7 DEVELOPMENT AND ASSESSMENT OF ALTERANTIVE REMEDIAL MEASAURES

The following sections will provide direction with regards to the alternative development and thought process, as well as the consideration of a range of remedial measures associated with the storm and sanitary systems to alleviate basement flooding.

7.1 Targeted Level of Service and Design Considerations

The same set of targeted level of service that was utilized in determining the existing storm and sanitary system performance was used to develop and size remediation alternatives. Please refer to **Section 6.1** for details.

In addition to meeting the targeted level of service, a number of other design considerations, which are based on the City's design guidelines, the study team's design experience with previous BFPP assignments as well as general assumptions were integrated during the alternative development and are presented in **Table 7-1**. The purpose of incorporating the study team's design experience is to proactively reduce the potential constructability issues during the constructability review and to streamline the constructability review process. A majority of the considerations were also presented to the City during the TM#3 Workshop #1 on April 29th, 2021, together with representative examples. The list of considerations provide clarity between the requirements from the RFP and modelling guidelines, as well as team's experience with BFPP studies. In summary, these considerations were used as a basis for the development of alternative solutions.

7.2 Screening of Alternative Remedial Measures

To minimize basement flooding occurrences and control wet weather flows several remedial measures were considered and evaluated. The measures are divided into four categories:

1. Source control measures;
2. Local measures;
3. Remedial measures applicable to the sanitary sewer system; and
4. Remedial measures applicable to the storm drainage system.

Table 7-2 lists the remedial measures and describes the advantages, disadvantages and general applicability of each measure. The information presented in the table was used as a screening method from which a short list of remedial measures was considered in the development of alternatives. The measures were subject to a quantitative assessment of their effectiveness. The resulting short list of the possible remedial measures is summarized below.

- **Source Control Measures:** These types of remedial measures had been thought to be historically difficult to implement due to the coordination, initiative and reliance in the cooperation of private properties owners. The only source control solution which has been historically carried further in the alternatives is roof downspout disconnection. In the past, the City encouraged residents on a voluntary basis to disconnect downspouts and re-direct runoff towards grassed areas and/or rain barrels. To move this program to a higher disconnection level, the City adopted a mandatory disconnection program aimed at obtaining at least 75% of the roof downspouts, City wide. During the field investigation in this study area, it was identified that approximately 52% of the residential roof downspouts are disconnected and 8% are partially disconnected. Therefore, further downspout disconnect efforts are required to achieve the disconnection goal of 75%. Although other source control measures were not further considered, these are encouraged by the City as voluntary initiatives that promote storm runoff control.

- **Local Remedial Measures:** These measures if properly implemented, can provide a high level of protection for individual properties. They are highly recommended especially for isolated cases of basement flooding or where the cause of flooding is not related to the City's sewer infrastructure. Although these measures were not included in the quantitative assessment nor the costing alternatives, they are recommended for implementation to enhance the preferred solutions and provide protection.
- **Sanitary System Remedial Measures:** All solutions identified as feasible will be evaluated for applicability to the study area on a case-by-case basis.
- **Storm System Remedial Measures:** All measures identified in **Table 7-2** are applicable to the study area. It should be noted that all remediation measures on private property are recommended for implementation to enhance the performance of all sewer systems. However, except for downspout disconnection, these measures are not included in the quantitative assessment, nor the costing analysis.

Implementation of the above measures across the entire system may result in the elimination of potential flooding concerns in some areas. Additional remedial measures, as explained in **Table 7-2**, have been developed for application in other areas. It should be noted that not every alternative is applied to all problem areas; only applicable/reasonable alternatives have been considered.

7.3 Development of Alternative Measures

Based on the list of feasible flood mitigation measures, alternative development considerations and the study team's design experience, solutions were developed and evaluated utilizing the InfoWorks model from TM#2. The preferred solutions were selected by prioritizing solutions that will fall under Schedule A/A+, have a lesser magnitude of social and construction impacts where feasible (e.g. catchbasin works versus sewer works), have no property / easement requirements (e.g. prioritizing solutions on City properties and avoid solutions that require easements) and have a streamlined review process by Agencies.

For the Schedule B project a combination of remedial measures were reviewed to reduce peak flows and lower the HGL and / or overland ponding depth until the models showed acceptable levels that meet the basement flooding design criteria.

Table 7-1: Alternative Development Considerations and Assumptions

Consideration	Sanitary System	Storm System	Notes
Targeted LOS Criteria	The maximum HGL shall be maintained below basement elevation during a storm equivalent to the May 12, 2000 storm as gauged at the City's Oriole Yard.	The maximum HGL for the storm sewer system shall be maintained below basement elevation (assume 1.8 m below the ground elevation) during the 100-year design storm. Follow the varying maximum allowable overland ponding depth and velocity for different types of roads.	The targeted LOS, as per RFP Section 2.2.1.a.8, is the foundation of the alternative development considerations.
Targeted LOS criteria non-compliant exceptions	Create a table that documents the criteria non-compliant nodes, the reasons for the criteria non-compliance and a justification of why the exceptions should be considered as acceptable by the City.		This consideration is part of RFP Section 2.3.12.q and further discussed during Monthly Progress Meeting No. 14 meeting minutes (March 2nd, 2021).
No decrease in pipe diameter from a larger size upstream to a smaller size downstream will be allowed regardless of an increase in grade	Applicable	Applicable	This consideration is integrated as per City's design criteria, Chapter 2 – Sanitary Sewers & Chapter 3 – Storm Sewers, Design Criteria for Sewers and Watermains (January 2021).
Minimum slope for in-line storage box culverts (min. 0.3%, 0.2% if necessary)	Applicable	Applicable	This consideration is integrated based on the team's design experience on previous BFPP studies.
Surcharging in valley	The general approach is to meet the targeted level of service (LOS) criteria study area wide, but there could be exceptions such as sewer surcharging in valley lands where there are no house connections to the sewer. This process should be documented in the report – list the different cases and the City will evaluate and approve where appropriate. Sanitary system may be reviewed in a more stringent manner.		This consideration is integrated and determined based on discussion from Monthly Progress Meeting No. 14 meeting minutes (March 2nd, 2021).
No peak flow increases to the receiving trunk sanitary sewer system	Applicable	-	This consideration is integrated as per RFP Section 2.2.1.a.6 & 8.
Catchbasin Inlet Controls (ICDs) (maximum 20L/sec per inlet control device, and not more than 33% of the total catchbasins)	-	Applicable	This consideration is integrated as per RFP Section 2.3.12.c.
Maximum width of storage box culverts is limited to 4.2 m	Applicable	Applicable	This consideration is integrated based on the team's design experience on previous BFPP studies as well as commercially available sizes as per MConn (https://mconproducts.com/precast-products/box-culverts-2/). Maximum width to be defined during Preliminary Design when more detailed information regarding infrastructure becomes available.
Minimum allowable size pipe outlets	250 mm	300 mm	This consideration is integrated as per City's design criteria, Chapter 2 – Sanitary Sewers & Chapter 3 – Storm Sewers, Design Criteria for Sewers and Watermains (January 2021).
Shallow pipes	Replacements will be provided to deepen shallow sanitary sewers to provide HGL below the basement level (1.8 m freeboard) during the May 12, 2000 storm event, except in cases where the shallow sanitary sewers do not connect to basements.	The required level of protection for shallow sewer systems, regardless of connection status to private properties, shall be no-surcharge conditions during a 100-year storm event with the	This consideration is integrated as per RFP Section 2.2.1.a.8 and Updated Modelling Guideline Section 8.6.3.

Consideration	Sanitary System	Storm System	Notes
		proposed HGL during the 100-year storm event being less or equal to the existing condition HGL.	
ICI areas follow the same 1.8m targeted LOS	Applicable	Applicable	This consideration is integrated as per discussion with the City during Monthly Progress Meeting No. 14 meeting minutes (March 2nd, 2021).
Construction to stay off major streets where possible	Applicable	Applicable	This consideration is integrated as per discussion with the City during TM#3 Workshop (April 29th, 2021) and the team's experience on previous BFPP studies.
Avoid easements and valley lands where feasible	Applicable	Applicable	This consideration is integrated as per discussion with the City during TM#3 Workshop (April 29th, 2021) and the team's experience on previous BFPP studies.
Easement priority: City > TRCA > Private	Applicable	Applicable	This consideration is integrated as per discussion with the City during TM#3 Workshop (April 29th, 2021) and the team's experience on previous BFPP studies.
Availability of space in the public right-of-way	Applicable	Applicable	This consideration is integrated based on the team's experience on previous BFPP studies.
Invert elevations of the existing tie-in pipes	Applicable	Applicable	This consideration is integrated based on the team's experience on previous BFPP studies.

Table 7-2: Evaluation of Remedial Measures

Control Type	Control Measure	Advantage	Disadvantage	Applicability	Feasibility	Comments
Source Control	Roof Leader and Other Storm Water Disconnection (75%)	Divert significant amount of roof and other runoff source disconnections from the storm and sanitary sewers thereby reducing the peak flows and volume of runoff.	Marginal flow. May require re-grading.	Applicable in areas where there are suitable overland flow outlets. To be assessed on an individual property basis.	Feasible	Efficient in wet weather flow reduction in sewers instead of sewer capacity expansion. 60% of the roofs discharge to the surface. An additional 15% will be assumed to be achieved.
	Soak Away Pits	Effective in reducing stormwater volume entering the sewer by redirecting roof drainage.	Implementation costs for retrofit would be considerably high due to disruption, damage, and restoration of property that requires homeowner maintenance.	Difficult to implement in already developed areas on public property. Not enforceable on private property.	Not Feasible	Area highly developed. Effective for low intensity, low volume events. Not effective for large, intense rainfall events.
	Porous Pavement	Reduces stormwater runoff through infiltration.	Requires the initiative/co-operation of private property owners. Low efficiency/cost ratio (will require financial incentive).	Applicable to any impervious surface.	Implement where possible	Area highly developed. Effective for low intensity, low volume events. Not effective for large, intense rainfall events.
	Inlet Control Device (ICD)	Highly effective in reducing peak flow rates to the sewer by temporarily retaining runoff in paved areas.	Ponding can occur for larger storm events temporarily limiting the use of the affected area. Potential for increased frequency of overland flow.	Most effective on even surfaces. The application may be restricted due to non-existing and/or inadequate overland flow capacity.	Feasible	Area highly developed. Effective in areas with low overland flow depth predicted. Maximum 20 L/s per ICD and not more than 33% of the total number of catchbasins is recommended for this study.
Local Remedial Measures	Backflow Prevention with or without Sump Pump	An effective solution for individual properties to prevent basement flooding due to sewer surcharge.	Requires installation in the home at homeowners' expense and detailed plumbing investigation; long-term performance dependent on homeowner maintenance.	May be applied in the building where a thorough investigation of plumbing connections confirms suitable location.	Feasible for appropriate homes	Provides the highest protection for individual properties. Preferable for isolated cases of basement flooding or locations of shallow sewers.
	Sump Pump for Foundation Drains	Disconnection of drains from sewer prevents hydrostatic pressure build-up on walls due to surcharge. Reduces I/I in cases of drain connections to the sanitary sewer.	Requires installation in the basement to reduce costs. Requires regular inspection and maintenance by homeowner. Requires electrical backup supply to work under power failure.	May be applied in the building where a thorough investigation confirms a suitable location for safe discharge away from the house. Financial subsidy made available from City.	Feasible for appropriate homes	Provides the highest protection for individual properties. Preferable for isolated cases of basement flooding or locations of shallow sewers.
	Lot Regrading	Effective in reducing local flooding and high I/I to foundation drains.	Potential increase in overland flow and potential flooding to adjacent properties.	Applicable in areas where overland flow does not cause a problem. To be assessed on an individual property basis.	Limited	Reduces local overland flooding problems.
	Rain Barrel	Reduces storm runoff by promoting re-use of roof runoff, thus reduces municipal water consumption.	Requires cooperation of home owner (may require financial assistance). Maintenance required to mitigate potential issues with mosquitoes.	Where space for barrel exists. May be used even where basement flooding has not occurred.	Feasible	Encouraged by the City.

Control Type	Control Measure	Advantage	Disadvantage	Applicability	Feasibility	Comments
Sanitary System	Replacing Perforated Sanitary Sewer Maintenance Hole Covers	Low-cost measure effectively reducing I/I in sanitary sewers.	None	At all streets where perforated sanitary maintenance hole covers exist so the overland flow can enter the storm sewer via catchbasins.	Feasible	Effective in reducing overland flow from entering the sanitary system.
	Sealing Sanitary Maintenance Hole Covers	Low-cost measure effectively reducing I/I in sanitary sewers.	None	At all streets where sanitary maintenance hole covers exist in low lying /sag areas so the overland flow can enter the storm sewer via catchbasins.	Feasible	Effective in low-lying areas. Reduces overland flow from entering the sanitary system.
	Pipe & Manhole Rehabilitation	Maintenance measure reducing I/I into sanitary sewer, thus reducing the need for construction.	None.	Should be focused where high I/I is evident.	Feasible	Easily identifiable I/I source. Part of O&M.
	System Storage (In-Line/Off-Line Storages)	Allows some flexibility regarding the location of construction. Construction generally less extensive than sewer replacement. Less O&M requirements than the underground storage tank. Does not require open space for implementation.	Requires favourable hydraulic conditions of existing sewer for optimal operation and minimal maintenance.	Anywhere where other utilities do not impose constraints and hydraulic conditions allow implementation.	Feasible.	Allows for no-net increase in sanitary flows to Don River STS.
	Pipe Upgrade (Pipe upsizing/Twinning)	Provides reduction/elimination of sewer surcharge and provides capacity for future growth.	Very disruptive construction due to the length of upgrades.	Anywhere where other utilities do not impose constraints.	Feasible.	Sanitary pipe upgrade required to improve flow capacity.
	Underground Storage Tank	More compact as storage is in one location and thus potentially less disruptive during construction than other alternatives for storage or flow capacity increases.	Requires open space for construction at the hydraulically effective location. Interferes with recreational land use during construction. Adds noticeable O&M costs of the system.	Applicable where and if open space (parkland, schoolyard, etc.) is available.	Feasible.	Limited opportunities as the study area is highly developed.
	Internal Diversion	Balances flow in existing systems with minimal construction.	Reduces/eliminates spare capacity in other parts of the system to accommodate more intensive storms.	Where system loadings vary substantially between areas and if receiving system can accommodate the influx.	Feasible.	Downstream impacts must be considered. Can be integrated with inlet control optimization. Construction of new pipes are required to balance flow in the existing system.
	Operations and Maintenance (i.e. Sewer Flushing)	Reduce I/I into sanitary. Prevent potential bottlenecks from grease/sediment build-up.	None.	Everywhere, particularly where basement flooding has occurred.	Feasible.	Continuation of maintenance cycles and inspections. More frequent O&M in areas of flooding occurrences.

Control Type	Control Measure	Advantage	Disadvantage	Applicability	Feasibility	Comments
Storm System	Inlet Control Devices (ICD)	Effective in controlling the storm water entering the storm system.	Water ponding will occur in open areas.	Applicable in situations where sewer surcharge causes basement flooding and overland flow is not a problem as the major drainage system has adequate outlet capacity and there are no sags in the street.	Feasible.	The entire area is suitable for inlet controls. Not desired at low points in the overland drainage system. Maximum 20 L/s per ICD and not more than 33% of the total number of catchbasins.
	Increase Inlet Capacity	Effective in rapidly conveying runoff from the ground into storm sewer system.	High capital costs and potential construction constraints if associated with new sewer construction. Very low capital cost if sewer capacity exists to accept additional flow in the system.	Applicable where the sewer system has extra capacity and overland flow causes flooding. Reduce overland flow depth.	Feasible.	Could be applied in low-lying areas where street ponding occurs, or areas where there's overland flooding issues with under-capacity sewer conveyance.
	System Storage (In-Line/Off-Line Storages)	Effective in regulating/moderating peak flows at locations where the capacity of a sewer is inadequate.	Costs can vary significantly depending on sewer depth and the presence of bedrock. Land/space requirements can limit the application of the inline/off-line storage.	Applicable in situations where head and space on the street are available. Most effective if the downstream sewer system does not have adequate capacity to convey the peak flow.	Feasible.	Option to avoid upgrading through private property. Limited ability to control HGL.
	Storm Relief Sewers/Pipe Upgrades/Outfall Upsizing	Effective in preventing surcharge of existing storm sewer system.	High capital cost due to construction constraints.	Applicable in situations where storm sewer is undersized.	Feasible.	Downstream impacts must be considered.
	Provide Stormwater Management Facilities	Effective in controlling storm water peak flows by temporarily storing runoff and releasing at a controlled rate. Added benefit of improved quality control.	The footprints of SW facilities occupy a significant amount of space.	Applicable where sufficient accessible open space is available.	Feasible.	Will require buy-in from different City departments. Safety must be considered.
	Overland Flow Diversion and Outlets	Reduced capture of runoff into the storm sewer by re-directing runoff into grass areas or overland routes with adequate capacity.	Difficult to implement urbanized areas due to limited availability of open/grassed areas.	Applicable in situations where accessible overland flow routes or natural channels are available.	Feasible.	Downstream impacts must be considered. Cannot be over private property.
	Internal Diversion	Balances flow in existing systems with minimal construction.	Reduces/eliminates spare capacity in other parts of the system to accommodate more intensive storms.	Where system loadings vary substantially between areas and if receiving system can accommodate the influx.	Feasible.	Downstream impacts must be considered. Can be integrated with inlet control optimization. Construction of new pipes is required to balance flow in the existing system.

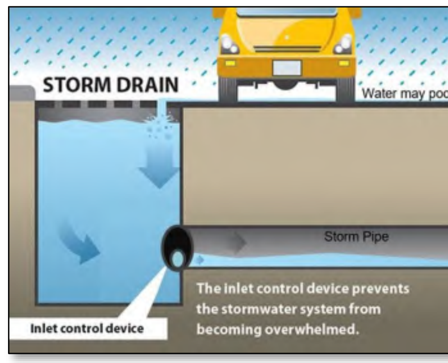
Considering that the Schedule B projects have alternative solutions which involve works on private properties, the following three types of alternatives were considered for each of the problem areas:

1. Alternative 1: Do Nothing:
   No mitigation measures would be taken for this alternative, with the exception of ongoing operation and maintenance activities together with emergency measures.

2. Alternative 2: Sewer Improvement Works within Easements
   This alternative involves improvement of the existing sewers that are on private property. Easements will need to be negotiated and obtained in order to implement the works. Improvement works include sewer upsizing to convey more flows.

3. Alternative 3: Catchbasin Improvement Works within Easements

   This alternative involves proposing Inlet Control Devices (ICD) on the existing catchbasins that are on private property to reduce the amount of contributing runoff to the sewer system. No construction works are expected as part of this alternative.



An illustration of an ICD (Source: Storm drains in Calgary)

7.4 Alternative Development Process and Sizing

Based on the list of feasible flood mitigation measures, alternative development considerations as listed in Section 7.1 and the study team’s design experience, solutions were developed and evaluated utilizing the InfoWorks model in order to meet the targeted level of service. The following describes the process of solution modelling and selection:

Sanitary Sewer System

The alternatives for the sanitary system are developed as follows:

1. Run the future conditions model under the May 12, 2000 event (Oriole Station) to identify any sewers that failed to provide the targeted level of protection for basement flooding;
2. Divert flow from the overloaded sewer to other parts of the sewer system that have adequate capacity; and / or
3. Increase sewer conveyance capacity by increasing sewer slope where feasible; and / or
4. Increase the capacity of the sanitary sewer system by upgrading the sewers to increase conveyance capacity and lower surcharge elevations below basement elevation; and / or

5. Provide in-line storage as required to ensure no net increase in the receiving sanitary trunk sewer peak flow under wet weather conditions;
6. If there are any known constraints that would prevent sewer upgrades (i.e. the requirement for an easement or access to private property), develop alternative solutions which will be presented in TM#4.

Storm Sewer and Overland System

The alternatives for the storm drainage system are developed as follows:

1. Run the 100-year design storm event to identify any sewers that failed to provide the targeted level of protection for basement flooding;
2. For storm sewers that indicate inadequate capacity, apply ICDs in street catch basins to limit the surface runoff entering the storm sewer while not exceeding the maximum allowable surface-ponding depth; and / or
3. If possible, divert flows from overloaded sewers to other parts of the sewer system that have adequate capacity; and / or
4. Increase the capacity of the local storm sewers to lower surcharge elevations below basement elevations; and / or
5. Apply storage (in-line or off-line) in areas where constraints preventing sewer upgrades are identified;
6. In areas where surface water ponding exceeds maximum allowable ponding depth:
    a. Provide additional inlets to the storm sewer if the sewers have adequate capacity.
    b. Collect excessive overland flow in a pipe/tank (*a “major system underground storage” dedicated for collecting excessive overland flow*) and release at a reduced flow rate to the existing sewer system if sewers do not have adequate capacity.

Shallow Storm Sewers

The alternative remediation measures for shallow storm sewers are developed as follows:

1. Identify shallow storm sewers that surcharge during the 100-year design event;
2. Check whether the surcharged storm sewer would pose any basement flooding concern, i.e. have a foundation drain connection.
3. If yes, check whether the surcharged shallow storm sewers have met the City’s minimum cover requirement. The minimum cover requirement is defined as 1.8m from road centreline to obvert of pipe and 1.2m from ground to obvert of pipe when in open spaces.
    a. If yes, upgrade the shallow storm sewer while maintaining the existing obvert elevation until a no surcharge condition is achieved.

   b. If not, then shallow storm sewers are subject to be upgraded or deepened. The new objective should be that of the 1.8m HGL clearance objective other than the no surcharging objective.
   c. In cases where shallow sewer deepening was limited by site conditions/constraints or cannot be achieved at a reasonable cost, a no surcharge condition must be achieved.
4. If no, record the location in the non-compliant exception table and provide reasons for why no solutions are proposed.

A combination of remedial measures were proposed for the different systems to reduce peak flows and lower the HGL and / or overland ponding depth until the models showed acceptable levels that meet the basement flooding design criteria.

7.5 Evaluation Criteria and Scoring System

In order to evaluate the alternative solutions identified in the previous sections evaluation criteria have been developed in order to select the preferred solution. The evaluation criteria include natural, socio-cultural, technical, and economic considerations. These criteria, together with a description of the criteria and measures for assigning scores are presented in **Table 7-3.**

7.6 Evaluation of Alternatives

For each of the comparative criteria a rating ranging from 1 to 4 (0 to 4 for capital cost criterion) was applied specific to the particular solution being evaluated where 1 represents the worst condition and 4 the best, as identified in **Table 7-4**. Based on this approach an overall rating based on the total scoring was obtained for each alternative solution. Subsequently a ranking was assigned for each alternative solution with the highest overall total assigned 1 and the others sequentially 2 and 3 based on the scoring. Where the total ratings are the same the same ranking was assigned. In the evaluation methodology proposed the best ranking corresponds to No. 1 and is the preferred solution. The worst ranking is the least desirable alternative.

A high-level summary of the existing system deficiencies and key features, as well as the explanation of scoring for each criterion of Alternative 2 and 3 for each project is provided below.

7.6.1 A65-ST-01 (William, Allen & Keele Area)

The HGL along various streets in the William, Allen& Keele Area is above the basement level and overland water levels exceed the threshold during the 100-year design storm. Various sewer segments are at capacity and there are bottlenecks within the system and the outfall is also at capacity. Both Alternative 2 and 3 includes sewer upsizing, storage box culverts, storm sewer downsizing and storm sewer slope change throughout the Schedule B project area. Alternative 2 proposes sewer upsizing while Alternative 3 considers inlet control device on the private property (350 Wildcat Road) where the City currently do not have an easement agreement. Alternative 2 is more expense than Alternative 3.

Natural Environment

No impact on the existing terrestrial system is expected for either Alternative 2 or Alternative 3 as the proposed works for both Alternatives are not adjacent to any vegetation, trees, parks or wildlife. Besides, as identified in **Section 4.3.2**, there is no designated Environmental Significant Areas in A65. As a result, a score of 4 is assigned to both solutions. There will be minimal impacts expected for the aquatic habitat, surface / groundwater, soil and geology and receiving water quality due to the type and location of proposed works for both Alternative 2 and 3; therefore, a score of 3 is assigned to Alternative 2 and 3.

Social-Cultural Environment

In general, none of the three alternatives would have much impact on land use, archaeological and cultural heritage and First Nations as all the project areas are developed and thus they have a score of 4 for these criteria. Alternative 2 is expected to have a greater level of disruption during construction in terms of access, construction impact, mitigation since larger infrastructure (sewer upsizing) is proposed. Therefore, Alternative 2 has a score of 2 whereas Alternative 3 (inlet control device) has a score of 4 as a result of its simple installation. Alternative 1 is expected to have the largest level of disruption after construction due to operation and maintenance activities associated with existing deficient drainage system. Alternative 3 also requires a certain level of effort after construction, e.g., maintenance on a regular basis, which leads to a score of 2.

Technical Considerations

Alternative 2 scores higher than Alternative 3 in effectiveness in reducing flooding. Alternative 1 scores the lowest. Alternative 2 is expected to be more feasible in terms of constructability and requires less operation and maintenance activities; thus, it scores higher comparing to Alternative 3. However, Alternative 2 and Alternative 3 are expected not to have potential impacts on the downstream or surrounding area infrastructure so they both score a 3.

Economic Considerations

For the construction cost and operation and maintenance cost criteria Alternative 2 scores lower than Alternative 3 in terms of Capital Construction Costs since inlet control devices are typically cheaper than sewer upgrades. However, inlet control devices would require some level of inspection and maintenance.

Table 7-3: Evaluation Criteria

Criteria	Description of Criteria	Measures for Assigning Scores
Natural Environment		
Potential Impact on Terrestrial Systems (Vegetation, Trees in Valleys and Parks, Wildlife)	Potential to impact terrestrial habitats or systems, including terrestrial features / functions (ANSIs, ESAs), unique vegetation species or wildlife	Scores are assigned as follows: • 4 – no impact on usage or vegetation • 3 – limited impact on usage or vegetation • 2 – moderate impact on usage or vegetation • 1 – significant impact on usage or vegetation
Potential Impact on Aquatic Systems, Aquatic Life and Aquatic Vegetation	Potential to impact aquatic habitats or systems, including possible impacts on aquatic life, features / functions	Scores are assigned as follows: • 4 – improves aquatic habitats or systems • 3 – no impact on aquatic habitats or systems • 2 – moderate impact on aquatic habitats or systems • 1 – significant impact on aquatic habitats or systems
Potential Impact on Surface and Groundwater	Potential to impact surface and groundwater characteristics (water volumes, recharge, etc.)	Scores are assigned as follows: • 4 – improves surface/groundwater characteristics • 3 – no impact on surface/groundwater characteristics • 2 – moderate impact on surface/groundwater characteristics • 1 – significant impact on surface/groundwater characteristics
Soils and Geology	Potential to impact soils and geology characteristics	Scores are assigned as follows: • 4 – improves soil and geology characteristics • 3 – no impact on soil and geology characteristics • 2 – moderate impact on soil and geology characteristics • 1 – significant impact on soil and geology characteristics
Receiving Water Quality	Potential to impact water quality at the receiving watercourse	Scores are assigned as follows: • 4 – improves water quality at receiving water course • 3 – no impact on water quality at receiving water course • 2 – moderate impact on water quality at receiving water course • 1 – significant impact on water quality at receiving water course
Socio-Cultural		

Criteria	Description of Criteria	Measures for Assigning Scores
Land-use Impacts (parks, ravines, open spaces)	Potential of alternative to impact vegetation, street trees, public parks and open spaces and associated wildlife	Scores are assigned as follows: • 4 – less than 20% of moderate - high caliber trees are impacted • 3 – 20-40% of moderate - high caliber trees are impacted • 2 – 41-60% of moderate - high caliber trees are impacted • 1 – 61-80% of moderate - high caliber trees are impacted • 0 – greater than 80% of moderate - high caliber trees are impacted
Community Disruption During Construction	Potential to disrupt the community in terms of access to the site, visibility, road access, construction of mitigation measure in valley lands / parks, possible noise / odour / light, short-term construction impact, etc.	Scores are assigned as follows: • 4 – no community disruption • 3 – minor community disruption • 2 – moderate community disruption • 1 – significant community disruption
Community Disruption After Construction	Potential to disrupt the community in terms of permanent impacts on visual appearance, odour, and safety	Scores are assigned as follows: • 4 – no community disruption • 3 – minor community disruption • 2 – moderate community disruption • 1 – significant community disruption
Potential Impacts to Archaeological and Cultural Resources	Potential for alternative to cause permanent impacts to natural heritage and cultural resources	Scores are assigned as follows: • 4 – no impacts to cultural resources • 3 – minor impacts to cultural resources • 2 – moderate impacts to cultural resources • 1 – significant impacts to cultural resources
Impacts to First Nations	Potential for alternative to cause impacts to First Nations	Scores are assigned as follows: • 4 – no impacts to First Nations • 3 – minor impacts to First Nations • 2 – moderate impacts to First Nations • 1 – significant impacts to First Nations
Technical Considerations		
Effectiveness in Reducing Surface and Basement Flooding	Effectiveness of the alternative in the reduction of basement flooding and/or surface flooding in the study area based on the design criteria considered.	Scores are assigned as follows: • 4 –achieves stated requirements or better • 3 –achieves stated requirements

Criteria	Description of Criteria	Measures for Assigning Scores
		• 2 –limited effectiveness in achieving stated requirements • 1 – no effectiveness in achieving stated requirements
Improvement to Runoff Quality	Effectiveness of the alternative in improving water quality of runoff	Scores are assigned as follows: • 4 – high level of runoff quality improvement • 3 – moderate level of runoff quality improvement • 2 – limited improvement to runoff quality • 1 – no improvement to runoff quality
Feasibility of Implementation	The extent to which the alternative is feasible in terms of availability of space, accessibility, ease of construction, construction requirements.	Scores are assigned as follows: • 4 – feasible in terms of stated considerations • 3 – partially feasible in terms of stated considerations • 2 – limited feasibility in terms of stated considerations. • 1 – not feasible in terms of stated considerations
Upstream/Downstream Impacts on Surrounding Area Infrastructure	The impacts of the alternative in increasing the peak flow rate and total flow in the downstream receiving water system, upstream surcharging, and the surrounding area infrastructure	Scores are assigned as follows: • 4 – reduces the peak flow and total flow upstream/downstream • 3 – maintains the peak flow and total flow upstream/downstream • 2 – moderate impact in increasing the peak flow and total flow upstream/downstream • 1 – significant impact in increasing the peak flow and total flow upstream/downstream
Impacts on Operating and Maintenance Requirements	Impacts the alternative will have on current and future operating/ maintenance needs to service the infrastructure	Scores are assigned as follows: • 4 – Improvement to operating and maintenance requirements • 3 – Maintains the current level of operating and maintenance requirements • 2 – Moderate impact in increasing operating and maintenance requirements • 1 – significant impact in increasing the operating and maintenance requirements
Economic		
Capital Costs	The relative estimated capital cost as compared to the other alternatives	Scores are assigned as follows: • 4 – no capital cost • 3 – lowest capital cost of alternatives 2 and 3

Criteria	Description of Criteria	Measures for Assigning Scores
		• 2 – within 10% of the lowest of alternatives 2 and 3 • 1 – within 20% of the lowest of alternatives 2 and 3 • 0 – greater than 20% of the lowest of alternatives 2 and 3
Operating/ Maintenance Costs	The relative operation/maintenance cost as compared to the other alternatives	Scores are assigned as follows: • 4 – Reduces operating and maintenance costs • 3 – Maintains current level of operating and maintenance costs • 2 – Moderate impact in increasing operating and maintenance costs • 1 – significant impact in increasing the operating and maintenance costs

Table 7-4: Evaluation of Alternatives for A65-ST-01: William, Allen & Keele Area

Evaluation Criteria	Alternative 1: Do Nothing	Alternative 2: Works within Easement	Alternative 3: Works within ROW
Physical/Natural Environment			
Potential Impact on Existing Terrestrial Systems	4	4	4
Potential Impact on Aquatic Habitat	3	3	3
Surface/Groundwater Impacts	3	3	3
Soil and Geology	3	3	3
Receiving Water Quality	3	3	3
Social/Cultural Environment			
Land Use Impacts (Parks, Ravines, Open Spaces)	4	4	4
Community Disruption During Construction	4	2	4
Community Disruption After Construction	1	4	2
Potential Impacts to Archaeological and Cultural Resources	4	4	4
Impacts to First Nations	4	4	4
Technical/Engineering Considerations			
Effectiveness in Reducing Surface and Basement Flooding	1	4	2
Improvement to Runoff Quality	1	1	1
Feasibility of Implementation (Constructability)	4	3	2
Potential Impacts on Upstream/Downstream and Surrounding Area Infrastructure	3	3	3
Impacts on Operating and Maintenance Requirements	1	4	1
Economic Environment			
Capital Construction Costs	4	0	3
Operation/Maintenance Costs	1	4	2
Total Score	**48**	**53**	**48**

8 PREFERRED ALTERNATIVES

8.1 Recommended Solutions

The preferred remedial measure for the Schedule B project is listed and described in **Table 8-1.** A detailed figure illustrating the preferred works for the project is provided in Appendix E. In addition to the proposed works, the following remediation measures are applicable to this project:

- Downspout disconnection of 75% for all the roofs (i.e. 75% was assumed as the baseline).
- Regular maintenance of sewers and catchbasins such as visual inspection and clearing blocked catchbasins, regular sewer flushing and cleaning of oil/grit separators.
- Replacement of perforated maintenance hole covers at low points with water-tight covers.
- Sealing of sanitary maintenance hole covers at low points with water-tight covers.
- Implementation of source control at lot level (i.e. backflow prevention, lot regrading in properties with reverse-sloped driveway, etc.) as stated in **Section 7.2** should be encouraged for the entire study area.

Table 8-1: Preferred Solutions

Project ID	Preferred Alternative
A65-ST-01: William, Allen & Keele Area	Alternative 2: Sewer Improvement Works within Easement

8.2 Effectiveness of the Preferred Alternatives

8.2.1 Achieving Basement Flooding Design Criteria

The effectiveness of the preferred alternatives in relieving basement flooding problems under the target basement flooding design criteria was determined using the InfoWorks model. The preferred alternative solutions were included in the model and simulations were carried out under the design storm conditions identified for the considered level of service. The following sections describe the sanitary and storm drainage system performance with the implementation of the preferred solutions.

Sanitary Sewer System

The results of the sanitary sewer system performance with the preferred Solutions under the May 12, 2000 storm are shown in **Figure 8-1**. The results show that the basement flooding criteria was achieved with the implementation of the preferred alternative.

There are a few exceptions where the basement flooding criteria are not met with the implementation of the preferred alternatives are areas located in the valley with no lateral basement connections. **Table 8-2** lists the sanitary nodes that are unable to meet the basement flooding protection criteria along with a description of why the criteria was not met.

Table 8-2: Exception – Sanitary Maintenance Holes with a Freeboard Less Than 1.8m

Manhole ID	Ground Elevation (m)	Predicted Water Level (m)	Freeboard (m)	Reasons for Criteria Noncompliance
MH4711907481	189.484	187.84	1.65	Considered low-risk, no house connections assumed at this location.

Storm Sewer System

The results of the storm sewer system performance with the preferred Solution under the 100-year design storm is provided in **Figure 8-2**. In general, the results show that preferred Solution provides the targeted level of protection for all properties in Area 65.

The locations where the basement flooding criteria are not met are areas located in the valley or a park with no lateral basement connections. Additional locations where basement flooding criteria was not met was along the CN railroad line, where **Table 8-3** lists the storm nodes that are unable to meet the basement flooding protection criteria along with a description of why the criteria was not met.

Overland System

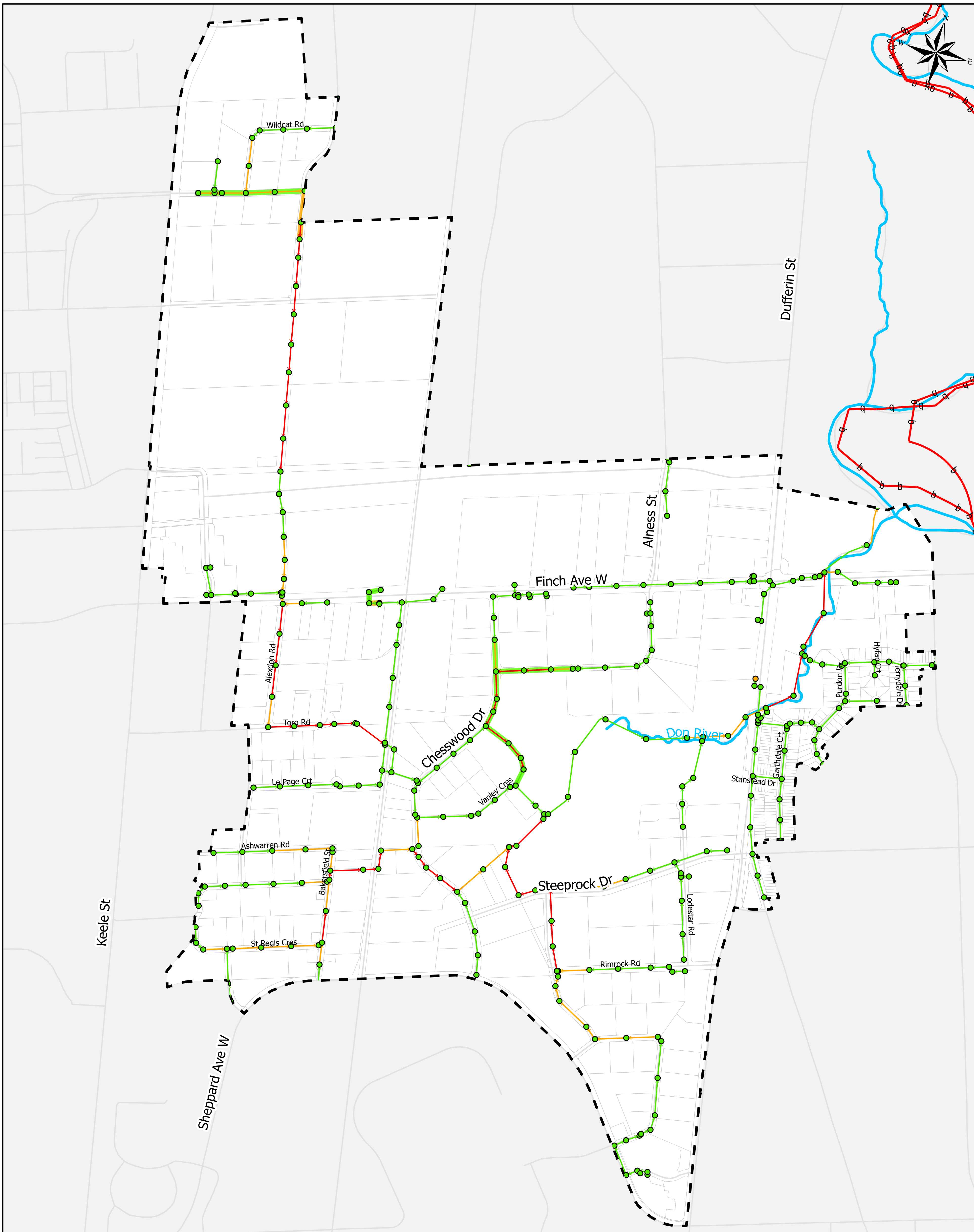
The results of the overland flow system under the 100-year design storm are illustrated in **Figure 8-3.** The results indicate that the overland flow depth is contained within the municipal right-of-way following the design criteria described in **Section 6.1.**

8.2.2 Impacts on and from Downstream Sewer System and Watercourses

Sanitary Sewer System

The sanitary sewer system in the study area discharges to the West Don sanitary trunk sewer (STS) that ultimately drains into the Ashbridges Bay wastewater treatment plant. The proposed sanitary system remediation measures consist of upgrading a selection of sanitary sewers providing storage control and improving flow conveyance. This will result in a net benefit in terms of the peak flow rate discharged to the trunk sewers. **Table 8-4** shows the comparison of the peak flows at the outlets to the sanitary trunk sewer under the existing and proposed conditions during the May 12, 2000 storm. The comparison was conducted based on the 2041 population growth.

As documented in TM#2, free-flow conditions are assumed at the trunk sewer connections since no trunk sewer back-up was determined within the study area. As a result, no impact from the trunk sewer system is expected.



Legend

- Municipal Boundaries
- Sanitary Boundary (Revised)
- Property Parcel
- Road Centreline
- Watercourse (TRCA, 2012)
- Sanitary Trunk Sewer

Proposed Improvements:

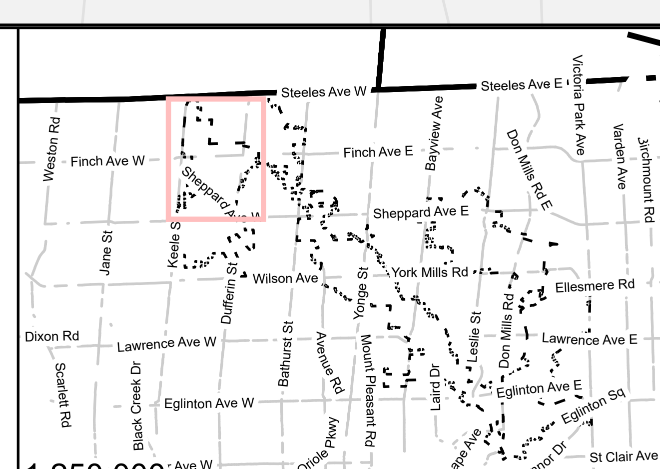
- Downsizing
- New Sewer
- Slope
- Storage
- Upsizing
- New Manhole

Hydraulic Grade Line:

- At or Above Surface
- Within Basement Level (0-1.8m)
- Below Basement (>1.8m)

Sanitary Sewers:

- Bottleneck
- At capacity
- Within Capacity



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Project: Toronto Basement Flooding Study Area 65

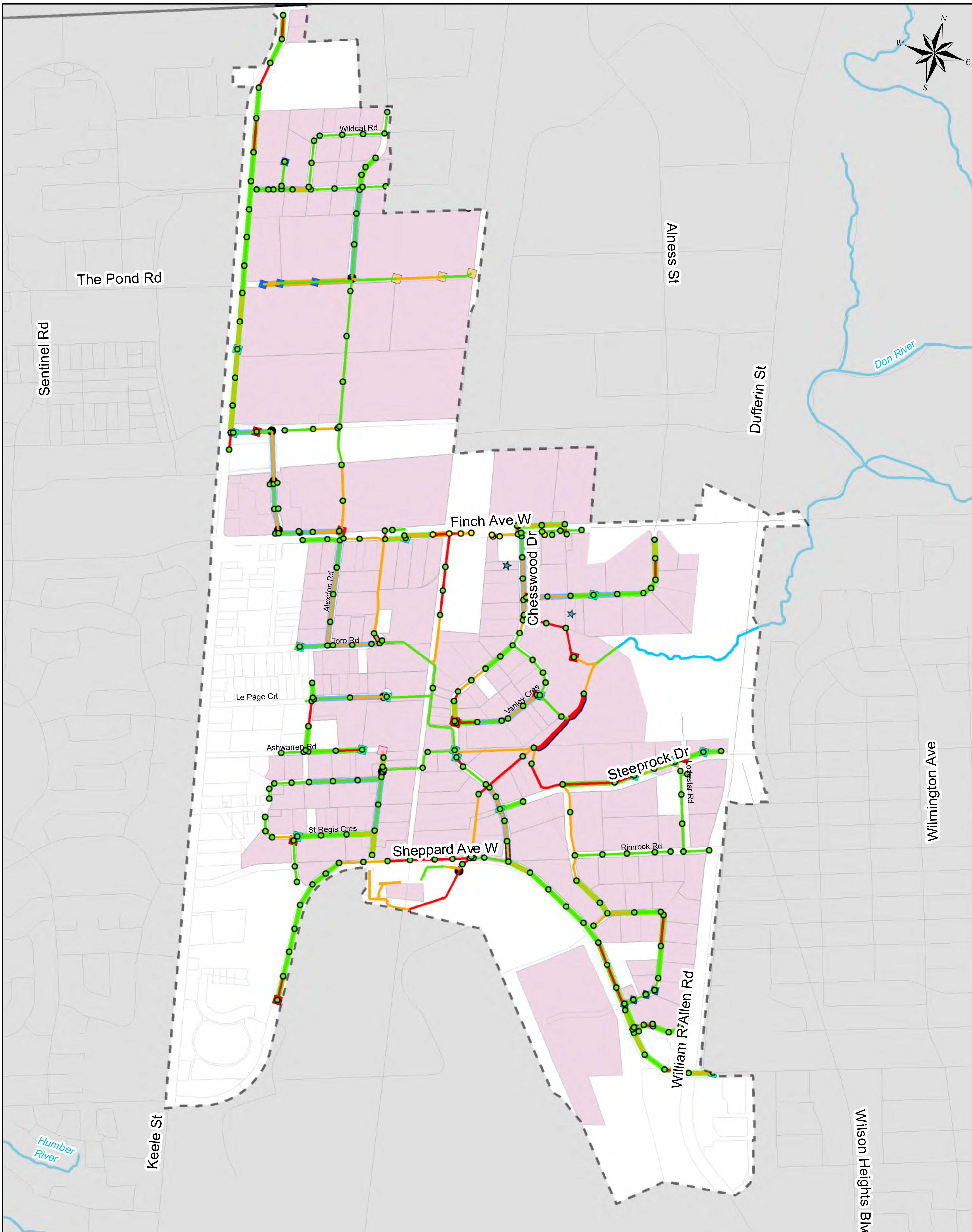
Figure 8.1 - Sanitary System Performance with Preferred Solutions Under May 12, 2000 Event, Future Conditions

Projection: NAD_1983_CSRS_MTM_10
Data Source: City of Toronto, TRCA, LIO

Date: November, 2021

0 0.15 0.3 0.6 Kilometers

1:12,000



Legend

Municipal Boundary

Proposed Catchbasin Improvements:

- New Manhole
- New Catchbasin
- Replace Existing Catchbasin with High Capacity Inlet
- Replace Existing Catchbasin with Inlet Control Device
- New Catchbasins and Replace Existing Catchbasin with Inlet Control Device
- New Catchbasins and Replace Existing Catchbasin with High Capacity Inlet
- New Manhole, New Catchbasins, and Replace Existing Catchbasin with High Capacity Inlet

Storm Boundary

ICI Areas

Property Parcel

Road Centreline

Watercourse (TRCA, 2012)

Proposed Sewer Improvements:

- Redirection
- New Storage
- New Storm Sewer
- Storm Sewer Slope Change
- Replacement of Storm Sewer with Storage Box Culvert; Storage
- Storm Sewer Upsizing
- Storm Sewer Downsize

Flooding Report Date (76):

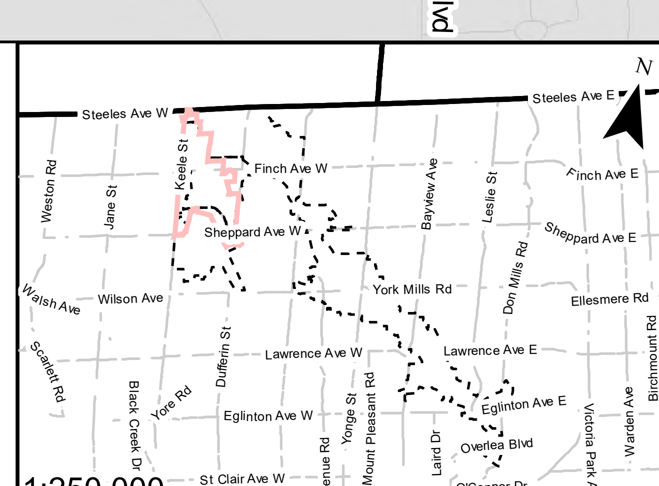
- May 12, 2000
- Aug 19, 2005
- Jul 8, 2008
- Jul 8, 2013
- Oct 16 & 20, 2014
- Aug 7, 2018

Stormwater Manhole:

- At or Above Surface
- Within Basement Level (0-1.8m)
- Below Basement (>1.8m)

Stormwater Sewers:

- Surcharge State = 2 (Bottleneck)
- Surcharge State = 1 (Backup)
- Within Capacity (No Surcharge)



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Project: Toronto Basement Flooding Study Area 65

Title: Figure 8.2 Storm System Preferred Solutions - 100Yr Design Storm

Projection: NAD_1983_CSRS_MTM_10
Data Source: City of Toronto, TRCA, LIO

Date: August, 2021

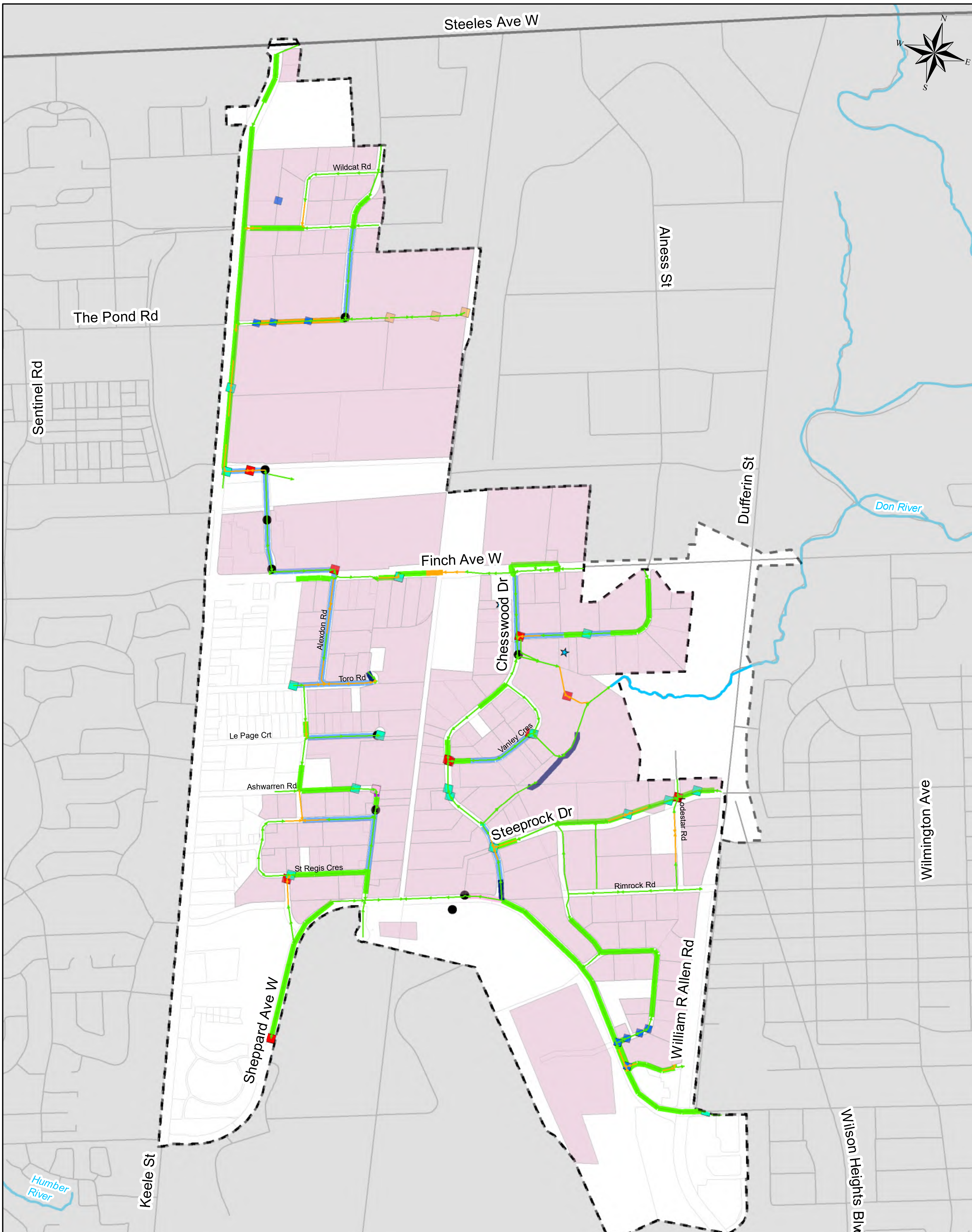
0 0.175 0.35 0.7 Kilometers

1:14,000

Table 8-3: Exception – Storm Maintenance Holes with a Freeboard Less Than 1.8m

Node ID	Ground Elevation (m)	Predicted Water Level (m)	Freeboard (m)	Reasons for Criteria Noncompliance
MH4712106502	195.44	196.427	0.99	The shallow storm sewers do not have to meet 1.8 m HGL criteria as there is no surcharging and the proposed HGL is not worse that the existing.
MH4712906526	195.35	196.36	1.01	The shallow storm sewers do not have to meet 1.8 m HGL criteria as there is no surcharging and the proposed HGL is not worse that the existing.
MH4717706687	198.00	199.224	1.23	The shallow storm sewers do not have to meet 1.8 m HGL criteria as there is no surcharging and the proposed HGL is not worse that the existing.
MH4712606495	195.26	196.728	1.46	The shallow storm sewers do not have to meet 1.8 m HGL criteria as there is no surcharging and the proposed HGL is not worse that the existing.
MH4685207370	178.86	180.183	1.32	Maintenance hole in the valley and it assumed no basement connections here.
MH4710106382	192.41	192.702	0.29	Storm sewer improvement at this location would require works below CN railroad bridge. Storm improvements to reduce the HGL at this location were proposed downstream to avoid work below the CN railroad bridge. Preventative measures at this location also included meeting the overland flow depth for collector roads. Additionally, this node may also be considered as an exception because it is assumed that there are no basement connections here.
MH4708906340	191.79	192.7	0.91	Storm sewer improvement at this location would require works below CN railroad bridge. Storm improvements to reduce the HGL at this location were proposed downstream to avoid work below the CN railroad bridge. Preventative measures at this location also included meeting the overland flow depth for collector roads. Additionally, this node may also be considered as an exception because it is assumed that there are no basement connections here.

Node ID	Ground Elevation (m)	Predicted Water Level (m)	Freeboard (m)	Reasons for Criteria Noncompliance
MH4707006281	192.33	193.314	0.99	Storm sewer improvement at this location would require works below CN railroad bridge. Storm improvements to reduce the HGL at this location were proposed downstream to avoid work below the CN railroad bridge. Preventative measures at this location also included meeting the overland flow depth for collector roads. Additionally, this node may also be considered as an exception because it is assumed that there are no basement connections here.
MH4711306420	192.97	194.665	1.69	Storm sewer improvement at this location would require works below CN railroad bridge. Storm improvements to reduce the HGL at this location were proposed downstream to avoid work below the CN railroad bridge. Preventative measures at this location also included meeting the overland flow depth for collector roads. Additionally, this node may also be considered as an exception because it is assumed that there are no basement connections here.



Legend

Proposed Catchbasin Improvements:
- New Manhole
- New Catchbasin
- Replace Existing Catchbasin with High Capacity Inlet
- Replace Existing Catchbasin with Inlet Control Device
- New Catchbasins and Replace Existing Catchbasin with Inlet Control Device
- New Catchbasins and Replace Existing Catchbasin with High Capacity Inlet
- New Manhole, New Catchbasins, and Replace Existing Catchbasin with High Capacity Inlet

- Municipal Boundary
- Storm Boundary
- ICI Areas
- Property Parcel
- Road Centreline
- Watercourse (TRCA, 2012)

Flooding Report Date (76):
- May 12, 2000
- Aug 19, 2005
- Jul 8, 2008
- Jul 8, 2013
- Oct 16 & 20, 2014
- Aug 7, 2018

Proposed Sewer Improvements:
- Redirection
- New Storage
- New Storm Sewer
- Storm Sewer Slope Change
- Replacement of Storm Sewer with Storage Box Culvert; Storage
- Storm Sewer Upsizing
- Storm Sewer Downsize

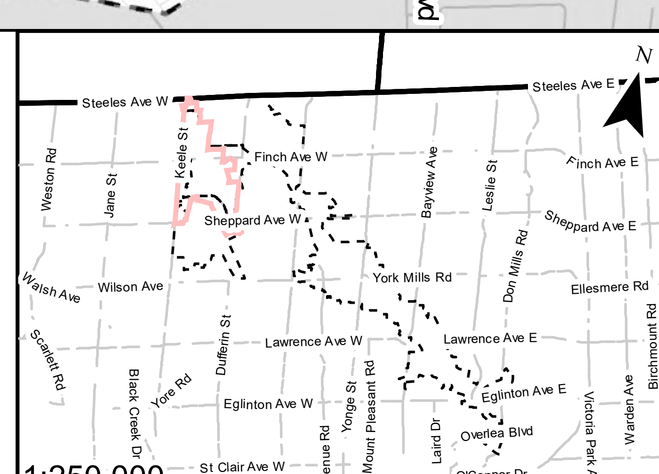
Rural Road Overland Depth
- >=0.235m
- <=0.15m

Local Road Overland Depth
- >=0.235m
- 0.15m - 0.235m
- <=0.15m

Open Channel Overland Depth
- >=0.5m
- 0.15m - 0.5m
- <=0.15m

Arterial Road Overland Depth
- >=0.227m
- 0.15m - 0.226m
- <=0.15m

Collector Road Overland Depth
- >=0.21m
- 0.15m - 0.21m
- <=0.15m



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Project: Toronto Basement Flooding Study Area 65

Title: Figure 8.3 Overland System Preffered Solutions - 100Yr Design Storm

Projection: NAD_1983_CSRS_MTM_10

Data Source: City of Toronto, TRCA, LIO

Date: August, 2021

0 0.175 0.35 0.7 Kilometers

1:14,000

Table 8-4: Peak Flows Outleting to Sanitary Trunk Sewer During May 12, 2000 Storm

Outlets ID	Peak Flow (m3/s) (Under May 12, 2000 Storm with 2041 Population)		Peak Flow Increase (%)
	Existing Conditions	Proposed Conditions	
MH5512525358	0.9	0.9	0%

Storm Sewer System

The proposed storage elements in Area 65 will reduce peak flow rates to the Don River at some locations. However, and despite the fact that the total tributary area to the Don River has not been changed and the overland flow will not be diverted to other watersheds, it is recognized that peak flows at various outfalls will be increased as compared to existing conditions. This is a result of the improvement of the conveyance capacity of the existing system and by providing conveyance for the trapped overland flow.

Table 8-5 compares the peak flow rate and maximum velocity for the 2- and 100-year design storm events between baseline and future conditions with the preferred solutions in place. The analysis revealed that the outfall shows decrease in peak flow rates during the 2-year storm and the 100-year design storm.

Table 8-5: Peak flows during the 2-year and the 100-year design storms

Assignment ID	Outfall ID	Outfall Shape	Outfall Diameter (mm)	2-Year Peak Flow (m3/s)			100-Year Peak Flow (m3/s)		
				Existing	Preferred Solution	Change	Existing	Preferred Solution	Change
A65-ST-01	OF4683907059	RECT	3000*2100	18.8	14.5	-23%	42.5	38.3	-10%

8.3 Cost Estimates and Cost Per Benefiting Property

Preliminary cost estimates were prepared for the preferred Solution for the Schedule B project using the Basement Flooding Protection Program Phase 4 – Cost Estimating Tool (CET) and Guideline (Version 4.1) provided by the City. This tool estimates cost based on the pipe size, depth and length of sewer. The CET was developed to ensure the cost estimates prepared for projects during planning, preliminary design, detailed design are based on uniform and consistent standards for all Basement Flooding EAs. It should be noted that:

- This study is identified as “Class 4 (EA Estimate)” by the guideline. The Cost Estimation Tool and Guideline uses percentages of the capital cost to define items that cannot be readily estimated (i.e. watermain replacement, water main service connections, permanent restoration).
- The unit rates used in this tool were developed through a comparison between BFPP1,2, 3 and 4 contracts that were able to provide unit costs for standard pipes and inlets.

- The unit cost has been reviewed by an engineer specialising in linear infrastructure. The unit costs were considered to be reasonable for cost estimation during this phase of the project. Additional unit cost reviews will be completed during the preliminary and detailed design phases of the project.
- The individual cost includes land acquisition or easements but excludes contingency, engineering costs or applicable taxes.
- Costs are rounded to the closest thousands.

The costs were then used to calculate the Cost Per Benefiting Property (CPBP) by dividing the Total Benefiting Household Cost by the total number of benefiting properties. It should be noted that the Total Benefiting Household Cost excludes the BF sanitary sewer and maintenance hole improvement works (unless relocated to accommodate other BF works), additional scope and provisional allowances. Benefiting properties are defined as the houses that move from not meeting the City's BFPP criteria to meeting the BFPP criteria with the implementation of the recommended improvements. The estimated construction cost and CPBP are summarized in **Table 8-6.**

Table 8-6: Estimated Cost Per Benefitting Property

Problem Area	Preferred Alternative	Estimated Costs	Cost per Benefitting Property
A65-01: William, Allen & Keele Area	Alternative 2: Sewer Improvement Works within Easement	$194,133,000	$744,075
Sub-Total		**$194,133,000**	**-**
Contingency (30%)		$58,240,000	-
Engineering Costs (10%)		$19,413,000	-
Total		**$271,786,000**	**-**

8.4 Review of Constructability

The constructability review was undertaken by Parsons to confirm the constructability, functionality and feasibility of each preferred Solution based on the information that is available at this point including the City's current design guidelines and modelling guidelines and GIS database provided at the onset of the study. Risks associated with implementing the proposed Solutions, such as schedule risks, impact to the public, permitting, land acquisition, and others were identified. Furthermore, property / easement requirements for the preferred Solutions were also reviewed and a preliminary cost estimate for each preferred Solution was prepared using the City's current CET. The sections as provided below include a summary of the constructability review approach, criteria and results. The constructability review report is attached as **Appendix D3**.

8.4.1 Constructability Review Approach and Criteria

As mentioned in **Section 7.1** the study team's design experience was utilized during solution development in order to assist in the constructability review process. Upon receipt of the background municipal infrastructure information and preferred Solutions the Preliminary Design (PD) team undertook the constructability review for four of the representative examples presented during the TM#3 Workshop (Robert Hicks Drive Area, Arjay Crescent Area, Wilson Avenue Area, and York Mills Road Area). The constructability review included:

- Hydraulic Criteria;
- Minimum Cover;
- Potential Utility Conflicts;
- Traffic Management;
- Archeologic Potential; and
- Easement Requirements

The proposed Solutions for the four representative examples were reviewed in detail against the City's hydraulic criteria, infrastructure conflicts, and property requirements to determine the constructability issues. The constructability review approach and the results for the four representative areas were presented to the City in a workshop on July 20th, 2021 to seek comments from City staff.

Based on discussions with the City during the July 20, 2021 workshop together with the consideration that there is limited private underground utility information at this stage in the design it was agreed that the greatest constructability risks amongst the preferred solutions for this study area would be with:

- Large diameter municipal infrastructure greater than 400mm diameter for watermains and 450mm diameter for sewers;
- Proposed works on arterial roads, or intersecting on an arterial road, where the potential conflict with large diameter private underground utilities is the highest; and
- Proposed design solutions which require temporary or permanent easements or property acquisition requirements.

Considering the large number of flood clusters within the four study areas it was also agreed that a simplified approach to the constructability evaluation would be appropriate. Thus, the constructability review criteria and constructability evaluation for the remaining preferred Solutions was simplified to the key constructability risks identified above.

Upon completion of the initial constructability review any preferred Solutions with constructability issues which are mainly related to the key constructability risks mentioned-above, were summarized and provided to the study team. The necessary changes to the preferred solution to address any constructability issues were then made.

8.4.2 Summary of Constructability Review

As noted above the constructability report addressed various considerations to address the constructability, functionality and feasibility of each preferred Solution. In addition, the report also summarizes items which are beyond constructability such as issues related to potential lane closures, hydraulic criteria and traffic impacts which will be considered at the preliminary or detail design stages. In general a number of conflicts were identified. In order to avert the conflicts there are numerous locations where design adjustments will need to be undertaken. Provided below is a summary of the three types of measures that will need to be undertaken to avoid typical utility conflicts. It should be emphasized that the conflicts as shown relate to only the storm, sanitary or water mains as information related to bell, gas, hydro etc. was not available. These potential conflicts will be addressed at the preliminary design stage for the preferred solutions that are brought forward.

- **Typical #1**: This situation occurs when a proposed storm box culvert is to be constructed and there is a conflict with respect to the sanitary sewer adjacent to the proposed box culvert. In this case it will likely be necessary to install a second sanitary sewer and realign the storm box sewer. The second sanitary sewer is also generally required in order to allow house laterals, which would not clear the top of the storm box culvert, to remain connected. An illustration of this situation is shown in **Figure 8-4**.
- **Typical #2**: This situation typically occurs at an intersection when the proposed infrastructure is in conflict with an existing storm or sanitary sewer or water main. In this situation the proposed infrastructure (typically a box culvert) would need to be divided as shown in **Figure 8-5**.
- **Typical #3**: This situation occurs when there is a minor increase or grade change in the proposed sewer in order to meet the hydraulic criteria as defined through the process. These situations were identified during the constructability review but were defined as minor issues which can be addressed at the preliminary design stage.

For some of the preferred solutions there is more than one conflict so Typical #1 and #2 may be required.

Table 8-7 shows the locations where constructability issues were identified. Also shown in the table is the typical, as noted above, which would be applied to address each issue.
Figure 8-6 illustrates all crossings between the proposed solutions and the watermains/sewers.

Table 8-7: Summary of Constructability Review Results

No.	Project ID	Approximate Location	Constructability Review Results Potential Utility Conflicts	Study Team Response
1	A65-SA-01	Champagne Drive Area	Yes	Typical Detail #2
2	A65-ST-01	William, Allen & Keele Area	Yes	Typical Detail #1 & #2

No.	Project ID	Approximate Location	Constructability Review Results Potential Utility Conflicts	Study Team Response
3	A65-ST-02	Finch Avenue W. Area	No	-

Note: "-" indicates no conflicts identified and no response required.

8.5 Implementation

Due to the City's capital budgeting limitations basement flooding projects are typically prioritized based on a number of factors to be included in the capital budget for implementation in the near future or placed on hold. One of the key factors is the CPBP. Projects that meet the City's CPBP threshold ($68,000) would be placed in consideration to move into the next phase and the ones that exceed the threshold would be placed on hold. The projects that meet the CPBP threshold should be scheduled in tandem with other divisional capital projects such as road resurfacing or watermain replacement as they occur and budget allows.

As mentioned in **Section 1.2**, thirteen Assignments with a total estimated construction cost of $47.25 million have been selected to move into preliminary design phase as part of the Capacity Assessment Study. These projects which have a final CPBP less than the City's CPBP threshold ($68,000) will be brought forward and budgeted in the City's capital budget within the next decade or so.

A65-ST-01 (William, Allen & Keele Area) will likely be placed on hold for a considerable period as it exceeds the CPBP threshold. Nevertheless, the actual implementation of the Schedule B project may range from a few years to a few decades. Moreover, an EA document typically needs to be revisited and updated every 10 years. Considering the unknown timeframe at this point supporting information for the Schedule B project may need to be updated prior to the implementation.

The objectives of this chapter are to define general requirements and describe the next steps for the Schedule B projects in order to move to the preliminary or detail design to construction stage which generally include:

- Additional Improvement Considerations;
- Updates to EA Document;
- Preliminary design;
- Considerations at detailed design;
- Mitigation of potential impact considerations;
- Environmental approvals and permitting; and
- Construction documents preparation and construction.

A general description for the next steps is provided in **Section 8.5.1** to **Section 8.5.7.** and a summary of the requirements for each Schedule B project is provided in **Section 8.5.8**.

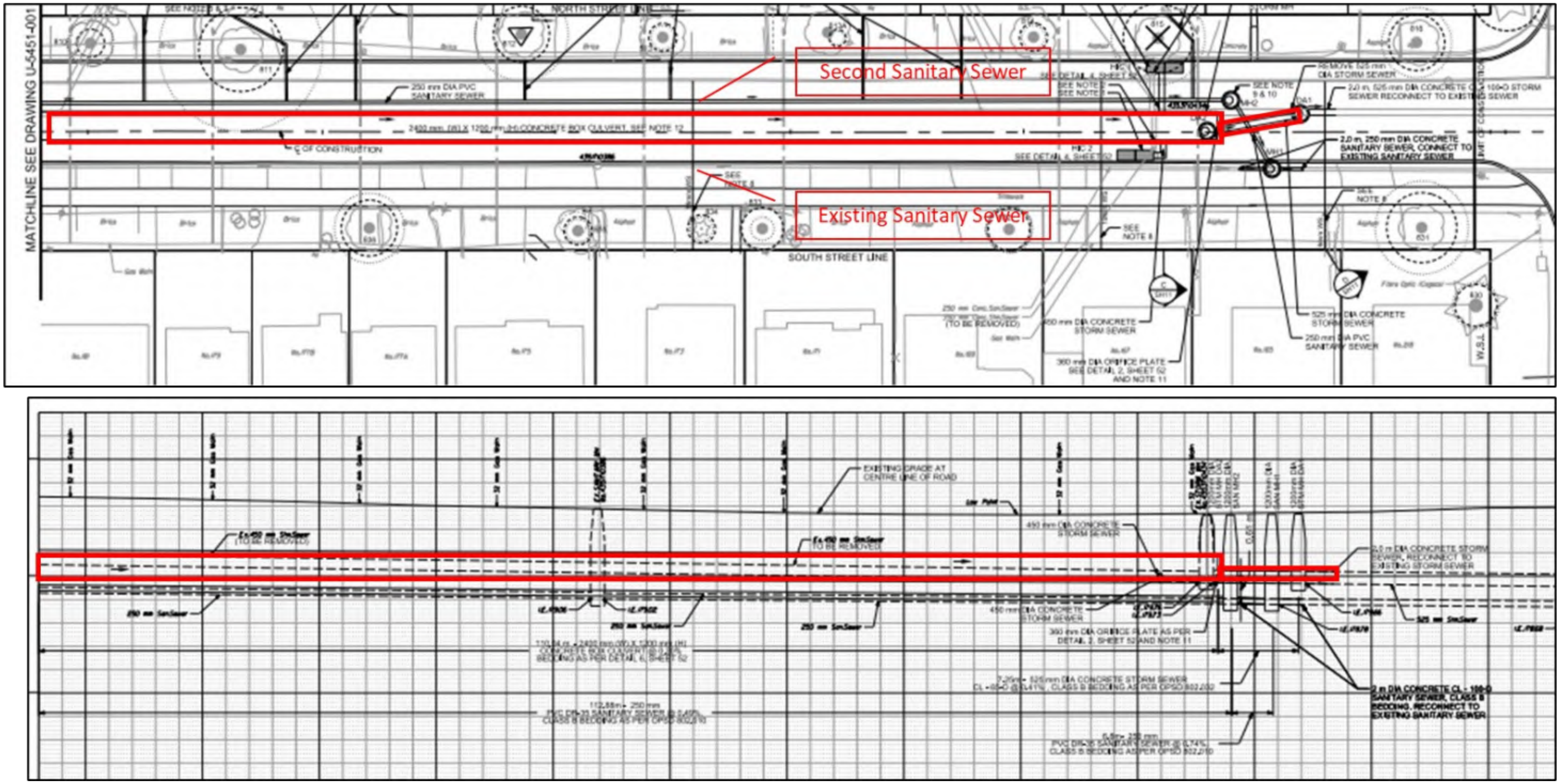


Figure 8-4: Typical Detail #1 – Implementation of a Second Sanitary Sewer

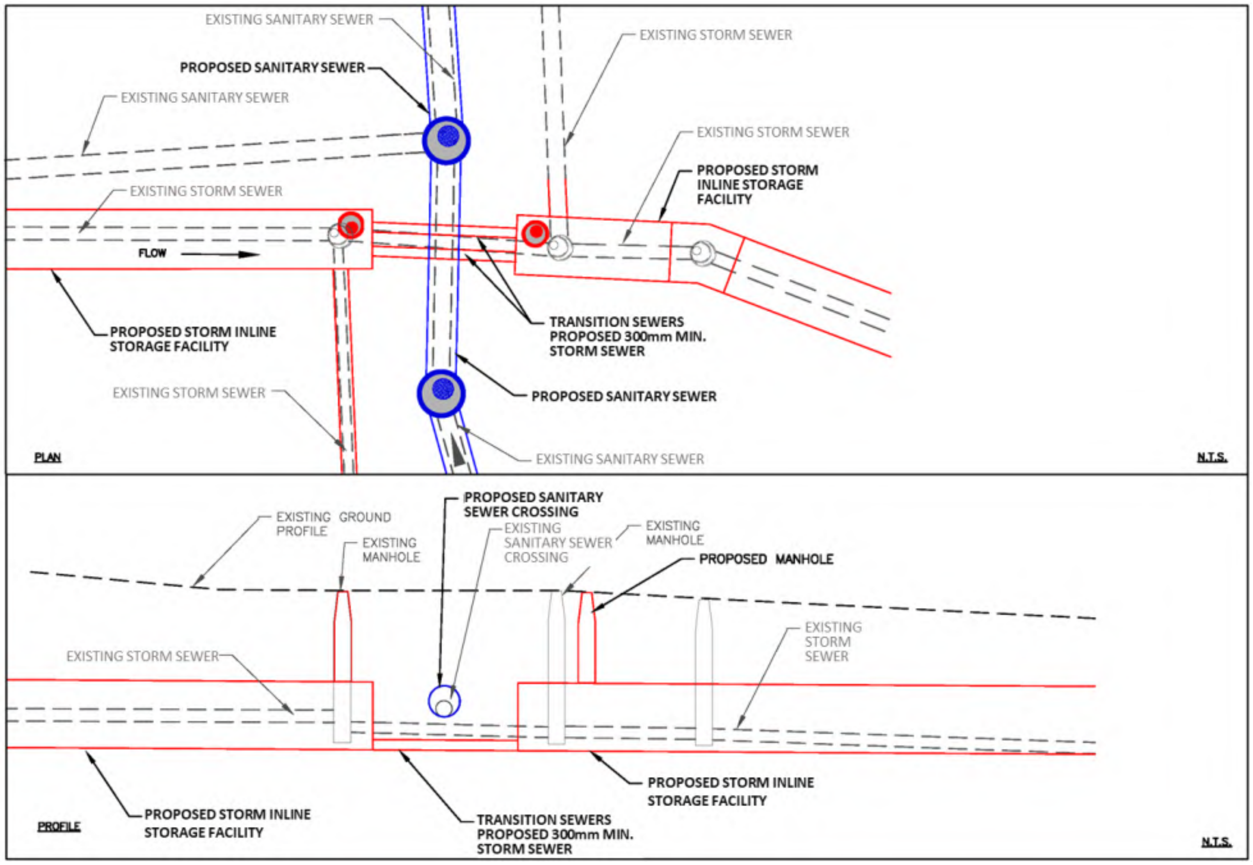
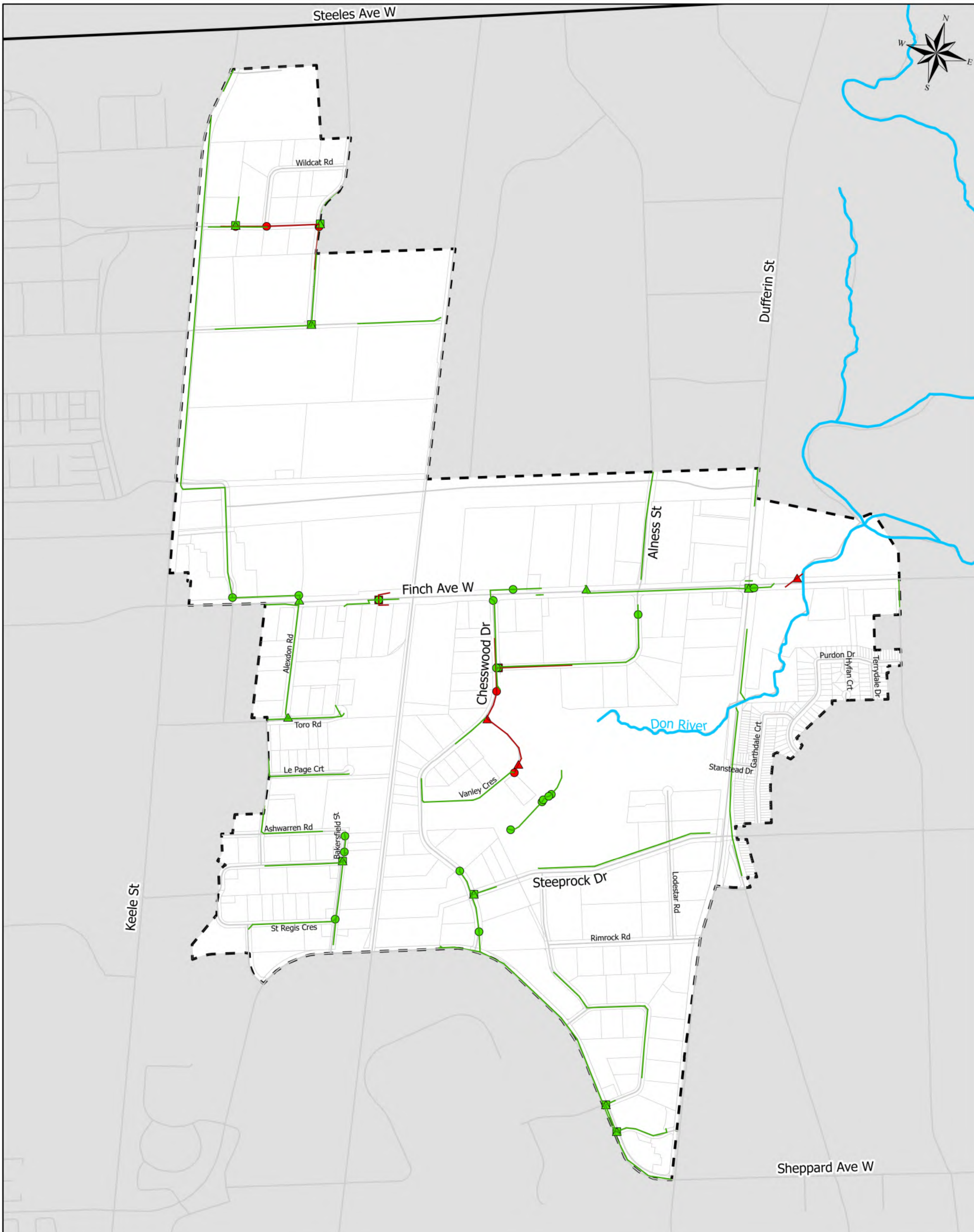


Figure 8-5: Typical Detail #2 – Control Detail for Proposed Inline Storage Facilities – Transition Sewer



Legend

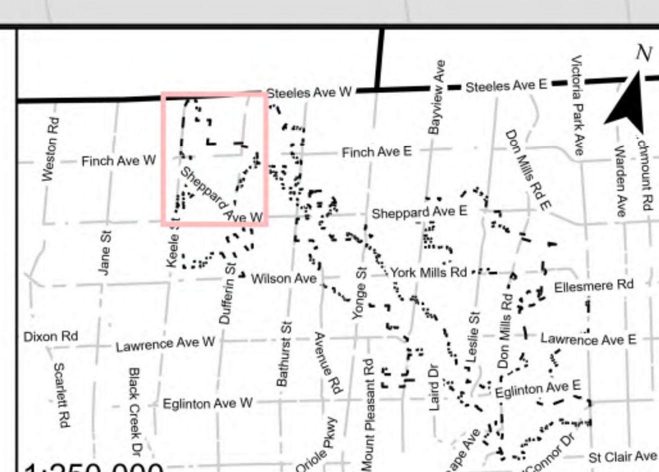
- Preferred Sanitary Solutions
- Preferred Stormwater Solutions
- Municipal Boundaries
- Property Parcel
- Road Centreline
- Watercourse (TRCA, 2012)

Potential Sanitary Sewer Solution Conflict:

- Crossing Existing Stormsewer
- Crossing Existing Watermain
- Crossing Existing Stormsewer | Crossing Existing Watermain

Potential Storm Sewer Solution Conflict:

- Crossing Existing Sanitary Sewer
- Crossing Existing Watermain
- Crossing Existing Sanitary Sewer | Crossing Existing Watermain



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Project: Toronto Basement Flooding Study Area 65

Figure 8.6
Potential Proposed Solution Conflicts

Projection: NAD_1983_CSRS_MTM_10
Data Source: City of Toronto, TRCA, LIO

Date: July, 2022

0 0.15 0.3 0.6
Kilometers

1:13,000

8.5.1 Additional Improvement Considerations

In addition to the proposed improvement works the following could be considered prior to undertaking preliminary or detailed design:

- Sealing of sanitary manhole covers is a very cost-effective remedial measure and could be implemented sooner than other measures which require consideration at the design and tendering stages.
- Implementation of roof downspout disconnections should have high a priority since this will significantly reduce potential basement flooding in most areas under the level of protection criteria. In some of the areas, the level of disconnection does not meet City's disconnection rate goal of 75%. Achieving a higher percentage of disconnection will be beneficial.
- Additional I/I investigation to identify the primary I/I sources. The outcome of this investigation may lead to refining the size and extent of the preferred remedial measures. As well, any reduction in I/I will reduce the risk of basement flooding from the sanitary system for the A65 – 01 William, Allen & Keele Area.

8.5.2 Updates to EA Document

As mentioned previously the implementation timeframe for this Schedule B project is currently unknown and could be a few decades. Typically, an EA document is to be revisited and updated every 10 years. Considering the unknown timeframe for the Schedule B project at this point supporting information for this project may need to be updated prior to the implementation. Some of the studies include:

- Natural Heritage Studies
  - Desktop assessment of terrestrial and aquatic conditions
- Fluvial Geomorphic Studies and Design
  - Geomorphic assessment of outfall channel and downstream stream segment
  - Erosion hazard assessment of receiving stream
  - Inventory of existing in-water erosion control structures
  - Post construction monitoring and reporting requirements of receiving channel
- Water Resources Studies
  - Confirmation of regulatory floodlines and downstream flood susceptibility
  - Hydraulic parameters of flood flows – frequent to regulatory
  - Significance of hydrologic impact to range of flood flows

8.5.3 Preliminary Design

The preliminary design will be undertaken for the Assignments that will be selected by the City as part of this project. The remaining Assignments will move into the preliminary design phase at a later stage based on the City's capital planning and coordination with other capital works and plans.

The preliminary design will include the following key tasks:

- Additional desktop and field data collection, including but not limited to:
  - Background information collection and review;
  - Consultation with utility companies;
  - Subsurface Utility Engineering Level B investigations;
  - Engineering surveys;
  - Tree survey; and
  - Archaeological and cultural heritage assessment.
- Review and analysis of rainfall and flow monitoring data collected during the study phase.
- Review of CCTV records.
- Additional modelling during the preliminary design phase.
- Preparation of preliminary design reports, including but not limited to:
  - Coordination with key stakeholders;
  - Completion and submission of a preliminary design package, including a 30% design package following City's standards and guidelines;
  - Preparation of cost estimates for all Assignments using the latest CET provided by the City;
  - Confirmation of Cost per Benefiting Properties calculations;
  - Identification of utility conflicts and relocation plans;
  - Confirmation of constructability, access/egress locations and staging areas;
  - Design of green infrastructure, if incorporated;
  - Refinement of solutions based on constructability and cost effectiveness;
  - Identification of Approval and Permitting requirements; and
  - Update of Scope Management Document.
- Coordination with other capital projects.

8.5.4 Considerations at Detailed Design

Should the City move forward with the Preferred Solutions then detailed design shall be initiated. The detailed design package should include the preparation of 50%, 70%, 95%, and final design drawings for review by the City and relevant stakeholders. The detailed design drawing package should include, but not be limited to, the following components:

- General plan (detailing structure, property lines and services);
- Site plan (including site access, staging and stockpile area delineation);
- Plan and profile drawings (detailing location of proposed utility bridge, existing utilities and existing bridge);
- Subsurface utility investigation (SUE) for field confirmation of all existing sewers, watermain and utilities;
- Erosion and sediment control plan (as per the Erosion and Sediment Guidelines for Urban Construction, GGHACA);
- Traffic management plan;
- Landscape restoration plan (including tree removal, preservation and planting plan); and
- Associated design brief.

A number of additional potential investigations during the detailed design stage that are recommended include:

- Geotechnical investigations to characterize subsurface conditions and requirements for groundwater monitoring, dewatering, pipe bedding and pavement structure;
- Species-at-Risk and other Species of Conservation Concern;
- Tree Inventories to be carried out by a certified arborist;
- Easement Acquisitions where appropriate; and
- Stage 2 Archaeological Assessment.

8.5.5 Mitigation Measures

The potential environmental and social impacts associated with the Preferred Solution are typically related to the construction, implementation and long-term usage of the remedial measures. The impacts and their potential sources and methods of mitigation are identified and discussed in the following sections.

Vegetation

Since a majority of the proposed remedial measures will occur within the municipal right-of-way, minimal impacts on vegetation are expected within the proposed project areas. Nevertheless, should any construction activities to be undertaken adjacent to existing trees where tree removal may be required, the following mitigation measures shall be implemented:

- Protective fencing around trees designated to remain;
- Mature trees to be avoided where possible so as to eliminate the need for their removal;

- Small trees, if removed, will be replaced or replanted. The replaced trees will be in accordance with City's requirements; and
- Root pruning, if required, will be done in accordance with City Standards.

Noise and Vibration

Truck traffic and construction equipment operation and general construction activities are potential noise and vibration sources. Mitigation measures include:

- Enforcement of the City's anti-noise by-law for all construction activities;
- Construction noise is not permitted from:
  - 7 p.m. to 7 a.m. the next day, except until 9 a.m. on Saturdays
  - All day Sunday and statutory holidays
- Pre-construction survey will be undertaken for houses which may be affected by soil vibration during construction activities; and
- Should rock excavation is required, blasting will not be permitted.

Fuel Spills

Fuel spills may occur during the onsite refueling of construction equipment with the potential to contaminate surface and groundwater. Mitigation measures include:

- Refueling in designated areas at a minimum distance of 15 m from a watercourse;
- Spill containment for on-site storage tanks; and
- Preparation of a spill clean-up contingency plan.

Traffic

Potential concerns includes local traffic disruption during construction due to closed roads or blockage of driveways. The following mitigating measures are proposed:

- Consultation will be held with the City's Transportation Department to determine which lane(s) of traffic will be maintained or detours utilized to ensure a constant flow of traffic during construction; and
- Homeowners will be notified if temporary blockage to their driveway during construction has to be considered, which will be kept to a minimum. Where possible, alternative short-term parking will be provided.

Private Property

Temporary disruptions to private property include access/egress to driveways and potential interruption of water and sanitary services to residences. Due to the maturity of the existing neighborhoods, these impacts can only be managed through a well-managed construction program that will require consultation with the City and the various agencies and liaising between property owners and construction crews.

Restoration

All sites/areas disturbed by construction activities shall be restored as per the following recommendations:

- Disturbed sidewalks, roads and parking areas will be restored to their existing conditions after construction;
- Removed small trees will be replanted or replaced;
- Disturbed park areas will be restored to their existing conditions; and
- Disturbance to private properties is to be restored to original conditions or better.

Safety During Construction

There are potential safety hazards resulting from construction activities including open excavations and operation of heavy machinery in or near public areas. The following mitigation measures are proposed:

- Construction areas to be fenced and signed where appropriate, especially in high-use recreation areas such as public parks or school properties; and
- High traffic areas to be monitored by construction personnel with appropriate signage, safety vests, and regard for pedestrian and road safety.

8.5.6 Environmental Approvals and Permitting

As part of the preliminary and detailed design phase, additional field investigations and analysis will be required, along with the preparation of plan and profile drawings outlining the proposed works that will require agency circulation for comment and approval. The following specific elements may be required:

City of Toronto Departments

The following departments shall be circulated and consulted in the design and construction phases:

- Community Development
  - Planning
- Public Works
  - Engineering Services
  - Operational Services;
  - Environmental Services;
  - Parks Services; and
  - Fleet and Transit Services.

Projects must comply with City of Toronto's Bylaws, Policies, and Permitting requirements, including an arborist inventory, Ecological Land Classification (ELC) assessment of the potential areas of impact and adjacent vegetation communities, and mitigation and compensation (e.g. tree replacements, restoration, and/or enhancements).

Urban Forestry Ravine & Natural Feature Protection Permit

The Ravine & Natural Feature Protection By-law, Chapter 658 of the City of Toronto Municipal Code regulates certain activities within protected areas, including the injury and destruction of trees, filling, grading, and dumping in defined areas. A Permit for Tree Removal and Tree Injury in a Protected Property is required to conduct injury or destruction of trees on ravine protected lands within the City of Toronto. A permit application package will need to be submitted to Urban Forestry Ravine & Natural Feature Protection including an arborist report, landscape / replanting plan, and site plan.

Potential impacts to multi-use trails must considered at the planning stage, and any trails that are removed during construction should be restored according the City of Toronto's trail use guidelines and AODA standards.

Ministry of Environment, Conservation and Parks (MECP)

Prior to March 2021 each element of the recommended infrastructure will require an MECP Environmental Compliance Approval for Sewage Works since these projects fall under Section 53 of the Ontario Water Resources Act (amended 2011).

The Ministry is moving forward in implementing a Consolidated Linear Infrastructure Permission Approach (CLI) for low-risk projects related sewage collection and stormwater management. The goal of this transition is to build important low-risk public infrastructure projects sooner by creating an efficient process for low-risk projects. The existing and future approvals will be incorporated into two consolidated Environmental Compliance Approval (ECA) – one for the municipal sanitary collection systems and one for the storm management works.

This is to be discussed with the City during the preliminary design phase with respect to the City's current CLI ECA progress.

Toronto Region Conservation Authority (TRCA)

For the Assignments that have works proposed on TRCA properties or regulated lands, permits for works associated with the infrastructure risk mitigation will be required from TRCA in accordance with Ontario Regulation 166/06 (Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses) and the Living City Policy (LCP).

For each applicable project additional background studies and field investigations may be required at the preliminary design stage. Some of the typical studies include the following:

- Natural heritage studies;
- Fluvial geomorphic studies and design; and
- Water resources studies.

A design package would need be submitted to TRCA with the design drawings, a design brief, and hydraulic model files. Scheduling of the project should allow for review of the submission by TRCA and revisions to the design and resubmission following receipt of comments from TRCA.

The proposed works within A65-ST-01 related to the easement are not with TRCA regulated limits and therefore no further consultation with TRCA is required.

Toronto Transit Commission (TTC) Consultation

Although no improvement works are proposed on TTC properties there are works proposed on major roads which may impact the TTC bus routes. Consultation with TTC is suggested during preliminary design and the consultation correspondence shall be included in the final report.

8.5.7 Contract Documents and Construction

A tender document package shall be prepared for the detailed design project with the intent that the proposed works be publicly tendered. The tender will be consistent with the requirements of the City of Toronto standards. The package shall include several sections common to most tenders as well as sections on:

- Special specifications;
- Schedule of quantities;
- Detailed cost estimates based on tender schedule of quantities; and
- Final detailed design drawings.

The proposed construction timing will be based on subsequent discussions within the City and will be integrated with the proposed timing for the proposed road construction in order to minimize the level of inconvenience to residents, businesses and commuters and maximize cost-savings.

8.5.8 Implementation Summary

Table 8-8 provides a summary for each Assignment including the type of improvement works, total estimated construction cost, the number of benefitting property counts, the calculated CPBP, EA schedule, as well as the requirements moving into next steps, such as TRCA approvals, additional stakeholder consultation.

Table 8-8: Summary Assignments and Implementation

Project ID	Project Location	Proposed Works for	Proposed Works Locations	Peak Flow Increase under		Total Construction Cost Estimates	CPBP	Timeframe	Additional Requirements
				2-Year Storm	100-Year Storm				
A65-ST-01	William, Allen & Keele Area	Storm & sanitary upgrades	Municipal ROW, private property	-23%	-10%	$194,133,000	$744,075	Unknown	• Additional stakeholder consultation (private property owner)

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The following conclusions can be drawn from the completion of this study:

1. No large storm events (>40mm in one hour as per the RFP) were captured within A65 during three-year rainfall and flow monitoring program that was implemented at the beginning of the Study. As a result, and as per the RFP requirements, the sanitary and storm drainage InfoWorks models have not been calibrated to flow monitoring data to date and flow generation is based on design standards and parameters recommended in the City's Modelling Guideline (July 2020).
2. Based on the review and interpretation of available background data, field investigations and resident input, the main causes of basement and surface flooding can be attributed to overloading of storm sewers, surcharge of sanitary sewers caused by excess inflow and infiltration and pipe bottlenecks and lack of a continuous major system with trapped overland flow paths causing surface flooding.
3. The preferred remedial measures consist of a combination of source control measures, conveyance improvements and storage elements in the storm and sanitary collection systems.
4. With the implementation of the preferred sanitary remedial measures the sanitary sewer system can convey the May 12, 2000 design storm event within City criteria with no net increase to peak flows in the West Don Sanitary Trunk Sewer. The preferred solutions were tested under 2041 anticipated population growth at 450 L/c/d and no further improvements or upsizing is required.
5. With the implementation of the preferred storm remedial measures the storm drainage system can convey both the major and minor systems during the 100-year design storm within the City surface depth and hydraulic grade line criteria with a few acceptable exceptions.
6. The recommended improvement works to help address the flooding issues within the Schedule B project area is estimated at a capital cost of $272 million including project delivery allowance and contingencies, excluding taxes.
7. A preliminary constructability review has been undertaken for the recommended Solutions to ensure constructability, functionality and feasibility of each preferred Solution based on limited infrastructure and utility information that is available. While no major "show stoppers" have been identified for the range of preferred Solutions a number of potential utility conflicts seem to be present. Recommendations have been provided by the study team to address the conflicts. However a more detailed constructability and conflict investigation is recommended during the preliminary design phase once additional infrastructure information is collected.
8. The Schedule 'B' Class EA process has been fulfilled through public consultation including notices, online posting of PIC materials, agency consultation and the submission of this project file document.

9.2 Recommendations

The following recommendations are made with respect to this study:

1. Where opportunity exists the City should proceed with short-term local measures including sealing of sanitary maintenance hole covers at low points in the road, implementation of inlet control devices and overland diversions where sufficient major system conveyance exists, continued promotion of the residential roof downspout disconnection program and continuation of the City's infiltration and inflow reduction and operations and maintenance programs.
2. The City should continue promoting the Basement Flooding Protection Subsidy Program. Implementation of the measures included in this program will provide protection to most residences and will enhance the performance and level of protection provided by the remedial measures in the preferred alternative.
3. The City should continue to enforce the Mandatory Downspout Disconnection Bylaw in order to ensure a roof disconnection rate of at least 75%.
4. The City should continue the rainfall and flow monitoring program for this study area and monitoring of rainfall-runoff response across the City including review and analysis of new basement and/or surface flooding complaints. The City shall undertake storm and sanitary calibration and validation with sufficient significant rainfall events.
5. The City to increase the level of detail of data collection following basement flooding events to better evaluate the suspected nature, cause, and relative severity of flooding.

10 REFERENCES

Department of Fisheries and Oceans. (April 14th, 2021). *Projects Near Water*. Retrieved on April 11, 2022, from https://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html

Environmental Registry of Ontario (March 17th, 2021) *Proposed changes to environmental approvals for municipal sewage collection works*. Retrieved on April 11, 2022, from https://ero.ontario.ca/notice/019-1080