

**- APPENDIX L -**

**CITY OF BRAMPTON**

**DOWNTOWN DRAINAGE STUDY  
PART 1: FLOOD RISK ASSESSMENT**

Report prepared for:

**The City of Brampton  
2 Wellington Street West  
Brampton, Ont.  
L6Y 4R2**

Prepared by:

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26 June, 2006  
Aquafor Reference No. 64587



26 June 2006

Reference: 64587

**The Corporation of the City of Brampton  
2 Wellington Street West  
Brampton, Ont.  
L6Y 4R2**

**Attention: Mr. R. Bino, P.Eng.  
Reference: Downtown Drainage Study - Part 1: Flood Risk Assessment**

Mr. Bino:

In response to your request, Aquafor Beech Limited is pleased to provide a draft report for Part 1 of the Downtown Drainage Study – Flood Risk Assessment. The objectives of the study include:

- update the draft hydraulic model for Etobicoke Creek to confirm the regulatory flood lines for the downtown Brampton SPA;
- determine the depths of flooding for the various portions of the SPA;
- review of flood protection requirements and possible flood protection measures; and
- estimate flood damages in comparison to the cost of any feasible flood relief alternatives.

One flood relief alternative in particular was identified to have a potential significant benefit in terms of flood relief for downtown Brampton, without being cost-prohibitive. As discussed, grading works to construct a berm/wedge near Church Street and Ken Willans Drive could protect downtown Brampton from the spill of floodwaters from Etobicoke Creek for all storm events up to and including the 350-year storm. The estimated \$2 million dollar cost of constructing the berm/wedge would result in a much larger \$4.4 million dollar savings in present-day flood damages.

We would suggest that the findings from this report be used as a “starting point” for discussions with the province and TRCA regarding the flood standard to be applied to new development in downtown Brampton. Given that the proposed “berm/wedge” strategy would remove the threat of flooding up to the 350-year storm for most of the downtown SPA, we would suggest that future development applications could proceed on a “best efforts” basis. At the very minimum, all residential units could be located above the Regional Storm flood elevation, with other uses (parking garages, commercial, industrial etc.) floodproofed on a “best efforts” basis, subject to urban design standards and technical feasibility.

Please contact myself at (905) 790-3885 extension 290, or Greg Frew at extension 276, if you have any questions.

Yours sincerely,

**AQUAFOR BEECH LIMITED**

Dave Maunder, MSc., P.Eng.  
Project Manager  
DEM:gf

## EXECUTIVE SUMMARY

This report has been prepared to address Part 1 of the Downtown Drainage Study, which investigates flood risks associated with Etobicoke Creek for the Downtown Brampton Special Policy Area (SPA), and reviews flood protection alternatives.

The Etobicoke Creek by-pass channel was built through downtown Brampton in the early 1950's in response to frequent flooding of the downtown area. Although no flooding has been experienced in downtown Brampton since the by-pass channel was constructed, a significant portion of the area remains within the regulatory floodplain of Etobicoke Creek. In the 1980's the flood-susceptible area of downtown Brampton was designated as a "Special Policy Area".

In the past few years, Brampton has experienced significant development pressures in the Downtown Special Policy Area. Opportunities for intensification within this area have been encouraged in order to comply with the new Provincial Policy Statement (PPS), which promotes intensification and redevelopment in built-up areas. In addition, the Draft Growth Plan for the Greater Golden Horseshoe has identified downtown Brampton as an Urban Growth Centre. However, when the new PPS came into effect, Toronto Region Conservation Authority (TRCA) and provincial representatives raised concerns about development applications in the Downtown SPA. Meetings were held with TRCA and Provincial representatives in an attempt to clarify the applicable policies. Highlights from the meetings included the following:

- within SPAs, new development will endeavour to provide as high a level of flood protection (up to the regulatory flood – Hurricane Hazel) as is possible. Where floodproofing to the regulatory flood level is not possible, the TRCA has generally established the 1:350 year flood event as the minimum required level of flood.
- the Brampton SPA policies were developed in the 1980's and did not contemplate major intensification;
- the Brampton SPA policy applies to *existing* development;
- the 350-year criteria may be applied for proposed *re*-development which does not result in an increased risk to life or property, such as a modification to an existing commercial site for example;
- the Regional Storm criteria applies to *new* development which increases the risk to life or property

As current SPA policies refer to the Regional Storm and 350-year storm events, a hydraulic model for Etobicoke Creek was setup to define the flood characteristics for these storms in the Downtown SPA. In both cases, floodwaters enter the downtown SPA at two locations:

- via "spill" at the north end of the existing concrete by-pass channel; and

- via “backwater” just south of the by-pass channel.

The flood characteristics, in terms of depths and velocities were investigated. The deepest flood zones are located upstream of the CNR embankment in downtown, and between Wellington Street and Mary Street. The highest flow velocities are predicted between the CNR line and Wellington Street.

Two general types of flood protection were investigated for downtown Brampton:

- general flood proofing techniques which may be used in the design of individual buildings; and
- flood relief measures to reduce or eliminate the flood flows entering the downtown area.

Flood protection requirements and alternatives were reviewed. The following was concluded with regard to the suitability of various alternatives for use in downtown Brampton:

#### Flood Proofing Measures

The suitability of floodproofing measures for future development applications will need to be evaluated on a site-by-site basis and consider factors such as landuse, flood depth, velocity, emergency access, streetscape, and cost. Depending on the specific characteristics of the site, the following may be feasible:

- elevated structures, provided that flood depths and grading requirements are not excessive;
- watertight floodwalls, subject to structural design considerations;
- watertight doors and seals, for shallow flood depths and non-residential landuses;
- intentional flooding for non-inhabitable structures.

#### Flood Relief Measures

Four alternatives for reducing or eliminating flooding in the downtown area were identified and discussed:

- re-design of the Etobicoke Creek bypass channel could potentially provide a lot of flood relief but is very expensive;
- larger railway openings in downtown would also be an expensive option with limited benefit;
- grading works to create a berm/wedge near Church Street and Ken Willans Drive could potentially eliminate spilling of floodwaters into downtown for the 350-year storm at a relatively low cost. This option could also include “raising” Roselea Park to at least the 350-year flood level or higher;

- grading works to widen the Etobicoke Creek floodplain downstream of the downtown area would provide moderate reductions in flood levels at south end of the flood zone, but would be expensive.

Based on the feasibility assessment, three flood relief strategies were investigated further:

- **“350-year berm/wedge” strategy** - grading works to create a berm/wedge near Church Street/Ken Willans Drive to the 350-year level. Estimated cost: \$2 million dollars;
- **“350-year combined” strategy** - a combination of grading works to create a berm/wedge near Church Street/Ken Willans Drive to the 350-year level, *and* grading works to widen the Etobicoke Creek floodplain downstream of the downtown area. Estimated cost: \$12 million dollars;
- **“Regional combined” strategy** – replacement of the by-pass channel and bridges with a wide natural channel and new bridges, *and* grading works to widen the Etobicoke Creek floodplain downstream of the downtown area. Estimated cost: \$35 million dollars.

The “350-year berm/wedge” strategy alone was found to completely eliminate spilling of flood flows into downtown for the 350-year storm. The “350-year combined” strategy provides additional benefit for the 350-year storm by preventing “backwater” from the main channel downstream. The “Regional combined” strategy eliminates spilling of flood flows into downtown for the Regional storm and reduces the “backwater” flood depths at the main channel downstream of the downtown study area.

Detailed flood damage cost estimates were completed for various storm events with and without the flood relief strategies in place. The following was concluded:

- without any flood relief, the existing flood damage costs resulting from the 100-year, 350-year, and Regional storms are estimated at approximately \$23.9 million dollars, \$29.3 million dollars, and \$78.7 million dollars, respectively.
- the “350-year berm/wedge” strategy removes flooding for most of the downtown properties for the 100-year and 350-year storms. However, this strategy has virtually no impact on Regional storm flood damages.
- the “350-year combined” flood relief strategy further reduces the estimated flood damages for the 100-year and 350-year storms. However this strategy provides a very minor reduction in Regional storm flood damages;

- the “Regional combined” strategy eliminates flood damages for the 100-year and 350-year storms, and significantly reduces Regional storm flood damages to approximately \$6.6 million dollars.

The potential benefits of the strategies, in terms of reduced flood damage costs, were converted to present-day values and then compared to the estimated costs to construct the flood reduction works. The following was concluded:

- the potential benefits of the “350-year berm/wedge” strategy, at almost \$4.4 million dollars, is over two times greater than the estimated \$2 million dollar cost.
- the “350-year combined” strategy provides only slightly higher benefits above the “350-year berm/wedge” strategy but costs significantly more, making it uneconomical.
- The “Regional combined” strategy is also considered to be uneconomical, with costs exceeding potential benefits by a factor of over 6.

Therefore, it was concluded that the “350-year berm/wedge” strategy is feasible and economical with the potential benefits outweighing the estimated costs by almost \$2.4 million dollars.

Depending upon provincial and TRCA decisions regarding the flood standard to be applied in the downtown Brampton SPA, the “350-year berm/wedge” relief strategy may be sufficient to allow future development to proceed. Given that the proposed “berm/wedge” strategy would remove the existing threat of flooding up to the 350-year storm for most of the downtown SPA, we would suggest that future development applications could proceed on a “best efforts” basis. At the very minimum, all residential units could be located above the Regional Storm flood elevation, with other uses (parking garages, commercial, industrial etc.) floodproofed on a “best efforts” basis, subject to urban design standards and technical feasibility.

Given that the works would be required to allow future development applications to proceed, there may be an opportunity for the City to recover the cost of the flood relief works through Development Charges.

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Appendix A: Hydraulic Model Results

Appendix B: Flood Damage Inventory

## **1.0 INTRODUCTION AND BACKGROUND**

### **1.1 Introduction**

The Downtown Drainage Study is being undertaken for the City of Brampton in two parts:

- Part 1 undertakes a flood risk assessment for the Downtown Brampton Special Policy Area (SPA), including the definition of flood hazards associated with Etobicoke Creek and a review of mitigative alternatives.
- Part 2 is intended to review drainage patterns and recommend stormwater management alternatives for existing and future development in Downtown Brampton.

This report has been prepared to address Part 1 of the Study.

### **1.2 Background**

The Etobicoke Creek by-pass channel was built through downtown Brampton in the early 1950's in response to frequent flooding of the downtown area. The by-pass consists of a concrete channel, approx. 600m long and 22m wide, extending from Church Street to the CN Rail line. Four bridges cross the channel over this reach:

- Church Street;
- Scott Street;
- Queen Street; and
- the CN Rail line

Photos 1.1 and 1.2 illustrate the by-pass channel.

Although no flooding has been experienced in downtown Brampton since the by-pass channel was constructed, a significant portion of the area remains within the regulatory floodplain of Etobicoke Creek. Past hydraulic modelling and floodplain mapping indicate that severe flooding would spill from Etobicoke Creek into downtown Brampton near the north end of the by-pass channel, and rejoin the main channel south of the by-pass channel.

In the 1980's the flood-susceptible area of downtown Brampton was designated as a "Special Policy Area". A Special Policy Area (SPA) designation is intended to address the significant social and economic hardships to a community that would result from strict adherence to provincial policies which generally restrict development within flood

**Etobicoke Creek By-pass Channel Through Downtown Brampton**



**Photo 1.1 –Low Flow**



**Photo 1.2 – Spring Runoff**

hazard lands. Review of the City’s Official Plan, Section 5.6.3 indicates the following with respect to the Downtown Brampton SPA:

- the placing or dumping of fill of any kind or the alteration of any watercourse shall not be permitted without the approval of the Toronto Region Conservation Authority (TRCA);
- no new buildings will be permitted within Regional Storm floodplain without appropriate floodproofing;
- where Regional floodproofing is technically impractical, no flooding for the 350-year storm;
- new buildings will not be permitted where flood depths or velocities would be a hazard to life.

In the past few years, Brampton has experienced significant development pressures in the Downtown Special Policy Area. The proximity to local transit, GO Bus and Train services, Brampton’s new Heritage Theatre and restaurants have made downtown Brampton an appealing area to re-develop. Opportunities for intensification within this area have been encouraged in order to comply with the new Provincial Policy Statement (PPS), which promotes opportunities for intensification and redevelopment in built-up areas. In addition, the Draft Growth Plan for the Greater Golden Horseshoe has identified downtown Brampton as an Urban Growth Centre.

When the new PPS came into effect, TRCA and provincial representatives raised concerns about development applications in the Downtown SPA. Meetings were held with TRCA and Provincial representatives in an attempt to clarify the applicable policies. Through these meetings, the provincial representatives have indicated the following:

- when considering “conflicting” policies, such as a desire to promote intensification yet prevent development within hazard lands, the province puts a priority on public health and safety;
- when the concept of SPAs was first introduced in provincial policies in the 1980s, major intensification was not contemplated. SPAs are historically developed portions of communities that exist in flood plains where the continuation of such areas would be difficult with strict adherence to provincial policies concerning new development. In this regard, the 2005 PPS states; “a Special Policy Area is not intended to allow for new or intensified development and site alteration, if a community has feasible opportunities for development outside the flood plain”. It was noted that the concept of a downtown Brampton SPA has been recognized since 1986 through the City’s official plan policies.
- in Southern Ontario Hurricane Hazel is used as the provincial standard to determine regulatory floodplain limits. In approved SPA’s new development may be permitted, subject to various conditions, where the level of flood protection required

is less than the established provincial standard. However, an acceptable minimum level of flood protection must be provided;

- within SPAs, new development will endeavour to provide as high a level of flood protection (up to the regulatory flood) as is possible. Where floodproofing to the regulatory flood level is not possible, the TRCA has generally established the 1:350 year flood event as the minimum required level of flood protection for new development. Notwithstanding the establishment of a minimum level of flood protection, each development application, on a site specific basis, must determine the “acceptability” of the remaining flood risk based on the directions in the PPS and related criteria defined in the supporting technical guidelines.
- it should be noted that Section 1.1.3.3 of the PPS also indicates that “intensification and redevelopment” shall be directed in accordance with the policies of Sections 2 and 3 of the PPS. Section 3 deals with “protecting Public Health and Safety” which includes flood hazards. As well, it is recognized that the downtown Brampton SPA is only a portion of the downtown Brampton urban area.

Additional meetings with TRCA representatives indicated the following:

- the Brampton SPA policies were developed in the 1980’s and did not contemplate major intensification;
- the Brampton SPA policy applies to *existing* development;
- the 350-year criteria may be applied for proposed *re*-development which does not result in an increased risk to life or property, such as a modification to an existing commercial site for example;
- the Regional Storm criteria applies to *new* development which increases the risk to life or property. In this case:
  - buildings should be floodproofed using “permanent dry passive” methods;
  - ingress/egress for new buildings to and from the development should be such that movement of people and vehicles are not prevented during flooding;
  - evacuation by emergency vehicles must be viable, based on safe flood depths and velocities;
  - any flood relief measures to reduce or eliminate the flood flows through downtown Brampton would have to be in place before TRCA approval would be granted.

The policies and recommendations listed above are reflected in recent conditions set forth by the City of Brampton for rezoning applications in the Downtown SPA, including the following:

- the development will be required to provide a minimum level of flood protection as determined by the regulatory authorities;

- any buildings or structures on the development will be required to be floodproofed to the Regional Storm event;
- safe ingress/egress must be provided under all flood events;
- each development application must determine the acceptability of the flood risk based on the directions in the Provincial Policy Statement and criteria defined in the supporting technical guidelines;

### **1.3 Study Objectives**

In light of the above background information, the Study Team was directed by the City to complete Part 1 of the Downtown Drainage Study with the following objectives:

- update the draft hydraulic model for Etobicoke Creek to confirm the regulatory flood lines for the downtown Brampton SPA;
- determine the depths of flooding for the various portions of the SPA;
- review of flood protection requirements and possible flood protection measures; and
- estimate flood damages in comparison to the cost of any feasible flood relief alternatives.

## **2.0 EXISTING FLOOD RISK CHARACTERISTICS**

This section summarizes the hydraulic modelling which was undertaken to define the existing flood characteristics in downtown Brampton.

### **2.1 Hydrology – Flood Flows**

Hydrologic modelling to define flood flows for Etobicoke Creek is currently being undertaken by TRCA. Draft results from this modelling study were provided for use in the Downtown Drainage Study. Draft flow rates are summarized in Table 2.1

### **2.2 Hydraulic Model Setup**

TRCA is in the process of updating its hydraulic modeling and floodplain mapping for the entire Etobicoke Creek watershed. A Draft version of the new Hec-Ras hydraulic model for Etobicoke Creek through the downtown Brampton study area was provided for use in the Downtown Drainage Study. This Draft model was refined to add greater detail in the downtown Brampton area. Modelling efforts focused on defining the flood risk characteristics for the 350-year storm and Regional Storm events.

An iterative process was used to “split” the total flow in Etobicoke Creek through downtown Brampton between the bypass channel and spill into the downtown core. The proportion of the flow between the bypass channel and downtown spill was adjusted until flood elevations were matched at the upstream spill location. The resulting flows are presented in Table 2.2 for the 350-year storm and Regional Storm.

### **2.3 Existing Flood Characteristics**

Review of topographic mapping indicates that flood flows will begin to spill into downtown Brampton at a low point near the intersection of Church Street and Ken Whillans Drive, immediately north of Rosealea Park. As flows increase, the additional spill takes place along the west bank of the bypass channel into Rosealea Park. From here, floodwaters are conveyed southwest through two openings in the CN Railway embankment at Main Street and Union Street, then southward via George Street and Main Street. Floodwaters are then conveyed eastward back to the main channel between Woodbrook Drive and Guest Street.

Hydraulic model results were used to map the flood susceptible lands in downtown Brampton, including the corresponding flood depths, as illustrated in Figures 2.1 and 2.2 for the 350-year storm and Regional Storm, respectively. Flood depths and velocities are summarized in Table 2.3. As shown, the deepest flood zones are located upstream of the

**Table 2.1**  
**Draft Flood Flow Rates for Etobicoke Creek\***

<b>Design Storm</b>	<b>Flow Rate</b>
2-year	47.6 m <sup>3</sup> /s*
5-year	70.3 m <sup>3</sup> /s*
10-year	85.9 m <sup>3</sup> /s*
25-year	106.9 m <sup>3</sup> /s*
50-year	122.8 m <sup>3</sup> /s*
100-year	139.2 m <sup>3</sup> /s*
350-year	173 m <sup>3</sup> /s**
Regional	573 m <sup>3</sup> /s*

\* Draft peak flow rates provided by TRCA (March'06), based on "ultimate" landuse scenario.

\*\* 350-yr flow rate extrapolated from 2-yr to 100-yr peak flow rates

**Table 2.2**  
**Split Flow Rates for Etobicoke Creek Through Downtown Brampton**

<b>Design Storm</b>	<b>Total Flow</b>	<b>Bypass Channel</b>	<b>Spill into Downtown</b>
350-year	173 m <sup>3</sup> /s	142 m <sup>3</sup> /s	31 m <sup>3</sup> /s
Regional	573 m <sup>3</sup> /s	280 m <sup>3</sup> /s	293 m <sup>3</sup> /s

**City of Brampton  
Downtown Brampton  
Drainage Study**

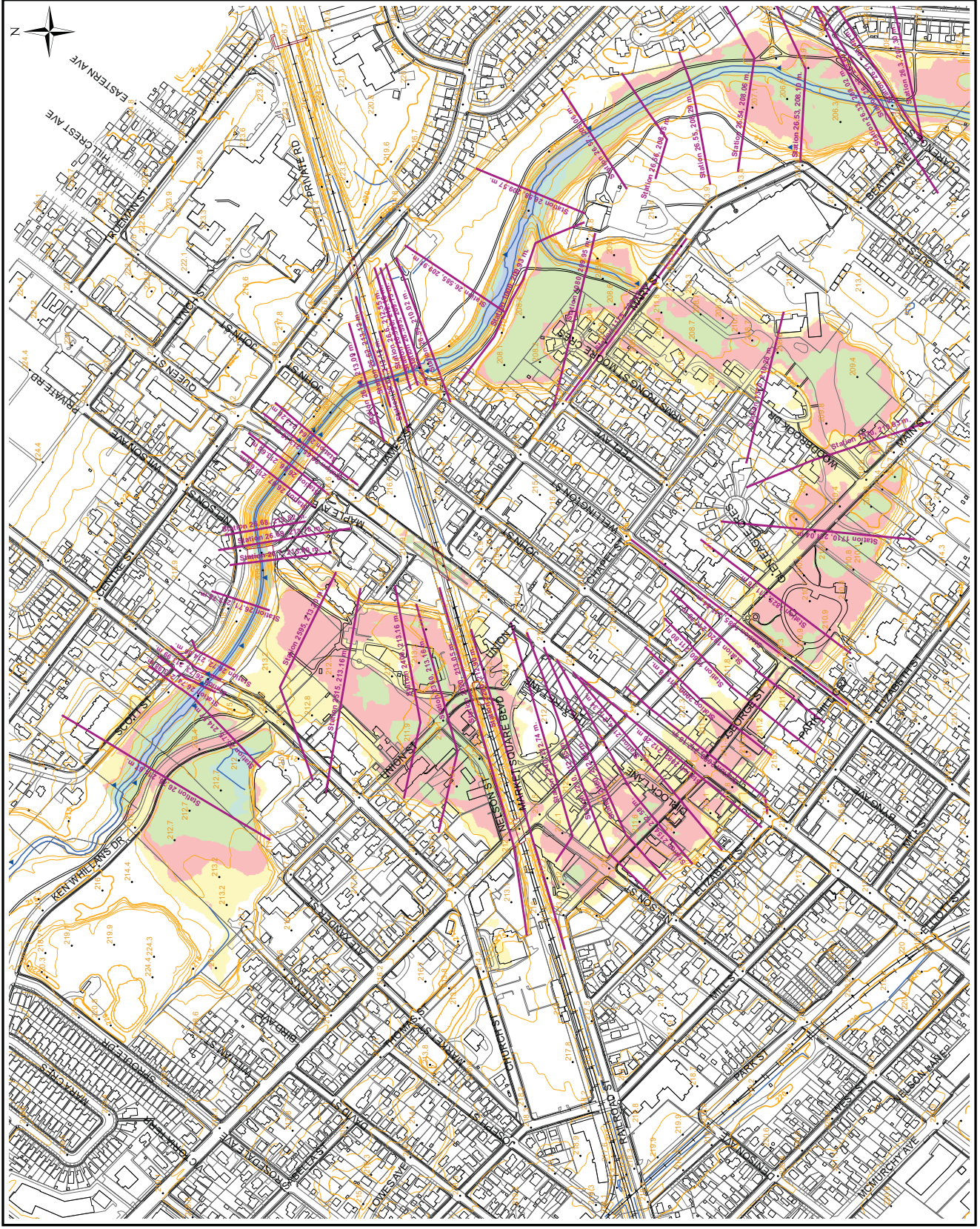
**Figure 2.1  
350-Year Storm,  
Existing Conditions**

**Legend**

**350-Year Flood Depth**

0.00 - 0.5
0.51 - 1
1.01 - 2
2.01 - 3
3.01 - 4
> 4

Hydraulic Model Section, Flood Elevation



**DRAFT**

# City of Brampton Downtown Brampton Drainage Study

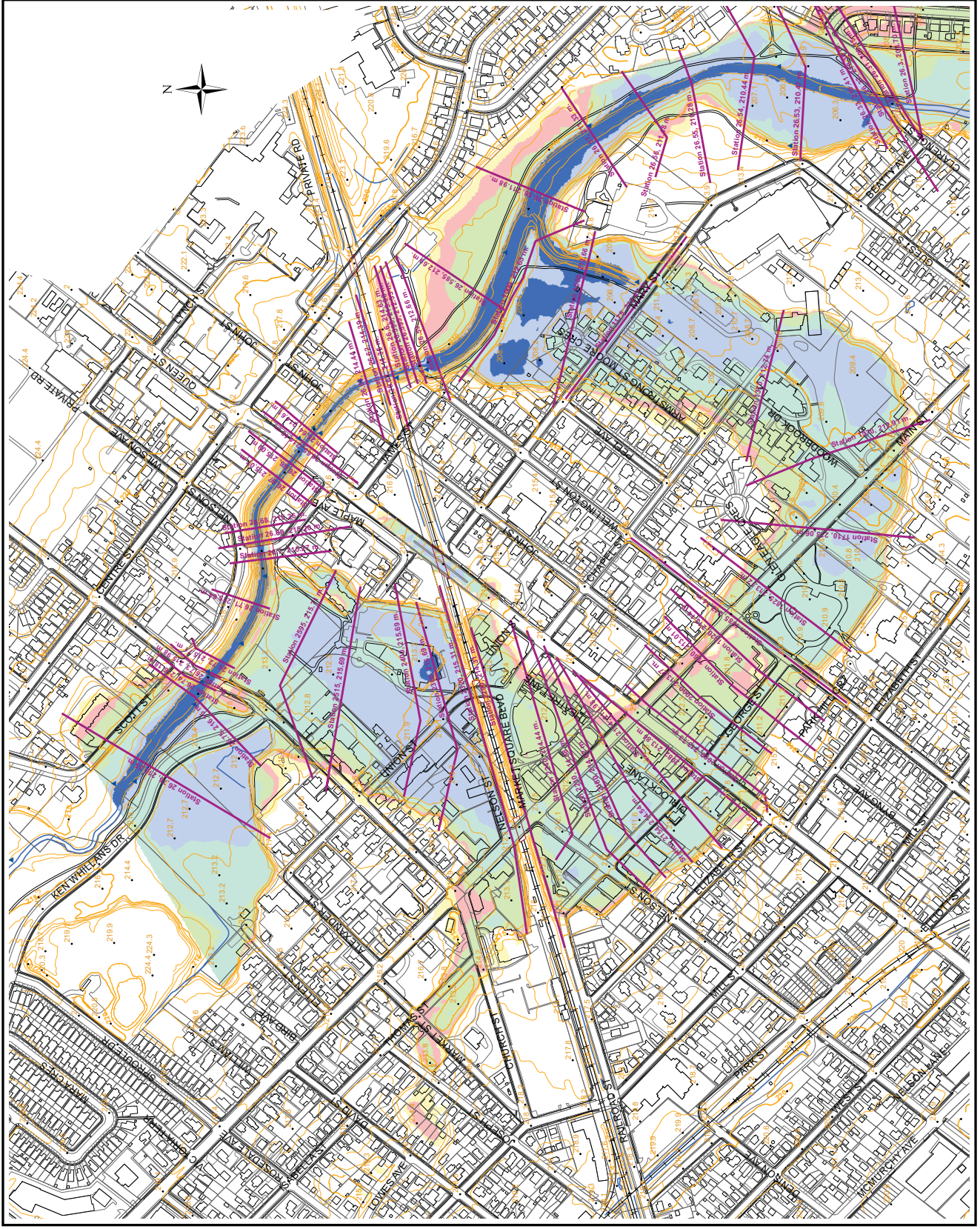
## Figure 2.2 Regional Storm, Existing Conditions

**Legend**

**Regional Flood Depth**

- 0.00 - 0.5
- 0.51 - 1
- 1.01 - 2
- 2.01 - 3
- 3.01 - 4
- > 4

Hydraulic Model Section, Flood Elevation



**Table 2.3**  
**Hydraulic Model Results:**  
**Flood Depths and Velocities through Downtown Brampton – Existing Conditions**

<b>Location</b>	<b>Regional Storm</b>	<b>350-year Storm</b>
Mary St. to Wellington St.	max. depth 3-4 m, velocity 0.7-1.2 m/s	max. depth 0.5-1.0 m, velocity 0.3-1.0 m/s
Wellington St. to Railway	max. depth 2-3 m, velocity 1-4 m/s  (flow concentrated down Main St and George St)	max. depth <1.0 m, velocity 1.0-2.5 m/s  (flow concentrated down George St)
Railway to Church St.	depth 3-4 m, velocity 0.5 m/s	max. depth 0.5-1.0 m, velocity 0.3 m/s

CNR embankment in downtown, and between Wellington Street and Mary Street. The highest flow velocities are predicted between the CNR line and Wellington Street.

It is important to note that model results indicate that flood flows would “back-up” into downtown Brampton from the downstream end of the by-pass channel, even if the spill was eliminated on the upstream end. For example, without a spill at the north end of the bypass channel, the floodwaters from the 350-year storm would still “back-up” from downstream of Mary Street to roughly Main Street. For the Regional Storm, floodwaters would still back-up throughout the downtown core.

Detailed hydraulic model results are provided in Appendix A. An inventory of flood-susceptible properties and an assessment of potential flood damage costs were also undertaken and are discussed further in Section 4.

### 3.0 FLOOD PROTECTION ALTERNATIVES

This section reviews alternative flood protection strategies for downtown Brampton. Alternatives are discussed in terms of their potential flood relief benefits, operation, suitability, relative cost and feasibility. Two general flood protection categories were assessed:

- general flood proofing techniques which may be used in the design of individual buildings; and
- flood relief measures to reduce or eliminate the flood flows entering the downtown area.

#### 3.1 Floodproofing Alternatives

Floodproofing measures are structural techniques incorporated into the design and construction of individual buildings to reduce or eliminate flood damages. Since these measures are best incorporated into the initial planning and design stages, floodproofing is generally more appropriate and economical for *new* buildings. Floodproofing of *existing* buildings is typically less practical and more expensive. In general, floodproofing measures are most appropriate where:

- flood depths are shallow;
- flood velocities are low; and
- the duration of flooding is short.

#### **Types of Floodproofing**

Floodproofing measures are classified as either “active” or “passive”, and provide either “wet” or “dry” protection.

#### **Active vs. Passive**

Floodproofing measures which require some form of action to prevent flooding are classified as “active” measures. Examples include sandbagging or closing watertight doors. Active measures almost always require advanced notice of flooding to be practical.

“Passive” floodproofing measures are defined as those that are already in place and do not require any advance notice or any other form of action to be effective. An example

would include the construction of a building on fill or with all openings above the flood elevation.

### **Dry vs. Wet**

“Dry” floodproofing measures are intended to keep a building and its contents dry during flood events. An example would include the design of a building with watertight walls and watertight doors and seals to hold back flood waters.

“Wet” floodproofing measures are intended to avoid structural damages and to minimize damage to building contents and cleanup in situations where flooding is expected. Wet floodproofing requires that all interior space below the flood level be unfinished, uninhabitable, and free of service panels. Examples may include arenas, stadiums, parking garages, and some industrial buildings.

Where floodproofing measures are proposed, TRCA has indicated a strong preference for dry passive techniques.

### **Technical Considerations**

When evaluating the feasibility of floodproofing measures for a development, several technical items should be considered.

#### 1. Landuse

The proposed type of landuse is a key consideration important. Residential and commercial uses would represent a higher risk to life and property than business or industrial uses. Habitable portions of buildings in particular should be designed to eliminate or minimize flood risks.

#### 2. Aesthetics

The design of any floodproofing measures for either existing or future buildings should also consider the architecture and aesthetics of the neighbouring properties. High flood walls or elevated entrances may be necessary to eliminate flooding but may not be compatible with a commercial streetscape for example.

3. Utilities

All mechanical and electrical systems should be designed and installed so that heating, lighting, ventilation, air conditioning, and other systems are not vulnerable to flooding. Backup power systems and generators should also be considered.

4. Threat to Life and Safe Access

Floodwaters represent a threat to life in terms of both the depth and the velocity of the flow. The forces acting on a person within a floodplain include a buoyant force which increases with flood depth, and a lateral force which increases with velocity. A common method of assessing floodplain risks is based on the combination of depth and velocity. Although no product rule is applicable to all persons, a reasonably conservative set of conditions would define a low risk area as one where:

- the depth of flooding is less than 0.8 metres;
- the velocity of the flood waters is less than 1.7 metres per second; and
- the product of the depth and velocity is less than 0.4

The above values should be considered when evaluating a potential development in terms of the ability to provide safe access (both ingress and egress) to people during an evacuation. Flood depths and velocities vary significantly throughout the flood-susceptible area of downtown Brampton. General model results were presented in Table 2.1, however the ability for future development applications to provide safe access is very site-specific. For example, many properties on the west side of George Street are on the fringe of the flood zone. Here, flood depths are higher on the side fronting onto George Street, however, the depths are lower and safe access may be feasible from the west side of the properties via Elizabeth Street.

Access for passenger and emergency vehicles should also be considered. For most passenger vehicles, a flood depth of approximately 0.3 metres represents the maximum depth before the cars begin to stall due to electrical contact or blockage of exhaust systems. Many emergency vehicles, including police cars, would experience the same constraints. Larger, heavier diesel vehicles such as ambulances and fire trucks may have higher road clearances and top exhausts, allowing safe access in slightly deeper flood waters.

5. Duration of Flooding

Any floodproofing measures should be designed to withstand the forces of the floodwaters over the anticipated duration of the flood. Given the size and hydrologic response time of the Etobicoke Creek watershed, flood conditions would likely last less than a day, possibly only a few hours in duration.

6. Flood Warning and Rate of Rise and Fall

The availability of advance flood warning is an important consideration when evaluating potential floodproofing measures. For example, the rapid hydrologic response of Etobicoke Creek means that advance warning of flooding in downtown Brampton is unlikely, and therefore “active” floodproofing measures will be difficult to implement.

7. Structural Integrity and Leakage

Buildings which are surrounded by flood waters are subject to unbalanced forces which rapidly increase with depth. These include both lateral forces (flow against a wall) and vertical forces (uplift). Without proper design, these forces can cause extensive structural damage or collapse. Research indicates that, for normal construction methods:

- structural damage can begin even at low flood depths, and 0.8 metres is the approximate upper limit for structural integrity;
- buildings with brick or concrete block veneer, begin to leak almost immediately when in contact with flood waters; and
- basements may be damaged by floodwaters which are as little as 0.2 metres above the basement floor;

Therefore, the design of any structural floodproofing measures, including floodproof walls and foundations, will need to consider these forces to prevent structural damage and to ensure that the interior of the structure remains dry. Alternatively, a building may be designed to minimize structural damage by intentionally allowing the building to flood in order to balance these forces. This is an example of a “wet” floodproofing measure which was discussed earlier.

**Alternatives and Feasibility for Floodproofing in Downtown Brampton**

Development pressures in downtown Brampton consist of proposed infill and re-developments with a mix of residential and commercial landuses, including at least four

current development applications. A future expansion of Brampton City Hall is also proposed.

A summary of alternative floodproofing measures is provided below, together with a discussion regarding their feasibility and applicability in downtown Brampton. A summary is also provided in Table 3.1. In general, the suitability of floodproofing alternatives for future development applications will need to be evaluated on a site-by-site basis since flood depths and velocities vary significantly throughout the downtown area. The flood depths illustrated previously in Figures 2.1 and 2.2 would provide a basis for evaluating the feasibility of floodproofing measures.

#### Elevated Structures

This option involves the construction of future buildings on top of fill so that the finished grade is above the anticipated flood elevation. This is a dry, passive method that may be feasible in those areas where only a shallow depth of flooding is predicted (eg. less than 1.0 metre). For deeper flood depths, the option may be technically feasible, but may lead to undesirable streetscapes, with entrances located well above street level. This would not lend itself to commercial properties in particular, where multiple steps would be required, possibly limiting handicap access. The placement of fill in the floodplain would require approval from TRCA.

#### Watertight Floodwalls

This option involves the use of watertight walls to construct a building, with no openings below the flood elevation. This is a dry, passive method which has been used previously in the construction of hi-rise apartment buildings in downtown Brampton. Examples are illustrated in Photos 3.1 and 3.2. The design of such a structure would have to account for hydrostatic/uplift forces.

In order for this to be a passive floodproofing measure, any opening or parking garage access would be located above the floodwall. For example, parking garage access would require an external ramp up to and above the top of the floodwall.

#### Watertight Doors and Seals

This is an active floodproofing technique which relies on the actions of individuals to secure the watertight doors and/or other closures. Given that active techniques require advance warning which is unlikely in the Etobicoke Creek watershed, this technique is generally not recommended, particularly for developments where life and property may be at risk, such as and residential landuses. This method may be feasible for commercial or industrial landuses, where flood depths are expected to be low and employees are always present and available to close the watertight openings when required.

**Table 3.1 – Summary of Alternative Floodproofing Measures**

Flood Proofing Measures	Classification	Notes / Feasibility
Elevate Buildings through grading/fill	dry, passive	<ul style="list-style-type: none"> <li>- may be feasible in areas of shallow flooding (&lt;1.0m)</li> <li>- not effective for the Regional Storm in many areas (depth &gt;1.0m)</li> <li>- streetscape limitations (commercial)</li> <li>- placement of fill would require TRCA approval</li> </ul>
Watertight floodwalls	dry, passive	<ul style="list-style-type: none"> <li>- may be feasible for future residential (apartment/condo) development;</li> <li>- applied in existing Brampton developments (Photo 3.1, 3.2)</li> <li>- requires special engineering design to withstand hydrostatic pressure/uplift</li> <li>- garage/parking access would be required via a ramp up and over the floodwall, above the flood level</li> </ul>
Watertight doors and seals	dry, active	<ul style="list-style-type: none"> <li>- may be feasible for shallow areas (&lt;0.5m)</li> <li>- requires special engineering design to withstand hydrostatic pressure/uplift</li> <li>- active measure that requires warning</li> <li>- not suitable for residential uses</li> </ul>
Berm around individual buildings	dry, passive	<ul style="list-style-type: none"> <li>- could require significant land around perimeter of building, depending on height and grading requirements</li> <li>- generally not feasible in downtown urban environment</li> </ul>
Allow buildings to flood	wet, passive	<ul style="list-style-type: none"> <li>- may be used to prevent structural damage from hydrostatic pressure/uplift</li> <li>- all service panels, etc. to be located above flood level</li> <li>- may be feasible for shallow flooding of non-inhabitable areas (garage/parking, industrial uses)</li> <li>- should consider potential for contamination from material storage</li> </ul>

## Examples of Floodwalls in Downtown Brampton



**Photo 3.1 – Seniors Residence adjacent to Roselea Park**



**Photo 3.2 – Hallmark Place, at Church Street and Ken Whillans Drive**

Floodproofed buildings will require engineering design to withstand hydrostatic/uplift forces.

#### Berm Surrounding Building

This is a dry, passive floodproofing technique in which an earthen berm is constructed around the perimeter of a flood-susceptible building to keep floodwaters out. This technique could require significant land around the perimeter of building, depending on height and grading requirements. Therefore, it may be feasible in rural settings or on large properties, but is likely not feasible in a downtown urban environment;

#### “Wet” Floodproofing

A building may be designed to minimize structural damage by intentionally allowing the building to flood in order to balance these forces. This is an example of a “wet” floodproofing measure which was discussed earlier. Wet floodproofing requires that all interior space below the flood level be unfinished, uninhabitable, and free of service panels. Examples may include arenas, stadiums, parking garages, and some industrial buildings where flood depths are expected to be shallow. Photo 3.3 illustrates an example of an apartment building in downtown Brampton. Here, the parking garage may flood during an extreme storm event, but the residences are constructed above the flood level.

### **3.2 Flood Relief Alternatives**

The objective of flood relief alternatives is to reduce or eliminate the flood flows entering the downtown area, thereby removing or reducing the portion of the area which is in the floodplain. Alternatives are discussed below and summarized in Table 3.2.

#### **Re-design of the Etobicoke Creek Bypass Channel**

A recent study looked at the removal of the existing concrete bypass channel through downtown Brampton and replacing it with a wider natural channel. (Dillon, 20003) Depending upon the ultimate width and configuration, the new channel could significantly reduce or eliminate flooding in downtown Brampton. Although the previous study did not include a hydraulic assessment or capacity estimates, it found that this alternative would require that the City acquire a significant amount of land on either side of the channel for expansion and replace the four bridge structures over the creek, including the CN Rail Line south of Queen Street.



**Photo 3.3 – “Wet” Floodproofing of Parking Garage, with Residences Located Above the Flood Elevation**

**Table 3.2 – Summary of Alternative Flood Relief Measures**

Flood Relief Measures	Cost Estimate*	Notes / Feasibility
Re-Design Bypass Channel	\$15-\$25 Million	<ul style="list-style-type: none"> <li>- potential to significantly reduce or eliminate spill of flood flows into downtown area</li> <li>- requires acquisition of private property</li> <li>- requires replacement of 4 large bridge structures</li> </ul>
Larger Railway Openings	\$10 Million	<ul style="list-style-type: none"> <li>- potential to reduce flood depths on north side of railway</li> <li>- no benefit to flood-susceptible lands south of railway</li> </ul>
Grading Works to Create Berm or “Wedge”	\$1-\$2 Million	<ul style="list-style-type: none"> <li>- potential to eliminate spill of flood flows into downtown for all events up to the 350-year storm</li> <li>- requires gentle grades (2-3%) to create a “wedge”</li> <li>- potential impacts to existing infrastructure and vegetation</li> <li>- grading considerations for adjacent properties and driveways</li> <li>- TRCA approval required for placement of fill in the floodplain</li> </ul>
Grading Works to Widen Downstream Floodplain	\$10 Million	<ul style="list-style-type: none"> <li>- potential to reduce Regional Storm flood levels between Wellington and Mary Street, and reduce 350-year flood level near Mary Street</li> <li>- no benefit to the flood-susceptible lands north of Wellington Street</li> <li>- requires removal of existing Recreation Centre and roughly 200,000 cubic metres of earth</li> <li>- potential impacts to existing infrastructure and vegetation</li> <li>- potential impacts from historical landfill site</li> </ul>

\* cost estimates at “concept level”

As part of this current study, preliminary hydraulic modelling was undertaken to provide a rough estimate of the corridor requirements. Assuming that future bridge replacements over the corridor will not restrict the channel's capacity, model results indicate that a stream corridor with a width of roughly 90 metres and depth of 5 metres is required to convey the full Regional Storm flow. Depending upon the ultimate width requirements for the re-designed channel, the cost for this alternative was estimated in the previous study to range from \$15 \$25 million dollars.

### **Larger Railway Openings**

Review of model results indicates that the CN Rail line through downtown Brampton causes floodwaters to “backup” on the north side of the railway. Therefore, widening of the existing railway openings at Main Street and Union Street was considered. This would provide limited flood relief to properties on the upstream side by lowering backwater levels, but would also be very expensive and provide no flood relief to downstream properties. The estimated cost for this alternative would be roughly \$10 million dollars.

### **Grading Works to Create Berm or “Wedge”**

Hydraulic model results indicate that flood flows begin to spill into downtown Brampton near the intersection of Church Street and Ken Whillans Drive. For the Regional Storm, further spilling also occurs over the west side of the bypass channel into Rosealea Park.

The hydraulic model was used to investigate the effectiveness of raising the land at this location to create a berm and prevent floodwaters from spilling into downtown. It should be noted that, to minimize the potential for scour and failure due to flooding, any grading works would have to be constructed with slopes that do not exceed 2-3%. The berm would therefore take the form of a “wedge” of land to which keeps floodwaters out of the downtown area. Model results indicate that raising the land by up to 1.2 metres at this location could potentially eliminate spill of floodwaters for all events up to and including the 350-year storm. Excessive flood depths for the Regional event make berming ineffective. Model results for this alternative are provided in Appendix A.

Field investigations were undertaken to further assess the feasibility of eliminating flooding up to the 350-year level using this alternative. Two options for constructing a berm/wedge at this location were identified:

- Option 1 - raising the profile of Church Street to a minimum elevation of 215.2 metres; and

- Option 2 – raising the profile of Ken Whillans Drive to a high point of 215.2 metres, just north of Church Street.

These options are illustrated conceptually in Figure 3.1 and 3.2. If this or other flood relief options were to be considered further, an Environmental Assessment would be recommended to define the potential social, economic and environmental impacts in more detail. Items to be considered in the use of these options include:

- grading constraints on adjacent private lands, including driveways (Photo 3.4);
- grading requirements on private lands;
- potential relocation or modification to existing utilities;
- disturbance to existing vegetation (Photo 3.5);
- disturbance to the existing pedestrian trail (Photo 3.6);

The extent of works for both berm options ranges between 100 to 200 metres. The estimated cost for these works is roughly \$1 to \$2 million dollars, and includes potential relocation/re-construction of existing utilities and services, and an aggressive re-vegetation plan to replace trees that would be affected by the grading works. Given that this option includes the placement of up to roughly 7,000m<sup>3</sup> of fill within the existing Etobicoke Creek floodplain, a permit from TRCA would be required for any such works.

In addition to the proposed berm near Church Street and Ken Whillans, an optional component of this strategy could involve placement of fill within Rosealea Park, immediately south, effectively “raising” the park to at least the 350-year flood level, and potentially to the Regional flood level. Although the proposed “berm/wedge” at Church Street, by itself, is sufficient to prevent spill of flood flows into the Park for the 350-year storm, “raising” the park would provide additional stability behind the existing concrete bypass channel, effectively replacing the existing “berm” at this location with a “wedge”.

### **Grading Works to Widen Downstream Floodplain**





As discussed in Section 2, even without a spill of floodwaters into downtown Brampton from the upstream end of the Etobicoke Creek bypass channel, floodwaters will still “backwater” into the downtown area from downstream of the bypass channel. Review of topographic mapping in this area indicates that the floodplain is “pinched” just upstream of Clarence Street, effectively reducing the overall flood conveyance capacity. This may be the result of historic grading works for the existing Recreation Centre on Mary Street. Therefore, the potential benefits of a wider floodplain at this location were investigated.

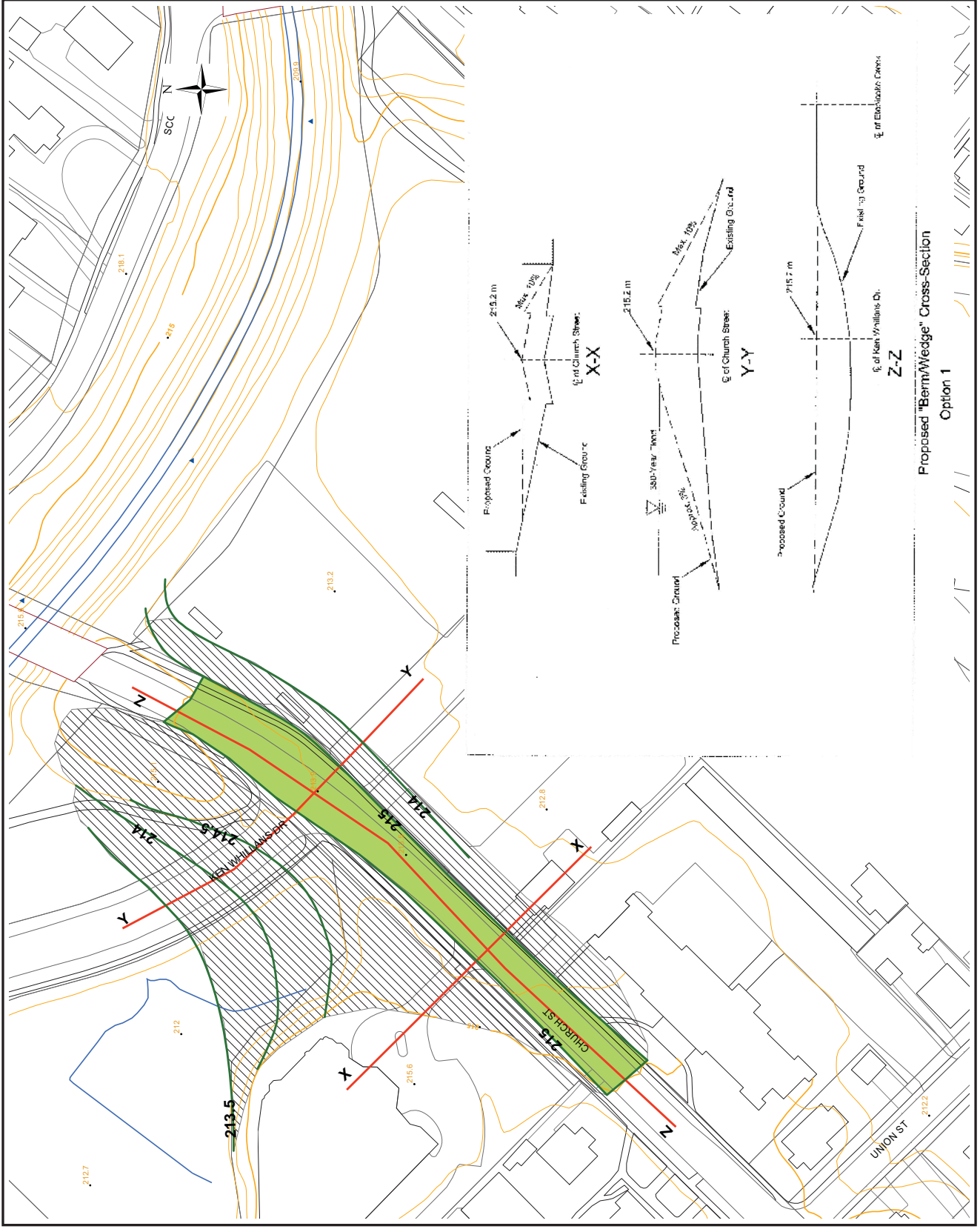
To assess the potential flood benefits of this alternative, the floodplain geometry was revised in the hydraulic model to simulate the removal of the Recreation Centre and

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**Figure 3.1  
Proposed "Berm/Wedge"  
Option 1**

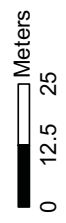
**Legend**

-  Crest of Bermed Area
-  Proposed Contour
-  Cross-Section Location
-  Extent of Grading (approximate)



**Proposed "Berm/Wedge" Cross-Section  
Option 1**

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**Figure 3.2  
Proposed "Berm/Wedge"  
Option 2**

**Legend**

- Crest of Berm/Wedge Area
- Proposed Contour
- Cross-Section Location
- Extent of Grading (approximate)



**Proposed "Berm/Wedge" Cross-Section  
Option 2**

**DRAFT**  
0 12.5 Meters



**Items to Consider for Berm/Wedge Flood Relief Alternative near Church Street and Ken Whillans Drive:**



**Photo 3.4 – Grading to Match Existing Properties (view west on Church St.)**



**Photo 3.5 – Existing Mature Vegetation (view north on Ken Whillans Drive)**

**Items to Consider for Berm/Wedge Flood Relief Alternative near Church Street and Ken Whillans Drive:**



**Photo 3.6 – Pedestrian Trail (adjacent to Ken Willans Drive)**

widening of the floodplain by roughly 150 metres through this reach. Model results indicate that a wider floodplain would achieve the following:

- reduced flood levels for the Regional Storm, ranging from a 0.5m reduction near Wellington Street up to a 1.5m reduction at Mary Street; and
- a 0.5 metre reduction in the 350-year flood levels at Mary Street.

If this or other flood relief options were to be considered further, an Environmental Assessment would be recommended to define the potential social, economic and environmental impacts in more detail. Items to be considered for this flood relief measure include:

- loss or relocation of the existing Recreation Centre;
- grading constraints adjacent to Mary Street;
- potential relocation or modification to existing utilities;
- disturbance to existing vegetation;
- disturbance and relocation of the existing pedestrian trail.

In addition to the above, it is noted that there may be a historic landfill near this location, and therefore, testing and proper disposal of the soils may also need to be considered.

Rough grading estimates indicate that this option would require the removal of roughly 200,000 cubic metres of earth. The estimated cost for this option could be in excess of \$10 million dollars, including the grading works, soil disposal, re-vegetation, and relocation of the Recreation Centre.

### **3.3 Summary**

Of the flood relief measures reviewed above, the following may be suitable for use in downtown Brampton:

#### Flood Proofing Measures

The suitability of floodproofing measures for future development applications will need to be evaluated on a site-by-site basis and consider factors such as flood depth, velocity, emergency access, streetscape, and cost. Depending on the specific characteristics of the site, the following may be feasible:

- elevated structures, provided that flood depths and grading requirements are not excessive;
- watertight floodwalls, subject to structural design considerations;
- watertight doors and seals, for shallow flood depths and non-residential landuses;
- intentional flooding for non-inhabitable structures.

### Flood Relief Measures

Four alternatives for reducing or eliminating flooding in the downtown area were identified and discussed:

- re-design of the Etobicoke Creek bypass channel and bridge structures could potentially provide a lot of flood relief but is very expensive;
- larger railway openings in downtown would also be an expensive option with limited benefit;
- grading works to create a berm/wedge near Church Street and Ken Willans Drive could potentially eliminate spilling of floodwaters into downtown for the 350-year storm at a relatively low cost;
- grading works to widen the Etobicoke Creek floodplain downstream of the downtown area would provide moderate reductions in flood levels at south end of the flood zone, but would be expensive.

#### 4.0 FLOOD DAMAGE AND COST-BENEFIT ASSESSMENT

The previous section reviewed alternative flood protection strategies for downtown Brampton. One strategy in particular was identified to have a potential significant benefit in terms of flood relief for downtown Brampton, without being cost-prohibitive. As discussed, grading works to construct a berm/wedge near Church Street and Ken Willans Drive could protect downtown Brampton from the spill of floodwaters for all storm events up to and including the 350-year storm. Therefore, this flood relief strategy has been investigated further by assessing potential flood damage costs and savings.

In addition, a “combined” flood relief strategy has also been investigated. The intent of the “combined” strategy is to not only prevent 350-year floodwaters from spilling into downtown Brampton at the north end of the bypass channel, but also to minimize “backwater” into the downtown area with grading works to widen the floodplain in the main channel south end of the bypass.

A third flood relief strategy was also investigated to compare the estimated costs and benefits of preventing Regional Storm floodwaters from spilling into downtown Brampton. This strategy includes the acquisition of significant lands to replace the existing concrete channel with a much wider natural channel which is capable of conveying the Regional Storm flow without spill into the downtown core. This is also a “combined” strategy which would also include grading works to widen the downstream floodplain to minimize “backwater” into the downtown core.

In summary, this section compares potential flood damage costs between existing conditions and three alternative flood relief strategies: two for the 350-year storm event, and one for the Regional Storm event:

- **“350-year berm/wedge” strategy** - grading works to create a berm/wedge near Church Street/Ken Willans Drive to the 350-year level;
- **“350-year combined” strategy** - a combination of grading works to create a berm/wedge near Church Street/Ken Willans Drive to the 350-year level, *and* grading works to widen the Etobicoke Creek floodplain downstream of the downtown area; and
- **“Regional combined” strategy** – replacement of the by-pass channel and bridges with a wide natural channel and new bridges, *and* grading works to widen the Etobicoke Creek floodplain downstream of the downtown area.

## 4.1 Hydraulic Model Results

### 350-Year Storm

The Etobicoke Creek hydraulic model was revised to assess the benefits of the two 350-year flood relief scenarios listed above. The extent and depth of flooding for the 350-year storm are compared between existing and proposed strategies in Figures 4.1 to 4.3. Flood depths and velocities are compared in Table 4.1a.

As shown, the “berm/wedge” strategy alone would eliminate spilling of flood flows into downtown, with depths and velocities reduced to zero between Church Street and Main Street. Some flooding would continue to be experienced between Main Street and Mary Street due to “backwater” of flow in the main channel downstream, however the depths and velocities at this location would be reduced. With the “350-year combined” strategy, flooding due to “backwater” for the 350-year event is eliminated between Church Street and Mary Street.

### Regional Storm

A basic hydraulic model was used to estimate the corridor requirements for a re-designed by-pass channel with capacity to convey the entire Regional Storm flow rate without spill into downtown Brampton. The model included the following assumptions:

- the corridor would include a “lowflow” channel, approximately 10m wide and 1.5m deep;
- 3:1 valley side slopes;
- all four existing bridge structures will be replaced, leaving no capacity restrictions from bridges;
- removal of the existing drop structure, and re-grading the new channel at approximately 0.5%.

Basic model results indicate that a stream corridor, approximately 90m wide and 5m deep would provide Regional Storm capacity.

The “Regional-combined” flood relief strategy discussed above includes not only a widening of the by-pass channel to eliminate spill of flood flows at the upstream side, but also grading works to widen the Etobicoke Creek floodplain downstream of the downtown area which reduces flood depths due to “backwater” at the downstream side. In effect, the model results indicate that the “Regional-combined” strategy would eliminate flooding from Church Street to Wellington Street. Further, the remaining flood-susceptible area between Wellington Street and Mary Street would experience flood depths roughly 2m lower than the existing scenario. Flood depths and velocities for the Regional Storm are compared between the existing scenario and proposed “Regional-combined” Strategy in Table 4.1b.



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**Figure 4.2  
350-Year Storm,  
"Berm/Wedge" Strategy**

**Legend**

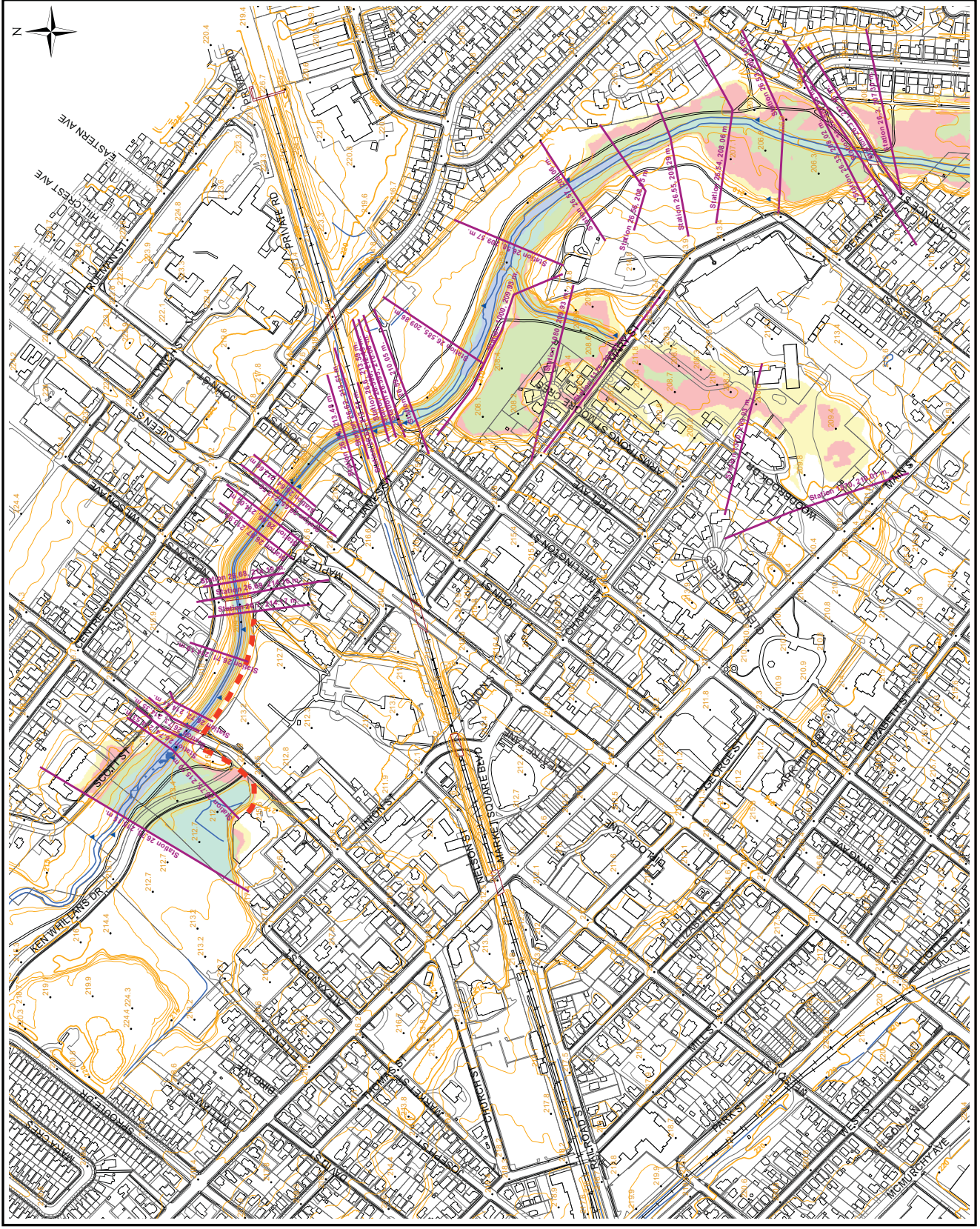
**350-Year Flood Depth**

0.00 - 0.5	0.51 - 1	1.01 - 2	2.01 - 3	3.01 - 4	> 4
[Light Yellow Box]	[Light Orange Box]	[Light Green Box]	[Light Blue Box]	[Medium Blue Box]	[Dark Blue Box]

Hydraulic Model Section, Flood Elevation

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0 100 200 Meters

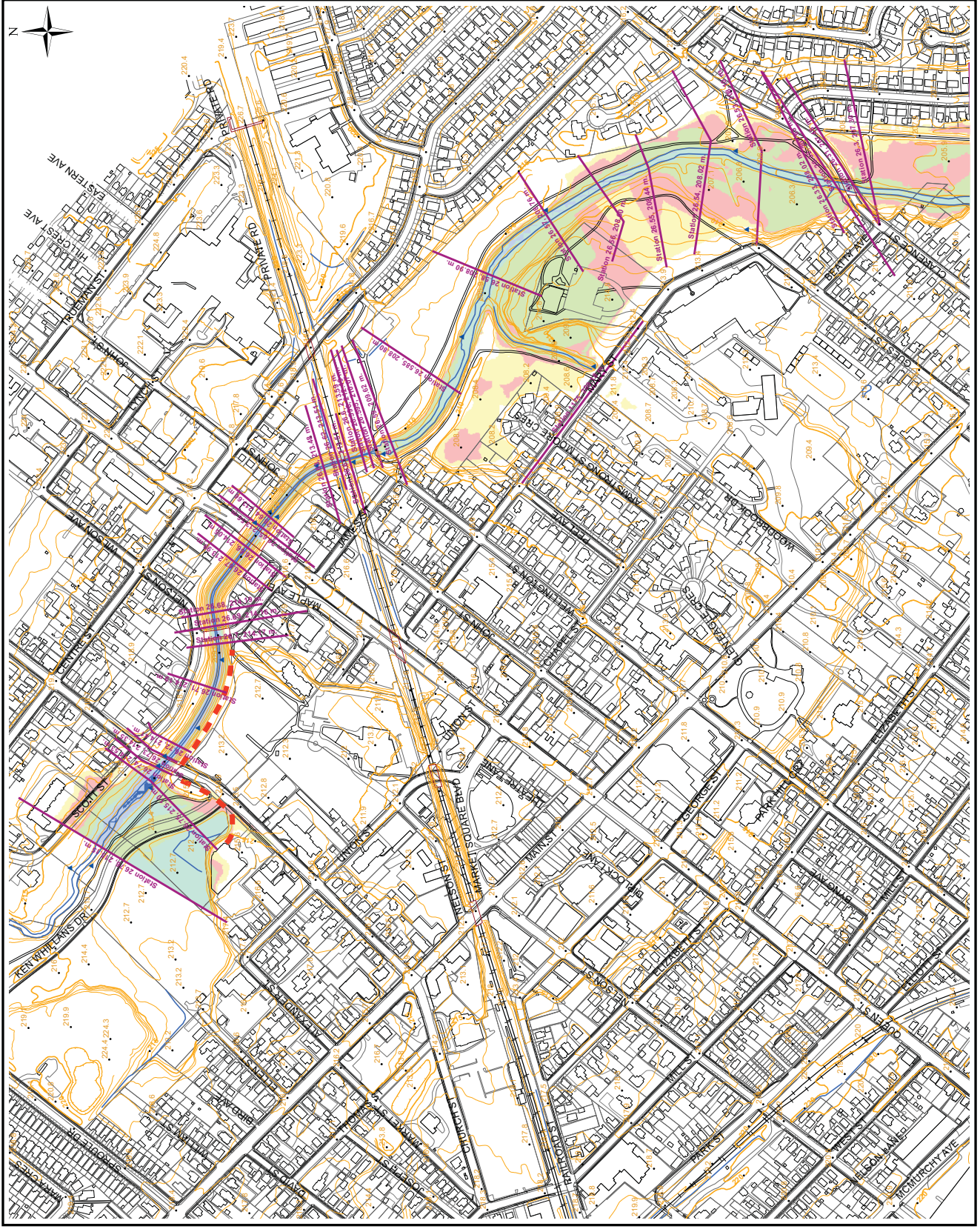
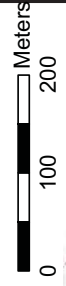


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**Figure 4.3  
350-Year Storm,  
Combined Strategy**

- Legend**
- 350-Year Flood Depth**
- 0.00 - 0.5
  - 0.51 - 1
  - 1.01 - 2
  - 2.01 - 3
  - 3.01 - 4
  - > 4
- Hydraulic Model Section, Flood Elevation

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**Table 4.1a**

**Hydraulic Model Results:  
Comparison of Flood Relief Strategies for 350-Year Storm**

<b>Location</b>	<b>Existing Conditions</b>	<b>350-year Berm/Wedge Strategy</b>	<b>350-year “Combined” Berm/Wedge and Wide Floodplain</b>
Mary St. to Wellington St.	max. depth 0.5-1.0 m, velocity 0.3-1.0 m/s	depth <1.0 m, velocity <0.3 m/s	depth = 0 m velocity = 0 m/s
Wellington St. to Railway	max. depth <1.0 m, velocity 1.0-2.5 m/s  (flow concentrated down George St)	depth = 0 m velocity = 0 m/s	depth = 0 m velocity = 0 m/s
Railway to Church St.	max. depth 0.5-1.0 m, velocity 0.3 m/s	depth = 0 m velocity = 0 m/s	depth = 0 m velocity = 0 m/s

**Table 4.1b**

**Hydraulic Model Results:  
Comparison of Flood Relief Strategies for Regional Storm**

<b>Location</b>	<b>Existing Conditions</b>	<b>Regional “Combined” New By-pass Channel and Wide Floodplain</b>
Mary St. to Wellington St.	max. depth 3-4 m, velocity 0.7-1.2 m/s	depth = 0-2 m velocity = 0 m/s
Wellington St. to Railway	max. depth 2-3 m, velocity 1-4 m/s  (flow concentrated down George St)	depth = 0 m velocity = 0 m/s
Railway to Church St.	max. depth 3-4 m, velocity 0.5 m/s	depth = 0 m velocity = 0 m/s

## 4.2 Estimated Flood Damage Costs

In order to estimate potential flood damage costs, an inventory of all existing buildings subject to potential flooding was assembled. Figure 4.4 illustrates the buildings in downtown Brampton which are susceptible to flooding for the 350-year and Regional storms. An inventory of these buildings, by address, is provided in Appendix B, together with existing landuses and estimated flood depths for existing conditions and for the three flood relief strategies.

Flood damage costs were then estimated under three main categories:

- direct damages – representing actual physical losses or damages to private structures (buildings, contents, vehicles) and public structures (buildings, roads, infrastructure). Direct damages were then estimated using the 1984 Ministry of Natural Resources “Flood Damage Estimation Guide”. This document predicts flood damages based on landuse, flood depth, and building area. The relationships derived from this document were adjusted for inflation and are summarized in Table 4.2.
- indirect damages – representing losses caused by interruption of normal activities, including loss of revenues and wages. Although this value is very difficult to determine, it is typically estimated under MNR guidelines at roughly 20% of the total direct damages.
- vehicle damages – although damage to vehicles is normally covered under direct damages, this third category was included to account for the two large underground parking lots at 2 Wellington Street (City Hall) and 5 Market Square Blvd which are within the Etobicoke Creek floodplain. Together, these two buildings have 912 underground parking spaces. The number of vehicles parked in these lots will vary significantly depending upon the time of day, however, for simplicity, an average value of \$10,000 was assumed for the loss of a vehicle at each parking space due to potential flooding.

Flood damages were estimated for the above categories for the 350-year storm and Regional storm. For comparison, flood damages were also estimated for the 100-year storm. Total estimated flood damages for each of the relief scenarios are summarized and compared in Table 4.3. Results from the assessment indicate the following:

- without any flood relief, the existing flood damage costs resulting from the 100-year, 350-year, and Regional storms are estimated at approximately \$23.9 million dollars, \$29.3 million dollars, and \$78.7 million dollars, respectively.

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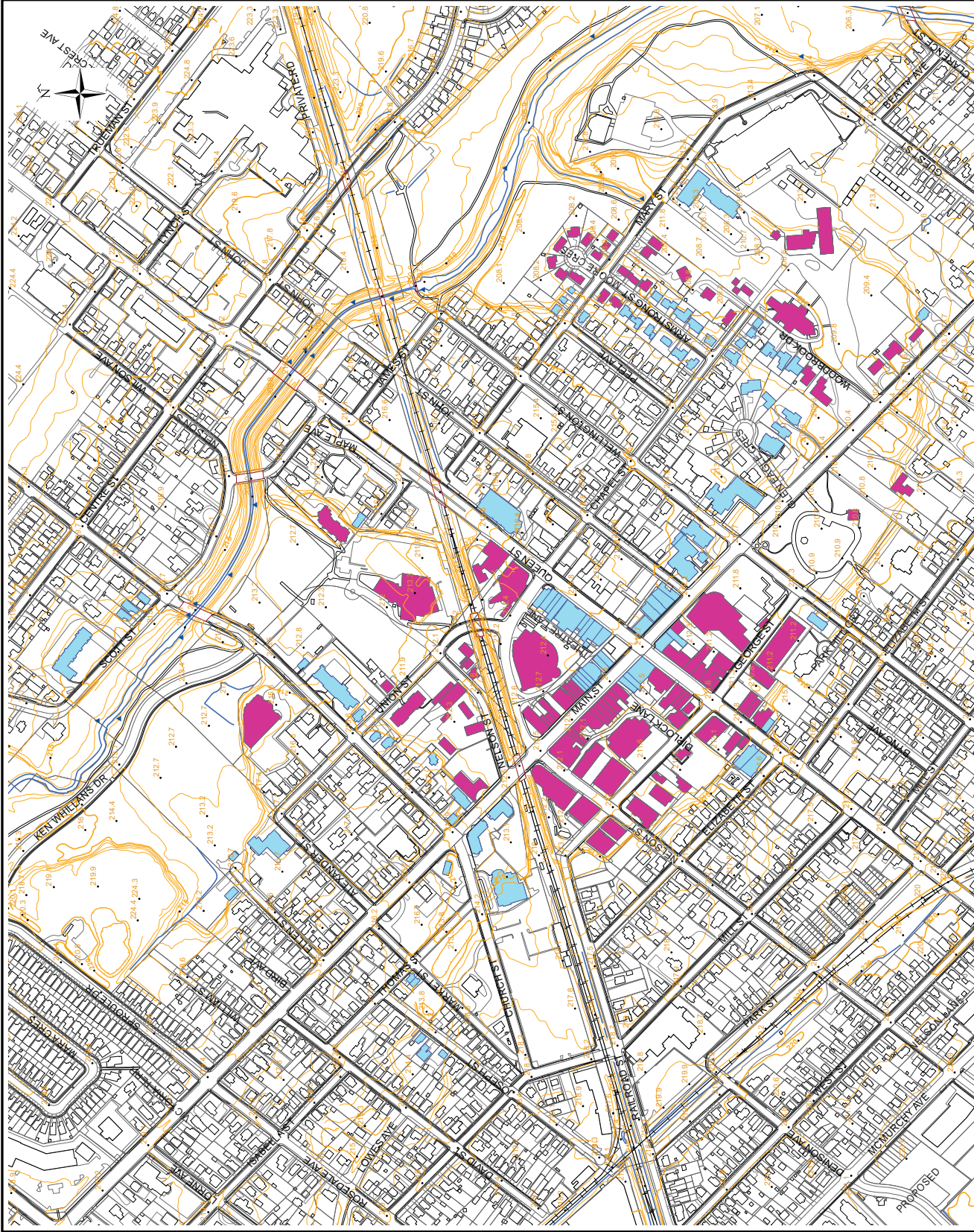
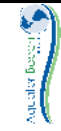
**Figure 4.4  
Existing  
Flood-Susceptible  
Buildings**

**Legend**

**Flooded Buildings**

- 350 Year & Regional Storms
- Regional Storm Only

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**Table 4.2**  
**Summary of Relationships Used To Estimate Flood Damage Values**

<b>Landuse</b>	<b>Landuse Code</b>	<b>Relationship*</b>
Residential, 1-storey home	R1	Cost = \$42,612 + \$10,370 x depth (m)
Residential, 2-storey home	R2	Cost = \$39,110 + \$10,650 x depth (m)
Residential, apartment/condo	R3	Cost = \$213,060 + \$51,850 x depth (m)
Office	A	Cost = [\$69.80 + \$190.10 x depth(m)] x Area (m2)
Medical	B	Cost = [\$170.30 + \$541.80 x depth(m)] x Area (m2)
Commercial - Clothing	C2	Cost = [\$140.50 + \$1,623.00 x depth(m)] x Area (m2)
Commercial - Stereo/TV	C3	Cost = [\$46.60 + \$683.50 x depth(m)] x Area (m2)
Commercial - Hardware	C5	Cost = [\$61.60 + \$206.60 x depth(m)] x Area (m2)
Commercial - Misc.	C6	Cost = [\$190.20 + \$702.90 x depth(m)] x Area (m2)
Grocery	E	Cost = [\$409.80 x depth(m)] x Area (m2)
Drug Store	F	Cost = [\$545.40 x depth(m)] x Area (m2)
Auto Service	G	Cost = [\$116.40 + \$521.40 x depth(m)] x Area (m2)
Restaurant	I	Cost = [\$32.20 + \$97.50 x depth(m)] x Area (m2)
Personal Service	J	Cost = [\$456.90 x depth(m)] x Area (m2)
Financial	K	Cost = [\$21.40 + \$240.30 x depth(m)] x Area (m2)
Theatre	M	Cost = [\$89.90 + \$85.20 x depth(m)] x Area (m2)
Institutional	N	Cost = [\$96.80 + \$337.70 x depth(m)] x Area (m2)

\* Costs in \$2005.

**Table 4.3**  
**Summary of Estimated Flood Damages**

<u>Relief Scenario</u>	<u>100-year Storm</u>	<u>Estimated Flood Damage</u>	
		<u>350-year Storm</u>	<u>Regional Storm</u>
<b>Existing conditions (i.e. no relief)</b>			
direct damages:	\$12,280,051	\$16,816,077	\$57,958,574
indirect damages:	\$2,456,010	\$3,363,215	\$11,591,715
undergournd parking:	\$9,120,000	\$9,120,000	\$9,120,000
<b>Total</b>	<b>\$23,856,061</b>	<b>\$29,299,292</b>	<b>\$78,670,289</b>
<b>350-year "berm/wedge"</b>			
direct damages:	\$179,502	\$1,216,581	\$57,862,209
indirect damages:	\$35,900	\$243,316	\$11,572,442
undergournd parking:	\$0	\$0	\$9,120,000
<b>Total</b>	<b>\$215,403</b>	<b>\$1,459,897</b>	<b>\$78,554,651</b>
<b>350-year "combined"</b>			
<b>(berm/wedge, downstream floodplain works)</b>			
direct damages:	\$0	\$0	\$55,493,045
indirect damages:	\$0	\$0	\$11,098,609
undergournd parking:	\$0	\$0	\$9,120,000
<b>Total</b>	<b>\$0</b>	<b>\$0</b>	<b>\$75,711,654</b>
<b>Regional "combined"</b>			
<b>(new wide by-pass, new bridges, d/s floodplain works)</b>			
direct damages:	\$0	\$0	\$5,525,908
indirect damages:	\$0	\$0	\$1,105,182
undergournd parking:	\$0	\$0	\$0
<b>Total</b>	<b>\$0</b>	<b>\$0</b>	<b>\$6,631,089</b>

- the “350-year berm/wedge” strategy removes flooding for most of the downtown properties for the 100-year and 350-year storms. As a result, flood damages are reduced significantly to approximately \$0.2 and \$1.5 million dollars, respectively. However, this strategy has virtually no impact on Regional storm flood damages.
- the “350-year combined” flood relief strategy further reduces the estimated flood damages from the 100-year and 350-year storms to \$0. However this strategy provides a very minor reduction in Regional storm flood damages;
- the “Regional combined” strategy eliminates flood damages for the 100-year and 350-year storms, and significantly reduces Regional storm flood damages to approximately \$6.6 million dollars.

A detailed breakdown of the flood damage estimates on a site-by-site basis is provided in Appendix B.

### **4.3 Cost-Benefit Comparison**

In order to assess whether any of the proposed flood relief strategies are economical, the potential benefits of the strategies, in terms of flood damage reductions, were compared. This requires discounting the flood damage estimates from future flood events to present-day values and then comparing them to present-day costs estimates for the relief works. To do so, the estimated flood damage costs for various storms were used, together with the probability of those flood events, to express flood damages in term of average annual costs. These annual cost series were then converted to present-day values.

Table 4.4 summarizes the average annual and present-day flood damage costs. As shown, the existing average annual flood damage cost for downtown Brampton is approximately \$400,900. The present value of these annual costs is roughly \$5.5 million dollars. Table 4.4 also summarizes the reduced annual and present-day flood damages associated with the proposed flood damage reduction strategies.

The estimated costs of the proposed flood relief strategies are then compared to the potential reductions in flood damage for in Table 4.5. As shown:

- the potential benefits of the “350-year berm/wedge” strategy, in terms of flood damage relief, is over two times greater than the estimated \$2 million dollar cost.
- the “350-year combined” strategy provides only slightly higher benefits above the “350-year berm/wedge” strategy but costs significantly more. In fact the cost of this strategy is almost 3 times larger than the potential present-day benefits, making it uneconomical.

**Table 4.4  
Estimated Present Value of Flood Damages**

**Existing (no flood relief)**

Return Period	Estimated Flood Damages			Total	Frequency	Average Annual Flood Damage
	Direct	Indirect	u/g Parking*			
50-year	\$0	\$0	\$0	\$0	0.020	\$0
100-year	\$12,280,051	\$2,456,010	\$9,120,000	\$23,856,061	0.010	\$238,561
350-year	\$16,816,077	\$3,363,215	\$9,120,000	\$29,299,292	0.003	\$83,712
Regional	\$57,958,574	\$11,591,715	\$9,120,000	\$78,670,289	0.001	\$78,670

Total Avg. Annual Damages: **\$400,943**  
Present Value of Damages\*\*: **\$5,533,315**

**350-Year "Berm/Wedge" (berm/wedge at Church St.)**

Return Period	Estimated Flood Damages			Total	Frequency	Average Annual Flood Damage
	Direct	Indirect	u/g Parking*			
50-year	\$0	\$0	\$0	\$0	0.020	\$0
100-year	\$179,502	\$35,900	\$0	\$215,403	0.010	\$2,154
350-year	\$1,216,581	\$243,316	\$0	\$1,459,897	0.003	\$4,171
Regional	\$57,862,209	\$11,572,442	\$9,120,000	\$78,554,651	0.001	\$78,555

Total Avg. Annual Damages: **\$84,880**  
Present Value of Damages\*\*: **\$1,171,405**

**350-Year "Combined" (berm/wedge at Church St. & wider floodplain near Mary St.)**

Return Period	Estimated Flood Damages			Total	Frequency	Average Annual Flood Damage
	Direct	Indirect	u/g Parking*			
50-year	\$0	\$0	\$0	\$0	0.020	\$0
100-year	\$0	\$0	\$0	\$0	0.010	\$0
350-year	\$0	\$0	\$0	\$0	0.003	\$0
Regional	\$55,493,045	\$11,098,609	\$9,120,000	\$75,711,654	0.001	\$75,712

Total Avg. Annual Damages: **\$75,712**  
Present Value of Damages\*\*: **\$1,044,877**

**Regional "Combined" (new wide by-pass channel, new bridges & wider floodplain near Mary St.)**

Return Period	Estimated Flood Damages			Total	Frequency	Average Annual Flood Damage
	Direct	Indirect	u/g Parking*			
50-year	\$0	\$0	\$0	\$0	0.020	\$0
100-year	\$0	\$0	\$0	\$0	0.010	\$0
350-year	\$0	\$0	\$0	\$0	0.003	\$0
Regional	\$5,525,908	\$1,105,182	\$0	\$6,631,089	0.001	\$6,631

Total Avg. Annual Damages: **\$6,631**  
Present Value of Damages\*\*: **\$91,514**

\* estimated flood damages to vehicles in underground parking at 2 Wellington St. & 5 Market Square Blvd. based on 912 spaces and average \$10,000 per vehicle.

\*\* assumes 7% interest rate over 50 year lifespan

**Table 4.5  
Comparison of Flood Relief Costs and Benefits**

<u>Relief Scenario</u>	<u>Estimated Cost</u>	<u>Present Value of Flood Damages</u>	<u>Flood Damage Savings</u>	<u>Benefit / Cost Ratio</u>
Existing conditions (i.e. no relief)	\$0	\$5,533,315	\$0	n/a
Grading to create berm/wedge	\$2,000,000	\$1,171,405	\$4,361,910	2.18
Grading to create berm/wedge and widen downstream floodplain	\$12,000,000	\$1,044,877	\$4,488,438	0.37
widen and regrade channel to convey Regional	\$35,000,000	\$91,514	\$5,441,801	0.16

- The “Regional combined” strategy is also considered to be uneconomical, with costs exceeding potential benefits by a factor of over 6.

Therefore, based on the above, the “350-year berm/wedge” strategy is feasible and economical with the potential benefits outweighing the estimated costs by almost \$2.4 million dollars.

Depending upon provincial and TRCA decisions regarding the flood standard to be applied in the downtown Brampton SPA, the “350-year berm/wedge” relief strategy may be sufficient to allow future development to proceed. If so, the actual construction of the “berm/wedge” strategy would potentially eliminate the requirement for future development proponents to provide costly flood protection measures at every site. Given this benefit to future development proponents, there may be an opportunity for the City to recover the construction costs for the flood relief strategies through Development Charges.

## **5.0 SUMMARY AND CONCLUSIONS**

This report has been prepared to address Part 1 of the Downtown Drainage Study, which investigates flood risks associated with Etobicoke Creek for the Downtown Brampton Special Policy Area (SPA), and reviews flood protection alternatives.

Current SPA policies refer to the Regional Storm and 350-year storm events. A hydraulic model for Etobicoke Creek was setup to define the flood characteristics for these storms in the Downtown SPA. In both cases, floodwaters enter the downtown SPA at two locations:

- via “spill” at the north end of the existing concrete by-pass channel; and
- via “backwater” just south of the by-pass channel.

The flood characteristics, in terms of depths and velocities were discussed.

Two general flood protection categories were assessed:

- general flood proofing techniques which may be used in the design of individual buildings; and
- flood relief measures to reduce or eliminate the flood flows entering the downtown area.

Flood protection requirements and alternatives were reviewed. The following was concluded with regard to the suitability of various alternatives for use in downtown Brampton:

### Flood Proofing Measures

The suitability of floodproofing measures for future development applications will need to be evaluated on a site-by-site basis and consider factors such as landuse, flood depth, velocity, emergency access, streetscape, and cost. Depending on the specific characteristics of the site, the following may be feasible:

- elevated structures, provided that flood depths and grading requirements are not excessive;
- watertight floodwalls, subject to structural design considerations;
- watertight doors and seals, for shallow flood depths and non-residential landuses;
- intentional flooding for non-inhabitable structures.

### Flood Relief Measures

Four alternatives for reducing or eliminating flooding in the downtown area were identified and discussed:

- re-design of the Etobicoke Creek bypass channel could potentially provide a lot of flood relief but is very expensive;
- larger railway openings in downtown would also be an expensive option with limited benefit;
- grading works to create a berm/wedge near Church Street and Ken Willans Drive could potentially eliminate spilling of floodwaters into downtown for the 350-year storm at a relatively low cost;
- grading works to widen the Etobicoke Creek floodplain downstream of the downtown area would provide moderate reductions in flood levels at south end of the flood zone, but would be expensive.

Based on the feasibility assessment, three flood relief strategies were investigated further:

- **“350-year berm/wedge” strategy** - grading works to create a berm/wedge near Church Street/Ken Willans Drive to the 350-year level;
- **“350-year combined” strategy** - a combination of grading works to create a berm/wedge near Church Street/Ken Willans Drive to the 350-year level, *and* grading works to widen the Etobicoke Creek floodplain downstream of the downtown area; and
- **“Regional combined” strategy** – replacement of the by-pass channel and bridges with a wide natural channel and new bridges, *and* grading works to widen the Etobicoke Creek floodplain downstream of the downtown area.

The “350-year berm/wedge” strategy alone would completely eliminate spilling of flood flows into downtown for the 350-year storm. The “350-year combined” strategy provides additional benefit for the 350-year storm by preventing “backwater” from the main channel downstream. The “Regional combined” strategy eliminates spilling of flood flows into downtown for the Regional storm and reduces the “backwater” flood depths at the main channel downstream of the downtown study area.

Detailed flood damage cost estimates were completed for various storm events with and without the flood relief strategies in place. The following was concluded:

- without any flood relief, the existing flood damage costs resulting from the 100-year, 350-year, and Regional storms are estimated at approximately \$23.9 million dollars, \$29.3 million dollars, and \$78.7 million dollars, respectively.

- the “350-year berm/wedge” strategy removes flooding for most of the downtown properties for the 100-year and 350-year storms. However, this strategy has virtually no impact on Regional storm flood damages.
- the “350-year combined” flood relief strategy further reduces the estimated flood damages for the 100-year and 350-year storms. However this strategy provides a very minor reduction in Regional storm flood damages;
- the “Regional combined” strategy eliminates flood damages for the 100-year and 350-year storms, and significantly reduces Regional storm flood damages to approximately \$6.6 million dollars.

The potential benefits of the strategies, in terms of reduced flood damage costs, were converted to present-day values and then compared to the estimated costs to construct the flood reduction works. The following was concluded:

- the potential benefits of the “350-year berm/wedge” strategy, at almost \$4.4 million dollars, is over two times greater than the estimated \$2 million dollar cost.
- the “350-year combined” strategy provides only slightly higher benefits above the “350-year berm/wedge” strategy but costs significantly more, making it uneconomical.
- The “Regional combined” strategy is also considered to be uneconomical, with costs exceeding potential benefits by a factor of over 6.

Therefore, based on the above, the “350-year berm/wedge” strategy is feasible and economical with the potential benefits outweighing the estimated costs by almost \$2.4 million dollars.

The potential significant reduction in flood risk to existing buildings for all storms up to the 350-year storm for this strategy should serve as a basis for discussions between the City and the Province and Conservation Authority regarding the standards for future development. Depending upon provincial and TRCA decisions regarding the flood standard to be applied in the downtown Brampton SPA, the “350-year berm/wedge” relief strategy may be sufficient to allow future development to proceed. Given that the proposed “berm/wedge” strategy would remove the threat of flooding up to the 350-year storm for most of the downtown SPA, we would suggest that future development applications could proceed on a “best efforts” basis. At the very minimum, all residential units could be located above the Regional Storm flood elevation, with other uses (parking garages, commercial, industrial etc.) floodproofed on a “best efforts” basis, subject to urban design standards and technical feasibility.

Given that the works would be required to allow future development applications to proceed, there may be an opportunity for the City to recover the cost of the flood relief works through Development Charges.