100-Year Storm Data Analysis

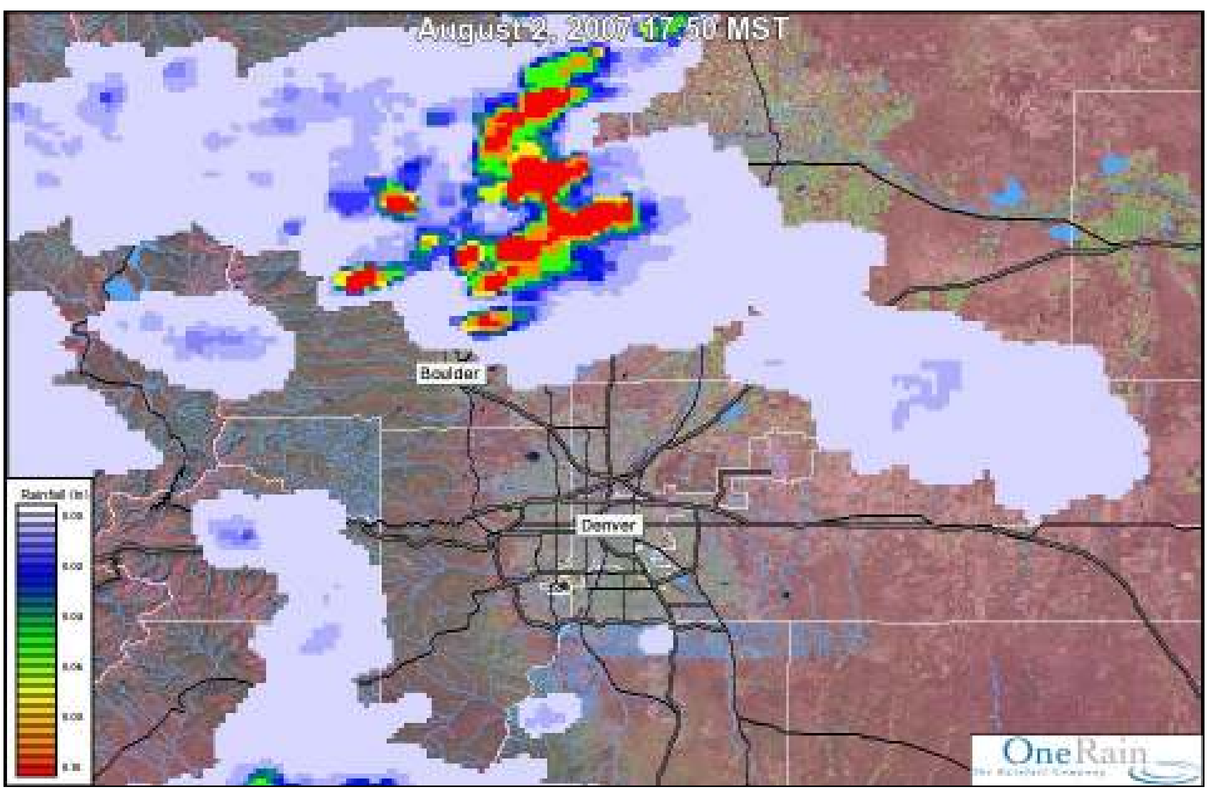
On the evening of August 2nd, 2007 a very intense rain event moved through southern Fort Collins, Colorado. Based on flows measured by the City, this was a 100-year event.

The intent of this analysis was to produce a data set simulating the behavior of the Urban Drainage and Flood Control District and Boulder County's combined flood warning system if this storm were to have moved through the most gage-dense area of this network. To accomplish this OneRain produced three deliverables:

- A video file (ft_collins_aug2.wmv) showing the progression of the storm over the Fort Collins, Boulder and Denver region
- A flat file (ft_collins_aug2_ALERT.xls) presenting the simulated rainfall had that storm traveled over the UDFCD ALERT network
- A flat file (ft_collins_aug2_intensity.xls)

In order to understand the behavior of the ALERT system OneRain investigated the behavior of the system based on recent data from our DIADvisor base station. With this information it was possible to discern the normal reporting conditions and how they relate during quite periods and stormy periods.

This system behavior was then modeled and tested against the available data set. This model was then applied to the 100-year recurrence interval event that hit Fort Collins. Using calibrated radar rainfall data the District/County gage network was moved under this storm to see how it would perform.

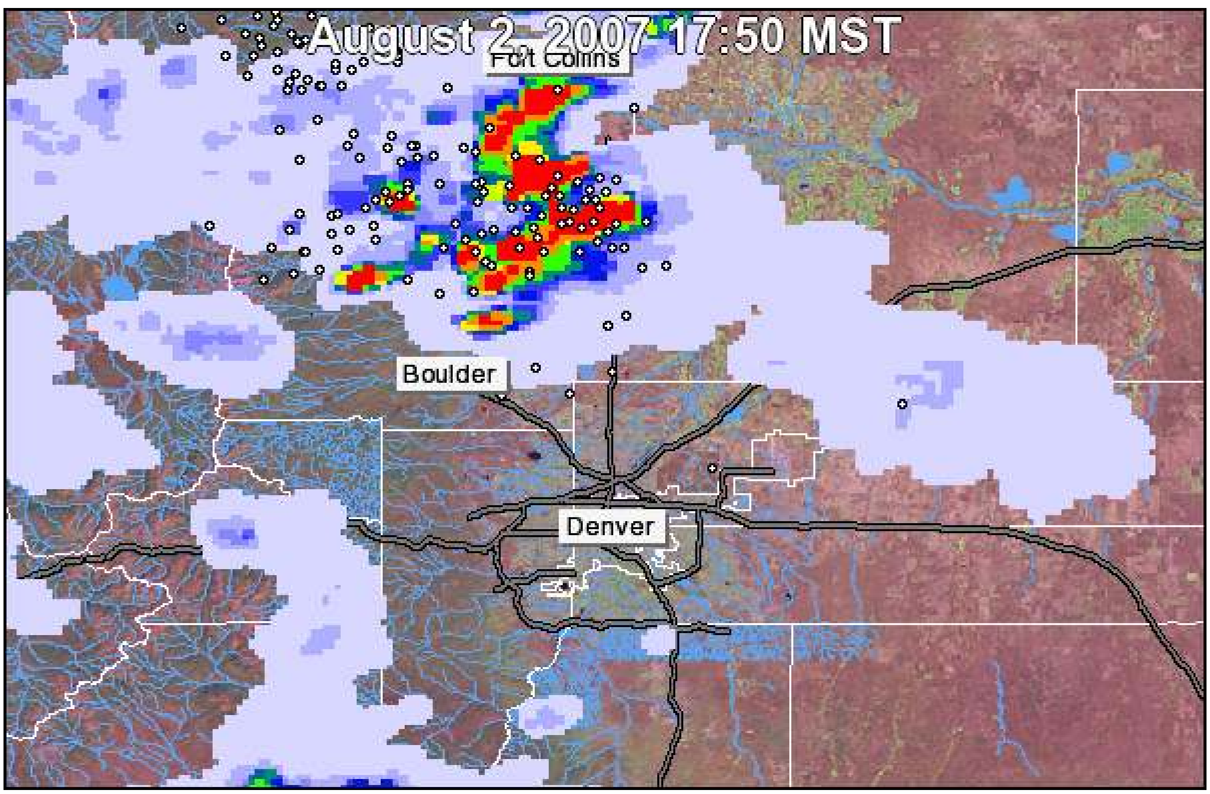


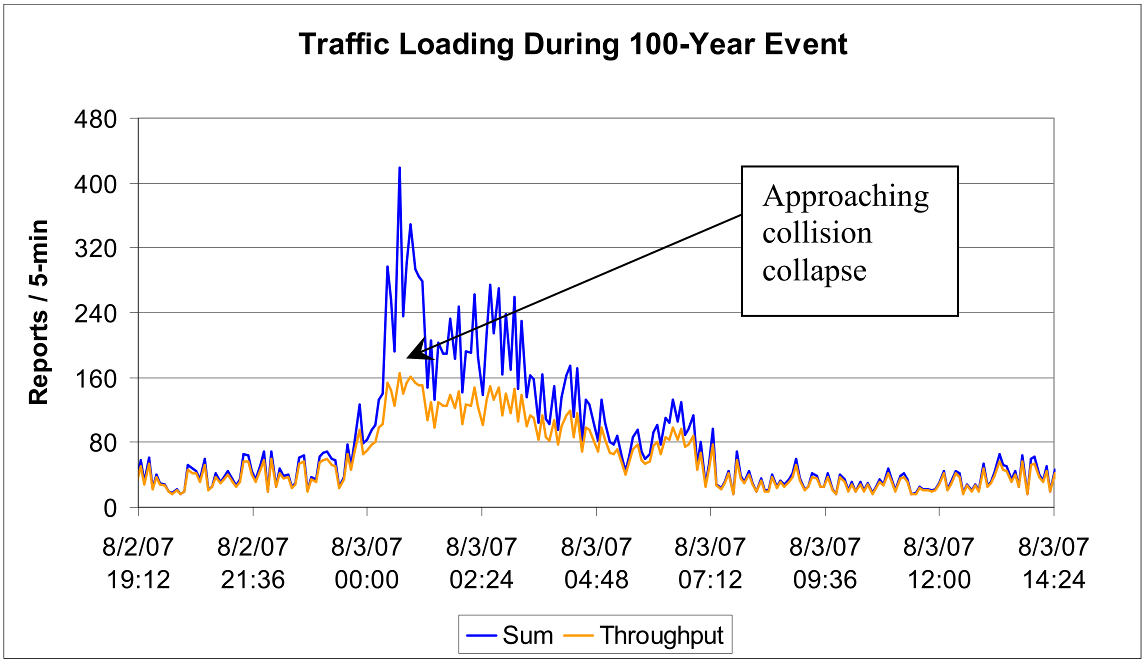
Application of the Poisson Process to a 10-Year Storm

OneRain performed a spatially adjusted radar calibration that covered the time period from 8/2/2007 12:16 to 8/3/2007 07:57. At latitude: 40.3669° N, longitude -104.896° W the calibrated NOAA weather radar reported 3.7" of rainfall in these three hours. According to Technical Publication 40 (1961) this exceeds the 100-year, 3-hour annual exceedence. The image below represents 5 minutes of rainfall accumulation; the red areas are approaching 0.2".

To simulate the behavior of the ALERT system during such a storm, OneRain programmatically "moved" the gage network under the storm. The new gage locations are shown as white dots on the map.

Running this simulation allowed for the construction of a time-series data set of rain tip reports which is shown on the next page.





The graph above shows a simulation of how the ALERT system would respond when subjected to this storm. The report count numbers for each 5-minute period is modeled from the rain, stage and weather gages, and does not include duplicates, other invalid reports, or other sensors. Using the trends for weather and water level reporting, it was possible to create a picture of the total offered load under the current system's configuration.

Model stage reporting behavior

Stage reporting in the June 2007 storms tended to peak about an hour after the rain reporting peaks. This collection of storms generally arrived in three pairs. Roughly, the time difference between peak rain reporting and peak stage reporting for the first storm in each pair was one hour. The time difference between the subsequent peaks tended to be shorter than one hour. This is most likely due to the antecedent soil saturation conditions. Modeling this behavior is rather complex. As a simplifying assumption the following equation was used:

$$\ln(RainCount + 1) \times Max / 6 + 2 \times rand \times Min$$

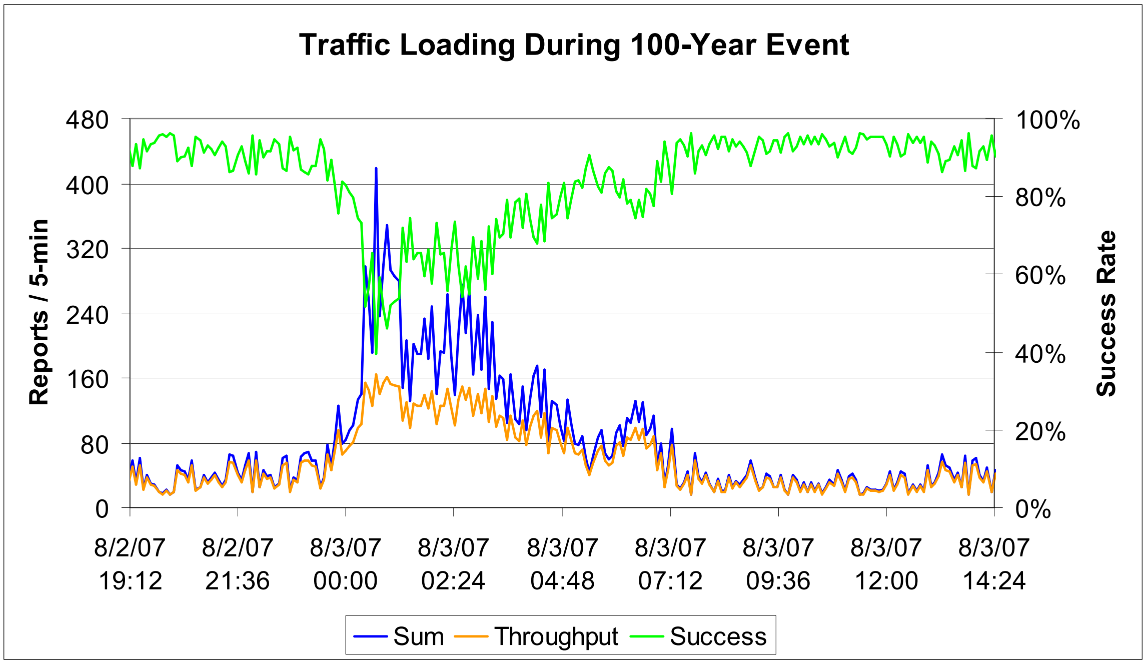
Where,
$RainCount \equiv$ count of rain sensor reports in the 5 minute interval
$Max \equiv 99^{th}$ percentile of stage sensor counts (45 reports in 5 minutes)
$Min \equiv 50^{th}$ percentile of stage sensor counts (4 reports in 5 minutes)
$rand \equiv$ random number between 0 and 1

As the rain sensor count increases, the stage values approach the maximum count value, and along the way the stage sensor count can fluctuate by ± the *Min* value.

Model weather reporting behavior

The weather sensors were treated as having consistent reporting across all intervals. An average number of 17 reports for all meteorological sensors was used throughout. The weather report count and stage report count values were added to the rain counts to arrive at the base offered load by the reporting sensors.

Once the stage, weather, and invalid traffic loads were estimated based on the rainfall traffic load, it was possible to visualize the system's performance under a high stress storm situation.



Attachments

The following documents are included on the companion CD

- Video file: ft_collins_aug2.wmv
- Data file: ft_collins_aug2_ALERT.xls
- Data file: ft_collins_aug2_intensity.xls

References

G.A. Hufford, A.G. Longley, W.A. Kissick, "A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode", NTIA Report TR-82-100, April 1982

Geoffry Grimmett and David Stirzaker, "Probability and Random Process", Third Ed., Oxford University Press, 2001

U.S. Department of Commerce, Weather Bureau, "Rainfall Frequency Atlas of the united States", Technical Paper No. 40, May 1964