**Exceedance Probability Analysis for the Colorado Flood Event, 9-16 September 2013**
**Hydrometeorological Design Studies Center (HDSC), National Weather Service, NOAA**
**September 17, 2013**

HDSC developed maps showing annual exceedance probabilities (AEPs) of the worst case rainfall for the Colorado event that started on September 9, 2013. AEP is probability of exceeding a given amount at least once in any given year at a given location. It is an indicator of the rarity of amounts of rainfall and is used as the basis of hydrologic design and regulation. The Colorado event delivered total rainfall amounts that exceeded 15 inches in some locations as it slowly moved through the area and caused extensive river flooding.

The rarity of this event is illustrated in four figures below. Figure 1 shows how the maximum rainfall amounts compared to corresponding precipitation frequency estimates for AEPs from 1/2 (50%) to 1/1,000 (0.1%) for durations from 15 minutes to 7 days for a rain gage in the Boulder area - Justice Center station (40.014 ˚N, 105.288 ˚W, 5400 ft elevation). The upper bound of the 90% confidence interval for 1/1,000 AEP is also shown in the figure to illustrate uncertainty associated with the calculation of AEPs, which increases as the AEP becomes smaller. The Justice Center gauge is an ALERT station maintained by the Urban Drainage and Flood Control District in Denver. The precipitation frequency estimates are from NOAA Atlas 14 Volume 8. As can be seen from Figure 1, for sub-hourly durations, the probability that a measured amount from Justice Center could be exceeded in any year was above 10%; probabilities rapidly decrease with duration and reach 1/1,000 at 24-hour. The accumulated rainfall continues increasing through 7 days, and corresponding AEPs are less than 1/1,000, but they remain below the 95% limit for the 1/1,000 AEP for all durations up to 4 days.

The maps in Figures 2, 3 and 4 show areas that experienced rainfall magnitudes with AEPs ranging from 1/10 (10%) to smaller than 1/1,000 (0.1% ) for 24-hour, 48-hour, and 7-day durations, respectively. Rainfall amounts for these durations are based on NOAA's 6-hour Stage IV quantitative precipitation estimates which were developed using multi-sensor precipitation analyses. Precipitation frequency estimates are again from NOAA Atlas 14 Volume 8. The durations shown in Figures 2, 3, and 4 were selected because they show the smallest AEPs for the largest areas. Note that the beginning and ending of the worst case observation period is not necessarily the same for each location. As a result, these maps do not represent isohyets at any particular point in time, but rather within the whole event.

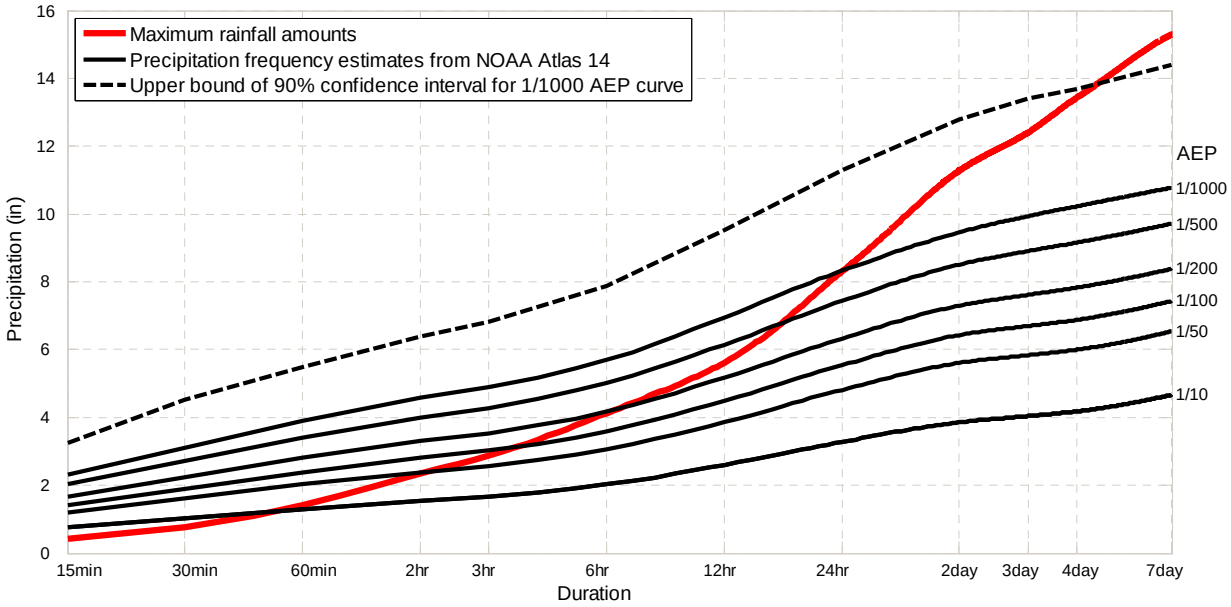


Figure 1. Maximum observed rainfall amounts in relationship to corresponding precipitation frequency estimates for the Justice Center gauge.

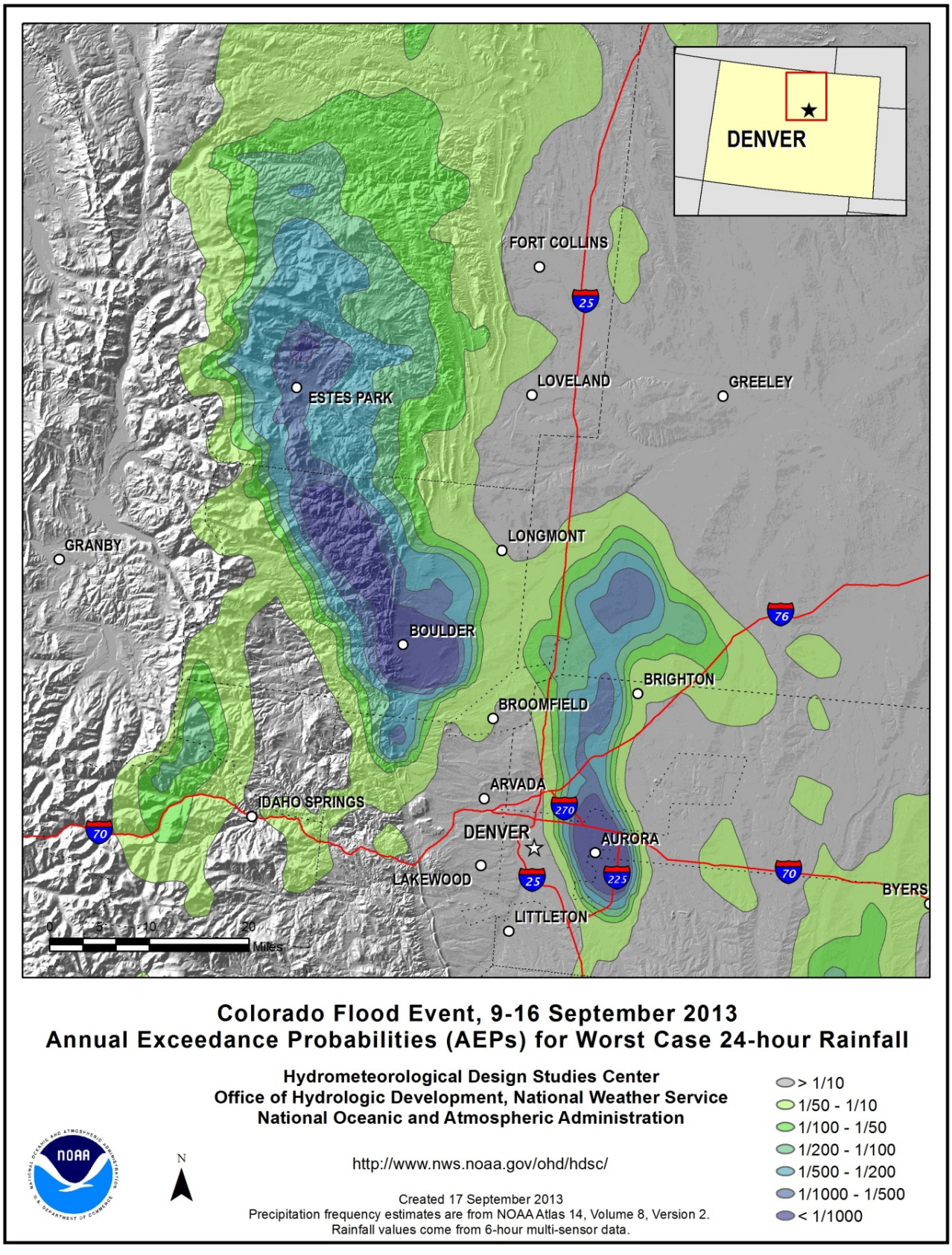


Figure 2. Annual exceedance probabilities for the worst case 24-hour rainfall.

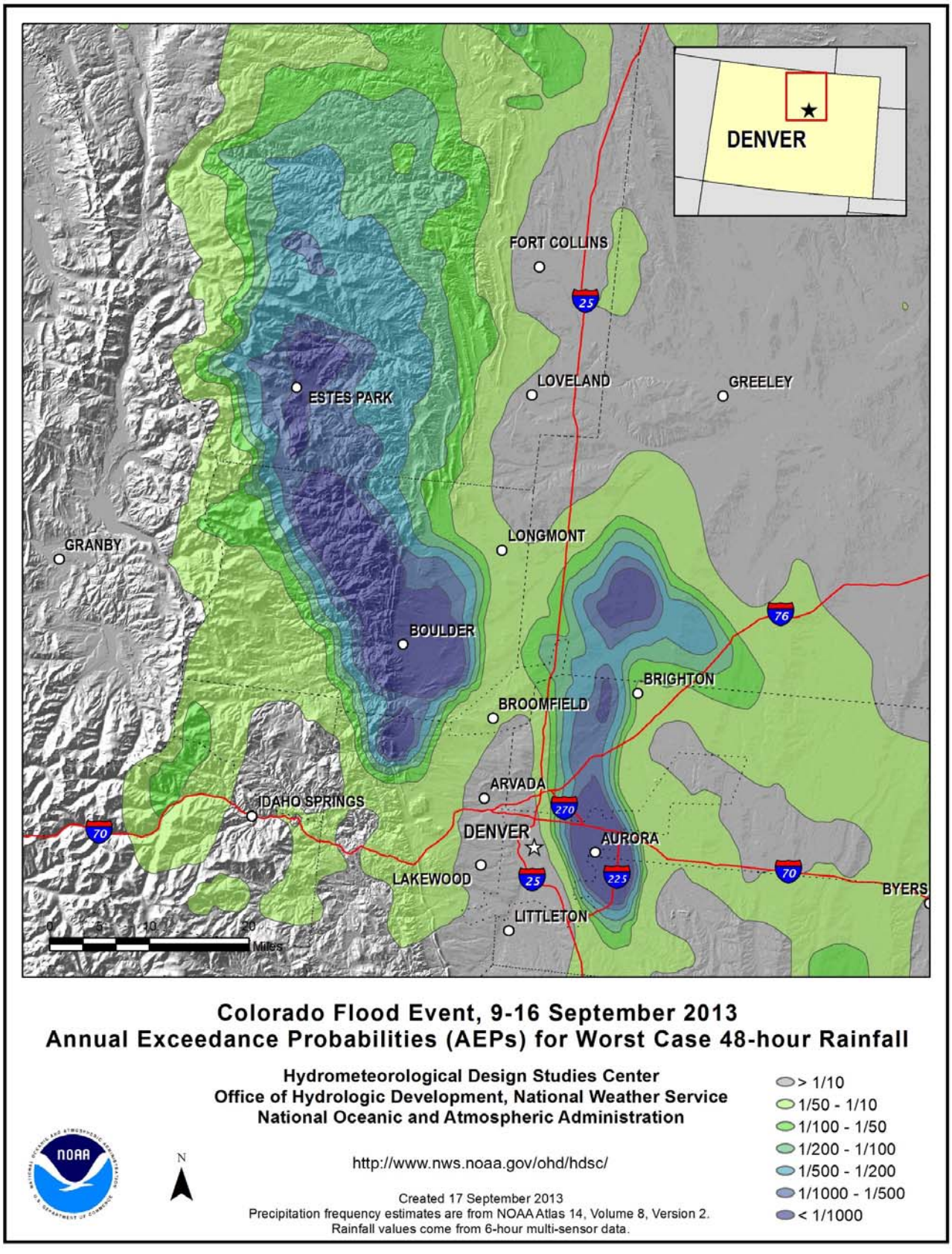


Figure 3. Annual exceedance probabilities for the worst case 48-hour rainfall.

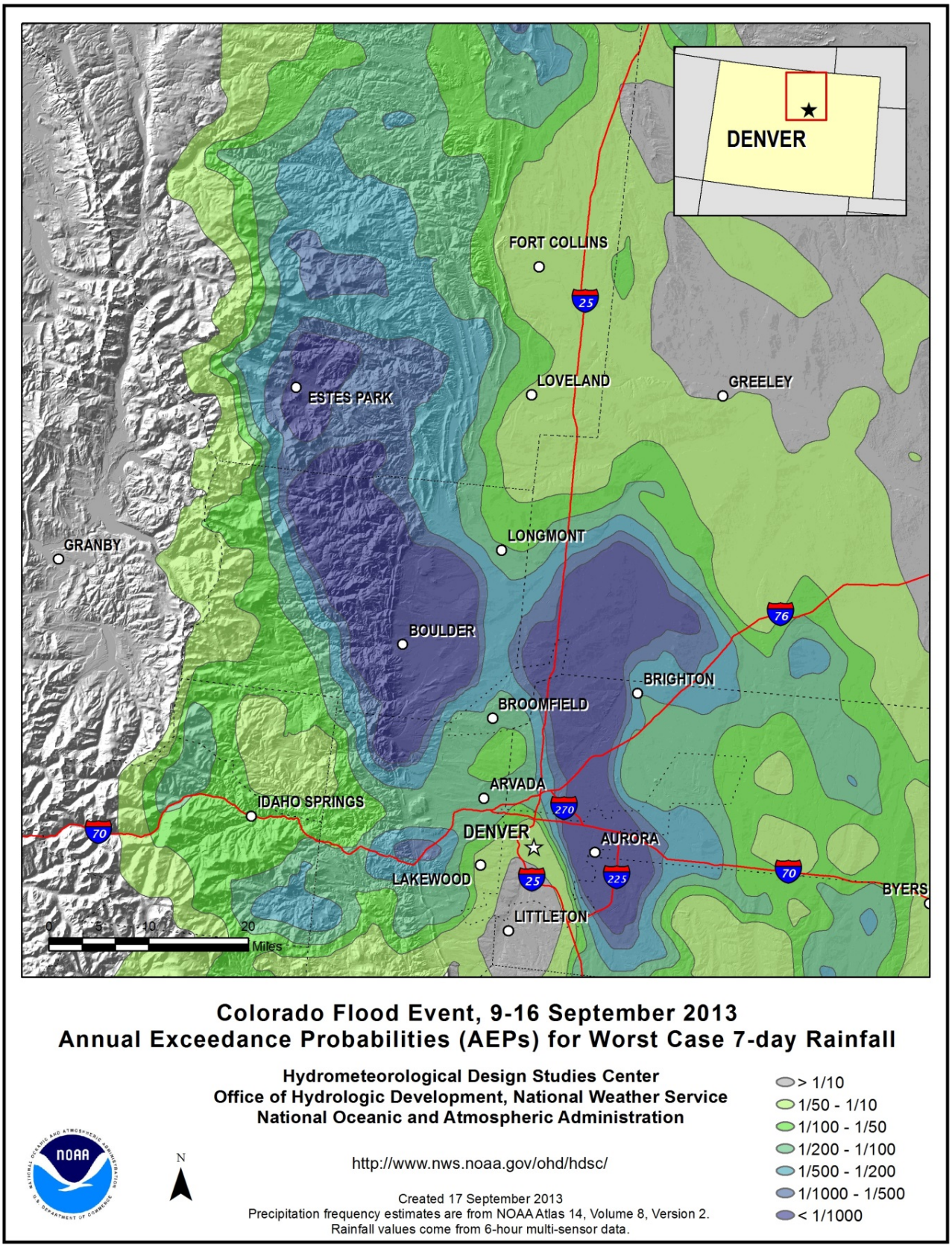


Figure 4. Annual exceedance probabilities for the worst case 7-day rainfall.