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Technical Memorandum

Date: **July 4, 2025**

Project #: **20-665**

Re: **Future Climate Change Conditions Assessment:**
Confirmation of Regional Flow as Governing Flow with Respect to Secondary Plan / Tertiary Plan Block Sizing in the Context of Future Climate Change Conditions (Alloa / Town of Caledon)

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1. Purpose and Scope

This memo provides technical justification—grounded in watershed modelling results, regulatory policy, and climate-data trends—that the Regional Storm (i.e., Hurricane Hazel) governs peak flows and flood levels for sub-watershed-scale drainage areas and general block planning purposes, even in the context of climate change considerations provided by the Town of Caledon and TRCA. The hydrology of the Alloa study area in the Town of Caledon was evaluated to demonstrate this. The hydrologic analyses were conducted using the Visual OTTHYMO (VO) model, which is the current subwatershed study model approved by TRCA for this area. The findings conclude that the Regional storm governs for:

- Pond block area requirements (pond sizing is based on Visual OTTHYMO model results)
- Conveyance calculations for open-channel and culvert/bridge crossings (channel and culvert capacity are evaluated using HEC-RAS, with Visual OTTHYMO flows as input).
- Hazard mapping / regulatory flood-plain delineation to establish development limits (flood mapping is evaluated using HEC-RAS, with Visual OTTHYMO flows as input).

It is important to note that storm sewer sizing, dual drainage analysis (major/minor system) and overland flow easements are sometimes designed using the Rational method and are only required to consider flows up to the 100-year storm; in this case, the 100-year storm may govern. In this case, should the Town choose to consider climate change / update IDF parameters, there could be an impact the design of sewers and storm drainage infrastructure within the subdivisions. However, these items do not impact channel or pond block sizing at the Secondary / Tertiary Plan stages.

2. Regulatory & Climatic Framework

The following table compares the definition and implementation of the Regional Storm (Hurricane Hazel) to the 100-year storm.

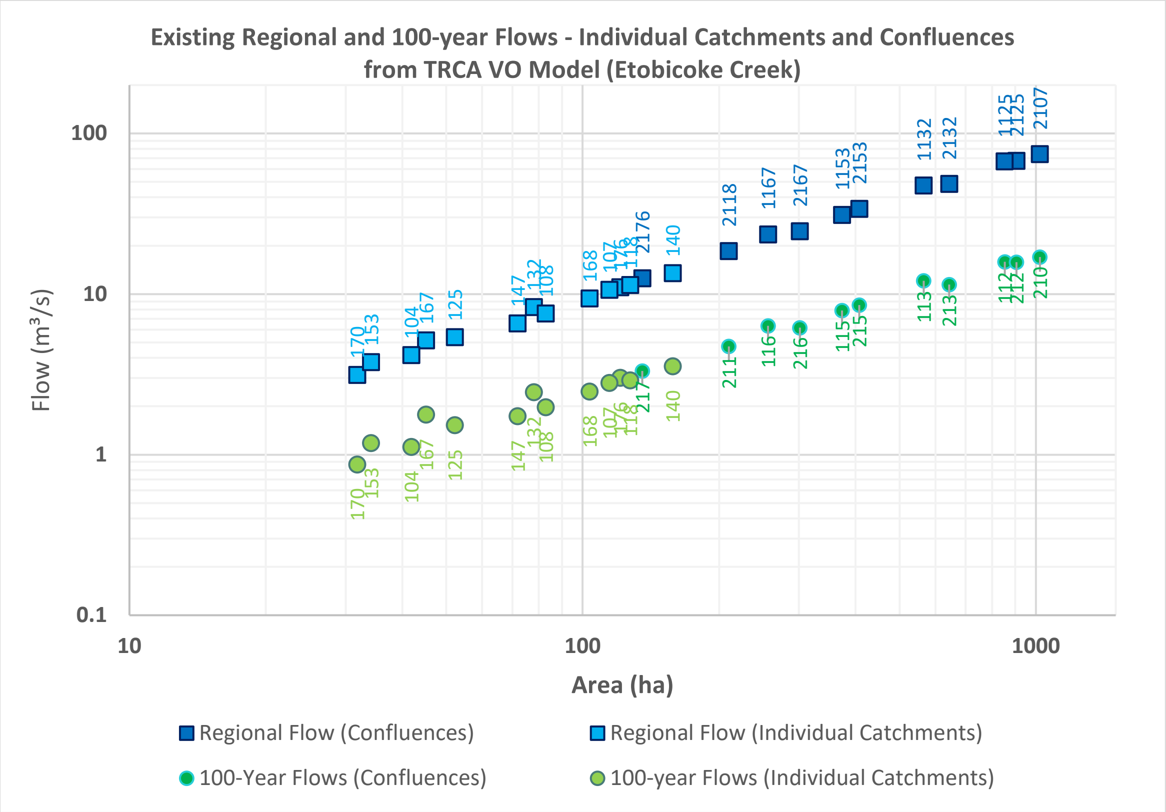
Table 2.1: Regional Storm versus 100-Year Storm Comparison

Item	Regional Storm (Hurricane Hazel)	100-Year Storm (current)
Definition	Observed extreme event, 15-17 October 1954. Regulatory flood standard under O. Reg. 166/06 and TRCA policy.	Synthetic storm derived from station-based IDF curves; based on statistical analysis of historical rainfall events.
Antecedent Moisture Condition	Conservative approach - AMC III (saturated) per TRCA technical guidelines (for modelling last 12 hours); AMC II conditions for modelling 48 hour Regional storm.	AMC II (average) unless otherwise directed
Climate-Change Adjustment	None. Independent Review of the 2019 Flood Events in Ontario (Special Advisor Doug McNeil, MNRF, Nov 2019) notes in Section 6.1.1.2 and Section 6.1.3.3 that "little guidance" exists on modifying storms for climate change and that "areas using a regional regulatory storm (i.e. Hurricane Hazel or the Timmins Storm) are less likely to see significant increases in the size of regulated flood-plains as these events have higher return periods (compared to the 100-year storm).	Municipality-specific. e.g. City of Burlington adopted +15 % intensities in 2020 (RCP 8.5, 2100) (burlington.ca, conservationhalton.ca) Town of Caledon currently has no specific requirement for climate adjustment but has identified potential methods of completing this (Climate Atlas, TRCA climate change forecasting, etc.)
Town of Caledon Requirements / TRCA Requirements	Uses unaltered Regional storm. TRCA requires mapping of the uncontrolled Regional floodplain assuming post-development conditions, which is a conservative assumption (assumes Regional control ponds do not function).	No IDF update as of 2025—the current design manuals reference Environment Canada 2003 curves (caledon.ca). Use current 100-year IDF parameters / potential climate change adjustment (TBD by Town).

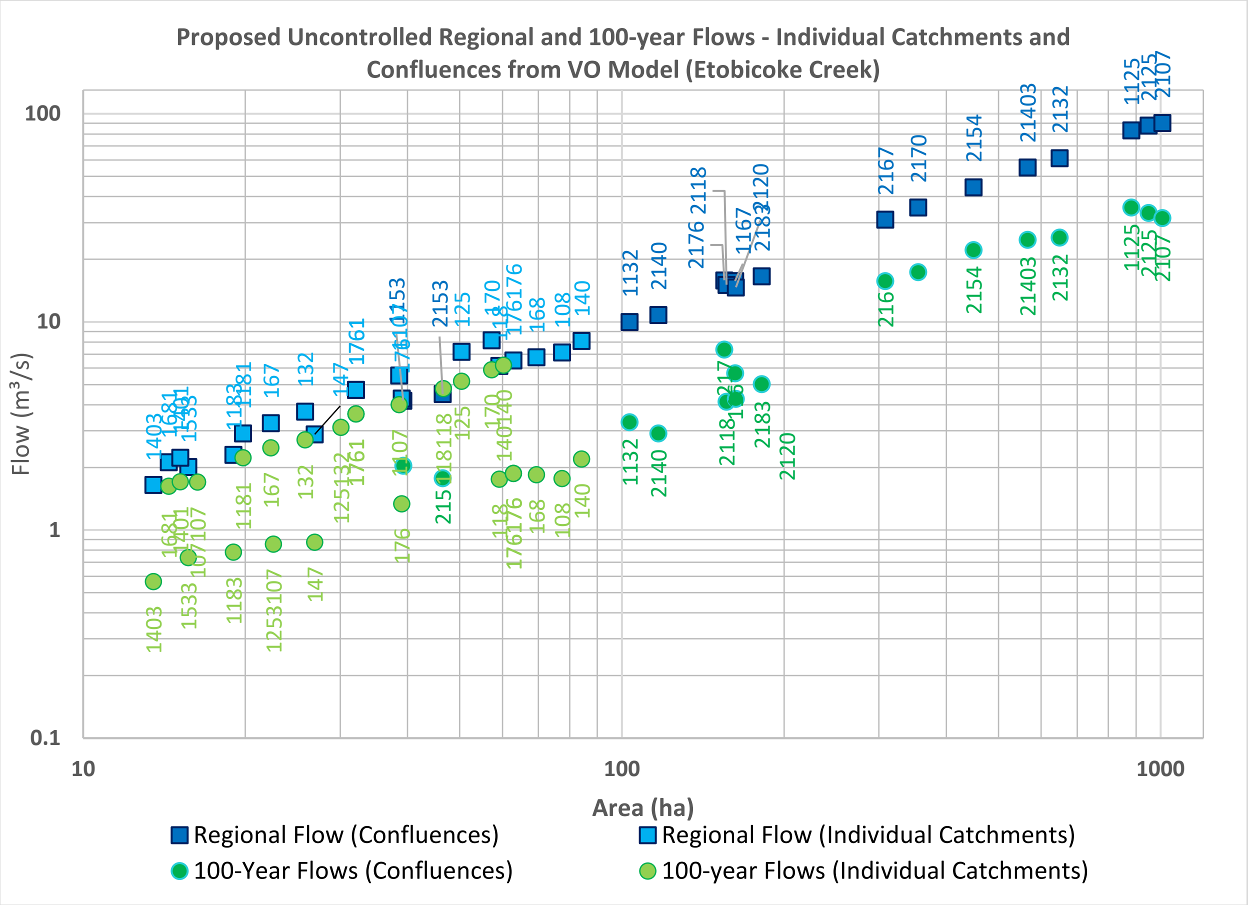
3. Alloa VO Model – Peak-Flow Comparison

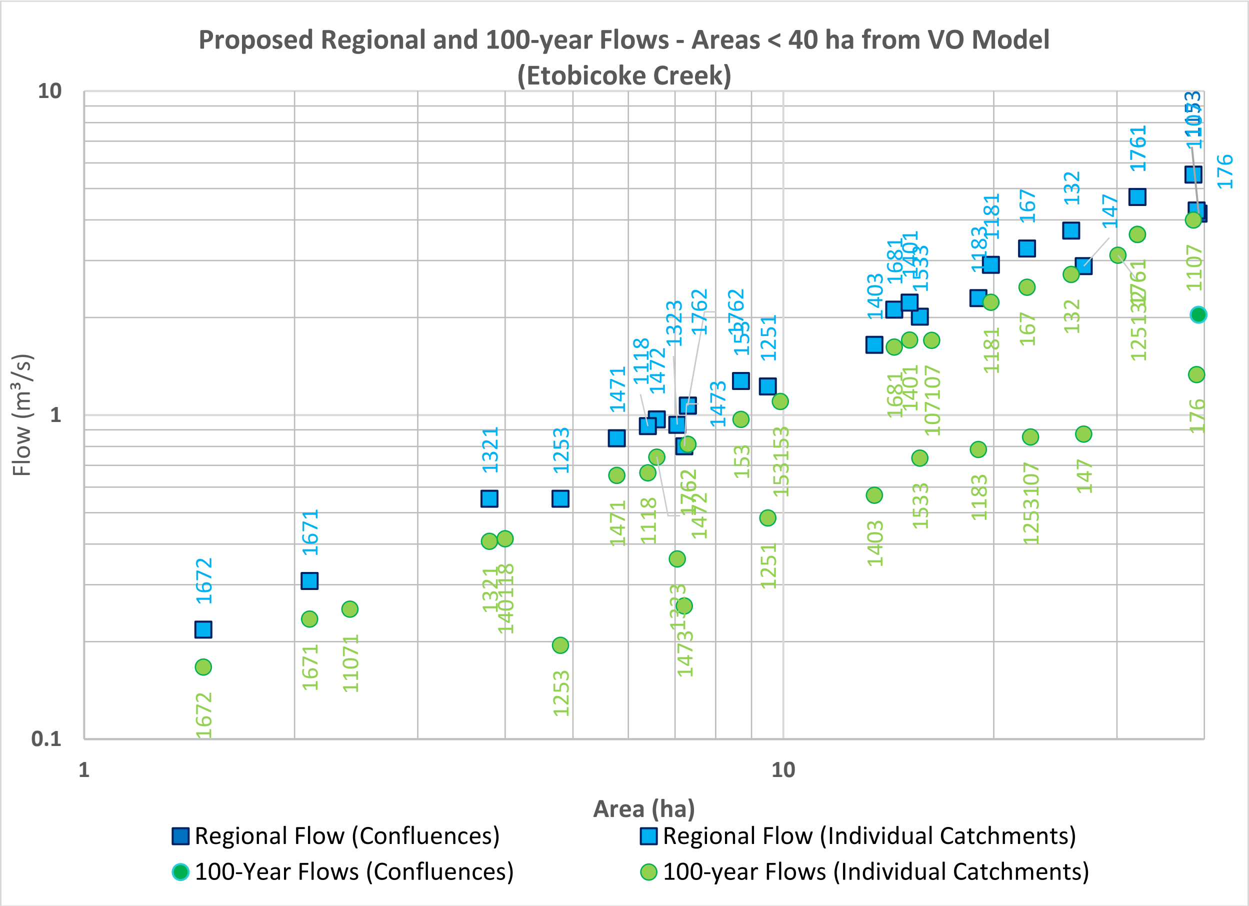
A direct export from the approved TRCA VO model (originally developed in the 2013 Etobicoke Creek Hydrology Update Study – ECHUS) shows that Regional peaks exceed the current 100-year Chicago storm peak flow for every catchment and confluence in the Alloa Study area. The following graph summarizes the results for various nodes (NHYDs) in the VO model. In general, the existing Regional flows are 290% to 440% higher than the existing 100-year results (average of 380% higher). This clearly indicates that the Regional flows used for conveyance calculations and flood mapping will always be greater than the 100-year storm flows in the Alloa study area, regardless of potential climate change adjustments to the 100-

year storm. It is unlikely that the 100-year storm will increase by ~300% based on a review of other climate change adjustments to the 100-year storm IDF parameters n other municipalities (e.g., 15% increase in the City of Burlington for RCP 8.5 / 2100).



A similar relationship is observable when comaring the post-development uncontrolled flows. The Regional flows are 130% to 400% greater than the 100-year flows (~220% higher on average). Since this is not immediatley clear on the graph, particularly for smaller drainage areas, the results tables are included in the attachments for ease of review. For smaller drainage areas, the 100-year storm is closer to the Regional storm, but even in these cases, the Regional storm is 130% of the 100-year storm flows. A graph focusing on the the smaller areas is provided to confirm that the Regional flows exceed the 100-year flows even for the small, developed areas, even if the 100-year flows were increased to account for climate change.


Proposed Uncontrolled Regional and 100-year Flows - Individual Catchments and Confluences from VO Model (Etobicoke Creek)
Flow (m³/s)
100
10
1
0.1
Area (ha)
10
100
1000
Regional Flow (Confluences)
Regional Flow (Individual Catchments)
100-Year Flows (Confluences)
100-year Flows (Individual Catchments)
1403
1681
1401
1533
1183
1181
167
132
147
1761
176
107
2153
125
170
118
176176
168
108
140
1132
2140
2176
2118
1167
2183
2120
2167
2170
2154
21403
2132
1125
2125
2107
1253107
2154
2118
2120



Proposed Regional and 100-year Flows - Areas < 40 ha from VO Model (Etobicoke Creek)

The volume of the 100-year storm (for various durations) and the Regional storm were also compared. The Regional storm has over 200% more precipitation than any duration of the 100-year storm. This, and the use of higher antecedent moisture conditions (AMC III vs AMC II) in the Regional storm, results in a significantly higher surface water runoff.

Table 3.1: Comparison of Regional Storm versus 100-Year Storm Precipitation

Duration (hours)	100-year [1] Total Precipitation Depth (mm)	Hurricane Hazel Total Depth (mm)
4	89.9	–
6	93.3	–
12	98.1	213 (last 12 hours)
24	101.5	–
48	–	285 (48 hour)

[1] 100-year depths based on Town of Caledon IDF parameters:
Average Intensity (mm/hour) at time "t" = storm duration = $4688/(t+17)^{0.9624}$
Total rainfall volume (mm) = average intensity (mm/hour) x duration (hours)

Therefore, pond storage requirements will be governed by the temporary detention of the larger Hurricane Hazel storm runoff, versus the 100-year storm runoff. This has been observed in nearly every subwatershed study / Regional pond design within the GTA – the Hurricane Hazel storm volume requirements are greater than the 100-year storm volume requirements. Even a modest increase in the 100-year IDF parameters to account for future climate change / increased intensity (such as the 15% increase in intensity as per City of Burlington's climate change adjustment[1]) would not generate more volume than Hurricane Hazel. The intensities and volumes would have to be more than double to approach the magnitude of Hurricane Hazel.

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[1] The City of Burlington's updated IDF parameters are based on the RCP 8.5 / year 2100 climate change scenario.

4. VO Model – Synthetic Flow Comparison

To further verify the conclusions from Section 3, synthetic catchments, parameters, and flows were generated and tested for hypothetical existing and developed catchments ranging from 1 ha to 1000 ha. Various storm distributions and durations were included in this comparison.

The following simplified approach was used to compute Time-to-Peak (T_p) and assign parameters for the range of hypothetical, “square-shaped” catchments (1 ha to 1000 ha) under three Curve Number (CN) scenarios, in order to create multiple hydrologic model runs comparing the Regional storm to the 100-year storm. The NASHYD command was used to simulate pre-development catchments, and the STANDHYD command was used to simulate post-development catchments.

- **Flow Path Length (L):**
  Each catchment is idealized as a square; the longest overland flow path is its diagonal:

  Length of diagonal (in meters) = 100 x (2 x Area)$^{0.5}$

- **Lag Time (t_{Lag})**, computed using the NRCS/SCS Upland (lag) formula (TR-55, Eq. 2-4), converted to hours, where L is the length (as per above, in feet), and S is slope (set at 0.01 m/m = 1%):

$$t_{Lag} = \frac{0.80}{1900} \times L^{0.8} \times \left(\frac{1000}{\text{CN}} - 9\right)^{0.7} \times S^{-\frac{1}{2}}$$

- **Time-to-Peak (T_p):**
  Assumed as 1.33 × t_{lag} per TR-55/SCS practice):

- **Curve Numbers:**
  - CN = 65 (AMCIII value of 81 used for Regional scenario)
  - CN = 75 (AMCIII value of 87 used for Regional scenario)
  - CN = 85 (AMCIII value of 93 used for Regional scenario)

- **Initial Abstractions (Ia):**
  - For the three CN scenarios noted above, the following initial abstractions were applied to the 100-year storm scenarios:
    - CN 65 → IA 15mm
    - CN 75 → IA 10mm
    - CN 85 → IA 5mm
  - For the Regional storm scenarios, IA was set to 0mm to simulate saturated conditions.

- **Post-development scenarios:**
  - The same CN and Ia values applied to the pervious portion of the post-development catchments (modelled as Visual OTTHYMO STANDHYD commands).
  - An imperviousness value of 80% was applied to both the 100-year and Regional scenarios.
- **Catchment Areas:** 1 ha, 2 ha, 5 ha, 10 ha, 25 ha, 40 ha, 45 ha, 50 ha, 55 ha, 60 ha, 75 ha, 100 ha, 250 ha, 500 ha, and 1000 ha areas were modelled.
- This approach uses CN term and catchment length to produce timing for a simple, single-segment, triangular for each hypothetical catchment. It is not a substitute for the detailed model results and Tp values in the approved Alloa model from the ECHUS study, but provides consistent T_p values scaled for the length and land use type to facilitate comparison of the hypothetical scenarios. The calculations used in this approach are based on USDA NRCS. 1986. *Urban Hydrology for Small Watersheds*, Technical Release 55 (TR-55), Chapter 2, Eq. 2-4 and USDA NRCS. 2007. *National Engineering Handbook*, Part 630 – Hydrology, Chapter 12.

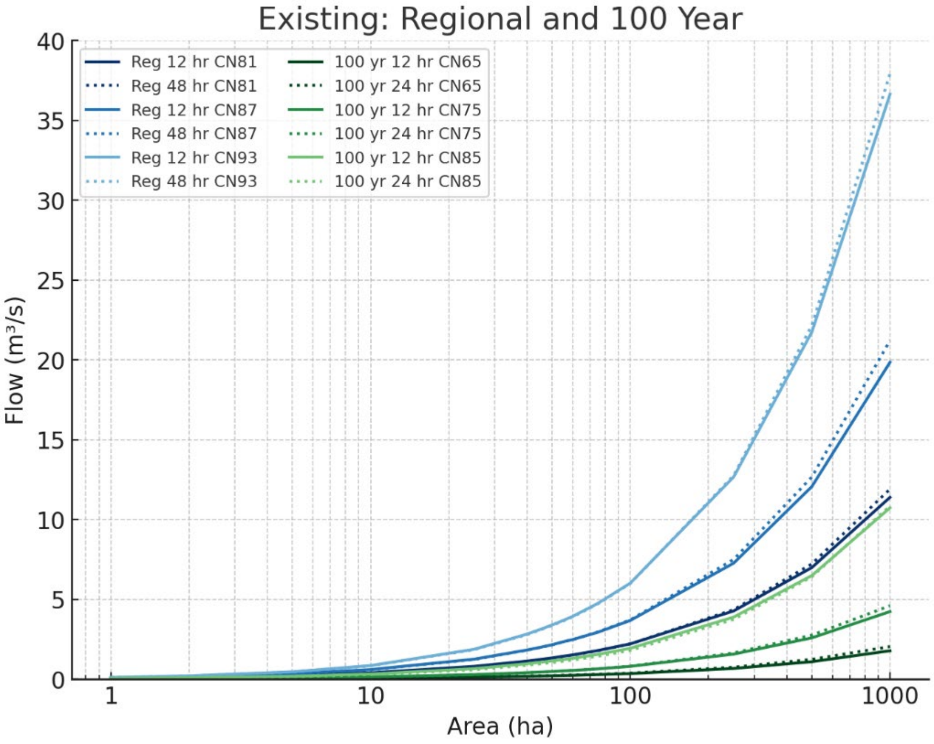
The following table of L, t_l, and T_p (hours) for each area and CN was generated and used to parameterize the Visual OTTHYMO model.

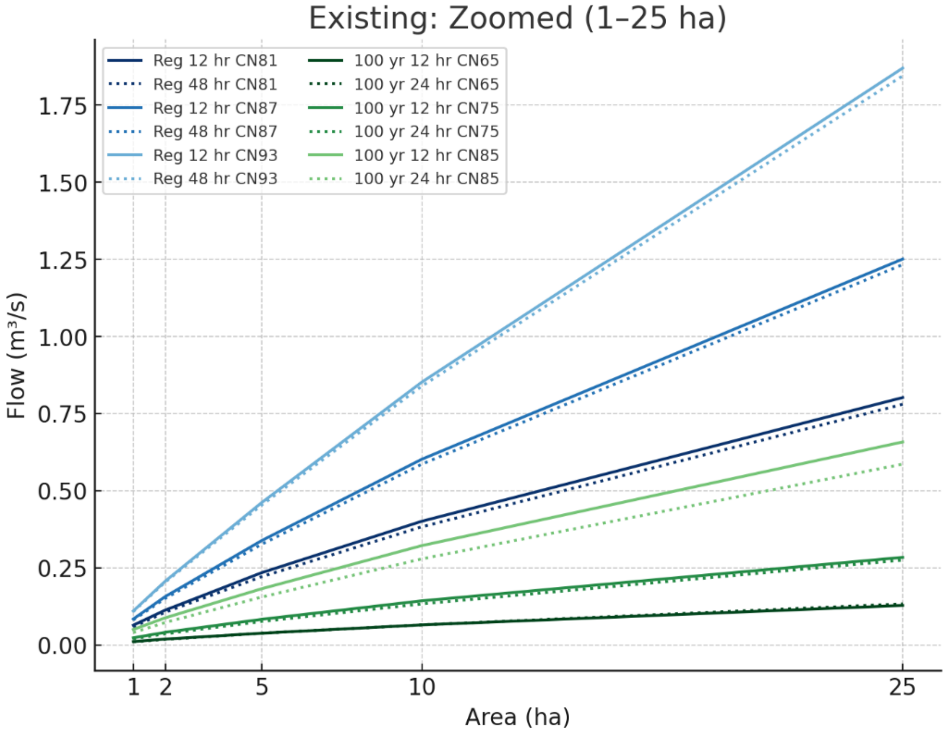
Table 4.1: L, t_l, and T_p (hours) (by Area)

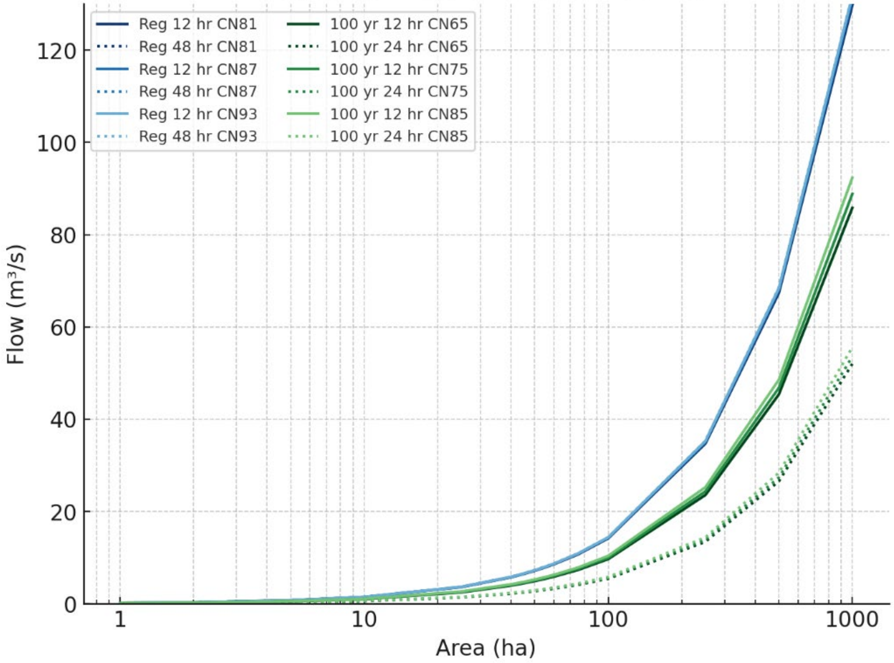
Area (ha)	Diagonal Length L (m)	L (ft)	Slope	Lag time (h) (CN=65/IA=15mm)	Lag time (h) (CN=75/IA=10mm)	Lag time (h) (CN=85/IA=5mm)	Time to peak Tp (h) (CN=65/IA=15mm)	Time to peak Tp (h) (CN=75/IA=10mm)	Time to peak Tp (h) (CN=85/IA=5mm)
1	141	464	1%	2.1	1.6	1.2	2.8	2.1	1.6
2	200	656	1%	2.8	2.1	1.5	3.7	2.8	2.1
5	316	1038	1%	4.0	3.0	2.2	5.3	4.0	3.0
10	447	1467	1%	5.3	4.0	2.9	7.0	5.3	3.9
25	707	2320	1%	7.6	5.8	4.2	10.1	7.7	5.6
40	894	2935	1%	9.2	7.0	5.1	12.2	9.3	6.8
45	949	3113	1%	9.6	7.3	5.4	12.8	9.7	7.1
50	1000	3281	1%	10.0	7.6	5.6	13.3	10.2	7.4
55	1049	3441	1%	10.4	7.9	5.8	13.8	10.6	7.7
60	1095	3594	1%	10.8	8.2	6.0	14.3	10.9	8.0

Area (ha)	Diagonal Length L (m)	L (ft)	Slope	Lag time (h) (CN=65/IA=15mm)	Lag time (h) (CN=75/IA=10mm)	Lag time (h) (CN=85/IA=5mm)	Time to peak Tp (h) (CN=65/IA=15mm)	Time to peak Tp (h) (CN=75/IA=10mm)	Time to peak Tp (h) (CN=85/IA=5mm)
75	1225	4018	1%	11.8	9.0	6.6	15.7	12.0	8.7
100	1414	4640	1%	13.2	10.1	7.4	17.6	13.4	9.8
250	2236	7336	1%	19.1	14.5	10.6	25.4	19.3	14.1
500	3162	10375	1%	25.2	19.2	14.0	33.5	25.5	18.6
1000	4472	14672	1%	33.2	25.3	18.5	44.2	33.7	24.6

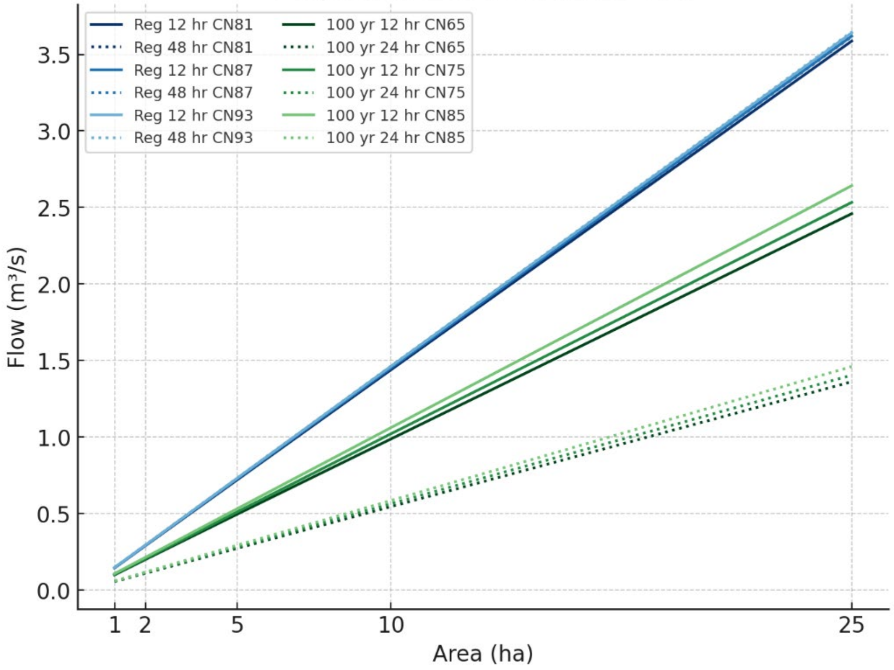
The following graphs summarize the results and illustrate that for both undeveloped and developed catchments, for all standard storm durations and distributions and a range of Curve Numbers and time to peak, the Regional storm governs in all cases. This would be the case even if modest increases (e.g. 15%) increases to the 100-year storm intensity were to be applied to simulate climate change.




Existing: Zoomed (1–25 ha)
Reg 12 hr CN81
Reg 48 hr CN81
Reg 12 hr CN87
Reg 48 hr CN87
Reg 12 hr CN93
Reg 48 hr CN93
100 yr 12 hr CN65
100 yr 24 hr CN65
100 yr 12 hr CN75
100 yr 24 hr CN75
100 yr 12 hr CN85
100 yr 24 hr CN85
Flow (m³/s)
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
1
2
5
10
25
Area (ha)



Proposed: Regional and 100 Year



Proposed: Zoomed (1–25 ha)

The Regional storm primarily exceeds the 100-year storm due to the antecedent moisture conditions which are applied to the Curve Number for Hurricane Hazel, but also due to the timing of the storm distributions and the drainage areas.

Although a 100-year storm may exhibit a higher instantaneous intensity (e.g. double or triple the Regional intensity in the most intense few minutes), that intensity only applies over a very short window—often far shorter than the watershed's time of concentration.

For large basins, a 100-year storm may dump its maximum intensity over a short period, i.e., minutes. Large catchments may take several hours to move water from the most hydrologically distant upstream area to the outlet. During a high-intensity storm, only part of the watershed has contributed runoff by the end of that period, and the sub-area peaks may not add up directly.

In contrast, Hazel's most intense rainfall was spread over several hours, matching or exceeding the catchment's time of concentration. By the time the storm ends, all sub-areas have sent runoff to the outlet, giving a larger combined peak.

5. Design Implications for Alloa Infrastructure Blocks

The following blocks identified on the Secondary and Tertiary Plan (ponds and channel) are affected by the storm / flows they must convey or otherwise manage. In all cases, the Regional storm governs the sizing of these blocks.

Table 5.1: Infrastructure Block Summary

Infrastructure Block	Subcategory	Rationale
Ponds	Storage Volume	Control of the larger Regional storm volume to 60% of the pre-development Regional flow (as per ECHUS requirements), plus and additional 214 m3/ha as per ECHUS far exceeds the volumes required to control the 100-year storm to the ECHUS targets. This component affects the pond block size.
	Emergency Spillway	Since the ponds provide Regional control, in the event of a blockage of the conventional outlet structure/ outlet pipe, the higher uncontrolled Regional storm flows must be conveyed from the spillway. This component generally does not affect the pond block size.
	Outlet Control structure	Varies, as the structure must be designed to convey various controlled flows from the extended detention target up to the Regional flow; the structure must however accommodate the largest release rate (i.e. the Regional flow targets as per ECHUS). This component generally does not affect the pond block size.
	Pond outlet pipe	The pond outlet pipe must be sized to convey the greatest controlled release rate from the pond, which is the Regional storm. This component generally does not affect the pond block size.
Channel Corridor	Conveyance Capacity & Hazard Mapping	TRCA flood hazard mapping criteria require evaluation of the greater of the 100-year or Regional storm (Hurricane Hazel). As the Regional storm flows are higher than the 100-year storm flows in all cases along the channel, the channel conveyance capacity, and ultimately the size of the channel block is governed by the Regional storm (as required by the TRCA).
	Crossing Design	While MTO standards allow some categories of road to have crossings designed to the 100-year storm flows (allowing Regional storm to spill across the ROW at crossings), the culverts have all been designed to ensure conveyance of the more conservative Regional storm flows to avoid overtopping or excessive backwater. The Region of Peel does not allow overtopping / major system conveyance across their intersections or crossings.
	Riparian storage	The Regional storm generates greater riparian storage targets compared to the 100-year storm. The Regional storm therefore governs channel corridor sizing to preserve riparian storage.

6. Conclusions

Across all sub-watershed-scale drainage areas modelled in Alloa, Regional storm flows unequivocally exceed 100-year flows—even if 100-year intensities are increased to account for climate change, such as the 15% increase applied by the City of Burlington to estimate RCP 8.5 / year 2100 conditions.

Consequently, infrastructure designed to control or convey the Regional storm flows is inherently resilient to future updates of IDF curves and fulfils TRCA regulatory flood-hazard mandates.

Regards,
Urbantech® Consulting

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PROVINCE OF ONTARIO

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Attachments:
Flow comparison tables

Existing Conditions Individual Catchments					Existing Conditions Major Confluences					
NHYD	**Area**	**Reg Flow**	**100-year Flow**	**Reg / 100-year Flow**	**Crossing**	**NHYD**	**Area**	**Reg Flow**	**100-year Flow**	**Reg / 100-year Flow**
	[ha]	**[m³/s]**	**[m³/s]**	**[%]**			**[ha]**	**[m³/s]**	**[m³/s]**	**[%]**
168	103.55	9.401	2.48	379%						
170	31.8	3.147	0.87	362%						
						2176	135.35	12.55	3.32	378%
176	121.04	11.045	3.014	366%						
						1167	256.39	23.59	6.34	372%
167	45.12	5.153	1.78	289%						
					Mississauga Road	2167	301.51	24.61	6.18	398%
147	71.89	6.588	1.74	379%						
						1153	373.4	31.19	7.9	395%
153	34.14	3.782	1.18	321%						
						2153	407.54	34.05	8.54	399%
140	157.95	13.504	3.55	380%						
						1132	565.49	47.55	12.09	393%
132	78.02	8.307	2.45	339%						
					Creditview Road	2132	643.51	48.56	11.46	424%
108	82.89	7.569	1.98	382%						
118	127.26	11.423	2.9	394%						
						2118	210.15	18.57	4.72	393%
						1125	853.66	66.97	15.88	422%
125	52.22	5.391	1.53	352%						
						2125	905.88	67.48	15.79	427%
107	114.63	10.655	2.8	381%						
					Chinguacousy Road	2107	1020.51	74.56	17	439%

Post-development Uncontrolled Conditions Individual Catchments					Post-development Uncontrolled Conditions Major Confluences					
NHYD	Area	Reg Flow	100-year Flow	Reg / 100-year Flow	Crossing	NHYD	Area	Reg Flow	100-year Flow	Reg / 100-year Flow
	[ha]	[m^3/s]	[m^3/s]	[%]			[ha]	[m^3/s]	[m^3/s]	[%]
168	69.4	6.777	1.848	367%						
1681	14.41	2.12	1.625	130%						
176	39	4.288	1.336	321%						
1761	32.08	4.716	3.614	130%						
						2176	154.89	15.859	7.373	215%
1762	7.3	1.071	0.814	132%						
						1167	162.17	15.723	5.673	277%
1672	1.48	0.218	0.167	131%						
176176	62.91	6.533	1.874	349%						
170	57.3	8.172	5.907	138%						
167	22.3	3.268	2.485	132%						
1671	2.1	0.308	0.235	131%						
					Mississauga Road	2167	308.28	31.021	15.733	197%
147	26.9	2.883	0.874	330%						
1471	5.78	0.85	0.652	130%						
1472	6.59	0.97	0.743	131%						
						1153	39.27	4.189	2.043	205%
1473	7.22	0.802	0.258	311%						
						2153	46.49	4.501	1.779	253%
						2170	354.77	35.522	17.384	204%
1533	15.67	2.013	0.738	273%						
140140	60.3	8.587	6.192	139%						
153	8.7	1.277	0.97	132%						
153153	9.9	1.452	1.104	132%						
						2154	449.34	44.445	22.156	201%
140	84.2	8.11	2.193	370%						
1401	15.15	2.228	1.708	130%						
140118	4	0.579	0.416	139%						
						1132	103.35	9.997	3.305	302%
1403	13.5	1.65	0.567	291%						

Post-development Uncontrolled Conditions Individual Catchments					**Post-development Uncontrolled Conditions Major Confluences**					
NHYD	**Area**	**Reg Flow**	**100-year Flow**	**Reg / 100-year Flow**	**Crossing**	**NHYD**	**Area**	**Reg Flow**	**100-year Flow**	**Reg / 100-year Flow**
	[ha]	**[m^3/s]**	**[m^3/s]**	**[%]**			**[ha]**	**[m^3/s]**	**[m^3/s]**	**[%]**
						2140	116.85	10.789	2.916	370%
						21403	566.19	55.233	24.846	222%
118118	46.6	6.647	4.792	139%						
132	25.8	3.715	2.718	137%						
1323	7.05	0.935	0.36	260%						
1321	3.8	0.553	0.408	136%						
					Creditview Road	2132	649.44	61.325	25.438	241%
108	77.4	7.151	1.773	403%						
1181	19.8	2.912	2.232	130%						
118	59.2	6.158	1.76	350%						
						2118	156.4	15.086	4.135	365%
1118	6.4	0.925	0.664	139%						
						2120	162.8	14.673	4.275	343%
1183	19.01	2.297	0.785	293%						
						2183	181.81	16.597	5.022	330%
125	50.4	7.194	5.199	138%						
						1125	881.65	83.224	35.481	235%
1253107	22.56	2.688	0.856	314%						
125132	30.1	4.3	3.116	138%						
1253	4.8	0.552	0.195	283%						
1254	0.54	0.078	0.057	137%						
1251	9.5	1.227	0.482	255%						
1252	0.38	0.055	0.04	138%						
						2125	949.53	87.741	33.455	262%
1107	38.6	5.527	4.007	138%						
107107	16.3	2.344	1.702	138%						
11071	2.4	0.348	0.252	138%						
					Chinguacousy Road	2107	1006.83	90.258	31.538	286%