KERR WOOD LEIDAL
consulting engineers

Appendix J

Climate Change Assessment

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J.1 Background

Kerr Wood Leidal Associates Ltd. (KWL) was retained by the City of Courtenay (City) to complete Phase 3 of the City-Wide Integrated Rainwater Management Plan (IRMP). As part of the IRMP, a calibrated model of the City's drainage system is being developed. To assess system performance in existing and future conditions, intensity-duration-frequency (IDF) curves are referenced for design storm intensities and volumes. Future conditions assessments require climate change to be considered for infrastructure sizing and performance. To support the IRMP work, KWL completed a limited climate change assessment to compare the City's existing IDF curve guidance to the most up-to-date projections available for climate change.

J.2 Climate Change Considerations

Climate change impacts to precipitation are critical considerations for assessing and designing storm infrastructure for the future. To reflect this, climate change updates or factors are incorporated into IDF curves to represent the projected increases to precipitation volume and intensity as a result of climate change.

In the City's Subdivision and Development Servicing Bylaw 2919 (March 2018), IDF curves are provided for a single climate station, with design storms ranging from 2-year to 100-year and storm durations of 15-minutes to 24-hours. These IDF curves represent the City's most recent guidance and are noted to include a 15% increase on historical rainfall intensities. Table 1 summarizes the City's current IDF values.

Table 1: City of Courtenay Bylaw 2919 IDF Curve Rainfall Intensity (mm/hr)

	Return Period					
Duration	**2-year**	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
15-minute	21.3	36.7	47.2	60.7	70.8	80.9
30-minute	16.3	26.9	34.1	43.1	49.9	56.7
1-hour	12.5	19.5	24.1	29.9	34.3	38.6
2-hour	9.5	14.7	18.2	22.6	25.9	29.1
6-hour	6.8	9.7	11.6	14	15.7	17.5
12-hour	5.1	6.7	7.8	9.1	10.1	11.1
24-hour	3.5	4.5	5.2	6.1	6.8	7.4

Climate change is an evolving science and as such projections are subject to change with time, science, and updated climate models. As the source of the 15% increase in IDF values is unclear and to check that the design storms in the City's bylaw 2919 that will be used for the IRMP storm system assessment are consistent with current predictions of climate change impacts to rainfall, KWL completed an independent climate change assessment on the Courtney Puntledge BCHP Environment Canada climate station (ID#1021990)

Climate Change Assessment

The climate change assessment was completed using *The Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change Version 5.0* (the 'Tool'). The online Tool was developed by the University of Western Ontario for climate change updates and projections for IDF curves: The Tool uses a dataset of up to 26 bias-corrected global circulation models (GCMs) produced by the Pacific Climate Impacts

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Consortium (PCIC) of the University of Victoria. The GCMs are evaluated under three future Shared Socioeconomic Pathways (SSPs) representing varying ranges of climate change protection applied (SSP1.26, SSP2.45, SSP 3.70, and SSP5.85). These scenarios replace the former Representative Concentration Pathways for green house gas emissions (RCP2.6, RCP4.5, and RCP8.5). The Tool then simulates IDFs for an ensemble of the GCMs for a selected future time horizon with climate change impacts incorporated.

As a conservative approach for infrastructure sizing amid uncertainty for future greenhouse gas emissions, the SSP5.85 (former RCP8.5) scenario is typically used to predict climate change impacts. The SSP5.85 applies higher greenhouse gas emissions rates and the upper boundary of the range of predictions for future warming, when compared to the SSP1.26, SSP2.45, and SSP 3.70 scenarios, which in turn leads to more severe climate change predictions. In addition to selecting an SSP scenario, the appropriate increase across all GCM projections must be selected. Existing guidance looks mainly at median and 95th percentile results, which represent a moderate and conservative projection for future climate change projections.

The IDF CC Tool provides projected increases based on the location of gauged climate stations. The Courtenay Puntledge BCHP climate station was chosen for the assessment as it is used as the rainfall station for the IDF curves in the City's Bylaw 2919. The Courtenay Puntledge BCHP climate station (ID: 1021990) has rainfall data from 1964-1995. The Environment Canada IDF data was used as the baseline IDF curve. This is consistent with the IDF station for the City's bylaw, however the curve from Environment Canada was used as the baseline in lieu of the City's bylaw IDF, as the City's bylaw IDF already has climate change considerations incorporated.

Climate Change IDF Curves

The climate change assessment was completed for the 2020-2080, time horizon, for infrastructure intended to have a life cycle of at least Year 2050. The ensemble of all 26 GCMs were analyzed and the median and 95th percentile projections for SSP5.85 of the 26 GCMs were reported.

The median and 95th percentile projected increases were assessed for the 2-year to 100-year design storms (across ranges from 1-hour through 24-hour durations). Table 2, Table 3, and Table 4 summarize the climate change factors for the median and 95th percentile projections for the 2020 to 2080 time horizon. Other time horizons representing Year 2050 were also checked but the 2020 to 2080 timeframe was found to produce the highest climate change increases.

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Table 2: Climate Change Factors Median Projection (2020 – 2080)

Climate Change Factors							
Duration	2-year	5-year	10-year	20-year	25-year	50-year	100-year
1-hour	1.11	1.10	1.11	1.13	1.12	1.13	1.14
2-hour	1.11	1.10	1.10	1.11	1.11	1.10	1.10
6-hour	1.11	1.10	1.10	1.12	1.12	1.12	1.13
12-hour	1.11	1.11	1.12	1.13	1.13	1.13	1.14
24-hour	1.10	1.11	1.13	1.14	1.13	1.14	1.16

Table 3: Climate Change Factors 95th Percentile Projection (2020 – 2080)

Climate Change Factors							
Duration	2-year	5-year	10-year	20-year	25-year	50-year	100-year
1-hour	1.16	1.20	1.22	1.24	1.24	1.27	1.30
2-hour	1.16	1.20	1.23	1.25	1.25	1.28	1.34
6-hour	1.16	1.20	1.23	1.24	1.24	1.28	1.30
12-hour	1.16	1.20	1.23	1.25	1.25	1.28	1.30
24-hour	1.17	1.20	1.23	1.25	1.26	1.29	1.30

Table 4: Climate Change Increase Range

2020-2080 Time Horizon		
Return Period	Median	95th Percentile
2-year	10 – 11%	16 – 17%
5-year	10 – 11%	20%
10-year	10 – 13%	22 – 23%
20-year	11 – 14%	24 – 25%
25-year	11 – 13%	24 – 26%
50-year	10 – 14%	27 – 29%
100-year	10 – 16%	30 – 34%

As the medians of the ensemble of GCMs for the SSP5.85 represent a moderate approach under status quo conditions for applying climate change, the median climate change projections represent best practices for estimating the 'most likely' future scenario. However, under highly conservative conditions, such as when there are extremely high risks and consequences (e.g., loss of life) or when assessing the major drainage system without a safe overland flow path, it is appropriate to use the 'worst case' future scenario among the ensemble of GCMs (i.e., 95th percentile).

In the case of the City of Courtenay, KWL's independent recommendation would be to adopt the median factors for the minor storm system and up to 50-year return period events and the 95th percentile for the major system for the 100-year return period. The median increase would result an increase of 10-14% and the 95th percentile would result in an increase of 25-34%. The City's current guidance incorporates a 15% increase across all durations, which represents a slightly more conservative estimate for the minor storm system than the current projections for this time horizon. However, for the major storm system, 15% is equivalent to a median climate

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change projection. As major storm infrastructure has high risk consequences, a more conservative increase should be considered.

Recommendations

KWL recommends that the City continue to use their IDF curves from the bylaw (which have a 15% increase incorporated) for design storms up to the 50-year event and to increase the 100-year IDF (across all durations) by an additional factor of 15% (approximately a 32% increase on historic intensities). Table 5 summarizes the recommended update to the City's IDF curve in the bylaw.

Table 5: Recommended IDF Curve Intensity (mm/hr) – 100-Year Values Updated

	Return Period					
Duration	**2-year**	**5-year**	**10-year**	**25-year**	**50-year**	**100-year**
15-minute	21.3	36.7	47.2	60.7	70.8	93.04
30-minute	16.3	26.9	34.1	43.1	49.9	65.21
1-hour	12.5	19.5	24.1	29.9	34.3	44.39
2-hour	9.5	14.7	18.2	22.6	25.9	33.47
6-hour	6.8	9.7	11.6	14	15.7	20.13
12-hour	5.1	6.7	7.8	9.1	10.1	12.77
24-hour	3.5	4.5	5.2	6.1	6.8	8.51

J.3 Conclusions & Recommendations

KWL completed a limited climate change assessment on the Courtenay Puntledge BCHP station using the online IDF CC Tool. Results of this assessment were used to compare and evaluate the City's existing IDF guidance in their 2019 bylaw. The results of this comparison indicate the City's current design storms adequately capture the climate change impacts for storms up to the 50-year design storm. However, the results indicate that the City's major system IDF does not reflect the 95th percentile of the climate change projections and should be updated such that major infrastructure is designed to incorporate an additional level of conservativeness.