APPENDIX A

CLIMATE CHANGE

Stantec

Memo

To:	Jakub Cyperling City of Waterloo	From:	Jenn Hale Kitchener ON Office
File:	1611-11191	Date:	May 22, 2015

Reference: Impacts of Climate Change on the Waterloo Sanitary Sewer Master Plan (WSSMP)

CLIMATE CHANGE BACKGROUND FOR CITY OF WATERLOO

Predicted future climate change impacts for Southwestern Ontario include higher temperatures and increases in precipitation, leading to an intensification of the hydrologic cycle (Simonovic, S. and Peck, A. 2009). Since 1948, the effects of anthropogenic climate change have resulted in an average temperature rise in Ontario of 1.3°C, and the trend in increasing temperature is projected to continue with the average temperatures during the winter expected to show a larger percentage increase than average summer temperatures (Expert Panel, 2009; TRCA, 2009). Due to the lag time in the warming of the oceans and ice sheets as compared to the atmosphere, the effects of climate change, which are already being experienced, will continue to be felt for decades after effective mitigation strategies are put in place (Expert Panel, 2009). Under climate change, scientists project that a warming climate will bring increases in the intensity, duration, frequency, and location of extreme precipitation, and in Canada an average increase in total annual precipitation (CSA, 2010; TRCA, 2009). In general, potential impacts of future climate change for Ontario include increased frequency of extreme weather such as intense rainfall (especially for shorter storm durations), droughts, freezing rain, smog events and heat waves. Weather is also likely to be more variable and less predictable from year to year (Expert Panel, 2009). Other potential impacts which have already begun to be observed and are expected to increase over the next 20 years are water shortages in the southern Ontario regions, including Waterloo and Wellington counties, as evapotranspiration increases with higher temperatures (Expert Panel, 2009). Over North America in general, extreme precipitation events which occur once every 20 years are projected to occur once every 12 to 13 years by mid-century and once every 8 to 9 years by 2081 to 2100 (CSA, 2010).

Since municipal sanitary sewers are designed in part based on historical precipitation information in the form of rainfall intensity-frequency-duration (IDF) curves, it is critical to consider climate change impacts in the design and planning of infrastructure (TRCA, 2009; Simonovic, S. and Peck, A. 2009). IDF curves draw on historical precipitation data to indicate the probability of occurrence of extreme rainfall events of various rates and durations for a given area (CSA, 2010). Historic climate and design storms are no longer considered representative of current or future climate, and as a result, infrastructure designed using historical IDF values may, under an increased rainfall scenario, provide a lower level of protection in the future (Simonovic, S. and Peck, A. 2009). The extent of climatic change and the impacts on precipitation events that can be expected depends to a large degree on future greenhouse gas (GHG) emissions at the global level, and though climate modelling has been developed to predict a range of scenarios, there is still a great deal of uncertainty on the model outcomes and how this can be applied at the local, municipal scale (TRCA, 2009). Though various statistical downscaling and analysis techniques have been developed, as the Expert Panel (2009) indicated, there is currently no climate change model projections at a fine enough temporal and spatial scale to suit the needs of regional and localized water management (MOECC, 2014).

Reference: Impacts of Climate Change on the Waterloo Sanitary Sewer Master Plan (WSS

Currently, in Ontario, there are no standard approaches for taking climate change effects into account in the stormwater management field for decision making or design and there is little technical guidance available from federal/provincial governments or elsewhere to municipalities on how to account for climate change adaptation (TRCA, 2009). An Ontario Ministry of the Environment and Climate Change (MOECC) review of municipal stormwater management in light of climate change, building on the Expert Panel (2009) recommendations, identified the need to improve technical guidance from the MOECC on the approval process for stormwater facilities and updating the 2003 Stormwater Management Planning and Design Manual to provide specific guidance on climate change adaptation; noting that resilient systems for municipal stormwater with emphasis on source control can be expected to provide co-benefits for sanitary sewer systems (MOECC, 2014). Additionally, while the Canadian Environmental Assessment Act mandates that the effect of climate change be evaluated in planning and design of infrastructure, it only legislates that adaptation be considered and does not provide any specific guidance for adaptation planning or practices (TRCA, 2009).

In the absence of specific guidance on climate change adaptation at the municipal level, methods employed by Canadian municipalities can be used as a guideline on how to best incorporate climate change into planning. These include: 1) modifying IDF curves used for designing infrastructure, 2) increasing safety factors in construction codes and standards to accommodate for additional uncertainty associated with future climate design values, and 3) taking proactive measures which will mitigate the effects of a range precipitation conditions by increasing the resiliency of infrastructure, for example through lot-level stormwater management practices. These are three general approaches which are currently being undertaken to deal with the variability in predications of the scope, magnitude, and type of impact on the environment as a result of future climate change (TRCA, 2009).

Environment Canada has recently (2012) updated the IDF curves across Canada which can be considered more accurate as they incorporate more recent rainfall data. However, while more accurate than the previous IDF curves which were developed decades ago, the method for generating IDF curves is still based on analysis of historical rainfall data and does not explicitly incorporate any projected future trends due to a changing climate (Environment Canada, 2012). There are customizable IDF tools currently being developed to incorporate climate change predictions into up-to-date historical weather data used to generate IDF curves, however to date this is only available in Draft form and has not yet been implemented for municipal planning or design purposes (Simonovic, S. et al, 2014). "No-regrets" measures to reduce runoff volumes and rates such as rainwater collection and re-use systems, sewer inflow control devices, disconnecting downspouts, green roofs, and land use planning that seeks to increase the amount of pervious area, have a benefit regardless of the degree of climate change. A study completed in 2009 by the Toronto and Region Conservation Authority (TRCA) conducted a survey with Canadian municipalities on climate change adaptation with respect to stormwater. Of the municipalities surveyed, a number recognized the importance of accounting for climate change and are in various stages of undertaking action on adaptation practices related to stormwater management. Examples of municipal steps taken to address climate change with respect to water infrastructure include:

- A study completed for the City of London examined the use of a IDF tool modified to include climate predictions, recommended to the City of London to evaluate a potential change of IDF curves in the range of 20% (Simonovic, S. and Peck, A. 2009).

- The data used by Halifax Regional Municipality to predict future temperature and precipitation has been generated through statistical downscaling based on global climate model results derived from the Canadian Global Coupled Model (CGCM1) (TRCA, 2009).
- The City of Vancouver and the City of Toronto are working to develop more representative IDF curves to account for extreme precipitation IDF curves and are also implementing stormwater initiatives, such as increasing pervious surfaces in urban areas, which will make it more resilient to the future impacts of climate change (TRCA, 2009).
- The City of Barrie has based an adaptation approach for stormwater infrastructure on a simple multiplier of recorded precipitation, assuming a 10% increase in annual precipitation will be required to be handled (TRCA, 2009)

In general, it can be expected a trend for overall increased total precipitation and more intense precipitation events over shorter durations can be expected for the City of Waterloo.

SELECTION OF DESIGN STORM EVENT

A standard design storm is not currently specified by the City of Waterloo for the purposes of sanitary system capacity assessment. Best practices based on the state of industry standards were reviewed, including what was used in the 2002 Master Plan. Design storms used by other organizations in Southern Ontario to evaluate the performance of sanitary systems include:

- 5-yr, 1 hour AES 30% Distribution (Region of Peel)
- May 12, 2000 Measured Historic Event (25- to 50-yr Return Period, City of Toronto)
- 25-yr, 12 hour AES Distribution (City of Kitchener)
- 25-yr, 3 hour Chicago Distribution (City of Guelph)
- 5-, 10- and 25-yr, 3 hour Chicago Distribution (2002 Waterloo Master Plan)

The City of Toronto design storm is intended for flooding studies rather than sewer capacity review; therefore, it was not considered applicable for this study. The Region of Peel completed an extensive review and concluded that the 5-yr, 1 hour AES 30% Distribution was characteristic of storm events in Southern Ontario. Therefore, it was initially selected to review the capacity of the City's sanitary network. Modeling results, however, indicated the 5-yr, 1 hour AES 30% Distribution did not result in any capacity constraints. The 3 hour Chicago storm events were subsequently reviewed to provide more conservative results and allow a degree of comparison to the historic work completed for the 2002 Master Plan. In an effort to be conservative and acknowledge the trend of increasing intensity associated with climate change impacts, more intense storms over shorter durations, the 10-yr and 25-yr storms were selected for capacity assessments.

STRATEGIES RELATED TO INTENSIFICATION AND CLIMATE CHANGE

There is a legacy of existing infrastructure built to older design standards based on historical information, an approach that continues to be used to this day due to the technical challenges and inherent uncertainties in developing climate-adjusted IDF curves for future periods. As a result, it is possible that this infrastructure may be subject to loadings which exceed original design capacity. While in some cases the effect of a changing climate may be offset by the effect of other conservative engineering assumptions used at the time of design (e.g. per capita rates, rounding up pipe sizes etc.), in other instances this may not be the case. For example, an ongoing infrastructure deficit may result in assets being used much longer than originally intended, perhaps leading to unanticipated surcharging and increasingly uneconomic operational and maintenance costs (i.e. sewer rehabilitation). Furthermore, there is the possibility that other design assumptions have been less than conservative, such as in urban drainage design where historically runoff coefficients and return periods have been under-estimated, or where large systems have been designed with little regard to the effects of future urban intensification and expansion (CSA, 2010).

Climate change was incorporated into this MP by selecting a more conservative IDF curve, representing a larger design storm over a shorter duration (refer to Section 2.4). Other strategies to accommodate future climate change as it relates to the City of Waterloo sanitary sewer system are provided in the following section:

GENERAL STRATEGIES FOR NEW INFRASTRUCTURE

Design of new infrastructure should consider the effects of anticipated climate change. Although there will normally be considerable uncertainty relating to the effects of projected climate change, especially at shorter storm durations, it may be possible in the particular location of interest to develop reasonable bounding estimates for consideration during design. Even if a defensible design estimate cannot be established, it will generally be possible at the early stages of infrastructure planning to design infrastructure that is resilient to a wide range of possible future climates.

Some general considerations for designing new infrastructure in the face of uncertain climate change include:

- **Capitalize upon local knowledge and data**: In all cases, a good knowledge of existing local conditions, including collection and analysis of historical data used to develop IDF information, continues to have high value in designing infrastructure under projected climate change scenarios. For example, understanding how systems have responded to past extreme conditions will normally be useful in understanding how systems are likely to respond to future extreme conditions (CSA, 2010).
- **Carefully consider the anticipated service life of infrastructure when applying IDF information**: Anticipated service life of new infrastructure becomes an increasingly important consideration under projected climate change scenarios. Previously, commonly used practice was to assume that historical data alone was a good indicator of future climate, meaning that, in theory, required design capacities for most drainage and stormwater infrastructure should not change over time. Due to projected climate change, this assumption is likely no longer valid, meaning that required design capacities may change over time (CSA, 2010).
- **Do not count on beneficial aspects of climate change**: In general, projected climate change is anticipated to adversely affect (i.e., increase the required design capacity of) most infrastructure commonly designed using IDF information. However, in some particular instances and some particular locations, there may be beneficial aspects, theoretically allowing a reduction in required design capacity as compared with design using historical

Reference: Impacts of Climate Change on the Waterloo Sanitary Sewer Master Plan (WSS

information. In these cases and because of the inherent uncertainty in projections for climate change, it would generally be recommended to neglect these beneficial aspects in selecting an ultimate capacity for infrastructure design, except in unusual circumstances. If these benefits do actually occur, then it may be possible to factor these considerations into schedules and plans for long-term operation and maintenance (i.e., reduction in estimated annual pumping capacities) (CSA, 2010).

- **Consider an adaptation design increment when investing in larger, long-lived infrastructure**: In general, installing infrastructure with increased capacity normally results in a relatively small additional incremental cost (i.e., the cost of increasing pipe size requirements to the next commercially available diameter) at the time of initial construction. In many cases, this may be a reasonable approach to provide allowance for projected climate change considerations (CSA, 2010).
- **Allow for future infrastructure upgrades where possible**: There may be cases where it is not prudent or realistic to initially construct all anticipated capacity required due to projected climate change (e.g., sanitary sewers and pump stations that might need to be upsized in the future due to the effects of climate change). In these circumstances, it may be reasonable to make appropriate considerations (e.g. acquire necessary lands) for this possible future expansion, but only complete the additional construction work when necessary (CSA, 2010).
- **Consider green infrastructure and low impact development**: Building infrastructure that is resilient to climate change does not necessarily have to mean building larger infrastructure. Green infrastructure (or Low Impact Development) approaches might be used instead of, or in conjunction with, larger infrastructure built to accommodate projected climate change. These approaches typically also have a variety of co-benefits, such as mitigation of climate change as well as ecological and social benefits (CSA, 2010).

STANTEC CONSULTING LTD.

Jennifer Hale, B.A.Sc.
Engineering Intern, EIT
Phone: (519) 585-7362
Fax: (519) 579-8806
Jennifer.Hale@stantec.com

REFERENCES

Canadian Standards Association (CSA). 2010. *Draft Standard: Technical Guide – Development, Interpretation and Use of Rainfall Intensity-duration-frequency (IDF) Information: Guideline for Canadian Water Resources Practitioners.*

Environment Canada. 2012. *Documentation on Environment Canada Rainfall Intensity-Duration-Frequency (IDF) Tables and Graphs. V2.20.*

Expert Panel on Climate Change Adaptation (Expert Panel). 2009. *Adapting to Climate Change in Ontario: Towards the Design and Implementation of a Strategy and Action Plan.* Prepared for the Ministry of the Environment.

Grand River Conservation Authority (GRCA) 2014. *Grand River Watershed Water Management Plan*. 2014. Prepared by the Project Team, Water Management Plan.

Ministry of the Environment (MOE). 2014. *Policy Review of Municipal Stormwater Management in the Light of Climate Change – Summary Report.*

Simonovic, S. and Peck, A. 2009. *Water Resources Research Report: Updated Rainfall Intensity Duration Frequency Curves for the City of London Under the Changing Climate.* The University of Western Ontario Department of Civil and Environmental Engineering.

Simonovic, S., Srivastav, R., Schardong, A., Sandink, D. 2014. *IDF Under Change Climate*. Webinar Presentation Materials presented by the University of Western and the Institute for Catastrophic Loss Reduction.

Toronto and Region Conservation Authority (TRCA). 2009. *Preparing for the Impacts of Climate Change on Stormwater and Floodplain Management: A Review of Adaptation Plans and Practices.* Prepared for the Region of Peel.