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Ms. Danielle Dellandrea
Project Coordinator | Toronto and Region Conservation Authority
101 Exchange Avenue, Vaughan, ON, L4K 5R6

via email to Danielle.Dellandrea@trca.ca

Status: Final
September 7, 2019

Dear Danielle,

Reference # 13017.101.L1.Rev0_Update2019WaterLevels

RE: UPDATED ANALYSES USING 2019 WATER LEVELS

As requested, Baird updated the extreme water level analyses and flood damage estimates from the Toronto Islands Flood Characterization report[i] and Toronto Islands Flood Risk Assessment report[ii] using water level data from 2019. In June 2019[iii], the mean water level for Lake Ontario peaked at 75.91 m IGLD85, which is 10 cm above the June 2017 monthly level. The maximum daily and maximum hourly water levels at Toronto were 2 cm (75.95 m IGLD85) and 5 cm (76.03 m IGLD85) above the maximum levels in 2017. Lake Ontario water levels continue to remain high and are above the 2017 levels (Figure 1).

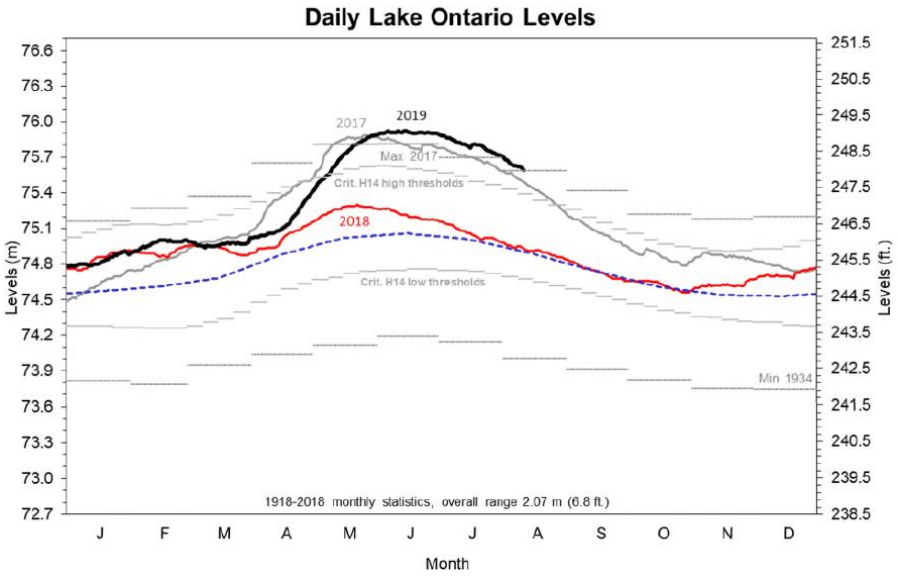

Figure 1: Lake Ontario Daily Water Levels (from International Lake Ontario - St. Lawrence River Board, August 12, 2019 Water Level & Flow Conditions Briefing)

Task #1: Update the return period water level analyses using the 2019 water level data

Baird updated the extreme water level analyses using the provisional monthly water level data for June 2019 and hourly water levels at Toronto up to August 12, 2019. The procedures follow those in the Flood Characterization Report (Baird, 2019a). The June 2019 monthly average water level for Lake Ontario was 75.91 m IGLD85. The updated static (monthly) water levels for Lake Ontario are provided in Table 1.

Table 1: Lake Ontario Return Period Static Water Levels

Data Range	Return Period Static Water Level (m IGLD85)							
	2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year
Flood Characterization Report (1962-2018)	75.14	75.34	75.46	75.60	75.70	75.79	75.88	75.99
Updated Analysis (1962-2019)	75.14	75.36	75.50	75.66	75.78	75.90	76.01	76.16

Storm surge was calculated by subtracting the “smoothed” static water levels from the hourly water levels at Toronto as described in Baird (2019a). No large storm surges have occurred yet this year and the extreme storm surge estimates are unchanged from the Flood Characterization report (Table 2).

Table 2: Toronto Harbour Return Period Surge Levels

Data Range	Return Period Surge Level (m)							
	2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year
Flood Characterization Report (1962-2018)	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.34
Updated Analysis (1962-2019)	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.34

The combined probability of extreme high lake levels and extreme storm surges were calculated using the updated data. The results of the analysis are provided in Table 3.

Table 3: Toronto Harbour Return Period Stillwater Levels

Type	Return Period Stillwater Level (m IGLD85)							
	2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year
Flood Characterization Report (1962-2018)	75.33	75.53	75.65	75.79	75.89	75.98	76.07	76.18
Updated Analysis (1962-2019)	75.33	75.56	75.70	75.87	75.99	76.11	76.22	76.37

The impact of the change in Lake Ontario regulation was estimated in Baird (2019a). As mentioned in Baird (2019a), the differences in water levels under the two plans are related to how the plans perform before the extreme water levels are reached. The estimated stillwater (peak hourly) water levels for Toronto under the 2014 Lake Ontario regulation plan are provided in Table 4. **The 100-year flood level should be updated to 76.2 m IGLD85.**

Table 4: Estimated Toronto Harbour Return Period Stillwater Levels Under 2014 Regulation Plan

Data Range	Return Period Stillwater Level (m)							
	2 year	5 year	10 year	25 year	50 year	100 year	200 year	500 year
Plan 2014 difference	0.05	0.12	0.15	0.15	0.12	0.07	0.07	0.07
Flood Characterization Report (1962-2018)	75.38	75.65	75.80	75.94	76.01	76.05	76.14	76.25
Updated Analysis (1962-2019)	**75.38**	**75.68**	**75.85**	**76.02**	**76.11**	**76.18**	**76.29**	**76.44**

Task #2: Update the damage estimates using the updated return period water levels

Baird updated the flood damage estimates and number of impact residential properties using the updated return period water levels. The number of impacted houses and residents on Ward's and Algonquin Islands at different flood levels is provided in Tables 5 and 6. The estimated number of impacted houses and residents in 2017 and 2019 use the peak daily water level for that flood event and do not consider mitigation actions such as sandbags, pumps, etc.

Table 5: Estimated Number of Residential Buildings Flooded at Different Flood Levels

Flood Return Period (Years)	2	5	10	25	50	100	200	500	2017 flood	2019 flood
Water Level (m IGLD85)	**75.38**	**75.68**	**75.85**	**76.02**	**76.11**	**76.18**	**76.29**	**76.44**	**75.93**	**75.95**
Ward's	6	6	45	111 (1)	133 (5)	134 (16)	139 (38)	139 (77)	79	83
Algonquin	0	0	6	25	46	54	62	74 (11)	11	12
Total	6	6	51	136 (1)	179 (5)	188 (16)	201 (38)	213 (88)	90	95
% of All Homes	2%	2%	20%	53%	69%	73%	78%	83%	35%	37%

*Estimated number of residential buildings with first floor flooding shown in parentheses

Table 6: Estimated Number of Residents Impacted at Different Flood Levels

Flood Return Period (Years)	2	5	10	25	50	100	200	500	2017 flood	2019 flood
Water Level (m IGLD85)	**75.38**	**75.68**	**75.85**	**76.02**	**76.11**	**76.18**	**76.29**	**76.44**	**75.93**	**75.95**
Ward's	13	13	98	241 (2)	288 (11)	290 (35)	301 (82)	301 (167)	171	180
Algonquin	0	0	13	54	100	117	134	160 (24)	24	26
Total	13	13	111	295 (2)	388 (11)	407 (35)	435 (82)	461 (191)	194	206
% of All Residents	2%	2%	20%	53%	69%	73%	78%	83%	35%	37%

*Estimated number of residents with first floor flooding shown in parentheses

The flood damage estimates were updated using the updated flood levels. Total direct and indirect damages (financial damages) for the residential and non-residential buildings is shown in Figures 2 and 3. Direct damages (structural and building contents damages) make up a high percentage of the total damages for the residential buildings. Indirect damages (e.g. business disruption) make up a large percentage of the total damages for the non-residential buildings.

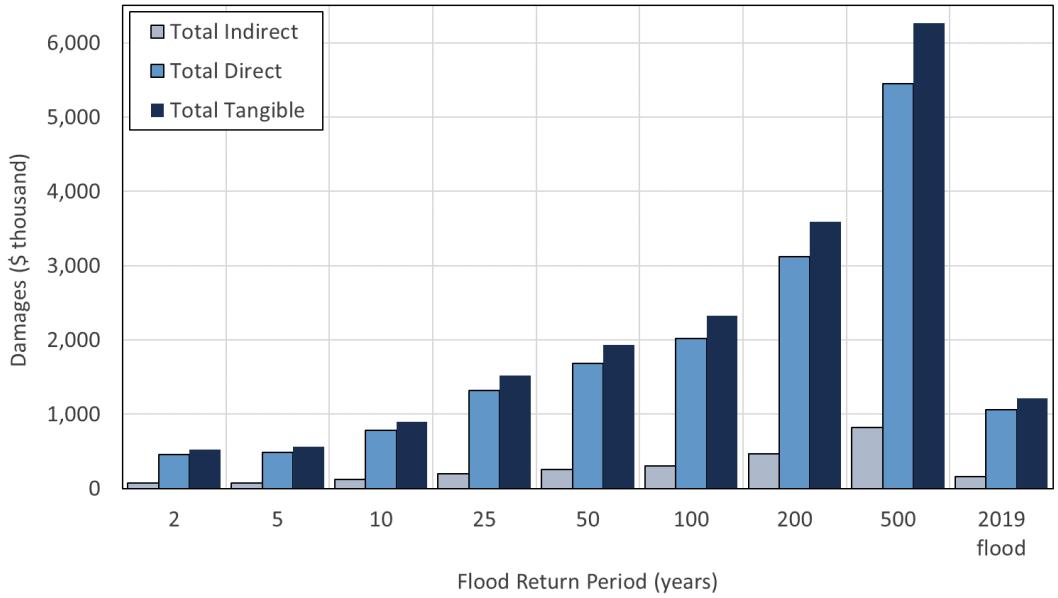

Figure 2: Residential Direct, Indirect and Total Tangible Damages for Different Flood Return Periods

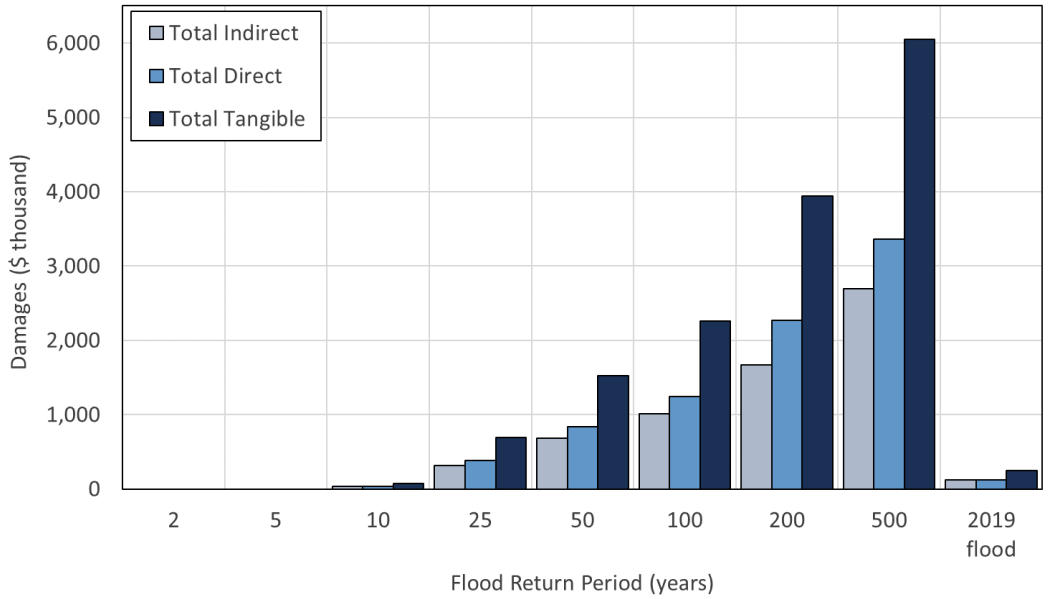

Figure 3: Non-Residential Direct, Indirect and Total Tangible Damages for Different Flood Return Periods

Total tangible (financial) damages for residential and non-residential buildings (excluding municipal buildings) by location is provided in Figure 5. Some houses on Ward's Island are impacted at the 2-year event, while buildings on Algonquin Island and other islands aren't impacted until about the 10-year or 25-year flood event.

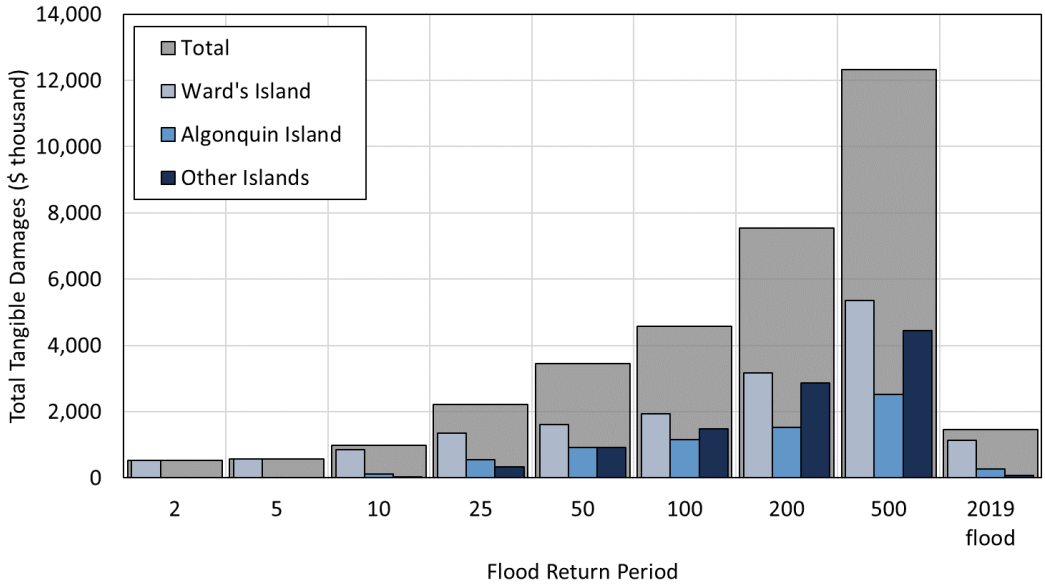

Figure 4: Total Tangible Damages for Different Flood Return Periods

The average annual damage is obtained by summing the area under the damage-probability curve shown in Figure 6. The average annual damages for the residential and non-residential buildings on Toronto Islands (excluding municipal buildings) is estimated to be $492,000 per year.

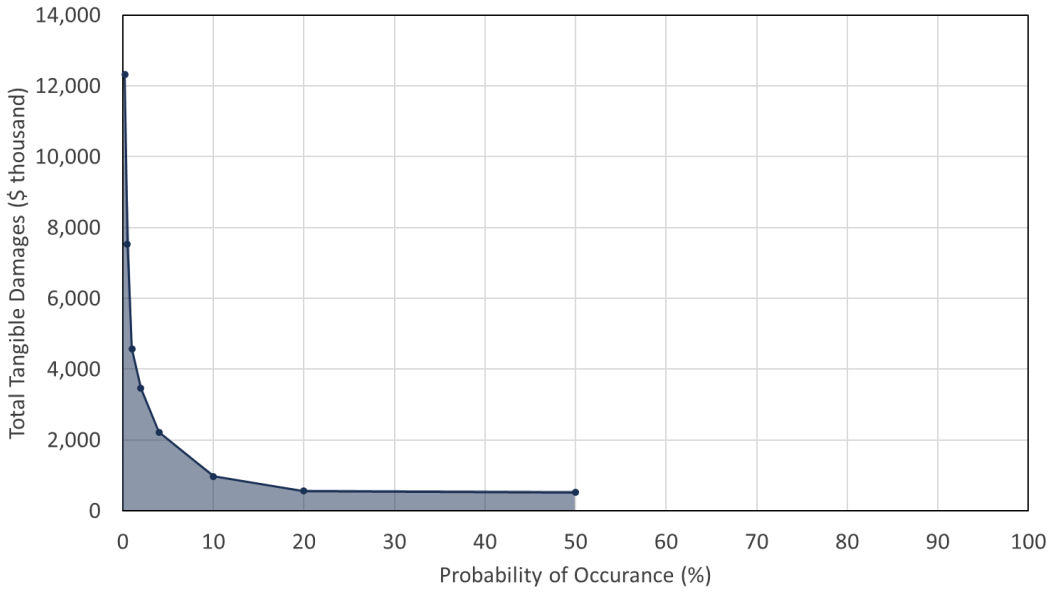

Figure 5: Total Tangible Damages vs. Probability Curve for Different Return Periods

In summary, the updated analyses resulted in an increase to the flood levels presented in the Flood Characterization report. Baird recommends that the 100-year flood level for Toronto Islands be increased to 76.2 m IGLD85. The estimated flood damages also increased as a result of the updated return period water levels. The estimated average annual flood damages to residential and non-residential buildings (not including municipal buildings) is $492,000. Flood mitigation actions such as the installation of sandbags and pumps may reduce the flood damages; however, the cost of the mitigation actions is not included in the damage estimates.

With thanks,

Josh Wiebe Digitally signed by jwiebe@baird.com Date: 2019.09.07 14:25:32 -04'00'

Josh Wiebe | Project Engineer
Baird & Associates
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CC: Danny Moro (TRCA), Nathan Plato (TRCA)

[i] Baird & Associates (2019a). Toronto Islands Flood Characterization and Risk Assessment Project: Flood Characterization Report. Prepared for Toronto and Region Conservation Authority. March 12, 2019.
[ii] Baird & Associates (2019b). Toronto Islands Flood Characterization and Risk Assessment Project: Flood Risk Assessment Report. Prepared for Toronto and Region Conservation Authority. April 30, 2019.
[iii] Great Lakes and Montreal Harbour Monthly Water Levels Bulletin prepared by the Canadian Hydrographic Service, June 2019. http://www.waterlevels.gc.ca/C&A/tidal-eng.html