250	1.03	50.50	156
4	"	AM10	A001	A002	60	3.32	14.81	199	912	5.00	3.80	19.01	4.15	0.00	83.95	300	0.80	56.23	149
5	"	AM10	A002	A003	60	0.78	15.59	47	958	5.00	4.00	19.98	4.37	0.00	85.15	300	0.93	65.46	130
6	"	AM10	A003	A004	60	0.77	16.36	46	1005	5.00	4.19	20.93	4.58	0.00	86.31	350	1.31	126.43	68
7	"	AM10	A004	A005	60	0.62	16.98	37	1042	4.96	4.34	21.54	4.75	0.00	87.10	350	1.38	133.21	65
8	"	AM10	A005	A001	60	12.66	29.64	760	1801	4.44	7.51	33.39	8.30	0.00	102.49	525	1.22	263.59	39
9	"	AM09	A001	A002	62	4.21	33.85	261	2062	4.33	8.60	37.21	9.48	0.00	107.48	525	1.08	232.79	46
10	"	AM09	A002	A079	0	0.00	33.85	0	2062	4.33	8.60	37.21	9.48	0.00	107.48	525	2.05	444.21	24
11	"	AM09	A079	A003	0	0.00	33.85	0	2062	4.33	8.60	37.21	9.48	0.00	107.48	450	1.85	294.48	36
12	"	AM09	A003	A004	0	0.00	33.85	0	2062	4.33	8.60	37.21	9.48	0.00	107.48	450	0.95	150.32	72
13	"	AM09	A004	A005	0	0.00	33.85	0	2062	4.33	8.60	37.21	9.48	0.00	107.48	450	0.91	144.10	75
14	"	AM09	A005	A006	0	0.00	33.85	0	2062	4.33	8.60	37.21	9.48	0.00	107.48	525	1.06	229.79	47
15	"	AM09	A006	A007	0	0.00	33.85	0	2062	4.33	8.60	37.21	9.48	0.00	107.48	450	0.89	141.96	76
16	C	AM09	A007	A008	60	4.08	37.93	245	2307	4.23	9.62	40.70	10.62	0.00	112.12	450	1.13	179.91	62
17	"	AM09	A008	A012	60	5.05	42.98	303	2610	4.13	10.88	44.92	12.03	0.00	117.76	450	0.76	121.07	97
18	D	AM09	A012	A011	60	0.89	43.87	53	2664	4.11	11.11	45.65	12.28	0.00	118.74	375	1.48	162.97	73
##																			

Since sanitary sewers will be in the ground until the end of their useful life, they must be sized *for the life of the asset.* The total peak I/I value is included to provide sufficient capacity in the sewer to convey domestic peak and peak I/I flows in the last year of service. This value is not a suitable acceptance testing number.

Some municipalities have recently been reducing the allowable peak long term I/I in their sanitary sewer design sheets to lower values. Presumably, this is to try to reduce allowable I/I in new sewers. There may be a more appropriate means of reducing I/I at year zero, as detailed in the balance of this report.

A more appropriate value to consider as an acceptable level of I/I in new sanitary sewers was also described in MOE Sanitary Sewer Design Guidelines (1985) for acceptance testing of sewers (this is now specified as the same value in the current Ontario Provincial Standard Specifications (OPSS), discussed in detail later) and is given as 0.075 L/millimeter diameter per 100 meters of sewer per hour. MOE (1985) then provided the "customary" unit conversion to: *22 L/cap/d* or *0.01 L/s/ha.*

Table 2 shows a comparison of using either 0.10 to 0.28 L/s/ha for peak long term I/I, or 0.01 L/s/ha for acceptance testing as measures of "acceptable" I/I.

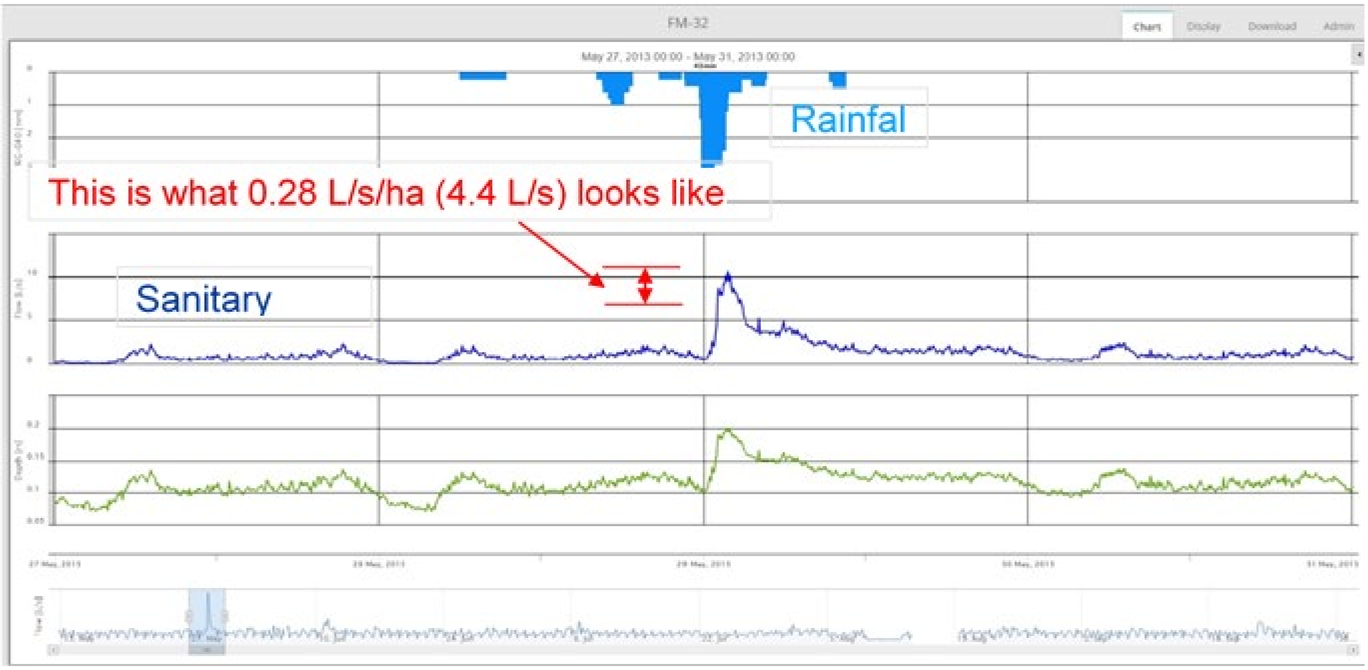
TABLE 2: COMPARISON OF LONG TERM ALLOWABLE I/I PEAK PER MOE 1985 (MOST RECENT) AND ACCEPTANCE TESTING (OPSS 2012) I/I VALUES

I/I Type	Minimum	Maximum
Long Term Peak I/I Allowance for Sizing Sewers	0.10 L/s/ha	0.28 L/s/ha
Allowable Leakage at Acceptance Testing	0.01 L/s/ha	
Percentage of Long Term Peak I/I Equivalent to Allowable Leakage at Assumption of Sewers	**10%**	**3.6%**

As shown in Table 2, the suggested value for leak testing at acceptance is between 4% and 10% of long term peak I/I. Using 0.28 L/s/ha (or even 0.10 L/s/h) is not an appropriate number for assumption testing of new sanitary sewer systems.

Figure 3 depicts what the long-term peak I/I allowance of 0.28 L/s/ha looks like on an actual flow graph. This is a new subdivision that was identified by the municipality as having unacceptable I/I. As shown, the peak I/I flows already exceed the 0.28 L/s/ha, meaning that in future, as longer term I/I occurs, these sewers may be inadequately sized to convey the flows.

FIGURE 3: GRAPHICAL DEPICTION OF I/I IN A SPECIFIC NEW SUBDIVISION



2.3 Costs of I/I

The costs of I/I are substantial, and many of these costs have not traditionally been included in engineering reports (such as Environmental Assessments and Master Plans), which typically only consider costs borne by the municipality. A long list of societal costs of I/I which should be considered include:

- Simple treatment costs [chemicals & energy (pumping & blowers)],
- The need to expand wastewater treatment plants (WWTPs) sooner than would otherwise be necessary,
- Pumping station energy, maintenance and expansion costs,
- Lost capacity in trunk sewers,
- Potential loss of development (Development Charges (DCs) & Tax Revenue) if capacity is lost (e.g. lost opportunity costs),
- City engineering & operations staff costs for I/I related issues (particularly flooding),
- Insurance losses (costs to insurers) for flooding,
- Uninsured losses (costs to homeowner) for flooding

- Compassionate grants paid by municipality for flooding,
- Disaster relief programs paid for by the Ontario or Federal government,
- Risks to homeowners of denial of insurance, increased premiums, and capping of payouts associated with flooding,
- Lost time from work, and
- Psycho-social impacts on affected residents.

More recently, municipalities have been considering a greater number of the abovementioned costs; however, to date, this work has identified no instance where all costs (regardless of who bears it) were considered.

The yearly cost of treatment alone is $50,000 for **1 L/s** of I/I is $50,000. The present value of a single **1 L/s** of I/I, over the 40-year life (before scheduled rehabilitation of a sanitary sewer), is **$1,000,000** (based on a simple calculation using unit treatment cost of $1.50/m^3$ and 3% interest. When considering treatment costs, full cost accounting suggests that we must consider also the costs associated with expansion of WWTPs and not just the marginal cost of the last m^3 being treated.

The costs to find and remove I/I later in the life of a sanitary sewer on the municipal side are substantial, the work is disruptive to residents, and it is difficult to get a reasonable benefit/cost ratio to justify doing the work. Typical steps in an I/I reduction program include large basin monitoring, small basin and area monitoring, inspection and testing, and then rehabilitation and pre- and post- rehabilitation monitoring. I/I rehabilitation projects are not always successful due to the complexity of the work and the ability of water to find another entry point into the sanitary sewer system once the initial entry point is sealed through rehabilitation.

The removal of I/I in sewers on the private side is much more problematic, since the municipality typically does not own these sewers. Wastewater professionals across North America now believe 50 to 60% of I/I originates on private property[9]. In recognition of this, a number of jurisdictions have moved to I/I reduction programs that are exclusively on the private side (East Bay Municipal Utility District, east of San Francisco).

The private side lateral is privately owned by the homeowner in most of Ontario, and there is no jurisdiction in Ontario that requires periodic inspection of this lateral (although there are many funding programs to support this work). The municipality has no direct control over I/I entering this private sewer.

I/I studies are common across Ontario, and a wide variety of deficiencies are identified. However, no substantial changes have been made to *how we construct sewer systems,* both public and private, so we can reasonably expect these phenomena to continue, unless we make changes. We need to prevent this I/I from getting into our sanitary sewer systems in the first instance.

As reported by Kesik,

> "long after the creation of our early 20th century municipal sewer systems, citizens discovered their inherited municipal infrastructure was either a legacy or a liability. Future generations will be able to devote their tax dollars toward aspects of civil society like education and healthcare, or they will have to dig up the past to rebuild a new future. What happens to our municipal infrastructure in the next few decades across many parts of Canada will greatly influence our nation's fiscal and environmental well-being in the second half of the 21st century."[10]

Inclusion of representation from the insurance industry has been a key component of this project. Average sewer backup claim amounts for Ontario disaster events over the past four years ranged from $12,000 to $30,000 per home (these are insured costs only).[11] Introducing additional I/I into upstream sewers only exacerbates this problem, which will continue to worsen with climate change. In a 2010 Climate Change Position Paper, the Association of Municipalities of Ontario (AMO)[12] reported that "extreme precipitation poses serious risks to municipalities' built capital, most significantly overloading sanitary and stormwater systems which can cause flooding and road washouts and damage to homes."

2.4 Summary of Results Across Ontario

Data and graphs were collected from municipalities who had undertaken flow monitoring downstream of new subdivisions. All graphs/data received clearly demonstrated unacceptable I/I (and had been identified as such by the contributing municipality). Several typical graphs are presented below.

Figure 4 depicts flows versus time in a new subdivision. The blue bar values are rainfall, and the red line represents flow in the sewer. As shown, flow in this sewer increased dramatically after a larger rainfall event. This depicts an inflow response (rainfall that enters sewers rapidly after a rainfall), and elevated flows linger for some time after a rainfall. It also shows an infiltration response (this can be observed by comparing the size of the baseflow to the diurnal pattern of domestic wastewater), but it is difficult to see on the scale of this graph.

Figure 5 depicts the hydraulic grade line above the sanitary sewer in various flow monitors, in response to a massive storm event (two rain gauges were available, shown as bar graphs at the top of the graph). These sewers are fewer than 20 years old, so were constructed after it became illegal across most of Ontario to connect foundation drains or roof leaders to the sanitary sewer system. Clearly, these sewers are directly responding to rainfall.

Figure 4: Somewhere in Ontario New Sewers Respond to Rainfall

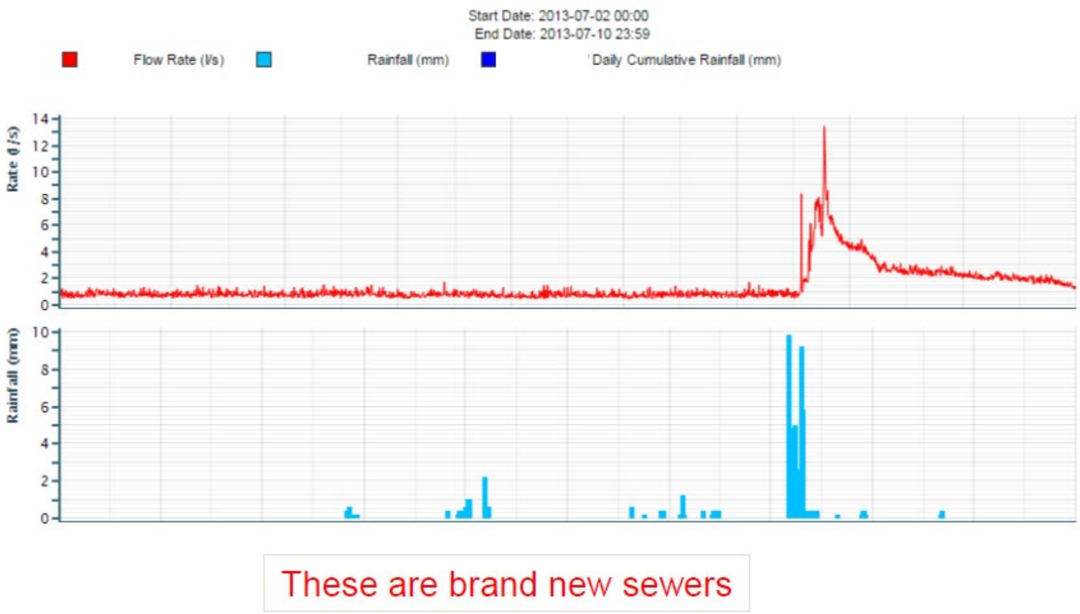


Figure 5: Binbrook Ontario: HGL in Sewers Fewer than 20 Years Old Appear to have Direct and Indirect Connections (July 22, 2012 Storm)[13]

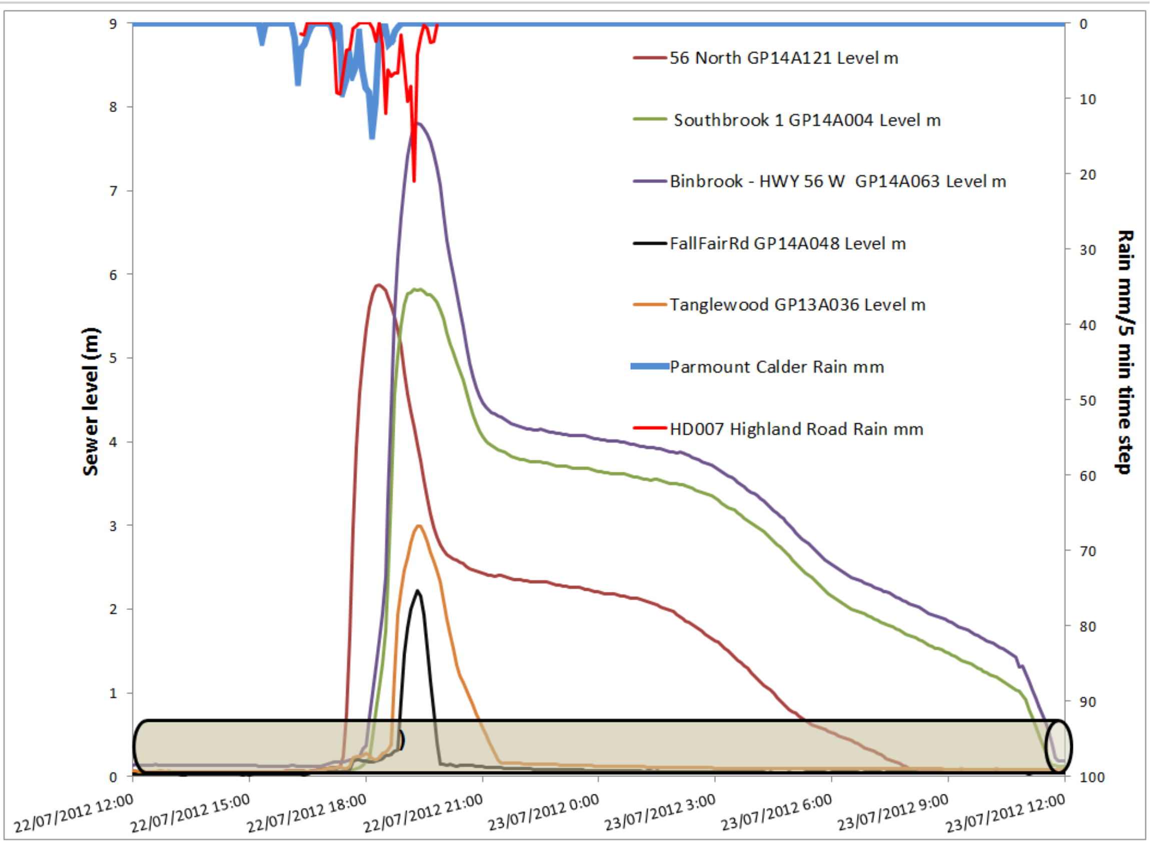
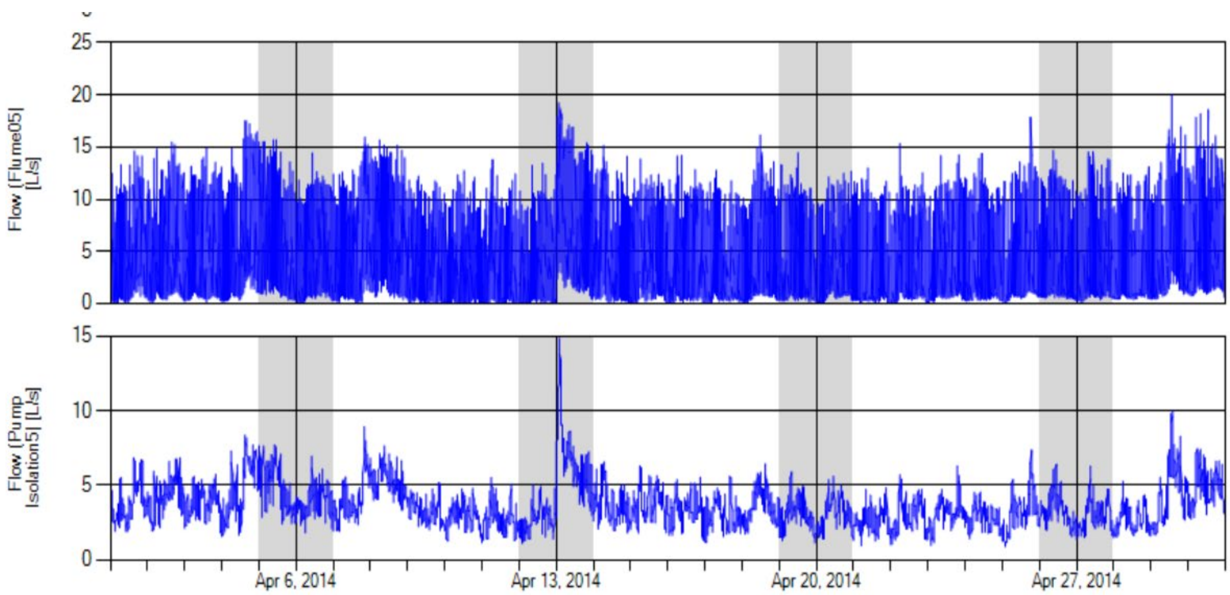


Figure 6 depicts both an infiltration (base flow) issue, as well as a significant response to rainfall. Baseflows are in the range of 2.5 L/s, which is excessive for the size of this

FIGURE 6: SOMEWHERE IN ONTARIO: FLOW FROM A NEW DEVELOPMENT DOWNSTREAM OF A PUMPING STATION



subdivision. Note that this is downstream of a sewage pumping station, so peaks are attenuated by the wet well (e.g., actual flow is a lot peakier).

2.5 Next Step: Detailed Interview of Municipalities & Other Stakeholders

After Phase 1 was completed (mid-2016), it was determined by the Steering Committee and RPWCO that additional work was required. RPWCO specifically requested that in-depth interviews of municipal staff and other stakeholders be undertaken, to determine, in detail, the causes and conditions of this I/I, both on the public and the private side.

Interviews of municipal staff were conducted in person with staff from development, planning, engineering, and building departments. Firstly, the results from across Ontario were presented to inform staff of the importance of the issue, and then they were surveyed. There were no fixed set of survey questions; information on specific practices was collected, but the balance of the interview involved an open discussion between the attendees about specific concerns or questions they had about I/I in new subdivisions. The interview was not designed to produce statistics, though some were gleaned from the information collected.

This methodology was informed, in part, by recent work on the I/I Program Best in Class Report completed by York Region[14], in which the original formal survey questions were found to be less effective at collecting specific details, practices and concerns from each jurisdiction. Also, for the current interviews, the opportunity for building and engineering departments to learn about each others' requirements, practices, challenges and opportunities was best served in a less formal environment.

Concurrently and subsequently, supplemental information was collected from individuals or smaller groups involved in all aspects of the development of new subdivisions, such as consultants, contractors, developers, builders and other industry representatives. Some of this information was solicited when results of the working sessions were ambiguous.

This project does not purport to examine what the specific defects are (they were often as-yet not identified by the municipality), but rather to determine *why* these deficiencies are occurring in the first place.

2.6 Public Side and Private Side Jurisdictions in Ontario

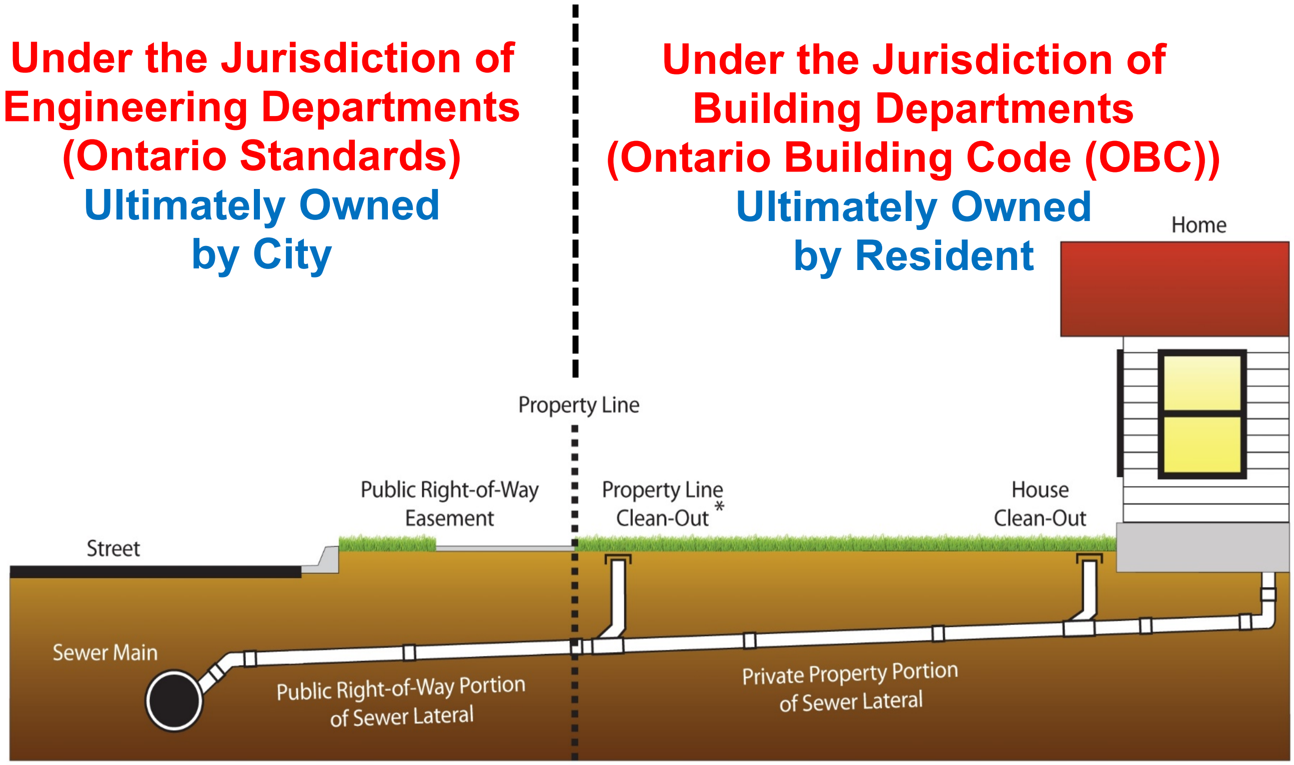
The "public side" comprises the mainline sanitary sewer and the sanitary lateral to the property line (there are a few exceptions in Ontario). This is the portion of the system that will ultimately be owned by the municipality; the "private side" is the lateral from the property line to the house, which will ultimately be owned by the homeowner. Note that during the construction of a new subdivision, the entire system is "owned" by the developer, until it is assumed/accepted by the Municipality. Figure 7 depicts that lateral on the public and private sides.

In Ontario, engineering/development departments oversee the public-side of sanitary sewer systems, and municipal building departments oversee private side systems. Private and public side systems fall under completely different legislative regimes, and are therefore treated separately here.

An I/I Program Best in Class Report[15] identified that the most effective I/I reduction programs across North America involved the cooperation of public (engineering) and private (building) departments. Building on this concept, working session interviews were conducted with engineering, development, operations and building staff, at all levels, in the same room.

In total, five upper-tier, approximately thirty lower-tier (with a variety of sewer ownership models), and six single tier jurisdictions were contacted and/or formally surveyed. All participants in the working sessions and interviews were promised confidentiality, so the sources of specific comments are not identified in this report. Preliminary results were presented at WEAO (2017)[16]. Results are presented for the public side in Section 3, and the private side in Section 4.

Figure 7: Graphic Depiction of Sanitary Lateral on Public and Private Side Lateral



* Not standard on all properties.

3 Interviews of Ontario Municipalities & Other Stakeholders: Public Side Results

3.1 General

Detailed interviews of Ontario Municipal Engineering and Development staff and discussions with other stakeholders were blind and interview participants were provided with anonymity. A variety of survey methodologies were used, including formal survey (working groups), e-mail, telephone and face-to-face interviews.

Results are presented visually first for some important metrics, and then described in more detail in the following sections.

3.2 Ontario Provincial Standard Specification and Drawings (OPSS/OPSD)

The Ontario Provincial Standard Specifications (OPSS) are used by the clear majority of municipalities in Ontario (either directly, or via location-specific specifications which are generally developed based on OPSS). Key specifications which govern required testing procedures for sanitary sewer and MH installations on the public side are described below.

OPSS 410 (Construction Specification for Pipe Sewer Installation in Open Cut – November 2012) is very clear regarding the Acceptance Testing of New Sanitary Sewers. The following tests are explicitly required:

- Mandrel testing,
- Air/water testing,
- 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),
- CCTV inspection, and
- Checking of every gasketed joint by feeler gauge.

OPSS 1351 (Material Specification for Precast Reinforced Concrete Components for Maintenance Holes, Catch Basins, Ditch Inlets and Valve Chambers – November 2014) is clear regarding acceptance testing on sanitary sewer MHs. The following tests are explicitly required:

- Step testing,
- Concrete testing, and
- Hydrostatic testing.

3.3 Results around Testing & Accepting of New Sewers on the Public Side as Reported by Municipalities

Results reported in this section were obtained directly from municipal staff and refer to their actual practices.

Detailed statistics of interview results are presented for the following OPSS public side metrics:

- Public Side Air & Water Testing,
- Maintenance Hole (MH) Infiltration Tests,
- Municipalities performing Mandrel Tests, and
- Municipalities performing CCTV of Public Side Laterals.

Not all participants provided answers for all questions; the number of responses included in the graphs is noted for each graph.

3.3.1 Public Side Air & Water Testing

Public side air or water testing provides information to the municipality regarding how watertight new sewers, including the lateral to property line, are when they are first constructed. At the time of this test, laterals are already connected to the mainline sewer, and are capped at the property line. As such, the test also evaluates the water tightness of the public side lateral.

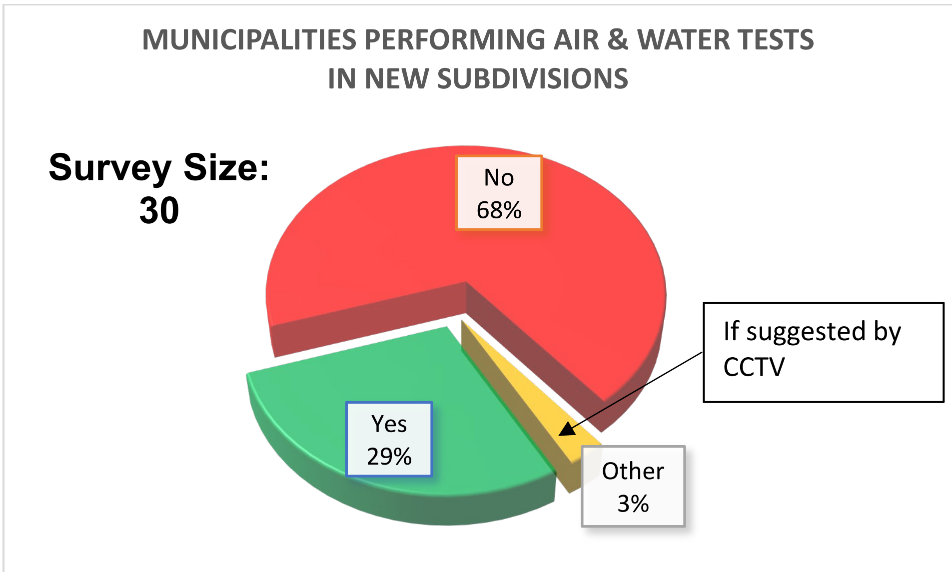
OPSS 410.07.16.03 (2012), Infiltration Test, specifies that allowable infiltration shall be calculated as 0.075 litres/millimetre diameter/100 meters of pipe sewer/hour. This is the same acceptance leakage testing suggested in the MOE Guidelines (1985) as discussed in Section 2. Figure 8 depicts the number of municipalities who currently require air or water testing of new sanitary sewers in new subdivisions on the public side.

It is important to note that air or water testing is the only way to confirm that joints in a new sanitary sewer system, including laterals to the property line, are not leaking beyond acceptable levels. Failure to perform one of these tests is a loss of critical information to a municipality. A single poorly connected joint can be a significant source of I/I in perpetuity. Nevertheless, as illustrated in Figure 6, 69% of surveyed municipalities do not require air or water testing to be performed.

Explanations by municipal staff, consultants and contractors for why this testing is not taking place included:

- Pressure from developers who tell municipal staff that this test is not required in other jurisdictions, and
- The length of time required to perform the test.

FIGURE 8: PERCENTAGE OF MUNICIPALITIES PERFORMING AIR OR WATER TESTING ON NEW SUBDIVISION SEWERS (N=30)



3.3.2 Public Side Maintenance Hole (MH) Infiltration/Exfiltration Tests

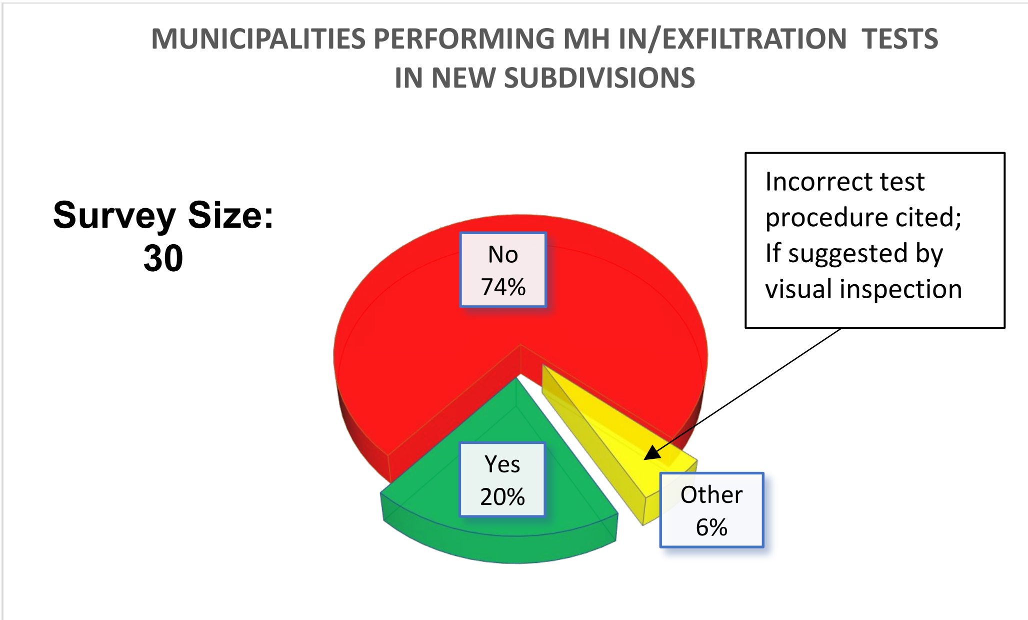
Public side maintenance hole (MH) Infiltration/Exfiltration tests provide information to the municipality regarding how watertight new MHs are when they are first constructed. Note that maintenance hole risers are typically adjusted prior to the laying of final asphalt, which usually occurs after the undergrounds are accepted. As such, the test performed per OPSS would not confirm the water tightness of these final risers.

Figure 9 provides the proportion of surveyed municipalities who call for Maintenance Hole Infiltration Tests. As shown in Figure 9, 74% of municipalities do not require the performance of infiltration or exfiltration tests on new maintenance holes. One municipality reported the application of incorrect testing procedures.

The reasons provided for not performing this test included:

- Pressure from developers who tell municipal staff that this test is not required in other jurisdictions,
- Not being clear about the importance of the test, and
- The length of time required to perform the test.

FIGURE 9: PERCENTAGE OF MUNICIPALITIES PERFORMING MH IN/EXFILTRATION TESTING (N=30)



3.3.3 Public Side Mandrel Tests

The purpose of the Mandrel test (or deflection test) is to confirm that a plastic pipe (typically small diameter PVC in new subdivisions) is not “out of round”. Unlike concrete pipe, which is structurally sound on its own, the structural support of plastic (PVC) pipe is provided by the backfill. As pipe deflection can indicate improper bedding and backfill practices, mandrel testing is critical to the long-term performance of PVC pipe. All plastic pipe, which is almost always PVC in new subdivisions, is categorized as a flexible conduit and depends on a properly constructed soil embedment for two important functions[17]:

- The side soil must provide passive resistance to allow the pipe to deflect and transfer the loads into the soil, and,
- Soil arching above the pipe will reduce the loads on the pipe.

A mandrel has Go + No Go proving rings which are pulled through the pipe from MH to MH, to verify that each deflection gauge is within acceptable OPSS tolerances. Figure 9 depicts a typical mandrel test setup.

FIGURE 10: TYPICAL MANDREL TEST SET UP[18]

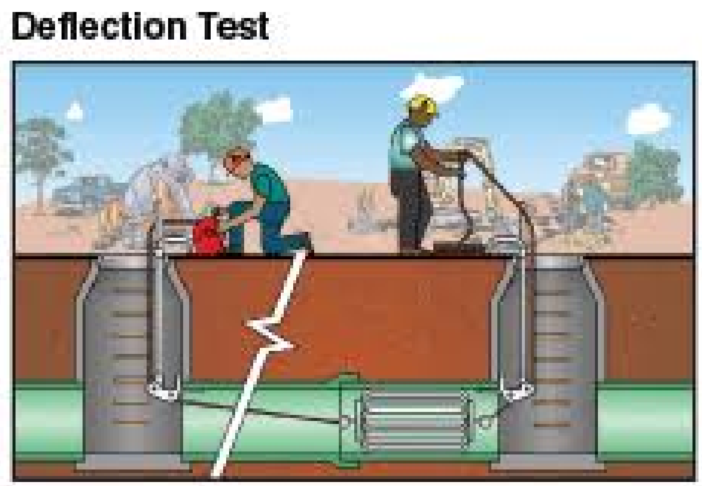
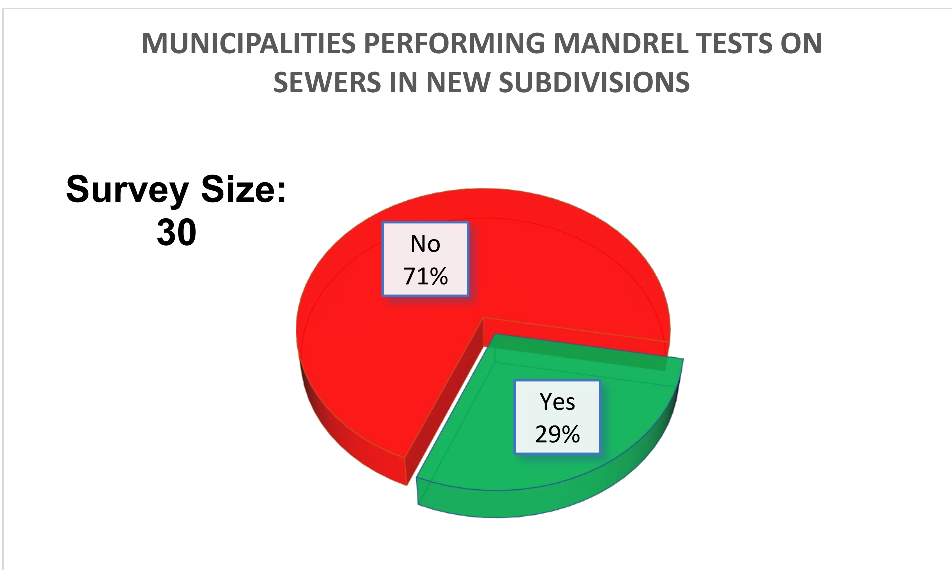


Figure 11 summarizes the number of municipalities performing this test. Mandrel tests are the most frequently performed of all the sanitary sewer tests required in OPSS specifications.

FIGURE 11: PERCENTAGE OF MUNICIPALITIES PERFORMING MANDREL TESTS (N=30)



However, if a sewer length fails a mandrel test, the only solution is to dig up the non-performing section, and reinstall it. A PVC pipe, once compressed out of round, cannot be fixed. It needs to be replaced. Nevertheless, during the survey, only one municipal operations staff member reported having required a contractor to re-install a PVC pipe that failed the mandrel test (one time). Another municipal staff had required that a pipe be dug up after failing the Mandrel, but the contractor re-installed the same pipe sideways (the structural integrity of this pipe is uncertain). These findings suggest that the function and importance of the mandrel test is not well understood in our industry.

These principles around the absolute need to provide adequate bedding and backfill for plastic pipe also apply to small diameter plastic drain pipe (private side sanitary lateral), which is discussed in the next section.

Reasons cited for not performing a mandrel test included:

- Pressure from developers (e.g., developers citing the argument that that this test is not required elsewhere), and
- There is not a perceived need to undertake the test.

3.3.4 CCTV of Laterals to Property Line

Most municipalities reported performing Closed Circuit Television (CCTV) inspection of mainline sanitary sewers one, two or three times during the course of the construction, final acceptance and warranty period, for sanitary sewers in new subdivisions. A few municipalities reported CCTV inspection of storm sewers.

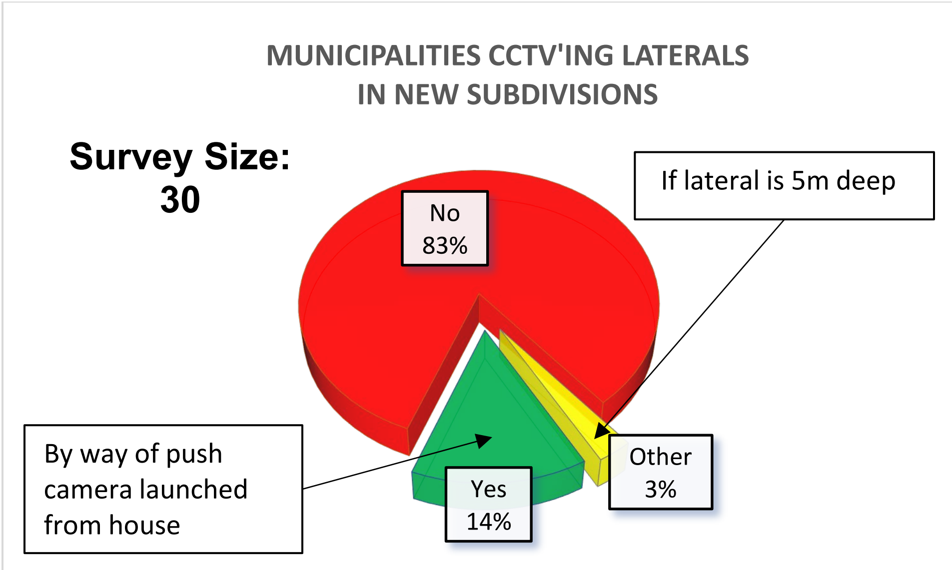
To perform CCTV inspections of laterals to the property line, CCTV equipment with a lateral launch camera is required, which is more expensive (estimated at 20%[19]) than standard CCTV. Unlike other inspections, it is not necessary for a municipal representative to be in attendance, since a recorded video is provided following the test. Nevertheless, study results indicated that CCTV inspection of lateral sewers from the mainline sanitary sewer to the property line (the extent of construction which is completed while the subdivision is under the jurisdiction of a municipality's development engineering department) is quite uncommon. Arguably, the lateral is also a "new sewer" as defined in OPSS 410 and needs to be inspected accordingly.

As shown in Figure 12, most municipalities are not performing CCTV inspection of the lateral from the mainline sanitary sewer to the property line. While this inspection will not provide information about the connection of the private side lateral at property line (which occurs later in the development process), it does provide the municipality with information on the robustness of the public-side lateral installation.

Reasons given for not requiring CCTV inspection of laterals to property line include:

- CCTV inspection of laterals is not called for in OPSS specifications,
- CCTV inspection is too expensive, and
- Pressure from developers to accept infrastructure quickly.

FIGURE 12: PERCENTAGE OF MUNICIPALITIES PERFORMING CCTV OF LATERALS TO PROPERTY LINE (N=30)



3.4 Additional Interview Comments on Public Side

In addition to the information on inspection and testing procedures collected during the interviews and in discussions with others in the industry, a great deal of related information and commentary was collected. This information is summarized in Table 3 and described in this section.

TABLE 3: SUMMARY OF ADDITIONAL COMMENTS/ISSUES COLLECTED FROM MUNICIPAL STAFF AND STAKEHOLDERS

Public Side Issue No.	Issue Identified
1	Engineering staff know little about Private Side construction.
2	Most municipalities reporting I/I in new subdivisions did not yet know the source of the I/I, but are aware of primary sources of I/I in their existing sewer systems.
3	A majority of municipal staff did not believe that they were following all of their own (or OPSS) standards.
4	No municipality reported requiring that every joint in new pipe be checked by feeler gauge per OPSS.
5	A few municipalities are updating their construction specifications to minimize opportunity for I/I to develop.
6	Municipal staff are interested in how they can upgrade their

	Development Agreement so it is more prescriptive in terms of I/I.
7	Contractors are using the sanitary sewer to provide site drainage during construction.
8	Municipal staff report that sometimes the CCTV tape doesn't match CCTV report, but very few review the tapes.
9	A few municipalities have implemented camera inspection of entire lateral (from inside the house).
10	Rehabilitated infrastructure has a substantially shorter life than infrastructure installed correctly.
11	Many people surveyed reported that contractors are not installing a watertight bulkhead on the sewer at the end of the day's work.
12	Fernco Couplings frequently used to join PVC pipe to concrete MHs require a specified torque.
13	There was a feeling among many surveyed that storm sewers need not be installed to minimize I/I.
14	Interview respondents reported that the Developer has detailed contracts with Builders, so could enforce leak free infrastructure.
15	Municipal staff report feeling pressure to approve development quickly.
16	Inspection of new sanitary sewers is undertaken by the Developer's consultant, not Municipal staff. This may be a conflict of interest.

1. One significant finding from the interviews was that engineering (development) staff working on the public side acknowledged that they knew very little about what happened in a subdivision once they had accepted the underground infrastructure.

2. Many of the reporting municipal engineering groups are discovering I/I in new subdivisions through the collection of flow monitoring data, but have not yet investigated the specific sources of I/I, so are not aware of the specific deficiencies contributing to this unacceptable I/I. All interview participants, however, were clearly able to identify "unacceptable" I/I, without the benefit of a specific acceptable I/I rate at acceptance (information about this was discussed in Section 2).

   However, interview participants did discuss a long list of deficiencies that they continue to discover in their existing sewer systems (including newer subdivisions). These deficiencies are well known and oft-reported upon, and include: inadequate bedding compaction, inadequate bedding (or bedding PVC pipe as if it was concrete pipe), poor jointing, offset joints, leaking joints, poor connections at lateral to mainline, poor connections at MH, MH risers not seated properly, MH bases not installed properly, MHs broken into carelessly, MHs leaking at joints, rehabilitated sewers leaking again after a few years. Municipalities reported that they typically did not detect these deficiencies until the subdivision had already been assumed by the municipality, which means that the municipality is responsible for the costs of rehabilitation. No deficiencies that are not already well known to the engineering industry were identified in this work.

3. All municipalities reported using a variety of standards, guidelines and checklists (many of these were confirmed online). Updates are completed from time to time, but few municipalities reported that they felt that their standards were completely current or being followed in the field. The majority of municipalities rely on OPSS and Ontario Provincial Standard Drawings (OPSD), which are respected resources and updated regularly. These standard Specifications and Drawings are invariably referenced in municipal manuals, guidelines and contract specifications.

4. OPSS calls for the checking of every bell and spigot joint by feeler gauge to ensure that the elastomeric ("rubber") gasket is correctly seated. No municipality reported requiring this test to be performed. Many reported that contractors will cut off a gasket found to be hanging in the sewer so it cannot be seen on CCTV.

5. Municipalities reported that they were starting to update contract specifications to require measures such as watertight frames and grates, composite lift rings, external waterproofing or wrapping of MHs, watertight sanitary sewers (to drinking water standards in wet areas), and hydrophobic grout injection (both for new subdivisions and for capital programs in general). One municipality states that if we can build watertight watermains, we can build watertight sewers.

6. One municipality reported that they are already enforcing new construction standards on the development industry and are actively working on amendments to development agreements, so are well into incorporating some of the recommendations suggested later in this report. Several others are working towards this.

7. Municipalities involved in this study advised that contractors are using the sanitary sewers for site drainage. One municipality reported a contractor draining the street by removing MH covers. This practice is illegal both because stormwater needs to be routed through a stormwater pond to remove sediment and some pollutants, and clean water is not permitted in sanitary sewers.

8. Many municipalities are not reviewing all CCTV reports/tapes due to time constraints. Several respondents reported that the CCTV reports do not always match the tapes (e.g., some deficiencies found on the tapes are not identified in the report). Some municipalities spot-check the tapes against the summary report. Some municipalities will not accept CCTV that is over one-year old. The problem of CCTV contractors not using the municipal nomenclature for MH numbers (e.g. they start at "1" and go up) persists, and makes it difficult to refer to tapes later with confidence about their location

9. One municipality has recently implemented push camera inspection from inside the house on 100% of the laterals. This is an excellent technique as it captures information on both the private and the public sides. Another municipality recently inspected laterals to property line as a pilot project, and 90% of them were found to

be unacceptable.

10. In one municipality, a trunk sewer was found to be leaking and was repaired with CIPP spot lining. Two years later, it was leaking again (the water had found its way to the ends of the CIPP liner sections). It has now been lined again, but it is expected that this trunk sewer will always be at risk.

11. OPSS 410 calls for a removable watertight bulkhead to be installed at the open end of the last pipe laid whenever work is suspended. Many municipalities reported that contractors often use a piece of wood supported by a stake, so that the excavation can drain. This is not a watertight connection as called for in OPSS, and introduces I/I into the sewer system while under construction.

12. The use of Fernco couplings (rubber “boots” used to connect PVC pipe to concrete manholes) is very common in our industry. The couplings require gear clamps to hold them in place, and the standard gear clamps need to be tightened to 60 inch-pounds with a torque wrench. No pipe laying contractor who participated in the interview was aware of this requirement, nor did they have torque wrenches on site.

13. Interview respondents and contractors advised that storm sewers are subject to significantly less inspection than sanitary sewers, which may be a problem long-term. The construction industry apparently has mixed opinions as to whether storm sewers need to be watertight/gasketed. They report installing these pipes accordingly.

14. Consultation with developers and builders indicated that the developer has significant control over the builders to whom it sells lots. Their contracts are long and complex. The developer could hold funds if the builders are not constructing private side infrastructure to minimize I/I. Even with multiple builders, this would be possible, though more difficult for the developer to enforce.

15. Many municipal employees reported feeling pressure from the developer, with the perception that developers will approach senior management and politicians if they are not satisfied. Whether this occurs or not, the perception is sufficient to discourage municipal employees from being too stringent with testing and acceptance. This is a significant and sensitive finding which should be discussed in greater detail across the industry. It is beyond the scope of this work to address this further.

16. Many representatives across the industry expressed concern that inspection was being undertaken by the Developer’s consultant staff, not City staff. The Developer does not necessarily have the same long-term interests as the City in providing leak-free infrastructure.

4 Interviews of Ontario Municipalities and Stakeholders: Private Side Findings

4.1 General

Like the collection of the public side testing data, the detailed interview of Ontario Municipal Building Departments was blind and interview participants were provided with anonymity. Many Building Inspectors, Building Plumbing Inspectors and Chief Building Officials (CBOs) were consulted during the course of this work. The Author attended a week-long course on the OBC Part 7 (Plumbing – House) delivered by the OBOA, in order to better understand the OBC as it relates to I/I issues. A variety of new subdivision building sites were visited (shadowing Building Inspectors), and inspection and testing procedures on the private side were observed first hand. However, it should be noted that the Author does not profess to be an expert on this complex document.

Results are presented visually first for some important metrics, and then described in more detail in the following sections. In total, information on private side testing practices for 20 jurisdictions was obtained.

4.2 The Building Code Act (1992)

The Building Code Act (1992) sets out Compliance, Objectives and Functional Statements for Ontario Regulation 332/12 (the Ontario Building Code), administered by the Ministry of Municipal Affairs and Housing (MMAH) in Ontario. The general guidelines provide the philosophy behind why certain requirements are called for in the OBC.

The Building Code Compendium states that "the Ontario Building Code is essentially a set of minimum provisions respecting the safety of buildings with reference to public health, fire protection structural sufficiency, accessibility and energy efficiency. It is not intended to be a textbook on building design, advise on which should be sought from professional sources." Arguably, if the OBC sets minimum provisions, we should always be meeting these, and exceeding them where appropriate.

4.3 The Ontario Building Code (OBC), (2012)

Relevant portions of the OBC which relate to survey results, are presented here.

4.3.1 General Provisions and Definitions

Division A of the OBC presents Compliance, Objections and Functional Statements, and Part 2 outlines objectives for plumbing.

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.”

The Ontario Building Code (OBC) refers to defined words or terms in italics. “*Sanitary Building Sewer*” is defined in the OBC as follows:

> *Sanitary Building Sewer means a pipe that is connected to a Sanitary Building Drain 1 000 mm outside a wall of a building and that conducts sewage to a public sewer or private sewage disposal system.*

That is, the sanitary drain inside the house is a *Sanitary Building Drain*, and once it is 1m outside the wall of the foundation, it becomes a *Sanitary Building Sewer*. This is known as the private side lateral in the engineering community.

> *Drainage system* means an assembly of pipes, fittings, *fixtures* and appurtenances on a property that is used to convey *sewage* … to a main sewer…
>
> *Sanitary Drainage System* means a drainage pipe that conveys *sanitary sewage* to a place of disposal, including the …*sanitary building sewer*...
>
> *Sewage* means *sanitary sewage* or *storm sewage.*

OBC Section 7.3, “Drainage Systems”, covers much of the acceptance and testing procedures recommended or required for *Sanitary Building Sewers*. However, there are many references to Compendiums and Appendices.

Relevant excerpts from the OBC that relate to results of the interviews performed as part of this project are described below.

4.3.2 Bedding and Backfill

Requirements for bedding on the private side, are covered under various areas of the OBC, as follows.

OBC Subsection 7.3.4. Support of Piping

7.3.4.6 Support for Underground Piping

> *(1)…nominally horizontal piping that is underground shall be supported on a base that is* ***firm and continuous*** *under the whole of the pipe.*

Volume 2 Compendium to OBC (Appendices are not part of OBC):

OBC Sentence A-7.3.4.6.(1))

Plastic piping installed underground must be support (sic) on a base that in (sic) continuous under all piping and fittings with a recommendation of at least 100mm of loose fill surrounding the piping. Plastic piping buried up to depths greater than 2.5m…. must have backfill that is free of large stones or frozen each, tamped by machine or poured as a wet slurry containing one part 6mm pea gravel and one part 12mm crushed stone.

OBC Subsection 7.3.5. Protection of Piping

7.3.5.1. Backfill of Pipe Trench

(1) Where piping is installed underground, the backfill shall be carefully placed and tamped to a height of 300 mm over the top of the pipe and shall be free of stones, boulders, cinders and frozen earth.

4.3.3 Testing of Sanitary Building Sewer

The OBC requires that the Sanitary Building Sewer be tested. Relevant excerpts from the OBC are listed here:

OBC Subsection 7.3.6. Testing of Drainage and Venting Systems

7.3.6.1. Tests and Inspection of Drainage or Venting Systems

(1) Except in the case of an external leader, after a section of drainage system or a venting system has been roughed in, and before any fixture is installed or piping is covered, ***a water or an air test shall be conducted****.*

(2) ***Where a chief building official requires a final test****, it shall be carried out after every fixture is installed* ***and before any part of the drainage system*** *or venting system* ***is placed in operation****.*

(5) A ***ball test shall be carried out on a*** *sanitary building drain,* ***sanitary building sewer****, storm building drain and a storm building sewer buried underground.*

7.3.6.2. Tests of Pipes in Drainage Systems

(1) ***Every pipe in a drainage system****, except an external leader or fixture outlet pipe, shall be capable of* ***withstanding without leakage a water test, air test and final test.***

7.3.6.4. Water Tests in Drain, Waste and Vent Systems

(1) Where a water test is made, all joints shall be tested with a water column of not less than 3 m.

(2) In making a water test,

(a) Every opening except the highest shall be tightly closed with a testing plug or a test cap, and

(b) The system or the section shall be kept filled with water for 15 min.

7.3.6.5. Air Tests

(1) Where an air test is made, it shall be conducted in accordance with the manufacturer's instructions for the piping materials, and,

(a) Air shall be forced into the system until a gauge pressure of 35 kPa is created, and

(b) This pressure shall be maintained for at least 15 min without a drop in pressure.

4.3.4 Inspection of Lateral at Property Line

The following clauses in the BCA and the OBC have been suggested as governing the inspection of the lateral at property line; however, neither appears to be distinct nor prescriptive.

Building Code Act (BCA), 1992

Role of Various Persons

1.1 (1) It is the role of every person who causes a building to be constructed,

(a) to cause the building to be constructed in accordance with this Act and the building code and with any permit issued under this Act for the building;

(b) to ensure that construction does not proceed unless any permit required under this Act has been issued by the chief building official; and

(c) to ensure that construction is carried out only by persons with the qualifications and insurance, if any, required by this Act and the building code. 2002, c. 9, s. 3.

Notice of readiness for inspection

10.2 (1) At each stage of construction specified in the building code, the prescribed person shall notify the chief building official or the registered code agency, if any, that the construction is ready to be inspected. 2002, c. 9, s. 17.

(2) After the notice is received, an inspector or the registered code agency, as the case may be, shall carry out the inspection required by the building code within the prescribed period. 2002, c. 9, s. 17.

Ontario Building Code (OBC), 2012

Permits

1.3.5.1. Prescribed Notices

(1) This Article sets out the notices that are required under section 10.2 of the Act.

(2) The person to whom a permit under section 8 of the Act is issued shall notify the chief building official or, where a registered code agency is appointed under the Act in respect of the construction to which the notice relates, the registered code agency of (excepts),

(a) readiness to construct footings,

(b) substantial completion of footings and foundations prior to commencement of backfilling,

(i) readiness for inspection and testing of,

(i) building sewers and building drains,
(iv) drainage systems and venting systems,

(n) substantial completion of installation of plumbing not located in a structure, before the commencement of backfilling.

4.4 Results around Testing & Accepting of New Sanitary Building Sewers on the Private Side as Reported by Municipalities

Detailed statistics of results are presented for the following private side metrics:

- Performance of 3m water column or air test of private side drainage system (*Sanitary Building Sewer* or private side lateral as it is known in the engineering community),
- Performance of ball test, and
- Inspection of connection at property line.

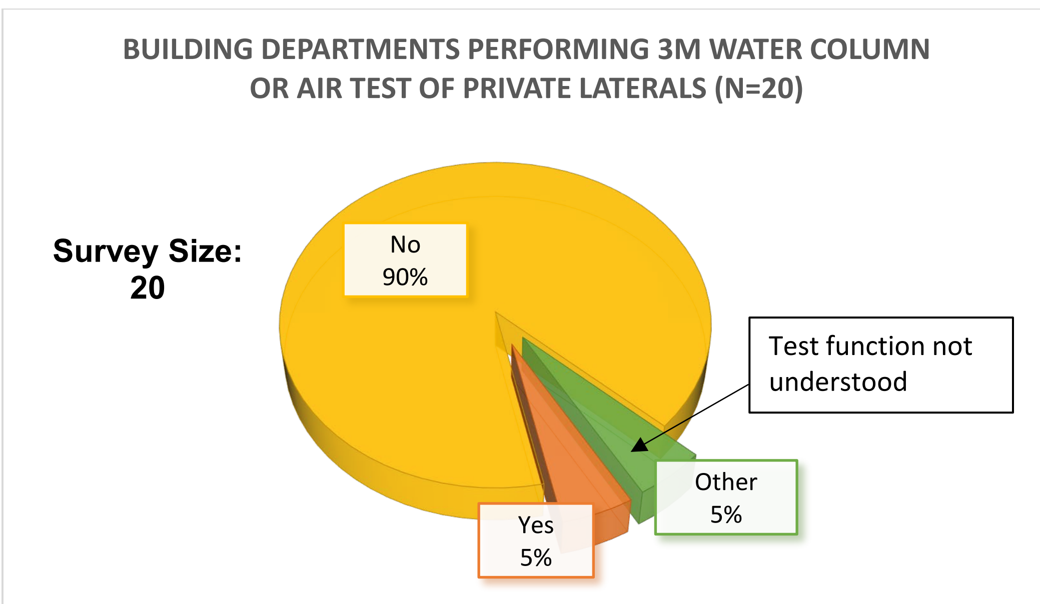
4.4.1 3m Water Column or Air Test of *Sanitary Building Sewer* (Private Side Lateral)

The purpose of the air or water test of the *Sanitary Building Sewer* (private side lateral) is the same as that of the test performed on the sanitary sewer the public side (per OPSS). The test is to ensure that the *Sanitary Building Sewer* has been installed such that an acceptable amount (or no) leakage is observed. This test is typically performed before the *Sanitary Building Sewer* is buried, so would not identify issues that occur once the sewer is backfilled. The public side lateral test, by contrast, is generally performed once the pipe is buried and the soils above it compacted.

In order to perform the water/air test, either the existing tee at the property line is plugged, or the contractor installs a temporary test tee. The test is performed, and once the *Sanitary Building Sewer* passes the test, the tee is either capped (where tee exists) or removed and the private side lateral is connected to the public side lateral.

Figure 13 illustrates the proportion of interviewed Building Departments requiring Water or Air tests per the OBC. Results indicated that most building departments do not insist upon an air or water test on the *Sanitary Building Sewer*.

FIGURE 13: PERCENTAGE OF BUILDING DEPARTMENTS PERFORMING 3M WATER COLUMN OR AIR TEST OF PRIVATE LATERALS (N=20)



The reasons provided for not performing this test varied. These included:

- Water tests are difficult as there is nowhere to which to drain the water once the test is completed,
- Neither building inspectors nor contractors have the required “standpipe” to hold the 3m column of water,

- Developers are not installing test tees at property line so there is no way to plug the *Sanitary Building Sewer* at that end (note that installation of a capped tee or wye is required per OPSS 410, discussed in Section 4),
- Building Inspectors are not permitted to scale the house frame (which is reported to be already constructed in some municipalities before the plumbing inspection takes place) for health & safety reasons,
- The test is for internal plumbing (this appears to be a misinterpretation of the Code: both internal and external tests are called for in the OBC, although this report only covers the test on the *Sanitary Building Sewer*), and
- Air tests results can be altered by the contractor using a faulty gauge (e.g. one set to the required pressure ahead of time). We asked whether the inspectors could carry a gauge with them, but were advised that all setups are different.
- Staffing constraints were identified as a factor that limited the application of these tests.

4.4.2 Ball Test of *Sanitary Building Sewer* (private side lateral)

A ball test involves dropping a heavy ball (similar to a pool ball) into the cleanout inside the house, and watching for it to appear in the cleanout at property line, where it is collected. The test may or may not be timed (a minimum 1% slope is required on the sanitary building sewer per the OBC, although 2% is recommended). No municipalities reported requiring a 2% slope on this Sewer.

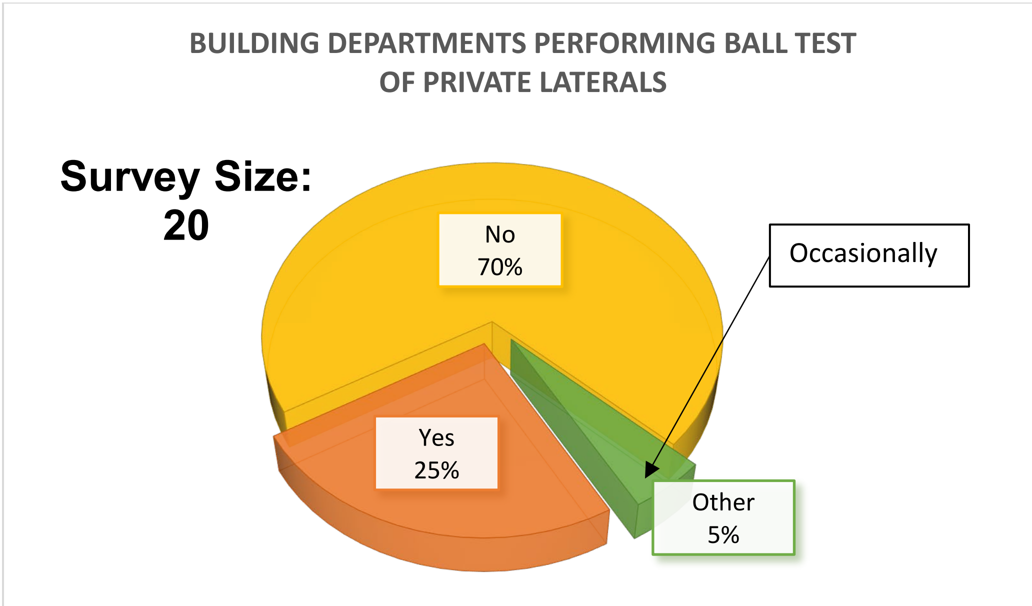
A ball test does not directly identify I/I; however, if there is a significant sag in the *Sanitary Building Sewer*, it may become lodged in the Sewer. It appears to be intended to ensure there is a positive slope on the drain. As illustrated in Figure 14, most building departments interviewed reported that they were not performing ball tests.

The reasons for not performing ball tests were given as follows:

- It is difficult for the inspector to get to the cleanout,
- Because only one inspector is typically on site, one end of the ball test is performed by the contractor. Two different inspectors in different Ontario jurisdictions advised that contractors were known to cheat the test. Specifically, contractors may carry an extra ball that is "caught" by the contractor in the event that the inspector's ball does not arrive at the cleanout at the property line,
- Cleanouts are not always being provided at the property line (despite being a requirement of OPSS) so there is no way to catch the ball, and

Inspectors were concerned about the ball being missed and making its way into the sanitary sewer system.

FIGURE 14: PERCENTAGE OF BUILDING DEPARTMENTS PERFORMING BALL TESTS ON SANITARY BUILDING SEWER

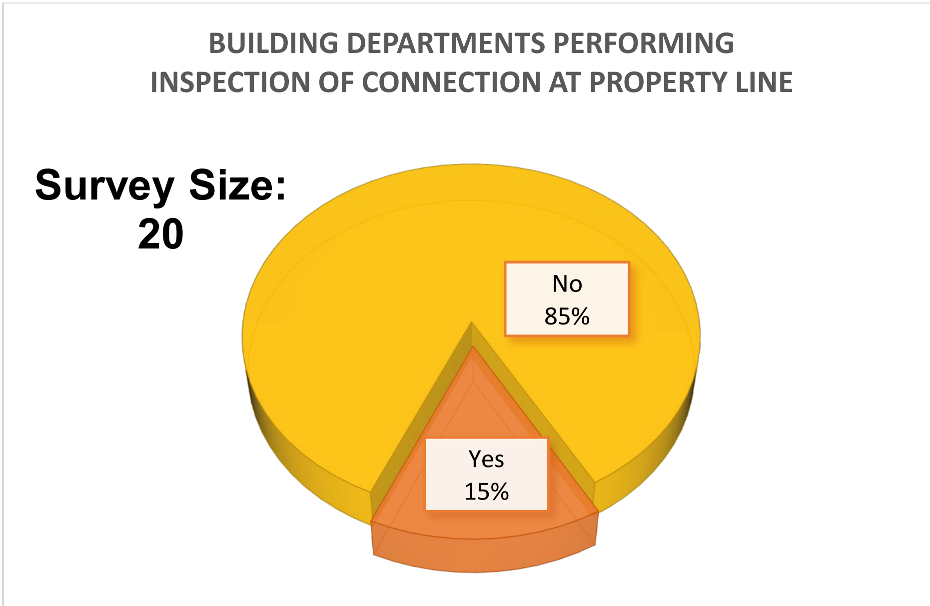


4.4.3 Inspection of Connection of Public Side Lateral to *Sanitary Building Sewer* at Property Line

The inspection of the connection of the public and private side sewer at property line is essential because this connection is frequently found to be leaking in existing systems. The municipal sewer system and lateral to property line is installed, buried and tested by the developer's contractor. When the builder arrives on site, the drain contractor (typically used) needs to dig up the end of the sanitary sewer lateral to connect the *Sanitary Building Sewer* to the public side lateral. Differential settlement associated with these two operations is foreseeable.

The percentage of jurisdictions interviewed for this study that are performing an inspection on every connection to the public sanitary sewer system is provided in Figure 15. As shown in Figure 15, most building departments are not checking this connection at property line.

FIGURE 15: PERCENTAGE OF BUILDING DEPARTMENTS INSPECTING EVERY CONNECTION AT PROPERTY LINE (N=20)



The reasons for not performing this inspection were given as follows:

- Lack of awareness of the importance of the connection (e.g. building departments not aware of I/I),
- Building Inspectors are not permitted to scale the house frame (which is reported to be already constructed by the time the plumbing inspection is performed in some municipalities) for health & safety reasons,
- This inspection is not considered a priority,
- In a subdivision with numerous builders, call outs to perform this inspection are constant, and the builders are not prepared to wait as it affects their ability to complete their work quickly, and
- Jurisdictional issues between municipal inspections and building inspections (i.e., neither group believed that they were responsible for this connection).

4.4.4 Backfill of Sanitary Building Sewer

The OBC has specific requirements for backfill of the *Sanitary Building Sewer*. However, these requirements are covered in several different sections of the Code (including Appendix A), as well as external documents, which likely makes it difficult for inspectors to interpret.

As described in Section 4.2.1, Article 7.3.5.1.(1) and Sentence A-7.3.5.1.(1) together call for 100 to 150mm of bedding for the Sanitary Building Sewer, and call for the backfill to be tamped (compacted) then compacting the backfill to 150mm above the lateral. The Code refers (circuitously) to OPSS 401 which clearly specifies bedding and backfill requirements.

4.5 Additional Interview Comments on Private Side

In addition to the information collected during the interviews and in discussions with others in the industry, a great deal of related information and commentary was collected. This information is summarized in Table 5 and described in this Section.

TABLE 4: SUMMARY OF ADDITIONAL COMMENTS/ISSUES ON PRIVATE SIDE COLLECTED DURING INTERVIEWS

Private Side Issue No.	Issue Identified
1	CBOs and Building staff acknowledge that they know little about I/I and Engineering Standards.
2	Bedding and backfill requirements for plastic pipe (most frequently used) are not generally understood by building officials.
3	Pipe quality on the private side is poor (thin-walled) and building officials expressed frustration with this.
4	Burying of the SBS often involved dumping "backfill" onto sewer from a height, resulting in damage to the plastic sewer.
5	Building inspections used to be carried out by specialized staff (e.g. plumbing, structural) but this is rare now.
6	Drain contractors used to be licensed in Ontario but this is no longer a requirement.
7	Tees at property line, when installed, are not being capped properly.
8	Contractors working in areas where new homes have flooded reported crushed and cracked SBS, as well as joints that have separated.
9	There are numerous types of adhesive (transition solvent cement) required for connections of disparate pipe types.
10	CBOs participating in the interviews reported that they needed to do a better job of inspections of outside services.
11	Tradesmen constructing new homes are discarding items into the sewer, which is illegal.
12	Tests that were always performed twenty years ago are no longer being done.

1. It was reported by almost all surveyed parties that they had no knowledge of I/I and the importance of preventing its entry into Sanitary Building Sewers. They were not aware that leaking *Sanitary Building Sewers* were a problem.

   Failure to construct *SBSs* to a watertight condition contributes to I/I in the system, which has been shown to contribute to the risk of sewage backup into basements. Therefore, it can be argued that failure to construction sanitary building sewers in a watertight condition is in contradiction of the *objectives* of the OBC.

On one field visit, a building inspector gave the contractor permission to bury the SBS, when there was a joint that had visibly come apart on one side.

2. Field observations indicated that bedding and backfill operations frequently do not meet OBC requirements to support the plastic pipe being used for the *Sanitary Building Sewer.*

   Building officials and stakeholders contacted during this survey were largely unaware of the bedding and backfill requirements for *Sanitary Building Sewers*. Figure 16 shows a picture of a typical installation observed in the field. There is no bedding provided.

FIGURE 16: INSTALLATION OF A SANITARY BUILDING SEWER

   Proper bedding was not observed on any site visit conducted during this interview.

3. The pipe typically used on the private side is thin-walled and frangible (although permissible in the OBC), in contrast to the thicker-walled, gasketed pipe used on the public side. Many broken pipes were observed on building sites. Many interviewees identified this as an issue.

4. Numerous building staff and stakeholders described that SBSs are frequently backfilled from a height, which can and does result in damage to the sewer. One building official advised that contractors backfilled with all kinds of inappropriate material found on site: bricks, rocks, pieces of wood, etc.

5. Building inspectors do not have specialized training in many municipalities. This requires that they be very familiar with many complex disciplines. It was suggested by several municipalities that the *Sanitary Building Sewer* inspection be carried out by a licensed plumber who is also a Building Inspector, since he would be expected to have much more detailed knowledge of these systems.

6. One of the sub-trades that developers use is drain contractors, who undertake the work of installing the Sanitary Building Sewer. This trade was formerly licensed in Ontario, which would have helped to ensure quality control, but is no longer licensed. A licensing model is currently operated by the Ontario Plumbing Inspectors Association (Certified Plumbing Systems Inspector - CPSI) but it is no longer Regulation. It appears that a few municipalities in Ontario are requiring the CPSI designation, but most are not.

7. It was reported by various parties that if a test tee is installed and left in place, building staff were not generally aware that this tee (if permanent) needed to be carefully sealed with a watertight, threaded cap or equivalent. Some municipalities report that they are aware of contractors simply placing a piece of wood against the inspection opening at the top/wye of the tee (which will certainly leak eventually if not immediately).

8. A contractor who provides protective plumbing equipment to homes that have flooded (including very new homes) noted that the private side lateral was frequently crushed, broken, and the joints were separated due to inadequate gluing methods, which led directly to flooding.

9. The OBC specifies standards for Transition Solvent Cement (adhesive) to connect disparate pipe types. The type of solvent cement used needs to be suitable for the two pipe types being connected (e.g. ABS to PVC). These solvent cements are colour coded by type. It was suggested in the interviews that the correct type of adhesive might not always be applied (e.g., if a contractor runs out of one type, he will substitute another).

10. Building officials, and particularly CBOs, expressed that they felt they were not undertaking sufficient inspection of the Sanitary Building Sewer installation.

11. A number of municipalities reported that tradesmen constructing homes were discharging unacceptable waste (mortar, drywall mud, paint, etc.) into the building drain. A few municipalities plug the connection of the subdivision sewer

to the existing system until occupancy permits are issued. Others expressed concern that this practice may have long term impacts on laterals (e.g. partially plugging them) and expose the municipality to risk.

12. Several Plumbing Inspectors (including Building Inspectors with Plumbing Certification and licensed plumbers) advised that these tests were performed regularly in the past (e.g., twenty years ago), but they have fallen out of favour due to pressure to keep development moving.

5 Discussion of Findings

This section contains additional comments by the author based on results of the interviews and extensive experience working with I/I. The opinions expressed here are the author's own.

5.1 Detailed Interviews of Ontario Municipalities: Additional Commentary on Public Side Findings

Poorly constructed sewers and appurtenances may significantly impact their useful life. Any time water can enter a sewer system it will gradually allow fines to migrate from the bedding, backfill or soils, which promotes movement, offset joints and potential structural collapse. This phenomenon cannot be "calculated" as conditions vary widely, but should be considered as an important reason why unacceptable I/I should not be permitted in new sewers.

The importance of well constructed and well functioning storm sewers on I/I in sanitary sewer systems is beginning to be recognized. Storm sewers and laterals are frequently shallower than sanitary sewers, and with the pipes often installed in the same, or a stepped trench, there is ample opportunity for the stormwater to infiltrate into the sanitary sewer system. Storm sewer systems are continuing to evolve and there is currently movement towards wide-scale application of Low Impact Development (LID) stormwater management measures. Measures such as infiltration galleries, exfiltration storm sewers and bioswales are often grouped as LID measures. Many of these measures depend on infiltration of stormwater into the ground and could increase I/I in sanitary sewer laterals and mainline pipes, if sanitary sewer systems are not watertight.

There have recently been some significant advances in CCTV deficiency coding, but no municipality reported using these to inform decisions about acceptance of new infrastructure. For example, Electroscan technology is currently being introduced in Ontario (OPSS Specification under review). Electroscan involves inspecting new, existing, and rehabilitated storm and sanitary sewers by low-voltage electric current flow. The variation of electric current flow is measured to detect and locate potential pipe leaks in pipes fabricated from electrically nonconductive materials such as brick, clay, asbestos cement, concrete, and plastic pipes. A defect in the pipe wall that leaks water will also leak electrical current, whether water infiltration or exfiltration is occurring at the time of the interviews. This may provide better information about I/I than CCTV (whose effectiveness is weather and season-dependant) and should be investigated by our industry. Other products are also entering the market.

Connection of PVC sewer to concrete MH by use of Fernco (or equivalent) connection should be evaluated by our industry. There are no data to confirm that the boots and the gear clamps being used (they are buried with the pipe) will last the proposed 75-year life of a PVC sewer.

The mandrel test has some limitations. This procedure, while conceptually simple, leaves much to be desired operationally and technically. A properly designed mandrel is guaranteed to stop at every defect that exceeds design tolerance. However, it can only locate one defect at time (since it stops at the defect). This is a major operational problem if the pipe under inspection has multiple defects. In the worst case, this pipe will have to be inspected once for each located defect to guarantee installation. Furthermore, while mandrels locate deficiencies well, they do not provide any measure of the magnitude of the defect – a 5% deflection stops the mandrel in just the same way as a 50% deflection. Profiles derived from laser devices, on the other hand, have all the strengths of mandrel inspection and none of the limitations. The adoption of laser technologies in the wastewater market has been rapid for use in existing pipes, and provides many benefits to owner/operators. However, adoption has been slower in new construction.[20]

Consulting engineering companies are typically hired by the developer to design and provide inspection services for the new public side infrastructure. They have a contractual relationship with the developer, but not the municipality. These companies would typically be expected to be under pressure from the developer to keep costs down. The interest of these companies is naturally in keeping their client (i.e. the developer) satisfied - rather than the municipality - and developers consulted during the interviews were not aware of I/I and its long-term effects.

Consultation with developers and builders indicated that the developer has significant control over the builders to whom it sells lots. Their contracts are long and complex. The developer could hold funds if the builders are not constructing private side infrastructure to minimize I/I. Even with multiple builders, this would be possible, though more difficult for the developer to enforce.

A Professional Engineer must certify that the works have been constructed in accordance with specifications (either by sealing As-Recorded drawings, or by submitting a letter which implies an engineer’s seal), in order to have the underground infrastructure accepted by the municipality and a portion of the LCs released. The industry may need to consider the ramifications of a Professional Engineer certifying work that was later found not to be performing to specifications (e.g. exhibiting unacceptable I/I).

If a sewer system is not carefully installed in the first instance, testing will simply reveal deficiencies that will need to be rehabilitated. Rehabilitated infrastructure has a significantly shorter life than correctly installed infrastructure. It is not the responsibility of the municipality to ensure that good construction practices are followed. This responsibility must rest with the contractor, through the developer.

Staff at different levels within the same organization were reporting different tests, procedures and requirements, both on the public and private sides. And, as reported by others, this study found that “…challenges are posed by a web of contributing factors comprising: complexity of legislation; jurisdictional conflicts; development pressures; municipal infrastructure; engineering design standards; procurement policies and practices; construction industry and workforce; climate change and extreme weather events."[21]

In addition, while leak testing is called for in OPSS, there are no sample tables on how to calculate the allowable leakage for some sample pipes and manholes. This requires the inspector to understand how to calculate this himself, which may not be within his skill set. By contrast, the OBC always uses tables to give actual numbers for various tests, to make things easier for the inspectors.

Municipalities are also starting to face legal consequences associated with not following their own bylaws and specifications. Since many of the issues reported in these interviews are already specified or mandated, many (municipalities) may be at risk of legal action if failure to perform appropriate inspection and testing results in flooding or other negative consequence for residents.[22]

These issues must be resolved from the top down, with substantial support from senior management and politicians, as well as from the bottom up, through staff. Further action on this issue must be made at the municipal level.

5.2 Detailed Interviews of Ontario Municipalities: Additional Commentary on Private Side Findings

If the OBC sets minimum provisions (OBC Compendium), we should be meeting those at all times, and exceeding them where appropriate.

The OBC has many references to external standards and documents, such as MMAH, OPSS, MOE/MOECC, and CAN/CSA documents. Building inspectors have very complex jobs and may not be familiar or have access to these standards. For example, the OBC refers to MOE 2008 Design Guidelines for Sewage Works, which in turn references OPSS 514 (now OPSS 510), Construction Specification for Trenching, Backfilling, and Compacting. OPSS is very prescriptive about backfill and bedding, bedding to be compacted in 200mm lifts maximum, and backfill to be compacted in 300mm lifts maximum and compacted to 95% of the maximum dry density. These are additional external documents that may make it challenging for building inspectors to perform their work. The finding that bedding and backfill requirements for the *Sanitary Building Sewer* were not well understood/not being implemented is significant.

Sanitary Building Sewer accepted pipe type and quality are specified in OBS Division 7. Reference is made to various CAN/CSA as well as ASTM Standards. A brief search for the current standards was time consuming and carried a significant cost to purchase a single Standard. The most recent Plumbing Products and Materials, CAN/CSA-B1800-15 - Thermoplastic non-pressure piping compendium, is dated 2015. Keeping up to date with these standards must be challenging for building inspectors.

All of the same issues with plastic pipe deflection and the need for structural support from the soils described for the public side sewers, apply to the Sanitary Building Sewer when it is plastic (as it almost always is in Ontario). This is not discussed or referenced in the OBS, so it is unlikely that building inspectors would be aware of this.

Since the pipe sections on the private side are typically glued together, any settlement can easily result in snapping these joints (glued joints do not flex the way gasketed joints do). This represents the risk of long term I/I. Since inspection of laterals in older systems frequently demonstrate leaking/root intrusion at joints, the inspection of bedding and backfill compaction is essential. As reported by a plastic pipe manufacturer, "glued joints will perform much worse than gasketed joints if the bedding and backfill are not done properly and will result in a much higher chance of the pipe cracking. In addition, thermal expansion from hot wastewater will also add internal stresses to the pipe which gasketed joints can accommodate better than glued joints."[23]

This is also important near the foundation wall, as failure to compact can result in water collecting and possible damage to building foundations. Ideally, the contractor would place the fill such that small amounts of granular bedding fall around the pipe until they are close to the invert. Labourers would shovel material under the pipe to "haunch" it/provide vertical and lateral support. The backfill would then be compacted with a jumping jack packer and would be repeated to the springline and then to 150mm above the pipe.

It was recognized by interview participants that cleanout caps on the sanitary sewer were being removed by contractors during construction. While problematic, this is a short-term issue (presumably once the roof is on, drainage is no longer required).

This becomes a long-term problem when the removal of cleanout caps is undertaken by residents once they assume occupancy, to avoid having to use or rely on a sump pump. If this were to take place during the maintenance period of the sanitary sewer system, it may be possible for the municipality to work through the developer to rectify it. If it takes place afterwards, public education and potential use of sewer use by-law enforcement may be required to resolve it. We have very little data to suggest the extent of this problem.

No municipality was identified as having proactive by law enforcement; it is almost always reactive. This way of doing business may need to change in order to address long term I/I (including looking for connected roof leaders, illegal connections to sanitary sewer, discharge of sump water to the sanitary sewer in order to avoid the use of a sump pump, etc.).

As summarized in the previous section, under the OBC, it is permissible to discharge foundation drain discharge to the sanitary sewer system. The interviews did not identify any municipalities who were allowing this during the engineering design and approvals phase. All Sewer Use By-Laws in Ontario contain a version of the clause:

> "The discharge to a Sanitary Sewer or Combined Sewer of water originating, directly or indirectly, from a source other than the Region water supply, including inflow and infiltration, is prohibited…"[24]

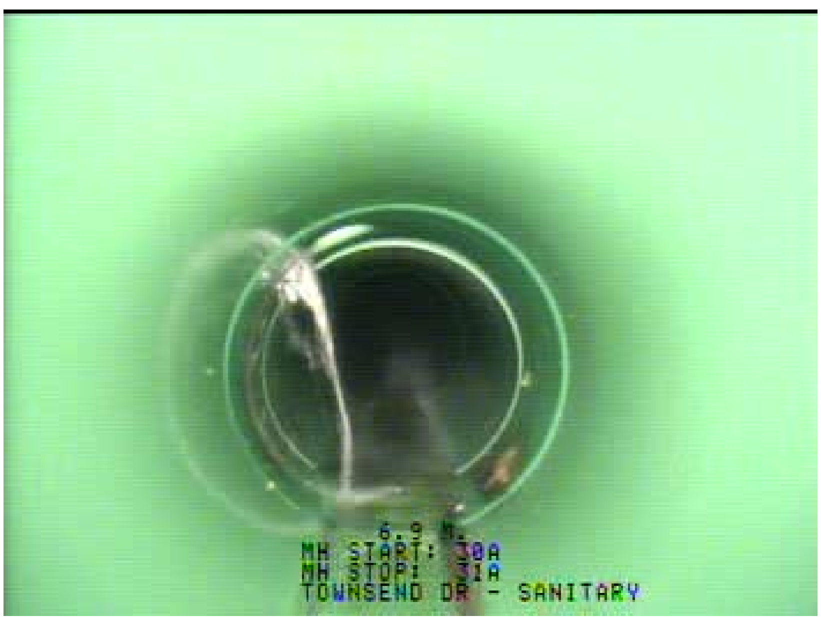
Effectively, the discharge of clean water from any source other than the water supply, into the sanitary sewer is prohibited. However, these discharges are still permitted by the OBC. A building inspector may not be aware of these by laws and engineering standards when approving installations in the field. It is essential that the OBC (and NBC) are updated to reflect this.

ICLR submitted a National Building Code (NBC) Change Request to have this clause in the NBC removed, in 2013[25], but it has yet to be approved. We should revisit this.

A common source of I/I in existing and new sewer systems is poor connection of lateral sewer at property line (different sized pipes, glue that did not set, offset joints).

The connection of the lateral sewer at property line without leakage is essential to resolving the issue of I/I in new subdivisions. This connection occurs after the mainline sanitary sewer and lateral sewer to property line have been accepted by the municipality. The inspection of the connection itself appears to fall under the aegis of the OBC (and is somewhat circuitous) and is thus undertaken by building department staff. Frequently, a few homes at a time are connected, so active inspection of each of these connections in a timely fashion would require substantial staff resources for this inspection alone to which most municipalities do not have access. Figure 17 shows a brand new sewer installation leaking at the property line.

FIGURE 17: CCTV STILL PHOTO OF LATERAL LEAKING AT PROPERTY LINE IN NEW SUBDIVISION



5.3 Additional Observations

There are legal issues around sewer infrastructure that need to be considered by municipalities. Since many of the issues reported in these interviews are already specified or mandated, they may be at risk of legal action if failure to perform appropriate inspection and testing results in flooding or other negative consequence for residents. A recent report published by ICLR[26] included the following observations which are directly related to I/I in new subdivisions:

"With respect to the application of mandatory measures, the study revealed:

- Two specific concerns about legal liability associated with application of mandatory measures for basement flood protection:
    - Fear of liability for not taking sufficient action to reduce flood risk; and
    - Fear of liability for taking action to reduce flood risk, whether related to the potential for private property damage or the lack of capacity to implement and enforce mandatory measures,

- Lack of opportunity, time, staff, financial resources and political willingness are key factors limiting capacity to monitor and enforce mandatory requirements,

- Despite the existence of clear by-law wording as it relates to access to private property, by-law wordings may not be clear about what types of actions may be performed once access is gained, whether homeowner consent is required for private property action, and whether there exists a difference in authority related to access to lots (outside of buildings) and access to the interior of private residential buildings; and

- Municipalities are reluctant to apply enforcement mechanisms that are unpopular among homeowners.

This research further shows that measures are most effective at encouraging specific lot-level measures for existing developments when they:

- Are coupled with political support,

- Are backed by provincial or regional mandates and funding,

- Fit into existing administrative systems, such as the building permit system,

- Are based on a clear understanding of jurisdiction, particularly with respect to access rights and municipal authority to assist with the required work when necessary, and

- Are supported by strong enforcement provisions."

These findings will be considered in the next phase of this work as we continue to develop strategies to resolve the issue of unacceptable I/I in new subdivisions.

These issues are beyond the scope of the current project but should be explored by municipalities.

6 Recommendations to Date

The existence of widespread, unacceptable I/I from new subdivision sanitary sewer systems in Ontario, both on the public and private side, has been established. Sources and root causes of I/I vary, so addressing it will require a variety of stakeholders/groups and regulators to participate in implementing solutions.

Recommendations in this section are made by Norton Engineering Inc. exclusively, and do not necessarily reflect the opinions of the Steering Committee members or organizations.

This section summarizes recommendations suggested (directly or indirectly) by the results of the interviews and the author's experience.

6.1 Proposed Recommendations for Next Steps for Norton Engineering & Steering Committee

- Continue with presentations/workshops to various organizations to increase awareness of this issue,
- Support interested Ontario municipalities in presenting the problem of I/I in New Subdivisions to Municipal Councils if requested,
- Present findings at Ontario Building Officials Association (OBOA) Annual Meeting & Training Sessions and local OBOA groups,
- Undertake consultation with OBOA officials to determine what changes to the OBC, if any, can reasonably be implemented to improve/enhance private side construction practices with a view to putting in Building Code Change Requests in the next cycle,
- Encourage municipalities to begin communicating with developers and developer groups about this issue (Peel Region has already started this process) and bring them to the table to find solutions, and
- Expand municipal interviews to other provinces, develop national recognition of the issue of I/I in new subdivisions.

6.2 Recommendations for Municipal Planning, Development and Engineering Groups

The overwhelming conclusion from the interviews conducted to date for this project is that municipalities are not generally requiring the inspection and testing procedures already required in their specifications (often OPSS). For municipalities who do not already have data on this subject, they should introduce, at least as a pilot project, flow monitoring of a few new subdivisions from the establishment of trunk systems, to final acceptance, to see if this problem exists for them.

Municipalities are encouraged to remember that the legacy "0.28 L/s/ha" allowance for peak extraneous flow on Sanitary Sewer Design sheets is used to *size pipes* for their lifetime and as such, should be never be used as an acceptable I/I number at acceptance. Practically speaking, given that the minimum size sewer in new subdivisions is currently 200mm diameter, there is generally ample capacity to domestic peak flows, but this does not account for the downstream infrastructure, which should not be expected to convey clean water potentially at the expense of new development, climate change safety factors, overflows and flooding. It is also largely unknown how systems with relatively high I/I at the time of construction will perform over time when exposed to extreme short-duration rainfall events (i.e., those that exceed 1:100-year return period levels, and which are expected to increase in frequency and severity because of changing climate conditions).

Meetings/workshops/training sessions with developers, consulting engineers and contractors should be continued, to present the problem and work together to find solutions.

Ultimately, the municipality has the power to ensure that new subdivisions are built free of unacceptable I/I: Letters of Credit can be held until leak-free infrastructure is delivered. Almost all existing Development Agreements refer to Acceptance of Underground Infrastructure when it is constructed to the satisfaction of the City Engineer. That can certainly be interpreted as once flow monitoring has demonstrated leak free infrastructure.

Some specific tasks that municipalities can undertake are included below. These are suggested as a result of interview findings, along with the experience of the author. They are summarized into increasingly rigorous categories:

Stage 1 Recommendations: (Getting Started Addressing I/I in New Subdivisions)
Stage 2 Recommendations: (Next Steps in Addressing I/I in New Subdivisions)
Stage 3 Recommendations: (Advanced solutions to I/I in New Subdivisions)

It is expected that additional recommendations will develop as the project proceeds.

6.2.1 Stage 1 Recommendations (Getting Started Addressing I/I in New Subdivisions):

- Install a flow monitor downstream of a new subdivision, at least as a pilot project, in your municipality. It is recommended that this monitor be established as soon as the trunk system is constructed (e.g. before the homes are built), since this will provide information on the public system before homes are connected. The monitor will likely need to be left in for 3 years minimum (during public side construction, house construction, and for a full year afterwards: flow monitoring should be left in place if results are not acceptable). This can be funded through DCs or the Subdivision Agreement. Most Subdivision Agreements reference the municipality accepting the infrastructure when it is constructed “to the satisfaction of the City Engineer”. Flow monitoring is another tool we can use to satisfy the City Engineer (or equivalent),

- Undertake a review of all Standards, Specifications, drawing references, subdivision agreements, checklists, capital program references, etc., to locate all references to inspection, testing and performance standards (e.g. OPSS, OPSD, local specifications, standard drawings, development manuals, etc.). Ensure compatibility between documents. The consulting community may be willing to assist with this since it is in their best interests to have consistent, well written standards,
- Review and update municipal documents (e.g. Official Plan, Development Manual, etc.), with a view to reduction of I/I in new subdivisions,
- Prepare process mapping for processes related to new subdivisions from inception to final acceptance. This exercise may identify redundancies and inconsistencies in processes that can be improved. Include staff at all levels (including inspectors). Evaluate whether some processes being undertaken are still required if those processes were established some time ago. Determine whether actual level of inspection and testing meets OPSS; if not, identify the causes of this,
- Update processes related to new subdivisions based on desired level of service. Be sure to include costs of not inspecting (e.g. 75 years of treating unacceptable I/I, as well as all other costs as available) when evaluating costs of inspection,
- Ensure inspection staff are fully trained in all aspects of construction that can lead to I/I,
- Ensure that existing, mandated testing procedures are being performed on all new sewer systems (mandrel testing, air/water testing, feeler gauge testing of joints, ex/infiltration testing of MHs). Confirm that these are being performed correctly, and what steps are being taken if they fail. These steps should be documented to assist municipal field inspection staff in enforcing requirements,
- Establish internal I/I working groups between development engineering, building departments and operations, to exchange knowledge and liaise regularly on issues related to I/I, and
- Participate and encourage involvement in research dedicated to developing low cost technology solutions to address I/I in new subdivisions.

6.2.2 Stage 2 Recommendations (Next Steps in Addressing I/I in New Subdivisions):

- Introduce QA/QC standard documents with signoffs for all inspection and testing on the public side to ensure these are being performed correctly and in a timely fashion,
- Evaluate how much time is available for Municipal staff to oversee consultant inspectors’ work. Evaluate whether this effort is adequate to ensure an appropriate

level of oversight. Make staffing adjustments as required to meet desired level of service,

- Consider a spot-check program with increasing oversight if systems are found to be failing, charging for each additional inspection. Determine most effective combination of testing by consulting engineering inspector and observation of tests by municipal staff,
- Encourage all staff, while on site, to manually check MHs for flow (non-entry). Check for watertight bulkhead. If there are no homes, the flow should be essentially zero,
- Prepare cost/benefit analyses on the utility of additional inspection versus other means of insisting on excellent construction procedures,
- Plug the downstream connection to the sewer system until the system is accepted. This will prevent (or highlight) discharges to the sewer system before Building Permits are issued (note that this has been identified as a risk as trades working on the homes are known to discharge paint, grout, and other deleterious materials),
- Determine the efficacy of CCTV inspection in preventing I/I. Evaluate the cost of additional CCTV inspections as compared to flow monitoring. Consider other technologies for the future,
- Introduce, at least as a pilot project, push camera inspection of lateral from the house. Consider escalating inspection rates with failures, and
- Monitor new pumping station flows immediately. Charge the developer for wastewater flows, if any, until assumption of subdivision.

6.2.3 Stage 3 Recommendations (Advanced Solutions to I/I in New Subdivisions):

- Introduce fees for development inspector oversight, to offset municipality costs when construction methods are poor. Charge the developer for each additional inspection,
- Insist that the developer pays for full time inspection of the construction of this sewer system, perhaps specifying a rate which will allow for an experienced inspector (very low-priced inspection, e.g. by students, may not be in the best interests of the municipality),
- Track performance of consultant inspection staff. If any inspection (e.g. CCTV, air/water, MH) indicates deficiencies, request and inspect consultant staff inspection records to ensure full time (if mandated), well performed inspection. Track occurrences of non-attendance on site of full-time consultant inspection staff. Subject poorly performing consultants to increased spot checking with the associated fees,
- Introduce, as good engineering practice, the plotting and review of bulk water and wastewater data, including pumped, billed, pumping station flows, etc., for newer subdivisions (where data is available), and compare them,
- Meet with developer groups to start the conversation around I/I on the public side,

- Update Subdivision Agreements to reflect a focus on mitigation of unacceptable I/I, up to and including establishment of flow monitoring at the downstream end as soon as the trunk system is established.
- Update internal standards to require a straight through MH with similarly sloped pipes at the downstream end of all new subdivisions to facilitate flow monitoring.
- Add a line item for flow monitoring in the next DC By-law update.

6.3 Recommendations for Municipal Building Department CBOs and Building Staff

- Introduce training in the concept of I/I to all staff at all levels through workshops, training, lunch and learns, etc.
- Liaise regularly with engineering staff,
- Prepare process mapping for processes related to new subdivisions from inception to final acceptance where the building department intersects with the project. Include staff at all levels, including inspectors. Determine whether actual level of inspection and testing being performed meets OBC. Identify areas where it does not, and determine if this can be improved,
- Prepare cost estimates for staff time to perform inspections according to OBC, and compare the cost benefit of this task versus flow monitoring at the downstream end of new subdivisions (which can be performed by engineering group),
- Introduce QA/QC standard documents with signoffs for all inspection and testing on the private side to ensure these are being performed correctly and in a timely fashion,
- Meet with developer groups to start the conversation around I/I on and the private side, and
- Meet with builders and contractors to start the conversation around I/I on the private side.

6.4 Recommendations to be taken to Municipal Senior Staff & Councils:

- Prepare regular reports on I/I in your community, and include all the costs of this I/I (include staff time, lost DC revenue, lost tax revenue, flooding costs), for review by Council, to garner political support for the required changes,
- Prepare a business case to minimize I/I in new subdivisions by comparing the lifetime costs of this I/I with the short terms costs of solutions to mitigate it (increased inspection, flow monitoring at downstream end of subdivision),
- Prepare a business case for By-law Enforcement staff to take a proactive approach in new subdivisions, and have them inspect regularly for illegal discharges to sewer system,
- Include budget for flow monitoring of new subdivisions in your DC By-law,
- Introduce issue of poor construction practices to your development community, and

- Consider implementation of inspection of lateral at real estate transfer.

6.5 Recommendations for Provincial Ministries (MOECC/MMAH)

The issue of I/I in New Subdivisions appears to be ubiquitous across Ontario, which suggests that solutions may ultimately need to be developed at the Provincial level.

It is recommended that MOECC consider how they could implement a province-wide solution to unacceptable I/I in new subdivisions, through their Regulatory oversight of the construction of new sanitary sewer systems. Changes to the Environmental Compliance Approval (ECA) process, to require flow monitoring in new subdivisions, could be considered.

It is recommended that MMAH consider how changes to the Ontario Building Code might assist in reducing unacceptable I/I in new subdivisions. This will be developed further in the next phase.

7 Next Steps

This work will be ongoing, under the direction of the Steering Committee, until this issue is resolved. Next year's focus will be on the private side. Potential tasks for 2017/2018 include:

- Continue with interviews/working sessions across Ontario, particularly larger municipalities, to obtain more data and to continue to educate engineering and building departments on the importance of reducing I/I at inception,
- Invite municipalities from other provinces in Canada to participate in the steering committee,
- Develop a more formal survey, from which statistics can be generated, to be delivered across Canada,
- Continue with presentations and workshops across Ontario and nationwide to continue to educate engineering, development and building departments about this issue,
- Support interested Ontario municipalities in presenting the problem of I/I in New Subdivisions to Municipal Councils. Develop municipality-specific cost/benefit analyses for these presentations using readily available data or published annual pumped water (with average Ontario water loss or municipality specific water loss factored in) and treated wastewater treatment data from annual reports,
- Present findings at Ontario Building Officials Association (OBOA) Annual Meeting & Training and local OBOA groups,
- Undertake consultation with OBOA officials to determine what changes to the OBC can reasonably be implemented to improve/enhance private side construction practices with a view to requesting Building Code change requests in the next cycle,
- Develop a Working Group of building officials to continue to understand the OBC as it relates too I/I, and test practical ideas and solutions for the private side, and
- Develop template for liaison between Building and Engineering groups to support new construction.

All of Which is Respectfully Submitted,

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8 References

[1] Durham Region Building Guideline Project, Sandink et al, Draft, (2017)
[2] Association of Municipalities of Ontario (AMO), (2010). Demonstrating Climate Change: AMO Climate Change Position Paper.
[3] Association of Municipalities of Ontario (AMO), (2010). Demonstrating Climate Change: AMO Climate Change Position Paper.
[4] Robinson, B., Stantec Consulting, Miller, R., Town of Woolwich (2010). Inflow and Infiltration is Not Supposed to Occur in New Subdivisions, Water Environment Association of Ontario (WEAO) Proceedings.
[5] Robinson, B., Stantec Consulting, Miller, R., Township of Woolwich (2012). Inflow and Infiltration is Not Supposed to Occur in New Subdivisions, Water Environment Federation (WEF) Proceedings.
[6] Robinson, B., Stantec Consulting, Miller, R., Township of Woolwich (2012). Inflow and Infiltration is Not Supposed to Occur in New Subdivisions, Water Environment Federation (WEF) Proceedings.
[7] Robinson, B., D'Amico, R., Motala, I., Sandink D., Hill, C. (2015). We need to address I/I in New Subdivisions Immediately! Presented at Water Environment Association of Ontario Technical Symposium. Niagara Falls (2015).
[8] Environment, Ministry of (1985). Guidelines for the Design of Sewage Works.
[9] Kesik, T. (2015). Best Practices Guide: Management of inflow and infiltration in new urban developments. Toronto: Institute for Catastrophic Loss Reduction.
[10] Kesik, T. (2015). Best Practices Guide: Management of Inflow and Infiltration in New Urban Developments. Toronto: Institute for Catastrophic Loss Reduction.
[11] Sandink, D. (2017). Wording adapted from PROPOSED CHANGE TO THE 2012 BUILDING CODE O.REG. 332/12 AS AMENDED CHANGE NUMBER: CC-B-07-04-01. Ontario Ministry of Municipal Affairs and Housing.
[12] Association of Municipalities of Ontario (AMO), (2010). Demonstrating Climate Change: AMO Climate Change Position Paper.
[13] Gainham, C. (2013). The Perfect Storm: New Development, High I/I and a 1000+ Year Event. Toronto: Presentation to ICLR Basement Flooding Symposium.
[14] Regional Municipality of York. (2016). Inflow and Infiltration Reduction Strategy 2015 Best-in-Class Update. XCG Consulting Limited & Norton Engineering Inc. Unpublished.
[15] Regional Municipality of York. (2016). Inflow and Infiltration Reduction Strategy 2015 Best-in-Class Update. XCG Consulting Limited & Norton Engineering Inc. Unpublished.
[16] Robinson, B., Smith, C., Peel Region (2017). Death by a thousand cuts: why are new subdivisions contributing significant I/I to our sewer systems? Presented at Water Environment Association of Ontario Technical Symposium. Ottawa (2017).
[17] ASTM Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications (2014). This practice provides recommendations for the installation of buried thermoplastic pipe used in sewers and other gravity-flow applications.
[18] From: http://ehancor.com/certification/postconstruction/deflectiontesting.htm
[19] R. Kowal, D.M. Robichaud, Personal Communication (2017).

[20] Source: Sewer Pipe Inspection: Mandrels vs. Laser Profiles, Red Zone Robotics, Posted May 9, 2011).
[21] Kesik, T. (2015). Best Practices Guide: Management of inflow and infiltration in new urban developments. Toronto: Institute for Catastrophic Loss Reduction.
[22] Kyriazis, J., Zizzo, L., and Sandink, D. (2017). Assessing local mandatory measures to reduce flood risk and inflow & infiltration in existing homes. Toronto: Institute for Catastrophic Loss Reduction.
[23] A. Sandovski, IPEX, personal communication
[24] Region of Peel (2010). THE REGIONAL MUNICIPALITY OF PEEL BY-LAW NUMBER 53-2010, A by-law to regulate the discharge of matter into the sanitary and storm sewage systems of the Regional Municipality of Peel.
[25] Sandink, D. (2013). NBC Code Change Request.
[26] Kyriazis, J., Zizzo, L., and Sandink, D. (2017). Assessing local mandatory measures to reduce flood risk and inflow & infiltration in existing homes. Toronto: Institute for Catastrophic Loss Reduction.