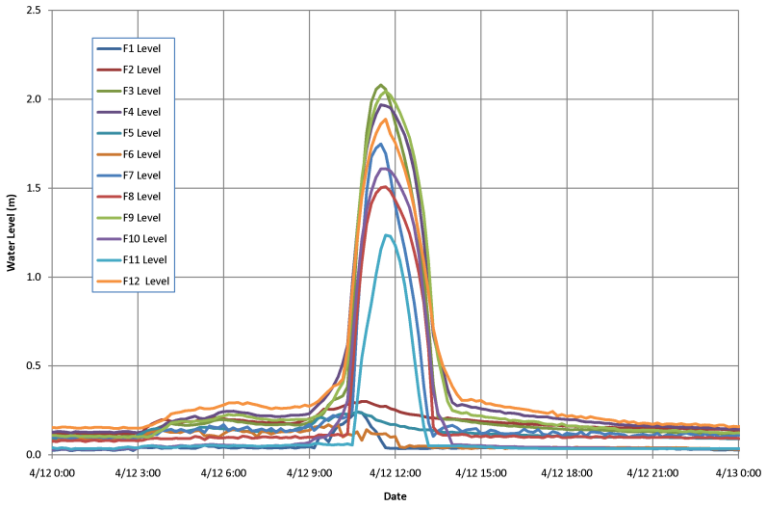
Lisgar District Basement Water Infiltration Investigation
Presentation of Final Report
City of Mississauga

March 26, 2015



Agenda

1. Purpose of Presentation
2. Summary of Findings
3. Study Area
4. Overview of Drainage Systems
5. City Activities
6. Summary of Potential Causes
7. Study Activities
   - *Monitoring*
   - *Testing*
   - *Analysis*
   - *Summary and Conclusions*
8. Mitigation Plan
9. Recommended Next Steps
10. Summary Report

1. Purpose of Presentation

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To present the findings of the consultant's assessment regarding the Lisgar District Basement Water Infiltration study, including:

- A summary of the field work and associated analysis
- The resulting conclusions regarding the main cause of the basement water infiltration, and other secondary factors
- The proposed Mitigation Plan

2. Summary of Findings

2. Summary of Findings

History of the Problem:

- Beginning in 2008, some homes experienced water seeping into their basements following certain rainfall events
- A total of 187 homes are known to have been affected to date.
- The City undertook a number of proactive measures
- In October 2011, the engineering consulting firm Amec Foster Wheeler Environmental & Infrastructure was retained to undertake an engineering study to determine the possible causes of this problem

2. Summary of Findings

Summary of the Primary Cause:

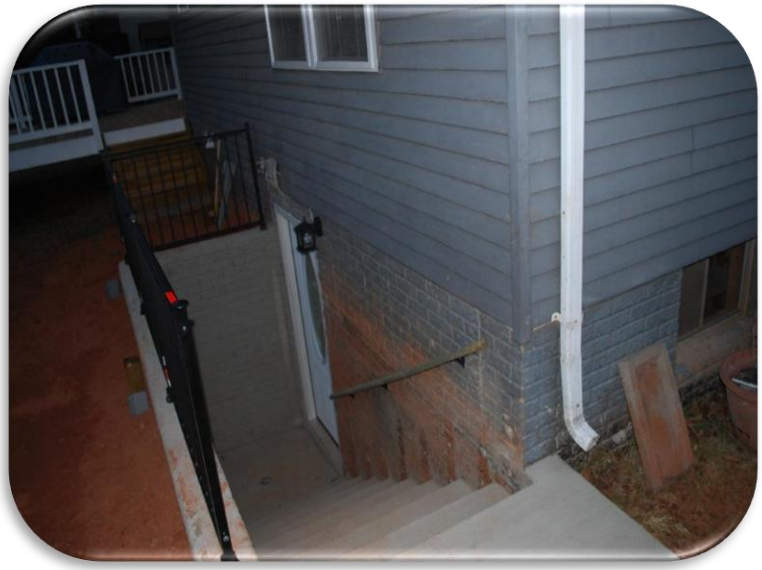
- Leakage from the storm sewer system (which is a normal and expected occurrence), combined with the presence of slow draining native soils (around the utility trench) results in water build-up
- If the build-up of water is significant, it travels up the bedding material around the Foundation Drain Collector (FDC) laterals servicing the homes and into the foundation weeping tiles
- Water then drains directly into the FDC pipes through the weeping tiles which can surcharge (overload) the system
- This condition, in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage may lead to water around the home's weeping tiles being unable to drain and potentially seeping into the basements of homes.

2. Summary of Findings

Potential Secondary Factors:

Some other identified issues and risk factors include:

- The depth of the FDC system and utility trench relative to weeping tiles in some locations (i.e. more susceptible);
- Pipe capacity in some sections of the FDC system;
- Potential inflows from groundwater and surface water sources (creek/pond via storm sewer outfall);
- Rain water and runoff from the lot or roof entering drains serving basement walkout areas that are connected to the FDC system.



2. Summary of Findings

Prioritized Action Plan:

Following measures are recommended as the highest priorities for the City:

a) *Strategic lining of priority storm sewers to minimize leakage (capital cost estimated to be $8M - $9M)*
b) *Construction of a utility trench dewatering system.(capital cost estimated to be $3M - $4M)*
c) *Additional monitoring to assess effectiveness of a) and b) (approximately $100,000)*

Other recommended actions may be staged over time, conditional on the results of the above, including:

a) *Building permanent FDC pumping stations for high flows (capital cost estimated to be $6M - $7M)*
b) *Replace deficient FDC pipe lengths when they reach the end of their engineered lifespan (capital cost estimated to be $2M - $3M)*

It is also suggested that residents who qualify for the City's Lisgar District Sump Pump Subsidy Program take advantage of this program.

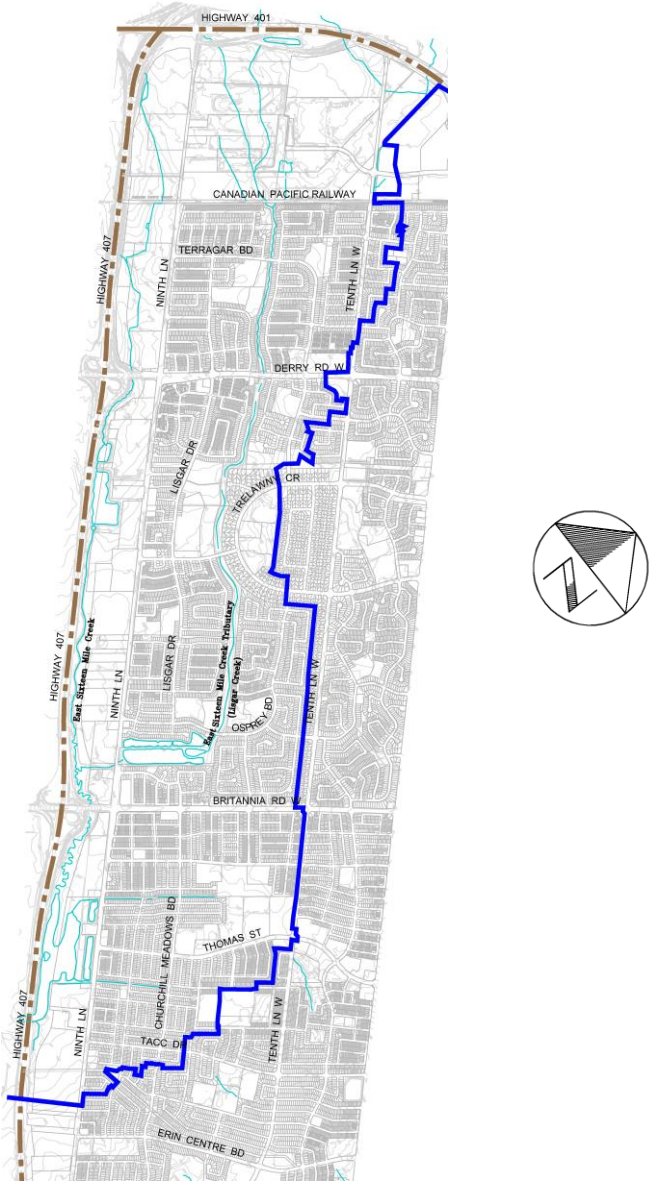
3. Study Area

3. Study Area

Study Area – Subwatershed Map:

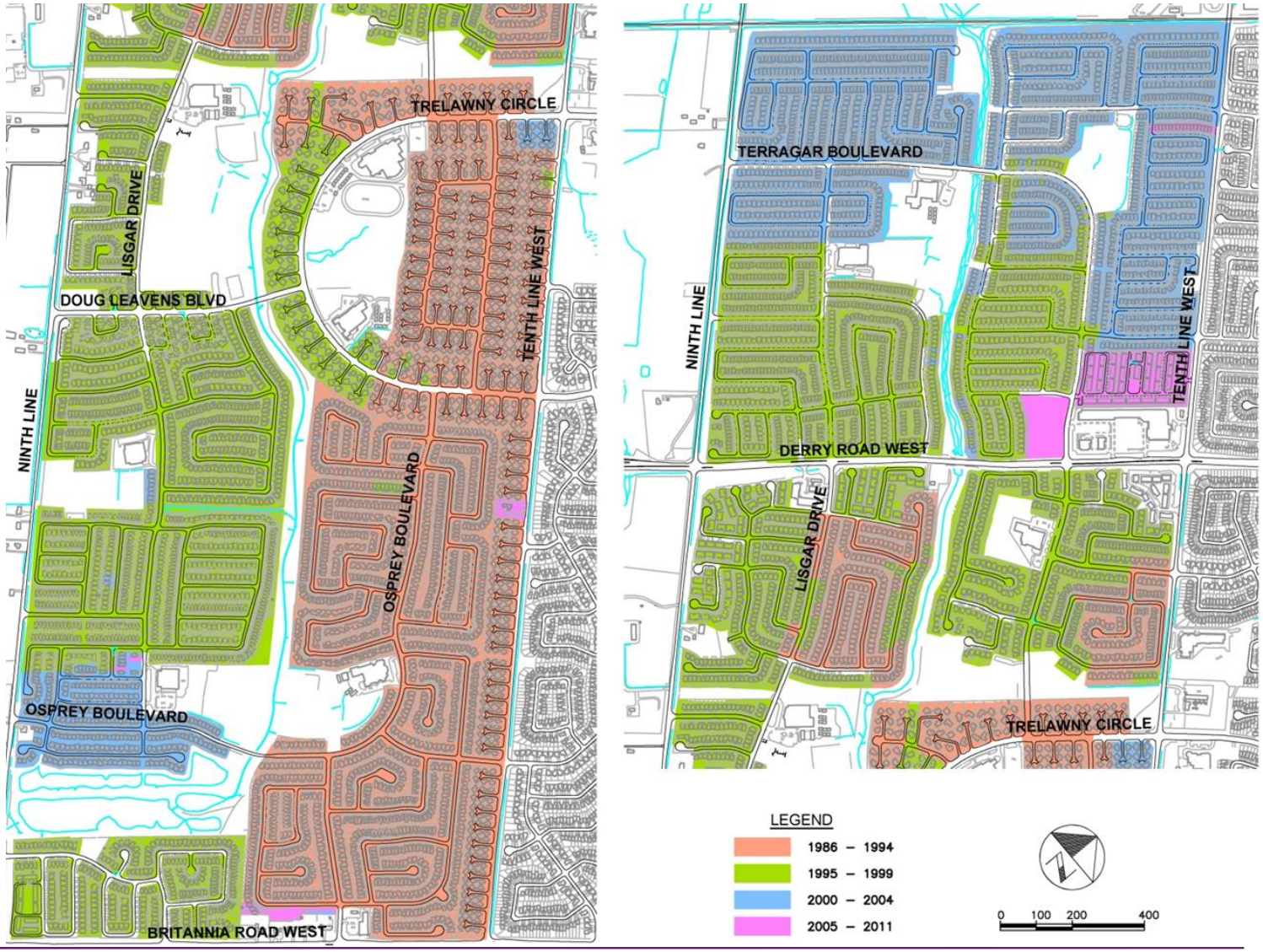
LEGEND

- WATERCOURSE
- CONTOUR (1m)
- MUNICIPAL BOUNDARY
- EAST SIXTEEN MILE CREEK WATERSHED BOUNDARY



3. Study Area

Study Area – Eras of Development:



4. Overview of Drainage System

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Typical Foundation Drainage Systems:

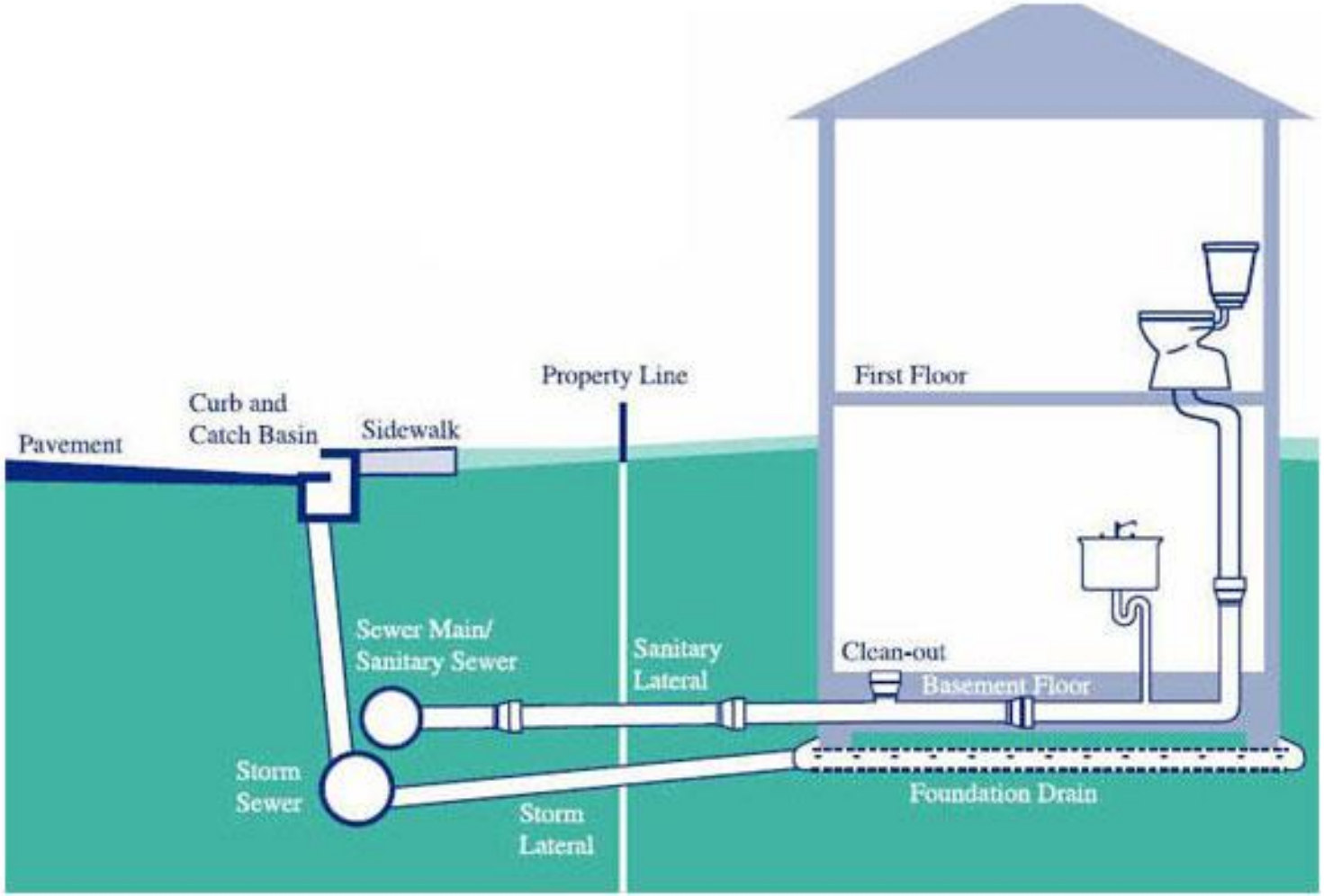
Typical Foundation Drainage Systems to address water build up around residential foundations:

i. Gravity Drainage to Storm Sewer
ii. Sump Pump to Front/Rear Yards or Storm Sewer
iii. 3-Pipe System – Foundation Drain Collector (FDC)

4. Overview of Drainage System

Typical Foundation Drainage Systems:

i. Gravity Drainage to Storm Sewer



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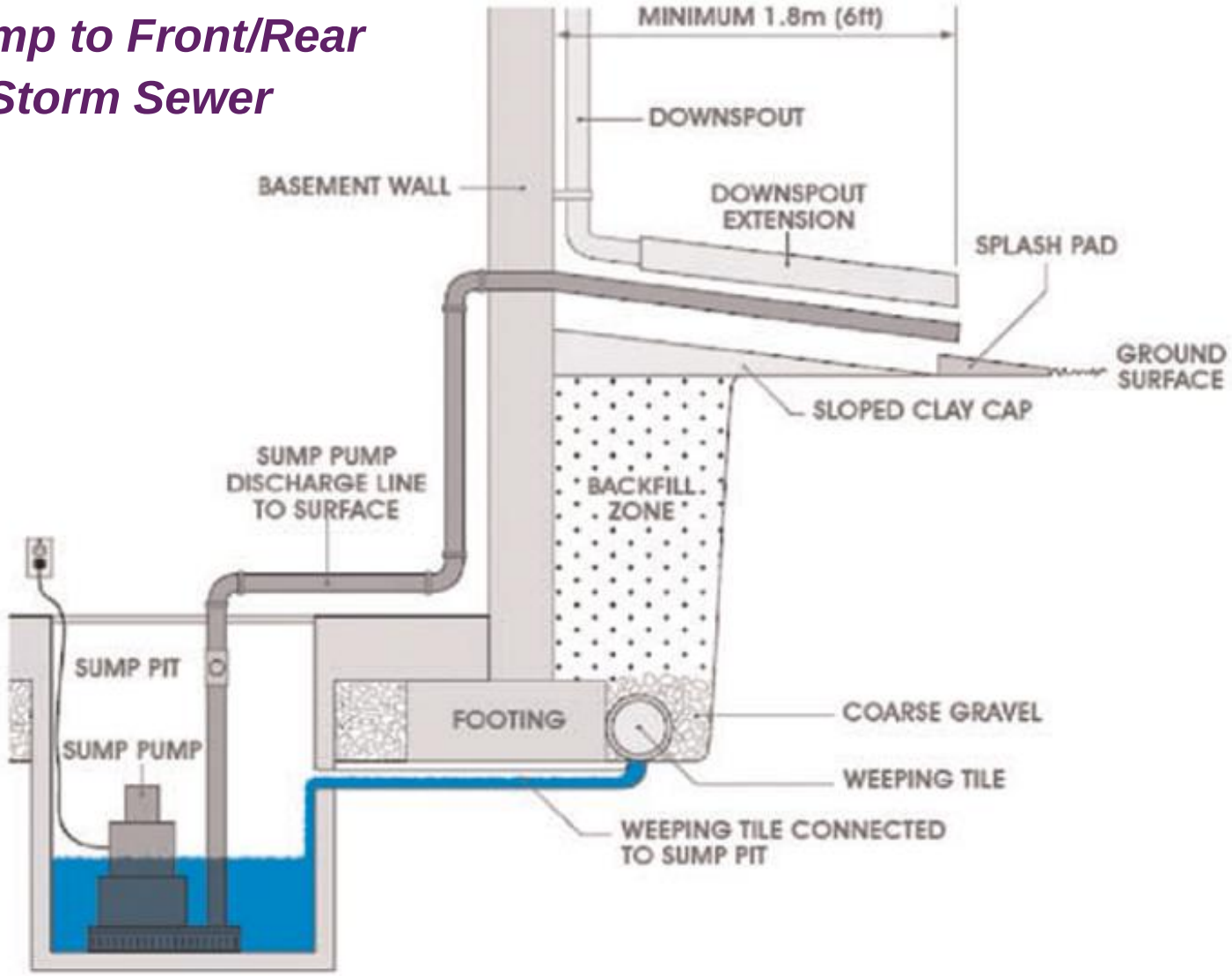
Typical Foundation Drainage Systems:

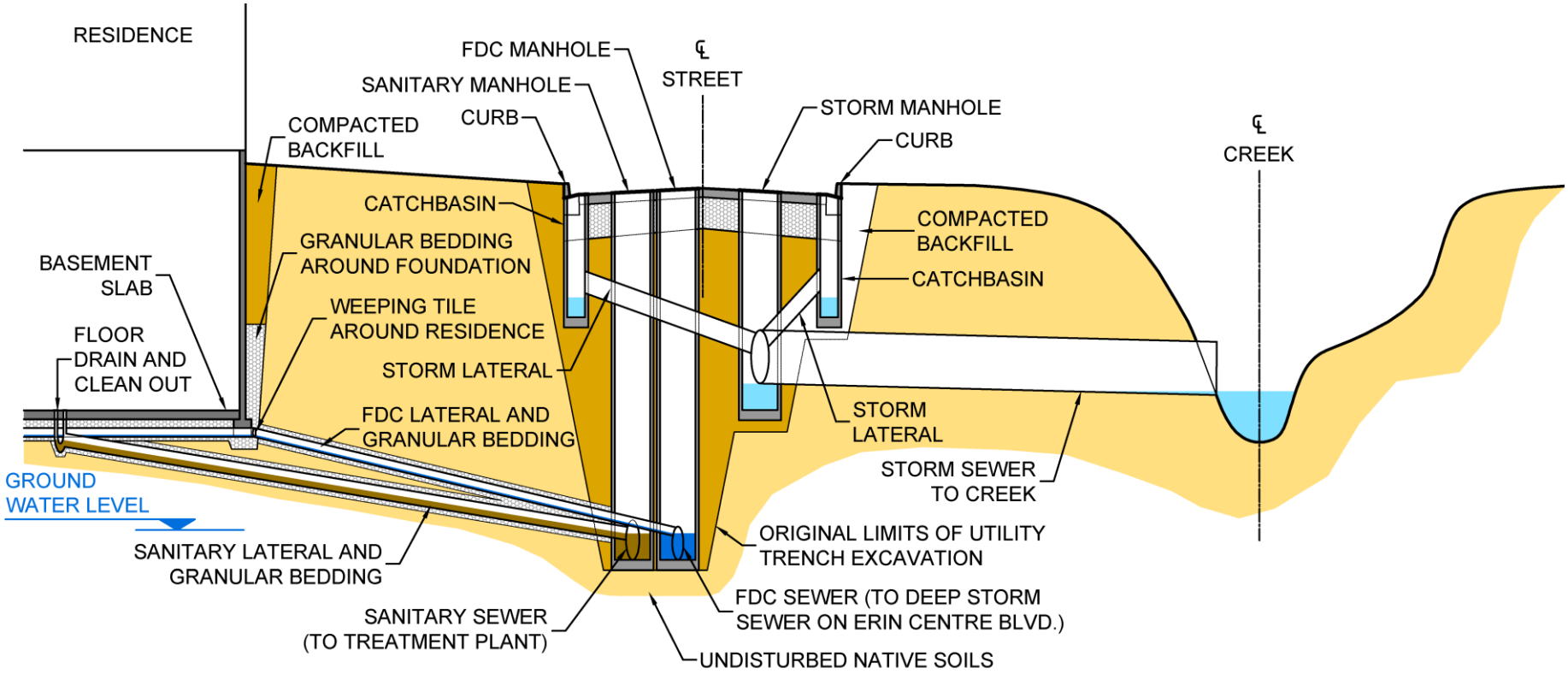
ii. Sump Pump to Front/Rear Yards to Storm Sewer



4. Overview of Drainage System

Typical Foundation Drainage Systems:

iii. 3-Pipe System - Foundation Drain Collector (FDC)



- "*This system virtually eliminates the probability of back-ups into foundation drains, which have caused considerable flooding, and damage to basements*" (Modern Sewer Design, 1980)

4. Overview of Drainage System

Type	Advantages	Disadvantage
Gravity to Storm Sewer	• no additional infrastructure • comparatively low cost • no reliance on mechanical system or power	• may back up if storm sewer is overwhelmed • some additional cost to upsize storm sewers
Sump Pump	• disconnected from municipal system	• requires homeowner to operate and maintain the system • mechanical system needs to operate to function • relies on power
Foundation Drain Collector	• dedicated, providing drainage for foundation only • no reliance on mechanical system or power • "virtually eliminates the probability of back-ups into foundation drains" • allows for smaller sized storm sewers • Successfully installed in numerous other municipalities without incident (Brampton, Vaughan, Barrie)	• comparatively high cost to install additional deep and long pipe systems

4. Overview of Drainage System

Why was the 3-Pipe System (FDC) used in Lisgar?

- Gravity drainage to the Sixteen Mile Creek Tributary not possible since creek is too shallow
- Alternatively, millions of cubic metres of material would have needed to be brought into area to elevate the land on average 1.5 m +\- (not practical/feasible)
- Sump pumps must always be maintained in good operating condition and also require a continuous supply of electricity; at the time (1980/1990's) sump pump system reliability not as robust
- 3 Pipe-System has been successfully used in other municipalities across Ontario and elsewhere

5. City Activities

5. City Activities

FDC and Storm Sewer:

- Video Inspection and Flushing of FDC and Storm Sewer Systems
- Identifying Sewer Cross-connections
- Sealing FDC Maintenance Access Lids and Cracks
- Cleaning Storm Sewer Outfalls to Creek
- Improvements to Overland Flow Routes
- High Water Protocol

5. City Activities

East Sixteen Mile Creek Tributary (“Creek”)and Osprey Marsh Stormwater Management Facility (“Pond”):

- Creek Vegetation Trimming and Debris Removal
- Sediment and Vegetation Removal from Bridge Crossings and Storm Outfalls
- Creek Inspection Protocol
- Reconfiguration of Osprey Marsh Stormwater Management Pond Outlet

6. Summary of Potential Causes

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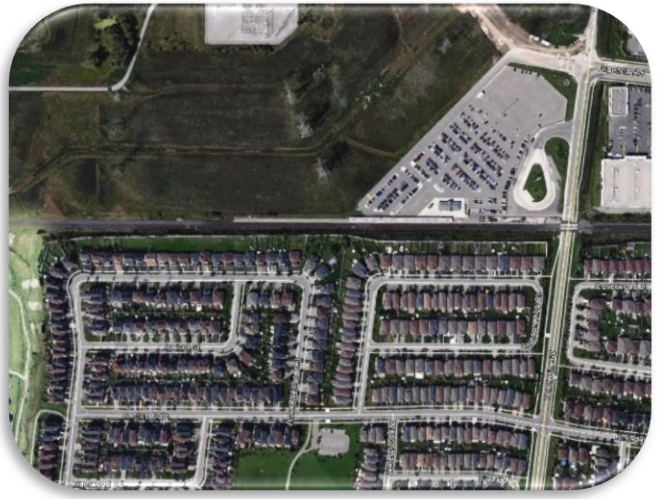
Changes Since Development of Lisgar District:

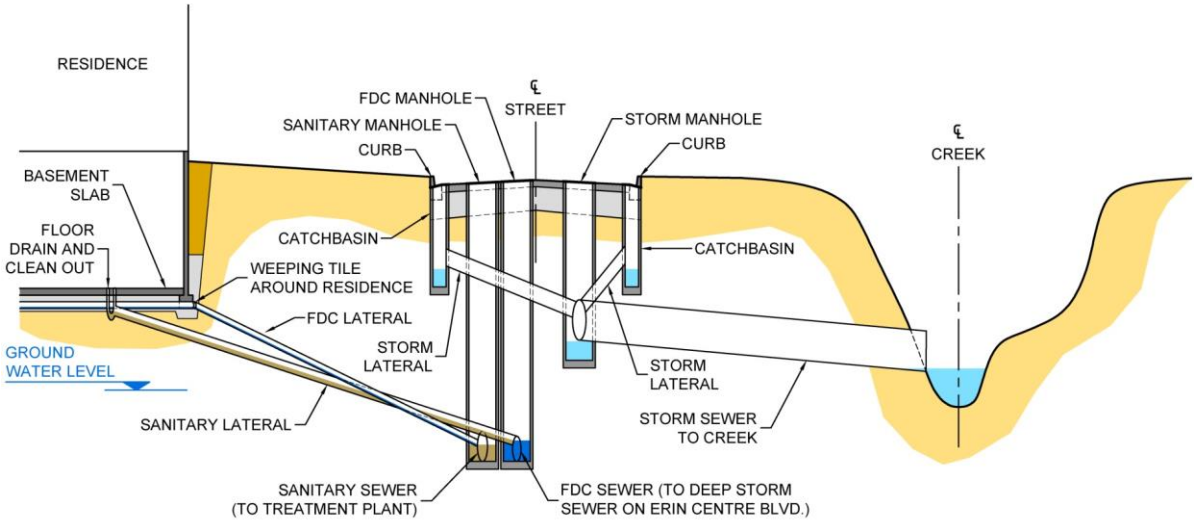
- Climate
- Development
- Creek Block Maturing with Vegetation
- Osprey Marsh Stormwater Management Pond
- Changes to Homes/Properties (lot grades, basement walkouts)
- Aging Basement Walls and Foundations
- Aging Infrastructure



6. Summary of Potential Causes

Other Potential Causes:

- Groundwater levels
- Sanitary Sewer system
- Private Weeper System (cross-connections and weeping tile system condition)
- Stormwater Leakage to Utility Trench



Cross-connection

6. Summary of Potential Causes

Other Potential Causes:

- Foundation Drain Collector
  - *a. Maintenance*
  - *b. Design*
  - *c. Hydraulics*
  - *d. Outlet*
  - *e. Depths*
  - *f. Inflow/Infiltration*
  - *g. Construction*

7. Study Activities

- *Monitoring*
- *Testing*
- *Analysis*
- *Summary and Conclusions*

7. Study Activities

Monitoring Work:
Groundwater – *Activities*

- Monitoring wells were installed at four main sites:
    - Black Walnut Trail at Scotch Pine Gate (late 2011);
    - Osprey Boulevard (late 2011);
    - Alderwood Trail (2013); and
    - Pondview Way (2014).

- Two primary types of monitoring wells were installed:
    - In the native (undisturbed) soils; and
    - In the gravel material, found in the utility trench

- Both water level and water temperature were monitored continuously at these sites.

7. Study Activities

Monitoring Work:
Groundwater - *Findings*

- Groundwater temperatures in the native soils do not vary greatly and are not affected by precipitation events.

- The shallow groundwater levels in the native soils do not increase rapidly during precipitation events

- The permeability (ability to move water) of the granular materials in the utility trench is up to 10 million times greater than the native soil (confirmed and discussed further in the Analysis section)

7. Study Activities

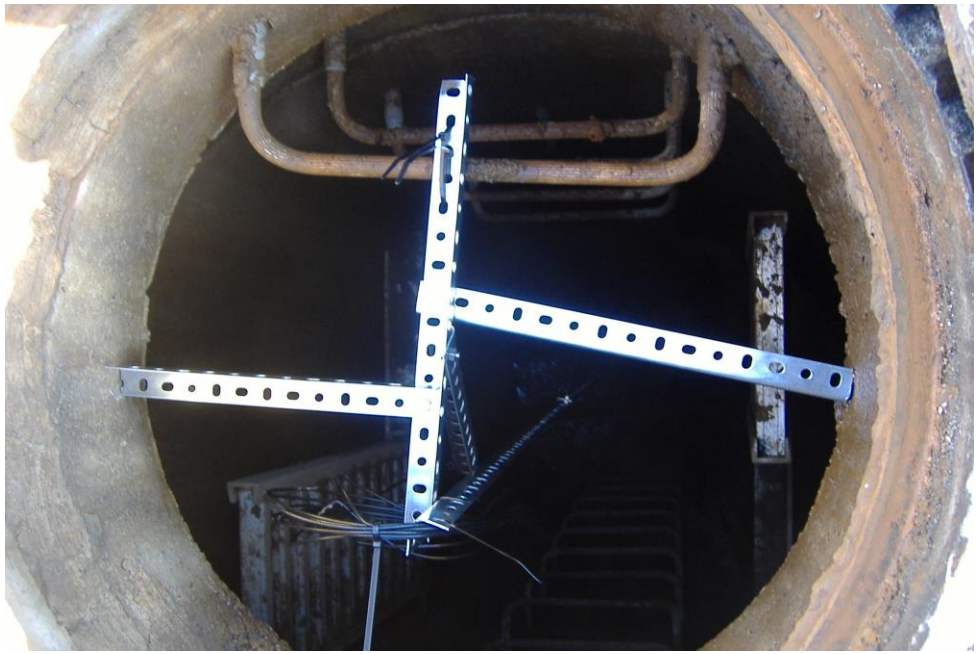
Monitoring Work:

FDC and Storm Sewer System - *Activities*

- Water level monitoring gauges were installed to observe how water levels in these systems respond to storm events – also recorded temperature

- A total of 17 water level monitoring gauges were installed within the FDC sewer system across the study area

- Three (3) water level monitoring gauges were installed within the storm sewer system.



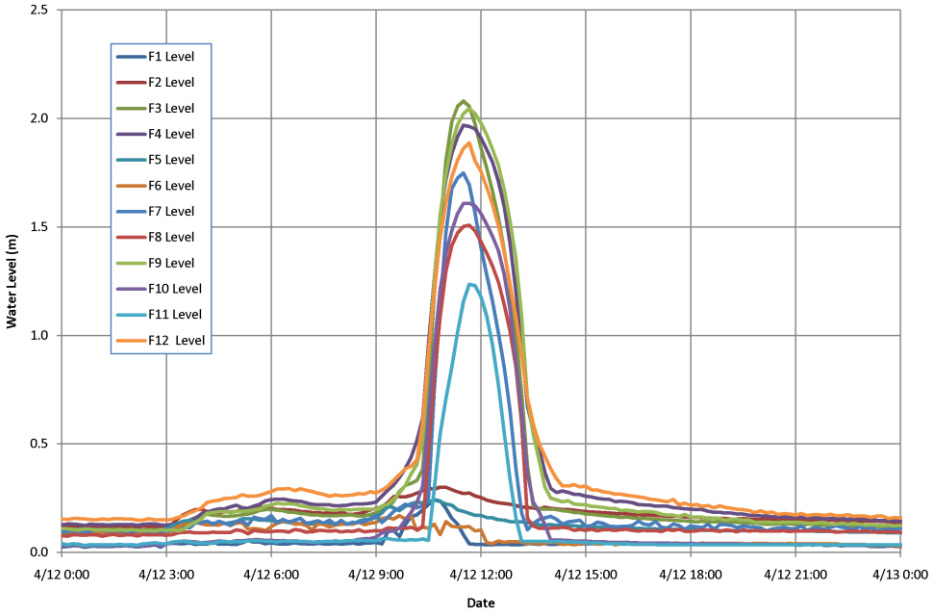
7. Study Activities

Monitoring Work:
FDC and Storm Sewer System - *Findings*

- The FDC system surcharges rapidly in response to rainfall events - occurs in different locations and amounts depending on the storm event

- Most prevalent along Black Walnut Trail and in the vicinity of Osprey Boulevard

- Strong indication that the excess water is coming from surface water sources rather than groundwater, based on:
  - Speed that FDC water level rises and falls
  - Water temperature signals



7. Study Activities

Monitoring Work:

Creek Tributary and Stormwater Management Pond – *Activities*

- Water level monitoring gauges were installed and monitored along the tributary of the east branch of Sixteen Mile Creek and within the Osprey Marsh Stormwater Management Pond

- Gauges were installed at five (5) different locations along the creek, as well directly within the pond

- A temporary rainfall gauge was also installed in the study area

7. Study Activities

Monitoring Work:
Creek Tributary and Stormwater Management Pond - *Findings*

- There is nominal creek flow from the GO Station channel, and no apparent connection between these flows and FDC surcharging

- There is no apparent connection between creek flows and FDC surcharging

- There is no apparent connection between water levels within the Osprey Marsh Stormwater Management Pond and FDC surcharging

GO Station

7. Study Activities

Testing Work:
Water Quality - *Activities*

- A sampling program was conducted to assess the chemical properties of the water found in the:
    - native soils (i.e. the groundwater);
    - utility trench (i.e. where the municipal services are);
    - creek;
    - Osprey Marsh Stormwater Management Pond; and
    - FDC system.

- Objective to identify any commonalities among the various different water sources




7. Study Activities

Testing Work:
Water Quality - *Findings*

- The water in the FDC system was found to be salt rich, similar to the utility trench, the tributary and the pond

- The water in the FDC system is therefore similar to surface water, and dissimilar to groundwater

- This similarity is particularly evident in winter conditions (road salt)

7. Study Activities

Testing Work:

Storm Sewer Leakage Testing – *Activities*

- Undertaken in 2013 at three sites where basement water infiltration occurred in the past

- Intent to confirm whether or not, under high flows, the storm sewer system would be expected to leak and contribute water to the utility trench

- Tests were comprised of:
  - *Blocking the storm sewers and filling them with water to replicate surcharge conditions*
  - *Addition of a safe green fluorescent dye to the storm sewer*
  - *Monitoring of the dye concentrations and water levels in the utility trench, groundwater and FDC system*

7. Study Activities

Testing Work:
Storm Sewer Leakage Testing - *Findings*

- At all three sites, the storm sewers leaked and at two sites the dye was detected in the FDC after only two hours

- Tests have proven that there is a flow path from the storm sewer to the FDC through the utility trench, with a response time consistent with that observed between ‘ideal’ storm events and instances of reported basement water infiltration

7. Study Activities

Testing Work:
Storm Sewer Outfall Collar Testing – *Activities*

- It was speculated that water from the creek or the Osprey Marsh Stormwater Management Pond could possibly move upstream through the storm sewer bedding at outfalls

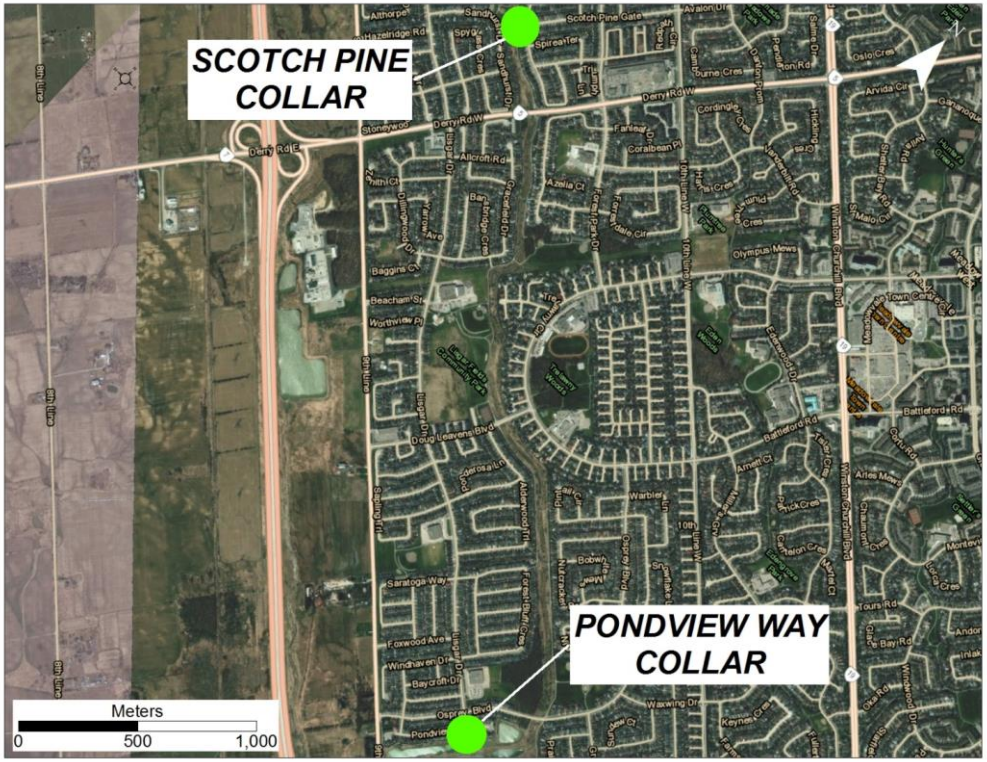
- As a test, impermeable concrete collars were installed in the utility trench near the outfall of the storm sewers at two locations

- These collars were installed with backflow valves that allow water from the utility trench to drain to the creek and pond, but not in the other direction

7. Study Activities

Testing Work:
Storm Sewer Outfall Collar Testing – *Findings*

- Monitoring is currently underway at both sites to assess the effectiveness of the collar in preventing elevated water levels in the utility trench



7. Study Activities

Analysis Work:

Groundwater - *Activities*

- Properties of native soils and granular materials measured at the groundwater monitoring sites (estimated using “slug” testing where a volume of water is either quickly added or removed to test response, as well as dye tracer tests and other analyses)

Groundwater - *Findings*

- As noted earlier, the permeability (ability to move water) of the granular materials in the utility trench is up to 10 million times greater than the native soils providing a ‘perfect’ pathway for water

Analysis Work:
Design Check of the FDC System – *Activities*

Three (3) Checks:

i. Comparison of the original number of intended residences to be served by the main FDC sewer system

ii. Comparison of original design sizes and slopes of the FDC sewers with as-constructed characteristics

iii. Verification of the design of the FDC trunk sewer (using original design approach), to determine if there is sufficient available capacity to handle expected flow rates

Analysis Work:
Design Check of the FDC System – *Findings*

- Some deficiencies have been identified in the as-constructed design of the FDC trunk sewer system which could impair the conveyance capacity of the FDC system; however none are considered to be the cause of basement water infiltration

- Observed FDC surcharging has been noted in areas which are a considerable distance from areas of identified FDC sewer deficiencies, which further confirms this finding

7. Study Activities

Analysis Work:

Computer Modelling of the FDC System – *Activities and Findings*

Q1: How much impact will high water levels at the downstream end of the FDC system (outlet) have on the Lisgar District?

A1: *Results show that high water levels downstream would have little impact on the FDC system performance within the Lisgar District, which further confirms that this is not a primary cause of FDC surcharging, although it may be a very limited contributing factor.*

Q2: How much potential impact would water draining into basement walkouts be expected to have on the FDC system?

A2: *Results show that based on the number of basement walkouts identified by City staff (and the estimated flows from those walkouts to the foundation drain), walkouts are not the primary cause of FDC surcharging, although they may be a contributing factor at specific locations.*

7. Study Activities

Analysis Work:

Computer Modelling of the FDC System – *Activities and Findings*

Q3: How much potential impact would storm sewer leakage have on the FDC system?

A3: *Results show that based on an average storm sewer leakage rate (calculated from the findings of the storm sewer leakage tests conducted in 2013), storm sewer leakage is the primary cause of FDC surcharging during storm events.*

Q4: Are there certain areas within the Lisgar District which contribute higher flows to the FDC system?

A4: *Based on the modelling results for an observed surcharge event in the FDC system along Black Walnut Trail, several areas have been identified as having much higher relative flow contributions to the FDC system. These identified areas are therefore considered a priority for the implementation of mitigation measures*

Analysis Work:
Computer Modelling of the FDC System – *Activities and Findings*

Q5: What measures would be most effective in reducing observed FDC surcharge?

A5: *Based on the modelling results for an observed surcharge event, two potential mitigation measures (which have been assessed using the model) have been shown to be effective at reducing FDC surcharge:*

FDC sewer upgrades - increasing the sizes of the deficient pipes to better carry higher flows and reduce surcharge; and
FDC pumping - actively pumping out the FDC during surcharge events to limit the amount of surcharging.

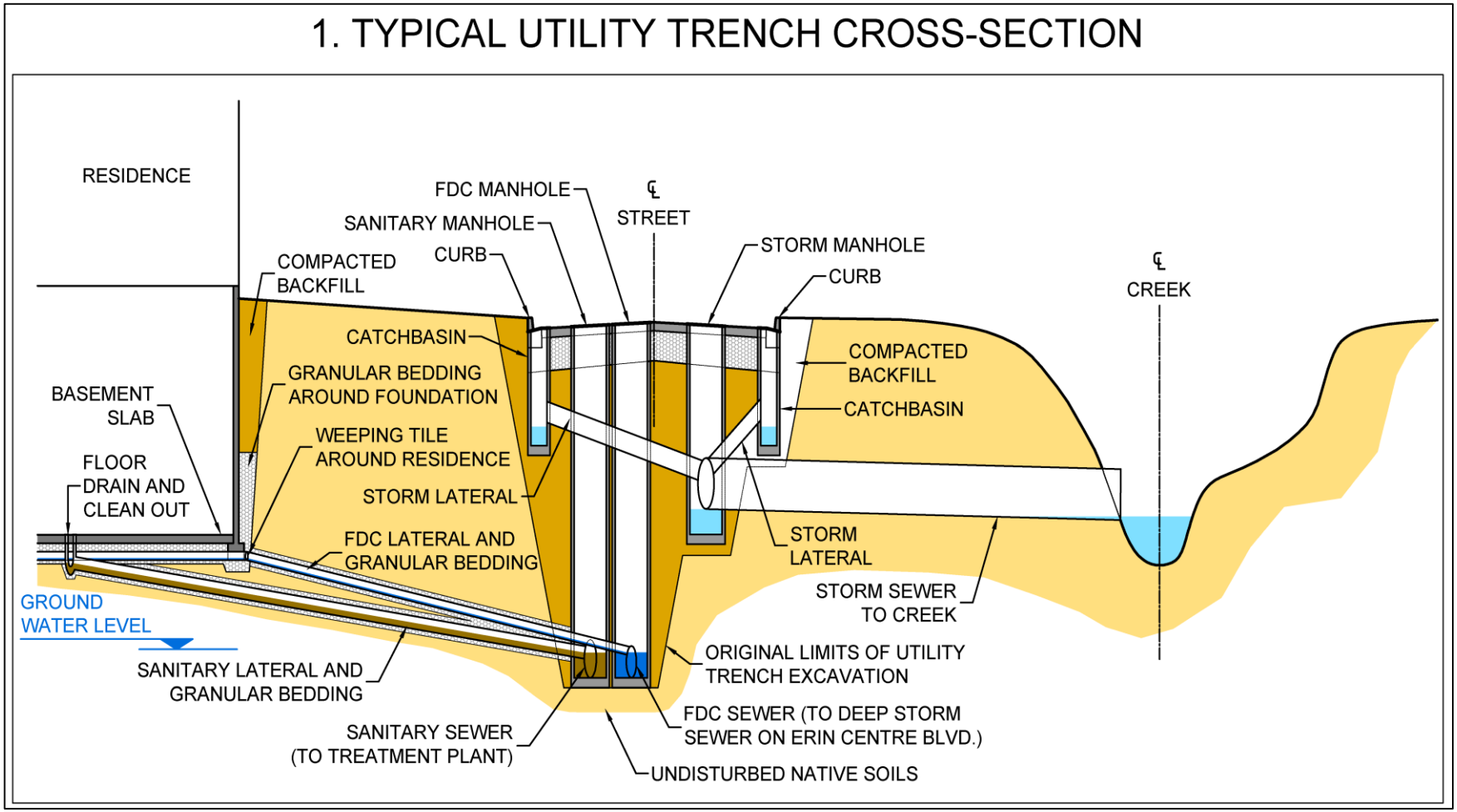
7. Study Activities

Summary and Conclusions:

Primary Cause – Stormwater to the Utility Trench

- Leakage from the storm sewer system (which is a normal and expected occurrence), combined with the presence of slow draining native soils (around the utility trench) results in water build-up
- If the build-up of water is significant, it travels up the bedding material around the Foundation Drain Collector (FDC) laterals servicing the homes and into the foundation weeping tiles
- Water then drains directly into the FDC pipes through the weeping tiles which can surcharge (overload) the system
- This condition, in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage may lead to water around the home's weeping tiles being unable to drain and potentially seeping into the basements of homes.

Summary and Conclusions:
Primary Cause – Stormwater to the Utility Trench



7. Study Activities

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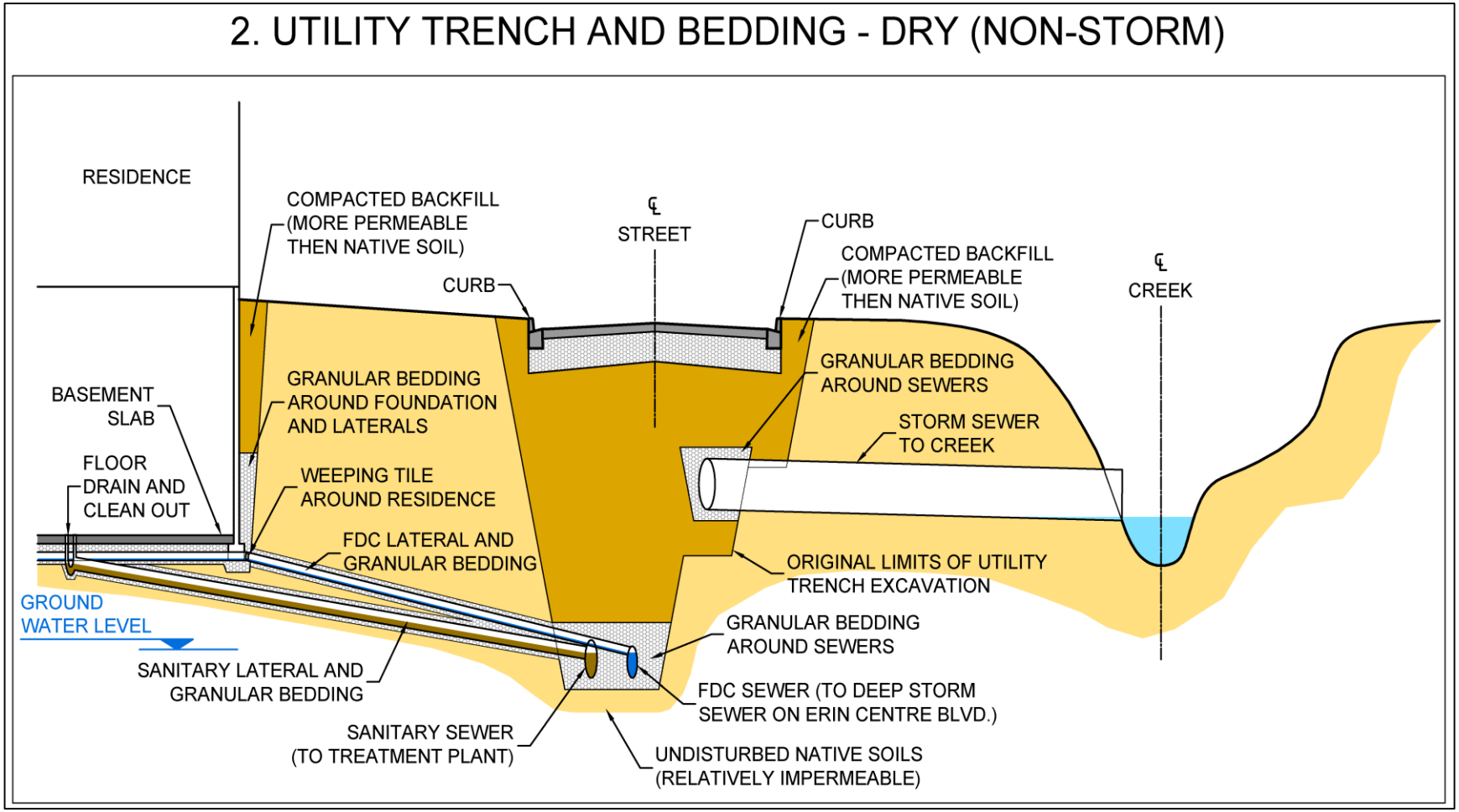

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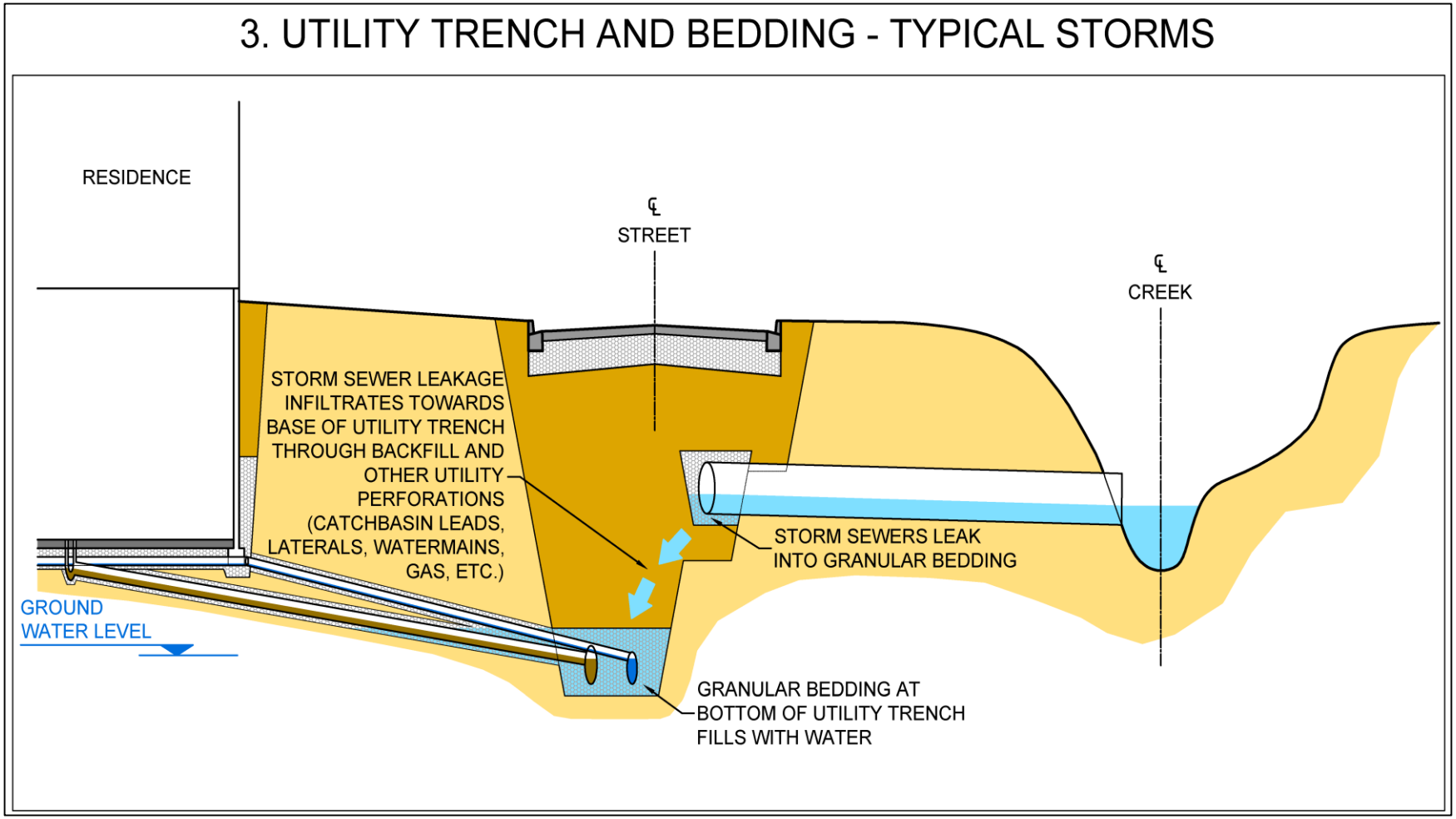
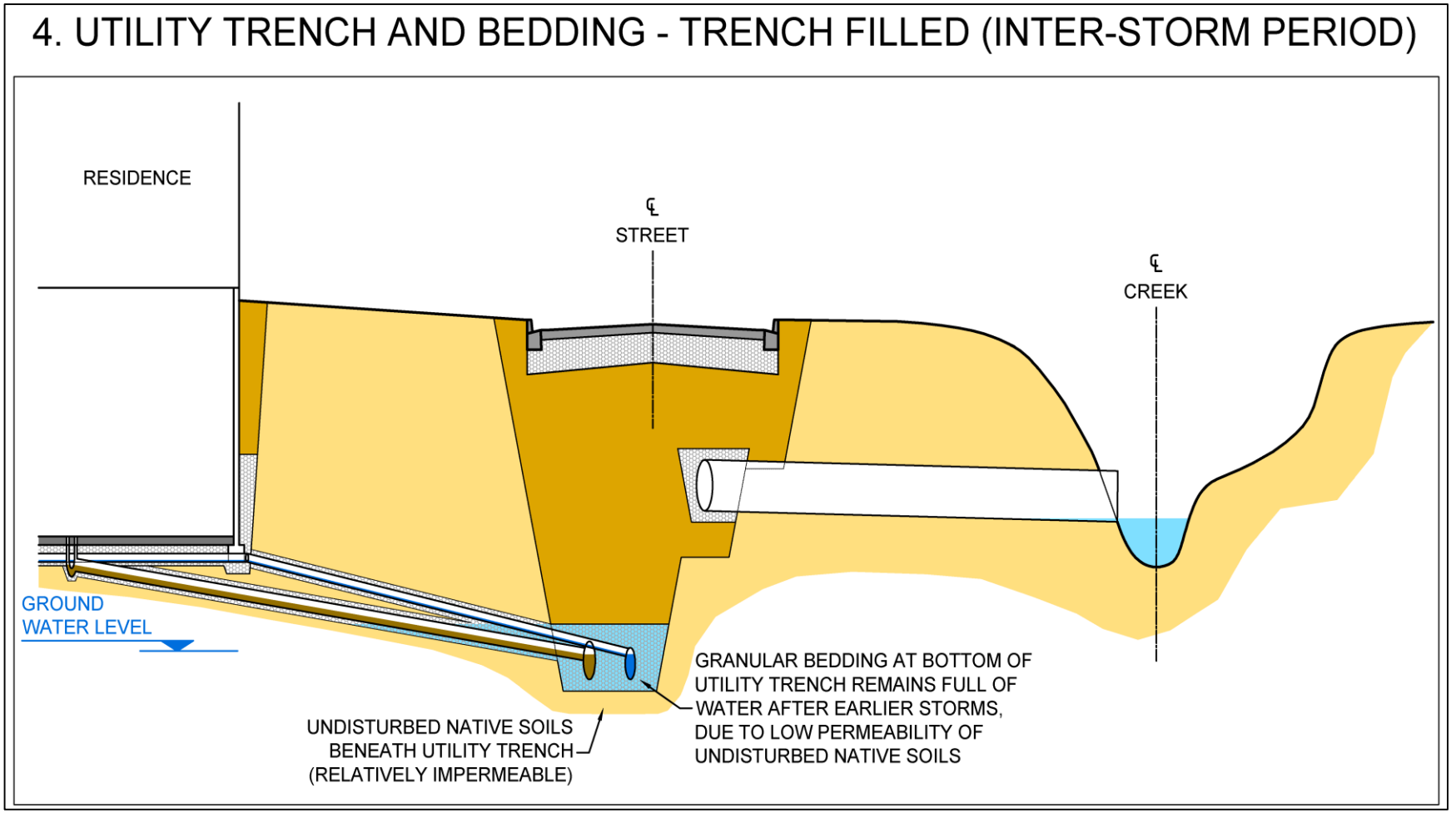


7. Study Activities

Summary and Conclusions:
Primary Cause – Stormwater to the Utility Trench



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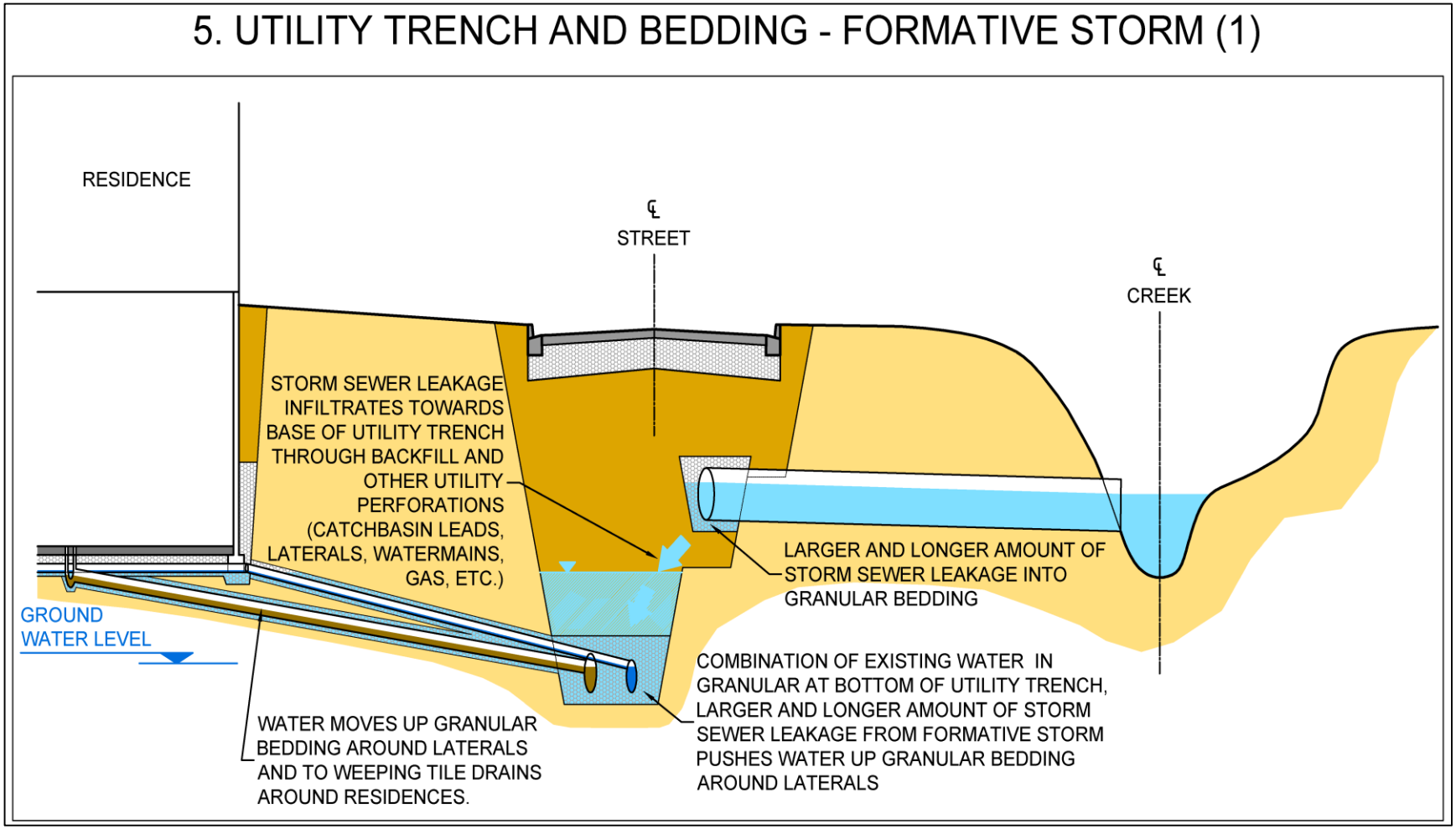
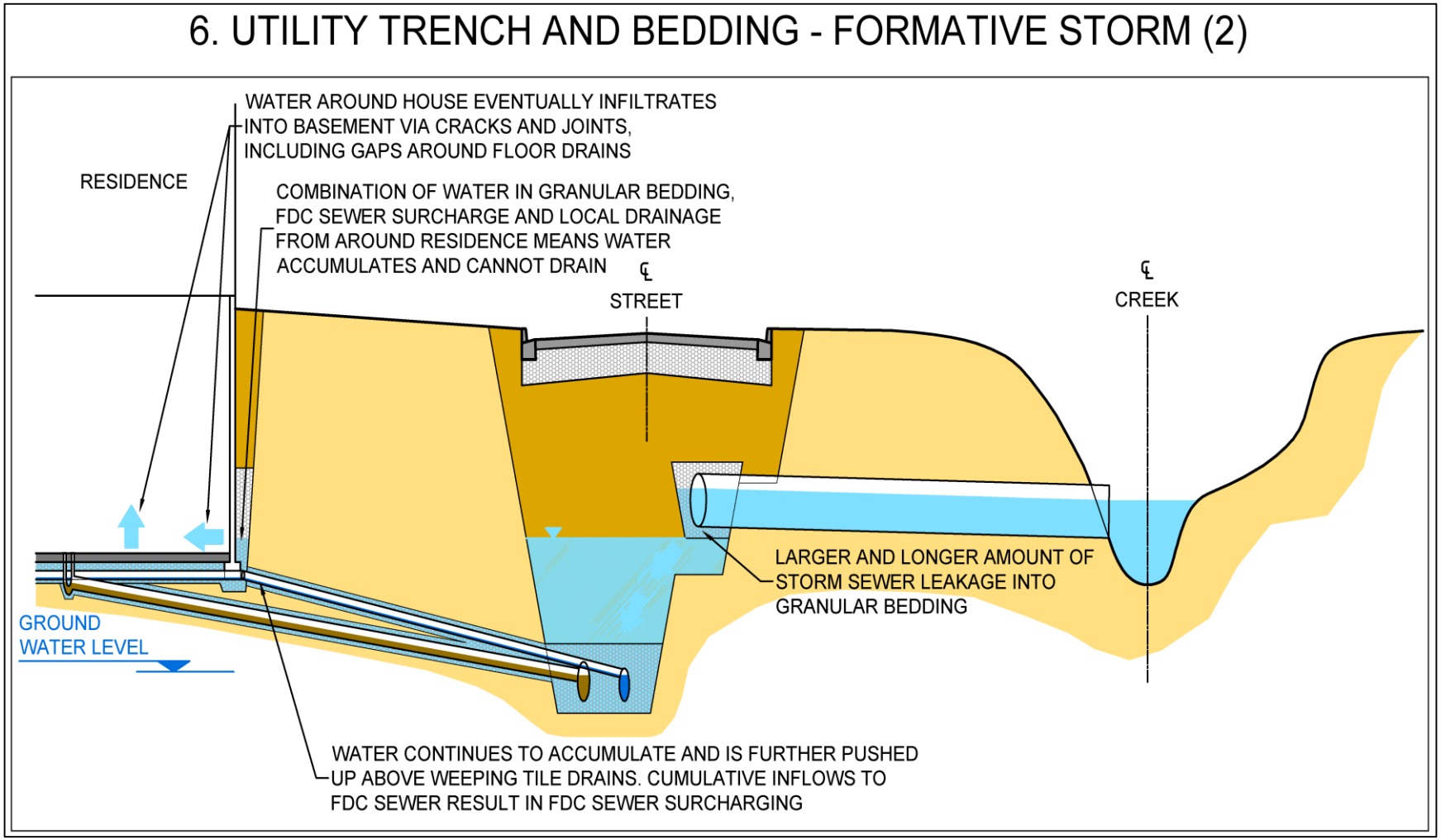


Summary and Conclusions:
Primary Cause – Stormwater to the Utility Trench



7. Study Activities

Summary and Conclusion: Assessment of Potential Factors

Potential Factor	Level of Influence
Stormwater to Utility Trench	Primary Cause
FDC and Utility Trench Depths	May increase risk of basement water infiltration at specific locations
Groundwater	May contribute additional flows to the FDC and utility trench (Not sufficient to cause problem)
Creek Backwater	
Osprey Marsh Pond (SWM) Backwater	
Basement Walkouts	
Inflow/Infiltration to FDC	
FDC Hydraulics	May affect conveyance capacity of FDC system (Not sufficient to cause problem)
FDC Design	
FDC Tailwater	
FDC Maintenance	
FDC Construction	
Cross-Connections	Not Applicable
Creek Maintenance	
GO Station	
Sanitary System	
Lot Grading	Insufficient information
Basement Construction / Changes	

8. Mitigation Plan

8. Mitigation Plan

Long List of Potential Alternatives:

Mitigation measures carried forward for further consideration:

1. *Strategic Lining of Storm Sewers*
2. *Construction of a Utility Trench Dewatering System*
3. *Construction of FDC Pumping Stations*
4. *FDC Sewer Upgrades*
5. *Sump Pumps*

Mitigation measures screened from any further consideration:

6. *FDC Backflow Preventers*
7. *Storage System*
8. *Storm Sewer Outfall Collars (pending results of monitoring)*
9. *Basement Walkout Covers*
10. *New FDC Outlet*
11. *Creek Remediation*

8. Mitigation Plan

Prioritized Action Plan:

These measures are recommended as the highest priorities for the City:

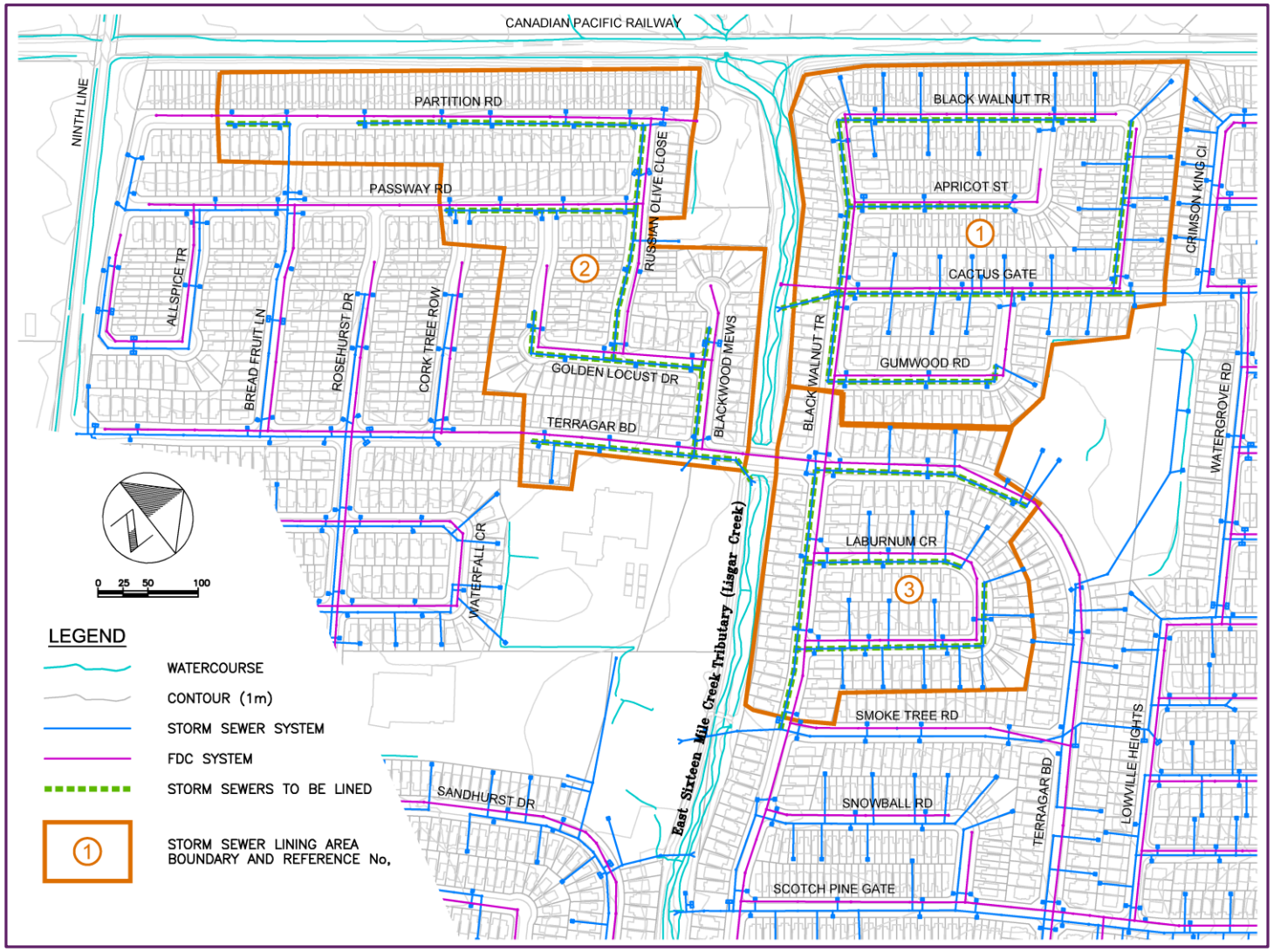
a) *Strategic lining of priority storm sewers to minimize leakage (capital cost estimated to be $8M - $9M)*
b) *Construction of a utility trench dewatering system.(capital cost estimated to be $3M - $4M)*
c) *Undertake additional monitoring to assess effectiveness of a) and b) (approximately $100,000)*

Other recommended actions may be staged over time, conditional on the results of the above, including:

a) *Building permanent FDC pumping stations for high flows (capital cost estimated to be $6M - $7M)*
b) *Replace deficient FDC pipe lengths when they reach the end of their engineered lifespan (capital cost estimated to be $2M - $3M)*

8. Mitigation Plan

Black Walnut Trail area – *Highest Priority*



8. Mitigation Plan

Prioritized Action Plan:

- It is also suggested that residents who qualify for the City's Lisgar District Sump Pump Subsidy Program take advantage of this program.
- To date, only 3 residents have applied to the program.
- The City will subsidize homeowners who install a sump pump up to 50% of the cost of the installation, to a maximum of $3,000
- Program details are available at: *http://www.mississauga.ca/portal/residents/lisgarsubsidy/*
- *Applications forms are available here tonight*

9. Recommended Next Steps

9. Recommended Next Steps

- A Corporate Report will be taken to General Committee on April 8th 2015 with recommendations planned for 2015 for General Committee's consideration

- Other potential mitigation measures may be considered as part of the 2016-2018 Business Planning process

10. Summary Report

10. Summary Report

- A copy of the Summary Report and tonight's presentation will be available tomorrow on the City's Lisgar Basement Water Infiltration Investigation webpage at: *http://www.mississauga.ca/portal/residents/lisgarinvestigation/*