Environment, Infrastructure and Community Services Committee Meeting
Agenda

Date: March 4, 2021
Time: 9:30 am
Location: Council Chambers - members participating remotely

Pages

1. Declarations of Interest:

2. Delegation(s):

Due to COVID-19 this meeting will be conducted as a virtual meeting. Only the chair of the meeting, along with a clerk and audio/visual technician, will be in council chambers, with all other staff, members of council and delegations participating in the meeting by calling in remotely. The meeting will be live webcasted, as usual, and archived on the city website.

Requests to delegate to this virtual meeting can be made by completing the online delegation registration form at www.burlington.ca/delegate or by submitting a written request by email to the Office of the City Clerk at clerks@burlington.ca by noon the day before the meeting is to be held.

It is recommended that delegates include their intended remarks, which will be circulated to all members of the standing committee in advance, as a backup to any disruptions in technology issues that may occur.

You should be aware that your notes are **MADE PUBLIC.** They are distributed to members of the standing committee and to meeting attendees, as well as being attached to the minutes posted on the city's website.

If you do not wish to delegate, but would like to submit feedback, please email your comments to clerks@burlington.ca. Your comments will be circulated to committee members in advance of the meeting and will be attached to the minutes, forming part of the public record.

3. Consent Items:

Reports of a routine nature, which are not expected to require discussion and/or debate. Staff may not be in attendance to respond to queries on items contained in the Consent Agenda.

3.1. Public tree removal report – 4417 Spruce Ave – Plan of Subdivision File No. 520-06/18 (RPF-04-21) 1 - 25

Approve the request by the applicant to remove four (4) City-owned trees in order to proceed with the proposed Plan of Subdivision application File No. 520-06/18 as outlined in roads, parks & forestry department report RPF-04-21; and

Instruct the applicant, Zeeshan Jafri, Modeno Homes, to provide compensation for the City-owned tree removals by providing cash-in-lieu of replacement totaling $2,000.00. The funds will provide for new tree plantings elsewhere in the City which includes care and maintenance for the first two (2) years; and

Direct that a tree permit be obtained for the removals and the associated development related permit fee of $680.00 plus HST; and

Direct that all associated costs with respect to the removal of the trees (including stump removal) will be the responsibility of the applicant. The contractor hired to remove the trees will require approval by the Manager of Urban Forestry or designate.

4. Regular Items:

4.1. Climate Adaptation Plan (EICS-03-21) 26 - 108

Receive and file environment, infrastructure and community services report EICS-03-21 regarding Burlington's upcoming Climate Adaptation Plan.

4.2. City Hall – One Window design update (EICS-05-21) 109 - 122

Receive and file environment, infrastructure and community services report EICS-05-21 providing One Window service counter and long-term design concepts and schedule for the 1st floor City Hall renovations.

5. Confidential Items:

Confidential reports may require a closed meeting in accordance with the Municipal Act, 2001. Meeting attendees may be required to leave during the discussion.

6. Procedural Motions:

7. Information Items:

8. Staff Remarks:

9. Committee Remarks:

10. Adjournment:

SUBJECT: **Public Tree Removal Report – 4417 Spruce Ave – Plan of Subdivision File No. 520-06/18**

TO: **Environment, Infrastructure & Community Services Cttee.**

FROM: **Roads, Parks and Forestry Department**

Report Number: RPF-04-21

Wards Affected: 4

File Numbers: Plan of Subdivision (520-06/18)

Date to Committee: March 4, 2021

Date to Council: March 23, 2021

Recommendation:

Approve the request by the applicant to remove four (4) City-owned trees in order to proceed with the proposed Plan of Subdivision application File No. 520-06/18 as outlined in roads, parks & forestry department report RPF-04-21; and

Instruct the applicant, Zeeshan Jafri, Modeno Homes, to provide compensation for the City-owned tree removals by providing cash-in-lieu of replacement totaling $2,000.00. The funds will provide for new tree plantings elsewhere in the City which includes care and maintenance for the first two (2) years; and

Direct that a tree permit be obtained for the removals and the associated development related permit fee of $680.00 plus HST; and

Direct that all associated costs with respect to the removal of the trees (including stump removal) will be the responsibility of the applicant. The contractor hired to remove the trees will require approval by the Manager of Urban Forestry or designate.

PURPOSE:

Vision to Focus Alignment:

- Support sustainable infrastructure and a resilient environment
- Deliver customer centric services with a focus on efficiency and technology transformation

Background and Discussion:

The subject property is located at the corner of Spruce Avenue and Tuck Drive, which will be severed into four (4) separate lots that will front onto Tuck Drive (See Fig. 1).

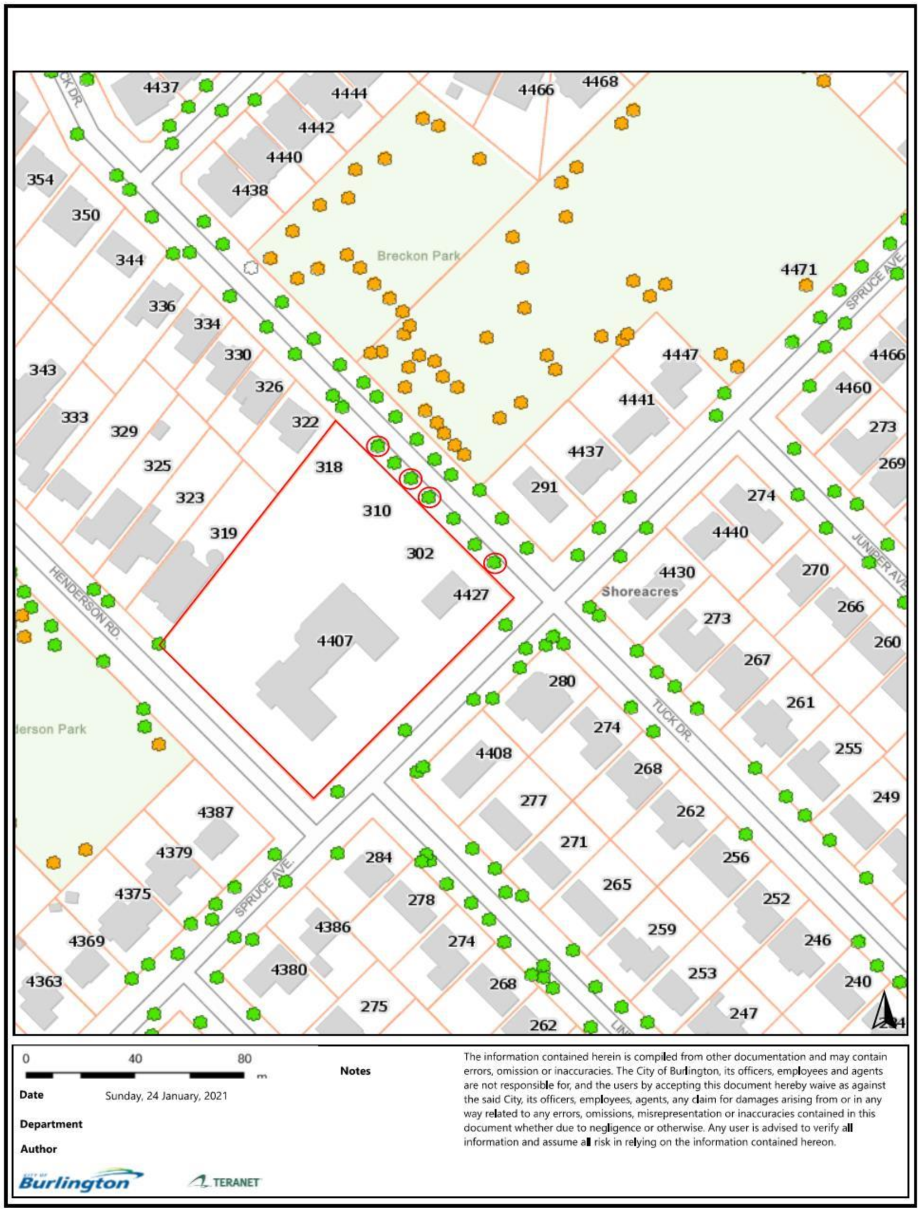


Figure 1: Subject Property, 4417 Spruce Ave

Forestry staff inspected the site on January 21, 2021. An application for Plan of Subdivision (File No. 520-06/18) has been submitted to create four (4) new detached residential dwellings. As part of a condition to satisfy their Plan of Subdivision, a Tree Permit must be obtained in order to facilitate the removal of City-owned trees in order to proceed with approval and construct the new dwellings. In accordance with the City of Burlington's Public Tree By-law 68-2013, Section 1.19 states, "The City Arborist shall not issue a Tree Permit for Trees located on Public Property immediately abutting Private Property for which a development application has been submitted, until such time as the development application has been approved and Council has also approved the removal of these trees".

Strategy/process

Four (4) City-owned trees are proposed to be removed due to conflicts with the proposed Plan of Subdivision. More specifically, two (2) trees will directly conflict with the proposed driveway construction (Tree No. 16 and Tree No. 18) and two (2) trees with directly conflict with the proposed sanitary/servicing line (Tree No. 19, and Tree No. 22) as described within the Scoped Arborist Report and illustrated on the Vegetation Management Plan submitted as Appendix C and D respectively. The subject trees that are proposed for removal are located within the boulevard of Tuck Drive. The trees proposed for removal are as follows:

1. Tree No. 16: Callery Pear (*Pyrus calleryana*): DBH 6cm
2. Tree No. 18: Callery Pear (*Pyrus calleryana*): DBH 7cm
3. Tree No. 19: Callery Pear (*Pyrus calleryana*): DBH 5cm
4. Tree No. 22: Callery Pear (*Pyrus calleryana*): DBH 7cm

All of the trees proposed for removal are small in size and considered to be in good condition, in both health and structure at the time of assessment. Based on the size of the trees to be removed, Forestry is in support of the removal of the above noted subject trees under the provision that cash-in-lieu fees are provided to the City as compensation for canopy loss.

Refer to Appendix A – Tree Inventory and Compensation Form completed by City staff, Appendix B – Site Photographs for additional details, Appendix C – for the Scoped Arborist Report and Appendix D – Vegetation Management Plan.

Options Considered

Forestry staff conducted a comprehensive review of the proposed plans with the applicant, which originally included five (5) City-owned trees to be removed, one of which was a 44 cm Norway Maple (Tree No. 20) shown on the Vegetation Management Plan (Appendix D). Through discussions with the applicant, measures were taken to redesign the site and the proposed driveway in order to save the tree. Additional review of the remaining trees relative to the proposed sanitary/servicing installation and driveways was completed and given the location of the City-owned trees in relation to the proposed works, the trees cannot be retained.

Financial Matters:

A total of $2,000.00 shall be paid by the applicant as compensation for the tree removals. These funds will be utilized to replace the loss in canopy within the City. In addition to the cash-in-lieu fees, a permit fee of $680.00 plus HST will be required. The total cost of tree and stump removals will be borne entirely by the applicant.

Total Financial Impact

Not applicable.

Source of Funding

Not applicable.

Other Resource Impacts

Note applicable.

Climate Implications

The removal of trees is always a concern as they provide the most cost-effective measure of carbon sequestration, in addition to providing a host of other ecological benefits associated with climate change. It is critical that in cases where trees must be removed, that they are sufficiently compensated for in the interest of replacing the canopy loss long-term.

Engagement Matters:

Conclusion:

The City's Forestry section has reviewed the proposed tree removals, and supports the removals as per the recommendations listed above.

Respectfully submitted,

Melissa Torchia

Supervisor, Forest Protection

(905) 333-6166 ext. 6121

Appendices:

A. Tree Inventory and Compensation Form
B. Site Photographs
C. Scoped Arborist Report
D. Vegetation Management Plan

Notifications:

Name Zeeshan Jafri

zeeshan@modeno.ca

Report Approval:

All reports are reviewed and/or approved by Department Director, the Chief Financial Officer and the Executive Director of Legal Services & Corporation Counsel.

Site:	4417 Spruce Ave / Tuck Drive

Existing Tree Information						Replacement Tree Information		Condition Factors		Compensation
Tree Number	Common Name	DBH (cm)	Condition Rating (%)		Comments	# of 50 mm trees required	Preliminary Tree Value	Avg Condition Rating (Health & Structure)	Construction Risk Factor (see below)	Value
			Health	Structure						
16	Callery Pear	6	70%	90%		1	$ 600.00	80%	100%	$ 480.00
18	Callery Pear	7	70%	90%		1	$ 700.00	80%	100%	$ 560.00
19	Callery Pear	5	70%	90%		1	$ 500.00	80%	100%	$ 400.00
22	Callery Pear	7	70%	90%		1	$ 700.00	80%	100%	$ 560.00
										$ 2,000.00

1. DBH / 5cm = # of trees req. to replace
2. # of trees req. to replace X $500 (cost of replacement) = Preliminary Compensation Value
3. Preliminary Compensation Value X Condition of Tree Factor X Risk Factor = Final Compensation Value

Tree Condition Considerations

Based on Tree Condition Assessment in GIS Inventory and Observations during Site Visit

Rating:	Factor:
Excellent	90-100%
Good	70-89%
Fair	50-69%
Poor	25-49%
Very Poor	0-24%

Construction Risk to Trees

Construction risk to trees is assessed by considering the following on a site by site basis: materials storage, existing and proposed utility and

Low Risk Factor (0-25% of Assessed Value):

- No work inside TPZ or CRZ (including grading, excavation, servicing, etc);
- No risk from construction traffic in CRZ;
- Hoarding shown on plan and installed as per SS12.
- Sliding scale based on proximity of tree (TPZ and CRZ) to construction area.

Medium Risk Factor (26-50% of Assessed Value):

- No work inside TPZ (including grading, excavation, servicing, etc);
- Minimal work occurring within the CRZ (impacting less than 10% of the CRZ area, including grading, excavation, servicing, etc)*;
- Risk from construction traffic/works within CRZ*;
- Hoarding shown on plan and installed as per SS12.

Medium-High Risk Factor (51-75% of Assessed Value):

- No work inside TPZ (including grading, excavation, servicing, etc);
- Work occurring within CRZ (impacting more than 10% of the CRZ including grading, excavation, servicing, etc)*;
- Risk from construction traffic/works within CRZ*;
- Arborist report not required but provided;
- Hoarding shown on plan and installed as per SS12.

High Risk Factor (76-100% of Assessed Value):

- Work inside TPZ (including grading, excavation, servicing, etc; only occurring under supervision of qualified ISA Certified Arborist
- Risk from construction traffic/works within TPZ and CRZ*;
- Arborist report required and provided;
- Hoarding shown on plan and installed outside of SS12 specification, with confirmation from City Arborist or Applicant's Certified Arborist.

*Risk can be reduced through use of mitigating actions (eg. Greater tree hoarding area to encompass remaining CRZ; Pre-Construction Root

CRZ – Critical Root Zone
MTPZ – Minimum Tree Protection Zone

- Please refer to the City of Burlington Tree Protection and Preservation Specification SS12A, available on-line for further information and tree protection requirements.
- Please refer to the City of Burlington Public Tree Bylaw 68-2013 for further information on your responsibility to protect city trees.

Appendix B – Site Photographs
RPF-04-21

Photograph No. 1: Tree #16 Callery Pear

Photograph No. 2: Tree #18 Callery Pear

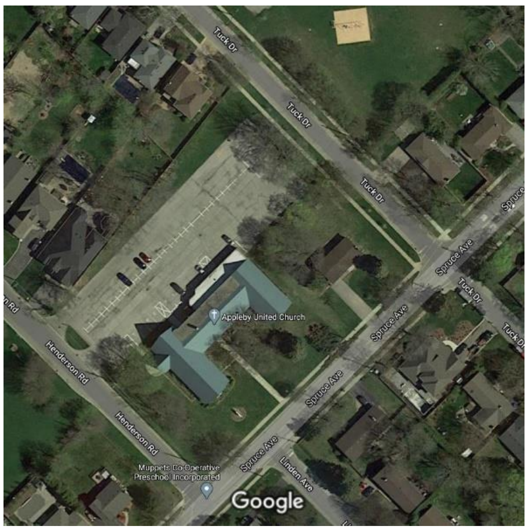
Photograph No. 3: Tree #19 Callery Pear

Photograph No. 4: Tree #22 Callery Pear

Photograph No. 5: View of trees along Tuck Street; facing southeast towards Spruce Avenue

SCOPED ARBORIST REPORT

Concerning the Tuck Drive Right-of-Way Trees Adjacent to:
4417 Spruce Avenue
City of Burlington, Ontario



November 11, 2020

Revised January 22, 2021

Prepared For:
adesso design inc.
218 Locke Street South, 2nd Floor
Hamilton, ON L8P 4B4

Prepared By:
Nate Torenvliet OALA, CSLA
Landscape Architect
ISA Certified Arborist ON-1782A
P: 905 638 5708
E: nate@environmentaldesign.ca

Table of Contents

Introduction

Due to the need for the Council of the City of Burlington to regulate and approve tree protection and removals within city right-of-ways according to City of Burlington By-law 68-2013, Adesso Design Inc., the project landscape architect, has requested the preparation of this scoped arborist report for the planned site alterations at the site at 4417 Spruce Avenue in Burlington, Ontario. The intention of the development proposal is to build new residential buildings on the site.

This report provides an inventory and assessment of the 8 trees along the Tuck Drive right-of-way relating to the subject site and outlines their removal and preservation requirements based on the site plans provided by Adesso Design Inc and in accordance with the current City of Burlington tree By-law.

This report is supplemental and should be understood in conjunction with related project plans prepared by Adesso Design Inc.

Method of Evaluation

Site observations were made on December 14, 2017 to evaluate and inventory all trees adjacent to the site along the Tuck Drive right-of-way. The trees were visually assessed in this evaluation for overall health, structure and vigor, as well as confirming their locations in relation to planned site alterations and ownership.

Tree inventory, as included in Appendix 1 is outlined according to the following categories:

- **Tree #** - corresponding to Adesso Design's vegetation identification table.
- **Ownership** – indicates whether the tree is public, private, or shared ownership.
- **Species** – botanical and common names are provided for each tree.
- **DBH** – 'diameter at breast height' (1.37 m above grade) for each tree in centimeters.
- **Condition** – an assessment of the overall health and quality of the tree rated on an ascending scale of poor-fair-good.
- **Comments** – Preserve or remove relative to planned site alterations, and width of the Tree Protection Zone, in meters for the protection of trees during construction. TPZ is based on DBH and may vary according to existing site conditions.

Table 1, Tree Inventory

Tree/Unit #	Owner	Common Name	Botanical Name	DBH (cm)	Condition	Comments
15	City ROW	Norway Maple	*Acer platanoides*	46	Good	Preserve with 3.0m TPZ
16	City ROW	Callery Pear	*Pyrus calleryana*	6	Good	In conflict with proposed driveway.
17	City ROW	Callery Pear	*Pyrus calleryana*	6	Good	Preserve with 1.2m TPZ
18	City ROW	Callery Pear	*Pyrus calleryana*	6	Good	In conflict with proposed drivway.
19	City ROW	Callery Pear	*Pyrus calleryana*	6	Good	In conflict with proposed servicing.
20	City ROW	Norway Maple	*Acer platanoides*	44	Good	Preserve with 3.0m TPZ
21	City ROW	Callery Pear	*Pyrus calleryana*	6	Good	Preserve with 1.2m TPZ
22	City ROW	Callery Pear	*Pyrus calleryana*	6	Good	In conflict with proposed servicing.

Discussion

Proposed Works

The intention of the development proposal is to build new residential buildings on the site. Trees along the Tuck Drive right-of-way adjacent to the site will be affected by the proposed site alterations and will require either removal or protection measures for the proposed development to occur.

Tree Ownership

All trees discussed in this report are located in the City right-of-way and are owned by the City of Burlington.

- **Trees 15 - 22** are located in the City ROW along Tuck Drive.

Tree Removals

Due to conflicts with the proposed site plan, 4 trees should be removed prior to the beginning of on-site construction.

- **Tree 16:** Is in conflict with the proposed driveway for building #1.
- **Tree 18:** Is in conflict with the proposed driveway for building #2.
- **Tree 19:** Is in conflict with a proposed service lateral required for building #2.
- **Tree 22:** Is in conflict with a proposed service lateral required for building #4.

Tree Preservation

Four (4) trees in the Tuck Drive ROW should be preserved. Due to their proximity to the planned site alterations the following trees require TPZ measures according to the City of Burlington's Tree Protection and Preservation Specifications (SPEC NO. SS12A):

- **Tree 15: Preserve with a minimum Tree Protection Zone of 3.0 meters.**
- **Tree 17: Preserve with a minimum Tree Protection Zone of 1.8 meters.**
- **Tree 20: Preserve with a minimum Tree Protection Zone of 3.0 meters.**
  Permission to injure this tree will be required as work for the proposed driveway construction will need to occur within the minimum TPZ. Excavation to depths of approximately 30cm will be required wherein some root severance may be necessary. Root damage should be treated as follows, according to the City of Burlington's standards:
  - Root pruning within the **Minimum Tree Protection Zone** of any tree requires root exploration via supersonic air tool or hydro vacuum unit to first remove the soil and expose the roots.
  - Roots under 2 cm in diameter can be pruned using a sharpened tool such as hand pruners or a sharpened spade under the supervision of the Construction Inspector.
  - Roots between 2 and 8 cm in diameter can be pruned by the arborist using a sharp tool, such as a handsaw, hand pruner or loppers and under the supervision of the Construction Inspector and the advisement of the Project Arborist.
  - All roots over 8 cm in diameter must be assessed by the Project Arborist prior to pruning unless the arborist on-site can confidently assess the effect of the removal of the root as not detrimental to the tree.
  - Root pruning within the Critical Root Zone and outside of the MTPZ, typically requires the use of a sharpened garden spade, cutting a line to a depth of about 30 cm by the on-site arborist under the advisement of the Project Arborist if needed. However, the same pruning protocol for the size of roots encountered (in the MTPZ) applies to the roots found within this area.
  - The trenches are typically backfilled with the same excavated soil or new topsoil or compost and hoarding should be installed along this trench to project the remaining roots.

  Overall, by minimizing these impacts using the mitigation measures described herein, and considering the minor encroachment, it is anticipated that this tree will tolerate the proposed injuries and recover.

- **Tree 21: Preserve with a minimum Tree Protection Zone of 1.8 meters.**

Tree Risk

No trees on the site posed any unacceptable level of risk at time of assessment.

Permit Requirements

Pursuant to City of Burlington By-law 68-2013, tree removals in the right-of-way of this site are subject to the approval by the Council of the City of Burlington.

Tree Protection Zones (TPZ's) (SPEC NO. SS12A)

Prior to issuance of the Tree Permit and Site Alteration Permit, tree protection measures for all retained trees must be in place and must remain in place during the entire construction period. These protection measures must be in accordance with City standards.

Trees within or adjacent to a construction site must be protected during construction by means of a barrier installed in accordance with City standards and meet the following specifications:

- No unauthorized activities may take place within the TPZ of a tree covered under any municipal permit process or agreement.
- If fill or excavated material must be temporarily located near the TPZ, a wooden barrier shall be used to ensure no material enters the TPZ.
- TPZ fencing shall consist of framed construction or snow fencing and be supported by solid wood framing.
- All TPZ locations should be clearly marked on site project plans.
- An informational sign should be mounted on TPZ hoarding and remain throughout the duration of the project. Example below.

Trees and TPZs should be monitored regularly by a consulting arborist throughout the duration of the project.

Figure 2, Tree Protection Signage

TREE PROTECTION ZONE

No grade change, storage of materials or equipment is permitted within this area.

This tree protection barrier must not be removed without the written authorization of the Town of Oakville.

Report any contraventions to;

Contact: ________________

Tel No.: ________________

Unauthorized removal of the tree protection barrier or other contraventions may result in prosecution.

Recommendations

Included here are general recommendations and suggested measures that will help ensure the health and survival of the preserved trees during and, most importantly, after the construction process is complete;

- TPZ's are suggested minimums, and as such it is recommended to keep all equipment and vehicular movement as far away from existing trees as possible;
- Any tree work such as trimming and branch removals should be carried out according to sound arboricultural practices, and should be performed by a certified arborist;
- All excavation near existing trees should be carried out in a sensitive manner – that is with keen attention to tree roots and soil movement. Large roots should be removed with a saw and by a certified arborist to minimize the damage to the tree as much as possible.

General Limitations of Tree Assessment

The assessment presented in this report is only valid at the time of inspection.

Tree risk assessments rely on identifying and assessing the structural condition of trees to determine weak points and failure potential. Assessment and management of tree risk is based on the science of biomechanics — the way trees grow for structural support and biological function. It must be understood that trees are dynamic, living organisms that are subject to internal and external changes over time.

Similarly, tree management relies on forecasting potential construction impacts and the ability of trees to withstand stresses due to compaction, excavation, filling and mechanical damage. The success of tree protection requires adherence to minimum standards as set forth by the municipality and best management practices by the contractor. The willingness of the owner to comply is also a mitigating factor.

We have made reasonable efforts to assess the overall condition of the trees on or adjacent to the subject property. No guarantee or warranty is offered, expressed or implied, that these trees or any of their parts will remain intact or in stable condition. We cannot predict or be held responsible for the behaviour of any tree regardless of its condition at the time of assessment.

To reduce risk to trees, human life or property we recommend ongoing inspections and evaluations during construction. Post construction evaluation and remediation should also be considered to promote the long-term health of trees.

Submitted by:

Nate Torenvliet
BLA, Dip. LD, LEED®AP, OALA Associate,
ISA Certified Arborist ON-1782A

Appendix 1: Site Photographs

Figure 1: Tree 15

Figure 2: Trees 16 - 19

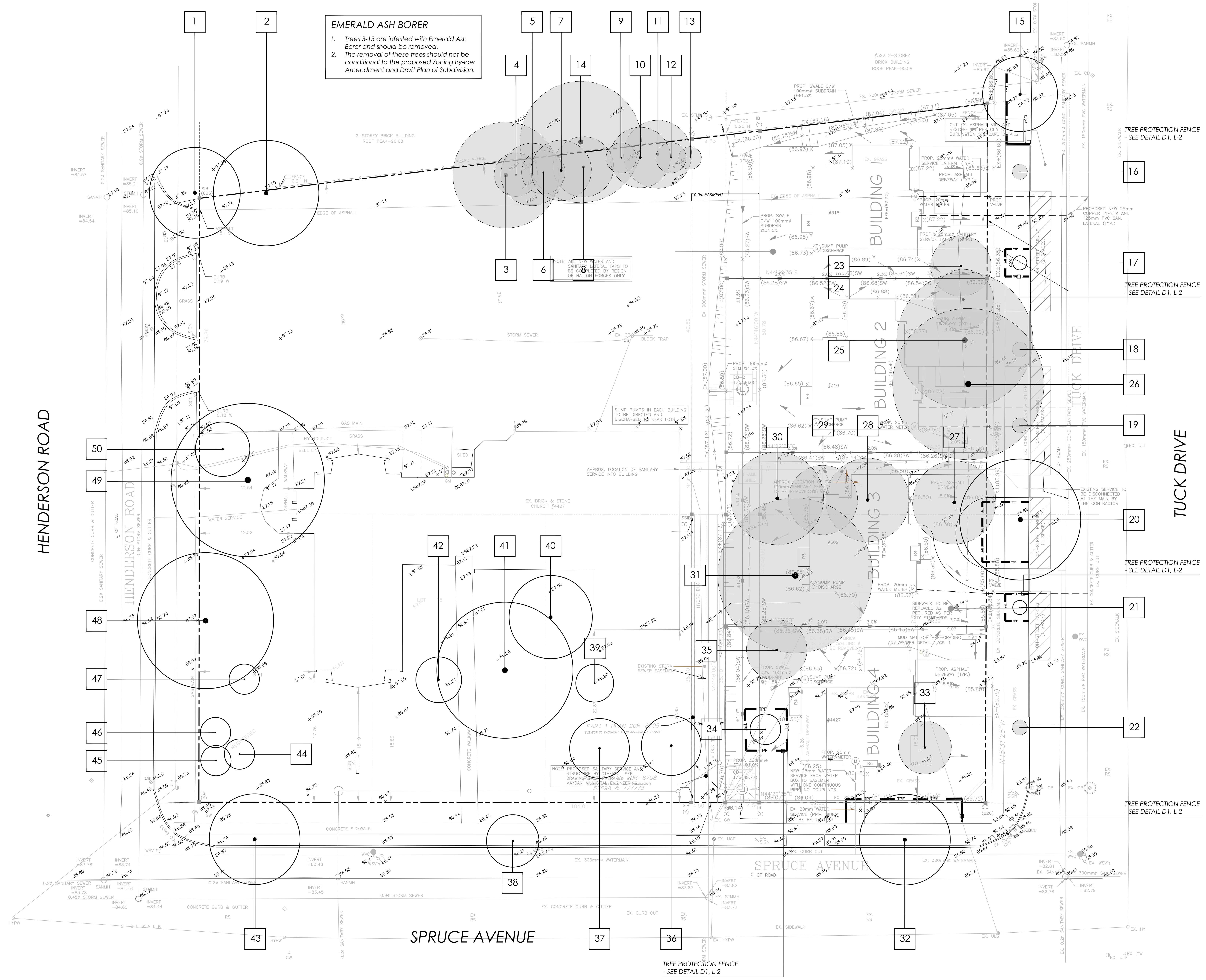
Figure 3: Trees 20 - 22

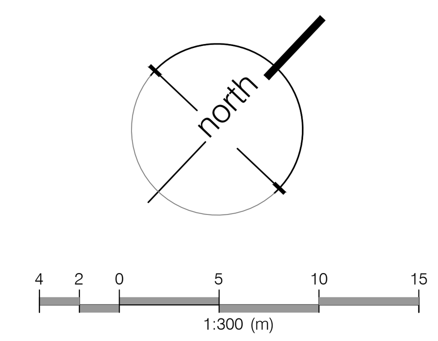
project #: 17-158

Appendix D of Report RPF-04-21

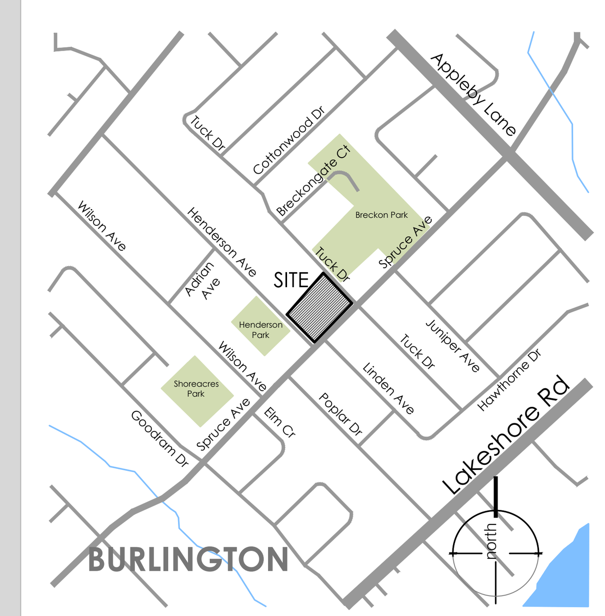
EMERALD ASH BORER

1. Trees 3-13 are infested with Emerald Ash Borer and should be removed.
2. The removal of these trees should not be conditional to the proposed Zoning By-law Amendment and Draft Plan of Subdivision.





KEY MAP - N.T.S.



LEGEND

- property line
- lot lines
- existing tree number (refer to chart)
- existing vegetation to remain
- existing vegetation to be removed
- existing elevations
- proposed elevations
- tree protection fence - see detail D1, L-2

NOT FOR CONSTRUCTION
ISSUED FOR REVIEW & COMMENTS ONLY

NOTE:
Vegetation inventory undertaken by Nate Torenvliet, ISA Certified Arborist (ON-1782A) on December 15, 2017.

REVISIONS/ SUBMISSIONS

#	DATE	DESCRIPTION
1	2018-05-07	First submission
2	2020-04-13	Revised as per engineering
3	2020-04-14	Issued for submission
4	2020-11-11	Issued for submission
5	2021-01-19	Issued for submission

STAMP

CLIENT
Zarin Homes

MUNICIPALITY
City of Burlington

PROJECT
4417 Spruce Avenue

MUNICIPAL FILE NUMBER
510-02/18 (24T-18002/B)

SHEET
Vegetation Management Plan

L-1

adesso design inc.
landscape architecture

218 Locke Street South, 2nd Floor
Hamilton, ON L8P 4B4
t. 905.526.8876
www.adessodesigninc.ca

project #: 17-158

EXISTING VEGETATION IDENTIFICATION TABLE

TREE/UNIT NO.	SPECIES (COMMON NAME)	SPECIES (BOTANICAL NAME)	DBH (cm)	CROWN CLASS*	CONDITION*	VEGETATION VALUE & PHYSICAL CONSTRAINTS	POTENTIAL IMPACTS FROM CONSTRUCTION	OWNERSHIP	RECOMMENDATION
1	Siberian Elm	Ulmus pumila	multi	D	Fair	Off property	None	Private	SAVE
2	Siberian Elm	Ulmus pumila	multi	D	Fair	Not surveyed	None	Private	SAVE
3	White Ash	Fraxinus americana	40	C	Poor	EAB infested	None	Private	REMOVE
4	White Ash	Fraxinus americana	15	S	Poor	EAB infested	None	Private	REMOVE
5	White Ash	Fraxinus americana	35	C	Poor	EAB infested	None	Private	REMOVE
6	White Ash	Fraxinus americana	30	C	Poor	EAB infested	None	Private	REMOVE
7	White Ash	Fraxinus americana	30	C	Poor	EAB infested	None	Private	REMOVE
8	White Ash	Fraxinus americana	25	C	Poor	EAB infested	None	Private	REMOVE
9	White Ash	Fraxinus americana	15	S	Poor	EAB infested	None	Private	REMOVE
10	White Ash	Fraxinus americana	30	C	Poor	EAB infested	None	Private	REMOVE
11	White Ash	Fraxinus americana	30,30	C	Poor	EAB infested	None	Private	REMOVE
12	White Ash	Fraxinus americana	20	C	Poor	EAB infested	None	Private	REMOVE
13	White Ash	Fraxinus americana	15	C	Poor	EAB infested	None	Private	REMOVE
14	Black Locust	Robinia pseudoacacia	60	C	Good	Off property	None	Public	SAVE
15	Norway Maple	Acer platanoides	46	D	Good	Off property	None	Public	SAVE
16	Callery Pear	Pyrus calleryana	6	D	Good	Off property	Conflict with proposed driveway	Public	REMOVE
17	Callery Pear	Pyrus calleryana	6	D	Good	Not surveyed, off property	None	Public	SAVE
18	Callery Pear	Pyrus calleryana	6	D	Good	Not surveyed, off property	Conflict with proposed driveway	Public	REMOVE
19	Callery Pear	Pyrus calleryana	6	D	Good	Not surveyed, off property	Conflict with proposed service lateral	Public	REMOVE
20	Norway Maple	Acer platanoides	44	D	Good	Off property	Some grading within root zone	Public	SAVE
21	Callery Pear	Pyrus calleryana	6	D	Good	Not surveyed, off property	None	Public	SAVE
22	Callery Pear	Pyrus calleryana	6	D	Good	Not surveyed, off property	Conflict with proposed service lateral	Public	REMOVE
23	White Ash	Fraxinus americana	50	C	Poor	EAB infested	None	Private	REMOVE
24	White Ash	Fraxinus americana	40	C	Poor	EAB infested	None	Private	REMOVE
25	Siberian Elm	Ulmus pumila	80	C	Fair	Some dieback in the canopy	Conflict with proposed driveway	Private	REMOVE
26	Manitoba Maple	Acer platanoides	40	C	Fair	Wide spread form	Conflict with proposed sidewalk	Private	REMOVE
27	Norway Maple	Acer platanoides	50	C	Fair	Some dieback in canopy	Conflict with proposed driveway	Private	REMOVE
28	Norway Maple	Acer platanoides	50	C	Poor	Some dieback in canopy	Grading in root zone due to proposed building	Private	REMOVE
29	Norway Maple	Acer platanoides	35	C	Poor	Dead	Grading in root zone due to proposed building	Private	REMOVE
30	Norway Maple	Acer platanoides	55	C	Fair		Grading in root zone due to proposed building	Private	REMOVE
31	Honey Locust	Gleditsia tricanthos	60	C	Good		Grading in root zone due to proposed building	Private	REMOVE
32	Honey Locust	Gleditsia tricanthos	45	D	Good	Off property	None	Private	SAVE
33	Colorado Spruce	Picea pungens	40	D	Good		Grading in root zone due to proposed building	Private	REMOVE
34	Crab Apple	Malus sp.	20	D	Fair		Minimal grading in root zone	Private	SAVE
35	White Spruce	Picea glauca	30	C	Good	Not surveyed	Grading in root zone due to proposed building	Private	REMOVE
36	Colorado Spruce	Picea pungens	55	D	Good		None	Private	SAVE
37	Colorado Spruce	Picea pungens	60	D	Good		None	Private	SAVE
38	Norway Maple	Acer platanoides	25	D	Good	Off property	None	Private	SAVE
39	Crab Apple	Malus sp.	25	D	Fair	Some dieback in canopy	None	Private	SAVE
40	Honey locust	Gleditsia tricanthos	35	C	Good		None	Private	SAVE
41	Honey locust	Gleditsia tricanthos	60	C	Fair		None	Private	SAVE
42	Crab Apple	Malus sp.	25	D	Fair		None	Private	SAVE
43	Honey Locust	Gleditsia tricanthos	40	D	Good	Off property	None	Private	SAVE
44	Crab Apple	Malus sp.	30	C	Good		None	Private	SAVE
45	Crab Apple	Malus sp.	25	C	Good		None	Private	SAVE
46	Crab Apple	Malus sp.	25	C	Good		None	Private	SAVE
47	Crab Apple	Malus sp.	25	D	Good		None	Private	SAVE
48	Honey Locust	Gleditsia tricanthos	55	D	Good		None	Private	SAVE
49	Norway Maple	Acer platanoides	60	C	Fair		None	Private	SAVE
50	White Birch	Betula papyrifera	35	C	Poor		None	Private	SAVE

* CROWN CLASS
Dominant- (D) Emergent canopy (receives full sunlight)
Co-dominant - (C) Not fully emergent (top of canopy receives sunlight)
Intermediate - (I) Sub-canopy tree (receives partial sunlight)

* CONDITION - consideration of trunk integrity, crown structure and crown vigor
Good - few or no issues related to trunk integrity, crown structure or crown vigor
Fair - minor issues related to trunk integrity, crown structure (form, some dead or damged branches) or crown vigor (20-80% healthy foliage)
Poor - issues with trunk integrity such as cavities or exposed dead wood, poor crown structure (poor form, no clear leader, significant dead or damaged branches) or poor crown vigor (<20% healthy foliage)

BOUNDARY TREES:

1. The Owner and Contractor must be aware of the Ontario Forestry Act, 1990 - specifically;
   Every person who injures or destroys a tree growing on the boundary between adjoining lands without the consent of the land owners is guilty of an offence under this Act. 1998, c. 18, Sched. I, s. 21.

MIGRATORY BIRDS AND NESTS:

1. The Owner and Contractor must be aware of the Migratory Birds Convention Act, 1994 - specifically;
   - No tree removal or construction activity shall contravene the Act.
   - Construction activities with the potential to harm migratory birds or their nest should be restricted from April 1 to July 31.
   - If work must occur during the migratory bird breeding season, a nest survey should be taken by a qualified avian biologist.
   - A mitigation plan (showing active nests and appropriate buffers) may be required for review and approval by the Canadian Wildlife Services.

ROOT PROTECTION ZONE NOTES:

1. The area within the dripline of all existing trees shall be properly protected with temporary fencing.
2. The area within the protective fencing shall remain undisturbed with no construction activity, grade changes, surface treatment, compaction, or excavation. Area shall not be used for the storage of building materials or equipment access/storage or project related garbage.
3. Tree protection measures shall be installed prior to any demolition, tree removal or construction and shall remain until the completion of fine grading and sodding or seeding.
4. Prune all trees for dead, diseased, weak or hazardous branches only. also trim back branches which will interfere with construction, prune for structural restoration where necessary.
5. No stockpiles and/or excavated material shall be placed within the tree preservation area.
6. No rigging cable shall be wrapped around or installed to trees.
7. Where root systems of protected trees are exposed directly adjacent to or damaged by construction work they are to be root pruned and the area back filled with topsoil to prevent root desiccation.
8. Any fine grading within the preservation area is to be done by hand. no heavy equipment is permitted within the preservation zone.
9. Sediment accumulations to be removed by subdivider/builder when sediment deposits reach within 150mm of top of filter fabric barrier.
10. A copy of the approved and signed Vegetation Management Plan will be on site for the duration of construction and available upon request.

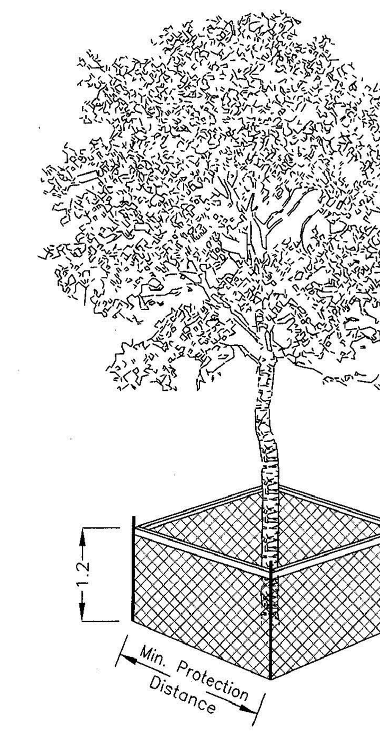


Table 1 – Tree Protection Zones

Trunk Diameter (DBH)[2]	Tree Protection Zone (TPZ) Minimum Protection Distances Required[3]	Critical Root Zone (CRZ) Distances Required[3 & 4]
<10 cm	1.8 m	1.8 m
11–40 cm	2.4 m	4.0 m
41–50 cm	3.0 m	5.0 m
51–60 cm	3.6 m	6.0 m
61–70 cm	4.2 m	7.0 m
71–80 cm	4.8 m	8.0 m
81–90 cm	5.4 m	9.0 m
91–100+cm	6.0 m	10.0 m

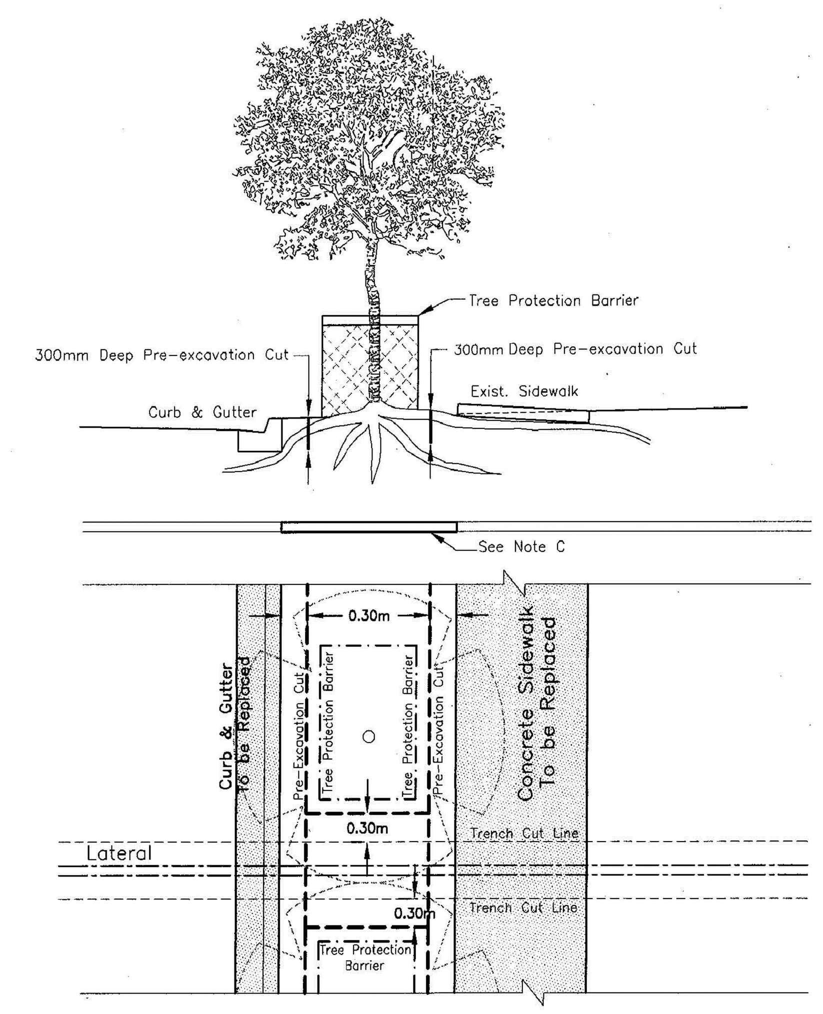
TREE PROTECTION BARRIER

1. Tree protection barriers for trees situated on the City road allowance where visibility must be maintained can be 1.2m high and consist of orange plastic web snow fencing on a wood frame of 2" x 4" s, supported on metal " T " bars, 2.0m c/c max. Where orange plastic web snow fencing creates a restriction to sightlines, page wire fencing shall be used.

2. Where some excavate or fill has to be temporarily located near a tree protection barrier plywood must be used to ensure no material enters the Tree Protection Zone.

3. All supports and bracing should be outside the Tree Protection Zone. All such supports should minimize damaging roots outside the Tree Protection Barrier.

4. No construction activity, grade changes, surface treatment or excavations of any kind is permitted within the Tree Protection Zone.



NOTE:
For excavations perpendicular to the curbing (ie. curbing, sidewalk,water or sewer laterals renewal)

a) when the open cut is within the Critical Root Zone of a tree, the contractor is to pre-cut the earth 300mm wider than the specified trench width to a depth of 300mm.

b) the contractor is to use a trench box to minimize the width of the open cut.

c) when the lateral replacement is within the Tree Protection Zone of a tree, the contractor is to complete the works using trenchless technologies.

Tree Protection (City of Burlington Std. Dwgs.) — 1 / L-2

SCALE: NTS

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NOTE:
Vegetation inventory undertaken by Nate Torenvliet, ISA Certified Arborist (ON-1782A) on December 15, 2017.

REVISIONS/ SUBMISSIONS

#	DATE	DESCRIPTION
1	2018-05-07	First submission
2	2020-04-13	Revised as per engineering
3	2020-04-14	Issued for submission
4	2020-11-11	Issued for submission
5	2021-01-19	Issued for submission

STAMP

ONTARIO ASSOCIATION OF LANDSCAPE ARCHITECTS
SCOTT PB HENDERSON
OALA
MEMBER

CLIENT
Zarin Homes

MUNICIPALITY
City of Burlington

PROJECT
4417 Spruce Avenue

MUNICIPAL FILE NUMBER
510-02/18 (24T-18002/B)

SHEET
Vegetation Inventory and Details — L-2

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landscape architecture

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www.adessodesigninc.ca

project #: 17-158

north

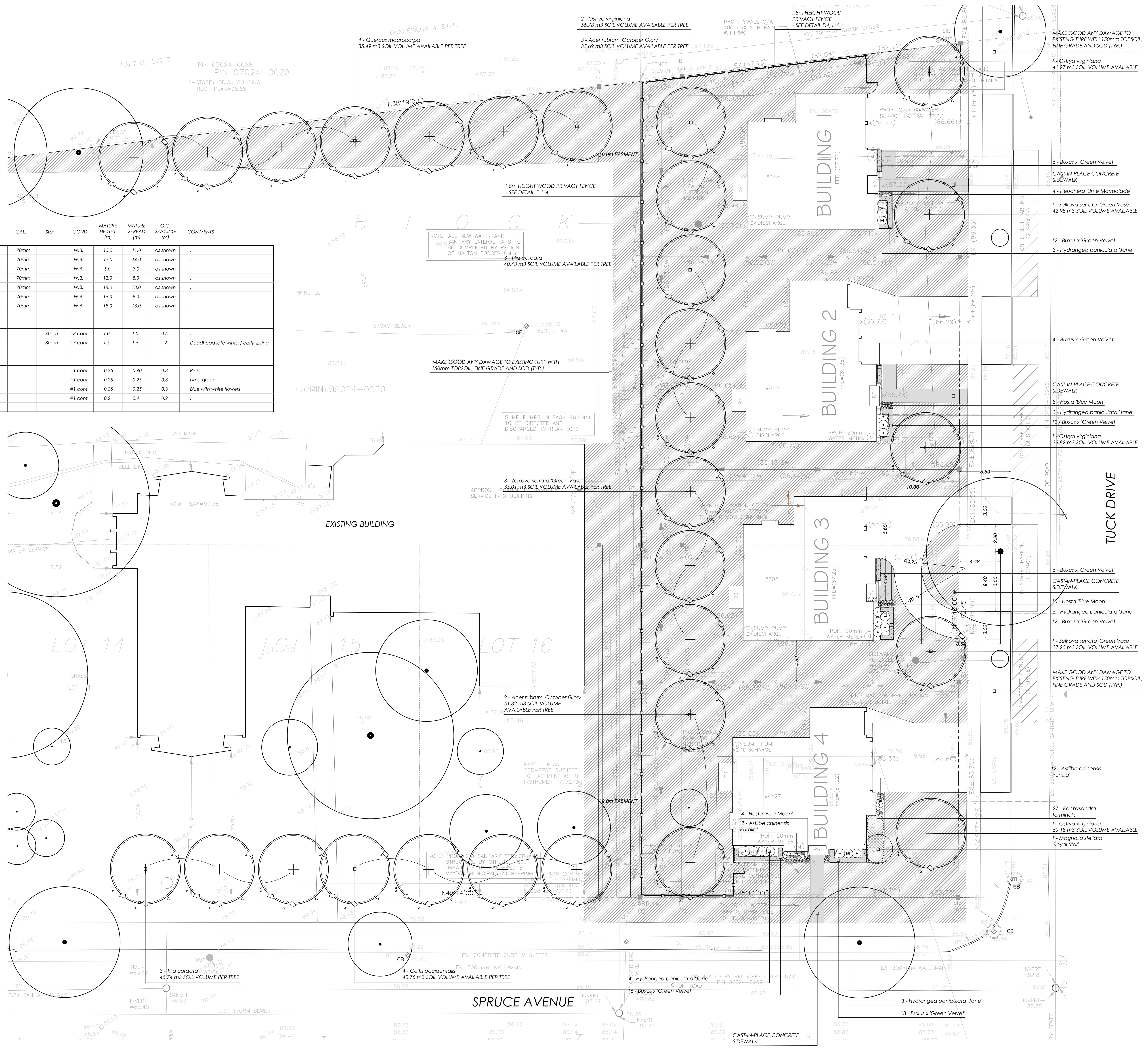
1:200 (m)

PLANT LIST

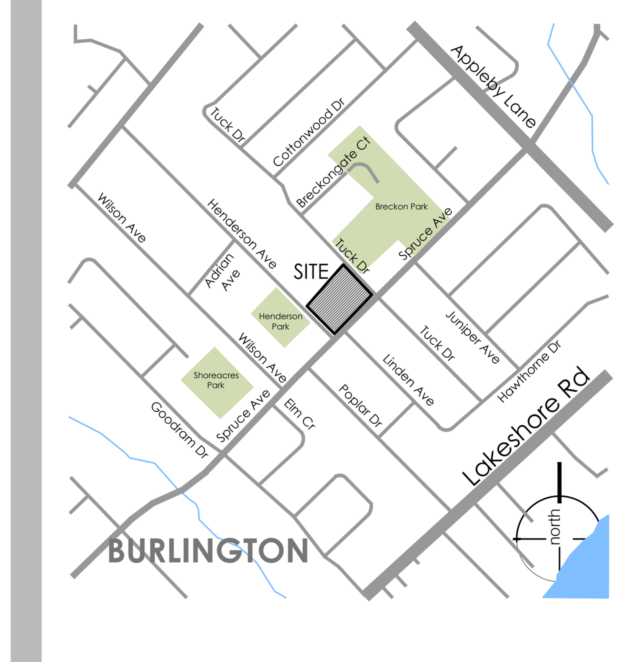
QNTY.	BOTANICAL NAME	COMMON NAME	CAL.	SIZE	COND.	MATURE HEIGHT (m)	MATURE SPREAD (m)	O.C. SPACING (m)	COMMENTS
	TREES								
5	Acer rubrum 'October Glory'	October Glory Red Maple	70mm		W.B.	15.0	11.0	as shown	.
4	Celtis occidentalis	Common Hackberry	70mm		W.B.	15.0	14.0	as shown	.
1	Magnolia stellata 'Royal Star'	Royal Star Magnolia	70mm		W.B.	5.0	3.0	as shown	.
5	Ostrya virginiana	Ironwood	70mm		W.B.	12.0	8.0	as shown	.
4	Quercus macrocarpa	Bur Oak	70mm		W.B.	18.0	13.0	as shown	.
6	Tilia cordata	Little Leaf Linden	70mm		W.B.	16.0	8.0	as shown	.
5	Zelkova serrata 'Green Vase'	Green Vase Zelkova	70mm		W.B.	18.0	13.0	as shown	.
	SHRUBS								
79	Buxus x 'Green Velvet'	Green Velvet Boxwood		40cm	#3 cont.	1.0	1.0	0.5	.
18	Hydrangea paniculata 'Jane'	Little Lime Hydrangea		80cm	#7 cont.	1.5	1.5	1.2	Deadhead late winter/ early spring
	PERENNIALS/ GRASSES								
24	Astilbe chinensis 'Pumila'	Chinese Astilbe			#1 cont.	0.35	0.40	0.3	Pink
4	Heuchera 'Lime Marmalade'	Lime Marmalade Coral Bell			#1 cont.	0.25	0.25	0.3	Lime-green
32	Hosta 'Blue Moon'	Blue Moon Hosta			#1 cont.	0.25	0.25	0.3	Blue with white flowers
27	Pachysandra terminalis	Japanese Spurge			#1 cont.	0.2	0.4	0.2	.

LANDSCAPE NOTES:

1. All work to be carried out in accordance with by-laws and codes having jurisdiction over site location.
2. Complete all work to the satisfaction of the Landscape Architect.
3. Report any changes, discrepancies or substitutions to the Landscape Architect for review. Obtain approval from the Landscape Architect before proceeding.
4. It is the contractor's responsibility to determine existing service locations.
5. Exact locations of plant material will be determined by placement of site services such as hydro vaults, meters, utilities roof rain water leaders, driveways, light standards, etc.
6. All plant material locations to be staked or marked out and approved by Landscape Architect prior to installation.
7. Supply all plant material in accordance with the Canadian Standards for Nursery Stock (8th ed.).
8. Install plant material according to details shown.
9. Disturbed soil areas around trees and shrubs are to be covered with shredded conifer bark mulch such as 'Canada Red' or 'Gro-Bark' mulch, or approved equivalent. Alternative mulches must be approved by the Landscape Architect.
10. Contractor to utilize layout dimensions where provided
11. Provide planting bed area as noted on the drawing or to accommodate mature size of plant material.
12. All support systems must be removed by the contractor at time of final acceptance. No extras will be paid to complete this work
13. Supply and place topsoil in accordance with OPSS 570 to a minimum depth of 150mm unless otherwise specified.
14. Supply and place sod in accordance with OPSS 571 unless otherwise specified.
15. Supply and place seed in accordance with OPSS 572 unless otherwise specified. All 5:1 or greater slopes to be seeded with tacifier. Contractor to provide necessary erosion control protection as required to ensure soil stabilization and proper seed germination.
16. All dimensions in meters unless otherwise noted.
17. If discrepancies arise between plant material count shown on drawing and plant list, the drawing shall be considered correct.
18. Contractor to provide minimum two (2) year warranty (including trees on municipal property) from date accepted on all work unless otherwise specified.
19. Any site plan or grading and servicing shown is for information only. Refer to approved drawings.
20. Not for construction unless stamped, signed and dated by Landscape Architect.
21. Drawings not to be reproduced without written consent from Landscape Architect.
22. Approval of landscape plan to be obtained from municipality.
23. All plant material to be planted a minimum of 1.0m from any swales or ditches.
24. For grading and servicing information refer to the consulting Engineer's drawings.
25. For lighting information and power distribution refer to the electrical consultant's drawings.



KEY MAP - N.T.S.



LEGEND

property line
existing tree
proposed deciduous tree
proposed shrub
proposed perennial
existing elevation
proposed elevation
min. 150mm topsoil, fine grade & sod
C.I.P. concrete

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City of Burlington

PROJECT
4417 Spruce Avenue

MUNICIPAL FILE NUMBER
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SHEET
Landscape Plan
L-3

adesso design inc.
landscape architecture

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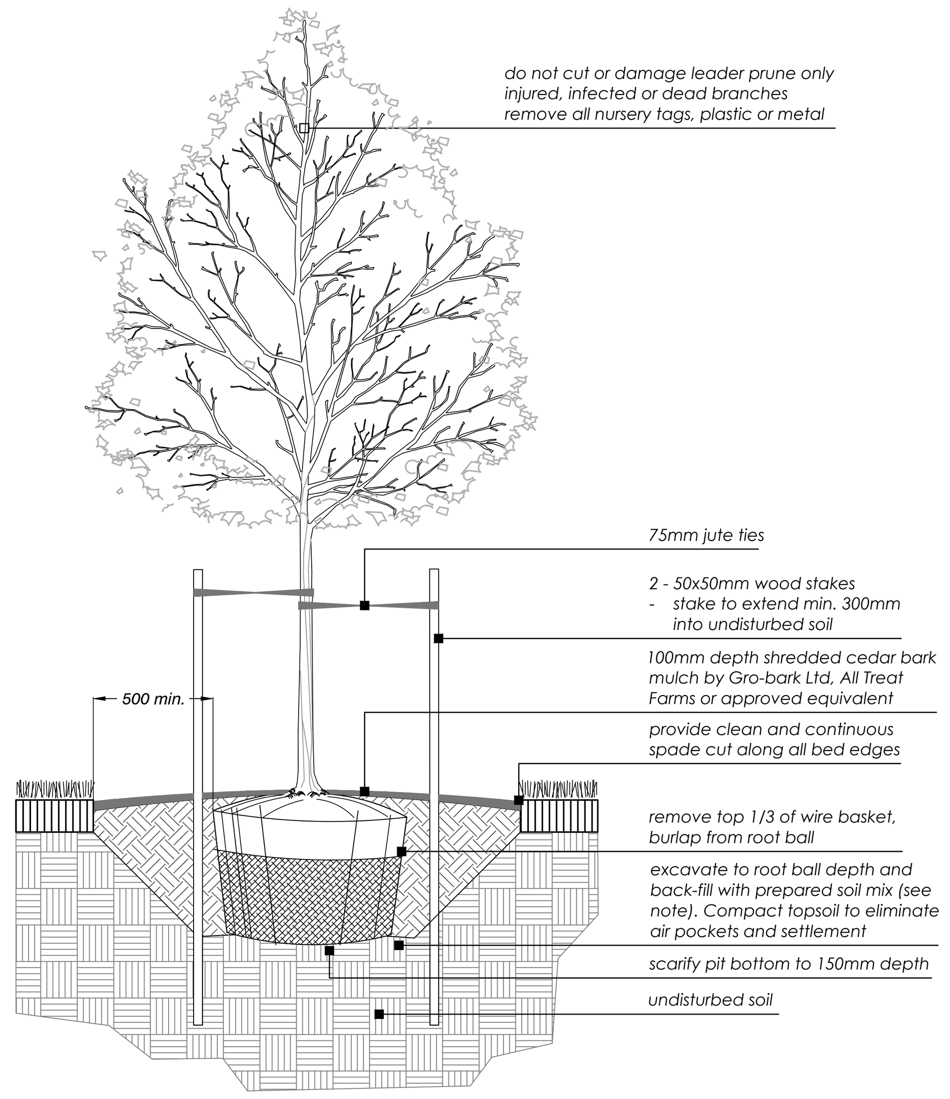
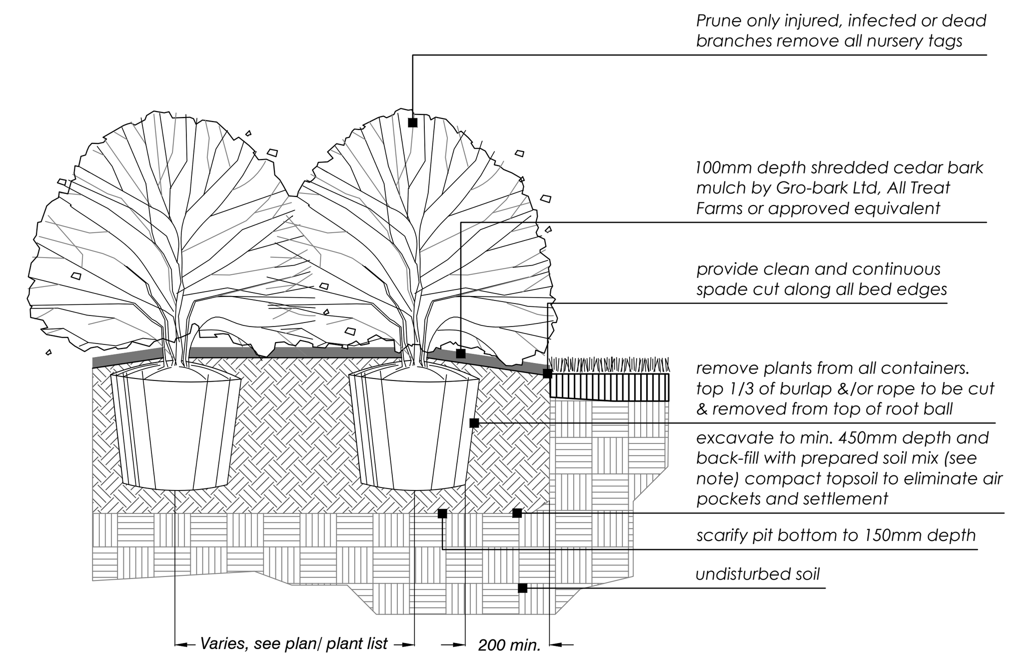
project #: 17-158



Balled & Burlapped/ Wire Basket Deciduous Tree

1 / L-4

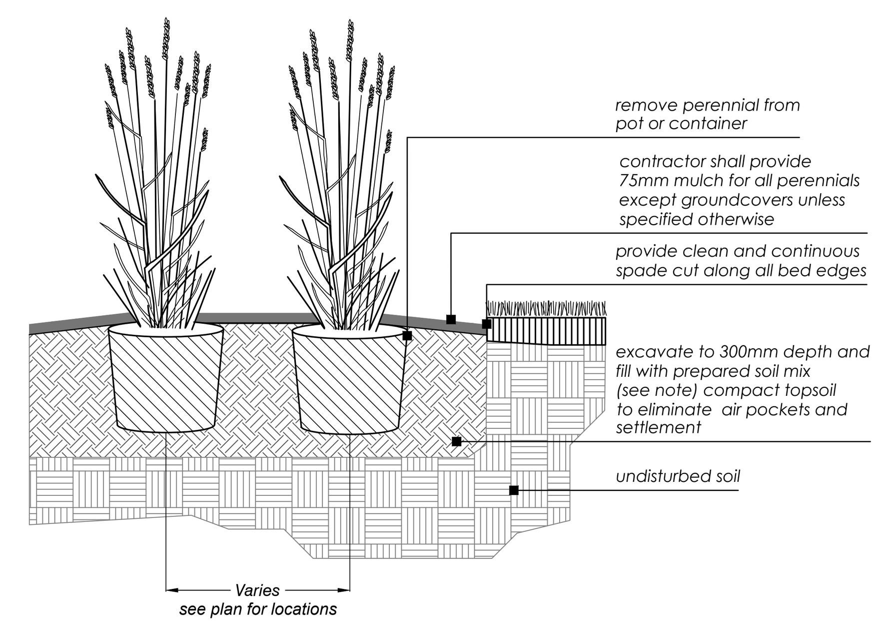
SCALE: NTS



Container Grown Shrub

2 / L-4

SCALE: NTS



Container Grown Perennial

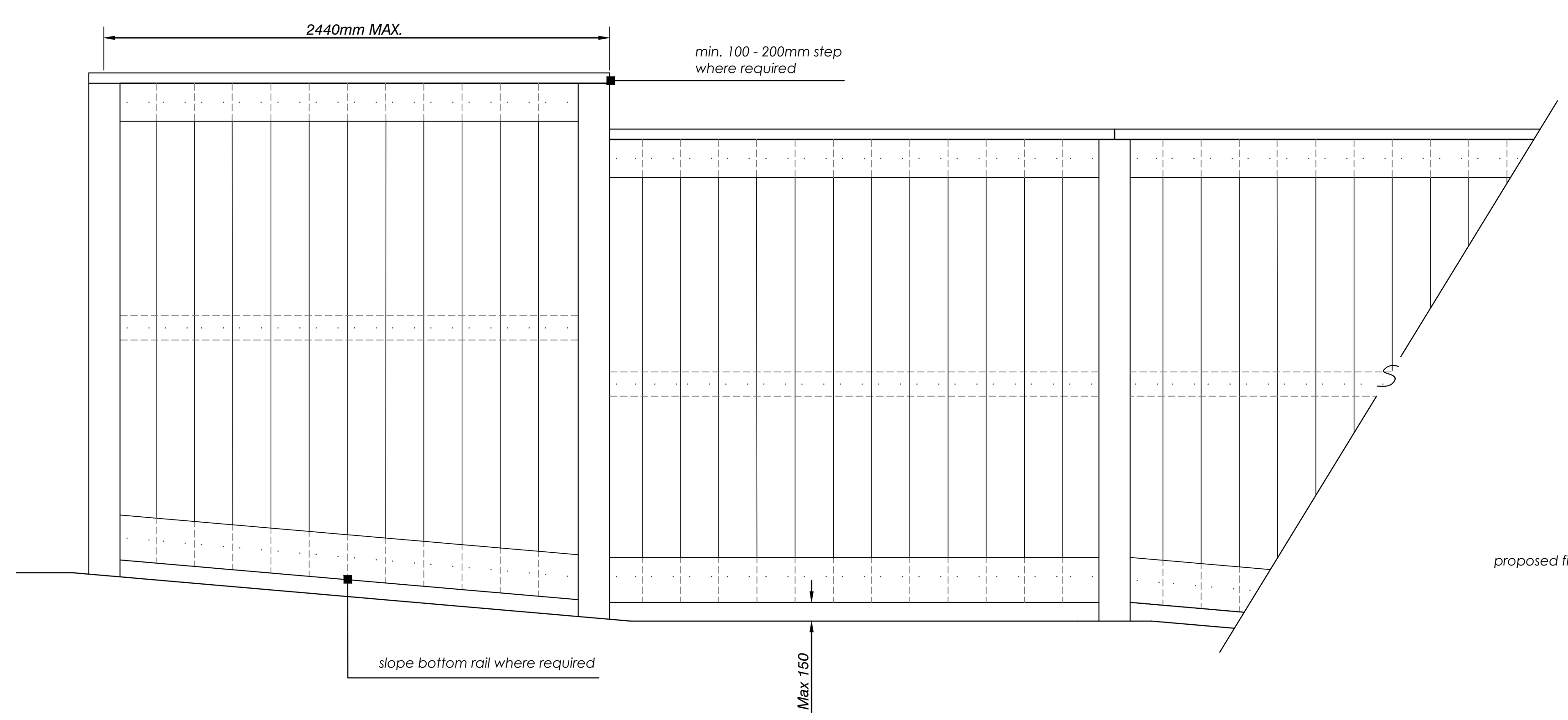
3 / L-4

SCALE: NTS

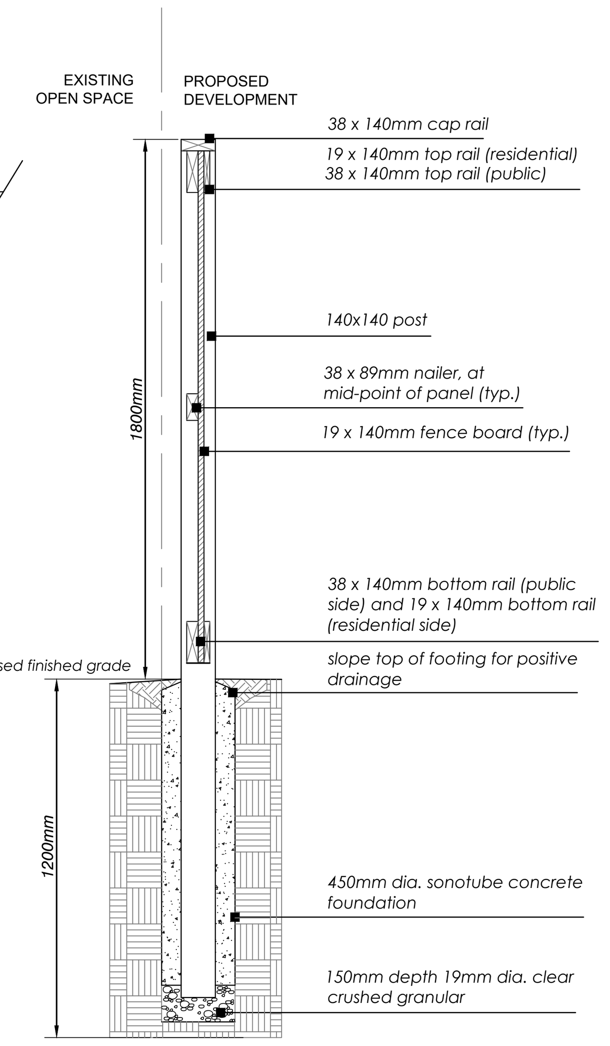
PLANTING NOTES:

1. Soil mixture: four (4) parts native soil, one (1) part well rotted compost.If existing soil is not suitable provide triple mix topsoil or approved equal.
2. Saucer shall be soaked with water and mulched immediately following planting.
3. Massed shrubs shall be planted in continuous mulched beds unless otherwise noted.
4. Staking schedule;
   - < 30mm caliper size/ 2500mm ht. - one stake
   - > 30mm caliper size/ 2500mm ht. - two stakes
   - > 70mm caliper - three stakes
5. All support systems must be removed once tree is established.
6. All trees to be straight and planted vertically regardless of slope.
7. Top of root flare shall be positioned 50mm above grade.
8. The following depths of soil are required for planting;
   - 15cm topsoil for sod;
   - 30cm of topsoil for perennials;
   - 45cm of topsoil for shrubs;
   - 90cm of topsoil for trees.

ELEVATION



SECTION



NOTES:

1. All materials, components and workmanship to conform to building and local by-laws.
2. All wood to be Pressure Treated (Spruce, Pine Fir) selected mainly for good appearance all members shall be free of wane and bark pockets. All torn grain shall be eliminated by sanding and planning. Members exhibiting moderate to heavy knots shall be well distributed throughout the site.
3. All cuts and holes that expose untreated wood should be liberally brush-coated with two applications of an end-cut preservative (copper naphthenate in ground contact or zinc naphthenate above ground) before the wood is installed. Follow the manufacturer's recommendations re: the application of suitable preservatives.
4. All wood to bear lumber grading stamp.
5. All fasteners shall have exterior grade finishes suitable for use with Pressure Treated lumber. Stainless steel, galvanized, zinc-dipped or ceramic-coated wood/deck screws are acceptable.
6. All galvanizing to be hot dipped in conformance to CSA standard C164.
7. Drive all fastener heads below surface of wood. Use sufficient size and quantity of fasteners to ensure a stable, secure structure.
8. Step fence panels minimum of 100 - 200mm at posts as required by grade conditions. Sloping of panels may be required for certain grade conditions - Consultant's approval required.
9. Lumber sizes are actual sizes rather than nominal sizes.
10. Concrete to have minimum compressive strength of 25 MPa @ 28 days with 5-7% air entertainment.
11. See landscape plan for fence location.

GENERAL LAYOUT NOTES

1. All fences adjacent to road allowances and walkways to be erected 0.15m onto private property. Fencing is not to be erected on the lot line or into any road allowance or easement.

2. Footing and excavation to be entirely on proposed development lands.

Wood Privacy Fence (1.8m height - pressure treated)

4 / L-4

SCALE: NTS

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SHEET
Details

L-4

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landscape architecture

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CITY OF Burlington

SUBJECT: Climate Adaptation Plan

TO: Environment, Infrastructure & Community Services Cttee.

FROM: Environment, Infrastructure and Community Services

Report Number: EICS-03-21

Wards Affected: All

File Numbers: 210-09

Date to Committee: March 4, 2021

Date to Council: March 23, 2021

Recommendation:

Receive and file environment, infrastructure and community services report EICS-03-21 regarding Burlington's upcoming Climate Adaptation Plan.

PURPOSE:

Vision to Focus Alignment:

- Support sustainable infrastructure and a resilient environment

Background and Discussion:

On April 23, 2019, Burlington City Council declared a climate emergency "for the purposes of deepening our commitment to protecting our economy, environment and community from climate change" and "that Council and staff immediately increase the priority of the fight against climate change and apply a climate lens to the plans and actions of the City of Burlington including the Council strategic workplan and future budgets."

The City has shown leadership with respect to plans to reduce greenhouse gas emissions – also known as climate mitigation. A net carbon neutral goal by 2040 for corporate emissions was first approved in Burlington's Strategic Plan 2015-2040 and confirmed again in July 2019 with the approval of the Corporate Energy and Emissions Plan: 2019-2024. In April 2020, Council approved a net carbon neutral goal by 2050 for community emissions in Burlington's Climate Action Plan. While work is underway to reduce the greenhouse gas emissions which contribute to climate change, we must also recognize that our climate is changing.

In 2018, the Intergovernmental Panel on Climate Change (an international body responsible for assessing the science related to climate change) reported that the world has already warmed by 1ºC above preindustrial levels (1850-1900) due to human activities and is projected to reach 1.5ºC by 2030-2052 at the current rate of warming. Canada is warming at a faster rate with overland temperatures increasing an average of 1.7ºC between 1948 and 2016 and about 2.3ºC for northern Canada with the majority of the warming due to human activities. Annual precipitation rates have also increased with extreme events becoming more frequent and intense.

Climate Projections for Burlington

The first step to developing a climate adaptation plan for Burlington is to identify local climate projections based on climate science. The Climate Projections Report for Burlington Region (Appendix 1) presents how Burlington's climate has and is projected to change from the recent past (1976-2005) to the immediate future (2021-2050) and near future (2051-2080) for two emission scenarios[1] (low and high). For consistency, the timeframes, emission scenarios, geographical area, and most of the climate categories and climate variables used in the report are based on the Climate Atlas of Canada's terminology when available. Additional data was gathered from scientific articles which might use different time frames or emission scenarios but are clearly acknowledged as such in the report.

The "Burlington Region" grid used in the Climate Atlas was identified by the Government of Canada's National Topographic System where grids are typically named after cities, towns or landmarks within the area. Since the area included all of Burlington and most of Oakville and in the spirit of cross jurisdictional collaboration, the City of Burlington's sustainability project coordinator worked with the Town of Oakville's environmental coordinator to develop a joint Climate Projections report primarily done

[1] Emission scenarios, also known as representative concentration pathways (RCPs) are based on the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC AR5) adopted in 2014. RCPs simulate how climate might change in response to different activities. Further details are provided in the Climate Projections Report for Burlington Region where RCP4.5 represents a low carbon scenario and RCP8.5 represents a high carbon scenario.

in-house with a few hours of in-kind support from ICLEI - Local Governments for Sustainability Canada staff.

The Climate Projections report presents over 40 climate variables under seven categories – temperature, hot weather, cold weather, precipitation, agriculture, extreme weather and Lake Ontario.

Under a high emissions scenario, Burlington's annual mean temperature is projected to increase by 4.2ºC from 8.6 to 12.8ºC by 2051-2080. However, the warming is not the same across all seasons with winter mean and winter minimum temperatures expected to increase by 4.7 and 5.2ºC respectively. An additional six weeks of temperatures over 30ºC are anticipated with about three of those weeks at over 34ºC. There will be more heat waves, each lasting longer, and many more 'tropical' nights when the temperature does not drop below 20ºC. Conversely, the number of cold days will decrease with the average coldest temperature increasing by 7.8ºC from -20.8 to -13ºC.

Annual precipitation is expected to increase by 10% on average with winter and spring precipitation increasing a greater amount and summer precipitation staying about the same. There will be more heavy precipitation days (10 mm or 20 mm days) and an increase in maximum 1-day and 5-day precipitation.

It is anticipated that there will be a longer frost-free season with the date of the last spring frost coming earlier and the date of the first fall frost coming later. Growing degree days which are used to assess the growth and development of different crops as well as insects and pests are projected to increase.

Extreme events are projected to become more frequent and intense with more precipitation falling in a shorter time frame. Wind gusts and freezing rain events (in December, January and February) are expected to increase.

The projected increase in annual temperatures, precipitation and extreme weather events will continue to impact the Great Lakes. Annual mean surface air and water temperature has increased over Lake Ontario and ice coverage and thickness has and will continue to decrease.

Three words which best summarize the Climate Projections report are "warmer," "wetter" and "wilder."

Infographics

The Climate Projections report is a 68-page document cover to cover. To make the content more relatable for Burlington residents, sustainability staff worked with creative services staff to develop a series of infographics to provide some key highlights under the themes of warmer, wetter and wilder. An image to represent the overall project was also created. In addition, icons were developed to represent various weather events such as extreme heat, high wind, ice storm, extreme rain and flooding, etc. The images are illustrated in Appendix 2.

Climate Impacts in Burlington

The City of Burlington is not immune to the impacts of climate change and has already experienced events projected to become more common. Examples include major events such as the ice storm in Dec. 2013 when the City opened three warming stations to serve households experiencing extended power outages and a flood in Aug. 2014 where 3,000 homes reported flooding and two evacuation centres were opened to serve residents. Other events such as extreme heat and cold, high wind, vector borne diseases and high lake levels have also had impacts in Burlington.

These events incur economic impacts (costs to repair or rebuild infrastructure, transportation impacts such as road closures and accidents, disruption to electrical systems), social impacts (mental health impacts of flooding, heat stress from extreme heat, slips and falls from freezing rain events, illness due to West Nile Virus and Lyme disease), and impacts to the natural environment (degradation of ecosystems, shifts in animal and plant species) to name a few.

Story Map

To help illustrate these events and associated impacts, sustainability staff worked with Geographic Information System (GIS) staff to develop a story map using a combination of text and multi-media content. Sustainability staff first created a story by researching and identifying some events that have taken place in Burlington under the categories of extreme heat, high winds, rainfall, high Lake Ontario levels, freezing rain, extreme cold and vector-borne diseases as examples of what could become more common in the future. Based on this data, GIS staff created maps to help highlight some of the stories and produced the story map.

Climate Adaptation in Burlington

Although the City of Burlington does not have a formal climate adaptation plan, staff do have direction from Burlington's Strategic Plan 2015-2040 and also from the 2018-2022 Burlington's Plan: From Vision to Focus to develop and implement a plan.

In addition, there are many programs or initiatives that are already in place or being developed to help us to adapt to a changing climate including:

- Climate Emergency declaration - requires applying a climate lens to City plans and actions including the Council strategic workplan and future budgets - Apr. 2019
- Flooding

  - Stormwater Management Design Guidelines - updated and approved June 2020
  - Urban-Area Flood Vulnerability, Prioritization and Mitigation Study update – July 2015 where an additional $20.4 million was approved in the 2016 Capital Budget and 2017-2025 Capital Forecast and final report – July 2017
  - (Halton) Enhanced Basement Flooding Prevention Subsidy Program report and webpage where subsidies were increased up to 100% coverage for some actions – July 2016
  - (Halton) Region Wide Basement Flooding Mitigation Study: Final Report and Recommendations – to develop and implement a program to reduce potential of future basement flooding - July 2015
- Extreme Heat
  - (Halton) heat warnings webpage and video about heat illness and how to take precautions and prevent health issues in extreme heat
  - Extended outdoor pool hours and opening of cooling centres during heat waves
  - Working in Hot Weather, a corporate health and safety standard – Feb. 2017
- Policy
  - Chapter 4 (Environment and Sustainability) of the new Official Plan – section 4.1 addresses climate change – April 2018
  - Sustainable Building and Development Guidelines within the new Official Plan – April 2018. These are currently under review providing an opportunity to strengthen climate adaptation measures
- Assets
  - Asset Management and Financial Strategy, opportunity to integrate climate adaptation into the upcoming update as mandated by Ontario Regulation 588/17 – by July 21, 2021 for core municipal assets and July 21, 2023 for all other municipal infrastructure assets
- Natural Assets
  - Cootes to Escarpment EcoPark System Lower Grindstone Heritage Lands Management Plan – approved Jan 2021
  - Municipal Natural Assets Initiative - Grindstone Creek Project with Burlington, Hamilton, Conservation Halton and Royal Botanical Gardens - launched Dec 2019

  - Urban Forest Master Plan – update to launch in 2021
  - Parks, Recreation and Cultural Assets Master Plan – currently under review
- Emergency Services
  - Burlington Emergency Management Program
  - Hazard Identification and Risk Assessment
  - Burlington Ready Program Community Advisory Group - to be reconvened in 2021

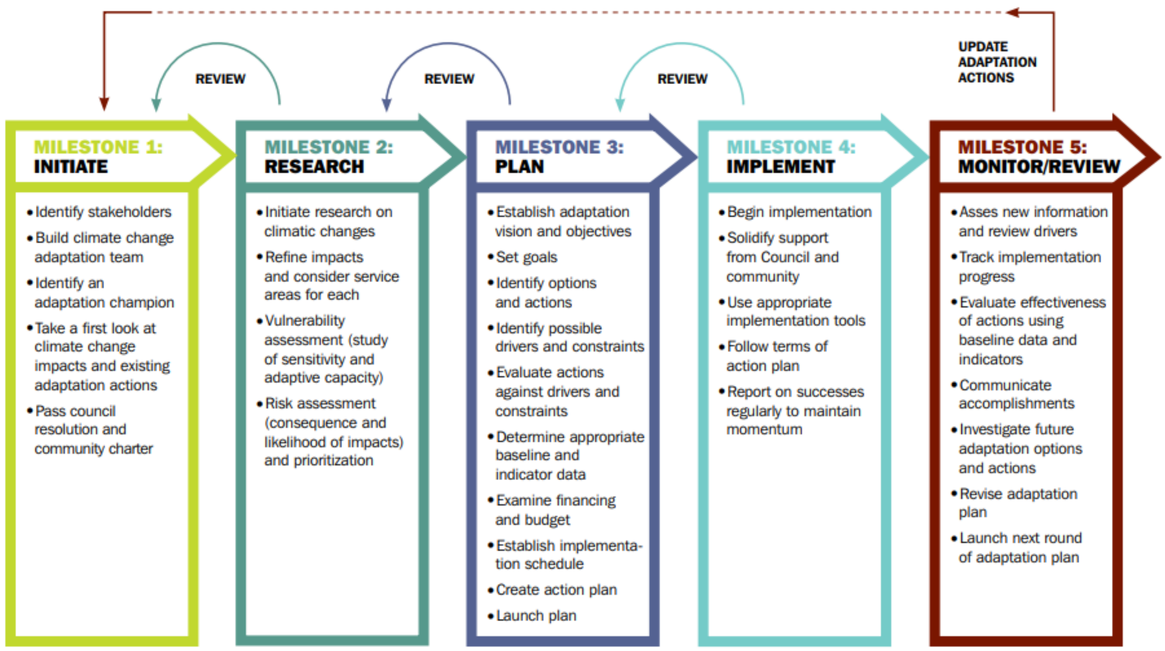
In 2016/17, the City participated in the Train-the-Trainer Initiative of the Great Lakes Climate Change Adaptation Project along with 15 other local and regional governments. This training will be beneficial as we go through the process of developing a formal climate adaptation plan.

In Dec. 2019, the City (Report CW-20-19) joined Global Covenant of Mayors for Climate and Energy (GCoM). This coalition of city leaders around the world are tackling climate change by pledging to cut greenhouse gas emissions (mitigation) and preparing for the future impacts of climate change (adaptation). The City of Burlington was one of 25 Canadian municipalities selected to participate in a one-year pilot program under GCoM Canada which offered technical support, training, networking opportunities and access to tools and resources. There are reporting requirements through this process including badges for commitment, assessment, goal and plan.

Strategy/process

As a member of GCoM, following specific reporting frameworks is required. Canada has well established reporting frameworks for both climate mitigation (FCM's Partners for Climate Protection (PCP) Program) and adaptation (ICLEI Local Governments for Sustainability's Building Adaptive and Resilience Communities (BARC) program) and municipalities are permitted to use these existing programs to meet GCoM's requirements.

BARC has a five-milestone process: initiate, research, plan, implement, and monitor/review as illustrated below. In ordinary circumstances, it takes municipalities about two years to move from the project launch date to producing a plan.



Milestone 1: Initiate (We are here).

- Direction to complete and implement an adaptation plan is outlined in Burlington's Strategic Plan 2015-2040 and the 2018-2022 Burlington's Plan: From Vision to Focus documents approved by City Council.
- The project is under the direction of the Executive Director of Environment, Infrastructure and Community Services.
- Two working teams have been identified – a staff team and a community stakeholder team. Additional stakeholders and the broader community will also have opportunities to be engaged using Get Involved Burlington, special online events, etc.
- Information on climate impacts will be shared with the teams for review and further development.

Milestone 2: Research

- The project manager co-developed the Climate Projections report in partnership with the Town of Oakville and ICLEI – Local Governments for Sustainability Canada.
- It is anticipated that it will take the rest of the year to complete milestone two (developing climate impact statements and carrying out vulnerability and risk assessments). A request for proposals (RFP) will be issued to hire a consultant to coordinate and facilitate the online workshops and produce a summary document.

Milestone 3: Plan

Based on the results of the work carried out in milestone 2, it is anticipated that the plan will be developed in 2022.

Vision to Focus

2018-2022 Burlington's Plan: From Vision to Focus, which was approved by City Council in July 2019, identified that this project be completed by March 2021. After consulting with staff from other municipalities and representatives from ICLEI Canada, staff realized that more time and resources are required to complete the plan and meet the reporting requirements for GCoM. The global pandemic also caused additional delays. However, staff have (i) researched and compiled the Climate Projections report in partnership with staff from the Town of Oakville with initial support from ICLEI Canada, (ii) developed a story map to highlight local climate impacts, and (iii) created some infographics.

Financial Matters:

Total Financial Impact

The 2020 budget approved $60,000 one-time funding for this project. However, based on the review of the process to meet the GCoM requirements to complete and report on the Climate Adaptation Plan, staff are suggesting an additional budget of $60,000 for a total of $120,000 to complete this project.

Source of Funding

The source of funding of $60,000 approved in the 2020 operating budget was from the Tax Rate Stabilization Reserve Fund. Some of this funding will be used to retain a consultant to carry out Milestone 2 of the BARC process identified on page 7 including the engagement process, the vulnerability and risk assessment workshops for staff and the community, and a follow-up report on this part of the process.

Additional funding is required to complete the adaptation plan (Milestone 3 of the process) including assessing the information and data gathered during the risk and vulnerability phase, reviewing current initiatives and identifying gaps in measures and programs to improve community resiliency, setting goals, etc. Staff are estimating up to $60,000 is required to complete this phase of the plan.

Staff are recommending that the additional funding required be diverted from previously approved funds to support the home energy retrofit project pending a successful FCM application. Staff expect a response from FCM on Burlington's application for the home energy retrofit project in the next two to four months. If the FCM application is denied, staff will report back to City Council for additional funding to complete Milestone 3 of the climate adaptation plan including a funding source. It should be noted that FCM does not currently have a funding stream to support developing climate adaptation plans.

Other Resource Impacts

As noted above, to mainstream climate adaptation, staff representing functional areas from across the corporation will need to dedicate their time to developing the plan. Staff time will also be required to engage community stakeholders to provide a broader lens to this important work.

Cost and benefits of investing in climate change adaptation

In Feb. 2020, the Insurance Bureau of Canada and the Federation of Canadian Municipalities released a report titled Investing in Canada's Future: The Cost of Climate Adaptation at the Local Level. This report highlighted that the benefits of investing in climate change adaptation and resilience outweigh the costs of investment by 6:1. It further stated that an annual investment of $5.3 billion (0.26% of Gross Domestic Product (GDP)) in municipal infrastructure and local adaptation actions is needed to adapt to climate change. International studies have shown an average of 0.60 to 1.25% of GDP is needed to minimize the worst impacts of climate change across sectors of the economy.

On Dec. 11, 2020, Canada released A Healthy Environment and a Healthy Economy, a $15 billion plan containing "64 strengthened and new federal policies, programs and investments to cut pollution and build a stronger, cleaner, more resilient and inclusive economy." One of the five pillars "embracing the power of nature to support healthier families and more resilient communities" includes investments such as:

- Up to $3.16 billion over 10 years to plant two billion trees across Canada.
- Up to $631 million over 10 years to restore and enhance wetlands, peatlands, grassland and agricultural lands. It was noted that natural wetlands have been shown to reduce climate related flooding costs by as much as 38%.
- Provide $98.4 million over 10 years to establish a new Natural Climate Solutions for Agriculture Fund.

The federal government is also planning to develop Canada's first-ever National Adaptation Strategy which will help inform where best to target policy programs and future investments.

Cost of climate change

Our weather is becoming warmer, wetter and wilder and Burlington is not immune to the impacts of a changing climate. A few examples are listed below:

- Dec. 2013 ice storm assistance program claim in Burlington was over $2 million
- Aug. 4, 2014 flood resulted in over 3,000 homes being flooded with $90 million in claims and $20.4 million was added to capital budget for stormwater management updates
- Apr. 4, 2018 wind storm – $82,000 in initial forestry related clean-up costs for the roads, parks and forestry (RPF) department; 8.5% of Burlington Hydro customers lost power
- Apr. 15, 2018 ice storm - $25,000 in initial forestry clean-up costs for RPF; 9% of Burlington Hydro customers lost power
- May 4, 2018 wind storm – RPF initial clean-up costs were $234,000; 43% of Burlington Hydro customers lost power

The 2011 Paying the Price: the Economic Impacts of Climate Change for Canada report by the National Roundtable on the Environment and Economy found that the economic impact of climate change on Canada could reach $5 billion per year in 2020 and between $21 and $43 billion per year in 2050. Considering this report only looked at a few factors under the categories of people (air quality impacts from higher temperatures leading to more hospital visits in Toronto, Montreal, Vancouver and Calgary), places (flooding damages to coastal dwellings due to sea level rise and increased storms) and prosperity (timber supply impacts from changes in pests, fires, and forest growth), the costs are likely higher.

Weather related insurance claims in Canada averaged $400 million between 1983 and 2008 and $1.8 billion between 2009 and 2017. The Insurance Bureau of Canada's (IBC) top 10 highest payout years on record include every year since 2016. In 2020, the IBC reported that severe weather caused $2.4 billion in insured damage while global loses from natural disasters hit $270 billion.

In addition to insured losses, there are also uninsured losses incurred by government, businesses and individuals. It has been reported that for every $1 of insured losses, there are $3 to $4 of uninsured losses.

Climate Implications

While Burlington is one of many local governments planning actions to mitigate greenhouse gas emissions to avoid the worst impacts of climate change, we must also do what we can to adapt to our changing climate which is predicted to be warmer, wetter and wilder. Actions related to climate adaptation are already being carried out. By going through the process to develop a plan, any potential gaps or areas needing further attention will be recognized and incorporated into the plan.

Engagement Matters:

Two working teams – staff and the community - will be struck to develop the plan. The project manager will also work with the engagement and volunteer manager to engage additional community stakeholders through the Get Involved Burlington platform. A community engagement plan will be developed to engage staff and the broader community throughout this project.

Conclusion:

While work is underway to reduce the greenhouse gas emissions which contribute to climate change, we must also plan for our warmer, wetter and wilder weather and adapt to climate change.

Rather than wait for a weather disaster to strike and then respond, a better plan is to reduce the risk before it happens. The benefits of investing in community adaptation and resilience outweigh the costs by a ratio of 6 to 1.

Respectfully submitted,

Fleur Storace-Hogan

Sustainability Project Coordinator

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Appendices:

A. EICS-03-21Climate Projections for Burlington Region
B. EICS-03-21 Infographics for Burlington Region

Report Approval:

All reports are reviewed and/or approved by Department Director, the Chief Financial Officer and the Executive Director of Legal Services & Corporation Counsel.

EICS-03-21- APPENDIX A CLIMATE PROJECTIONS FOR BURLINGTON REGION.DOCX

Prepared by: City of Burlington, Town of Oakville and ICLEI Canada
January 2021

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Glossary

The definitions below have been taken from the Intergovernmental Panel on Climate Change (IPCC)[i] and Natural Resources Canada[ii] unless otherwise cited.

Baseline - A climatological baseline is a reference period, typically three decades (or 30 years), that is used to compare fluctuations of climate between one period and another. Baselines can also be called references, reference periods or climate normal.

Burlington Region – The geographic area identified as '030M05' in Government of Canada's National Topographic System which includes the City of Burlington and most of the Town of Oakville. All grid squares in the Climate Atlas of Canada are usually named after cities, towns or landmarks within the area, to make it easier to identify where a grid square is located – in this case Burlington Region. All the data associated with each grid is the average of all the climate model grid points (which are 10 km x 10 km) within the grid square.[iii]

Climate Atlas of Canada – First launched in April 2018 and created by the Prairie Climate Centre at the University of Winnipeg with financial support from Environment and Climate Change Canada, Health Canada and others. It is an innovative climate science and communications tool that allows users to visualize and interact with climate data as well as the human stories about climate change and climate action on the landscape from coast to coast to coast.[iv]

Version 2 was released on July 10, 2019. Twenty-four different global climate models are used along with advanced statistical techniques that preserve daily patterns in the global models to downscale temperature and precipitation data to smaller geographical grids, as identified by the Government of Canada's National Topographic System, for two emission scenarios (RCP4.5 and RCP8.5).[v] Climate Atlas of Canada is often referred to as Climate Atlas in this report.

Climate Change - Changes in long-term weather patterns caused by natural phenomena and human activities that alter the chemical composition of the atmosphere through the build-up of greenhouse gases which trap heat and reflect it back to the earth's surface, also known as the greenhouse effect.

Climate Model – Models of varying complexity are used to represent the climate system. They are used as a research tool to study and simulate the climate and for operational purposes, including monthly, seasonal and interannual climate predictions. They are a numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes and accounting for some of its known properties. The data presented in this report is based on global climate models (GCMs).

Climate Projections - The simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models.

Coupled Model Intercomparison Project (CMIP) - A climate modelling activity from the World Climate Research Programme coordinates and archives climate model simulations based on shared model inputs by modelling groups from around the world. The CMIP3 multimodel data set includes projections using Special Report on Emissions Scenarios (SRES) as used in the IPCC Fourth Assessment Report (AR4). The CMIP5 data set includes projections using the Representative Concentration Pathways (RCPs) as identified in the IPCC Fifth Assessment Report (AR5).

Emissions Scenarios - A simplified representation of future climate based on comprehensive scientific analyses of the potential consequences of anthropogenic climate change. It is meant to be a plausible representation of the future emission amounts based on a coherent and consistent set of assumptions about driving forces (such as demographic and socioeconomic development and technological change) and their key relationships.

Ensemble Approach - A system that runs multiple climate models at once, to represent the uncertainty associated with the modelling process. Research has shown that this provides a more accurate projection of annual and seasonal temperatures and precipitation than a single model would on its own. The Climate Atlas uses the mean or average of the 24 climate models.

Greenhouse Gas (GHG) - Those gaseous constituents of the atmosphere, both created by natural and human activity, that absorb and emit radiation at specific wavelengths within the spectrum of thermal (heat) infrared radiation, emitted by the Earth's surface, the atmosphere itself, and by clouds. Water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and chlorofluorocarbons (CFCs) are the six primary greenhouse gases in the Earth's atmosphere in order of abundance. In addition, there are a number of entirely human-made GHGs in the atmosphere.

Intergovernmental Panel on Climate Change (IPCC) - Created in 1988 by the World Meteorological Organization and the United Nations Environment Programme, the objective of the IPCC is to provide governments at all levels with scientific information that they can use to develop climate policies. The IPCC currently has 195 members. Thousands of people from all over the world contribute to the work of the IPCC. [vi]

Radiative forcing - The change in the value of the net radiative flux (i.e. the incoming flux minus the outgoing flux represented as W/m^2) at the top of the atmosphere in response to some perturbation, in this case, the presence of greenhouse gases.

Representative Concentration Pathway (RCP) - Four greenhouse gas concentration trajectories were adopted by the IPCC for its Fifth Assessment Report (AR5)[vii] in 2014 to simulate how climate might change in response to different levels of human activity. It supersedes Special Report on Emissions Scenarios (SRES) projections published in 2000.[viii] RCPs usually refer to the portion of the concentration pathway extending up to the year 2100.

RCP4.5 - Moderate projected GHG concentrations, resulting from substantial climate change mitigation measures. It represents an increase of 4.5 W/m^2 in radiative forcing to the climate system. Climate Atlas of Canada and this report consider this pathway to be the 'Low Carbon Scenario.'

RCP8.5 - Highest projected GHG concentrations, resulting from business-as-usual emissions. It represents an increase of 8.5 W/m^2 in radiative forcing to the climate system. Climate Atlas of Canada and this report consider this pathway to be the 'High Carbon Scenario.'

Special Report on Emissions Scenarios (SRES) – SRES refers to the scenarios described in the IPCC SRES.[ix] These scenarios are grouped into four scenario families (A1, A2, B1 and B2) that explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting GHG emissions. These scenarios were used in the Fourth Assessment Report (AR4) in 2007.[x]

1.0 Introduction

The purpose of this report is to summarize climate projections for Burlington Region. It presents how local climate has and is projected to change from the baseline timeframe of 1976-2005 until predominantly 2080 for the climate variables listed in Table 1. This report is a necessary first step towards the development of a climate adaptation plan. It will be used to apply a climate lens to corporate and community master plans and programs to reduce vulnerability and increase resiliency.

For consistency, this report uses terminology as identified in the Climate Atlas of Canada including the term Burlington Region which encompasses both the City of Burlington and the Town of Oakville as shown in Figure 1.

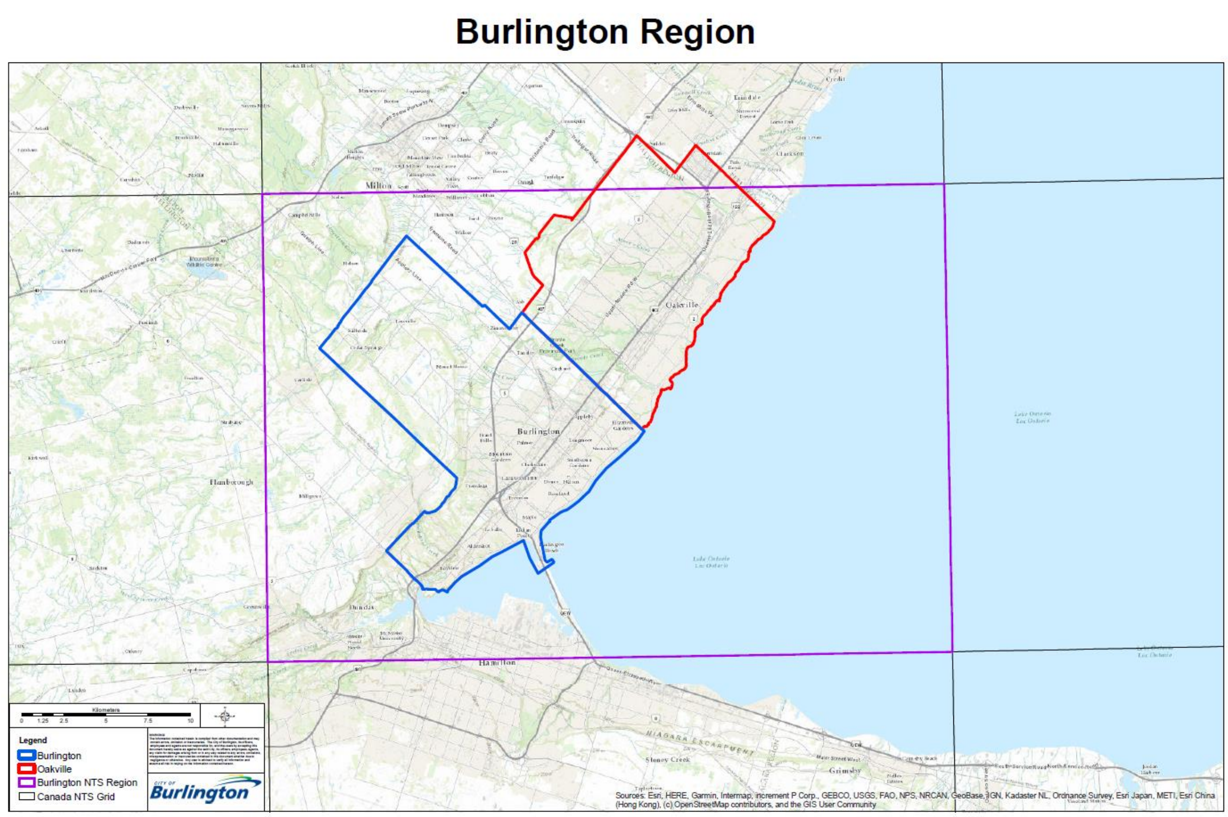


Figure 1: Map of Burlington Region

2.0 Climate Variables

The broad range of climate variables impacting Burlington Region are listed and defined in Table 1. Definitions within the Temperature, Hot Weather, Cold Weather, Precipitation and Agriculture categories were taken from the Climate Atlas of Canada (climateatlas.ca), including the name and description of the climate variables.[xi] Definitions for the variables within the Extreme Weather and Lake Ontario categories are taken from references sourced within sections 5.6 and 5.7 below.

Table 1: Summary of Climate Variables

Category	Climate Variable	Description	Unit
Temperature	Mean Temperature	The average temperature of the day.	°C
	Minimum Temperature	The lowest temperature of the day.	°C
	Maximum Temperature	The highest temperature of the day.	°C
Hot Weather	Warmest Maximum Temperature	The highest temperature of the year.	°C
	Number of Heat Waves	The total number of heat waves per year. A heat wave occurs when at least three days in a row reach or exceed 30°C.	# of Heat Waves
	Average Length of Heat Waves	The average length of a heat wave. A heat wave occurs when at least three days in a row reach or exceed 30°C so this number will always be three or greater.	Days
	Longest Spell of +30°C Days	The maximum number of days in a row with temperatures 30°C or higher.	Days
	Hot (+30°C) Season	Number of days per year when 30°C temperatures can be expected.	Days
	Very Hot Days (+30°C)	A day when the temperature rises to at least 30°C.	Days
	Extremely Hot Days (+32°C)	A day when the temperature rises to at least 32°C.	Days
	Extremely Hot Days (+34°C)	A day when the temperature rises to at least 34°C.	Days
	Tropical Nights	The lowest temperature of the day does not go below 20°C.	Nights
	Cooling Degree Days (CDD)	Annual sum of the number of degrees Celsius that each day's mean temperature is above 18°C. It is a measurement designed to quantify the demand for energy needed to cool buildings.	# of °C
Cold Weather	Freeze-Thaw Cycles	Number of days when the air temperature fluctuates between freezing and non-freezing temperatures.	Days
	Frost Days	A day when the coldest or minimum temperature is lower than 0°C.	Days
	Icing Days	A day when the maximum temperature is at or below 0°C.	Days

Category	Climate Variable	Description	Unit
	Coldest Minimum Temperature	The very coldest temperature of the year.	°C
	Heating Degree Days (HDD)	Annual sum of the number of degrees Celsius that each day's mean temperature is below 18°C. It is a measurement designed to quantify the demand for energy needed to heat a building.	# of °C
	Freezing Degree Days (FDD)	Annual sum of the number of degrees Celsius that each day's mean temperature is below 0°C.	# of °C
	Mild Winter Days (-5°C)	A day when the temperature drops to at least -5°C.	Days
	Winter Days (-15°C)	A day when the temperature drops to at least -15°C.	Days
Precipitation	Precipitation	The total amount of rain, drizzle, snow, sleet, etc. Frozen precipitation is measured according to its liquid equivalent: 10 cm of snow is usually about 10 mm of precipitation.	mm
	Heavy Precipitation Days (10 mm)	A day on which at least a total of 10 mm of rain or frozen precipitation falls.	Days
	Heavy Precipitation Days (20 mm)	A day on which at least a total of 20 mm of rain or frozen precipitation falls.	Days
	Wet Days	The number of days in a year with at least 0.2 mm of rain/snow.	Days
	Dry Days	The number of days in a year with less than 0.2 mm of rain/snow.	Days
	Max 1-day Precipitation (mm)	The amount the precipitation that falls on the wettest day of the year.	mm
	Max 5-day Precipitation (mm)	The wettest consecutive five-day period.	mm
Agriculture	Frost-Free Season	The approximate length of the growing season (from the last spring frost to the first fall frost), during which there are no freezing temperatures to kill or damage plants.	Days
	Date of First Fall Frost	The first date in the fall or late summer when the daily minimum temperature is at or less than 0°C. This date marks the	Date

Category	Climate Variable	Description	Unit
		approximate end of the growing season for frost-sensitive crops and plants.	
	Date of Last Spring Frost	The spring date after which there are no daily minimum temperatures at or less than 0°C. This marks the approximate beginning of the growing season for frost-sensitive crops and plants.	Date
	Corn Heat Units (CHU)	A temperature-based index of growing-season heat to estimate whether the climate is warm enough but not too hot to grow corn.	# of °C
	Growing Degree Days (GDD) (Base 5°C)	Annual sum of the number of degrees Celsius that each day's mean temperature is above 5°C. Generally, 5°C GDDs are used for assessing the growth of canola and forage crops.	# of °C
	Growing Degree Days (Base 10°C)	Annual sum of the number of degrees Celsius that each day's mean temperature is above 10°C. Generally, 10°C GDDs are used for assessing the growth of corn and beans.	# of °C
	Growing Degree Days (Base 15°C)	Annual sum of the number of degrees Celsius that each day's mean temperature is above 15°C. Generally, 15°C GDDs are used to assess the growth and development of insects and pests.	# of °C
Extreme Weather	Freezing Rain Events	Average percentage change in the number of annual freezing rain events.	%
	Wind Gusts	A relationship between the peak gust speed and mean wind speed.	km/h
	Rainfall Intensity-Duration-Frequency (IDF)	The annual maximum rainfall intensity for specific durations. Common durations are: 5-min, 10-min, 15-min, 30-min, 1-hr, 2-hr, 6-hr, 12-hr, and 24-hr.	mm/h
Lake Ontario	Lake Levels	Annual changes in lake water levels as compared to an average.	m
	Lake Temperature	Change in water temperatures, predominantly summer surface water temperatures.	°C
	Ice Cover	Trend in ice coverage relative to a baseline.	Days/year

3.0 Climate Change Modelling and Downscaling

Unless otherwise stated, the data presented in this report is based on global climate models (GCMs) and emission scenarios defined by the Intergovernmental Panel on Climate Change (IPCC), drawing from the Fifth Assessment Report (AR5) publications.

Many different methods exist to construct climate change scenarios. However, GCMs are the most conclusive tools available for simulating responses to increasing greenhouse gas (GHG) concentrations, as they are based on mathematical representations of atmosphere, ocean, ice cap, and land surface processes.[xii] Wherever possible, the data presented in this report uses an ensemble approach, which refers to a system that runs multiple climate models at once. Research has shown that this provides a more accurate projection of annual and seasonal temperatures and precipitation than a single model would on its own.

GCMs use grid cells often larger than 100 kilometres. To better understand local impacts and vulnerabilities, climate data is often needed at a smaller resolution. To get finer resolution data, climate modellers use dynamic or statistically downscaling methods. Dynamically downscaled models, also known as regional climate models (RCMs), simulate the climate of a smaller region (grid cells are usually 10 to 50 kilometres in size) and rely on information provided by GCMs. Statistically downscaled models use statistical relationships between local climate variables (such as precipitation) and large-scale variables (such as atmospheric pressure). The relationship is then applied to projections from GCMs to simulate local climate.[xiii] The climate model data presented in the Climate Atlas used a statistically downscaled method - specifically the Bias-Correction/Constructed Analogues with Quantile mapping reordering, Version 2 (BCCAQv2) method which preserved daily patterns in the global climate models.[xiv] This work was done by the Pacific Climate Impacts Consortium.

4.0 Emissions Scenarios

Emissions scenarios are based on models developed by a series of international climate modeling centers. Each emission scenario presents a different possible future based on socioeconomic storylines used by analysts to make projections about future GHGs and to assess future vulnerability to climate change. Producing scenarios requires estimates of future population levels, economic activity, the structure of governance, social values, and patterns of technological change.

4.1 Representative Concentration Pathway Scenarios

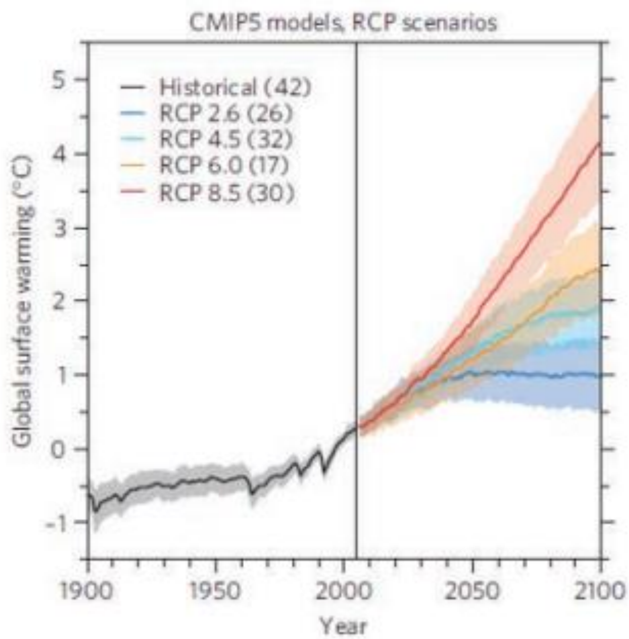
Representative Concentration Pathways (RCPs) are the newest set of climate change scenarios that provide the basis for the IPCC Fifth Assessment Report (AR5).[xv] The new RCPs have replaced the Special Report on Emissions Scenarios (SRES) to be more consistent with new data, new models, and updated climate research from around the world. The RCPs contain information regarding emission concentrations and land-use trajectories and are meant to be representative of the current literature on emissions and concentration of GHGs. The premise is that every radiative forcing pathway can result from a diverse range of socioeconomic and technological development scenarios.[xvi] RCPs are identified by their approximate total radiative forcing in the year 2100 relative to 1750, and are labeled as RCP2.6, 4.5, 6.0 and 8.5. These four RCPs include one mitigation scenario leading to a very low forcing level (RCP2.6), two stabilization scenarios (RCP4.5 and RCP6.0), and one scenario with continued rising GHG concentrations (RCP8.5).[xvii] The RCPs also consider the presence of 21st century climate policies, as compared with the no-climate policy assumption of the SRES in the Third and Fourth Assessment Reports.[xviii]

For this report, projections will use RCP4.5 representing a moderate increase in projected GHG concentrations and RCP8.5 representing the highest projected GHG concentration, as that data is publicly available for many climate indicators. RCP8.5 is referred to as a 'business as usual' pathway, representing a future where regular economic growth continues with emissions continuing to increase. Table 2 provides a description of each RCP scenario, while Figure 2 illustrates the projected global warming associated with the four scenarios.[xix]

Table 2: IPCC Fifth Assessment Report Climate Change Scenario Characteristics

Scenario	Description	Pathway	CO_2 equivalent (ppm)	Temp anomaly (°C)
RCP2.6	Lowest projected GHG concentrations, resulting from dramatic climate change mitigation measures implemented globally. It represents an increase to 3.0 W/m^2 mid-century and a decline to 2.6 W/m^2 in radiative forcing to the climate system by 2100.	Peak and decline	~490	1.5
RCP4.5	Moderate projected GHG concentrations, resulting from substantial climate change mitigation measures. It represents an increase of 4.5 W/m^2 in radiative forcing to the climate system. The Climate Atlas refers to this scenario as the 'Low Emissions Scenario.'	Stabilizing without overshoot	~650	2.4
RCP6.0	Moderate projected GHG concentrations, resulting from some climate change mitigation measures. It represents an	Stabilizing without overshoot	~850	3.0

Scenario	Description	Pathway	CO_2 equivalent (ppm)	Temp anomaly (°C)
	increase of 6.0 W/m^2 in radiative forcing to the climate system.			
RCP8.5	Highest projected GHG concentrations, resulting from business-as-usual emissions. It represents an increase of 8.5 W/m^2 in radiative forcing to the climate system. The Climate Atlas refers to this scenario as the 'High Emissions Scenario.'	Rising	~1370	4.9



Note that the number of models used is given in brackets and the shading (coloured envelopes) represents all model results.

Figure 2: Global Temperature Change Relative to 1986-2005 for the RCP Scenarios Run by Coupled Model Intercomparison Project (CMIP5)

4.2 Time Periods

Climatic projections are typically provided within time periods of 30 years. Additionally, a consistent baseline period is established so that projections can be accurately compared with historical trends. In this report, the time periods of 2021-2050 (immediate future) and 2051-2080 (near future) are used most frequently as well as 1976-2005 for the baseline (recent past). Many climate variables are also divided into seasonal timeframes, defined below in Table 3.

Table 3: Seasonal Timeframes

Season	Months
Winter	December, January, February
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November

4.3 Uncertainty

While it is not possible to anticipate future climatic changes with absolute certainty, climate change scenarios help to create plausible representations of future climate conditions. These conditions are based on assumptions of future atmospheric composition and on an understanding of the effects of increased atmospheric concentrations of GHGs, particulates, and other pollutants. Uncertainty is factored into climate change scenarios, models, and data, and reflects the complex reality of environmental change and the evolving relationship between humans and the planet.

The Climate Atlas identified some important limitations with specific climate variables.

1. Precipitation is more difficult to model than temperature. However, longer-term averages of monthly, seasonal and annual precipitation totals are produced with greater confidence than point- or time-specific precipitation projections.
2. Heavy Precipitation Days are likely underestimated for frequency and intensity as climate models likely don't capture the intense, localized events such as thunderstorms. However, there is greater confidence in longer-term averages of monthly, seasonal and annual precipitation totals.
3. Daily Mean Temperature is often calculated taking the average of 24 individual hourly measurements made in a day. However, since only daily maximum and daily minimum temperatures were available, the Climate Atlas uses the averages of those.
4. Date of First Fall Frost, Last Spring Frost and Frost-Free Season are calculated using standard weather station observations, which are usually at 1.2 m above the ground. Since ground level temperature can be colder than surface air temperature (1.2 m), the length of the Frost-Free Season presented is likely longer than the actual length of the season at ground level.[xx]

5.0 Local Climate Trends and Projections

The Climate Atlas presents data related to climate change for Burlington Region under five different categories: Temperature, Hot Weather, Cold Weather, Precipitation and Agriculture. Within each category, multiple climate variables are presented under a low and high emissions scenario for different time periods compared to the baseline. Appendix A provides a summary of local climate variables and trends in the five climatic categories under a high emissions scenario.

Two additional categories – Extreme Weather and Lake Ontario – are also included in the section below with information based on other sources and referenced accordingly.

5.1 Temperature

All temperature variables for Burlington Region are projected to experience warming for RCP4.5 and RCP8.5. Documenting general trends in temperature change can be helpful for understanding the future distribution of ecological communities including invasive species migration and vector-borne diseases, temperature-related morbidity (disease) and mortality (death), cooling and heating requirements for buildings, and much more.[xxi]

5.1.1 Mean Temperature

Mean Temperature shows the average temperature in an area over a given period. As shown in Table 4 below, the baseline seasonal Mean Temperature over Burlington Region was 6.8°, 20.3°, 10.5° and -3.4˚C for spring, summer, fall and winter respectively. This gives a year-round average temperature of 8.6˚C for 1976-2005. According to RCP8.5, Burlington Region could experience an increase of 4.2˚C in average annual temperature and 4.7˚C in average winter temperature in the near future (2051-2080).

Table 4: Mean Temperature for Burlington Region – RCP4.5 and 8.5

Emissions Scenario	Period	Baseline 1976-2005 (°C)	2021-2050 (°C)			2051-2080 (°C)		
			Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	Spring	6.8	6.5	8.6	10.5	7.4	9.4	11.7
	Summer	20.3	20.6	22.1	23.6	21.3	23.2	25.1
	Fall	10.5	10.8	12.4	14.0	11.5	13.3	15.0
	Winter	-3.4	-3.8	-1.2	1.3	-2.7	0.0	2.6
	Annual	8.6	9.3	10.5	11.8	10.0	11.5	13.1
RCP8.5	Spring	6.8	6.5	8.6	10.8	8.4	10.6	12.9
	Summer	20.3	21	22.4	24	22.8	24.6	26.5
	Fall	10.5	11	12.7	14.3	12.8	14.6	16.3
	Winter	-3.4	-3.5	-1	1.6	-1.3	1.3	4
	Annual	8.6	9.4	10.7	12	11.4	12.8	14.4

5.1.2 Maximum and Minimum Temperature

Maximum and Minimum Temperature trends show the average high temperature and the average low temperature for a given period.

In terms of Minimum Temperature, Table 5 shows the baseline Minimum Temperature across each season at 2.0°, 14.9°, 6.1° and -7.0°C for spring, summer, fall and winter respectively. Seasonal Minimum Temperature is projected to increase substantially under RCP8.5, with an increase of 3.6°C in spring, 4.0°C in summer, 3.9°C in fall and 5.2°C in winter by 2051-2080.

The increases in average Minimum Temperature in the summer and winter months are particularly noteworthy. With the summer Minimum Temperature rising from an average of 14.9°C to 18.9°C, this could result in an increase of Tropical Nights which are described below. In addition, with average winter Minimum Temperature rising from an average of -7.0°C to -1.8°C, this could result in less snow and more mixed precipitation.

Table 5: Minimum Temperature for Burlington Region – RCP4.5 and 8.5

Emissions Scenario	Period	Baseline 1976-2005 (˚C)	2021-2050 (˚C)			2051-2080 (˚C)		
			Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	Spring	2.0	1.9	3.7	5.3	2.7	4.5	6.6
	Summer	14.9	15.2	16.5	17.8	15.8	17.5	19.3
	Fall	6.1	6.3	7.8	9.3	7.1	8.6	10.2
	Winter	-7.0	-7.4	-4.6	-2.0	-6.1	-3.3	-0.5
	Annual	4.0	4.7	5.9	7.1	5.5	6.9	8.4
RCP8.5	Spring	2.0	1.9	3.8	5.8	3.7	5.6	7.8
	Summer	14.9	15.6	16.8	18.2	17.4	18.9	20.6
	Fall	6.1	6.6	8.1	9.6	8.3	10.0	11.5
	Winter	-7.0	-7.1	-4.4	-1.6	-4.6	-1.8	0.9
	Annual	4.0	4.9	6.1	7.3	6.9	8.2	9.7

In terms of Maximum Temperature, Table 6 shows seasonal average baseline temperature for Burlington Region at 11.6°, 25.7°, 14.9° and 0.3˚C for spring, summer, fall and winter respectively. Similar to Mean and Minimum Temperature, Burlington Region will experience an increase in seasonal Maximum Temperature. Average summer Maximum Temperature is projected to reach over 30˚C with average winter Maximum Temperature increasing to 4.4˚C by 2051-2080 according to RCP8.5.

Table 6: Maximum Temperature for Burlington Region – RCP4.5 and 8.5

Emissions Scenario	Period	Baseline 1976-2005 (˚C)	2021-2050 (˚C)			2051-2080 (˚C)		
			Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	Spring	11.6	11.1	13.5	15.8	11.8	14.4	17.0
	Summer	25.7	25.9	27.7	29.5	26.6	28.9	31.0
	Fall	14.9	15.1	17.1	19.0	15.8	17.9	19.8
	Winter	0.3	-0.2	2.2	4.6	0.7	3.3	5.9
	Annual	13.2	13.7	15.2	16.6	14.4	16.1	17.8
RCP8.5	Spring	11.6	11.1	13.5	16.0	12.9	15.4	18.0
	Summer	25.7	26.3	28.0	29.8	28.1	30.3	32.5
	Fall	14.9	15.3	17.2	19.1	17.3	19.3	21.3
	Winter	0.3	-0.1	2.3	4.9	1.8	4.4	7.2
	Annual	13.2	13.9	15.3	16.7	15.7	17.4	19.1

Average annual Minimum and Maximum Temperatures are projected to experience a similar increase as an annual Mean Temperature, as shown for the RCP8.5 scenario for Burlington Region in Figure 3.

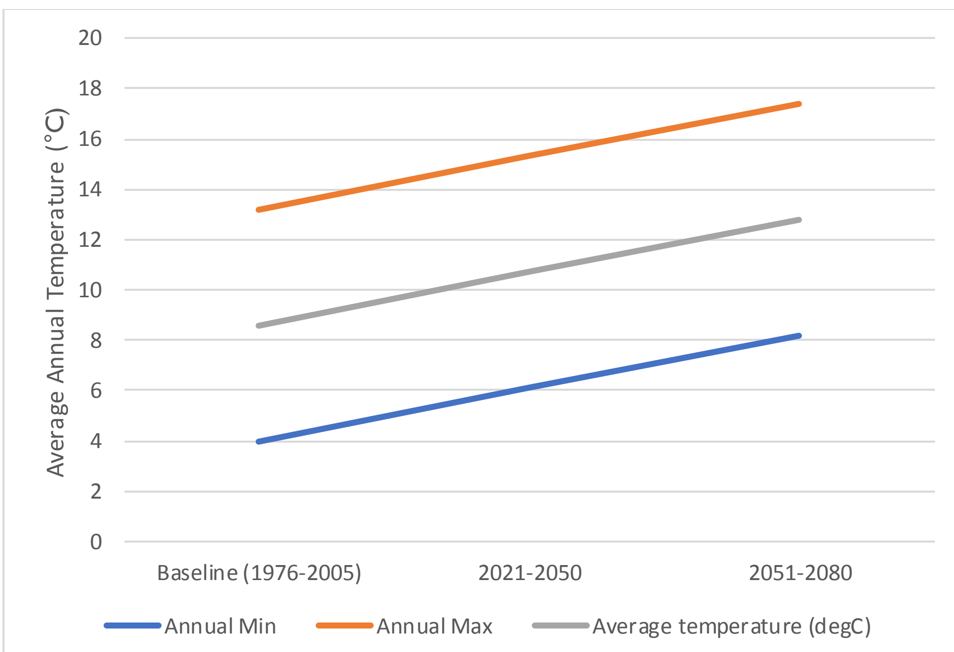


Figure 3: Annual Temperature for Burlington Region - RCP8.5

In addition to the average Maximum Temperature, the Warmest Maximum Temperature in a given year is also expected to increase (i.e. the single, hottest day of the year). For Burlington Region, the baseline average Warmest Maximum Temperature was 34.2°C. According to RCP8.5, the average Warmest Maximum Temperature will increase to 36.5°C in the immediate future (2021-2050), and to 39°C in the near future (2051-2080). These temperatures do not factor in additional warming due to the humidex which could make it feel 5 to 10°C warmer.

5.2 Hot Weather

Historically Canada was a winter peaking climate where more energy was used in the winter to heat homes. In recent years, this has shifted resulting in increased energy use in the summer to cool homes. Hot weather presents new heat related risks, such as heat exhaustion and heat stroke, and limits outdoor exposure and activities. It also impacts whether plants and animals thrive, increases the risk of drought, and can lead to more thunderstorms increasing the risks of flash flooding, lightning and hail.[xxii]

5.2.1 Very Hot Days, Extremely Hot Days and Hot Season

The Climate Atlas presents the number of days where the daily maximum temperature results in a Very Hot Day exceeding 30°C or Extremely Hot Days of 32°C and 34°C for Burlington Region as seen in Table 7.

Days where the daily maximum temperatures exceed 30°C, 32°C and 34°C present the greatest threats to community health due to heat-related illnesses. Specific groups, such as those who work outside, infants and young children, older adults (over the age of 65), those with chronic medical conditions, people experiencing homelessness, people planning outdoor sports or activities, and those with limited mobility may be more adversely affected.[xxiii] Moreover, higher summer temperatures increase electricity demand for cooling possibly leading to electricity reliability issues during heat waves.

The baseline average number of Very Hot Days when the maximum temperature was greater than or equal to 30°C was 16 days for Burlington Region. This is expected to increase to an average of 61 days in the 2051-2080 period under the RCP8.5 scenario as shown in Table 7. This means there will be over two to five times more days above 30°C by 2080 in the study region.

The number of Extremely Hot Days will also increase significantly under both a low and high emissions scenario. Burlington Region experienced six days of Extremely Hot Days (32°C) in the baseline period. This is expected to increase over six-fold to an average of 39 days by 2051-2080 under RCP8.5. Extremely Hot Days (34°C) could increase from almost 2 days to over 21 days on average, an almost 13-fold increase.

Table 7: Very Hot and Extremely Hot Days (30, 32 and 34°C) for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Variable	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
			Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	30°C or more	16.0	14.5	32.9	53.1	20.8	44.2	67.2
	32°C or more	6.0	4.0	16.6	32.8	7.4	25.2	45.7
	34°C or more	1.7	0.4	6.8	17.3	1.3	12.1	27.8
RCP8.5	30°C or more	16.0	17.1	35.5	54.7	36.2	60.9	85.3
	32°C or more	6.0	5.2	18.3	34.2	17.4	38.8	61.2
	34°C or more	1.7	0.7	7.8	18.6	5.7	21.6	40.3

In addition to an overall increase in Very Hot and Extremely Hot Days, Burlington Region is also expected to see an increase in the Warmest Maximum Temperature – i.e. the temperature of the hottest day of the year. In the baseline period, Burlington Region's average Warmest Maximum Temperature was 34.2°C increasing to 36.5°C in 2021-2050 and expected to reach 39.0°C in 2051-2080 for RCP8.5.

While the number of Very Hot Days with temperatures at or above 30°C is expected to increase overall, the length of the Hot Season (the number of days from the first day of the year with temperatures at or above 30°C to the last day of the year with temperatures at or above 30°C)[xxiv] is also expected to increase. Table 8 outlines the length of the Hot Season for Burlington Region. The baseline average length of the Hot Season was 70.5 days. By 2051-2080, Burlington Region can expect an increase to 123.7 days according to RCP8.5 – almost double the length of the Hot Season previously.

Table 8: Length of the Hot Season (30°C) for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	70.5	63.4	99.9	134.2	76.1	109.8	141.9
RCP8.5	70.5	68.7	102.0	134.9	90.1	123.7	156.4

5.2.2 Heat Waves and Tropical Nights

Heat Waves are defined as prolonged periods of extremely hot weather, which may be accompanied by high humidity. The Climate Atlas defines a Heat Wave as three days in a row where temperatures reach or exceed 30°C. Heat waves are location-specific; a heat wave is usually measured relative to the usual weather in the area and relative to normal temperatures for the season. Temperatures that people from a hotter climate consider normal can be termed a heat wave in a cooler area. Thus, understanding shifts in local climate can help inform particular strategies to mitigate population exposure in ways that are appropriate with local norms and behaviours. High, persistent temperatures not only impact human health as previously noted but also increase the risk of drought, which can severely impact food production. High temperatures can also lead to more intense and frequent extreme weather events including thunderstorms, risks of flash flooding, lightning, hail and perhaps even tornadoes.[xxv]

Halton Region, which includes the City of Burlington and the towns of Oakville, Halton Hills and Milton, issues a heat warning when Environment and Climate Change Canada forecasts:

- Two consecutive days with the temperature 31°C or higher during the day and 20°C or higher overnight, or
- Two consecutive days with a humidex of 40°C or higher.

In addition, an extended heat warning is issued when forecasting:

- Three consecutive days with the temperature 31°C or higher during the day and 20°C or higher overnight, or
- Three consecutive days with a humidex of 40°C or higher.[xxvi]

Though the parameters slightly differ between the Climate Atlas and Halton Region, the data presented in the Climate Atlas can still illustrate the degree in which Heat Wave events will become more frequent and prolonged in Burlington Region.

The Climate Atlas considers two variables for Heat Waves – the annual Average Length of Heat Waves, and the annual Number of Heat Waves. The annual Number of Heat Wave events measures the average number of times per year where the temperature reaches or exceeds 30°C for at least three days in a row. The baseline Number of Heat Waves for Burlington Region was 2.1, as presented in Table 9 and Figure 4. In the 2051-2080 period according to RCP8.5, Burlington Region can expect to experience almost seven Heat Wave events per year. This is over triple the current number of occurrences.

Table 9: Annual Number of Heat Waves for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (#)	2021-2050 (#)			2051-2080 (#)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	2.1	1.7	4.5	7.4	2.6	5.7	8.7
RCP8.5	2.1	2.0	4.8	7.5	4.1	6.7	9.5

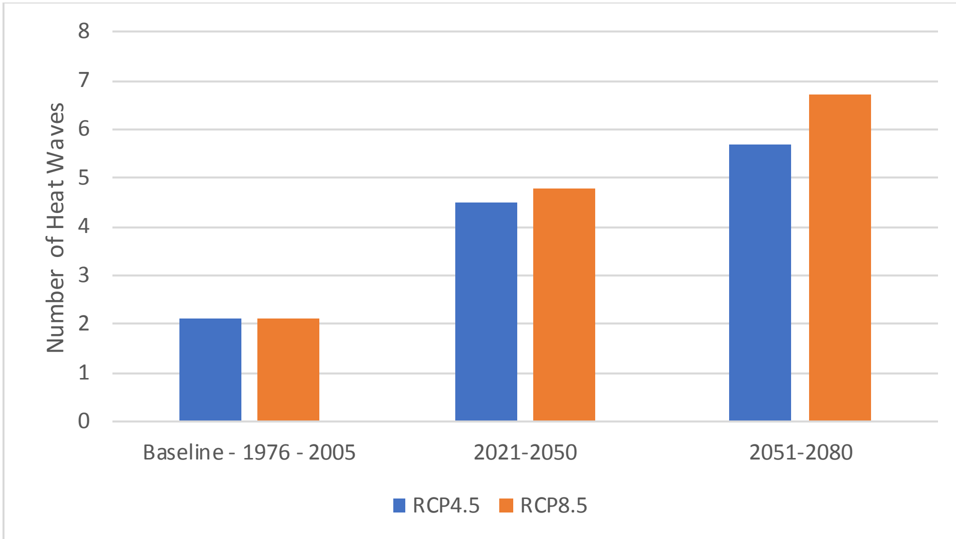


Figure 4: Annual Number of Heat Waves for Burlington Region - RCP4.5 and 8.5

With regards to the Average Length of Heat Waves (in days), Burlington Region experienced an average of 3.7 days of heat wave conditions in the baseline period as displayed in Table 10. In the 2051-2080 period, according to RCP8.5, Burlington Region can expect to see an average heat wave event occurring for 8.1 days – over double the current length.

Table 10: Annual Average Length of Heat Waves for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	3.7	3.3	5.2	7.4	3.9	6.2	9.3
RCP8.5	3.7	3.6	5.5	8.0	4.9	8.1	12.9

Overall, Heat Wave events are projected to occur more frequently and for longer periods of time. While Table 10 outlines the annual Average Length of Heat Wave events, Table 11 outlines the Longest Spell of +30ºC Days. The baseline average Longest Spell of +30°C Days for Burlington Region was 3.9. By 2051-2080 according to RCP8.5, Burlington Region could experience 18.2 consecutive days where temperatures exceed 30°C. This could result in an Extended Heat Warning for Burlington Region for almost two and a half weeks.

Table 11: Longest Spell of +30°C Days for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	3.9	2.9	7.5	13.9	4.2	10.8	19.6
RCP8.5	3.9	3.3	8.4	15.7	6.8	18.2	34.2

Traditional patterns of hot weather during the day which then cool off at night can often be enough to mitigate exposure to extreme temperatures.[xxvii] However, during periods of extended heat, many people are at risk from suffering heat exhaustion or heat stroke when experiencing prolonged exposure during hot summer days if nighttime temperatures fail to drop below 20°C (Tropical Nights).[xxviii] There is an increasing trend of nighttime temperatures warming faster than daytime temperatures, especially in places which typically experienced cooler overnight low temperatures. [xxix]

Table 12 and Figure 5 show that the baseline average number of Tropical Nights for Burlington Region was 8.1. In 2051-2080, according to RCP8.5, Burlington could experience 36.7 more Tropical Nights on average representing a fivefold increase and about one-and-a-half months of Tropical Nights.

Table 12: Annual Tropical Nights for Burlington Region – RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Nights)	2021-2050 (Nights)			2051-2080 (Nights)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	8.1	8.2	19.3	32.6	12.4	28.2	48.5
RCP8.5	8.1	10.8	22.4	36.6	26.2	44.8	66.0

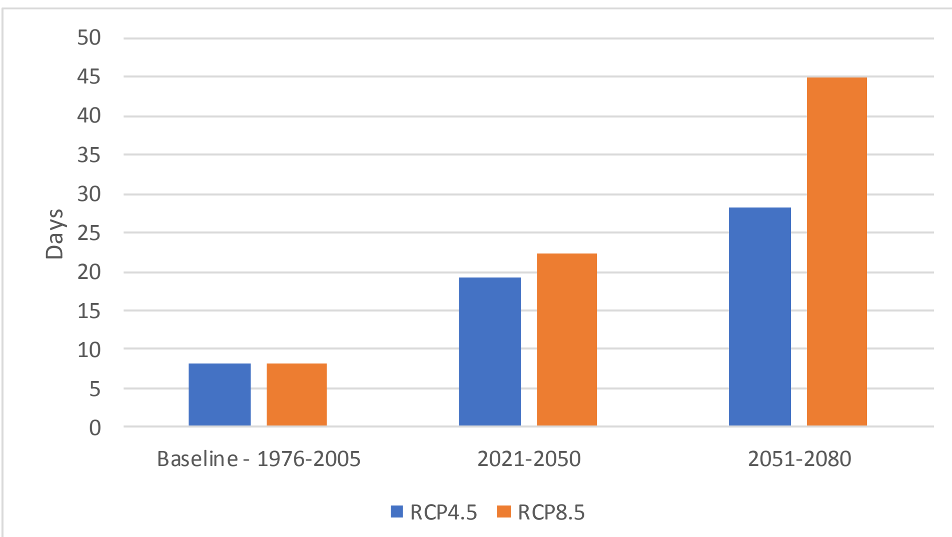


Figure 5: Annual Tropical Nights for Burlington Region - RCP4.5 and 8.5

5.2.3 Cooling Degree Days

Cooling Degree Days (CDD) is an indicator of energy consumption due to air conditioner use during the summer. It is a simple calculation of the number of degrees Celsius that each day's mean temperature is above 18°C. If a location shows an increase in projected CDD values, this implies that it will experience hotter or longer summers requiring more energy (and thus money) to cool buildings for comfort and safety. [xxx] This will have significant impacts for those who do not have access to air conditioning in their homes or apartments.

CDDs are projected to increase significantly in Burlington Region, more than doubling across the region in the 2051-2080 period according to RCP8.5 as shown below.

Table 13: Cooling Degree Days for Burlington Region – RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (# of °C)	2021-2050 (# of °C)			2051-2080 (# of °C)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	315.7	345.9	499.5	658.0	421.3	616.9	837.1
RCP8.5	315.7	383.5	535.1	693.2	580.1	797.0	1033

5.3 Cold Weather

Cold Weather is an important aspect of life in Canada, as many places are well adapted to very cold winters. Overall, the frequency and severity of cold days are decreasing across Canada including in Burlington Region, while the number of hot days is increasing.

It should be noted that the artic is warming much faster than the rest of the world. Researchers are seeing more evidence that the melting arctic ice could be impacting the jet stream, a column of air in the upper atmosphere that helps drive weather systems. A warmer Arctic Ocean radiates more heat to the atmosphere in winter, creating less of a temperature contrast between the Arctic air and the atmosphere in regions further south.[xxxi] Usually the jet stream is relatively straight from west to east with few dips. However, when the jet stream weakens and becomes more unstable, it has larger dips which push cold arctic air further south (polar vortex) or warm air from the south further north.[xxxii] This can not only result in more heat or drought conditions but also more extreme cold spells with extreme precipitation lingering for longer than normal.[xxxiii]

It is important to know how our winters will change in the future, because just like hot temperatures cold temperatures affect health and safety, determine what plants and animals can live in the area, limit or enable outdoor activities, define how we design our buildings and vehicles, and shape our transportation and energy use.[xxxiv]

5.3.1 Mild Winter Days and Winter Days

A Mild Winter Day is a day when the temperature drops to at least -5°C. Mild Winter Days indicate how much a location experiences moderately cold temperatures. This variable can be important for certain tourism or recreational industries within Burlington Region. For example, ski slope operators generally require temperatures below -5°C to make artificial snow[xxxv] and temperatures between -7°C to -17°C are recommended for outdoor skating rinks.[xxxvi] The baseline number of Mild Winter Days was 66.6. By 2051-2080 according to RCP8.5, that number could decrease to an average of 27.3 days as shown in Table 14. This means transitioning from over two months of Mild Winter Days to less than one month.

Table 14: Mild Winter Days (-5°C) for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	66.6	26.6	47.5	67.5	16.3	37.6	60.7
RCP8.5	66.6	25.4	46.3	67.2	9.2	27.3	48.3

Winter Days, defined as a day where the temperature drops to at least -15°C, are also projected to decrease across Burlington Region. Table 15 shows that by the end of the century, there could be an average of one day a year where average temperatures dip below -15°C.

Table 15: Winter Days (-15°C) for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	11.2	0.3	4.6	11.2	0.0	2.3	7.1
RCP8.5	11.2	0.3	4.0	10.4	0.0	0.9	3.3

In addition to an overall decrease in Winter Days and Mild Winter Days, Burlington Region is also expected to see a decrease in the Coldest Minimum Temperature – i.e. the temperature of the coldest day of the year. In the baseline period, Burlington Region's average Coldest Minimum Temperature was -20.8°C. According to RCP8.5, Burlington's average coldest temperature will increase to -16.9°C in 2021-2050, and -13.0°C in 2051-2080.

5.3.2 Frost Days and Icing Days

Other variables of cold temperatures are Frost Days and Icing Days. Both are good indictors of the length and severity of the winter season and can help to understand freeze and thaw patterns throughout the region, and document risks relating to morbidity and mortality from traffic accidents, damage to roads and infrastructure, facility closures and more.

A Frost Day is a day with frost potential – meaning the minimum temperature is below 0°C. Frost days are predicted to decrease an average of 52 days by the 2080s in RCP8.5 as shown in Table 16.

Table 16: Frost Days for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	126.0	80.2	102.2	122.4	64.3	90.0	113.9
RCP8.5	126.0	77.7	100.1	123.3	47.3	74.0	97.7

Similarly, the number of Icing Days are projected to decrease as shown in Table 17 and Figure 6. Icing Days are the total number of days when the daily maximum temperature is at or below 0°C. A reduction in days below 0°C could have an impact on the survival and spread of blacklegged ticks, which carry the bacteria that causes Lyme disease, as ticks can be active in temperatures above 4°C.[xxxvii] While deer ticks are most active in spring and fall, warmer winters could extend their window of activity.

Table 17: Icing Days for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	48.0	14.8	32.2	49.3	9.0	25.1	44.8
RCP8.5	48.0	15.2	31.8	49.7	4.4	17.5	34.6

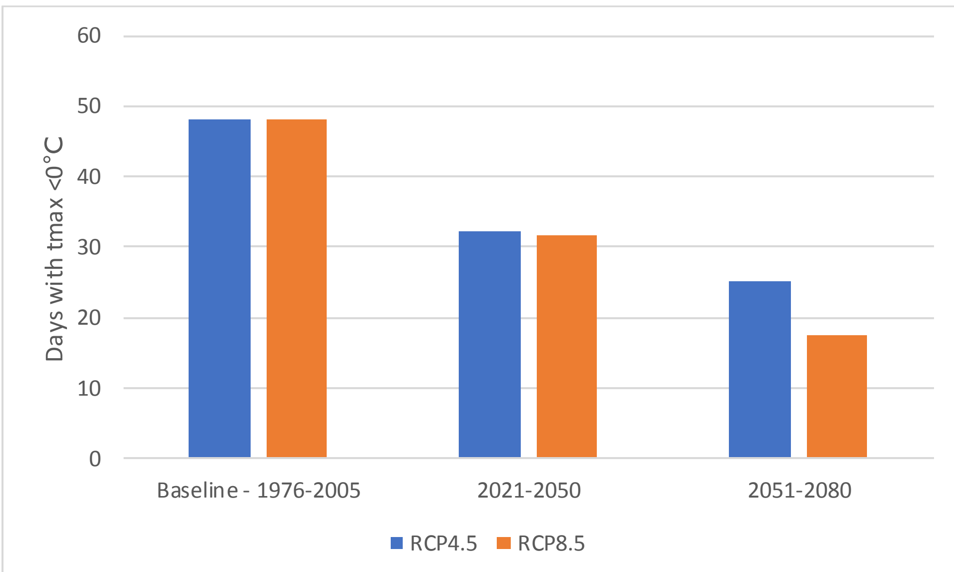


Figure 6: Icing Days for Burlington Region - RCP4.5 and 8.5

5.3.3 Freeze-Thaw Cycles

Freeze-Thaw Cycles are the number of days when the air temperature fluctuates between freezing and non-freezing temperatures. Under these conditions, it is likely that some water at the surface was both liquid and ice at some point during the 24-hour period.[xxxviii]

Freeze-Thaw Cycles can have major impacts on infrastructure. Water expands when it freezes, so the freezing, melting and refreezing of water can over time cause significant damage to roadways, sidewalks, underground pipes and other outdoor structures. Potholes that form during the spring, or during mid-winter melts, are good examples of the damage caused by this process.[xxxix]

Freeze-Thaw Cycles are projected to decrease slightly this century – from 63.3 days in the baseline, to 54.7 days in the immediate future, to 44.5 days in the near future according to RCP8.5 as shown in Table 18 and Figure 7. This is likely due to the fact that overall, the days are getting warmer, and Burlington Region is likely to experience a decrease in the number of days that reach a minimum temperature at or below -1°C.

Table 18: Freeze-Thaw Cycles for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	63.3	43.0	56.2	69.5	38.1	51.5	65.2
RCP8.5	63.3	41.2	54.7	68.7	28.5	44.5	59.8

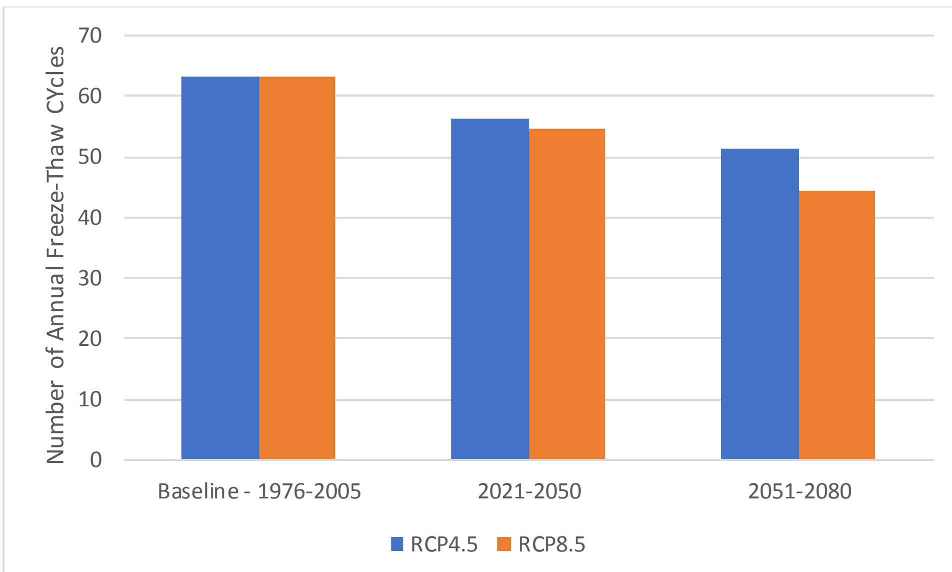


Figure 7: Freeze-Thaw Cycles for Burlington Region - RCP4.5 and 8.5

5.3.4 Heating Degree Days and Freezing Degree Days

Similar to Cooling Degree Days (CDD), Heating Degree Days (HDD) are equal to the number of degrees Celsius a given day's mean temperature is below 18°C. For example, if the daily mean temperature is 12°C, the HDD value for that day is equal to 6°C. If the daily mean temperature is above 18°C, the HDD value for that day is set to zero.[xl]

Heating Degree Days are a measure of how much heating is required in a year. An average temperature below 18°C is when heating is required to maintain a comfortable temperature inside buildings. A place that gets many days with average temperatures below 18°C will require more energy (and thus money) to heat buildings for comfort and safety.[xli]

As shown in the figure below, HDD are expected to decrease, implying that Burlington Region will be experiencing less severe cold events in the future. This could mean a reduction in heating costs and GHG emissions for heating during the winter months.

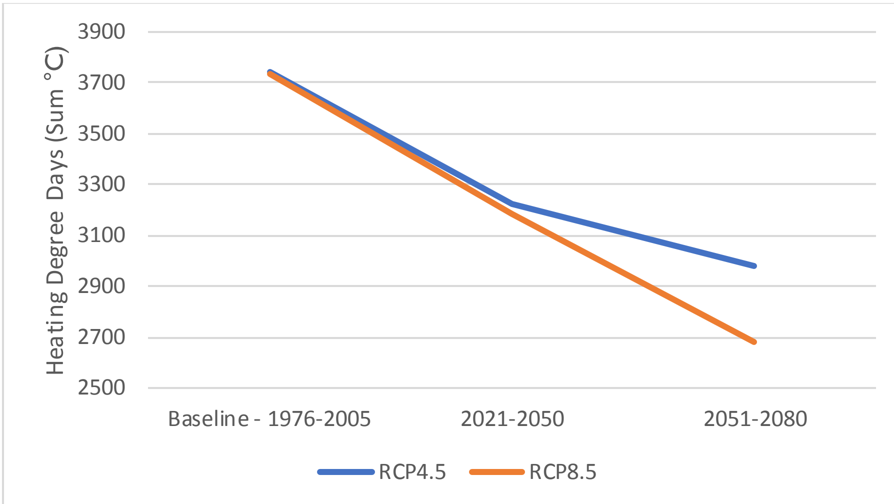


Figure 8: Heating Degree Days for Burlington Region - RCP4.5 and 8.5

Similarly, Freezing Degree Days (FDD) begin to accumulate when the daily mean temperature drops below freezing: if a day's mean temperature is -21°C, for example, it increases the annual FDD value by 21. Days when the mean temperature is 0°C or warmer do not contribute to the annual sum. High FDD values are associated with relatively cold conditions: places with high FDD values likely get many days with temperatures significantly below freezing. If projections show a decrease in FDDs, then that location is likely to experience shorter or less severe winters.[xlii]

Areas with high FDD indicate higher levels of snow and ice accumulation, which is an important consideration for snow clearance and removal.[xliii] These areas would also likely require larger amounts of energy for heating buildings and homes.

As shown in the figure below, FDD are expected to decrease significantly until 2080 which implies that Burlington will experience less days where the temperature is significantly below freezing.

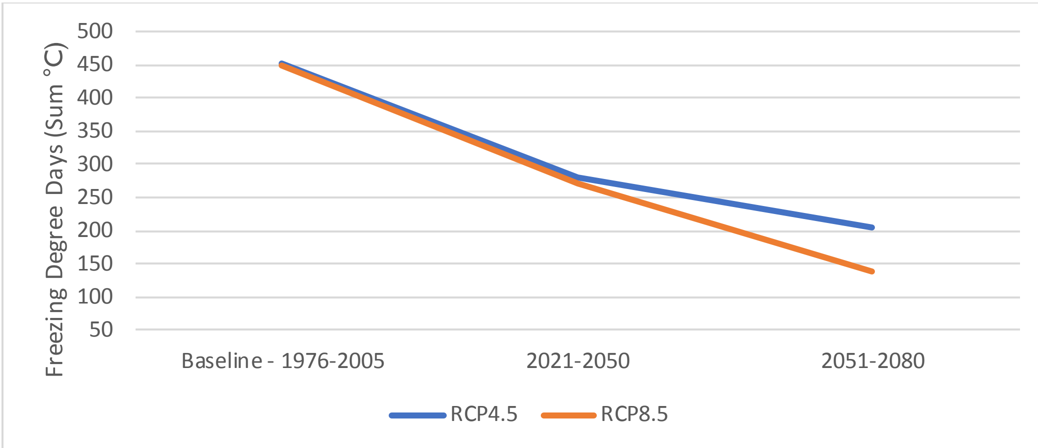


Figure 9: Freezing Degree Days for Burlington Region - RCP4.5 and 8.5

5.4 Precipitation

Precipitation patterns are critical for many important issues including water availability, crop production, electricity generation, wildfire suppression, snow accumulation, seasonal and flash-flooding, and short- and long-term drought risk.[xliv] They are also important drivers of migration and breeding for amphibians and some fish species. A local example is the annual migration of Jefferson Salamanders which is triggered by spring rainfall.

In this section, projections of precipitation accumulation as well as extreme precipitation variables are presented. Freezing rain and Intensity-Duration Frequency (IDF) curves are presented in the Extreme Weather Events section.

5.4.1 Mean Precipitation

The average Annual Precipitation is projected to slightly increase over the coming decades. For Burlington Region, this increase will be from a baseline of 811 mm to approximately 864 mm in the 2021-2050 period, and to 889 mm by the 2051-2080 period under the RCP8.5 scenario as shown below.

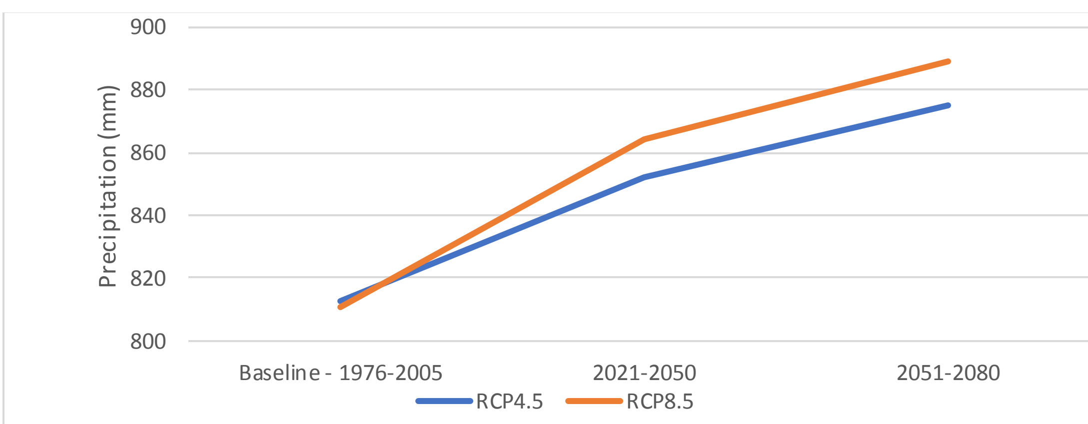


Figure 10: Annual Precipitation for Burlington Region - RCP4.5 and 8.5

On a seasonal basis, spring, winter and fall precipitation accumulations are projected to increase by 2051-2080 with spring and winter experiencing the greatest increases while summer precipitation will remain relatively consistent. Table 19 presents the Annual and Seasonal Precipitation projections for Burlington Region under RCP4.5 and 8.5. Figure 11 presents the Seasonal Precipitation projections under RCP8.5.

Table 19: Annual and Seasonal Precipitation for Burlington Region – RCP4.5 and 8.5

Emissions Scenario	Period	Baseline 1976-2005 (mm)	2021-2050 (mm)			2051-2080 (mm)		
			Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	Spring	210	148	225	310	155	232	318
	Summer	208	128	211	309	122	211	314
	Fall	213	136	220	319	141	229	329
	Winter	181	127	197	273	133	204	278
	Annual	811	686	852	1025	691	875	1071
RCP8.5	Spring	210	154	232	321	164	245	337
	Summer	208	123	210	306	120	207	311
	Fall	213	137	222	319	135	223	325
	Winter	181	132	200	276	141	214	296
	Annual	811	688	864	1045	714	889	1080

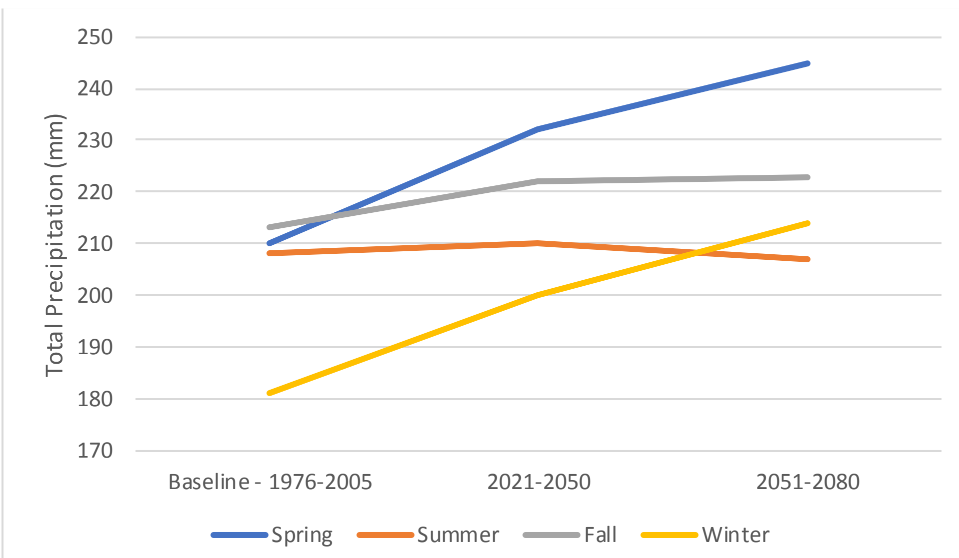


Figure 11: Seasonal Precipitation for Burlington Region - RCP8.5

5.4.2 Dry Days and Wet Days

Two indicators that measure the frequency of rain events are the number of Wet Days and the number of Dry Days. The number of Wet Days measures the number of days in a year with more than 0.2 mm of rain/snow, while the number of dry days measure the number of days with less than 0.2 mm of rain/snow which is consistent with the Meteorological Service of Canada.[xlv]

Table 20 and Table 21 depict the number of annual projected Wet Days and Dry Days for Burlington Region, respectively. The tables show very little change in terms of the number of Dry Days and Wet Days for Burlington Region overall.

Table 20: Number of Annual Wet Days for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	154.2	137.6	154.3	170.1	137.9	154.4	171.1
RCP8.5	154.2	138.5	155.2	171.5	137.8	153.7	169.3

Table 21: Number of Annual Dry Days for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	210.4	194.3	210.3	227.2	193.7	210.2	226.7
RCP8.5	210.4	193.2	209.5	226.1	195.5	210.9	227.0

5.4.3 Heavy Precipitation

The projections of several extreme precipitation variables, with the exception of freezing rain and IDF curves, are presented in this section.

Heavy Precipitation Days are days on which at least a total of 10 mm or 20 mm of rain or frozen precipitation falls. Frozen precipitation is measured according to its liquid equivalent: 10 cm of snow is usually about 10 mm of precipitation.[xlvi] As stated in section 4.3 of this report, Heavy Precipitation Days are likely underestimated for frequency and intensity as climate models likely don't capture the intense, localized events such as thunderstorms.

Max 1-Day Precipitation and Max-5 Day Precipitation indicate the amount of precipitation that falls on the wettest day of the year, and the five wettest days of the year respectively. The Max 1-Day Precipitation amount could be the result of a short but intense precipitation event such as a storm or because a moderate amount of snow/rain falls continuously all day, rather than all at once.[xlvii]

Table 22 and Table 23 respectively show the projected Heavy Precipitation Days (both 10 mm and 20 mm) and the Max 1-Day and 5-Day Precipitation for Burlington Region.

Table 22: Heavy Precipitation Days for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Variable	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
			Low	Mean	High	Low	Mean	High
RCP4.5	Heavy Precipitation Day (10 mm)	24.8	19.0	26.6	34.5	19.5	27.4	36.0
RCP8.5		24.8	19.4	27.1	35.2	20.2	27.8	35.5
RCP4.5	Heavy Precipitation Day (20 mm)	6.1	3.6	7.1	11.0	4.0	7.8	12.1
RCP8.5		6.1	3.7	7.3	11.1	4.2	8.2	12.2

Across Burlington Region, Heavy Precipitation Days (10 mm) are expected to increase by approximately three days and Heavy Precipitation Days (20 mm) are expected to increase by two days. Max 1-Day and 5-Day events are also expected to increase. While the greatest increase in precipitation is projected to be for Max 5-Day events (from 64 mm to 73 mm), the greatest impact will be felt with Max 1-Day events (from 42 mm to 48 mm) as more rain will fall in less time by 2051-2080 for RCP8.5.

Table 23: Maximum 1-Day and 5-Day Precipitation for Burlington Region- RCP4.5 and 8.5

Emissions Scenario	Variable	Baseline 1976-2005 (mm)	2021-2050 (mm)			2051-2080 (mm)		
			Low	Mean	High	Low	Mean	High
RCP4.5	Max 1-Day Precipitation	42	29	45	72	29	46	71
RCP8.5		42	29	45	71	31	48	75
RCP4.5	Max 5-Day Precipitation	64	47	69	104	47	71	103
RCP8.5		64	46	68	98	49	73	107

Changes in the above extreme precipitation variables are visually presented in Figures 12 and 13 for Burlington Region under RCP8.5.

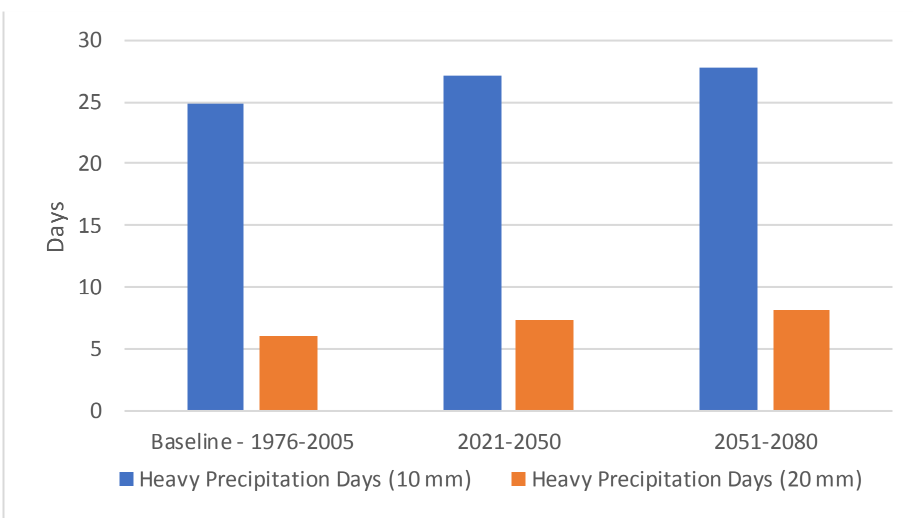


Figure 12: Heavy Precipitation Days for Burlington Region - RCP8.5

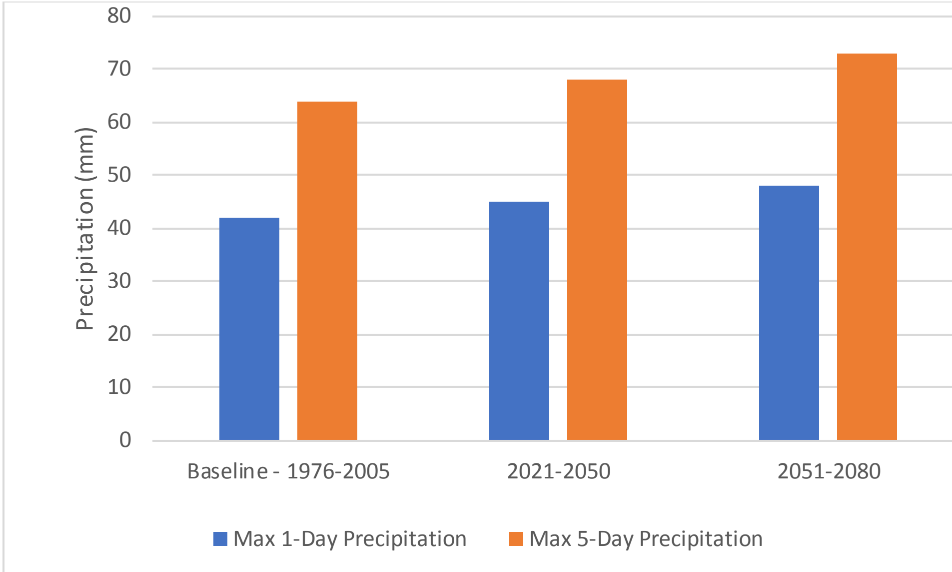


Figure 13: Max 1-Day and 5-Day Precipitation for Burlington Region - RCP8.5

It's important to understand projections for heavy rainfall events, as they can create many challenges. In cities and towns, heavy rainfalls can overwhelm storm drains and cause flash flooding. They can also cause problems in rural areas by drowning crops, eroding topsoil, and damaging roads.[xlviii]

5.5 Agriculture

Climate change creates both risks and opportunities for Ontario agriculture. Changes in seasonal temperatures, precipitation events, the length of growing seasons, and the timing of extreme heat and cold days all determine the types of crops that can be grown now and in the future.[xlix] Managing for increased agricultural productivity and working to reduce risks under climate change will require careful consideration of changing weather and climate conditions, as well as key landscape and soil characteristics, crop suitability, farm management options, and policy and program support.[l]

5.5.1 Frost Variables

Changes in the length and timing of the frost-free season affect plant and animal life, but also our social, psychological, and physical experience of the changing seasons.[li]

The Frost-Free Season is the approximate length of the growing season, during which there are no freezing temperatures to kill or damage plants.[lii] Table 24 and Figure 14 depict that the length of the frost-free season is expected to increase, from a baseline of 184 days per year, to 227.9 days per year in 2051-2080 according to RCP8.5 for Burlington Region. This lengthening of the frost-free seasons means plants and crops have a longer window to grow and mature.[liii]

Table 24: Length of Frost-Free Season for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (Days)	2021-2050 (Days)			2051-2080 (Days)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	184.0	179.9	203.1	227.5	184.0	210.8	236.8
RCP8.5	184.0	180.7	205.4	232.1	200.1	227.9	257.3

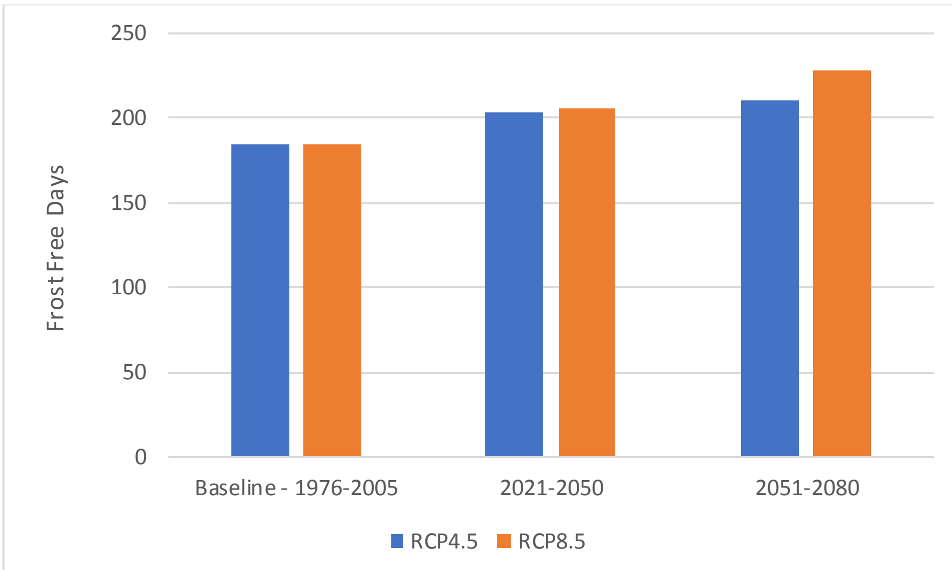


Figure 14: Length of Frost-Free Season for Burlington Region - RCP4.5 and 8.5

Not only is the overall Frost-Free Season becoming longer, the dates of first and last frosts of the year are also changing. The arrival of frost marks the end of the growing season and announces the imminent return of winter. Projections for Burlington Region indicate a later Date of First Fall Frost, meaning the seasonal transition from warmer to colder weather is happening later in the year.

Table 25 outlines the expected changes to Date of First Fall Frost and Date of Last Spring Frost for Burlington Region. According to RCP8.5, the Date of First Fall Frost could shift from a baseline of October 26th to potentially November 20th in the 2051-2080 period. Similarly, the Date of Last Spring Frost is expected to occur earlier – a change from a baseline of April 22nd to April 3rd by the 2051-2080 period according to RCP8.5.

As stated in section 4.3 of this report, Date of First Fall Frost, Last Spring Frost and Frost-Free Season are calculated using standard weather station observations, which are usually at 1.2m above the ground. Since the ground level temperature can be colder than the surface air temperature at 1.2m, the length of the Frost-Free Season presented is likely longer than the actual length of the season at ground level.

Table 25: Date of First and Last Frost for Burlington Region - RCP 4.5 and 8.5

Emissions Scenario	Variable	Baseline 1976-2005	2021-2050			2051-2080		
			Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	Date of First Fall Frost	Oct. 26	Oct. 20	Nov. 6	Nov. 22	Oct. 23	Nov. 11	Nov. 29
RCP8.5		Oct. 26	Oct 21	Nov. 7	Nov. 26	Oct. 31	Nov. 20	Dec. 10
RCP4.5	Date of Last Spring Frost	Apr. 22	Mar. 29	Apr. 13	Apr. 28	Mar. 25	Apr. 11	Apr. 27
RCP8.5		Apr. 22	Mar. 28	Apr. 13	Apr. 27	Mar. 13	Apr. 3	Apr. 20

5.5.2 Corn Heat Units

Corn Heat Units (CHU) is a temperature-based index often used by farmers and agricultural researchers to estimate whether the climate is warm enough to grow corn. One of the common climate variables used to assess the viability of growing a crop in a region is average annual CHUs. The CHUs expected in a region's growing season are used to assess whether corn, or a particular variety of corn, is likely to fully mature in that region.[liv] Generally, at least 2200 CHUs are required to mature most varieties of corn.[lv] Table 26 outlines the annual projected CHUs for Burlington Region.

Table 26: Corn Heat Units for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Baseline 1976-2005 (# of °C)	2021-2050 (# of °C)			2051-2080 (# of °C)		
		Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	3495	3639	4078	4492	3874	4375	4845
RCP8.5	3495	3725	4166	4596	4333	4815	5323

Overall, CHUs are projected to increase from a baseline of 3495 to 4815 by the 2051-2080 period under RCP8.5.

5.5.3 Growing Degree Days

Growing Degree Days (GDD) provide an index of the amount of heat available for the growth and maturation of plants and insects. Different base temperatures (5°, 10° and 15°C) are used to capture results for organisms that demand different amounts of heat.

GDDs accumulate whenever the daily mean temperature is above a specified threshold temperature. Generally, 5°C GDDs are used for assessing the growth of canola and forage crops; 10°C GDDs are more appropriate for assessing the growth of corn and beans; and 15°C GDDs are used to assess the growth and development of insects and pests.[lvi] Table 27 outlines the GDDs for Burlington Region across 5°, 10°, and 15°C thresholds respectively.

Table 27: Growing Degree Days for Burlington Region - RCP4.5 and 8.5

Emissions Scenario	Variable	Baseline 1976-2005 (# of ºC)	2021-2050 (# of ºC)			2051-2080 (# of ºC)		
			Low	**Mean**	**High**	**Low**	**Mean**	**High**
RCP4.5	Growing Degree Days (Base 5ºC)	2333	2448	2757	3040	2622	2990	3344
RCP8.5		2333	2523	2816	3108	2950	3333	3733
RCP4.5	Growing Degree Days (Base 10ºC)	1353	1435	1685	1916	1569	1872	2166
RCP8.5		1353	1497	1737	1974	1834	2149	2469
RCP4.5	Growing Degree Days (Base 15ºC)	626.5	676.9	869.7	1059	773.5	1015	1269
RCP8.5		626.5	725.7	912.8	1103	976.9	1232	1503

All GDDs are expected to increase across all emission scenarios and time periods. This indicates that there will be more days per year that meet these temperature thresholds. While these present some opportunities for agriculture (i.e. longer growing seasons), it also could signal an increase in the survival of pests and other invasive species due to warmer temperatures in the winter months.

5.6 Extreme Weather Events

Canada has seen more frequent and intense extreme events over the last 50-60 years than ever before. These events come in the form of extreme heat days, more instances of extreme precipitation and flooding, wind storms, and ice storms. In Canada, models show return periods, or the estimated interval of time between occurrences, of extreme events in the future will be shorter.[lvii]

5.6.1 Rainfall Intensity-Duration-Frequency

Extreme and heavy rain events are expected to become more intense and more frequent.[lviii] As Southern Ontario is the most intensely urbanized area of the province, the magnitude and costs associated with flooding is significantly higher than elsewhere in the province.

Stormwater management systems depend on Intensity–Duration–Frequency (IDF) curves as a standard design tool, where rainfall intensity (mm/h), duration (how many hours it rained at that intensity) and frequency (how often that level of a rainstorm repeats itself) are stated.[lix] However, due to climate change, the extreme precipitation data represented by IDF curves will be subject to change over time.

5.6.1.1 City of Burlington

The City of Burlington used Western University's "Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change – version 4.0" (www.idf-cc-uwo.ca).

Existing gauged data from Environment Canada stations (in this case the Royal Botanical Gardens station for the years between 1962 and 2016) is integrated with predictions obtained from Global Climate Models (GCMs) to assess the impacts of climate change on IDF curves. GCMs developed for IPCC Assessment Report (AR5) are used to provide future climate scenarios to the year 2100 for the various RCPs (RCP2.6, 4.5 and 8.5).[lx]

Using Western University's tool, the 5-year and 100-year event data showed a percentage increase ranging from eight to 16 percent for the three emission scenarios from Burlington's 1999 IDF curves. Based on this data, the City of Burlington used a 15 percent increase to apply to the City's 1999 IDF curves to update and generate Burlington's new official 2020 IDF curves. These IDF curves were approved and adopted by Burlington City Council in June 2020 as part of the new Stormwater Management Design Guidelines and are being used for all new developments and redevelopments in Burlington.[lxi]

Table 28 and Figure 15 outline the historical IDF curves for the City of Burlington using gauged data from the Royal Botanical Gardens station, while Table 29 and Figure 16 outline Burlington's 2020 IDF curves currently in use.

Table 28: Historical Precipitation Intensity Rates (mm/h) for City of Burlington (1962-2016)

Duration	T (years)					
	2	**5**	**10**	**25**	**50**	**100**
5 min	97.39	124.71	141.56	161.54	175.48	188.60
10 min	68.93	88.20	100.98	117.15	129.16	141.11
15 min	54.86	70.10	81.28	96.82	109.44	122.97
30 min	35.81	45.73	52.37	60.84	67.19	73.55
1 h	22.25	27.83	31.02	34.58	36.90	38.98
2 h	13.80	17.72	20.17	23.12	25.21	27.19
6 h	5.69	7.81	9.44	11.79	13.8	15.98
12 h	3.36	4.51	5.44	6.88	8.16	9.65
24 h	1.99	2.56	3.04	3.77	4.42	5.19

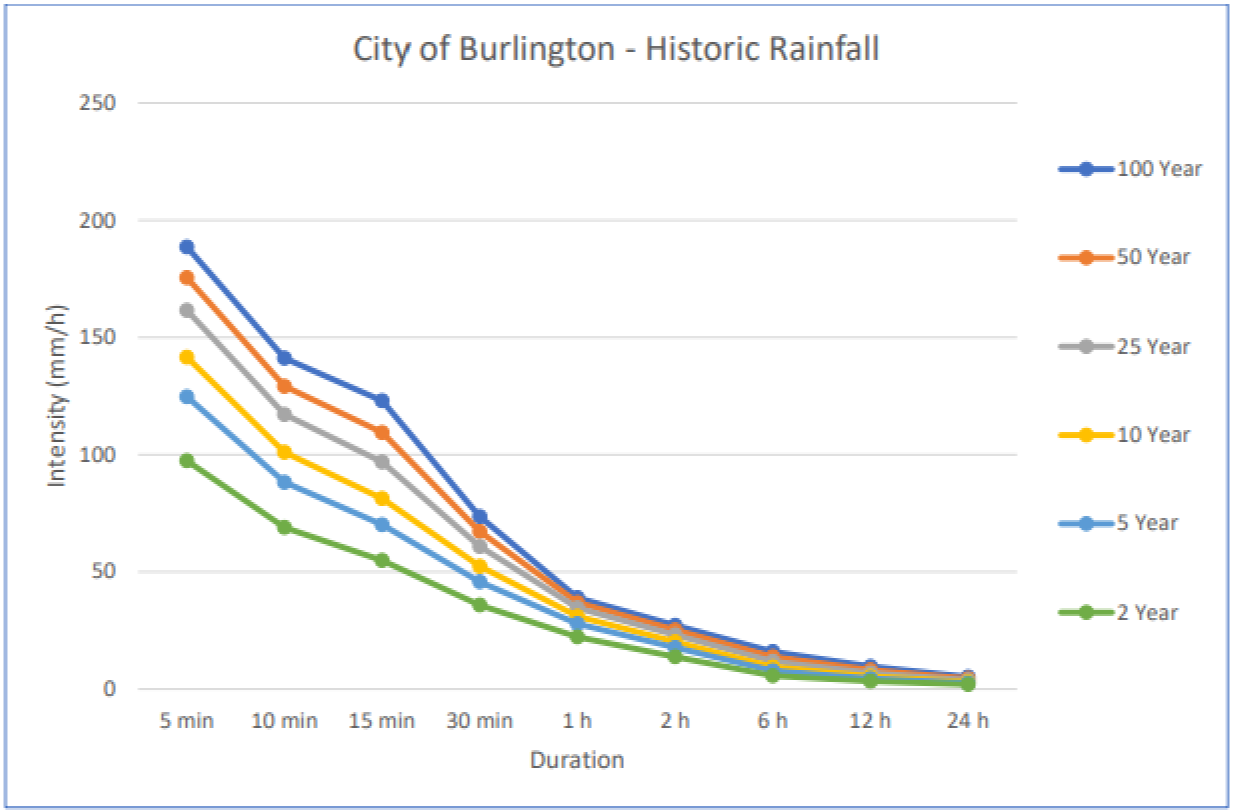


Figure 15: Historical IDF Curve for the City of Burlington (1962-2016)

Table 29: City of Burlington 2020 IDF curve (mm/h)

Duration	T (years)					
	2	**5**	**10**	**25**	**50**	**100**
5 min	105.00	138.10	158.48	184.39	203.26	222.16
10 min	78.39	101.31	116.31	135.38	149.30	163.18
15 min	63.41	81.32	93.39	108.73	119.94	131.09
30 min	41.64	53.03	60.93	70.98	78.35	85.63
1 h	25.96	33.05	37.99	44.29	48.91	53.46
2 h	15.67	20.05	23.07	26.91	29.74	32.50
6 h	6.82	8.84	10.18	11.89	13.16	14.38
12 h	4.00	5.23	6.03	7.05	7.80	8.53
24 h	2.34	3.09	3.56	4.17	4.62	5.05

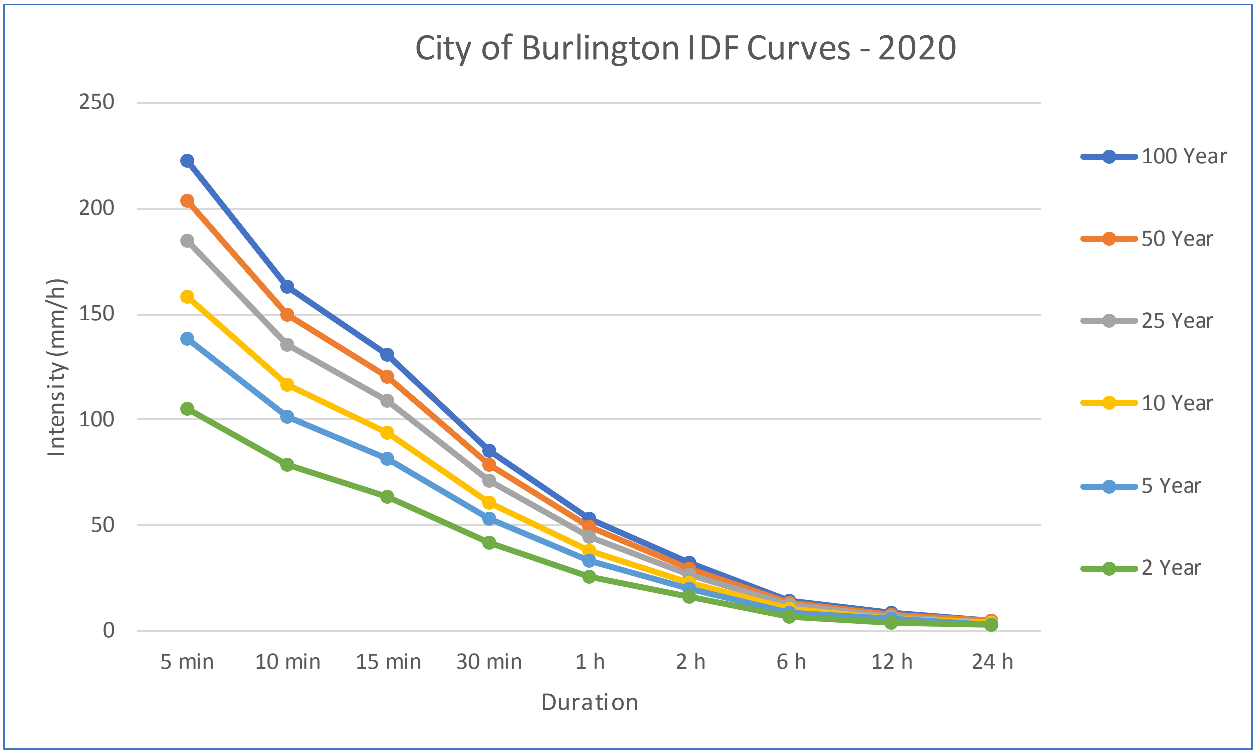


Figure 16: City of Burlington 2020 IDF curve

5.6.1.2 Town of Oakville

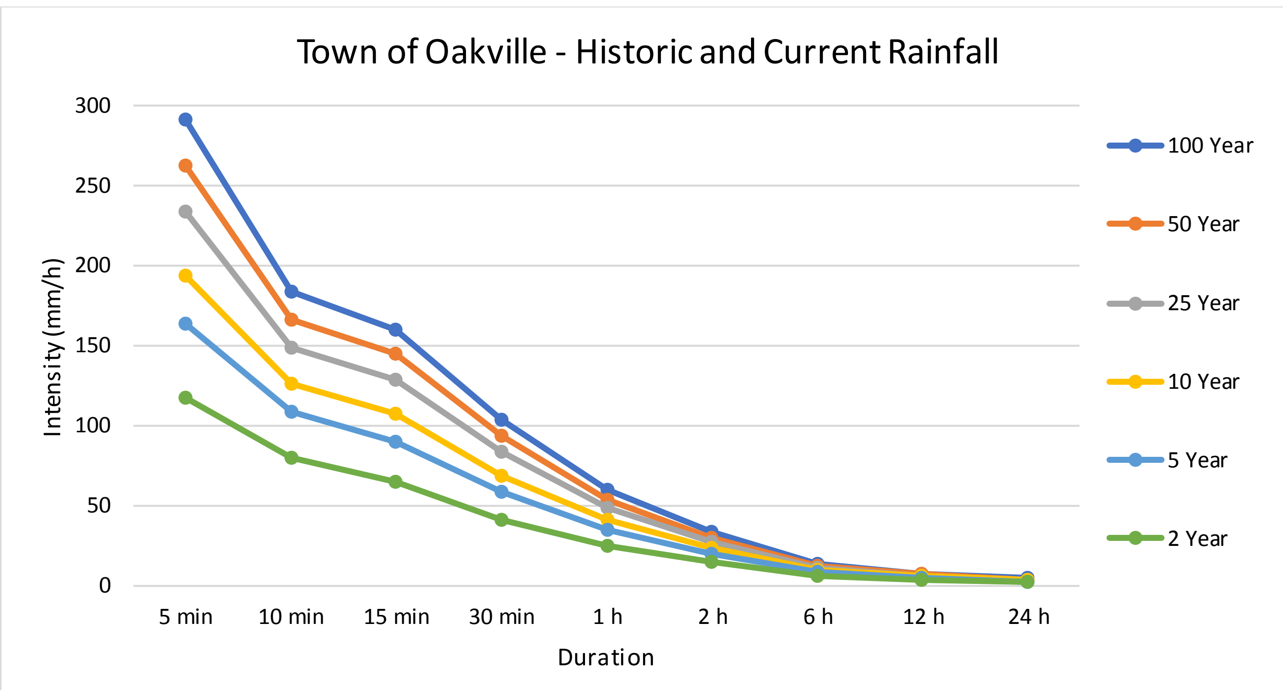
The Town of Oakville defines its rainfall standard in the Development Engineering Procedures and Guidelines Manual.[lxii] It is noted in this manual, that there is no satisfactory meteorological data for Oakville, therefore it will be using the data available from the Toronto Bloor Street station, or Toronto City Station (Gauge ID 6158355). This station has continuous rainfall data from 1940 to 2007 more than any other in closer proximity.[lxiii]

The Town of Oakville's historic IDF curves were developed in 2011 but also serve as the town's current IDF curves. It was realized through the development of the 2019 Stormwater Master Plan that the 2011 IDF values were sufficiently conservative when compared to various IDF relationships developed using many scenarios and several climate tools. The current IDF values were found to provide sufficient resilience to the projected increases in extreme precipitation events.[lxiv] Table 30 and Figure 17 depict the rainfall IDF values that shall be used for all frequencies from 1:2 years to 1:100 years.[lxv]

Table 30: Historic and Current Precipitation Intensity Rates for the Town of Oakville (1946-2007)

Duration	T (years)					
	2	**5**	**10**	**25**	**50**	**100**
5 min	117	164	194	233	262	291
10 min	80	108	126	149	166	183
15 min	65	90	107	129	145	160
30 min	41	58	69	83	93	103
1 h	25	35	41	48	54	60
2 h	15	20	23	27	30	33
6 h	6.1	8.1	9.4	11	12	13
12 h	3.6	4.6	5.3	6.2	6.8	7.5
24 h	2	2.5	2.9	3.4	3.7	4.1

Figure 17: Historic and Current IDF Curve for the Town of Oakville (1946-2007)



Appendices B and C outline the projected IDF curves under RCP4.5 and RCP8.5 for the City of Burlington and Town of Oakville which are included in Burlington Region. Overall, the curves indicate that the intensity of rainfall events are expected to increase. Increases in the intensity of rainfall events as a result of climate change are a major threat to infrastructure systems, especially stormwater infrastructure systems and the transportation systems they protect. Higher rainfall intensities lead to more severe storms, with expected increases in damages related to residential, street, and flash flooding.

5.6.2 Freezing Rain

Although rare in occurrence, Freezing Rain events have the potential to negatively impact personal safety, infrastructure, transportation, trees and utilities incurring substantial response and recovery costs.[lxvi]

A study conducted by the Meteorological Service of Canada branch of Environment Canada observed the possible impacts of climate change on Freezing Rain using downscaled future climate scenarios. This report was published in 2007 and applies the SRES climate scenarios from the IPCC AR4 report.[lxvii] This study focused on four regions in south-central Canada, with the Southern Ontario region specifically focused on the Windsor to Toronto corridor which includes Burlington Region. The six months that Freezing Rain occurs in Canada, were divided into two categories, the three warmer months (November, March and April) and the three colder months (December, January and February).

For the Southern Ontario region Freezing Rain events are projected to decrease from the baseline (1958-2001) in the warmer months by 10 and 15 percent by 2050 and 2080 respectively and increase in the colder months by 40 percent in 2050 and up to 45 percent in 2080.[lxviii] The report concludes that as temperatures increase, more Freezing Rain events are projected to occur across south-central Canada. This increase is more substantial in the short term and as you move south to north and southwest to northeast across the entire study area.

5.6.3 Wind Gusts

High wind speeds and wind gusts, that are not classified as tornadoes, are an important climate variable to consider as they cause considerable damage to properties, infrastructure and trees. They often impact electrical power distribution and transmission lines due to downed trees and poles.[lxix] A 2012 study led by Environment Canada researchers observed the possible impacts of climate change on future Daily and Hourly Wind Gust events in the Province of Ontario. The study area was divided into four regions with Region 1 covering Burlington Region. This study used SRES scenarios from the IPCC Fourth Assessment Report (AR4) where A2 represents a high emissions scenario and B1 represents a low emissions scenario.[lxx]

The authors included some specific wind speeds for the study as they were pre-identified thresholds. For example, 28 km/h is the minimum value to record wind gust observations; 40 km/h related to wind turbines; and 70 and 90 km/h triggered Environment Canada wind gust warnings.[lxxi]

Overall, the study found that Ontario will experience more Wind Gust events (both hourly and daily) by the end of the century. Under the A2 high emissions scenario for the area which includes Burlington Region, annual mean frequency of Hourly Wind Gust events will increase by 15 percent (greater than 28 km/h), 21 percent (greater than 40 km/h) and 19 percent (greater than 70 km/h) by the end of the century. While future Hourly Wind Gust events (90 km/h) are projected to increase from 1.4 hours from the baseline period of 1994-2007 to 2.4 hours by

2046-65 for the high emissions scenario representing a 70 percent increase, the authors of the study stated that it would be inappropriate to attribute a percentage change to 80 and 90 km/h events as they are less frequent. Daily Wind Gusts are also predicted to increase by six, 11 and 22 percent for the same wind categories by the end of the century as shown in Table 31.[lxxii]

Table 31: Percentage Increase in the Frequency of Future Daily and Hourly Wind Gust Events from Current Conditions – A2 scenario

Wind Gust Event (km/h)	Daily wind gust (% increase)		Hourly Wind Gust (% increase)	
	2046-2065	**2081-2100**	**2046-2065**	**2081-2100**
28 or more	4	6	8	15
40 or more	7	11	13	21
70 or more	14	22	17	19

5.7 Lake Ontario

About 11 million people live in Lake Ontario's watershed with nine million in Canada and two million in America. Lake Ontario is the smallest of the five Great Lakes by shoreline, the second smallest by volume and the third deepest. Combined the Great Lakes account for 21 percent of the world's freshwater by volume. Their size (244 000 km^2) influences local climate producing a moderating lake breeze especially in the summer and fall and lake effect precipitation, which is further influenced in the winter by the presence and degree of lake ice.[lxxiii]

5.7.1 Lake Levels

Water levels in the Great Lakes have fluctuated considerably over multi-decadal time scales, rising over the past several years following a period of record low levels. The changes in Lake Ontario water levels result from fluctuations in surface water temperatures, and precipitation. Over the past several decades, monitoring indicates that Lake Ontario has experienced a 3.5 percent increase in over-lake precipitation and a 9.8 percent increase in overland runoff.[lxxiv]

The Department of Fisheries and Oceans Canada uses the 1985 International Great Lakes Data (IGLD) collected from six gauging stations located on Lake Ontario at Port Weller, Toronto, Cobourg, Kingston, Rochester and Oswego. Figure 18 compares the average annual water levels from 2009-2019 to that of the baseline, 1976-2005.[lxxv]

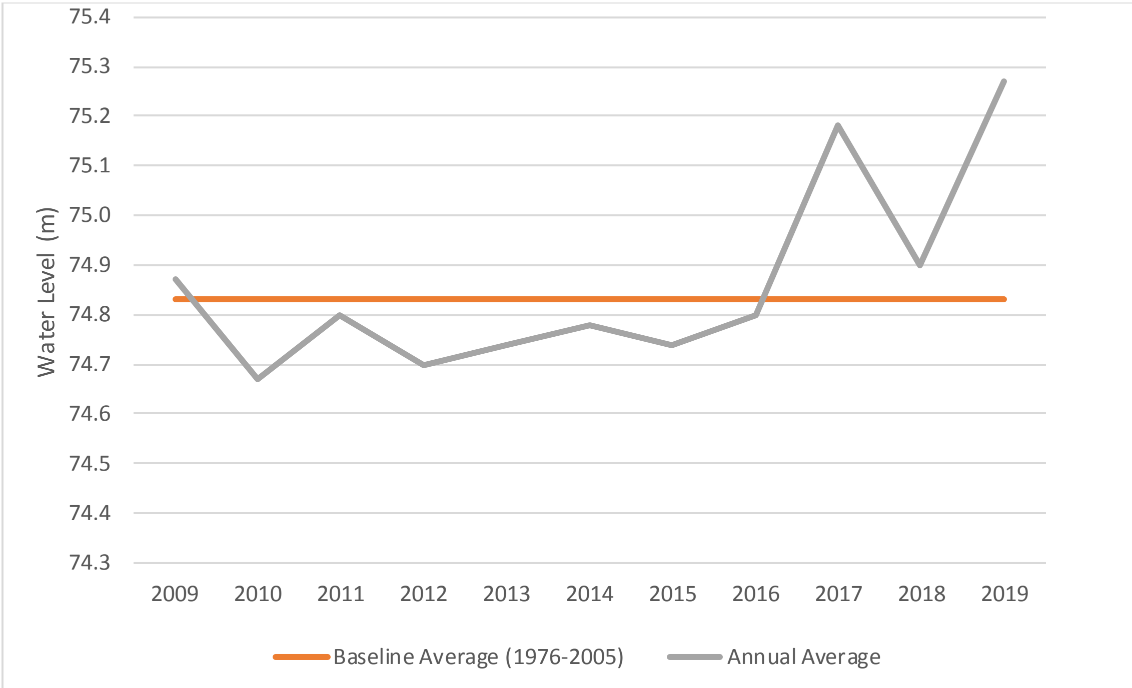


Figure 18: Annual Water Levels (2009-2019) Compared to the Baseline

In 2017 and 2019, Lake Ontario experienced extremely high-water levels due to record-breaking precipitation events in the basin. Burlington Region experienced extensive shoreline flooding, that was intensified by easterly winds, damaging infrastructure and natural areas such as lakeside parks, trails, beaches and harbours. Figure 19 shows the monthly average water levels in 2017 and 2019 compared to the baseline years of 1976-2005.[lxxvi]

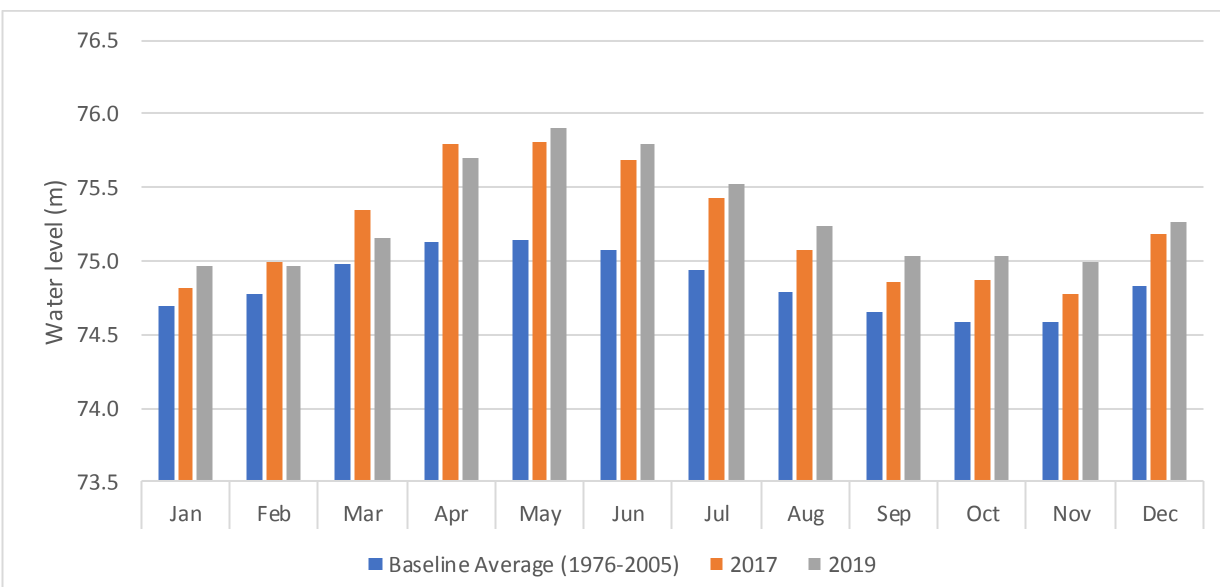


Figure 19: Baseline Water Levels Compared to the Record-Breaking Lake Levels of 2017 and 2019

Several studies indicate that climate change is already impacting the Great Lakes water levels causing shoreline flooding and erosion when lake levels are high and power transmission and ship navigation issues when levels are low. The projected increase in annual temperatures, precipitation and extreme weather events resulting from climate change will continue to impact the Great Lakes basin.[lxxvii] Lake level modelling conducted in 2011 foresees a central tendency toward small drops in lake levels to the end of the 21st century, with a considerable probability of small rises which is in contrast to the large drops projected using the older methodology.[lxxviii]

5.7.2 Lake Temperature

Climate change alters the exchange of heat between the atmosphere and the Great Lakes impacting overall lake temperature, ice cover duration and the seasonal mixing of lake water.[lxxix]

Between 1970 and 2009, annual mean surface air and water temperatures increased (1.43°C and 1.26°C respectively) in Lake Ontario. Seasonally, surface water temperature increased at a faster rate than air temperature in spring and summer whereas air temperature increased at a faster rate than water temperature in fall and winter.[lxxx] Research using fine-scale (versus lake or basin scale) trends also show a significant warming trend in summer surface water temperatures around the eastern regions of Lake Ontario from 1994 to 2013 as shown in Figure 20.[lxxxi]

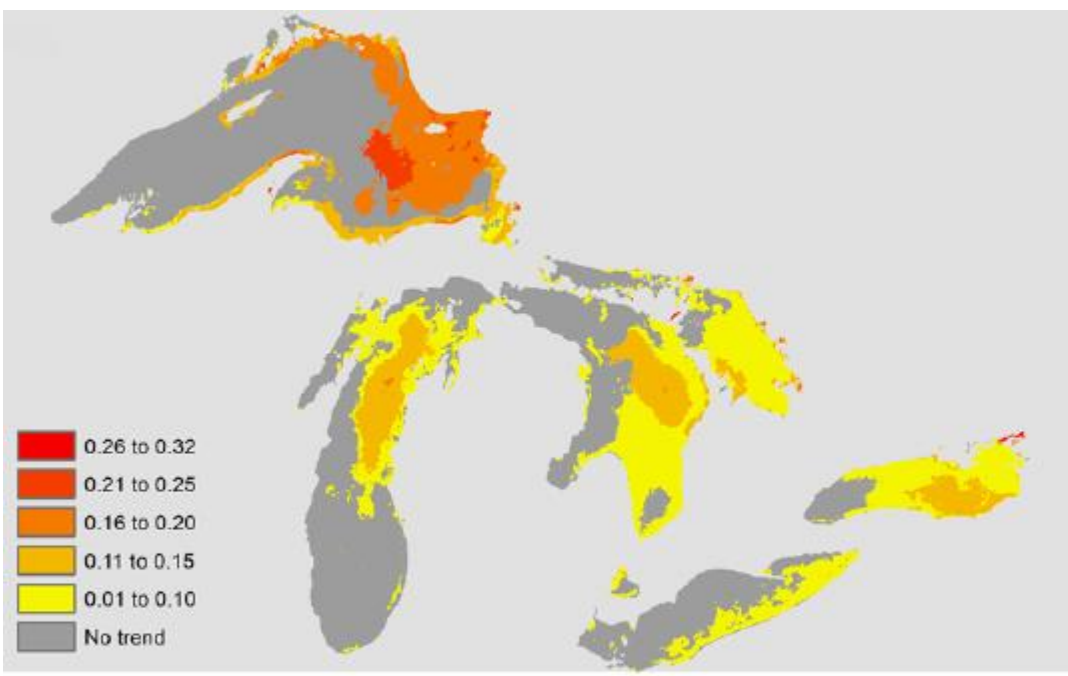


Figure 20: Summer Surface Water Temperature (°C/year) (1994-2013)

Lakes in our climate tend to have defined layers with different water temperatures throughout the water column. Mixing of these layers tends to occur twice each year; in the spring and in the fall when lake surface temperature rises or falls to 4°C. Seasonal mixing of lake water is occurring earlier in the spring and later in the fall.[lxxxii] This could be contributing to a summer thermal stratification season (the last occurrence of a 4°C lake surface temperature in spring and the first occurrence of 4°C in fall)[lxxxiii] in Lake Ontario that was lengthened by about 12 days between 1970 and 2009.[lxxxiv] Notwithstanding the above section on wind gusts (greater than 28 km/hr), surface wind speed has declined about 2.88 to 4.75 km/h over Lake Ontario over four decades.[lxxxv] Since Lake Ontario does not have as much ice cover as other Great Lakes, wind speed could have a greater influence than ice cover on lake surface temperature as lower summer wind speed will result in warmer surface water.[lxxxvi]

5.7.3 Ice Cover

Various studies show a decrease in ice cover on the Great Lakes. Figure 21 shows the decreasing trend in yearly maximum ice coverage in the Great Lakes from 1973 to 2018. [lxxxvii]

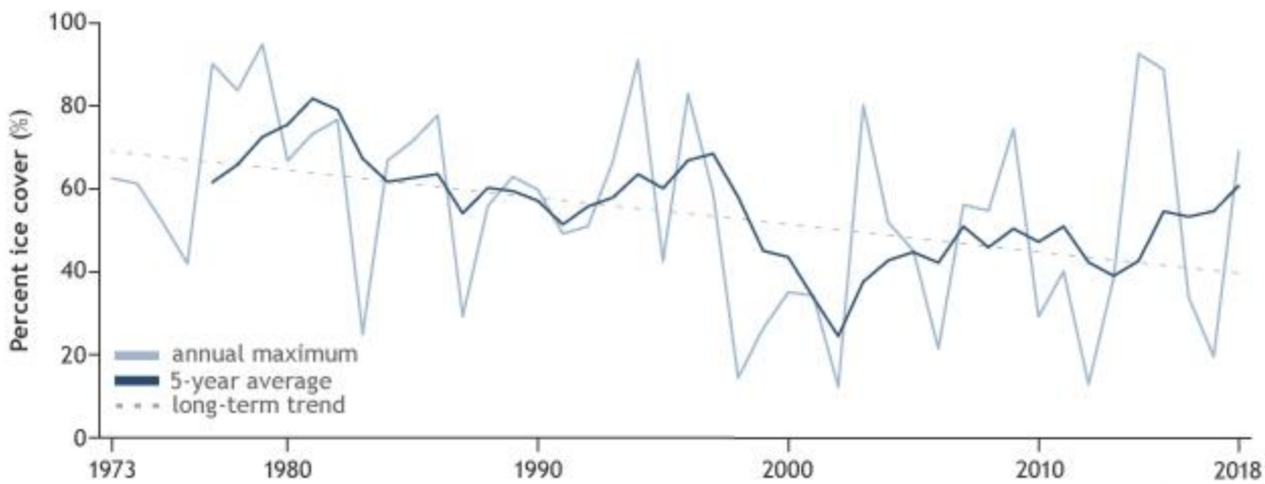


Figure 21: Time Series of Yearly Maximum Ice Cover in the Great Lakes (1973-2018)

As seen in Figure 22, the greatest decline in seasonal ice cover duration occurs in the northern and eastern Great Lakes especially along the shorelines.[lxxxviii]

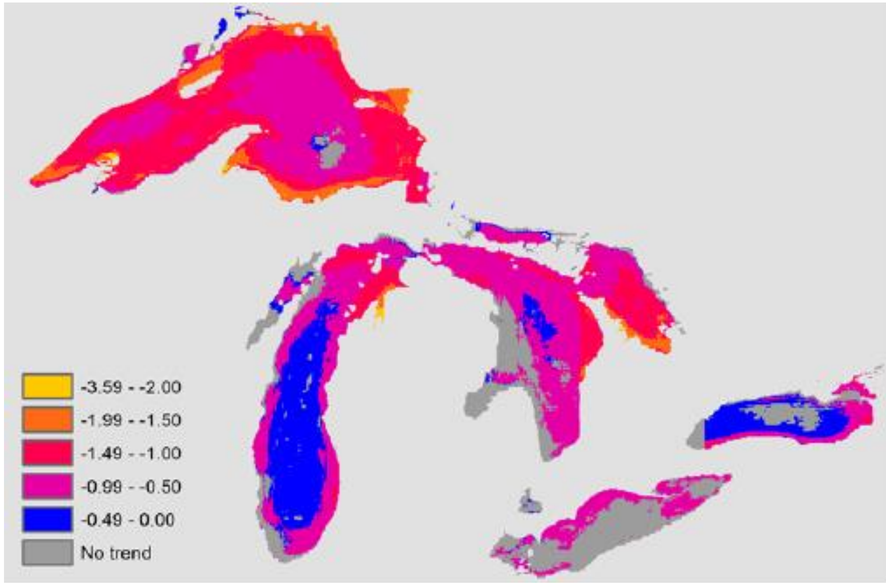


Figure 22: Seasonal Ice Cover Duration (days/year) (1973-2013)

A study of Great Lakes ice cover between 1973 and 2010 found a significant overall decrease in ice cover of 71 percent with Lake Ontario experiencing the most loss at 88 percent.[lxxxix] Between 1970 and 2009, Lake Ontario's surface air temperature warmed four times faster than air temperature in winter perhaps contributing to the decline.[xc]

Another study examined the ice coverage of Lake Ontario for the past, present and future under four categories: very light, light, moderate and heavy. There was a decline of heavy ice seasons for Lake Ontario from six per decade (1840s to 1870s – the most distant climate normal) to one per decade (1980s to 2000s – the most recent climate normal). The same study projected future ice coverage using GCMs for both RCP4.5 and 8.5. Under both scenarios, heavy ice seasons will no longer occur as early as the 2050s with very light ice seasons going from 10 percent in the baseline period (1981-2010) to 73 (RCP4.5) or 100 (RCP8.5) percent by the 2080s as seen in Figure 23.[xci]

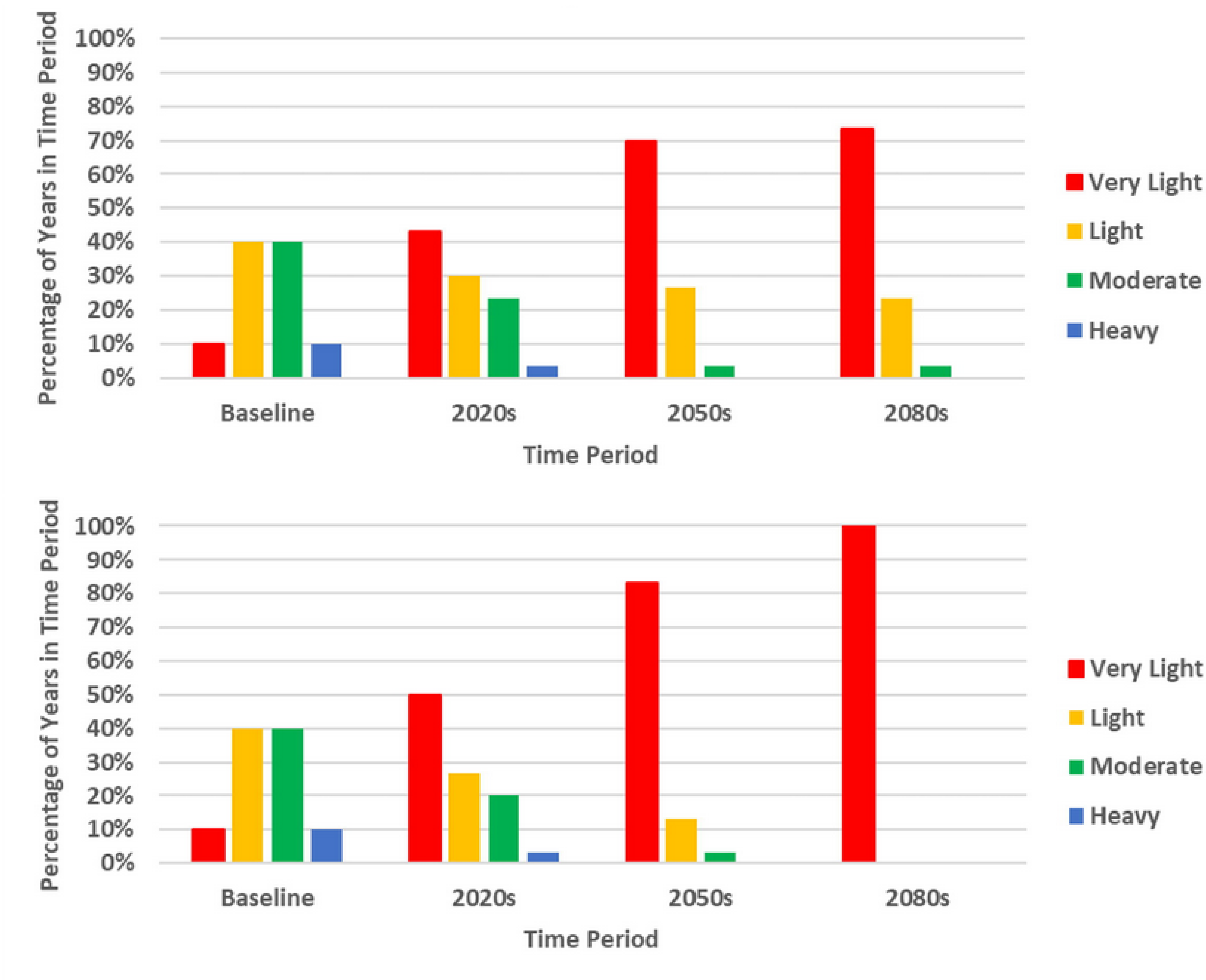


Figure 23: Projected Ice Conditions for Lake Ontario (2011-2100), based on RCP4.5 (top) and RCP8.5 (bottom), including the Baseline Time-Period for Context

6.0 Conclusion

The information provided in this report provides how and to what degree climate change is projected to affect Burlington Region. Increases to annual temperatures, precipitation and extreme events can have major impacts with tremendous ecological, infrastructural, economic and sociological effects for the community. The information in this report will be used to inform proactive adaptation planning across the community and corporation, and may be integrated into asset management practices, emergency management planning, outreach and communications, as well as other climate adaptation programs.

APPENDICES

Appendix A: Summary of Local Climate Variables and Trends

The content in this appendix shows:

- Mean data for climate variables under the categories of Temperature, Hot Weather, Cold Weather, Precipitation and Agriculture under a high emissions scenario (RCP8.5), and
- The trend between the baseline period of 1976-2005 and the near future (2051-2080).

Tables A1: Temperature Climate Variables and Trends – RCP8.5

Period	Annual Mean Temp (°C)	Spring Mean Temp (°C)	Summer Mean Temp (°C)	Fall Mean Temp (°C)	Winter Mean Temp (°C)
1976-2005	8.6	6.8	20.3	10.5	-3.4
2021-2050	10.7	8.6	22.4	12.7	-1.0
2051-2080	12.8	10.6	24.6	14.6	1.3
Trend	↑4.2°C	↑3.8°C	↑4.3°C	↑4.1°C	↑4.7°C

Period	Annual Min. Temp (°C)	Spring Min. Temp (°C)	Summer Min. Temp (°C)	Fall Min. Temp (°C)	Winter Min. Temp (°C)
1976-2005	4.0	2.0	14.9	6.1	-7.0
2021-2050	6.1	3.8	16.8	8.1	-4.4
2051-2080	8.2	5.6	18.9	10.0	-1.8
Trend	↑4.2°C	↑3.6°C	↑4°C	↑3.9°C	↑5.2°C

Period	Annual Max. Temp (°C)	Spring Max. Temp (°C)	Summer Max. Temp (°C)	Fall Max. Temp (°C)	Winter Max. Temp (°C)
1976-2005	13.2	11.6	25.7	14.9	0.3
2021-2050	15.3	13.5	28.0	17.2	2.3
2051-2080	17.4	15.4	30.3	19.3	4.4
Trend	↑4.2°C	↑3.9°C	↑4.6°C	↑4.4°C	↑4.2°C

Tables A2: Hot Weather Climate Variables and Trends – RCP8.5

Period	Very Hot Days (30°C or more) (Days)	Extremely Hot Days (32°C or more) (Days)	Extremely Hot Days (34°C or more) (Days)	Length of Hot Season (30°C) (Days)	Cooling Degree Days (# of °C above 18°C)
1976-2005	16	6	1.7	70.5	315.7
2021-2050	35.5	18.3	7.8	102	535.1
2051-2080	60.9	38.8	21.6	123.7	797
Trend	↑44.9	↑32.8	↑19.8	↑53.3	↑481.4

Period	Annual # of Heat Waves (#)	Length of Heat Waves (Days)	Longest Spell of 30°C Days (Days)	Annual # of Tropical Nights (>20°C) (Nights)	Average warmest max temp (°C)
1976-2005	2.1	3.7	3.9	8.1	34.2
2021-2050	4.8	5.5	8.4	22.4	36.5
2051-2080	6.7	8.1	18.2	44.8	39.0
Trend	↑4.6	↑4.4	↑14.3	↑36.7	↑4.8

Tables A3: Cold Weather Climate Variables and Trends – RCP8.5

Period	Mild Winter Days (-5°C or less) (Days)	Winter Days (-15°C or less) (Days)	Frost Days (Min. Temp < 0°C) (Days)	Icing Days (Max Temp = or < 0°C) (Days)	Freeze-Thaw Cycles (Days)
1976-2005	66.6	11.2	126	48	63.3
2021-2050	46.3	4	100.1	31.8	54.7
2051-2080	27.3	0.9	74	17.5	44.5
Trend	↓39.3	↓10.2	↓52	↓30.5	↓18.8

Period	Heating Degree Days (# of °C below 18 °C)	Freezing Degree Days (# of °C above 0 °C)	Average Coldest minimum temperature (°C)
1976-2005	3739	450.6	-20.8
2021-2050	3185	271.0	-16.9
2051-2080	2680	138.5	-13.0
Trend	↓1059.4	↓312.1	↑7.8

Tables A4: Precipitation Climate Variables and Trends – RCP8.5

Period	Annual (mm)	Spring (mm)	Summer (mm)	Fall (mm)	Winter (mm)
1976-2005	811	210	208	213	181
2021-2050	864	232	210	222	200
2051-2080	889	245	207	223	214
Trend	↑10%	↑17%	↔ 0%	↑5%	↑18%

Period	Dry Days (mm)	Wet Days (mm)	Heavy Precip. Days (10 mm)	Heavy Precip. Days (20 mm)	Max 1-Day (mm)	Max 5-Day (mm)
1976-2005	210.4	154.2	24.8	6.1	42	64
2021-2050	209.5	155.2	27.1	7.3	45	68
2051-2080	210.9	153.7	27.8	8.2	48	73
Trend	↔	↔	↑3 days	↑2.1 days	↑16%	↑15%

Tables A5: Agriculture Climate Variables and Trends – RCP8.5

Period	Frost-Free Season (Days)	Date of Last Spring Frost	Date of First Fall Frost
1976-2005	184	Apr. 22	Oct. 26
2021-2050	205.4	Apr. 13	Nov. 7
2051-2080	227.9	Apr. 3	Nov. 20
Trend	↑43.9 (longer)	↓18.8 (earlier)	↑ 25 (later)

Period	Corn Heat Units (# of °C)	Growing Degree Days Base of 5°C (# of °C)	Growing Degree Days Base of 10°C (# of °C)	Growing Degree Days Base of 15°C (# of °C)
1976-2005	3495	2333	1353	626.5
2021-2050	4166	2816	1737	912.8
2051-2080	4815	3333	2149	1232
Trend	↑1320	↑1001	↑797	↑605.0

Appendix B: Rainfall IDF Curves for the City of Burlington

The following were generated by the City of Burlington using Western University's Computerized Tool for the Development of Intensity-Duration-Frequency (IDF) Curves under Climate Change – version 4.0 (www.idf-cc-uwo.ca) using RCP4.5 and 8.5 for the periods of 2021-2050 and 2051-2080 to be consistent with the years used in the Climate Atlas of Canada. Precipitation data from existing Environment Canada stations (Royal Botanical Gardens in Burlington) is integrated with predictions obtained from Global Climate Models developed for IPCC Assessment Report (AR5) to assess the impacts of climate change on IDF curves.[xcii]

Rainfall Intensity Rates - RCP4.5 (2021-2050)

Table B1: Rainfall Intensity Rates (mm/h) for the City of Burlington – RCP4.5 (2021-2050)

Duration	T (years)					
	2	**5**	**10**	**25**	**50**	**100**
5 min	104.97	135.39	155.41	179.42	196.41	210.04
10 min	74.17	95.48	110.26	128.23	140.8	153.56
15 min	58.9	75.58	88.26	105.19	119.77	135.31
30 min	38.52	49.48	57.16	66.56	73.2	80.22
1 h	23.98	30.27	34.06	38.57	41.58	43.88
2 h	14.87	19.23	22.26	25.65	28.16	30.19
6 h	6.09	8.42	10.21	12.76	14.91	17.34
12 h	3.6	4.85	5.87	7.38	8.67	10.25
24 h	2.13	2.76	3.28	4.05	4.71	5.52

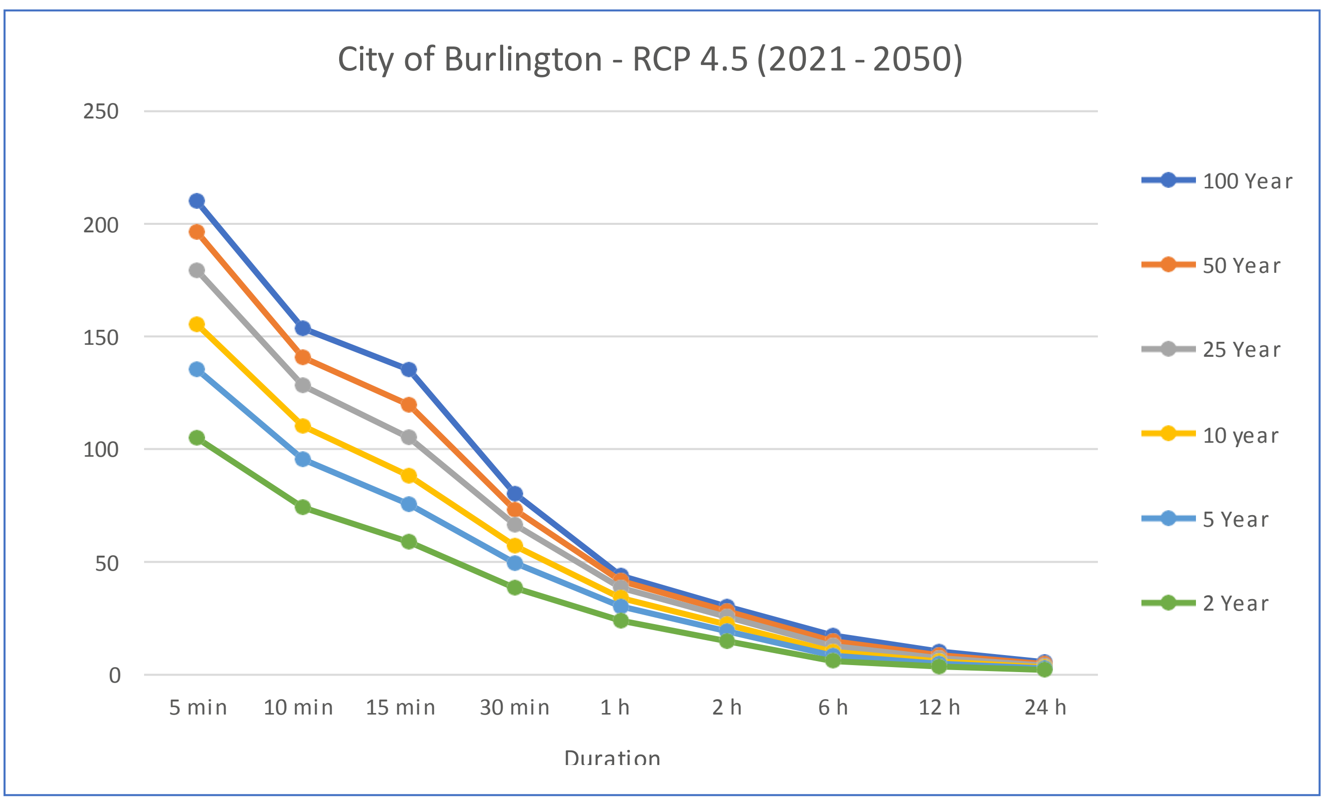


Figure B1: Rainfall Intensity Rates (mm/h) for City of Burlington – RCP4.5 (2021-2050)

Rainfall Intensity Rates - RCP4.5 (2051-2080)

Table B2: Rainfall Intensity Rates (mm/h) for the City of Burlington – RCP4.5 (2051-2080)

Duration	T (years)					
	2	**5**	**10**	**25**	**50**	**100**
5 min	109.14	137.62	156.39	176.41	192.18	207.06
10 min	77.25	97.21	111.17	127.79	141.41	154.18
15 min	61.37	77.28	89.01	105.22	119.42	131.89
30 min	40.13	50.41	57.64	66.36	73.55	80.26
1 h	24.89	30.79	34.39	38.07	40.49	42.77
2 h	15.47	19.54	22.27	25.25	27.61	29.85
6 h	6.35	8.59	10.25	12.78	14.93	16.76
12 h	3.75	4.96	5.89	7.41	8.68	9.76
24 h	2.22	2.83	3.3	4.06	4.71	5.24

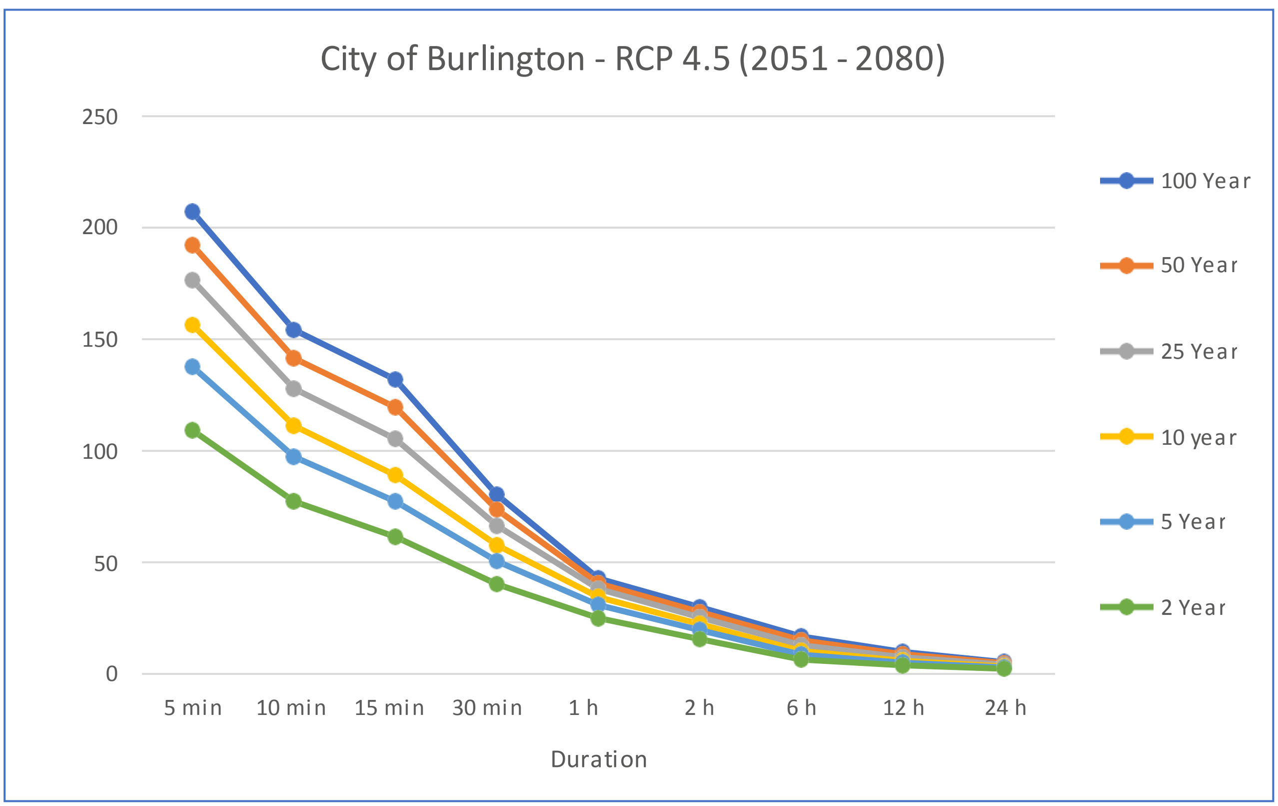


Figure B2: Rainfall Intensity Rates (mm/h) for City of Burlington – RCP4.5 (2051-2080)

Rainfall Intensity Rates - RCP8.5 (2021-2050)

Table B3: Rainfall Intensity Rates (mm/h) for the City of Burlington – RCP8.5 (2021-2050)

Duration	T (years)					
	2	**5**	**10**	**25**	**50**	**100**
5 min	107.63	136.93	154.88	175.55	189.14	199.63
10 min	76.08	96.78	110.27	126.56	137.46	146.42
15 min	60.46	76.85	88.7	103.98	114.27	124.52
30 min	39.53	50.18	57.18	65.68	71.3	76.1
1 h	24.58	30.57	33.98	37.74	39.79	41.79
2 h	15.25	19.45	22.06	25.1	27.18	28.67
6 h	6.24	8.55	10.29	12.52	14.35	16.18
12 h	3.68	4.93	5.91	7.25	8.4	9.6
24 h	2.18	2.81	3.3	3.97	4.56	5.16

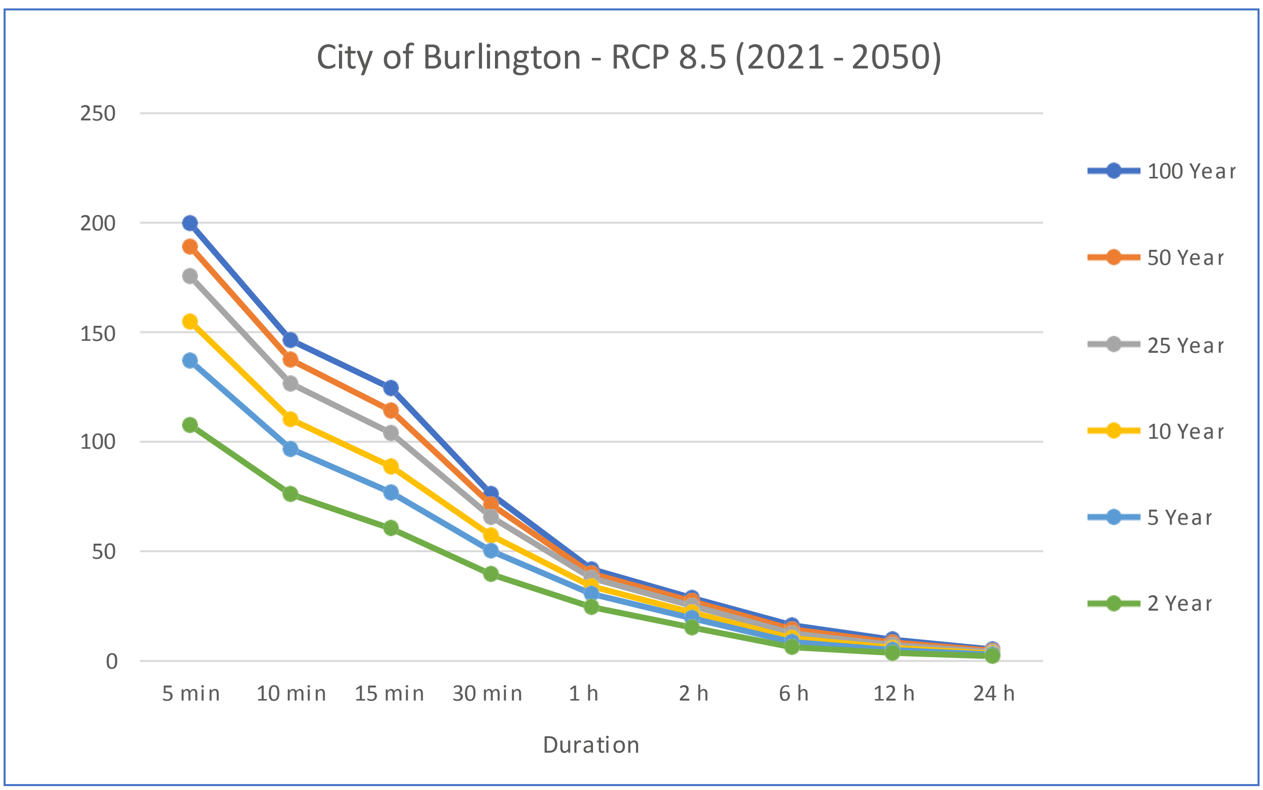


Figure B3: Rainfall Intensity Rates (mm/h) for City of Burlington – RCP8.5 (2051-2080)

Rainfall Intensity Rates - RCP8.5 (2051-2080)

Table B4: Rainfall Intensity Rates (mm/h) for the City of Burlington – RCP8.5 (2051-2080)

Duration	T (years)					
	2	**5**	**10**	**25**	**50**	**100**
5 min	115.03	148.82	171.78	196.72	213.76	229.53
10 min	81.5	105.09	121.03	141.18	151.62	167.68
15 min	64.59	83.34	97.33	115.68	130.02	144.63
30 min	42.35	54.48	62.77	73.27	78.8	87.29
1 h	26.32	33.24	37.19	42.1	44.93	47.43
2 h	16.3	21.14	24.47	28.16	30.7	33.02
6 h	6.7	9.26	11.28	14.15	16.36	18.69
12 h	3.96	5.34	6.49	8.14	9.53	11.11
24 h	2.34	3.04	3.63	4.46	5.17	5.99

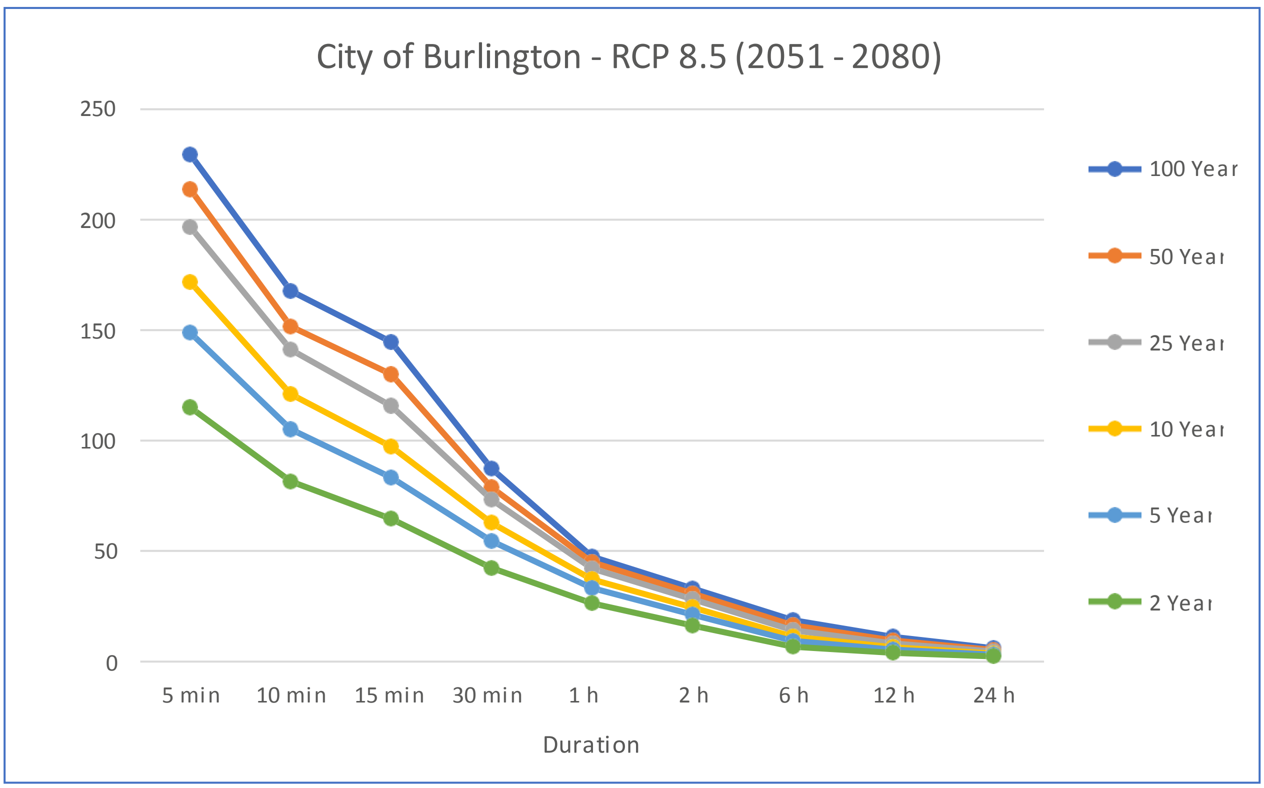


Figure B4: Rainfall Intensity Rates (mm/h) for City of Burlington – RCP8.5 (2051-2080)

Appendix C: Rainfall IDF Curves for the Town of Oakville

The following information was generated by the Town of Oakville using Western University's Computerized Tool for the Development of Intensity-Duration-Frequency (IDF) Curves under Climate Change – version 3.0 (www.idf-cc-uwo.ca). Version 3.0 allows the town to apply the 50+ years of data from Bloor Street Toronto Station to Oakville providing a more comprehensive look at historic and projected trends.

Version 3.0 applied the same two emission scenarios, RCP4.5 & 8.5 but slightly different timeframes. The 2050 and 2080 timeframes selected for assessment represent the five-decade periods of 2015 - 2065 and 2045 - 2095 respectively. These time periods were selected for alignment with the end years of the pre-defined time periods used by the Ontario Climate Change Data Portal (OCCDP). The future rainfall scenarios are compiled from a variety of sources including Environment and Climate Change Canada, University of Western Ontario IDF CC Tool, Ontario Climate Change Data Portal, Ministry of Transportation Ontario Trending Tool.[xciii]

Rainfall Intensity Rates - RCP4.5 (2015-2065)

Table C1: Rainfall Intensity Rates (mm/h) for Town of Oakville

Duration	Return Period (years)					
	2	5	10	25	50	100
5 min	115.9	155	180.8	226.9	262.8	288.3
10 min	80.8	111.6	134.5	177.3	214.1	245.6
15 min	63.2	87.3	105.8	140.3	170	195.3
30 min	41	58	70.8	94	113.4	129.4
1 h	25.5	39	51.3	76.7	102.6	131.1
2 h	15.8	24.7	32.7	48.4	63.7	79.6
6 h	6.8	10.6	14.2	21.7	29.3	35.6
12 h	3.9	5.8	7.5	11.1	14.7	17.8
24 h	2.3	3.3	4.1	5.8	7.4	8.9

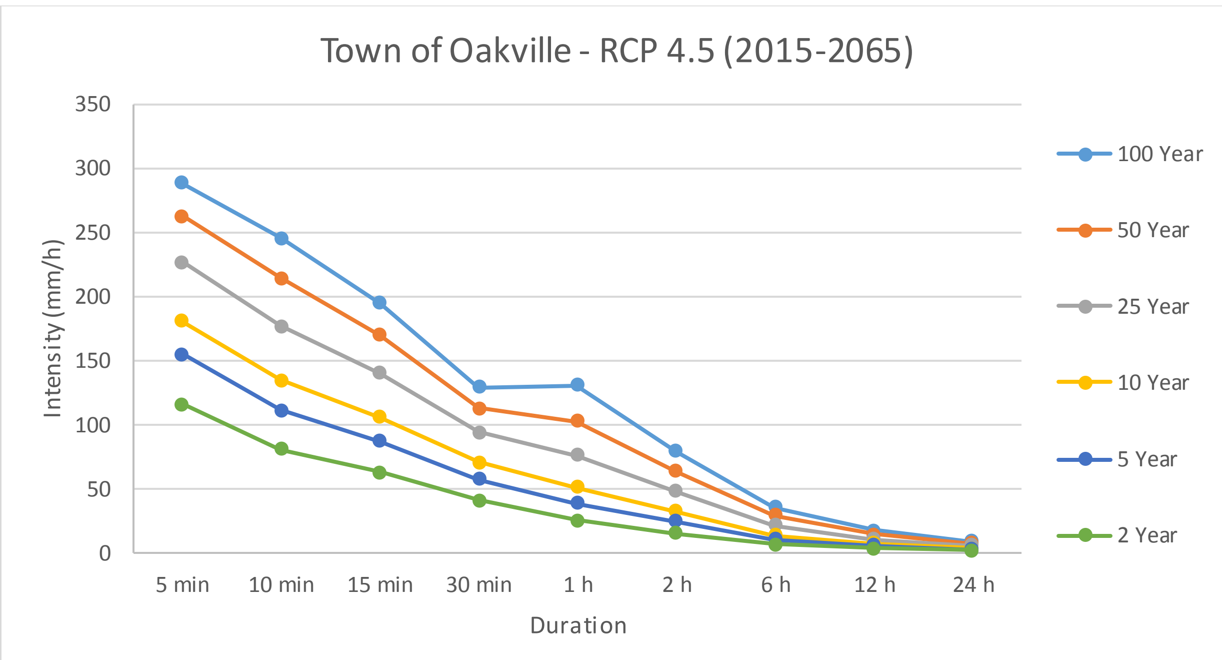


Figure C1: Rainfall Intensity Rates for Town of Oakville

Rainfall Intensity Rates - RCP4.5 (2045-2095)

Table C2: Rainfall intensity Rates (mm/h) for Town of Oakville

Duration	Return Period (years)					
	2	5	10	25	50	100
5 min	127.3	187.6	221.1	264.6	300.4	333.5
10 min	88.7	135.1	164.5	206.8	244.7	284.1
15 min	69.3	105.7	129.3	163.6	194.3	225.9
30 min	45	70.2	86.5	109.6	129.6	149.7
1 h	28	47.2	62.8	89.5	117.3	151.7
2 h	17.3	30	40	56.5	72.9	92.1
6 h	7.5	12.9	17.4	25.3	33.5	41.2
12 h	4.3	7	9.2	12.9	16.8	20.6
24 h	2.5	4	5.1	6.8	8.4	10.3

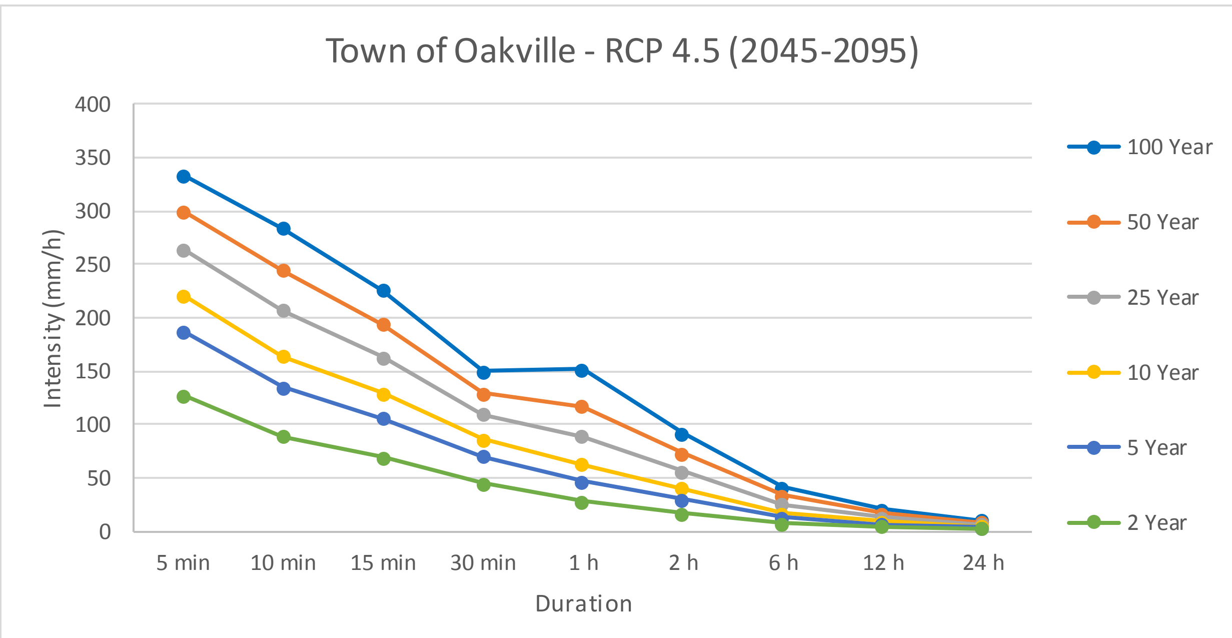


Figure C2: Rainfall Intensity Rates for Town of Oakville

Rainfall Intensity Rates - RCP8.5 (2015-2065)

Table C3: Rainfall Intensity Rates (mm/h) for Town of Oakville

Duration	Return Period (years)					
	2	5	10	25	50	100
5 min	126.2	171.9	201.4	238.4	267.9	288.5
10 min	88	123.8	149.8	186.3	218.2	245.8
15 min	68.8	96.9	117.8	147.4	173.3	195.5
30 min	44.6	64.3	78.8	98.7	115.6	129.5
1 h	27.7	43.3	57.2	80.6	104.6	131.2
2 h	17.2	27.4	36.4	50.9	64.9	79.6
6 h	7.4	11.8	15.8	22.8	29	35.7
12 h	4.2	6.4	8.4	11.6	15	17.8
24 h	2.4	3.6	4.6	6.1	7.5	8.9

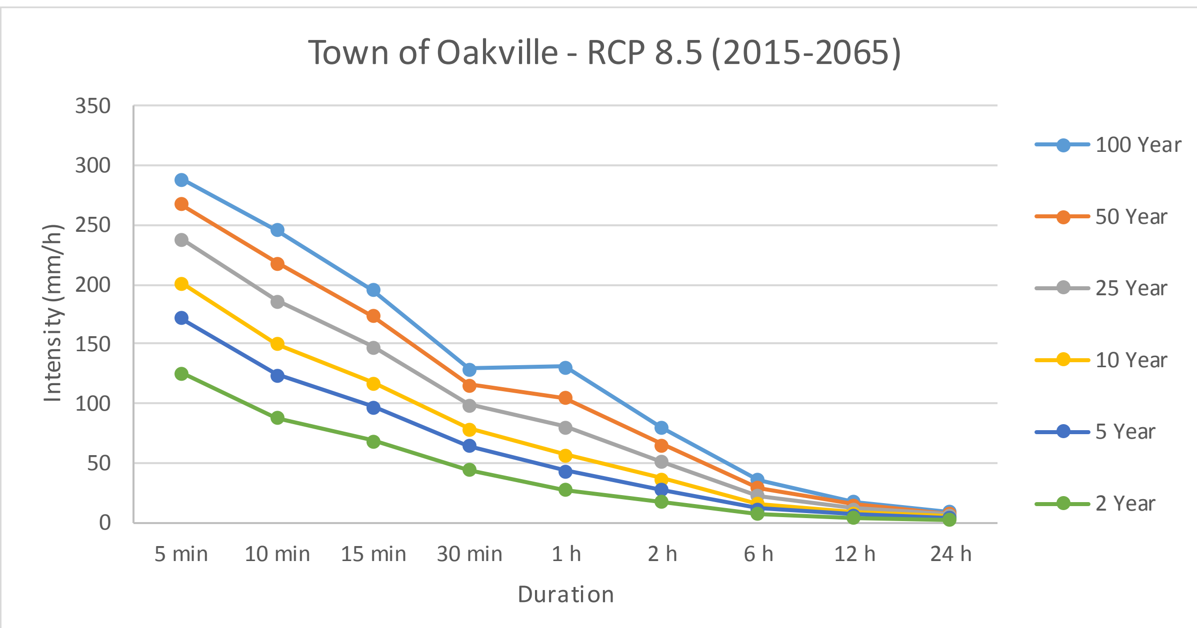


Figure C3: Rainfall Intensity Rates for Town of Oakville

Rainfall Intensity Rates - RCP8.5 (2045-2095)

Table C4: Rainfall Intensity Rates (mm/h) for Town of Oakville

Duration	Return Period (years)					
	2	5	10	25	50	100
5 min	134.7	189.5	236.2	280.1	308.4	344.1
10 min	94	136.4	175.8	219	251.3	293.1
15 min	73.4	106.8	138.1	173.2	199.5	233.1
30 min	47.6	70.9	92.4	116	133.1	154.4
1 h	29.6	47.7	67.1	94.8	120.5	156.6
2 h	18.4	30.3	42.7	59.8	74.8	95
6 h	7.9	13	18.6	26.8	34.4	42.6
12 h	4.5	7.1	9.8	13.7	17.2	21.3
24 h	2.6	4	5.4	7.2	8.7	10.6

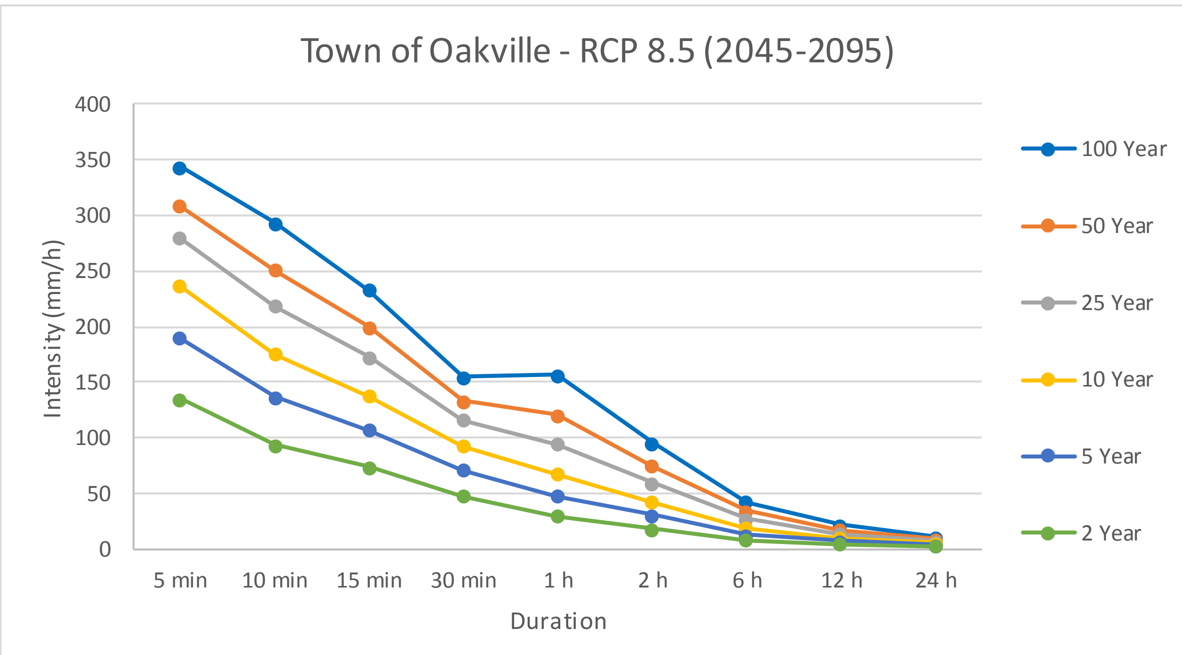


Figure C4: Rainfall Intensity Rates for Town of Oakville

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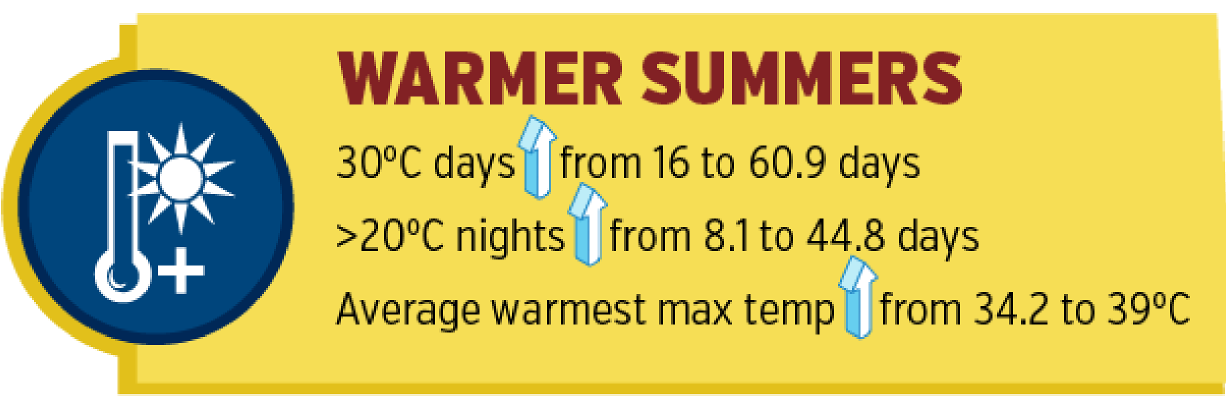
Infographics for Burlington Region

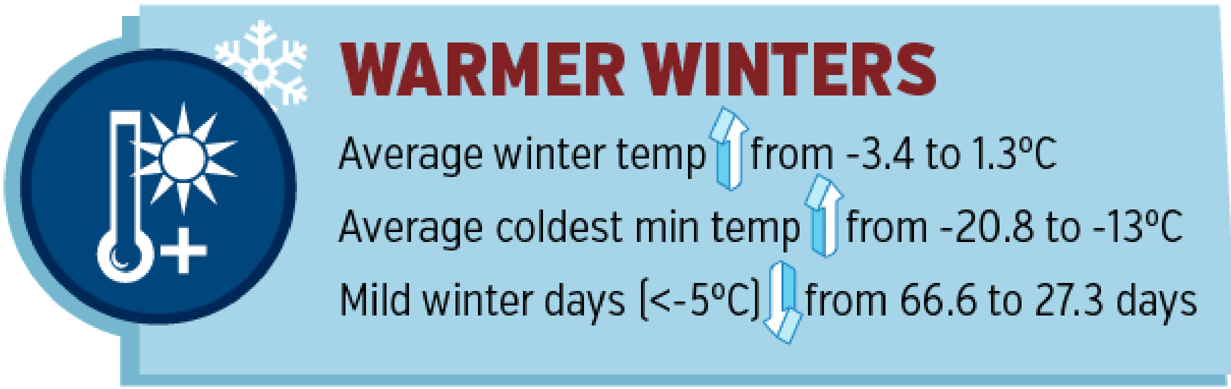
The following infographics were developed in-house to support the content presented in the Climate Projections Report for Burlington Region.

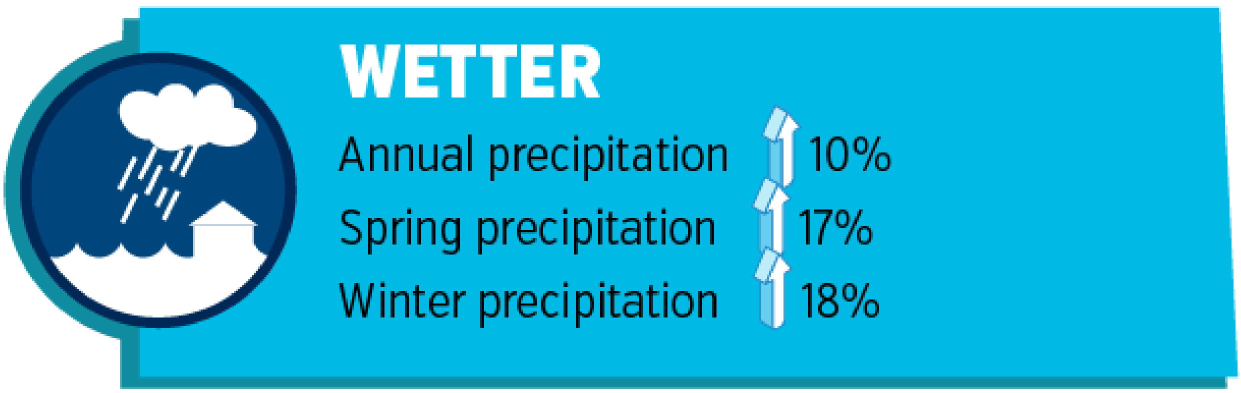
Project Infographic: Warmer, Wetter and Wilder

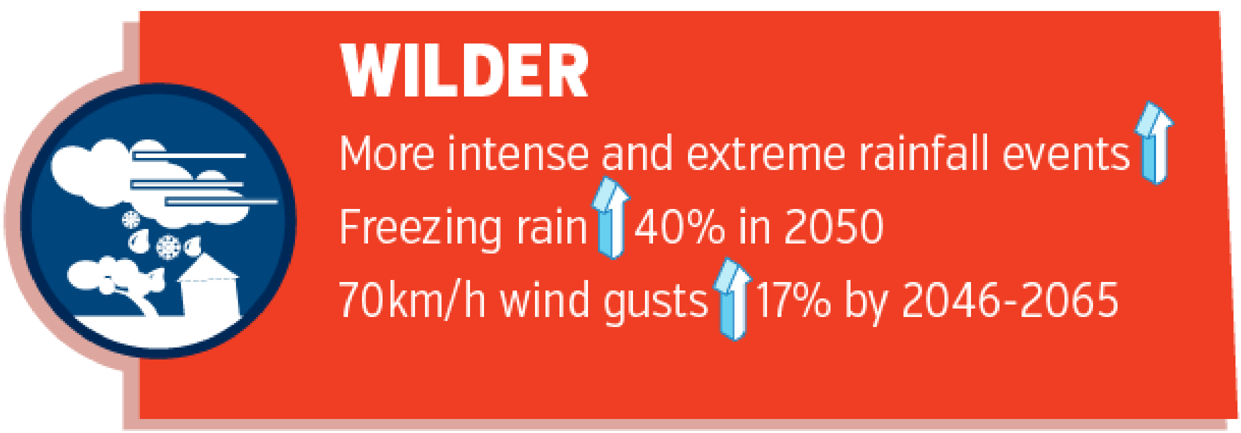
Additional Infographics

The infographics presented below provide a snapshot of what is projected under the themes of "warmer, wetter and wilder" in Burlington. All scenarios are for high emissions (RCP8.5) which is how the world is currently trending. The "warmer" and "wetter" infographics are for 2051-2080 while the "wilder" infographic is for the dates specified.









Story map icons

Below is a timeline of events which are highlighted in the story map available at https://storymaps.arcgis.com/stories/d3d173cc02b947bd909e326c4baaaf36. The story map was created to profile events which have already taken place in Burlington and which are projected to become more common.


2002 West Nile Virus in Halton
July 2013 Extreme heat
Dec. 2013 Ice storm
Aug. 2014 Extreme rain and flooding
Jan 2014 Extreme Cold
Nov. 2014 High wind
March 2017 High wind
Spring 2017 High lake levels
Sept. 2017 Extreme heat
Oct. 2017 High wind
April 2018 High wind
April 2018 Ice storm
May 2018 High wind
Summer 2018 Extreme heat
Jan. 2019 Extreme cold
March 2019 Halton a risk area for Lyme disease
Spring 2019 High lake levels
July 2019 Extreme heat
Oct. 2019 High wind
Dec. 2019 High wind and freezing rain
July 2020 Extreme heat
Nov. 2020 Extreme heat
Nov. 2020 High wind

CITY OF Burlington

SUBJECT: City Hall – One Window Design Update

TO: Environment, Infrastructure & Community Services Cttee.

FROM: Environment, Infrastructure and Community Services

Report Number: EICS-05-21

Wards Affected: All

File Numbers: 175-02-7

Date to Committee: March 4, 2021

Date to Council: March 23, 2021

Recommendation:

Receive and file environment, infrastructure and community services report EICS-05-21 providing One Window service counter and long-term design concepts and schedule for the 1st floor City Hall renovations.

PURPOSE:

Vision to Focus Alignment:

- Support sustainable infrastructure and a resilient environment
- Building more citizen engagement, community health and culture
- Deliver customer centric services with a focus on efficiency and technology transformation

Background and Discussion:

The City had initiated a study to review office space requirements and work space requirements in 2019 and had retained +VG Architects to assist in this process. As a continuation of this project staff and +VG worked with both Service Burlington and Development Application Processing staff to create a customer focus space on the first floor of City Hall which has not seen a major renovation since it was built in 1985. This project is in line with The Red Tape Red Carpet Task Force report that was approved by council on September 23, 2019 and included amongst its 22 recommendations, recommendation 16 to:

Create an “Open for Business” customer service window, ideally on the first floor of City Hall, co-locating key staff from different business-related departments for easy public access and on-the-spot collaboration & problem solving.

The Red Tape Red Carpet Task Force also included recommendation 12 to “Develop a clear vision and associated branding strategy at the City of Burlington with respect to business attraction and development.” Work on what is now known as the Burlington One Brand initiative commenced pre-COVID-19, but the bulk of the work has been paused as a result of the pandemic. However, the development of the One Brand and the Burlington brand promise will be front of mind as we design the look and feel of the customer service window, and how staff and customers will interact with the space. The Burlington brand will be directly influenced and guided by the physical space, technology, and culture at City Hall, so it is crucial that these initiatives are in alignment.

This report will provide an update on the City Hall first floor design concept. The renderings in this report provide a framework for future design and the mainly neutral finishes will allow for future flexibility with accent colours once the One Brand initiatives are completed. The concepts show how the new physical space which has been reconfigured to address the existing concerns and allow for a greater customer experience. Furniture in place is flexible allowing for reconfiguration in the lobby space for various event situations. Workstations behind the counter can be reconfigured to suit evolving work requirements. Public Safety has remained a top priority in the design concept including accessibility, ergonomics, and security.

Strategy/process

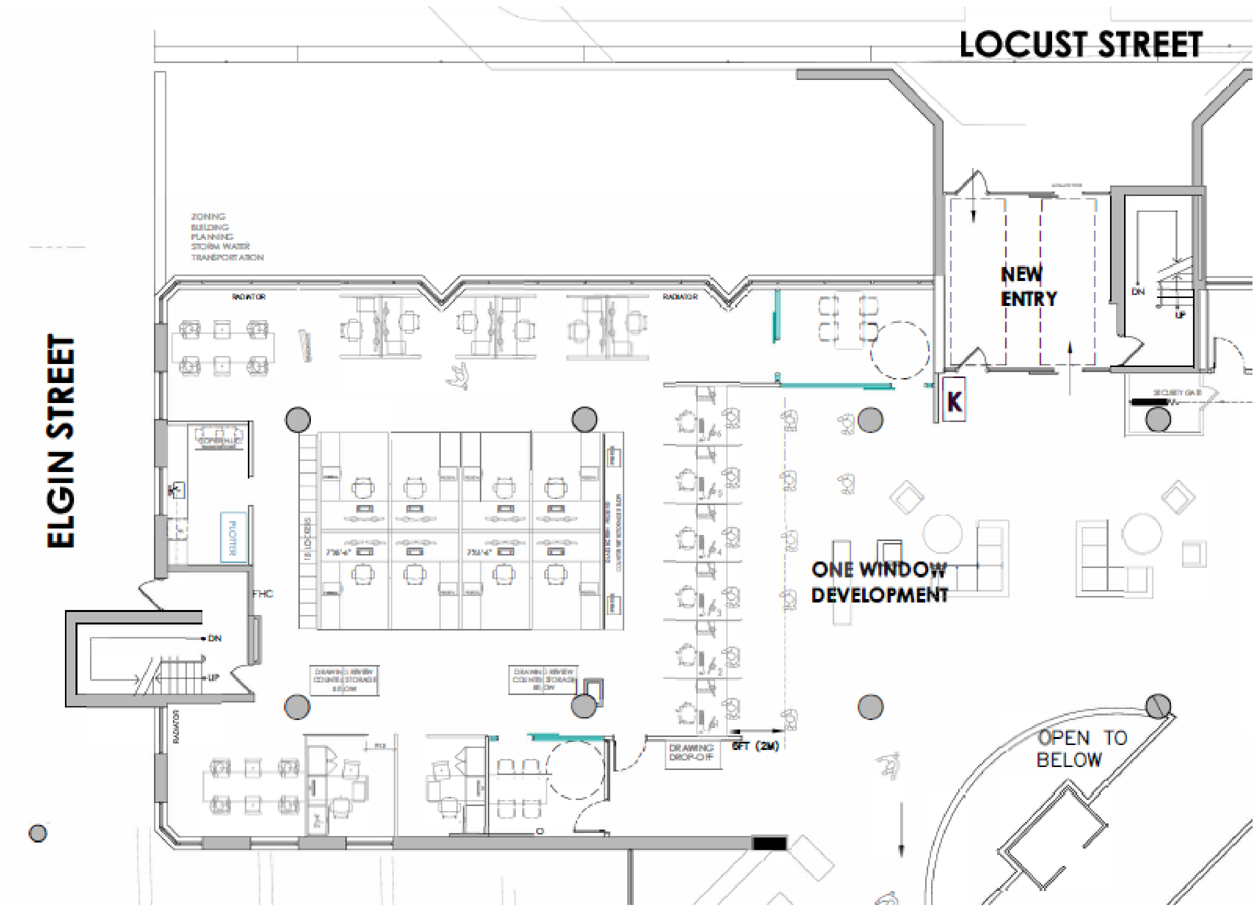
This process has been in collaboration with multiple department stakeholders all with a common goal to achieve exceptional customer service. It has to be understood that the space and concepts shown is just one of the tools used to achieve this. Aligned with this is also the technology requirements to assist with a remote workforce, which has been highly used during the pandemic. Further technology enhancement including software will be needed to empower staff and customers during the development application process.

The following are a few design features that were incorporated into the City Hall first floor area:

New One Window Development Counter and additional supporting consultation rooms

This design feature incorporates the recommendation in the Red Tape Red Carpet report identifying an “Open for Business” customer service window ideally located on the first floor. The counter allows for the customer to obtain all the information required during the development application process. Design items include:

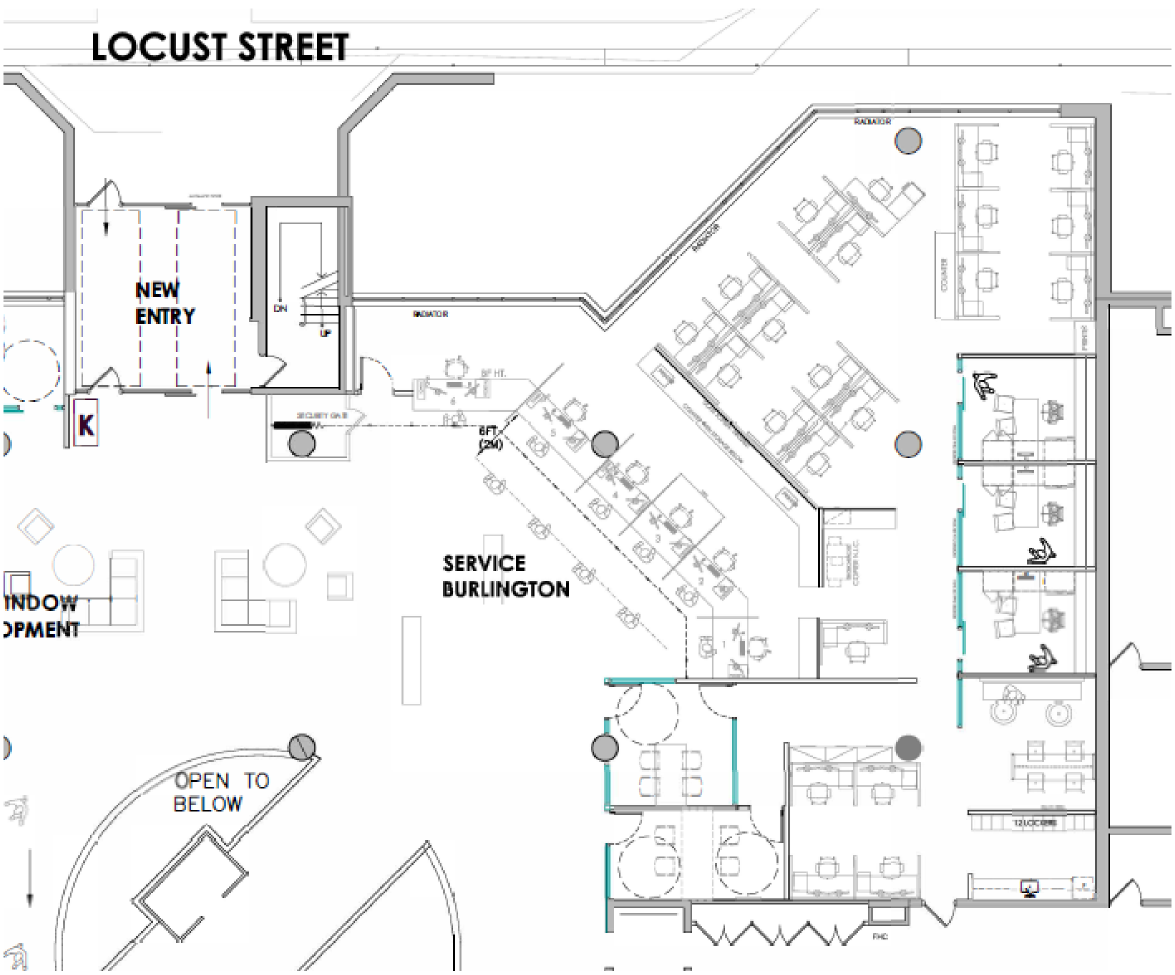
- 6 stations complete with technology
- Supporting workstations behind the counter
- 2 Consultation Rooms
- Queuing space in front of the counter
- Supporting lobby space furniture



New Service Burlington Counter and additional supporting consultation rooms

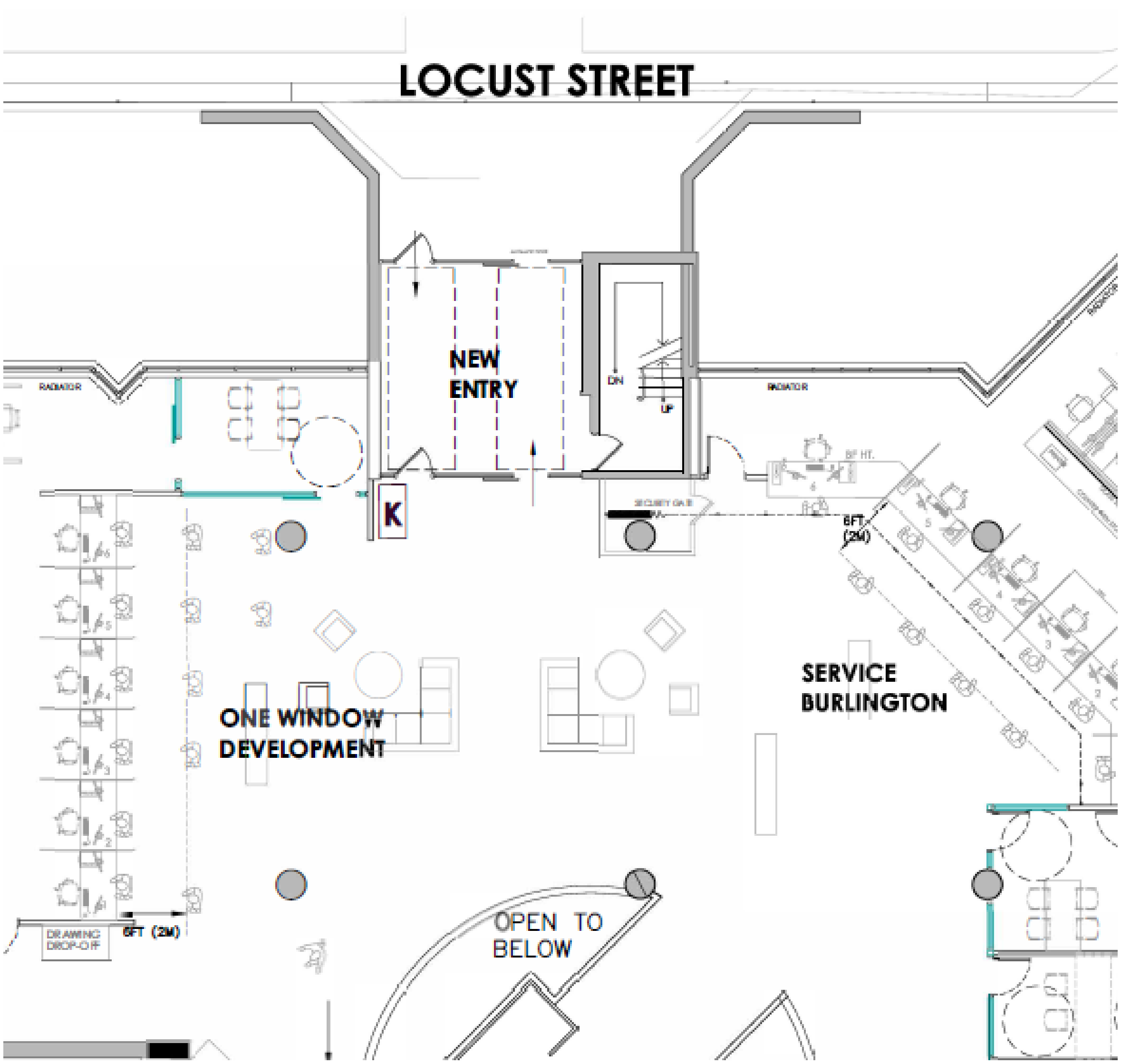
A large aspect of this design was to allow for the customer to wait in a queuing area without being in the flow of traffic around the lobby atrium, which assists with privacy while being served at the counter. The addition of consultation rooms allows for longer conversations to take place as well as first attendance meetings. Design items include:

- 6 stations complete with technology
- Supporting workstations behind the counter
- 2 Consultation Rooms
- Queuing space in front of the counter
- Supporting lobby space furniture



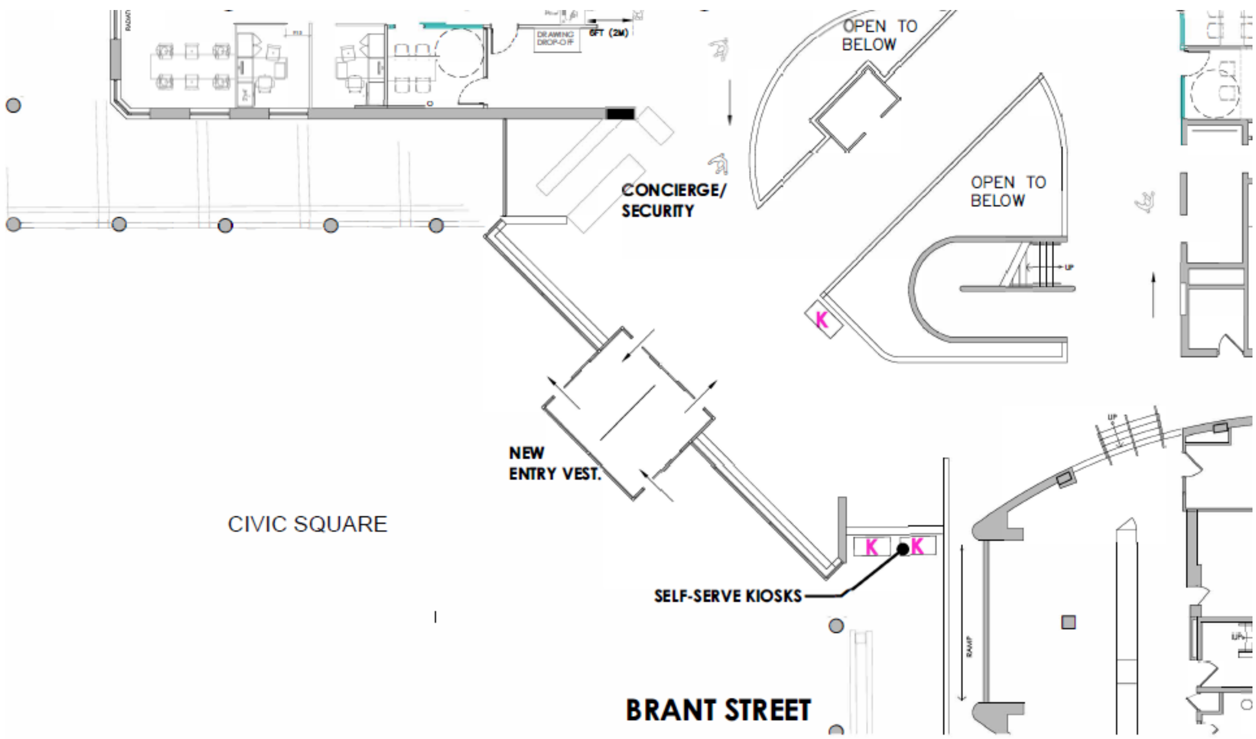
Realigned Locust Street entrance

As the service counters and customer serve experience is a key item in the design of the first floor space, we have an opportunity to correct some building performace features including the Locust Street entrance vestibule. The widening of the entrance allows for improved accessibility as well as proper timing between doors when opening and closing. This reduces the amount of heat loss from the lobby space aswell as improve customer comfort by avoiding sudden infiltration of ouside air.



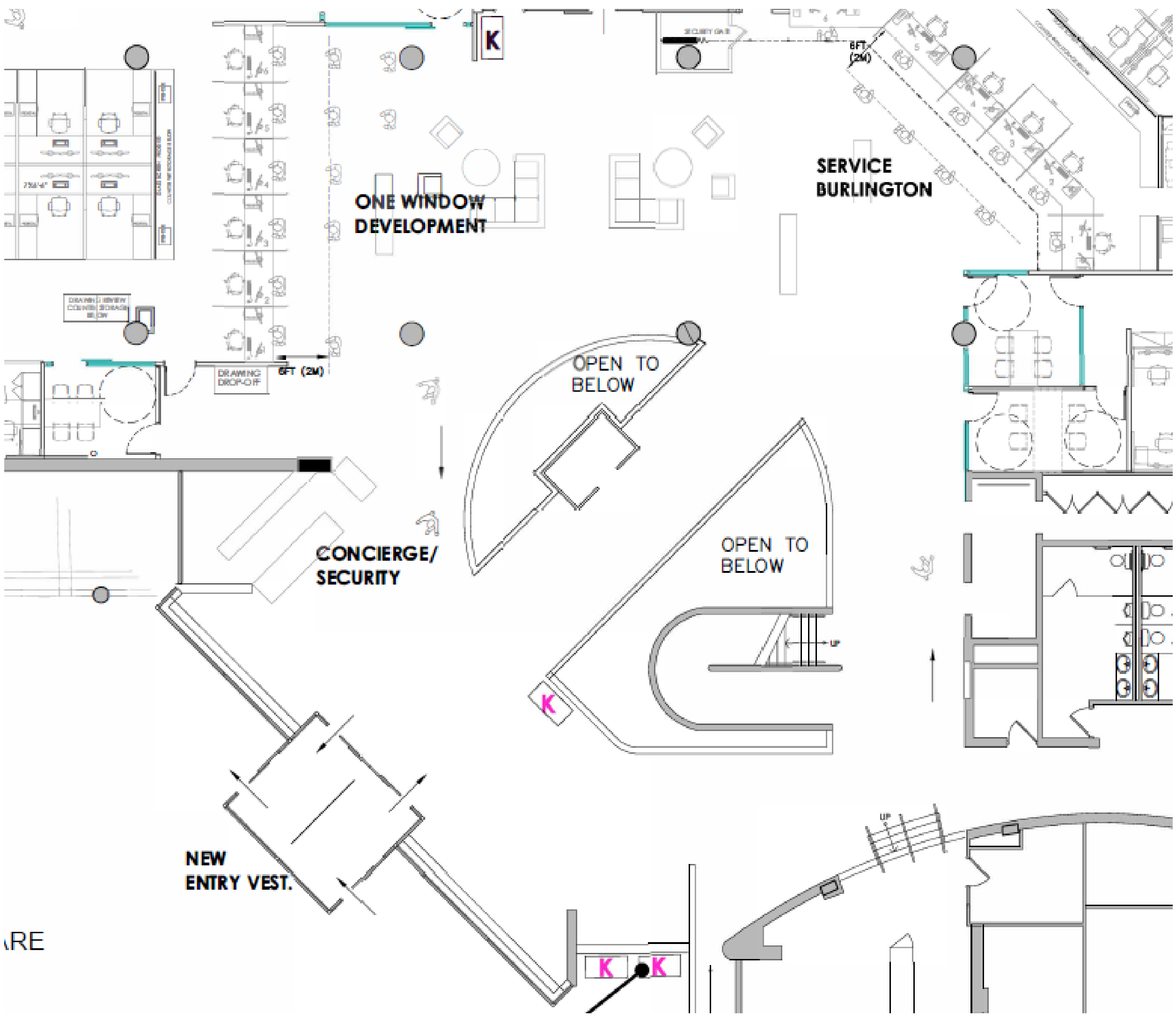
New Front Entrance connecting Civic Square to the lobby space and relocated Security/Concierge Desk

In collaboration with the Civic Square project it is important that the two spaces align and achieve design excellence. There is an opportunity to enhance the city hall space by pulling similar Civic Square design elements into the lobby space which is enhanced by a new front entrance connecting the two spaces. The timing of this work would be phased after the customer service counters are completed and combined with construction work associated with the Civic Square project.

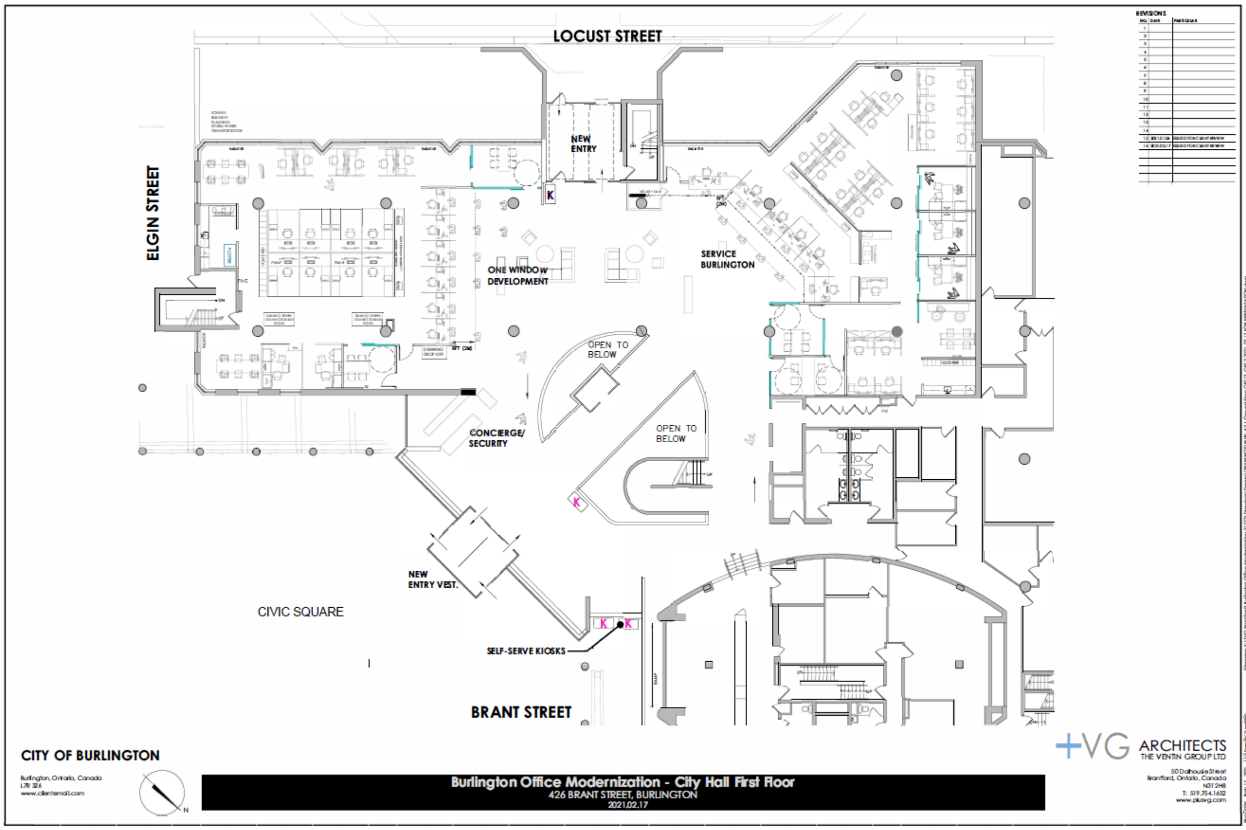


Additional floor space including a link connecting the front entrance to the Service Burlington Counter

Another design feature that allows for additional collaboration space, physical distancing as well as a link to the Service Burlington counter is the addition of a bridge across the opening in the Atrium. This design element allows for additional floor space during events as well as collaboration for small meetings. As the City Hall Atrium space is used for special events including speaking events and other public events, the addition of the bridge increases the activity space and enhances the other design elements.



Overall Floor Plan

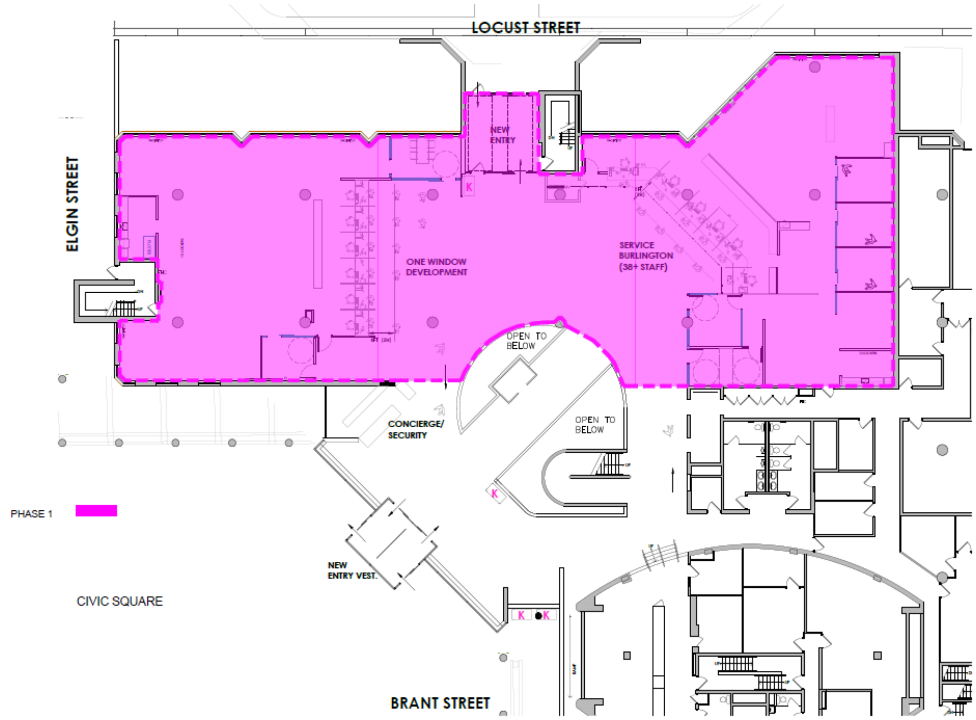


Renderings:

Project Phasing

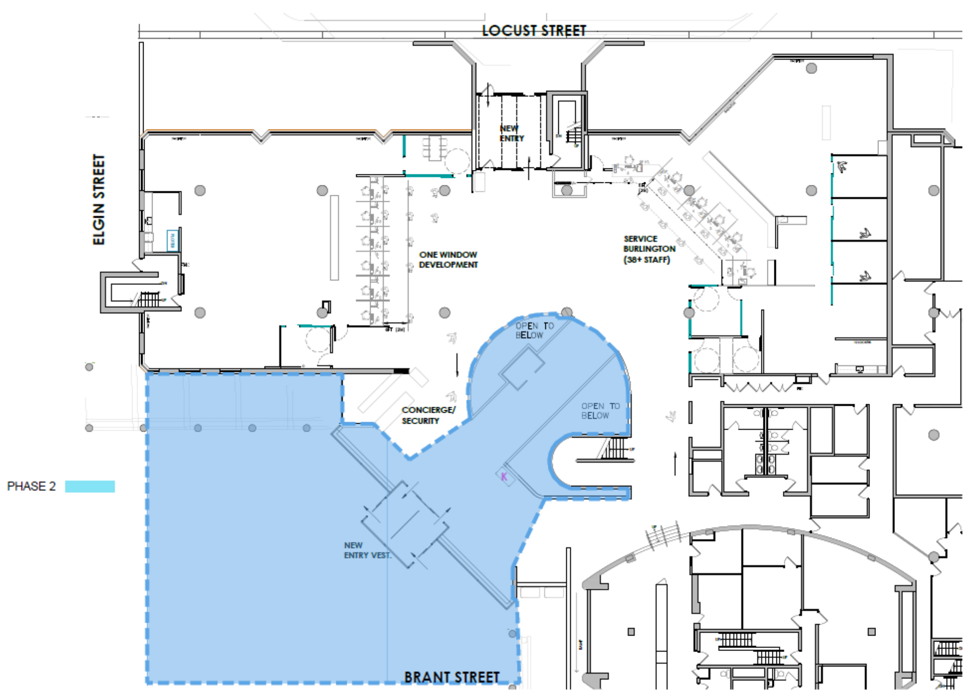
As this project will take place within an existing occupied facility, phasing will be required to maintain service delivery and customer expectations. An option at his time is to relocate the Service Burlington counter to another location within city hall. This would allow for Phase 1 to incorporate both service counters and Locust St. entrance. Timing for construction of this work is Q3 2021 – Q2 2022.

Phase 1



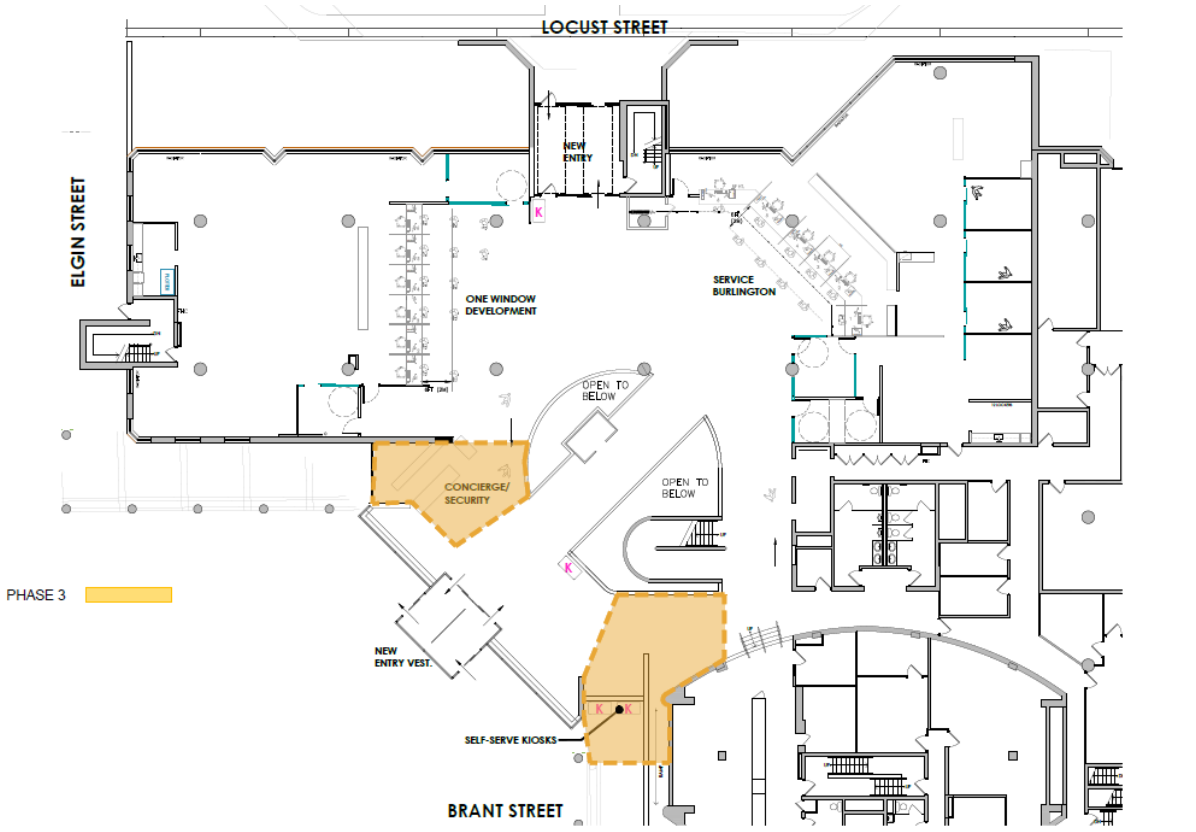
Phase 2

Phase 2 would be completed and incorporated into the Civic Square Project



Phase 3

Phase 3 would be incorporated after the new entrance is completed that would include removal of the existing entrances and adding the security and concierge desks.



Options Considered

Multiple configurations of the service counters and support space on the first floor have been considered and reviewed with stakeholders. The goals are to create a space that is safe, functional and customer focused which has been applied to the design shown in this report.

Financial Matters:

Source of Funding

Funding has been approved in the 2021 capital budget to proceed with this work.

Other Resource Impacts

Other staff have been assigned to provide project management during the design and construction phase.

Climate Implications

As this project provides an excellent opportunity for renewal of aging infrastructure, the renewal of the HVAC distribution system within the construction zones will be completed. This will compliment the recent completion of the main HVAC units in the lower mechanical room and enhance the overall energy performance of the facility. The changes to the locust street doors will allow for less infiltration of outside air, allowing the heating and cooling systems to use less energy.

Engagement Matters:

Various departments have been involved in the city hall first floor design process including staff from Development Application, Service Burlington, Engineering Services, and Facility Operations.

Conclusion:

This report has been submitted to provide an update on the design concepts for the first floor of City Hall. Design Development is proceeding for Phase 1 and construction is anticipated to be completed Q2 of 2022. Following phases will be brought forward with further updates.

Respectfully submitted,

Ken Pirhonen

Manager of Facility Assets

905-335-7600 ext 7408

Report Approval:

All reports are reviewed and/or approved by Department Director, the Chief Financial Officer and the Executive Director of Legal Services & Corporation Counsel.