# Building Code Regulations and Engineering Standards as they relate to I/I in Sanitary Sewer Systems

**April 2018**

**Norton Engineering Inc.**
**243 Glasgow Street**
**Kitchener ON N2M 2M3**

NORTON ENGINEERING

# Table of Contents

# Table of Figures



# Table of Tables



# Appendix

# Acknowledgements

The authors would like to acknowledge the significant support provided by the funding partners of the Project to Reduce Unacceptable I/I in New Subdivisions. Funding partners since inception include:

Region of Peel
Region of York
Institute for Catastrophic Loss Reduction (ICLR)
City of Windsor
City of London
Region of Halton
Region of Waterloo
Town of Orangeville
City of Cambridge

In addition, the authors would like to acknowledge the significant time and effort provided by the following:

- Norm Litchfield, Meritech Consulting Inc.
- Randy Kowal, D.M. Robichaud
- Bill Plewes, Town of Collingwood
- Chris Smith, Region of Peel
- Anthony Parente, Region of Peel
- James McAloon, Capital Region District (Victoria)
- Ehsan Roshani, NRC
- Allen Lucas, City of Kingston
- Alex Sandowski, IPEX
- Chris Manzon, City of Windsor
- Rob Vani, City of Windsor
- Cariad Garratt, Pinna Sustainability Inc.

# 1 Introduction

The issue of Inflow and Infiltration (I/I) and the resulting negative impacts in sanitary sewer systems have become chronic across North America. The engineering community across North America has recently concluded that 50% of I/I is originating on the private side (industry experts now estimate that I/I from private property sources accounts for 50 to 60% of total I/I).[1,2] The private side is regulated under Building Codes in Canada.

Sanitary sewers are designed to account for long term I/I, which is expected to gradually increase over time as a system ages. In recent years, however, sources of I/I originating in new construction have been identified. In a 2015 to 2017 study of Unacceptable I/I in New Subdivisions in Ontario,[3] data on recent flow monitoring from the downstream end of new subdivisions were collected from municipalities. In 34 out of 35 subdivisions, unacceptable levels of I/I were observed. This early work revealed that the specific sources of unacceptable I/I were typically not yet identified by the municipality (whether the source was construction on the public or the private side was unknown). The causes and conditions of this I/I, which are wide-ranging, were discussed in detail in that report. The I/I appears to be a result of issues on both the private side and the public side.

Inflow and infiltration (whatever the source, whether public or private side) can be a costly affair. On both the public and private sides, it is a potential factor in basement flooding (with associated health risks) and can cause significant reduction in the hydraulic capacity of sanitary and storm sewers. Such diminished hydraulic capacity may become even more consequential, given the more intense and more frequent peak flows associated with climate change. These impacts are extensively documented elsewhere.

This report provides insight into a group of issues identified in the 2015 to 2017 Study: construction detail in relevant sections of the Ontario Building Code[4] (OBC) that do not appear to provide sufficient protection from the development of I/I on the private side. Since I/I is studied largely by the engineering community rather than the building community, it is understandable that the OBC is not as rigorous as public side guidelines in preventing I/I into new sewers. The purpose of this report is to outline the specific language in the OBC[5] which relates to I/I potential and compare it to public side documents (which are typically applied by designers of municipal sewage collection systems) on the same topic.

This document covers only discrepancies in the written information contained in the two types of documents. While previous work focusing on I/I in new subdivisions in Ontario indicates that improved application and enforcement of building codes and standards would help reduce I/I, this report does not address this issue (this topic is covered extensively elsewhere[6]).

Section 2 describes the National Building Code of Canada (NBCC), the National Plumbing Code of Canada (NPCC) and the Ontario Building Code (OBC), for context. Section 3 describes the guidelines and standards that are applied to public side construction, including Ontario Ministry of Environment (MOE: now Ministry of

Environment and Climate Change; MOECC) Guidelines for the Design of Sewer Systems (2008), the Ontario Provincial Standards, and municipal bylaws that govern allowable discharges into sewer systems. Section 4 identifies specific items in the OBC and compares them to the public side guidelines and standards. Section 5 examines the broad goals of the OBC, and how these can be interpreted as requiring all possible measures to prevent the entry of I/I into new private side sewers. Section 6 contains an analysis of all of the above, and a summary.

This report is intended to be read by professionals working on the public side (typically engineering staff) and the private side (building staff), since it would benefit the industry to have both groups more knowledgeable about the others' work.

# 2 National and Provincial Building Codes

## 2.1 Introduction

This section introduces the Building Codes to readers who are unfamiliar with them. It covers the following documents:

- The National Building Code of Canada 2015 (NBC)
- The National Plumbing Code of Canada 2015 (NPC)
- The Ontario Building Code 2012 (OBC)

Model Codes are developed at the national level, and may be adopted, as is or with modifications, by provinces and territories. In order to understand the OBC in context, this report also briefly describes both the NBC and the NPC, as both have components which are adopted in the OBC. Provisions from the NBC include broad objectives of the code, and from the NPC, detailed prescriptive descriptions of acceptable installations (known as "Acceptable Solutions" in the code). The codes are described briefly below.

## 2.2 National Model Construction Codes

### 2.2.1 National Building Code of Canada (NBCC)

The National Building Code of Canada 2015, together with the National Plumbing Code of Canada 2015, the National Fire Code of Canada 2015 and the National Energy Code of Canada for Buildings 2015, is an objective-based National Model Code that can be adopted by provincial and territorial governments.

In Canada, provincial and territorial governments have the authority to enact legislation that regulates building design and construction within their jurisdictions. This legislation may include the adoption of the National Building Code (NBCC) without change or with modifications to suit local needs, and the enactment of other laws and regulations regarding building design and construction, including the requirements for professional involvement.

The NBCC is a model code in the sense that it helps promote consistency among provincial and territorial building codes. Persons involved in the design or construction of a building should consult the provincial or territorial government concerned to find out which building code is applicable. Codes Canada are developed by the Canadian Commission on Building and Fire Codes (CCBFC).[7]

In Canada, provincial and territorial governments have the authority to enact legislation that regulates the design and installation of plumbing systems within their jurisdictions.

This legislation may include the adoption of the National Plumbing Code (NPC) without change or with modifications to suit local needs, and the enactment of other laws and regulations regarding plumbing system design and installation, including the requirements for professional involvement.[8]

Ontario, along with British Columbia, Alberta and Quebec, is a jurisdiction that adopts the NBCC and NPCC with considerable revision. With respect to the design, installation and inspection of sanitary building sewers, however, there are relatively few differences between the OBC and the NBC. None of these differences are critical with respect to risk of I/I occurrence in Part 9 residential buildings. For clarity, these are not identified throughout the text (as several other source documents are compared). The differences between the specific items in OBC and the NBCC and NPCC relevant to this work are identified in Appendix A, for reference.

### 2.2.2 National Plumbing Code of Canada (NPCC)

The National Plumbing Code is the source of the acceptable solutions outlined in the OBC. Portions of the NPC which deal with any construction which may contribute to I/I are examined here to determine whether an acceptable solution in the OBC came directly from the NPC or was modified for the OBC.

With respect to the design, installation and inspection of sewers, which are the topic of this report, there are relatively few differences between the OBC and the NPC. A summary of each item related to I/I as presented in the NPC and the OBC is identified in Appendix A.

## 2.3 The Ontario Building Code (OBC)

The construction of all new buildings in Ontario falls under the jurisdiction of the Ontario Building Code. The Building Code is administered at the level of municipal government, through the designation of a Chief Building Official (CBO). The designation of a CBO is specifically identified in the Municipal Act as designated authority of the municipal government.

### 2.3.1 General Provisions of the OBC

The Ontario Building Code is a regulation made under the Building Code Act and sets out technical requirements for the construction, renovation and demolition of buildings. 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, advice on which should be sought from professional sources.” (excerpt from the Preface to the Building Code Compendium).

## 2.3.2 The Building Code Act 1992 (O.Reg. 332/12)

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.

## 2.3.3 Layout of the Ontario Building Code (OBC) 2012

The OBC is comprised of two Volumes: Volume 1 and Volume 2. Volume 1 is divided into three Divisions, as follows:

> **Division A** consists of three parts and deals primarily with compliance (containing the application provisions) and the *objectives* and *functional statements* (for use in determining *alternative solutions*). This Division is essential to understand how and when to apply each part of the code.
>
> **Division B** (excerpts from which are presented in Section 4 of this report), consists of twelve parts (Part 2 is currently "reserved") that outline the *acceptable solutions* of the code (prescriptive type solutions). Division B contains many references to external documents (such as CSA, ASTM, ASME, etc.) and versions that are relied upon in the OBC. It should be noted that the OBC reference to these external documents is static (if another code or standard issues a newer version, the OBC still refers to the dated version in the Code).
>
> **Division C** contains the administrative provisions of the code.

Volume 2 contains Appendices A & B and the Supplemental Standards. Volume 2 does not form part of the OBC but is rather supplemental material to it. Appendix A provides explanatory material to assist users in understanding the code better by explaining the intent, and in some cases, the rationale, for the legislative requirements contained in Volume 1. Appendix A of Volume 2 contains some references to Part 7 requirements, which are of interest to this work. OBC Volume 1, Division 2, Part 7 contains most of the provisions of the Code that relate to sewer pipes and which in turn may result in I/I. A few additional provisions are also contained in Part 5 and Part 9.

## 2.3.4 Defined Terms in the OBC

The concept of "defined term" is very important in building codes. It ensures that all parties are working from the same definition of a particular word, rather than using colloquial or generally accepted use. Defined terms in the OBC are shown in the code in italics, which mean that they have a specific, defined meaning for the purposes of the code. They are listed in Section 1.4 of Division A, Part 1.

Defined terms that are relevant to this paper include:

> *Sanitary building drain* means a building drain that conducts *sewage* to a *building sewer* from the most upstream *soil* or *waste stack, branch* or *fixture drain* serving a water closet.
>
> *Sanitary building sewer* means a pipe that is connected to a Sanitary Building Drain 1 000mm (1m) outside a wall of a building and that conducts sewage to a public sewer or private sewage disposal system.
>
> *Drainage System* means an assembly of pipes, fittings, *fixtures* and appurtenances on a property that is used to convey *sewage* and *clear water waste* to a main sewer or a *private sewage disposal system*, and includes a *private sewer*, but does not include *subsoil drainage piping*.

That is, the 100mm (4”) sanitary sewer inside the house is a s*anitary 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. Requirements for the construction of the Sanitary Building Sewer are contained within the OBC.

Additional critical terms related to I/I that are defined in the OBC include the terms “sanitary sewer” and “storm sewer:”

> *Sanitary sewer* means a sewer that conducts *sanitary sewage.*
>
> *Storm sewer* means a sewer that conveys *storm sewage.*

Critically, the term “sewer” is not a defined term in the OBC. Therefore, items in the OBC that refer to “sewers” may be interpreted in manner that refers to either a storm or a sanitary sewer. As illustrated in this report, failure to define the term “sewer” may lead to situations where storm water infrastructure is not inspected on the private side and may introduce risk of excessive I/I in new construction.

Table 1 summarizes the areas of the code that are referenced in this report. Objectives and Functional Statements in the OBC will be presented following the detailed comparison of public side and private side regulations. This will help to put into perspective the need to follow best practice for construction on the private side. Readers not familiar with the OBC are encouraged to look up the appropriate references for context (the code is available free of charge online).

This report relates primarily to Group C, residential buildings as defined in Division A Part 1, Article 1.1.2.4. (1)(c)(i), specifically Division C, Table 3.5.2.1., as a detached house, semi-detached house, townhouse or row house containing not more than two dwelling units in each house.

Although this report largely concerns itself with sanitary (and sometimes storm) sewer laterals from single family homes, the observations made doubtless apply to all new building types.

### TABLE 1: OBC SPECIFIC ITEMS REFERRED TO IN THIS REPORT

| Code Reference | Description |
|---|---|
| **DIVISION A** | **DEFINITIONS** |
| | *Drainage System* |
| | *Sanitary Building Sewer* |
| | *Sanitary Drainage System* |
| | *Sewage* |
| **DIVISION B** | **ACCEPTABLE SOLUTIONS** |
| **Part 7** | **PLUMBING** |
| Section 7.3. | Drainage Systems |
| Subsection 7.3.4. | Support of Piping |
| Article 7.3.4.6. | Support for Underground Horizontal Piping |
| Subsection 7.3.5. | Protection of Piping |
| Article 7.3.5.1. | Backfill of Pipe Trench |
| Subsection 7.3.6. | Testing of Drainage and Venting Systems |
| Article 7.3.6.1. | Tests and Inspection of Drainage or Venting Systems |
| Article 7.3.6.2. | Tests of Pipes in Drainage Systems |
| Article 7.3.6.4. | Water Tests in Drain, Waste and Vent Systems |
| Article 7.3.6.5. | Air Tests |
| Subsection 7.4.5. | Traps |
| Article 7.4.5.3. | Connection of Subsoil Drainage Pipe to a Sanitary Drainage System |
| **Part 9** | **HOUSING AND SMALL BUILDINGS** |
| Section 9.14. | Drainage |
| Subsection 9.14.5. | Drainage Disposal |
| Article 9.14.5.1. | Drainage Disposal |
| Article 9.14.5.2. | Sump Pits |
| Subsection 9.14.6. | Surface Drainage |
| Article 9.14.6.1. | Surface Drainage |
| Section 9.26. | Roofing |
| Subsection 9.26.18. | Roof Drains and Downspouts |
| Article 9.26.18.2. | Downspouts |

# 3 Public Side Guidelines for Sanitary Sewers (MOE Guidelines and Ontario Provincial Standards)

The design of sanitary sewers is governed by a wide variety of legislation in Ontario. This report focuses on those that are most proximate to the OBC, i.e. those guidelines and standards that relate most closely to the detailed OPS requirements. They include MOE Design Guidelines for Sewage Works, OPS Standards and Specifications, and Sewer Use Bylaws. Each of these is described below.

## 3.1 MOE Design Guidelines for Sewage Works, 2008

The Ministry of the Environment and Climate Change (MOECC; formerly MOE) periodically publishes guidelines that govern the design and construction of infrastructure in Ontario. The most recent version of MOE/MOECC Guidelines for Sewage Works was published in 2008.

MOE Design Guidelines for Sewage Works, Chapter 5, covers the design of sewers over 34 pages. It discusses the design of storm and sanitary sewers, manhole and pipe design and construction issues, and a variety of related topics. MOE Design Guidelines are a peer-reviewed document intended for an audience that includes municipal engineers and engineering consultants involved in the design of municipal infrastructure. It should be noted that the Guidelines explicitly state that the use of actual, site-specific data is encouraged (i.e. one size does not fit all). Design of sewers on the public side always includes site-specific data, such as geotechnical reports (which cover groundwater elevations, soil types and likely infiltration rates) and a land survey, which defines overland flow paths.

MOE Design Guidelines for sewers specifically reference OPSS and OPSD, where the details of many of the design and construction requirements are described. MOE Design Guidelines are cited only once in the OBC, regarding private sewers (7.1.5.5.). This provision does not apply to discharges to the municipal sewer systems that are the focus of this report.

## 3.2 OPS Standards and Specifications

OPS documents are widely respected in Ontario and are heavily relied upon in public engineering design and construction. They represent the guidelines under which sewers are designed and constructed on the public side. Similar organizations likely exist for all provinces and territories in Canada; however, it is beyond the purview of this document to review them all.

The OPS Organization consists of two owners and eight partners. OPS is served by nine specialty and three management committees. Over ninety meetings are held per year. There are approximately 280 Standard Specifications (OPSS) and 760 Standard Drawings (OPSD).

**OPS Owners include:**

Municipal Engineers Association (MEA)
Ontario Ministry of Transportation (MTO)

An OPS partner is an organization that has regular membership on an OPS committee.

**OPS Public and Private Partners include:**

Consulting Engineers of Ontario (CEO)
Electrical Contractors Association, Ontario (ECAO)
International Municipal Signals Association (IMSA)
Ontario Good Roads Association (OGRA)
Ontario Road Builders' Association (ORBA)
Ontario Sewer and Watermain Construction Association (OSWCA)
City of Toronto

OPS supporters number about twenty and include organizations that contribute expertise on an ad hoc basis. OPS has two publication cycles per year (April and November), and over five reviews are undertaken per Standard per revision.

**OPS Mandate**

The mandate of the Ontario Provincial Standards for Roads and Public Works (OPS) organization is to develop and maintain consistent, cost-effective methods to improve the administration of road building in Ontario by providing:

- a comprehensive set of standard specifications and drawings
- source lists for products, services, and technical solutions

**OPS Mission Statement**

The Ontario Provincial Standards for Roads and Public Works (OPS) organization:

- develops and publishes a comprehensive set of standard specifications and drawings; and
- manages the evaluation, classification, and recording of information related to materials and products,

for use in the construction of roads and public works in Ontario.

**OPS Objectives**

- Develop and improve the administration, safety and environmental aspects, and cost effectiveness of the design and construction of roads, structures, sewers, watermains, and electrical services
- Review and update all standards on a five- to fifteen-year cycle to ensure they meet the needs of the users and are current with the technology, material, and methods employed by the engineering and construction industry
- Manage the evaluation, classification, and recording of information as related to products, services, and technical solutions
- Publish updates to the standards
- Promote the use of OPS on a province-wide basis

The OPS was first contemplated in 1977, and the first set of documents was published in 1984. OPSS and OPSD documents are developed based on a very wide range of experience across the engineering, regulatory and construction industries across Ontario. They are regularly peer-reviewed and updated and represent the best available design and construction practices in our industry. Most organizations in Ontario use OPS documents exclusively (e.g. Ministry of Transportation) and refer to them in their construction specifications. OPS has two distinct sets of standards: OPSS.MUNI and OPSS.MTO. This report refers to OPSS.MUNI specifications.

## 3.3 Sewer Use Bylaws in Ontario

For the purposes of this report, bylaws refer to a law of local or limited application passed under the authority of a higher law (e.g. provincial or federal). A local council or municipal government gets its power to pass bylaws through a law of the national or regional government, which specifies what the town or city may regulate through bylaws. It is therefore a form of delegated legislation.

Within its jurisdiction and specific to those areas mandated by the higher body, a municipal bylaw is no different than any other law of the land and can be enforced with penalties or challenged in court. Municipal bylaws are often enforceable through the public justice system.

Common bylaws regulate vehicle parking and stopping, animal control, building and construction, licensing, noise, sewer use, zoning and business, and management of public recreation areas.

Sewer Use Bylaws clearly define what public sewers can and cannot be used for. They define allowable temperature, pH, odour, chemistry, quality, quantity, and origin of the sewage or stormwater.

MOE periodically publishes Model Sewer Use Bylaws (most recently in 1988), which many municipalities adopt, at least in part. However, bylaws are enacted at the municipal level, so they are not the same across Ontario.

# 4 Engineering (Public Side) Guidelines and OBC (Private Side) Regulations with Respect to Specific Construction Practices Related to Risk of I/I

There are a number of areas in which MOE Guidelines & OPSS/OPSD differ from the OBC with respect to aspects of construction which may affect the risk of I/I entering sewers. While there is significant overlap in the various provisions/requirements, this document endeavours to separate them into cohesive categories.

This section documents excerpts from Public Side and Private Side Codes and Standards which relate to the risk of I/I developing.

## 4.1 Pipe Design

***MOE Design Guidelines for Sewage Works 2008***

**Chapter 5. Design of Sewers (5.7.9)**
**Pipe Materials**

Sewers should be designed to prevent damage from superimposed live, dead and frost induced loads. Proper allowance for loads on the sewer should be made for soil type, groundwater conditions, as well as the width and depth of the trench. Where necessary, special bedding, haunching and initial backfill, concrete cradle, or other special construction should be used to withstand potential superimposed loading or loss of trench wall stability.

In choosing pipe material, the designer should consider the following factors:

- Life expectancy and use experience;
- Ease of handling and installation;
- Physical strength;
- Type of joint - water tightness and ease of assembly;
- Availability and ease of installation of fittings and connections;
- Availability in sizes required; and
- Cost of materials, handling and installation.

Design of sanitary sewers on the public side requires engineering analysis. MOE Design Guidelines include specific instructions regarding the design of sewers. Although many of these provisions may not apply on the private side, some of them do.

The Guidelines advise that loads, including live, dead, and frost-induced, should be considered. These should be considered in the context of soil type, groundwater, and trenching. Loads are likely similar in most lateral installations. Private side laterals are installed at the minimum allowable depth/slope until property line, at which point they descend to the depth of the public sanitary sewer, if necessary. This avoids unnecessary excavation on the private side.

The designer of a public sanitary sewer and lateral is instructed to consider the life expectancy of the pipe, ease of handling, strength, joints, installation issues, fittings, sizing, and costs, particular to each application.

***MOE Design Guidelines for Sewage Works 2008***

**Chapter 5. Design of Sewers (5.7.11) Installation**

Installation specifications should contain appropriate requirements based on the criteria and standards established by industry in its technical publications. Requirements should be set forth in the specifications for the pipe and methods of bedding and backfilling thereof so as not to damage the pipe or its joints, impede cleaning operations and future tapping, nor create excessive side fill pressures and ovulation of the pipe, nor seriously impair flow capacity.

Excavation for placing sewer pipes, backfilling and compacting should be specified in accordance with *Ontario Provincial Standards Specifications* (OPSS) 514, *Construction Specifications for Trenching, Backfilling and Compacting*.

Final backfill should be placed in such a manner as not to disturb the alignment of the pipe. Ring deflection testing should be performed on all sewers constructed using plastic pipe. The designer should reference OPSS 410, *Construction Specifications for Pipe Sewer Installation in Open Cut* for details on the testing procedure.

Design parameters to be taken into account include considering installation requirements, which need to be considered concurrently with design. For example, MOE Guidelines speak specifically to backfill operations (see Section 4.5). It requests that installation requirements be based on industry recommendations. It speaks specifically to using bedding and backfill measures which will not damage the pipe, nor cause ovulation. Ovulation of PVC pipe may occur when the backfill is not installed according to the installation requirements of the PVC pipe manufacturer.

OPSS standards for trenching, backfilling and compacting, as well as for construction of open cut sewer pipes, are specifically referenced in the Guideline.

## 4.2 Pipe Design with Respect to Foundation Drain Connections

***MOE Design Guidelines for Sewage Works 2008***

**Chapter 5. Design of Sewers**

**5.4.7 Foundation Drainage**
It is recommended that foundation drainage be directed either to the surface of the ground or storm sewer system, if one exists.

The connection of the foundation drains to a sanitary sewer system is strongly discouraged by the ministry because of the serious negative impact such connections might have on the system and the operation of the sewage treatment plant.

**5.5.2.4 Foundation Drainage**
It is essential that foundation drainage be directed to storm sewer systems or in accordance with local municipal best management practices taking into account on-site drainage/infiltration conditions. Since sanitary sewers are not designed to accept these flows (i.e., rainwater leaders and/or foundation drains), serious damage/problems may result, such as cracking of basement floor slabs or flooding of basements if foundation drainage is discharged to the sanitary sewers. It is recommended that foundation drainage be directed either to the surface of the ground or storm sewer system, if one exists.

**5.7.14 Foundation Drainage**
The connection of foundation drains to a sanitary sewer system is strongly discouraged by the ministry because of the serious negative hydraulic impacts that such connections can have on the sewer system and the potential hydraulic overloading of the sewage treatment plant.

The connection of foundation drains to sanitary sewers is no longer an acceptable design practice in Ontario (nor in much of Canada). This practice was largely discontinued in the early 1980s, although homes constructed prior to that frequently have them connected. For homes serviced by combined sewer systems, foundation drains may also be connected to sanitary building sewers. Combined sewers are no longer permitted in Ontario.

MOE Design Guidelines are not as prescriptive as one would expect regarding foundation drain connections. Section 5.4.7 states that “it is recommended”, rather than “shall be”. Similar wording is found in several other locations in the Guidelines. The guideline recommends that foundation drainage be designed with onsite drainage and infiltration conditions in mind. It is presumed that this wording will be amended in the next update to MOE Design Guidelines for Sewage Works.

The Ontario Building Code permits the connection of foundation drains to sanitary sewers.

Specifically, Part 7, Article 7.4.5.3. of the OBC specifies that where it is not possible to connect to a storm system or to the ground, a foundation drain may connect to a *sanitary drainage system* (a drainage system that conducts *sanitary sewage*). It also states in Part 9 that foundation drains shall connect to a sewer (or other). The term sewer is not defined in the OBC so it must refer to a *sanitary sewer* or *storm sewer.*

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

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

***OBC 9.14.5.1.***
***Drainage Disposal***

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

***Sample Sewer Use Bylaws (Ontario)***

Peel Region: "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"

Niagara Region: "No person shall discharge…any of the following: Storm water, water from drainage of roofs or building foundations or land or from a watercourse, or uncontaminated water except that which may be discharged into a combined sewer"

City of Brampton: "No person shall-discharge or cause to be discharged any storm water, surface water, roof runoff or subsurface drainage to any sanitary sewer."

Sewer Use Bylaws in Ontario are typically very clear regarding the discharge of materials other than biological waste into sanitary sewers. Peel, Niagara Region and Brampton's bylaws are cited as examples.

The enforcement of bylaws in Ontario is typically reactive, not proactive, so it is unlikely that a bylaw officer would be inspecting construction sites (which are still owned by the developer when they are being constructed). Bylaws apply to both public and private property.

So, the drainage of excavations to the sanitary sewer during home construction is common, but likely illegal. Unique discharge permits issued by the operating authority are permitted by bylaw, but it is unlikely these would be issued for discharges from new development (which are required to be pre-treated for sedimentation prior to discharge in any case).

## 4.3 Pipe Design with Respect to Storm Drainage

Similar to foundation drain discharges, storm water discharge to sanitary sewers is no longer acceptable in Ontario.

***MOE Design Guidelines for Sewage Works 2008***

**Chapter 5. Design of Sewers (5.5.2.5) Extraneous Sewage Flows**

Due to the extremely high peak flows that can result from roof downspouts, they should not, under any circumstance, be connected directly or indirectly via foundation drains to sanitary sewers.

MOE Design Guidelines are very clear regarding the connection of downspouts to sanitary sewers. They should not, under any circumstances, be connected.

Part 7 of the OBC does state categorically that storm drainage is not to be connected to a sanitary sewage works.

**OBC Part 7 Plumbing**
***7.1.5.2. Storm Drainage Systems***

**(1)** Every storm drainage system shall be connected to a public *storm sewage* works or a designated storm water disposal location but shall not be connected to a *sanitary sewage* works.

Other sections of the OBC, however, are not as clear on this issue. Both Part 5 and Part 9 imply that downspouts may be connected to a sanitary sewer (sewer can mean *sanitary sewer* or *storm sewer* in the OBC).

**OBC Part 5 Environmental Separation**
***5.6.2.2.* Accumulation and Disposal**

(3) Where downspouts are provided and are not connected to a sewer, provisions shall be made to,

(a) divert the water from the *building*, and
(b) prevent *soil* erosion.

**OBC Part 9 Housing and Small Buildings**
***9.26.18.2. Downspouts***

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

## 4.4 Jointing

> ***MOE Design Guidelines for Sewage Works 2008***
>
> **Chapter 5. Design of Sewers (5.7.11) Joints**
>
> The types of joints and the materials used should be included in the specifications. Sewer joints should be designed to minimize infiltration and to prevent the entrance of roots throughout the life of the system.

MOE Design Guidelines are very clear with respect to joints: the types of joints selected, and the materials used, should be designed to minimize infiltration and to prevent the entrance of roots throughout the life of the system.

MOE Design Guidelines appear to be silent on how the public side sanitary sewer lateral is to be left at the property line.

> ***OPSS 410 (November 2012): CONSTRUCTION SPECIFICATION FOR PIPE SEWER INSTALLATION IN OPEN CUT***
>
> 410.07.13 Service Connections
>
> Service connections shall be plugged at the property line with watertight caps or plugs. Plugs or caps shall be braced sufficiently to withstand test pressures.

OPSS 410 refers only to plugging the public side lateral at property line and does not specify a fitting or other means of connection to the private side sewer.

> ***OPSS 1841 (November 2015): MATERIAL SPECIFICATION FOR NON-PRESSURE POLYVINYL CHLORIDE PIPE PRODUCTS***
>
> Polyvinyl chloride service connection pipe shall be according to CSA B182.1 and have bell and spigot joints with elastomeric gaskets.

OPSS 1841 requires that PVC pipe (including sanitary laterals) have bell and spigot gaskets.

> ***OBC 7.2.5.10.(1) Plastic Pie, Fittings and Solvent Cement Used Underground***
>
> *Plastic pipe, fittings and solvent cement used underground outside a* building *or under a* building *in a* drainage system *shall be certified to,*
>
> (a) ASTM F628, "ABS Schedule 40 Plastic Drain, Waste and Vent Pipe with a Cellular Core
>
> (b) CAN/CSA-B181.1, "Acrylonitrile-Butadiene-Styrene (ABS) Drain, Waste and Vent Pipe and Pipe Fittings",
>
> (c) CAN/CCSA-B181.2, "Polyvinylchloride (PVC) and Chlorinated Polyvinylchloride (CPVC) Drain, Waste and Vent Pipe and Pipe Fittings
>
> ***OBC 7.2.5.11. Transition Solvent Cement***
>
> Solvent cement for transition joints shall conform to,
>
> (b) CCN/CSA-B181.2 "PVC and CPVC Drain, Waste and Vent Pipe and Pipe Fittings".

The OBC permits drainage pipes certified to a variety of sources, including ASTM and CSA Standards. These include glued (not gasketed) pipe. It should be noted, however, that Standards need to be purchased (and are often quite expensive), so it is not a simple matter to check standards, and the OBC references hundreds of them.

The OBC also specifies the types of Transition Solvent Cement that can be used to joint them.

## 4.5 Bedding and Backfill

**OPSS 401 (November 2015): CONSTRUCTION SPECIFICATION FOR TRENCHING, BACKFILLING, AND COMPACTING**

**401.05.01 Embedment Material** (for flexible pipe: from bottom of trench to bottom of the backfill)

Embedment material shall be one of the following, as specified in the Contract Documents:

a) Granular A.
b) Granular B, Type I, II, or III with 100% passing the 26.5 mm sieve.

**401.07.10 Backfilling and Compacting**

**401.07.10.03 Bedding**

The surface upon which the pipe is to be laid shall be true to grade and alignment. Bedding material placed in the haunches shall be compacted prior to continued placement of cover material.

Bedding material shall be placed in layers not exceeding 200 mm in thickness, loose measurement, and each layer shall be compacted according to OPSS 501 before a subsequent layer is placed.

Bedding material shall be placed in uniform layers not exceeding 200mm in thickness, loose measurement, and each layer shall be compacted according to OPSS 501 before a subsequent layer is placed.

**401.07.10.04 Cover**

Placing cover material is defined similarly to Bedding, shown above.

**401.07.10.05 Backfill**

Backfill material shall be placed in uniform layers not exceeding 300 mm in thickness, loose measurement, for the full width of the trench and each layer shall be compacted according to OPSS 501 before a subsequent layer is placed.

Backfill materials shall be placed to a minimum depth of 900 mm above the crown of the pipe before power operated tractors or rolling equipment shall be used for compacting. Uniform layers of backfill material exceeding 300 mm in thickness may be placed with the approval of the Contract Administrator.

Installation of pipe is covered extensively in OPSS and OPSD. It is also referenced in MOE Guidelines (see above discussion).

As described in OPSS 401, for flexible pipe (such as PVC), the embedment typically starts 300mm below the pipe, at the bottom of the trench (see OPSD 802.010).

Then, the embedment continues to 300mm (typical) above the crown of the pipe (outside of the top of the pipe).

The embedment material for flexible pipe must be granular A or granular B.

Compaction is essential to ensure that the pipe is installed securely in place and must occur in lifts. In addition, compaction to 95% maximum dry density is required, which obliges the attendance of a geotechnical engineer to undertake testing.

Compacted haunching is required, to compact the soil beside and beneath the round pipe.

And finally, backfill needs to be carefully placed, in lifts, simultaneously and equally on both sides of the pipe. It is required that 900mm of cover be installed and compacted before any heavy equipment is permitted to complete compaction.

**OPSS 410 (November 2012): CONSTRUCTION SPECIFICATION FOR PIPE SEWER INSTALLATION IN OPEN CUT**

**410.07.12 Pipe Installation**

Pipe shall not be laid until the preceding pipe joint has been completed and the pipe is carefully embedded and secured in place.

In addition, OPSS 410 specifies that a new pipe segment shall not be laid until the preceding one is complete and secure. This would ensure that well placed pipe lengths will not be disturbed by moving an adjacent length, and potentially affecting the previous pipe's bedding or jointing.

The OBC provides a single sentence to provide direction to installers around support for underground piping. It speaks to a base that is firm and continuous under the entire pipe. Appendix A provides some additional information, but it does not appear to be prescriptive. The bedding requirements are vague.

A subsequent sentence (7.3.5.1.(1)) refers to backfill to a 300mm height over the pipe but does not include under which application this would be required, or any performance specifications. The associated Appendix shows a pipe in a trench box, so sentence 7.3.5.1.(1) does not appear to be applicable to the sanitary building sewer.

The OBC does not distinguish between embedment material and backfill (which are the terms used for PVC pipe).

**OBC 2012**

***7.3.4.6. Support for Underground Horizontal Piping***

(1) Except as provided in Sentence (2), *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 legally 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.

**7.3.5.1.(1) Backfill of Pipe Trench**

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.

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

**OBC Reference A-7.3.5.1.**

This page in Appendix A shows a drawing of a pipe in a trench box and repeats Sentence 7.3.5.1.(1). In addition, it states "Standard Dimension Ratios for piping in deep fill, under vehicle driveways or parking vacilities (sic) may not be sufficient requiring heavier schedule piping to be use (sic) along with engineered compaction for the full depth of the trench"

## 4.6 Leak Testing of New Pipe

Newly laid pipe is subject to testing on both the public (OPSS) and private (OBC) sides. Public side testing, however, is more prescriptive.

**OPSS 410 (November 2012): CONSTRUCTION SPECIFICATION FOR PIPE SEWER INSTALLATION IN OPEN CUT**

**410.07.16 Field Testing**

Field tests described in this subsection shall be applied to sanitary and storm pipe sewers. No part of the work shall be accepted until the pipe sewers are satisfactorily tested following completion of installation of service connections and backfilling.

**410.07.16.03 Infiltration Test**

Dewatering operations shall be discontinued at least three days prior to conducting the test and allow for the groundwater level to stabilize. Infiltration tests shall be conducted when the groundwater level at the time of testing is 600 mm or more above the crown of the pipe for the entire length of the test section. The test section is normally between adjacent maintenance holes.

**410.07.16.04 Exfiltration Test**

Exfiltration tests shall be conducted when the groundwater level is lower than 600 mm above the crown of the pipe or the highest point of the highest service connection included in the test section.

**410.07.16.04.02 Testing With Water**

The test section shall be slowly filled with water ensuring that all air is removed from the line. A period of 24 hours for absorption or expansion shall be allowed prior to starting the test, except if exfiltration requirements are met by a test carried out during the absorption period.

The distance from the maintenance hole frame to the surface of the water shall be measured. **After allowing the water to stand for one hour**, the distance from the frame to the surface of the water shall again be measured. The leakage shall be calculated using volumes.

**410.07.16.04.03 Low Pressure Air Testing**

The test section shall be filled slowly until a constant pressure of 24 kPa is maintained. If the groundwater is above the pipe sewer being tested, the air pressure shall be increased by 3.0 kPa for each 300 mm that the groundwater level is above the invert of the pipe.

The air pressure shall be stabilized for five minutes and then regulated to maintain it to 20.5 kPa plus the allowance for groundwater, if any. After the stabilization period, the time taken for a pressure loss of 3.5 kPa shall be recorded.

OPSS 410 requires the testing of pipe sewer in open cut. The test specifications are clear and depend on the groundwater elevation in the area of the test section (greater or less than 600mm above the crown of the pipe or the highest point of the highest service connection).

Dewatering operations must be halted prior to the test to ensure that natural groundwater levels are in place when the testing is done (although, practically, groundwater levels vary with seasons).

The test lasts for an hour for water and as long as it takes for a specified pressure drop for air. Air testing also takes into account groundwater level during testing.

These tests are quite prescriptive and provide guidelines for what is allowable.

In addition, public side testing occurs after the pipe is buried, so will demonstrate the reliability of the joints under near final conditions. Any joint displacement occasioned by backfill operations will be identified if the pipe is tested after it is buried.

The OBC specifies that an air or water test be performed after a section of drainage system has been roughed in but not yet buried. This suggests that the test refers to both internal plumbing (upstream of the cleanout) and external plumbing (sanitary building sewer). *Drainage system* is a defined term in the OBC and refers to pipes on a property used to convey *sewage* to a main sewer.

Both water tests and air tests are specified, but allowable leakage is not. Sentence 7.3.6.2.(1) specifies that every pipe in a drainage system should be leak-free. An equivalent water column pressure (25mm) is included for final (smoke) tests, but not for the initial tests.

**OBC 2012**

**7.3.6.1. Tests and Inspection of Drainage or Venting Systems**

(1) After a section of drainage system has been roughed in, and before any fixture is installed **or piping is covered**, a water or an air test shall be conducted. (NPC: same)

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

**7.3.6.2. Tests of Pipes in Drainage Systems**

(1) Every pipe in a drainage system 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.
(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.

## 4.7 Inspection of Lateral Connection at Property Line

The inspection of the lateral connection at property line is essential to ensuring that I/I does not occur. Since the sanitary sewer system on the public side, including laterals to property line, are constructed, buried and tested before Building Permits are issued, the inspection of this connection falls to Building Departments (at this point in the development process the engineering groups are not typically involved).

**OPSS 410 (November 2012): CONSTRUCTION SPECIFICATION FOR PIPE SEWER INSTALLATION IN OPEN CUT**

**410.07.13 Service Connections**

Service connections shall be plugged at the property line with watertight caps or plugs. Plugs or caps shall be braced sufficiently to withstand test pressures.

OPSS 410 instructs contractors to plug the connection at the property line, such that it is watertight. The air or water test performed on the public side necessarily also test these lateral stubs (which are already buried). The tests fail if the plugs or caps are not watertight to the test pressures.

The OBC does not explicitly require the inspection of this connection. It does have “Prescribed Notices”, which specify when the CBO must be notified that the drainage systems are ready for inspection and testing. It does not specifically include (or exclude) the connection at property line.

**OBC 2012**
**1.3.5.1. Prescribed Notices**

(2) The person to whom a permit under section 8 of the Act is issued shall notify the *chief building official* of,

(i) readiness for inspection and testing of,
(i) building sewers and building drains,
(iv) drainage systems

Section 5 of this report identifies some of the general provisions of the OBC that suggest the obligation to perform this inspection. However, many jurisdictions across Ontario are not currently performing it.[9]

# 5 Objectives and Functional Statements 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, advice on which should be sought from professional sources."

Thus far, this report has focused on the detailed Division B (acceptable solutions) in the OBC. These are prescriptive type solutions. This section discusses the overarching statements in the OBC, which refer to the reasons why the specific acceptable solutions are suggested.

## 5.1 OBC Division A, Part 2

A number of the objectives in the OBC suggest that buildings should be constructed such that risk of I/I and flooding is kept to an absolute minimum.

Division A, Part 2 of the OBC contains Objectives of the Code. The Objectives which appear to relate to minimizing I/I and flooding are summarized in Table 2.

**TABLE 2: OBC DIVISION A: HEALTH & SANITATION OBJECTIVES**

| Item & Category | Number | Objective |
|---|---|---|
| Health – Sanitation | OH2 | 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. |
| | OH2.1 | 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 the *building* will be exposed to an unacceptable risk of illness due to unsanitary conditions caused by exposure to human or domestic waste. |
| | OH2.4 | 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 the *building* will be exposed to an unacceptable risk of illness due to unsanitary conditions caused by contact with contaminated surfaces. |
| | OH2.6 | An *objective* of this Code is to limit the probability that, as a result of the design or *construction* of a *building*, a person 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. |

All of the Objectives in OH2 identify limiting the probability of the risk of exposure due to unsanitary conditions.

## 5.2 OBC Division A, Part 3

There are many Functional Statements in the OBC which discuss the reasoning behind provisions in the code. These are found in Division A, Part 3, Functional Statements, Table 3.2.1.1., and Statements relevant to this work are summarized in Table 3.

**TABLE 3: OBC FUNCTIONAL STATEMENTS RELATED TO I/I AND FLOODING**

| Item | Number | Function |
|---|---|---|
| 11. | F112 | To provide adequate treatment of sanitary sewage and effluent. |
| | F113 | To minimize the risk of injury as a result of contact with sanitary sewage or partially treated effluent. |
| 13. | F132 | To limit excessive demand on the infrastructure. |
| | F133 | To limit excessive peak demand on the infrastructure. |

# 6 Observations

This report has thus far outlined the areas where the OBC is not aligned with public side guidelines and standards, specifically with respect to the *sanitary building sewer* or the private lateral. This section outlines why it is essential that building codes match "engineering" standards, particularly with respect to pipe design, installation, connections and testing to prevent I/I from entering pipes on the private side. From the engineers' point of view, these are of essential importance to the long-term life and function of a pipe (regardless of type).

## 6.1 Acceptable Solutions in the OBC

### 6.1.1 Pipe Design

MOE Guidelines contain a detailed description of how pipe should be designed, bedded, jointed, backfilled and tested, to produce long lasting, high quality sewers. MOE Guidelines are cited only once in the OBC (with respect to private sewers, in Article 7.1.5.5., which do not apply to sanitary building sewers).

OPS Standards and Guidelines represent the best information we have with respect to the balance between practicality and durability in the installation of sanitary sewer systems. Contractors, builders, regulators, municipalities, engineers and others contribute to keeping these documents current. Neither OPSS nor OPSD is mentioned in the OBC at all. It does not appear that pipe "design" is called for at all on the private side; it is not mentioned in the OBC.

OBC Sentence 7.3.5.1.(1) specifies that the backfill shall be carefully placed and tamped to 300m over the top of the pipe, but does not include performance specifications. The associated Appendix reference (A-7.3.5.1.) shows a trench box, which is typically used in deeper installations than those associated with private side laterals. The application of Sentence 7.3.5.1.(1) is not clear.

#### 6.1.2 Pipe Design with Respect to Foundation Drains Connections

The OBC does not explicitly prohibit this connection, even though it is widely forbidden in public side sanitary sewers. The concern with this connection not being explicitly unacceptable in the OBC is that an inspector in the field may not be familiar with the provisions of OPSS, OPSD or MOE Design Guidelines. Nor are they likely to be familiar with I/I and its implications (as reported by building officials during preliminary work on this topic[10]). Practically, if an issue arose in the field, and an inspector was asked to permit a foundation drain connection to the sanitary building drain, they would consult the OBC and find that this was allowable. This does not appear to be good practice.

### 6.1.3 Pipe Design with Respect to Storm Drainage

The OBC has some ambiguity with respect to the connection of storm drainage to the sanitary sewer. While it is explicitly prohibited in Part 7, language in Part 5 and Part 9 suggest that it is permissible. While it is presumed that most building inspectors would understand that such a connection is not permissible, their primary direction must come from the OBC. If it is ambiguous, there is a risk that such connections would be permitted (and legally so from the point of view of a building inspector). A change from the term *sewer* to *storm sewer* in the OBC would effectively remove this discrepancy.

### 6.1.4 Jointing

There are three types of joints to consider on the sanitary building sewer: joints subject to tree roots, regular joints, and joints (connections) at the property line.

Joints that are partially or totally blocked by tree roots on the private side are frequently identified during CCTV inspection of existing laterals in areas with high I/I. (Robinson, personal experience, R. Kowal, personal communication). Roots can only block laterals if they can find entry to them. This suggests that historic installation of sanitary building sewers did not include long-term, integral joints. The fact that unacceptable I/I is shown to exist in new subdivisions (though the public and private side sources are not distinguished) suggests that modern jointing is also allowing I/I (field observations have confirmed this[11]). Of course, the presence of trees or large bushes with deep roots near the sanitary or storm lateral is necessary for root blockage to occur. Trees were previously more common on the private side, but modern subdivisions appear to feature boulevard (public side) trees, which may move the problem to the public side.

For joints not subject to tree root intrusion, proper jointing is still essential in preventing the entry of I/I into sewer systems. Joints that have separated allow groundwater and infiltrated surface water to enter the sewer and contribute to I/I for the life of the inadequate joint. With glued joints, the sanitary building sewer becomes a (+/-) 8m long rigid pipe with +/- four joints, which is of course prone to snap at the joints even if properly installed.

The success of glued joints depends on careful installation and are prone to the risk of user error during construction,[12] more so than gasketed joints. Many contractors and building inspectors have pointed out that there are a variety of solvent cement types, depending on the materials being connected, and that sometimes one is substituted for another for expediency.[13] Each solvent cement is designed for a particular application, and is colour coded according to CAN/CSA-B181.2.: PVC to PVC is grey; ABS to PVC is white; CPVC to PVC is clear or yellow. ABS cement does not work on PVC and should never be used on it.[14] However, surveys[15] indicate that the correct cement is not always being used in practice. Failure of glue to bond can create an immediate entry point for I/I at joints and has been identified as a significant source of I/I in studied subdivisions.[16]

It does not appear that we are adhering to MOE Guidelines (which calls for design to minimize infiltration and to prevent the entrance of roots throughout the life of the system) when allowing the installation of poorer quality joints on the private side.

The joint between the public side lateral and the private side sewer is best served by an appropriate fitting, since differential settlement (they are compacted at different times) on either side of the property line can snap it if glued. This connection is made by the private side pipe layer, who connects to a plugged public side lateral, so this fitting is best supplied by their forces. It appears that use of DR28 or DR35 gasketed pipe is most common on the public side, so this fitting should be easy to order ahead of time.

Displaced or offset joints (frequently the result of poor jointing) reduce the life of the private side sewer, potentially substantially. As water starts to infiltrate into the pipe, it carries soil fines with it. This allows the bedding to shift, potentially widening the gap in the joint, which then allows further gravitation of larger soil materials into the pipe, which can cause further shifts in the bedding and backfill. Depending on the circumstances, this can have a significant impact on the life of entire pipe runs.

So “service connection pipes” (public side laterals) are required to have gasketed bell and spigot joints, presumably based on years of engineering study of pipe strength, quality and performance. The OBC permits glued joints on the *sanitary building sewer.*

### 6.1.5 Bedding and Backfill

Proper bedding and backfill of plastic pipe is essential to the integrity and lifespan of the *sanitary building sewer*. Plastic pipe is now being used extensively on both the public and private sides. Unlike concrete pipe (which possesses a high degree of stiffness), plastic pipe is made of visco-elastic material and thus gets part of its structural integrity from the soil around it. The instructions related to support for underground horizontal piping (OBC 7.3.4.6.) are woefully inadequate (only two sentences are provided). There is some clarification provided Appendix Note A-44 and A-45, but these are not legally part of the code. Also, A-7.3.5.1. shows a diagram of a pipe “trench” with a trench box, but it is not clear in what application this applies. In any event, the appendices do not form part of the code.

Incorrectly or inadequately laid pipe has high potential for introducing I/I into the sewer system. Gaps at joints, either due to inadequate jointing, inadequate bedding, or inadequate backfill, introduce a long-term opportunity for the introduction of I/I. If there are gaps, the bedding will slowly degrade, and as the fines migrate into the pipe, the remaining bedding is likely to shift. This increases the gaps and allows larger and larger soil particles into the pipe and increases the shifting of the pipe. The potential for I/I increases, and the functional life of the pipe decreases.

Inadequately laid pipe can be a direct contributor to sewer lateral backup and hence flooding. Representatives from the insurance industry[17] indicate that the majority of claims associated with basement flooding are related to private side issues (including the sanitary building drain). It is probable that inadequate pipe laying also increases the risk of flooding.

So currently, there are vastly different requirements for installation of pipe on the public versus private sides. There is no expectation that soil conditions will differ between the public side versus the private side in a single subdivision, so this should be addressed.

### 6.1.6 Leak Testing of New Pipe

The OBC, like OPSS, calls for leak testing of new infrastructure. However, the leak testing article does not differentiate between the testing of internal plumbing, and that of the sanitary building sewer. It refers to "every pipe in a *drainage system*", *drainage system* being a defined term in the OBC meaning "an assembly of pipes…on a property that is used to convey sewage… to a main sewer". OBC Sentence 7.3.6.4.(2) states that in making a water test, every opening except the highest shall be tightly closed with a testing plug or a testing cap, and the system or section shall be kept filled with water for 15 minutes. It does not specify whether this is for indoor piping or the sanitary building sewer, although the definition of *drainage system* implies both. This is confusing to interpret. Most CBOs in Ontario report interpreting this clause as only calling for internal leak testing,[18] but the author believes that it applies to both internal plumbing and the sanitary building sewer (and short portion of the drain).

The duration of testing on the private side is considerably shorter (one quarter) than that required on the public side. Depending on soil and groundwater conditions, this could affect test results substantially. Both water tests and air tests are permitted/specified in the OBC, but allowable leakage is not (Paragraph 7.3.6.2. specifies "without leakage"). An equivalent water column pressure (25mm) is included for final (smoke) tests, but not the initial tests*.*

The OBC requires a final test only at the discretion of the CBO. OBC Sentence 7.3.6.1.(1) states that where a final test is required, it shall be carried out after every fixture is installed, but before any part of the drainage system is placed into operation. This wording suggests that the final test occurs before the sanitary building sewer is buried. The testing of sewers on the public side takes place after the pipe is buried. Burial of the pipe represents a significant risk for the development of I/I, since backfill operations can easily shift pipe that is not well bedded/backfilled.

It does not appear to currently be practical to test the sanitary building sewer after burial, unless a cleanout to ground is installed on the sanitary lateral at property line (since this test requires that the downstream end of the system be plugged). Installation of cleanouts at property line is not common in Ontario. Per the OBC, the lateral is always buried before the plumbers start their indoor plumbing work.

No municipality interviewed in Ontario has identified testing of the *sanitary building sewer* following burial (nor does it appear to be called for in the OBC). Since burial itself is most likely to introduce I/I, no testing after burial does not achieve the goal of minimizing I/I.

### 6.1.7 Inspection of Lateral Connection at Property Line

The connection of the sanitary lateral at property line is a major source of I/I in existing systems. As reported by D.M. Robichaud,[19] this is likely because of differential settlement due to the timing of the installation of the pipes on each side of the property line, as well as the disparate pipe types used and the need to connect them with appropriate fittings. As is well known, each separate connection point poses a possible threat where roots or water could potentially infiltrate, and the nature of the size transition connection/test tee is a prime spot for this type of service issue or I/I. It is for these reasons that the section of pipe usually found at or around the property line is very often the source of headaches for municipal owners due to the precarious location of said problems at the property line.[20]

Since the inspection of this connection is not explicitly called for in the OBC (except peripherally in Article 1.3.5.1. Prescribed Notices, which call for inspections at specific times, without reference to the connection at property line), it appears that this inspection is not being undertaken in many cases.[21]

It would be prudent to explicitly include this inspection, as well the performance expectations around it, in Part 7 of Division 2.

## 6.2 Objectives and Functional Statements of the OBC

Division A of the OBC sets the framework for the whole document. It basically outlines the overarching goals which set the groundwork for the regulations around construction in the first place. The OBC itself is a set of minimum provisions respecting the safety of buildings with respect to public health and energy efficiency, among other things. Arguably, if the OBC sets minimum provisions, we should be meeting those at all times, and exceeding them where appropriate or possible. Failure to construct *sanitary building sewers* and *sanitary building drains* to a watertight condition contribute to I/I in the system, which could in turn compromise public health through basement flooding.

### 6.2.1 Health & Sanitation Objectives

Both I/I and basement flooding can occur as a direct result of inadequate pipe design, installation, or final connection. According to the Objectives in OH2, it is required that the probability that a person in the *building* will be exposed to an unacceptable risk of illness due to unsanitary conditions, is limited. This would include body contact with untreated sanitary sewage as they attempt to retrieve possessions from a flooded basement.

Basement flooding may occur as a direct result of poor pipe design, installation or final connection, and represents a risk of injury as a result of contact. The immediate health impacts described in the literature are predominantly non-communicable and include death, injuries and physiological distress; infectious diseases were also a potential risk. Injuries requiring medical attention can occur shortly before a flood (e.g., during evacuation), and during and after the event (e.g., drowning, musculoskeletal stress, punctures and lacerations, electrocution and carbon monoxide poisoning[22].

This injury may include mental health risks associated with residential basement flooding. In their systematic review of fluvial flooding events, Fernandez et al. identified that flooding can cause general psychological distress, anxiety, Post-Traumatic Stress Disorder and depression.[23] It is presumed that similar symptoms might follow storm, sanitary or overland flooding. Following the Alberta floods in 2013, an increase in injuries was detected among Calgary residents, including a 75% increase in the average weekly administration of post-exposure prophylaxis against tetanus. Mental health impacts in High River (the area hardest hit) residents were observed among females through a 1.64-fold and 2.32-fold increase in new prescriptions for anti-anxiety medication and sleep aids respectively.[24] There are many studies identifying these kinds of impacts.

Although the risk of physical injury is well understood during and after flood events, there are also mental health impacts associated with residential basement flooding which should be considered as an additional reason to reduce the risk of basement flooding.

### 6.2.2 Functional Statements

Functional Statement F112 refers to adequate treatment of sanitary sewage. When a sewer system is exposed to high I/I, particularly wet weather I/I, it becomes much more difficult to treat to normal standards, since the organic load at a wastewater treatment plant depends on fairly consistent flows. When sewers fill with water as a result of rainfall, very high peaks can result, and it becomes difficult to operate the WWTP effectively. Partial bypass of the WWTP may be necessary when peaks are especially high, resulting in discharge of raw sewage to receiving water, thus violating Functional Statement F112.

Functional Statement F113 has a similar impact to the OH2 objectives discussed in the previous section: basement flooding may occur as a direct result of poor pipe design, installation or final connection, and represents a risk of injury as a result of contact. This injury may include mental health risks as noted above.

Functional Statements F132 and F133 are particularly important statements. They state that limiting excessive demand and peak demand on the infrastructure are functional statements of the OBC. I/I originating on private property directly impacts demand on infrastructure.

## 6.3 Summary

It can be argued that failure to take all reasonable care to ensure that sanitary building sewers are constructed to a watertight condition is in contradiction of the objectives and functional statements of the OBC (and NPCC and NBCC). It would be prudent for the

OBC to reflect engineering standards used on the public side. It is essential that both the engineering and the building community work together, to our respective Standards and Codes, to eliminate this I/I from occurring in the first place.

# 7 Next Steps

This report outlined many areas in which there is not consistency between public side and private side guidelines/standards/regulations. This work, however, has focused specifically on these documents as written. Many areas which are beyond the scope of this study need further investigation. In addition, it is suggested that additional consultation take place to ensure that we have a complete picture of interpretations and application of Guidelines, Standards and Legislation. Items for further investigation (including some not directly related to the content of the report, but nonetheless collected) include:

1. Sewer Use Bylaws have been reported as a weak point in the process and are being interpreted differently across the province (by both engineering and building staff). It has been reported variously that bylaws apply to the user, not the constructor and that bylaws are enforceable on developer sites (prior to assumption). The confirmation of the application of bylaws should be investigating opportunities to have bylaw officers become more active around new construction. Bylaw departments in a municipality are separate from both building departments and engineering/development departments. It is not common for bylaw inspectors to inspect new construction sites (although it was reported in one location in Ontario[25]). It appears to be common for homebuilders to drain excavations to the sanitary sewer,[26] which suggests that building inspectors are probably not familiar with Sewer Use Bylaws. It has been noted elsewhere that building inspectors and development engineering staff might benefit from receiving training and perhaps delegated authority in the proper enforcement of Sewer Use Bylaws.[27]

2. On the public side, pipes are designed for the conditions in which they will operate. This does not appear to be the case on the private side (the OBC simply allows certain pipe types, without commentary). It is recommended that the expertise of the geotechnical engineer used on the public side, also make recommendations on the private side, to ensure that the installed pipe is suitable for those specific site conditions. Mechanisms by which this can be achieved should be investigated.

3. The pipe type used for the Sanitary Building Sewer needs further investigation. Various Standards around pipe referenced in the OBC were examined, but no long-term, in-situ (buried) testing of this pipe was identified. Studies in existing (newer and older) systems frequently show leaking laterals which strongly suggests that the design life (meaning a life which maintains structural integrity and has integral joints) of SBSs does not match the life of the house, if the average house is expected to last 75 or 100 years. However, there is currently very little messaging to homebuyers that laterals have a finite design life and may need periodic replacement. Given that sewers installed on the public side are generally considered for rehabilitation after +/- 40 years, and are installed under much more stringent conditions, it is not likely that the thin-walled pipe being installed currently has a design life of 75 or 100 years. It is recommended that the life of installed pipe on the private side is investigated,

and that messaging to residents around private side lateral design life be developed and implemented.

4. The OBC specifies that an air or water test be performed after a section of drainage system has been roughed in but not yet buried. This suggests that the test refers to both internal plumbing (upstream of the cleanout) and external plumbing (sanitary building sewer). Drainage system is a defined term in the OBC and refers to pipes on a property used to convey *sewage* to a main sewer. This is not the interpretation of many building inspectors across Ontario.[28] It is recommended that this be clarified.

5. One suggestion made during the course of this work was that contractors voluntarily upgrade private side glued pipe type to gasketed pipe, in exchange for non-performance of the air or water test. Using gasketed pipe on the private side will cost an estimated $50 per typical new home with an 8m setback (at retail prices). This should be investigated.

6. The specific solvent cement used to connect pipe types is clearly laid out in the OBC (and the solvent cements are colour coded). However, it has been identified by many in the industry that the correct cement is not being used in all cases. This may lead to immediate I/I. This issue should be discussed with stakeholders, and an action plan for addressing it should be developed.

7. Since the connection of the sanitary building sewer to the sanitary lateral at P/L cannot practically be tested, and is not prescribed in any Code, it is recommended that we develop a more resilient, leak proof design for this connection and adapt it in building codes.

8. The requirement for BWVs in the OBC is difficult to interpret (it references the upstream MH on the public side). It is recommended that this be dissected, and sketches be prepared for boundary conditions to determine when, and if, it applies.

9. Some municipalities require that storm and sanitary laterals be colour coded so that the risk of cross connections is minimized. Others require a 125mm lateral for storm (versus the 100mm for sanitary) for the same reason. This is an excellent practice but does not appear to be widespread. It is recommended that information on this issue be collected across Ontario and recommendations made as to how to implement it in all municipalities.

10. There is a discrepancy in the requirement to inspect storm infrastructure on the private side: several building departments advise that they do not undertake this inspection. This is of grave concern for I/I, since poorly constructed storm infrastructure around the house will doubtless end up in foundation drains, which are not designed to convey this amount of water.  This issue needs to be addressed in more detail.

11. Part 7 of the OBC prohibits the connection of storm drainage to sanitary sewers. However, both Part 5 and Part 9 suggest that it is allowable. Reducing this risk by explicitly prohibiting the connection in both Part 5 and Part 9 is recommended.

This report summarizes the written information in the various guidelines, specifications and codes. Although some commentary has gratefully been received from reviewers, wider and more formal consultation is required before acceptable solutions are proposed.

**All of Which is Respectfully Submitted,**

**Norton Engineering Inc.**
**Barbara A. Robinson, M.A.Sc., P.Eng., President**

# 8 References

[1] Kesik, T. I/I Best Practice Guidelines, 2015. ICLR, Toronto.

[2] York Best in Class I/I Programs in North America, 2015 (unpublished)

[3] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[4] Ontario Building Code, 2012.

[5] Note that plumbing provisions are incorporated into Part 7 of the Ontario Building Code. Part 7 of the OBC is adapted from the National Plumbing Code of Canada.

[6] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[7] Canadian Commission on Building and Fire Codes (CCBFC), National Research Council of Canada.

[8] National Building Code of Canada, 2015. Ottawa, 2015. National Research Council of Canada 2015.

[9] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[10] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[11] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[12] Personal Communication, Alex Sandowski, IPEX Pipe.

[13] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[14] B. Plewes, Town of Collingwood, Personal Communication

[15] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[16] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[17] Confidential

[18] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[19] Kowal, R., Pike, L. Door No. 3: A Common Sense Approach to Lateral Lining. Trenchless Technology, April 2013.

[20] Kowal, R., Pike, L. Door No. 3: A Common Sense Approach to Lateral Lining. Trenchless Technology, April 2013.

[21] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

[22] Sahni, V., Scott, A. N., Beliveau, M., Varughese, M., Dover, D. C., & Talbot, J. (2016). Public health surveillance response following the southern Alberta floods, 2013. *Can J Public Health*, *107*(2), 142–148.

[23] Fernandez, A., Black, J., Jones, M., Wilson, L., Salvador-Carulla, L., Astell-Burt, T., & Black, D. (2015). Flooding and Mental Health: A Systematic Mapping Review. *PLOS ONE*, *10*(4). https://doi.org/10.1371/journal.pone.0119929

[24] Sahni, V., Scott, A. N., Beliveau, M., Varughese, M., Dover, D. C., & Talbot, J. (2016). Public health surveillance response following the southern Alberta floods, 2013. *Can J Public Health*, *107*(2), 142–148.

[25] Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

26 Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.

27 Kesik, T. I/I Best Practice Guidelines, 2015. ICLR, Toronto.

28 Robinson, B. et al. 2017. Project to Address Unacceptable Inflow and Infiltration (I/I) in New Subdivisions. Phase 1 final report (2015-2017). Norton Engineering Inc., York Region, City of London, City of Windsor, Institute for Catastrophic Loss Reduction and Region of Peel.