Exceedance Probability Analysis for the Central Texas Rainfall Events Of Late October 2015

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Introduction

The Hydrometeorological Design Studies Center (HDSC) analyzed annual exceedance probabilities (AEPs) for two rainfall events that occurred in central Texas: (1) near Corsicana on 24 - 25 October and (2) near Austin on 30 October. AEP is probability of exceeding a given amount of rainfall for a given duration at least once in any given year at a given location. It is an indicator of the rarity of rainfall amounts and is used as the basis of hydrologic design.

For the AEP analysis, we look at a range of durations and select one or two critical durations that show the lowest exceedance probabilities for the largest area, i.e., the "worst case(s)." Since the beginning and ending of the worst case period is not necessarily the same for all locations, the AEP maps do not represent isohyets at any particular point in time, but rather within the whole event.

Underlying data

The underlying data for the AEP analyses are rainfall observations and point rainfall frequency estimates for a range of durations and frequencies.

Hourly rainfall data at 4km grid resolution come from the National Centers for Environmental Prediction (NCEP), Environmental Modeling Center's (EMC) Stage IV analysis. Stage IV data is a mosaiced product of regional hourly and 6-hourly multi-sensor (radar + gauges) precipitation estimates (MPEs) produced by the 12 River Forecast Centers. Hourly rainfall grids for each event were aggregated to overlapping 3, 6 and 24 hour durations and the maximum amount of rainfall was extracted for each selected duration for each grid cell inside the area of interest.

We obtained gridded rainfall frequency estimates from the Weather Bureau's Technical Paper 40 - TP40 (Hershfield, 1961), which is still the valid NWS precipitation frequency document for the state of Texas. We first digitized paper cartographic maps from TP40 for 3-hour, 6-hour, and 24-hour durations and for 1/10, 1/50 and 1/100 AEPs (an example of a map from TP 40 is shown in Figure 1) and then used the standard spatial interpolation tools available in ArcGIS to derive gridded estimates at 4km resolution.

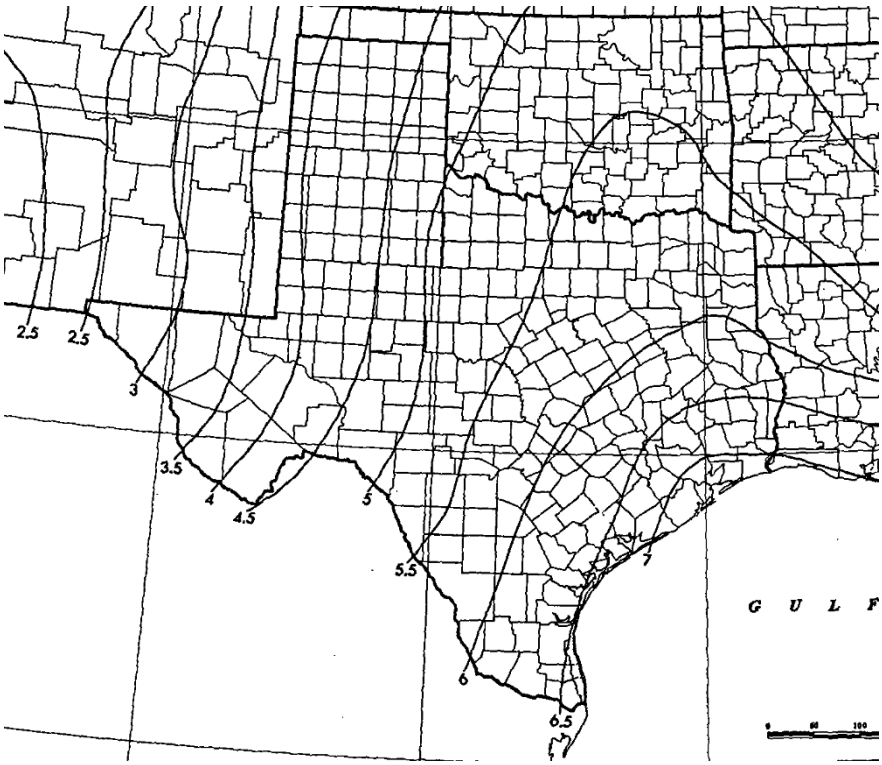

Figure 1. Cartographic map from TP40 showing precipitation frequency estimates for Texas for 3-hour duration and 1% AEP (100-year average recurrence interval).

Since the TP40 estimates are available only for selected AEPs up to the 1/100, we adopted simplified NOAA Atlas 14 methodology to extrapolate estimates to 1/200 and 1/500 AEP. We collected rain gauge data from the National Centers for Environmental Information's (NCEI) database for 13 stations in the region of interest and extracted annual maximum series (AMS) at 3 selected durations (3-hour, 6-hour, and 24-hour). From the AMS, we calculated regional L-moment statistics and then the parameters of the GEV distribution, which were used to produce precipitation frequency estimates for a range of durations and AEPs. For more information about regional frequency analysis, please see documentation for NOAA Atlas 14 Volume 9 (Perica et al., 2013). Extrapolation to 1/200 and 1/500 AEPs utilized the inherently strong linear relationship that was found to exist between precipitation frequency estimates for consecutive frequencies (R^2 value above 0.99). 1/200 AEP gridded estimates were obtained by applying the ratio of rainfall frequency estimates for 1/200 and 1/100 AEP from the GEV distribution to 1/100 AEP grid from the TP40. Similar method was applied to obtain 1/500 AEP gridded estimates.

Development of AEP grids

The maximum 3-hour, 6-hour, and 24-hour precipitation grids were converted to AEP maps by comparing them to the TP40 grids (extrapolated to 1/500 AEP).

For the Corsicana storm of 24 - 25 October, the critical duration was 24 hours. The map in Figure 2 shows areas that experienced 24-hour rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/500 (0.2%). According to this analysis, the Automated Surface Observing System (ASOS) C David Campbell Field-Corsicana Municipal Airport gauge KCRS, 5 miles SE of Corsicana, experienced rainfall magnitudes over 20 inches, with an AEP lower than 1/500 (0.2%) at the 24-hour duration.

For the Austin storm of 30 October, we created AEP maps for 3-hour and 6-hour durations. For this event, for example, the Lower Colorado River Authority (LCRA) rain gauge at Highway183 and Onion Creek reported the following maximum precipitation rates:

Duration (hours)	Time period (CDT)	Precipitation (inches)
2	8:55 to 10:55	10.81
3	8:26 to 11:26	13.07
6	5:55 to 11:55	14.21

The LCRA gauge captured rainfall magnitudes with AEPs lower than 1/500 (0.2%) for multiple durations. Figure 3 and Figure 4 show areas that experienced rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/500 (0.2%) for the 3-hour and 6-hour durations, respectively.

References

Hershfield, D.M. (1961). Technical Paper No. 40, Rainfall Frequency Atlas of the United States for durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years, U.S. Weather Bureau, Washington D.C.

Perica, S., D. Martin, S. Pavlovic, I. Roy, M. St. Laurent, C. Trypaluk, D. Unruh, M. Yekta, G. Bonnin (2013). NOAA Atlas 14 Volume 9 Version 2, Precipitation-Frequency Atlas of the United States, Southeastern States. NOAA, National Weather Service, Silver Spring, MD.

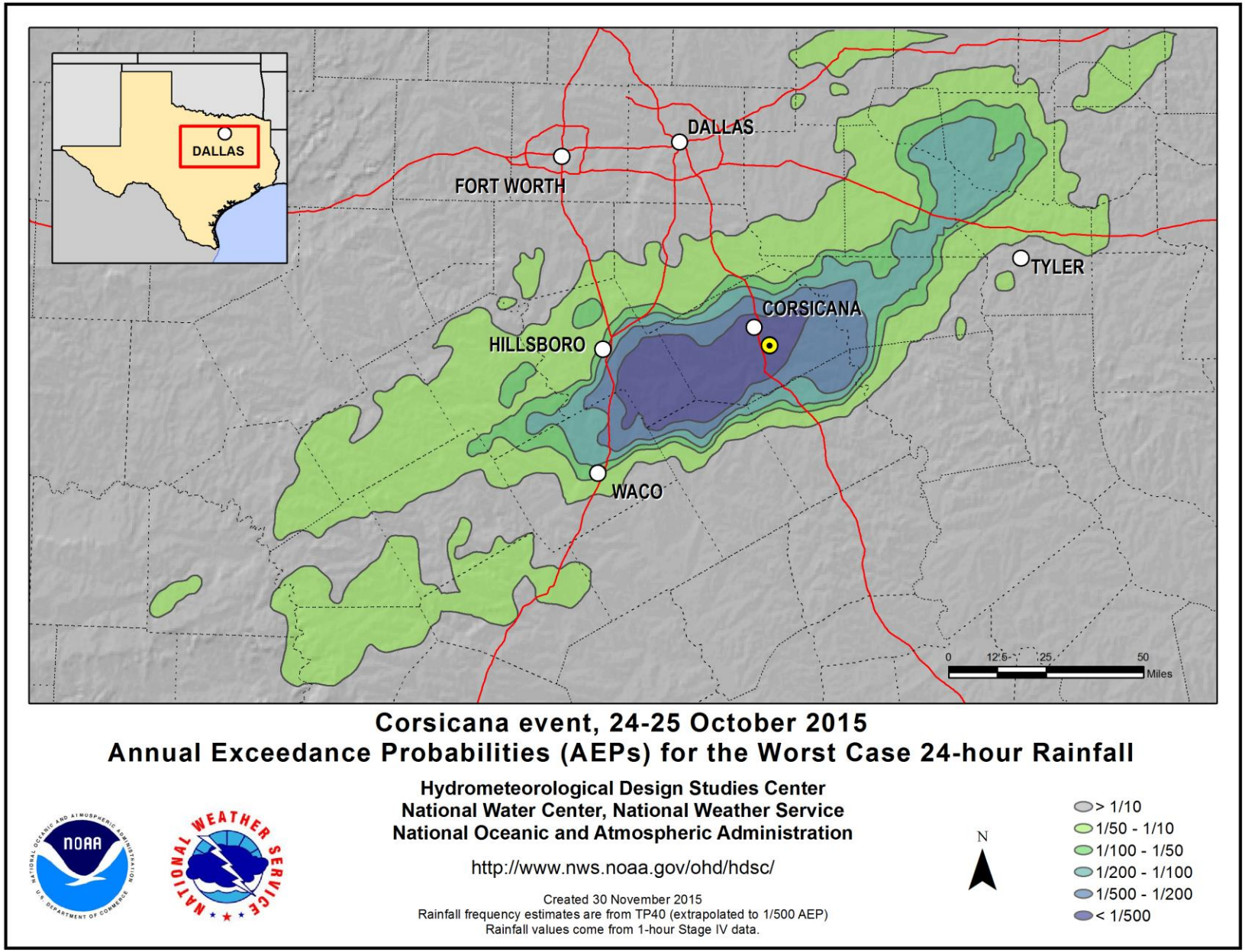

Figure 2. Annual exceedance probabilities for the worst case 24-hour rainfall from 24 to 25 October 2015. The yellow marker is the location of the KCRS gauge.

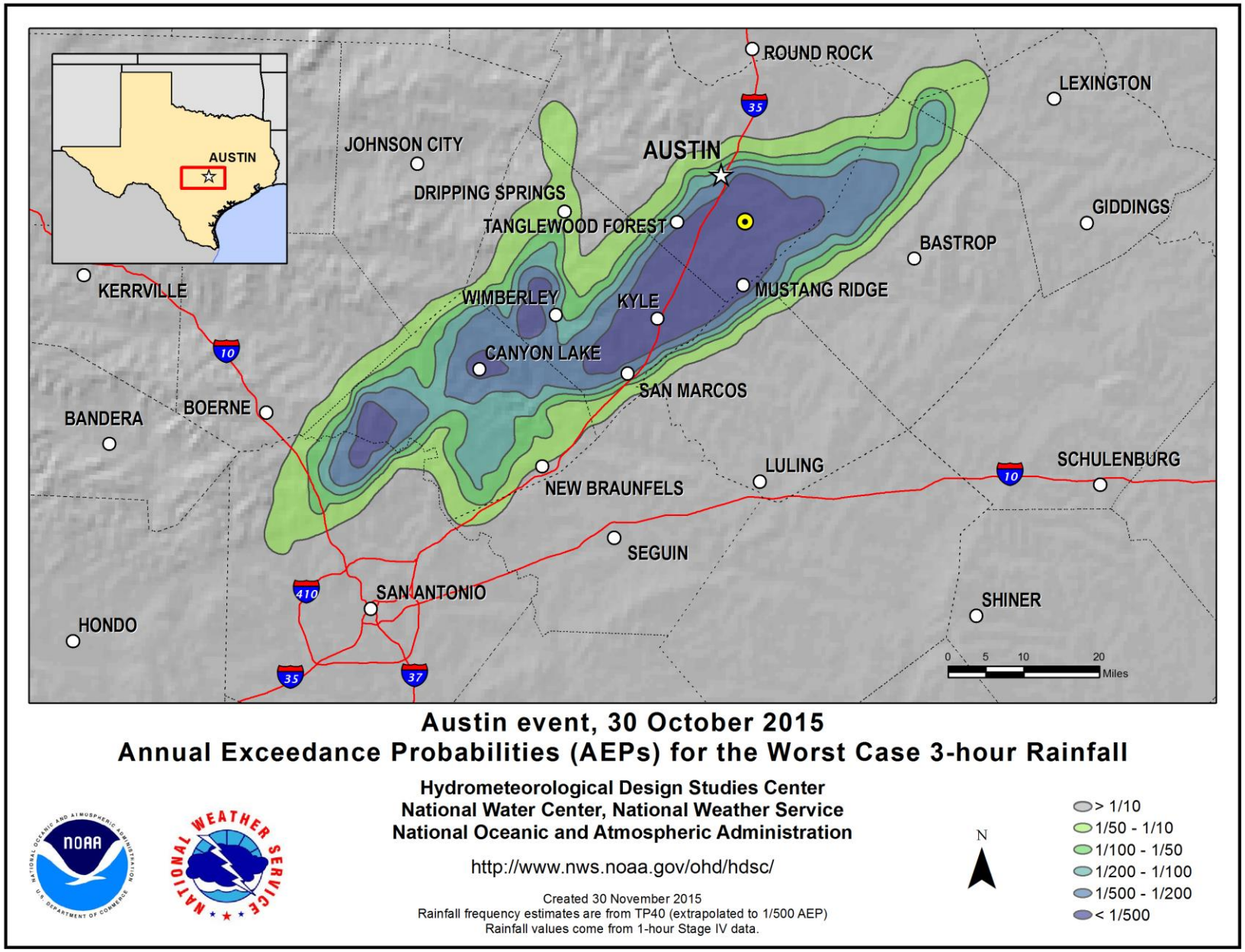

Figure 3. Annual exceedance probabilities for the worst case 3-hour rainfall from 30 October 2015. The yellow marker is the location of the LCRA gauge.

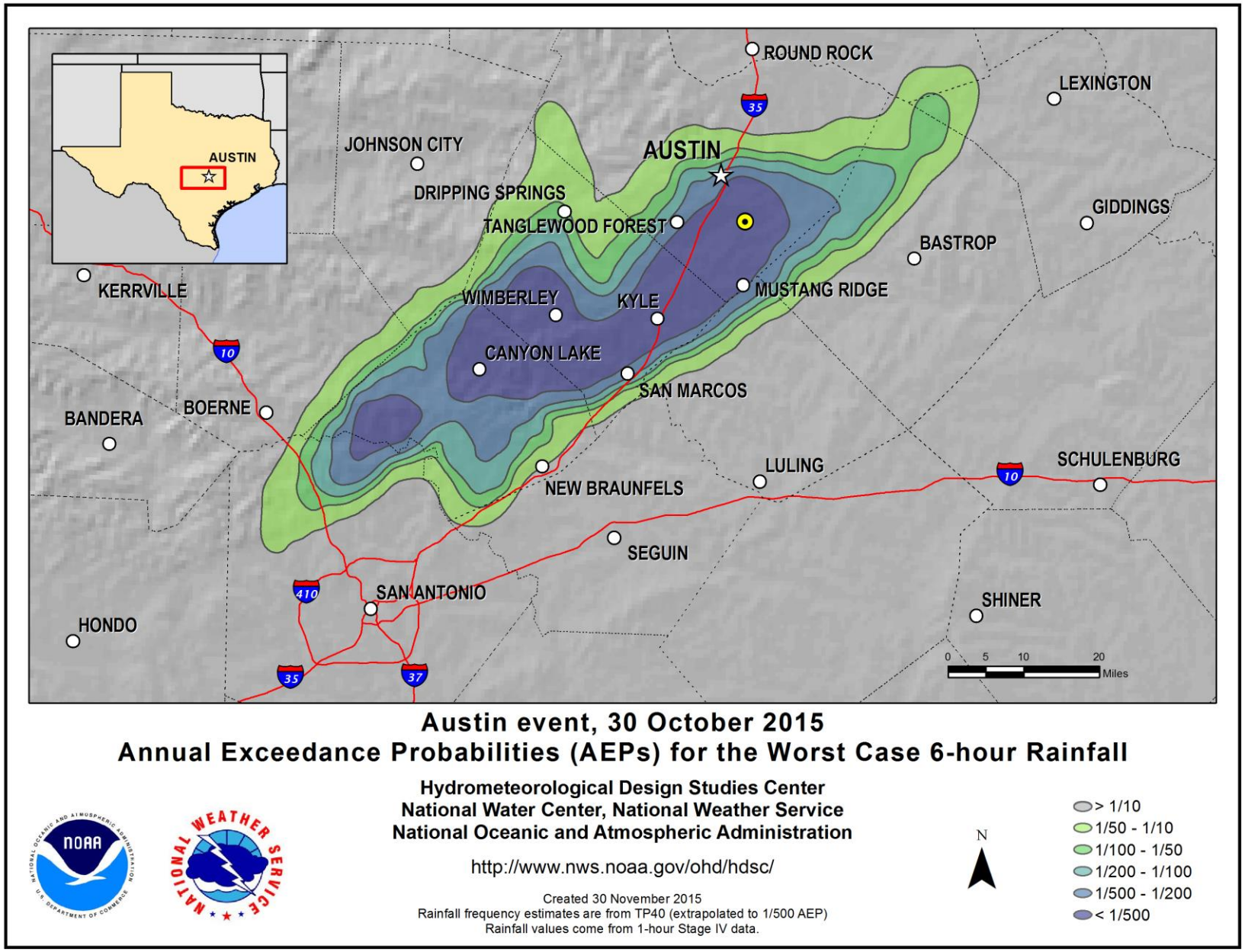

Figure 4. Annual exceedance probabilities for the worst case 6-hour rainfall from 30 October 2015. The yellow marker is the location of the LCRA gauge.