Analysis of Extreme Rainfall and Consequences

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Background/Objectives. Extreme rainfall is a current problem causing major flooding in cities and rural areas in almost all regions of the world. The current status of climate modeling is not yet able to simulate extreme rainfall events, and it is now generally acknowledged that current estimates of projected increases are underestimating both storm intensity and frequency with all of the associated risk involved. Projecting changes in severe storms is also challenging because of Global Climate Model (GCM) limits on grid size that make it hard to capture and represent small-scale, highly local physics. The most recent scientific literature paints a complex picture of climate-related changes to extreme rainfall, making estimating the intensification of rainfall extremes more complex than any simple approach can provide. This represents a very significant challenge for municipalities and utilities to prepare for and adapt to impacts related to extreme storms, whether it results in riverine flooding or urban flooding due to insufficient capacity to manage extreme runoff events.

Approach/Activities. The study represents a comprehensive literature review of the current state of science in estimating expected changes in extreme rainfall due to climate change. From this review, extreme rainfall guidance has been developed to help use the current science to assess potential increases in storm intensity and frequency for incorporating projections into design and planning at the municipal level. The review includes the results of studies that utilize the three main approaches to estimating changes to extreme rainfall intensity and frequency:

- Use of regional climate models
- Use of convection permitting models
- Adaptive percentage increases that depend on temperature increases (as represented by future time horizons) and rainfall frequency. The most common estimates start with and adjust the Clausius-Clapeyron relationship, suggesting a 7% increase for each temperature increase of 1 degree Celsius.

Results/Lessons Learned. Some of the more important results of the study indicate that:

- Shorter duration, longer return period events will likely see the largest rainfall increases in a warmer climate.
- The design and use of rainfall intensity–duration–frequency curves must be adjusted for both an overall increase in magnitude and a steepening of the curve.
- Current measures vary from multiplying historical design rainfall by a simple constant percentage to modulating correction factors based on return periods and to scaling them to the Clausius-Clapeyron relationship based on projected temperature increases.

Unfortunately, all of the current projections and measures of extreme rainfall fail to recognize a possible super Clausius-Clapeyron scaling of extreme rainfall and, perhaps more importantly, the increasing scaling toward shorter-duration rainfall and the most extreme rainfall events that will significantly impact stormwater runoff in cities and in small rural catchments.