Technical Memorandum

To: Cary Clark, P.Eng., Manager of Development & Stormwater Engineering
City of Burlington

Date: June 26, 2024

From: Calvin Paul, Eeshan Kumar and Matt Senior

Project No: CA-EI-WW23011105

Subject: **Preliminary Flood Mitigation Alternatives Assessment for Burlington GO and Downtown Areas**

1 BACKGROUND

The MTSA (Major Transit Station Area) Phase 2 Study Reporting was finalized by WSP March 6, 2023 ("MTSA Phase 2 Flood Hazard Assessment – Burlington GO and Downtown"). Final hydrologic and hydraulic models were issued as part of this work.

Subsequently, Conservation Halton (CH) undertook additional revisions to the modelling. As per their e-mail of April 26, 2023 (ref. Irwin-Malik\Senior) it was noted that CH modified flow inputs to the hydraulic modelling to better reflect the results in the final hydrologic modelling (which includes revisions made by CH staff to the hydrologic modelling regarding inflows to the East Rambo Pond). To WSP's understanding, these changes resulted in decreases in the Regional Storm flow to the East Rambo Pond (approximate reduction of 10 m^3/s +/-), and also removed a previously implemented structure attenuation flow correction input at the East Rambo CNR culvert. CH also noted that they revised the modelling to run the shallow water equations within HEC-RAS. As such, the modelling and summaries provided in the March 2023 reporting may no longer reflect the currently approved modelling results (as implemented by CH but reviewed and approved by WSP).

Following report finalization (and additional modelling updates by CH) it is understood that the City is receiving numerous development applications for the study area. Several areas are indicated as impacted by spill flows during the Regional Storm Event. In general, the model results indicate that spill flows from the East Rambo Pond flow through the CNR culvert at the western limit of the pond, and then westerly down Plains Road and ultimately to the Brant Street underpass, where the modelling results indicate the spill volume accumulates sufficiently to continue spilling southerly along Brant Street. It is understood that development proponents are challenged in implementing

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site-specific flood management measures, including satisfying the floodproofing and flood management requirements of CH.

To WSP's understanding, the previously noted modelling changes by CH reduced the Regional Storm spill flow down Brant Street from 19.1 m^3/s (i.e. Drawing 5D in the March 2023 report) to 12.8 m^3/s in the latest CH model. Notwithstanding the reduction, the Regional Storm spill is still indicated.

Other potential developments in the subject areas, including Lower Rambo Creek, are also potentially impacted by increased floodplain limits and spill flows as identified by the Phase 2 Study and subsequent updates.

In conjunction with the preceding, it is understood that the approval of the March 2023 MTSA study (and associated mapping) was reviewed at the CH Board of Directors on October 19, 2023.

> *Agenda Item 7.3 – CH Board Report No. CHB 08 23 04*
>
> *THAT the Conservation Halton Board approves updated flood hazard mapping for the Lower Rambo Creek watershed based on the results of the "Major Transit Station Area (MTSA) Phase 2 Flood Hazard Assessment, Burlington GO and Downtown" report prepared by WSP, dated March 6, 2023, and local updates completed by Conservation Halton staff;*
>
> *And*
>
> *THAT the Conservation Halton Board directs staff to incorporate the approved mapping into Conservation Halton's Approximate Regulation Limit mapping in 30 days to allow time for Burlington City Council to discuss the initiation of a City study that assesses and evaluates potential solutions to mitigate or reduce flood hazard risks in downtown Burlington / Burlington GO MTSA and build climate change resiliency, in collaboration with Conservation Halton.*

It is assumed that based on the wording above that CH will automatically incorporate the current mapping in 30 days, unless revisions or updates are proposed by the City (and presumably also accepted by CH) in that time.

2 PURPOSE

As per the preceding, the City retained WSP (original proposal of November 7, 2023) to support the completion of an evaluation of flood hazard mitigation alternatives to mitigate identified spill zones or flood impacted areas.

The study initially focused on the Brant/Fairview Streets spill, which WSP notes that the spill occurs only for the Regional Storm Event (i.e. Hurricane Hazel), for which climate change adjustments are not typically considered.

Based on subsequent discussions with City staff and the development of an updated\draft Terms of Reference (as discussed with City staff at a meeting January 29, 2024), WSP has also conducted an evaluation of flood hazard mitigation alternatives for the Lower Rambo Creek in the Downtown Burlington area.

It should be noted that Conservation Halton (CH) staff have separately undertaken an assessment of other potential areas of concern, including the east branch of Rambo Creek (CNR to Fairview Street) and the Hager-Rambo Diversion Channel (Fairview Street to the downstream limits at Indian Creek). WSP has not summarized any of those works as part of the current memorandum.

For the purposes of the current scope, no "climate resiliency" measures were considered. The focus was upon developing and assessing (at a conceptual\preliminary level) potential alternatives which may either reduce or eliminate the upstream spills thereby reducing the floodplain limits in the area by undertaking measures on public lands for the time being while ensuring no off-site impacts from implementation. It was assumed that other alternatives (i.e. other off-site measures such potential purchase and re-purposing of private property, and on-site measures such as active floodproofing) would be considered by others or at a later date.

This memo provides the findings of WSP's assessment for the Brant/Fairview Streets Spill and Burlington Downtown area and recommendations for infrastructure improvements with approximate overall cost estimates. WSP has utilized the HEC-RAS 2D models developed for the MTSA Phase 2 Study (updated by CH) for this assessment and has incorporated changes to the model geometry to reflect recently constructed or approved development sites.

3 INFRASTRUCTURE IMPROVEMENTS

Based on discussions with City staff, the focus of infrastructure improvements has been on measures that could be implemented on City-owned properties, and which would not exacerbate flooding impacts to adjacent areas or properties. The sequence of alternatives / scenarios have been adjusted to reflect the sequence with which modeling would be expected to be completed, i.e., generally from upstream to downstream.

3.1 Infrastructure Improvements along Upper Rambo Creek

3.1.1 ALTERNATIVES NOT ADVANCED

— *Roly Bird Park – Potential Flood Storage*

This alternative considered the potential to provide offline flood control storage for Rambo Creek, to reduce inflows to East Rambo Pond and thus potential spill flows to Brant and Fairview. Based on an initial review, it was determined that based on the most current hydraulic modelling (HEC-RAS) of the creek (refer to "Technical Memo: Hydrology and Hydraulic Model Updates" by Matrix Solutions Inc, June 1, 2023) it was evident that the

Regional Floodplain would already encroach into the park, and thus it was considered unlikely it could be used for storage purposes. In addition, any such works would likely negatively impact the recreational uses within the park. As such, this alternative was not assessed further.

— *East Rambo Pond – Potential Retrofit and Storage Increase*

This alternative was considered to evaluate whether the existing flood control facility could be retrofitted to maximize (increase) available active storage volume. While it was noted that the permanent pool within the FCF could likely be lowered slightly based on the invert elevation of the outlet structure, there were limited opportunities to widen the footprint of the pond or gain storage through steepening of side slopes. A preliminary re-grading assessment indicated that approximately 11,000 m^3 of additional storage could be achieved through deepening. This was assessed through further hydraulic modelling (HEC-RAS); the results indicated no decrease in spill flows at Brant Street. This is considered attributable to the relatively modest amount of additional storage volume compared to the overall volume within East Rambo Pond. In addition, the storage volume would be utilized during the initial portions of the storm resulting in negligible differences at the peak of the storm.

— *Brant Street Road Profile Adjustments*

This alternative was reviewed to determine if there was any potential to adjust the road profile and grades along Brant Street in the vicinity of the railway underpass to increase ponding\storage and minimize spills to the south. Based on a preliminary review, it was determined that given the need to meet adjacent property grades (driveways and entrances) and existing topographic constraints, that re-grading would not be feasible.

3.1.2 POTENTIAL ALTERNATIVE SOLUTION #1 – CONVEYANCE CAPACITY INCREASE ALONG RAMBO CREEK

The solutions under this alternative are primarily focused upon better capturing spill flow along Plains Road and directing it to Rambo Creek by improving the conveyance capacity of the associated culverts in this area through to the outlet to the Hager-Rambo Diversion Channel at Fairview Street. Refer to the locations presented in Figure R1.

Figure R1: Culvert Locations (Rambo Creek)

— *Culvert ID 19*

This culvert is located along Rambo Creek just upstream of Plains Road East (Parking lot near Courthouse). The existing culvert is a reinforced concrete box culvert with a span and rise of 2.5 m and 1.7 m respectively and 26.06 m in length. It was proposed that this culvert be replaced by an open bottom structure with a 7.32 m span and 2.44 m rise precast box culvert.

— *Culvert ID 20*

This culvert is located along the north ditch of Plains Road, where the driveway entrance to the courthouse building is located (pathway for spill flow from East Rambo Pond). The existing culvert is approximately a 600 mm diameter HDPE (Big 'O') culvert, 27.4 m in length. It was proposed that this culvert be replaced with a 3.05 m span by 1.37 m rise reinforced concrete box culvert.

— *Culvert ID 21*

This culvert is located on Rambo Creek on Plains Road East. The existing structure is a reinforced concrete box culvert with a span and rise of 4.2 m and 1.6 m respectively and 37.2 m in length. It was proposed that this culvert be replaced by an open cut with a 7.93 m span and 2.44 m rise precast box culvert. *Culvert ID 22*

This culvert is located on Rambo Creek at the CNR (spur line) just downstream of Plains Road East. The existing structure is a reinforced concrete box culvert with a span and rise of 4.2 m and 1.7 m rise respectively and 23 m in length. It was proposed that twin 2100 mm circular steel pipes be jack and bored to convey more flows downstream.

— *Culvert ID 23*

This culvert is located on Rambo Creek at Queensway Drive just downstream of CNR Culvert ID 22. The existing structure is a reinforced concrete box culvert with a span and rise of 4 m and 1.5 m rise respectively and 17.2 m in length. It was proposed that this culvert be replaced by an open cut with a 7.93 m span and 2.44 m rise precast box culvert.

— *Culvert ID 25*

This culvert is located on Rambo Creek at the CNR (main line) just upstream of De Paul's Lane. The existing structure is a 2850 mm circular pipe and 32.2 m in length. It was proposed that twin 2100 mm circular steel pipes be jack and bored to convey more flows downstream.

The total cost of implementing all of the preceding works in sequence is estimated to be approximately $9.7 million. Costs includes a 30% contingency but do not include engineering\design or construction administration\inspection fees.

Based on the hydraulic modelling results, the preceding conveyance upgrades would eliminate spill flow from the Brant Street underpass, as the inundation depths do not pond sufficiently to cause spill. However, there is a slight spill from Rambo Creek on to Fairview due the increased flow to the channel, which ultimately spills down Brant Street (refer to Figure R2). However, the magnitude of the simulated spill flow is relatively minor (0.56 m^3/s instead of 13.1 m^3/s) and could potentially be resolved with further design modifications.

The impact to downstream areas of the additional spill flows being directed to the Hager-Rambo Diversion Channel has not been assessed by WSP.

Figure R2: Simulated Regional Storm Floodplain and Spill with Rambo Creek Culvert Improvements in Place

3.1.3 POTENTIAL ALTERNATIVE SOLUTION #2 – CAPTURE AND CONVEYANCE ALONG BRANT STREET

— *Capture along Brant Street and Conveyance to Hager-Rambo Diversion Channel*

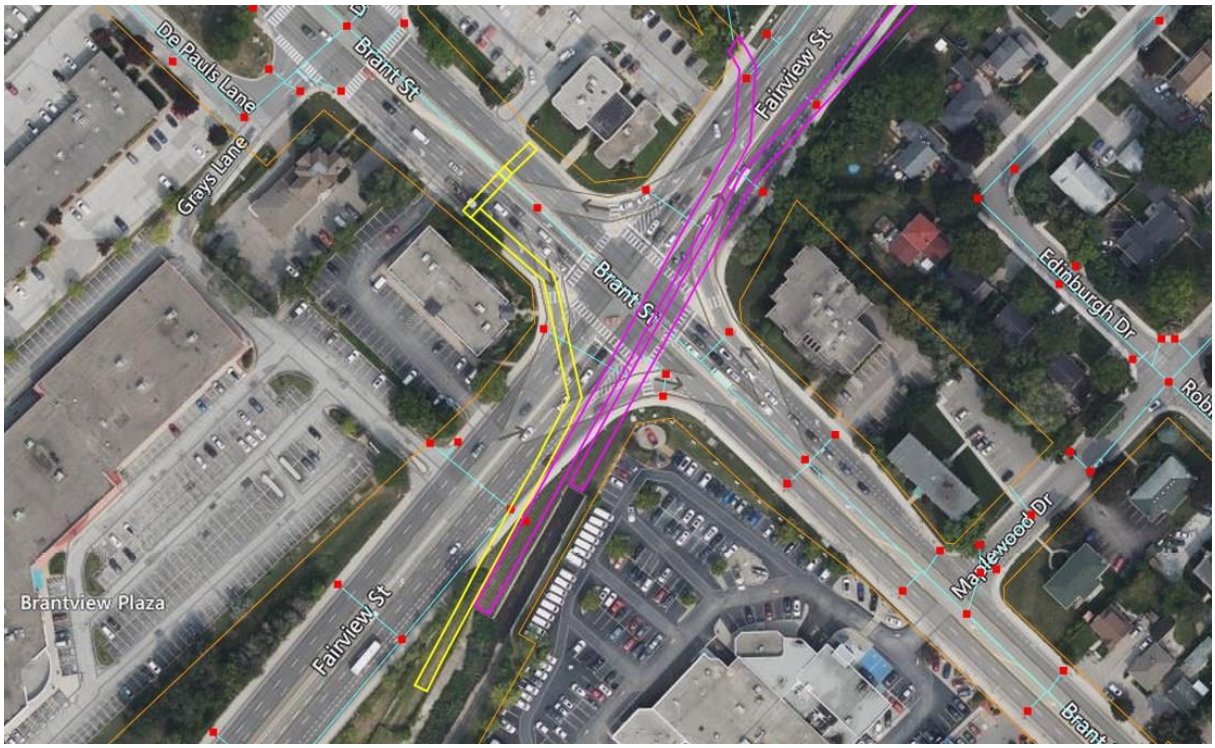
This alternative would involve a trench\open grate capture system spanning the full width of Brant Street north of Fairview Street to capture potential spill flows and re-direct them to the Hager-Rambo Diversion Channel downstream of Brant Street. A conceptual layout is presented in Figure R3.

Based on a simplified assessment (no modelling), a 3.0 m wide x 1.5 m high box culvert at 0.5% slope would be required to capture and convey the full estimated Regional Storm spill flow of 13.1 m^3/s. It is assumed that the intake grate would span the full width of Brant Street (26 m and would likely coincide with the box culvert structure.

A preliminary construction cost of approximately $6 million has been estimated, based on a high-level cost of $30,000 per metre and the approximate total length of 200 m, including the capture trench. This excludes engineering\design or construction phase support fees.

Overall, the costs for Alternative Solution #2 are lower than those for #1; and this alternative would make use of the underpass for storage during the Regional Storm Event. The impact to downstream areas of the additional spill flows being directed to the Hager-Rambo Diversion Channel has not been assessed by WSP.

Figure R3: Conceptual Layout of Capture and Diversion Sewer (in Yellow)



3.2 Infrastructure Improvements along Lower Rambo Creek (Downtown)

The proposed infrastructure improvements presented here assume the elimination of upstream spills (such as Brant and Fairview spills, Argon Court spills; previously reviewed by CH), unless explicitly specified otherwise. The alternatives have been tested for the 100-year design storm event as it was the governing storm event for the Burlington Downtown area (with upstream spills excluded). A review of potential infrastructure enhancements has been conducted to assess potential beneficial impacts. A series of summary figures have been attached to each of the alternatives noted below to present the simulated benefit with respect to flood inundation reduction (HEC-RAS 2D modelling from the Phase 2 study with upstream spills eliminated as noted previously).

- *Alternative 1: Upsizing Blairholm Avenue Enclosure and Courtland Place Culvert*

  The Blairholm Avenue enclosure is a 128 m long enclosure that was modeled as a 2.69 m span and 1.725 rise ellipse within the HEC-RAS 2D model. The existing structure for Courtland Place is a reinforced concrete box culvert with a 4.6 m span, 1.25 m rise and 10.3 m in length. It is proposed that for Blairholm Avenue, another horizontal elliptical enclosure similar to the existing structure in size be added (twinning) to eliminate spills in this area (and to eliminate the need for a full reconstruction\replacement). However, costs may increase if a full removal of the existing enclosure is needed and replaced with a single combined conduit (enclosure). Additionally, Courland Place culvert is recommended to be upgraded to a 6 m span by 1.25 m rise box culvert. The benefit of this alternative (Figure 1; attached) would be to eliminate simulated flood inundation on Blairholm and Courtland, and greatly reduce inundation at the backyard asphalt playground at the St John Catholic Elementary School property.

- *Alternative 2: Upsizing the Victoria Avenue Culvert*

  The existing Victoria Avenue structure is a reinforced concrete box culvert with 3 m wide span, 1.5 m rise and 14 m in length. A potential replacement for this culvert would be a 6 m span by 1.5 m rise precast box culvert. The combined benefit of Alternative 2 and Alternative 1 is presented in Figure 2 (attached). The additional upgrade would further reduce simulated flooding on Victoria Avenue.

- *Alternative 3: Upsizing of Elizabeth Street Enclosure*

  This alternative is for sizing of the 3600 mm wide box culvert located on Elizabeth Street, starting 20m north of Caroline St. to the open channel located 30 m north of Maria St which is approximately 110 m in length. It was modeled as a 3.6 m wide span and 1.8 m rise box culvert (enclosure) within the HEC-RAS 2D model. Based on the modelling results, a proposed upgrade to this enclosure would be a 6 m wide span and 1.8 m rise box enclosure.

However, it should be confirmed that if the existing structure can be widened or a parallel enclosure be added instead for full removal to reduce the costs. In addition, the increased width may not be able to be feasibly connected to the open channel immediately downstream. It would also result in a discrepancy in conveyance structure size with the enclosure further downstream. The modelling results indicate that the enclosure would function more as a storage element than actual conveyance of flow.

Overall, the benefits of this alternatives are presented in Figure 3 (attached). As evident, this alternative would eliminate flooding on Caroline Street, Elizabeth Street. Minor flooding would remain for the municipal parking lot on the north side. The resulting upgrade would result in minor peak flow increases further downstream (Martha Street\Waterfront Trail). However, given the constructability issues with this option, other alternatives should be considered.

— *Alternative 4: A flood barrier wall just upstream of Caroline Street in combination with Creek Widening*

This alternative was tested for comparison to Alternative 3.

A 110 m long barrier wall (preliminary 1 m height; to be further refined) wrapping around the creek and the parking lot just north of Caroline Street was modeled within the HEC-RAS 2D model to provide storage for creek spill flows. Additionally, the section of Lower Rambo Creek from just upstream of Caroline Street to the existing pedestrian bridge near Emerald Crescent was widened to increase conveyance capacity and storage volume. The creek was modified as a 10 m bottom with a 20 m wide top width and 2H:1V side slopes. The proposed geometry of the creek resulted in a cut of approximately 1,500 cubic meters.

Furthermore, we considered a second scenario where the upstream spills (Brant and Fairview Spills) remain unaddressed. In this case, WSP modeled a longer barrier wall – 175 m in length around the creek and parking lot. The same creek modifications were retained.

Based on the modelling results (see attached Figures 4A and 4B), this alternative would similarly address off-site spill and flooding impacts. Ponding within the municipal parking area would however be expected. Overall, Alternative 4 is considered preferable to Alternative 3 as costs would be expected to be lower than Alternative 3, and ease of construction is considered higher.

— *Alternative 5: Upsizing of Martha Street and Waterfront Trail Culverts*

The existing structure for Martha Street is a 2.95 m wide span and 2.35 m rise con-span arch structure which is 12 m in length. The existing structure for Waterfront Trail is a 6.4 m wide span, 1 m rise box culvert with 20 m length. The Martha Street structure was proposed to be

modeled as a 6 m wide span and 2.35 m rise box culvert, and the Waterfront Trail structure was modeled with same span but with a rise of 3 m. It is important to note that the proposed increase in the rise of the waterfront trail crossing assumes feasibility. However, utility conflicts in the area may necessitate relocations, which could potentially result in higher costs. A thorough assessment of the feasibility and associated expenses would be essential in making an informed decision and both structures will need to be replaced to achieve desired results.

Based on the simulation results (see attached Figure 5), the primary benefit of this option would be the elimination of flooding on Martha Street and minor elimination of flooding just south of Waterfront Trail.

The combined estimated construction cost for all of the preceding excluding Alternative 3 (as noted previously, Alternative 4 would be assumed to be preferable for works in that area and sufficient to provide the necessary degree of flood remediation) would be $7.0 million. This estimated cost again includes a 30% contingency but does not include engineering\design or construction administration\inspection fees.

4 CONCLUSIONS

For the current assessment, WSP's focus has been on developing and evaluating potential alternatives to reduce or eliminate spills in the area. These measures primarily involve public lands, ensuring no adverse impacts beyond the implementation site. WSP assumed that other options such as purchasing and repurposing private property or implementing on-site floodproofing would be explored by others or at a later stage.

This assessment for the Brant Street Spill and Burlington Downtown area should be considered preliminary and the infrastructure upgrades proposed here will need to be confirmed during future design phases.

The findings of the assessments completed by Conservation Halton for the east branch of Rambo Creek and the Hager-Rambo Diversion channel have not been summarized herein but should be considered in conjunction with these findings. Given the potential impacts to downstream properties from the proposed spill mitigation alternatives at Brant\Fairview, further study is likely required to determine further required measures and sequencing of works.

For the Downtown area, it is expected that a further assessment will be required to confirm prioritization and sequencing, based on the overall benefit (i.e. flood and spill inundation limits), cost, and potential impacts to other areas.

LEGEND

- BASE (EXISTING CONDITION) INUNDATION BOUNDARY
- ALTERNATIVE (PROPOSED CONDITION) INUNDATION BOUNDARY

Imagery Sources:

1 Inundation Boundary: RAS Mapper Version 6.4.1

2 Aerial Image: Google Hybrid

DRAWN	C. PAUL
CHECKED	E. KUMAR

ALTERNATIVE 1

DRAFT FLOOD MITIGATION ALTERNATIVES

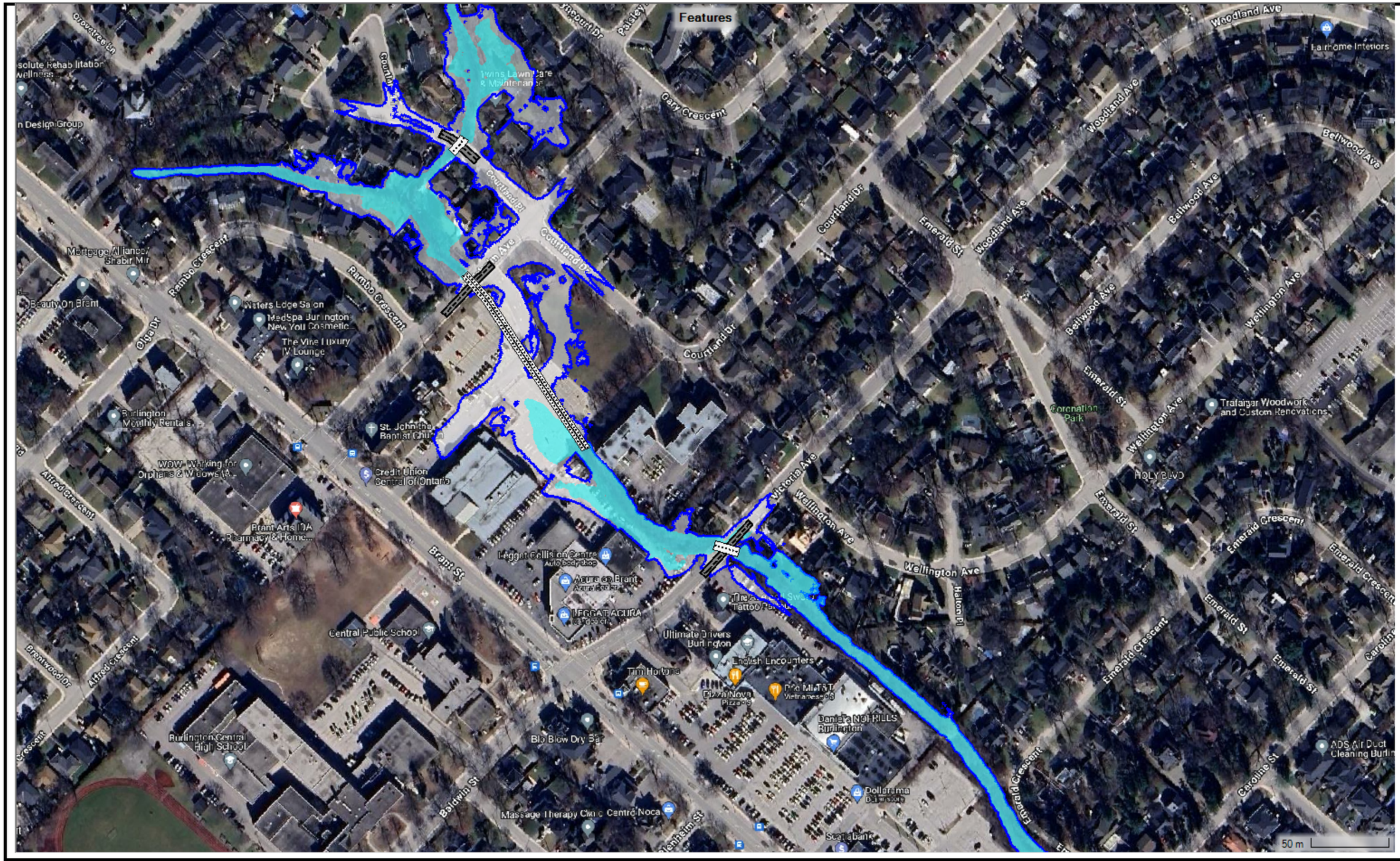
Burlington Flood Hazard Study

City of Burlington

Plot Date: 14 May 2024

Project No. CA-EI-WW23011105

Figure No. 1



Imagery Sources:

1 Inundation Boundary: RAS Mapper Version 6.4.1

2 Aerial Image: Google Hybrid

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ALTERNATIVE 2

DRAFT FLOOD MITIGATION ALTERNATIVES
Burlington Flood Hazard Study
City of Burlington

Plot Date: 14 May 2024

wsp

Project No.	Figure No.
CA-EI-WW23011105	2

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LEGEND

- **BASE (EXISTING CONDITION) INUNDATION BOUNDARY**
- **ALTERNATIVE (PROPOSED CONDITION) INUNDATION BOUNDARY**

Imagery Sources:

1 Inundation Boundary: RAS Mapper Version 6.4.1

2 Aerial Image: Google Hybrid

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ALTERNATIVE 3

DRAFT FLOOD MITIGATION ALTERNATIVES

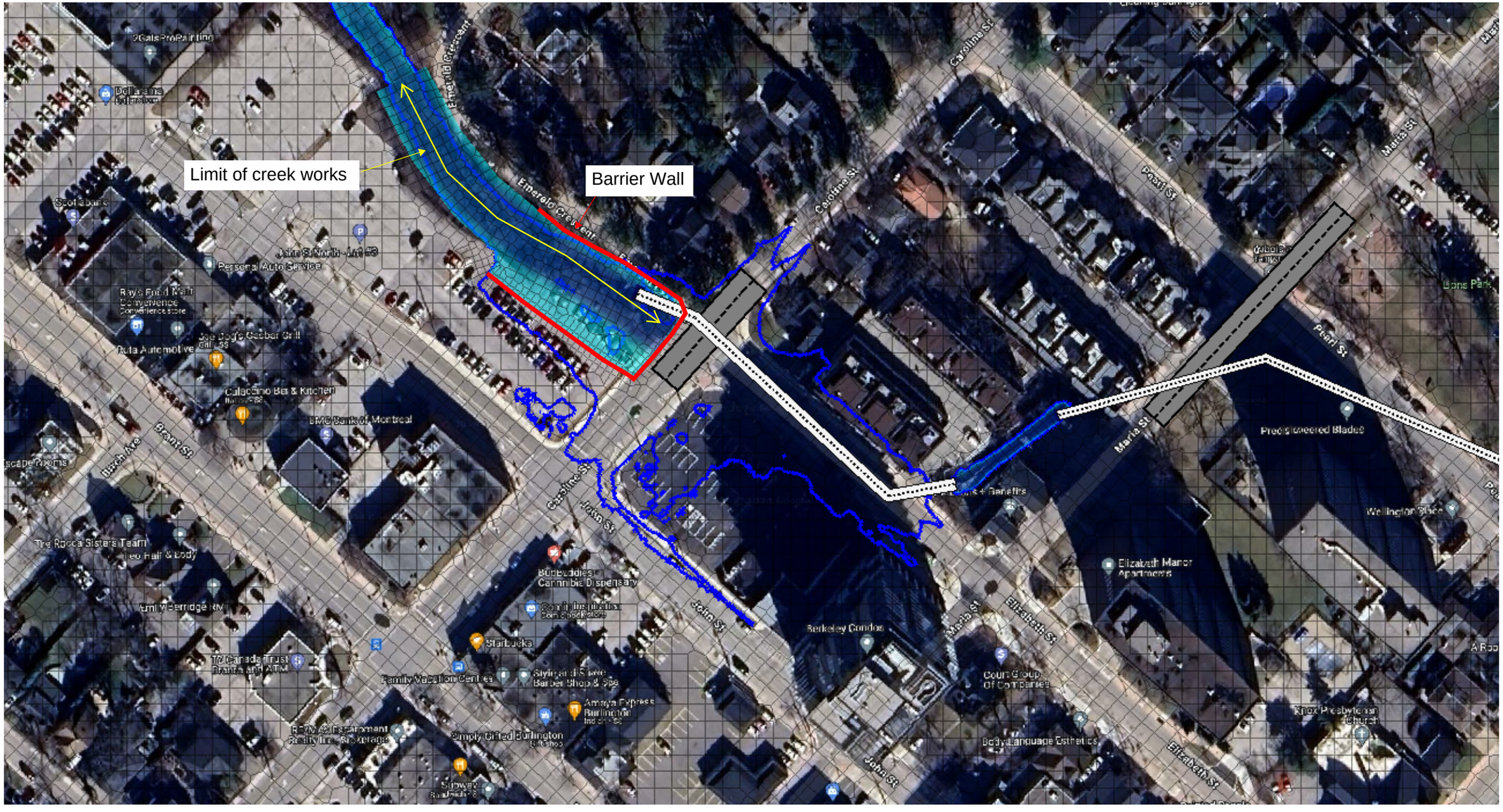
Burlington Flood Hazard Study

City of Burlington

Plot Date: 14 May 2024

Project No. CA-EI-WW23011105

Figure No. 3



LEGEND

- **BASE (EXISTING CONDITION) INUNDATION BOUNDARY**
- **ALTERNATIVE (PROPOSED CONDITION) INUNDATION BOUNDARY**

Imagery Sources:

1 Inundation Boundary: RAS Mapper Version 6.4.1

2 Aerial Image: Google Hybrid

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ALTERNATIVE 4A (NO SPILLS)

DRAFT FLOOD MITIGATION ALTERNATIVES

Burlington Flood Hazard Study

City of Burlington

Plot Date: 14 May 2024

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Project No. CA-EI-WW23011105

Figure No. 4A

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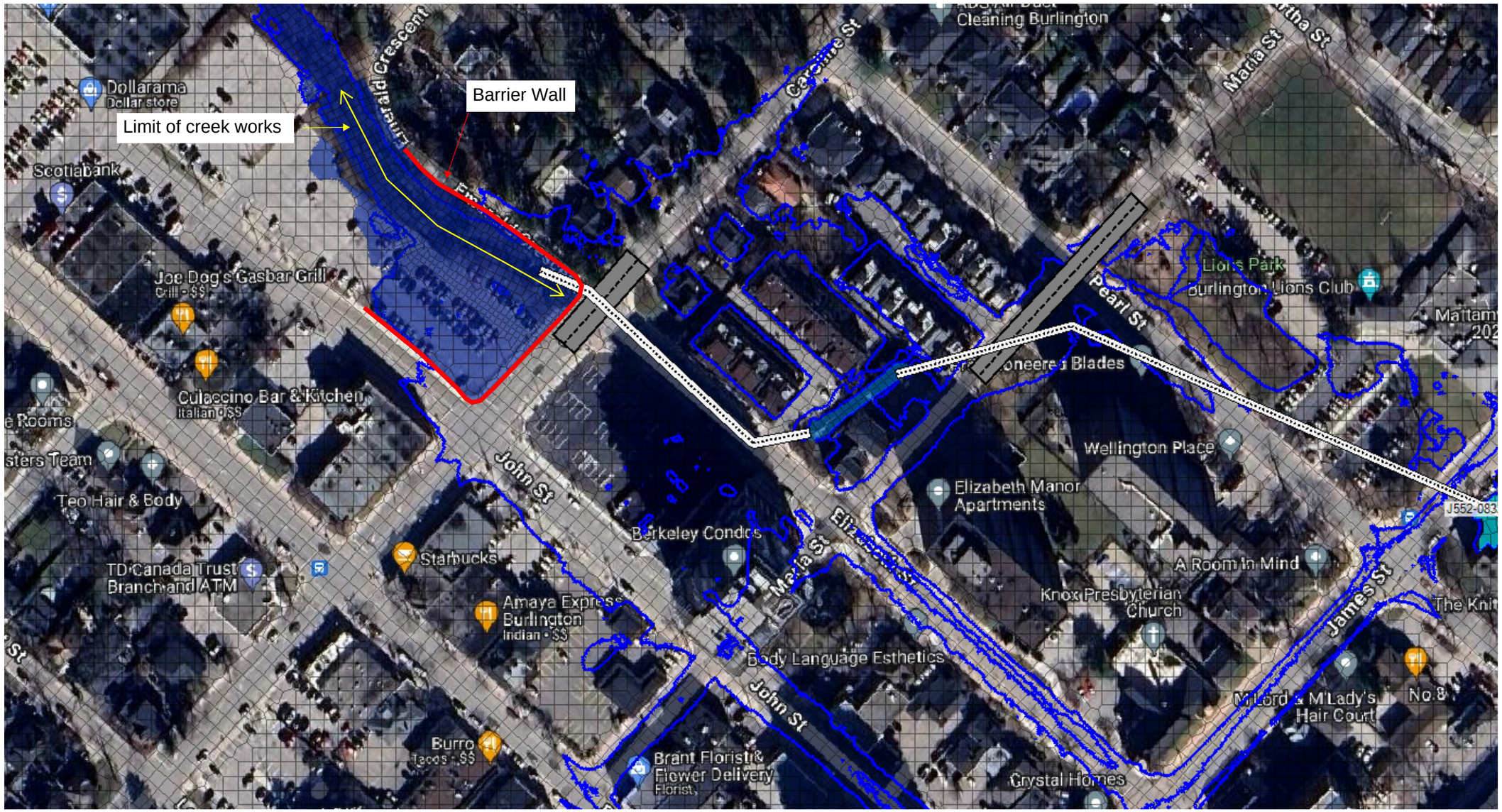

LEGEND

- **BASE (EXISTING CONDITION) INUNDATION BOUNDARY**
- **ALTERNATIVE (PROPOSED CONDITION) INUNDATION BOUNDARY**

Imagery Sources:

1 Inundation Boundary: RAS Mapper Version 6.4.1

2 Aerial Image: Google Hybrid

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ALTERNATIVE 4B (WITH SPILLS)

DRAFT FLOOD MITIGATION ALTERNATIVES

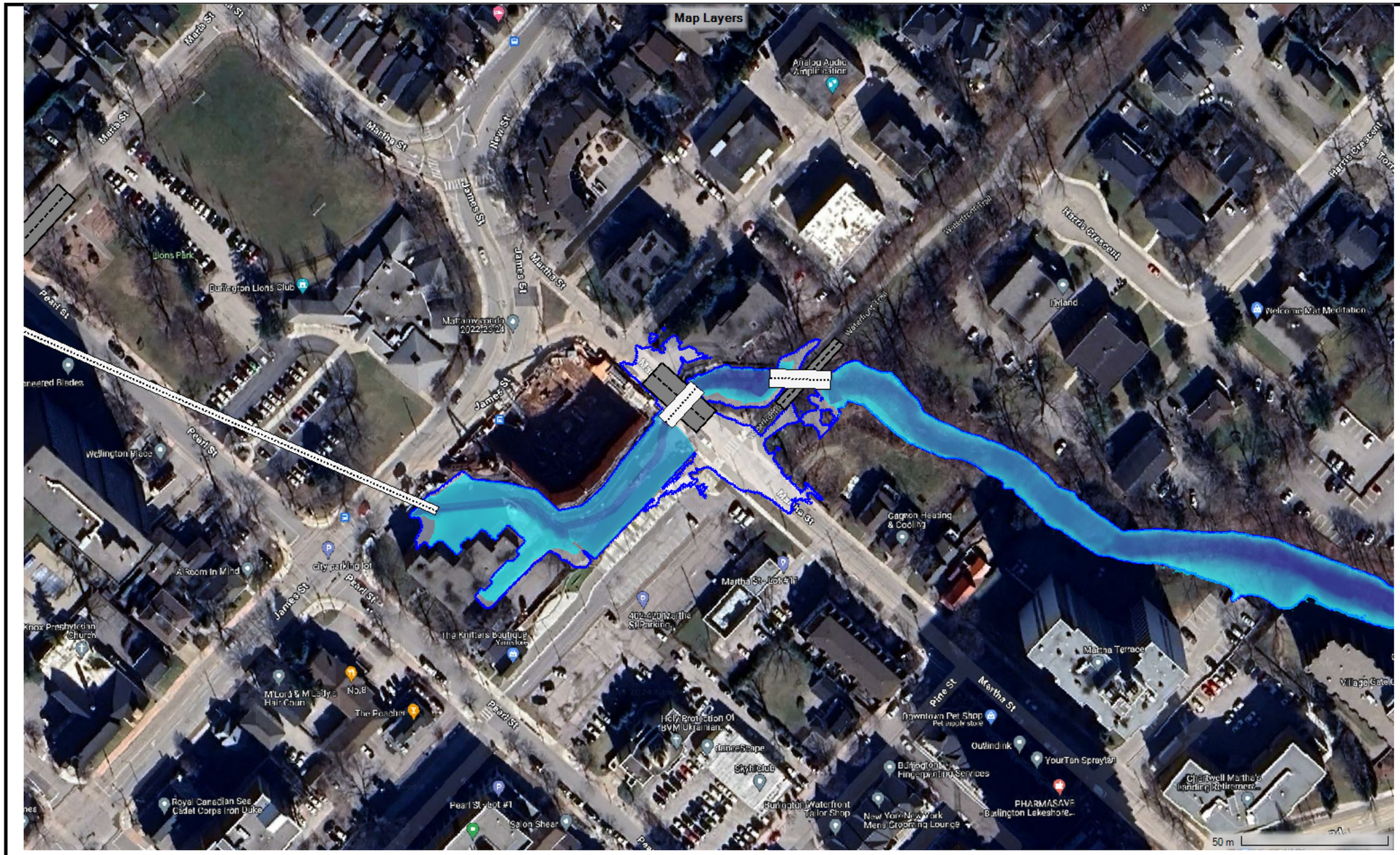
Burlington Flood Hazard Study

City of Burlington

Plot Date: 14 May 2024

Project No. CA-EI-WW23011105

Figure No. 4B



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LEGEND

- **BASE (EXISTING CONDITION) INUNDATION BOUNDARY**
- **ALTERNATIVE (PROPOSED CONDITION) INUNDATION BOUNDARY**

Imagery Sources:

1 Inundation Boundary: RAS Mapper Version 6.4.1

2 Aerial Image: Google Hybrid

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ALTERNATIVE 5

DRAFT FLOOD MITIGATION ALTERNATIVES

Burlington Flood Hazard Study

City of Burlington

Plot Date: 14 May 2024

Project No. CA-EI-WW23011105

Figure No. 5