

# Assessing Arid Area Extreme Precipitation Using Doppler Radar and Rain Gages

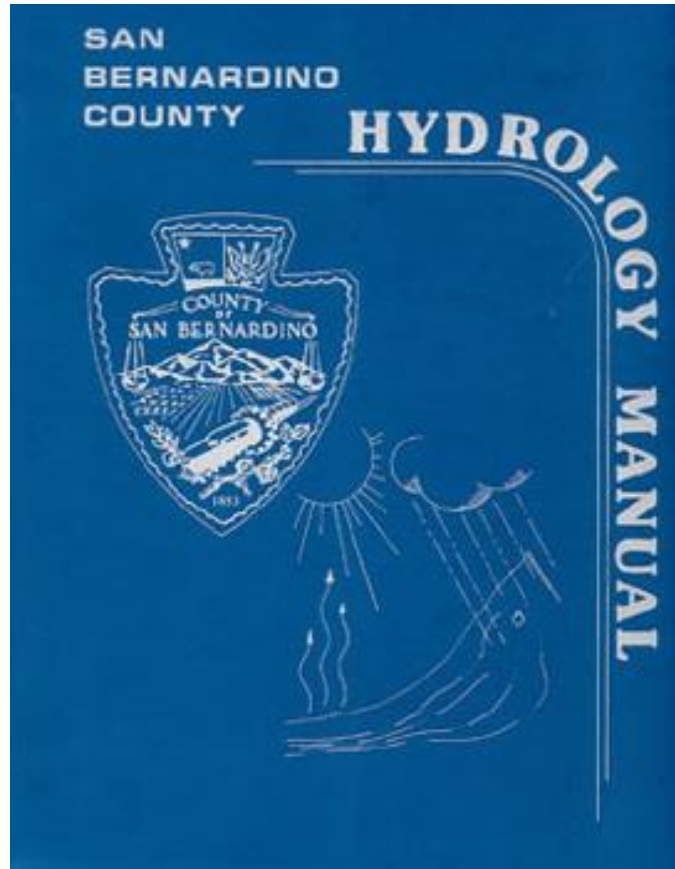
## Investigators

**Theodore V. Hromadka, II**, Ph.D., Ph.D., Ph.D., D. WRE, PE, L.G., P.H.,  
Professor, Department of Mathematical Sciences, United States Military Academy, West Point, NY

**Prasada Rao**, Ph.D., Professor, Department of Civil and Environmental Engineering, California  
State University Fullerton

# Overview

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- The San Bernardino County Hydrology manual was written initially in 1987.
- This effort is aimed at analyzing the rainfall events over the last 2 decades and make recommendations to the County.

# Research Goal

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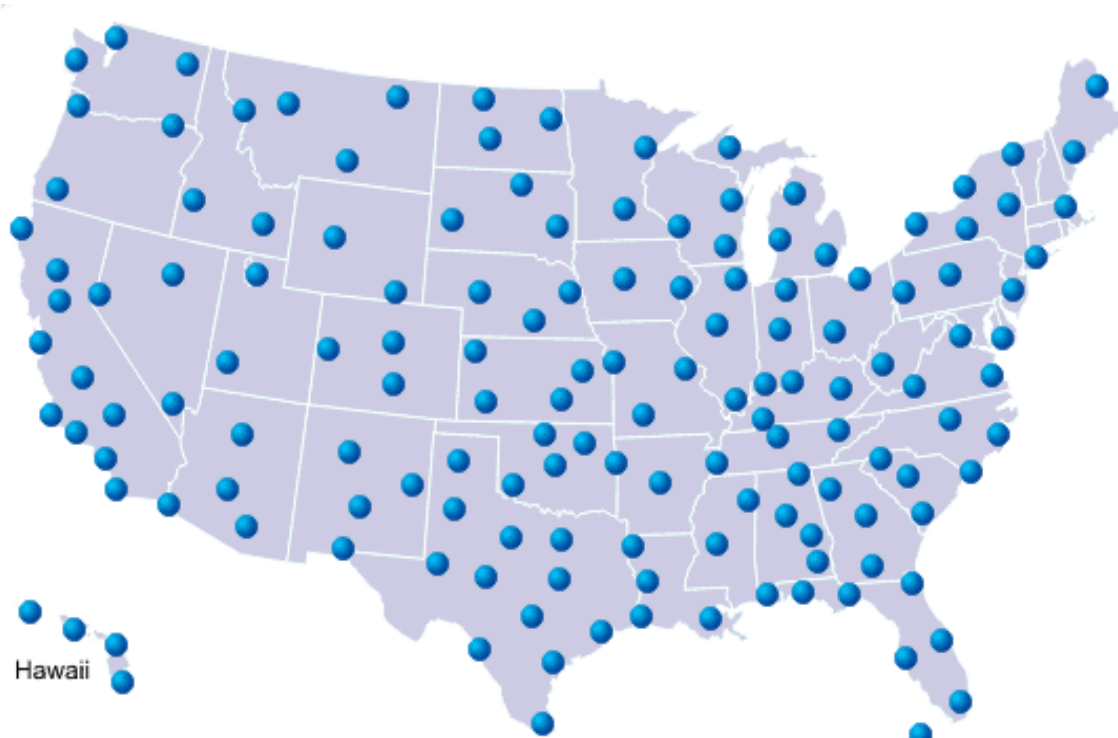
Use RADAR estimated precipitation data, from NWS, to assess possible correlation between Doppler Radar precipitation estimates and rain gage measurements. Focus is on the Arid Southwest United States.

# Region of Interest



San Bernardino County is the largest Mainland county in the US (20,105 sq miles) and fifth largest in population (2M)

# WSR – 88D Radar Network



The Weather Surveillance Radar (WSR-88D) is the technical name for the 159 high resolution S-band Doppler weather Radar, which are part of the NEXRAD (Next Generation Radar) network

# Radars of Interest



KNKX – San Diego

KESX – Las Vegas

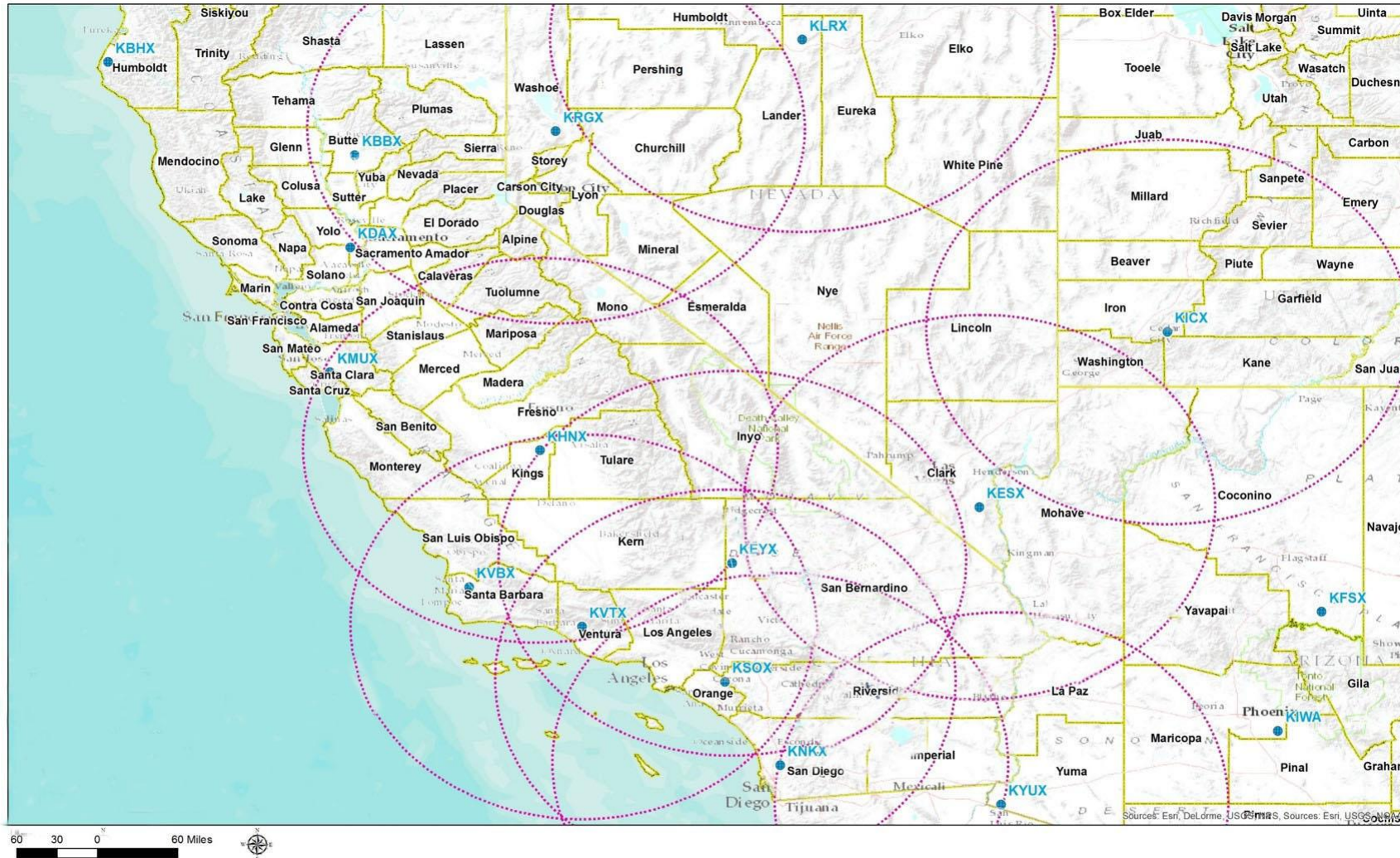
KSOX – Santa Ana

KYUX - Yuma

KEYX - Edwards



# Key Radar Aerial Coverage



# Processing the Rainfall Data

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- Identify key storm events with RADAR coverage that are affecting the San Bernardino County
- The precipitation data (one hour data) was downloaded off the NOAA website ([www.ncdc.noaa.gov/nexradinv/](http://www.ncdc.noaa.gov/nexradinv/)) for each of the storms
- The LVL3-one-hour data summarizes 1-hour precipitation intensity by assigning the precipitation amounts to a 2km by 2km grid

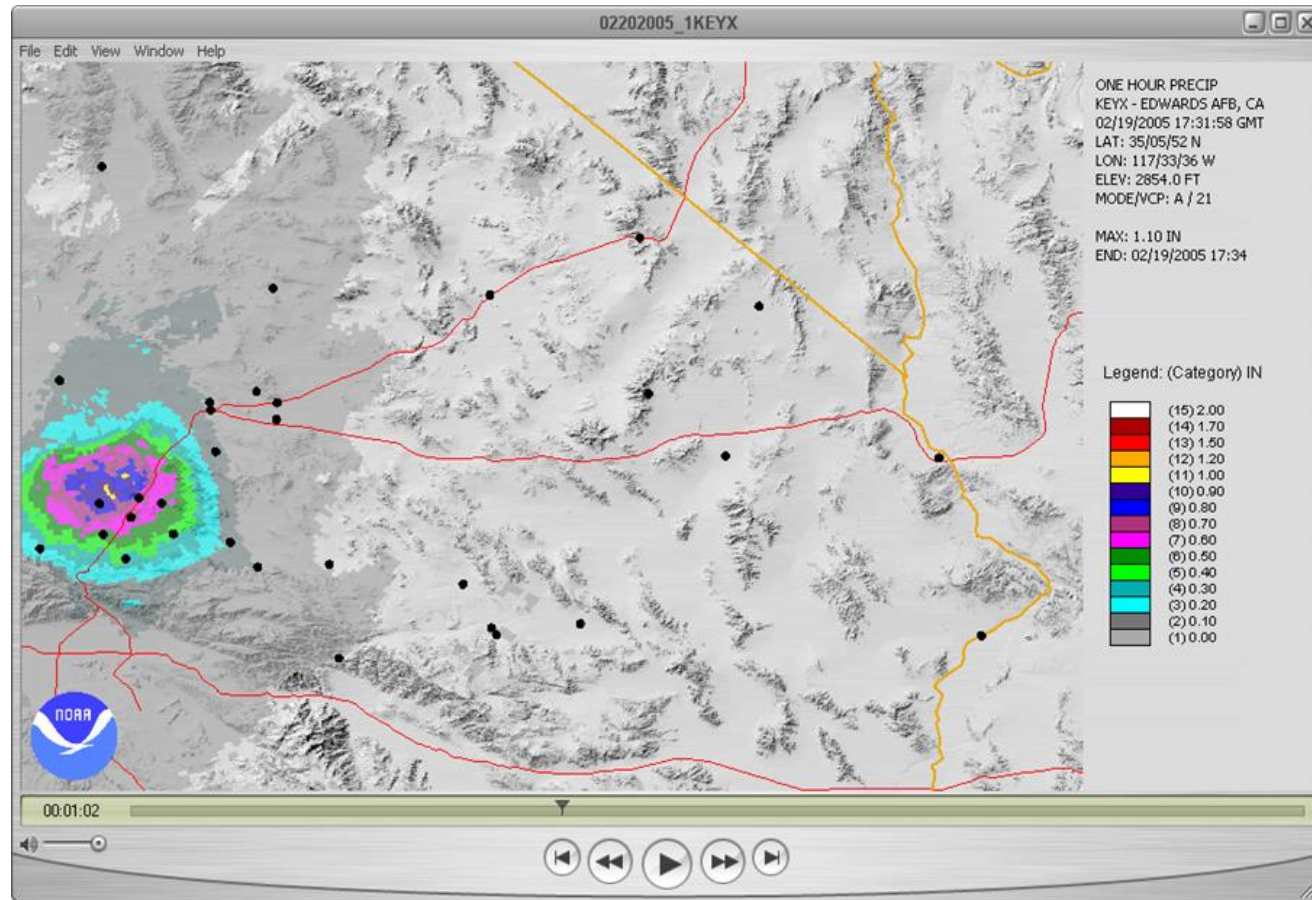


# Processing the Rainfall Data

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- For each of the storms, three days of data (when available) were downloaded.
- Create a Doppler animation for the storm using the NOAA Weather and Climate Toolkit.
- From these animations, the 3-hr, 2-hr, 1-hr, 30-minute and 15-minute peak rainfall peak durations were identified.

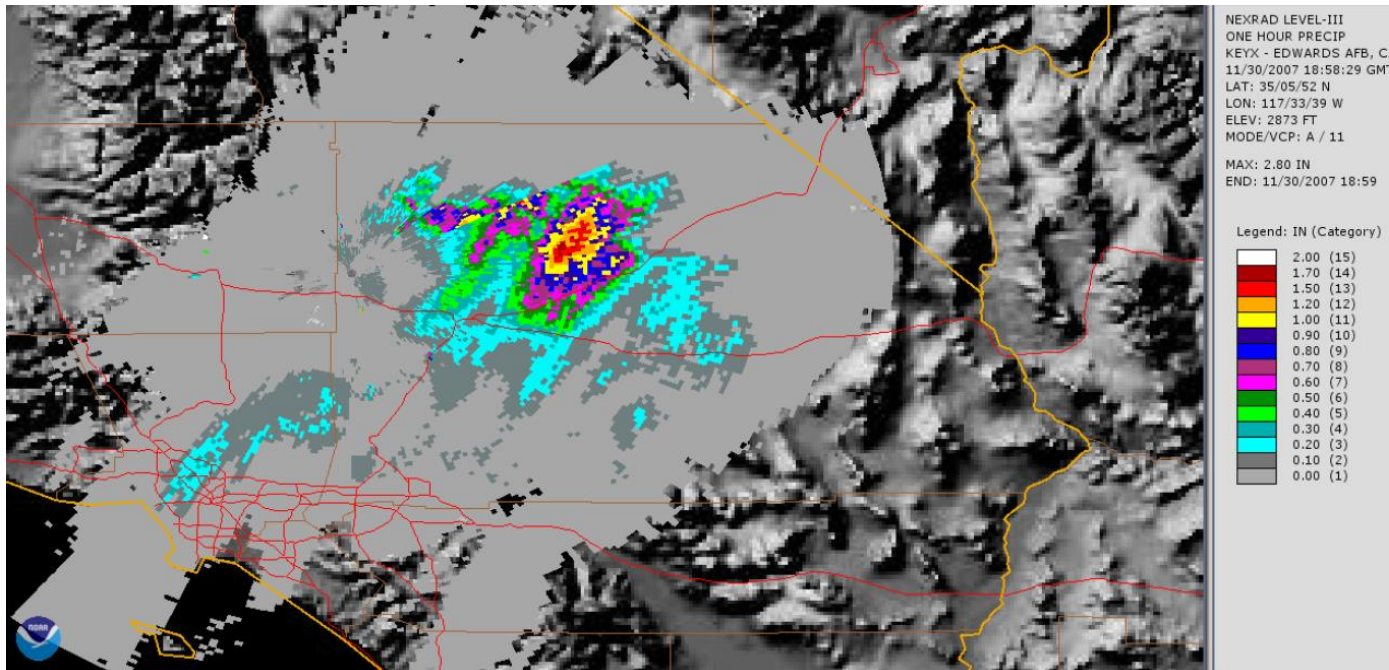
# Case Study



## Peak Rainfall Durations for 2/19/2005 storm for KEYX

Time	Start	End
3 hour	15:51	18:59
2 hour	16:03	18:06
1 hour	17:06	18:06
30 min	17:16	17:46
15 hour	17:23	17:38
Peak time	17:31	

# Processing the Rainfall Data



Peak Rainfall Durations for  
11/30/2007 storm for KEYX

3 Hours	18:03	21:02
2 Hours	18:13	20:12
1 Hour	18:33	19:33
30 min	18:43	19:13
15 min	18:53	19:08
Peak time	18:58	

# Number of Storms Analyzed

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- Candidate Storm Count
  - 1999-2006 – 156 Candidate Storms
  - 2007-2015 – 55 Candidate Storms
- Nine (9) Possible Significant Storms Identified

# Number of Storms Analyzed

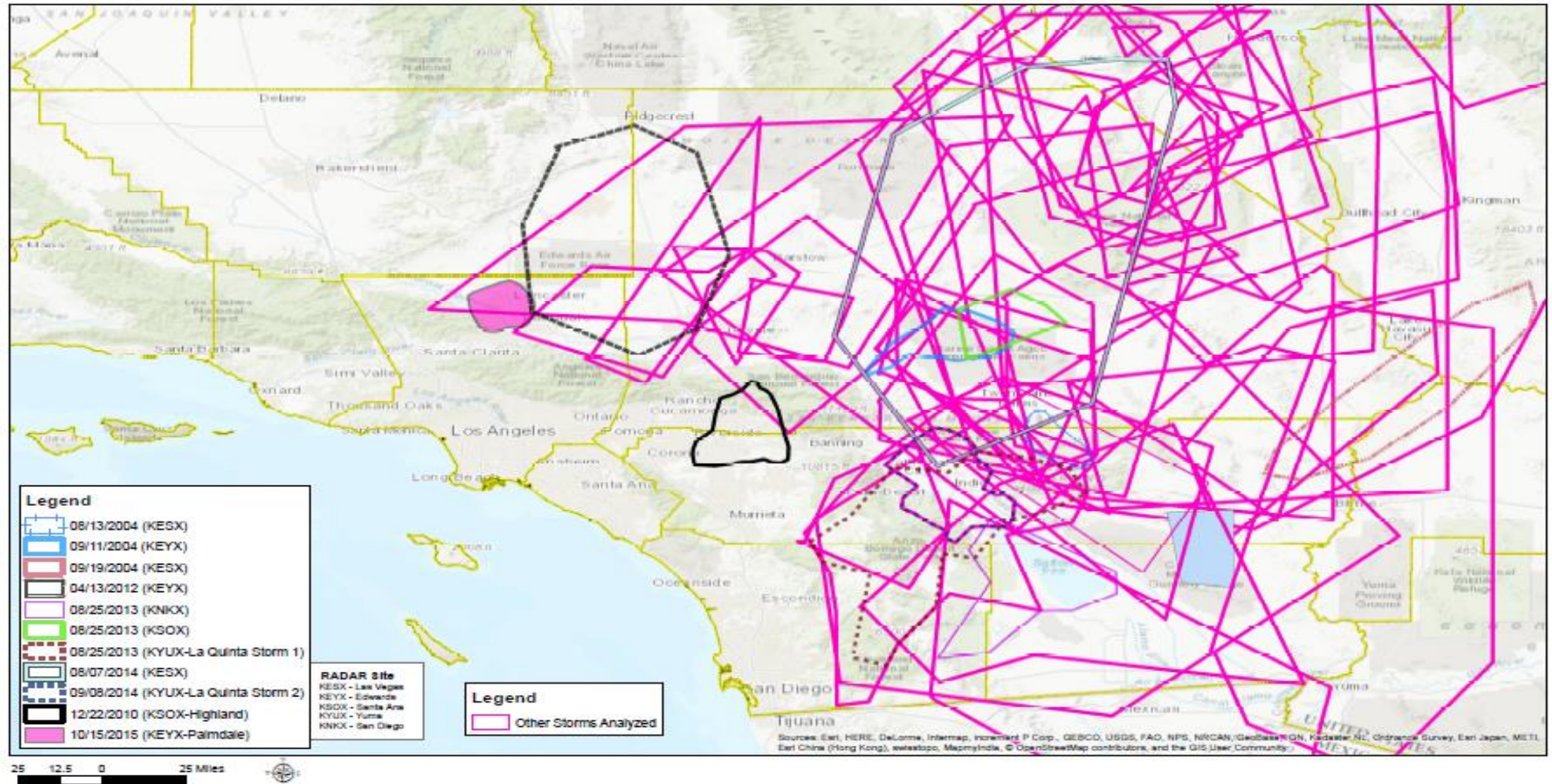
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Some storms were eliminated from further consideration for one of the following reasons:

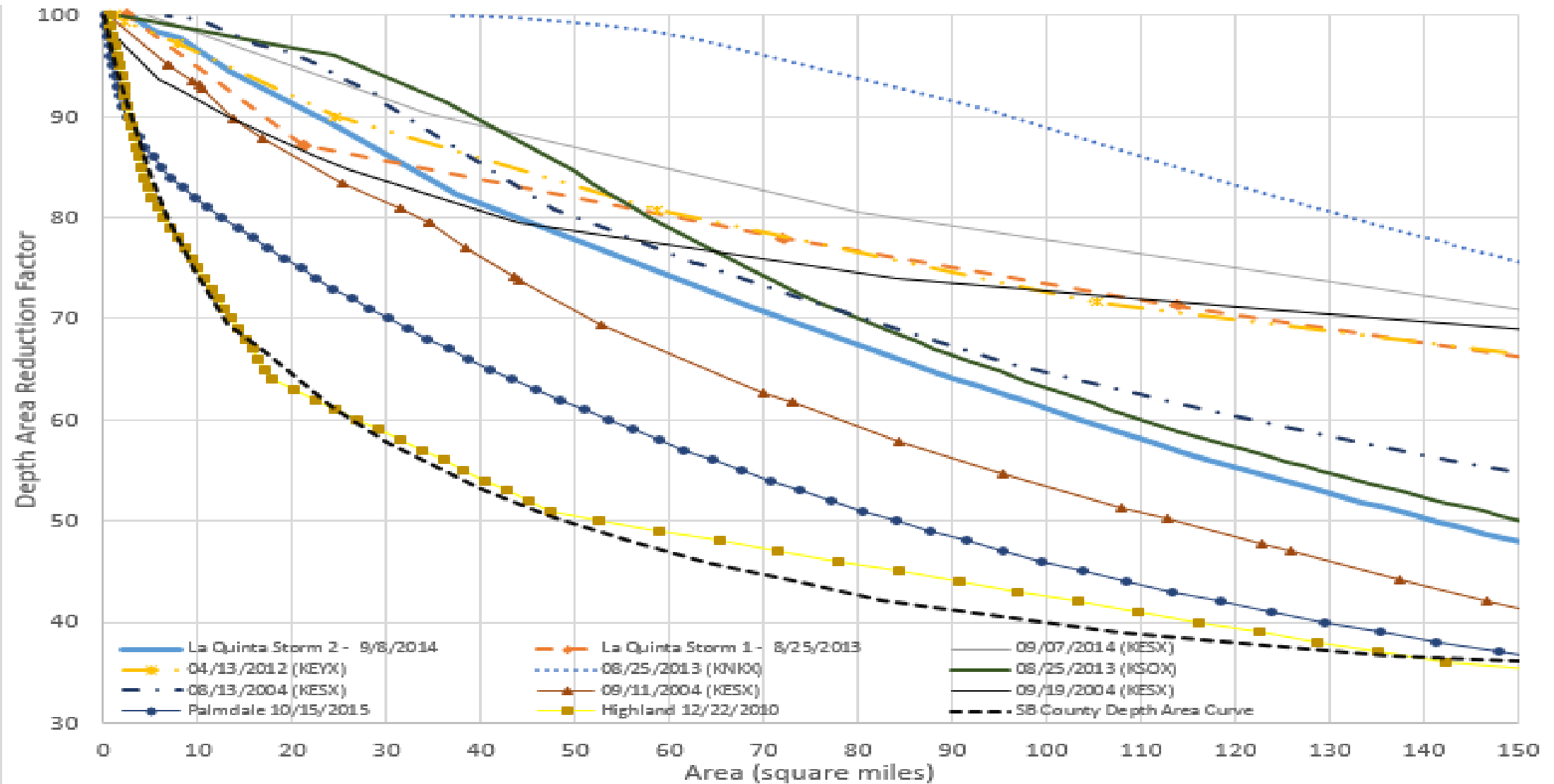
- a) no Radar data available for the date
- b) available Radar data was corrupt
- c) no storm appeared on the Radar as being recorded at the rain gauges
- d) if same storm was measured on multiple Radar sites, the site with the best coverage was selected.



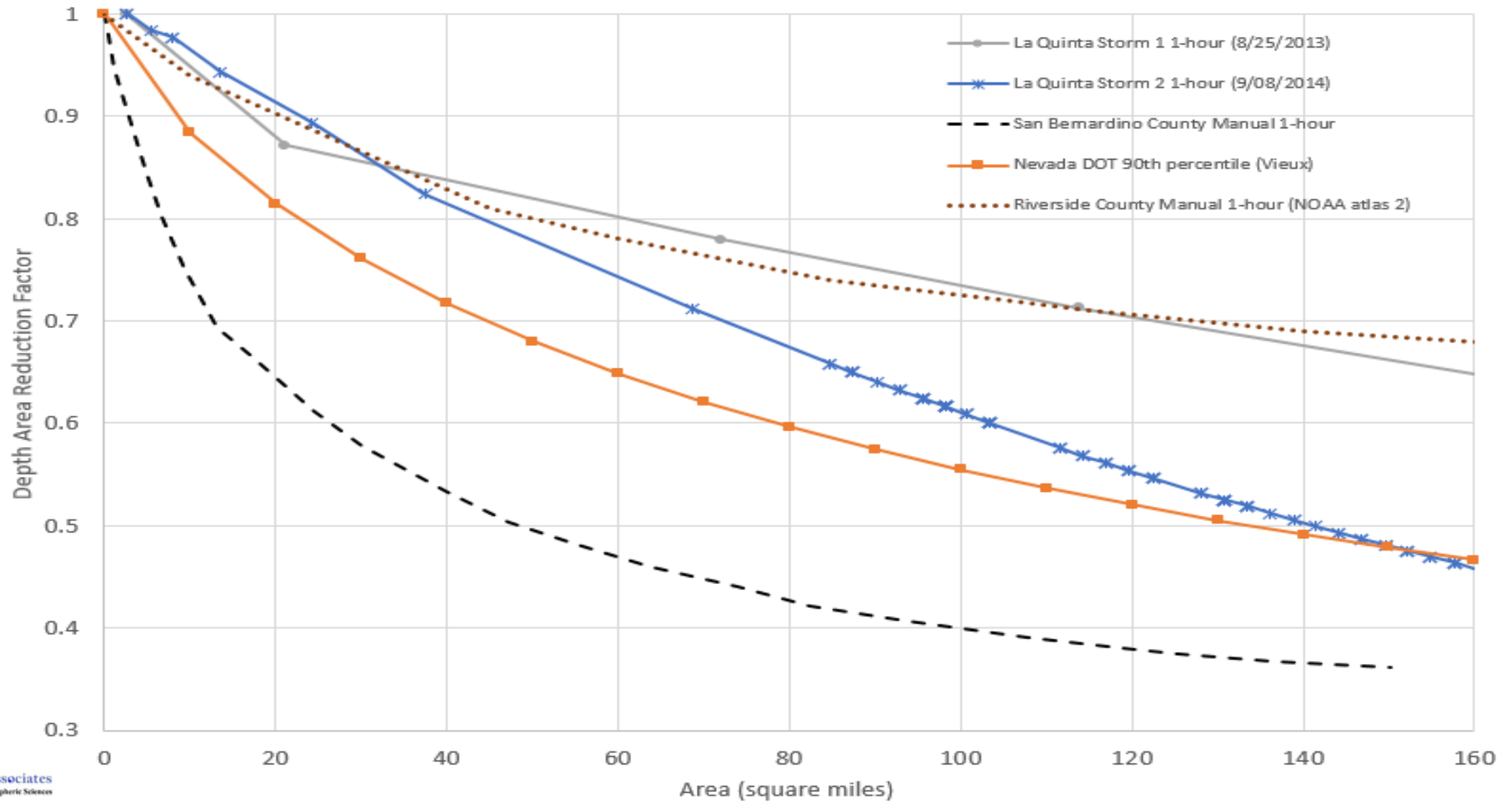
# Analyzed storm locations (1997-2015)



# Correlation of DOPPLER RADAR Data to Aerial Extent versus Published DARF Curves



# Comparison of 1 hour Uncalibrated DARF curves



# Comparison of 1-hour Peak Duration Precipitation Depth-Area Reduction Factors

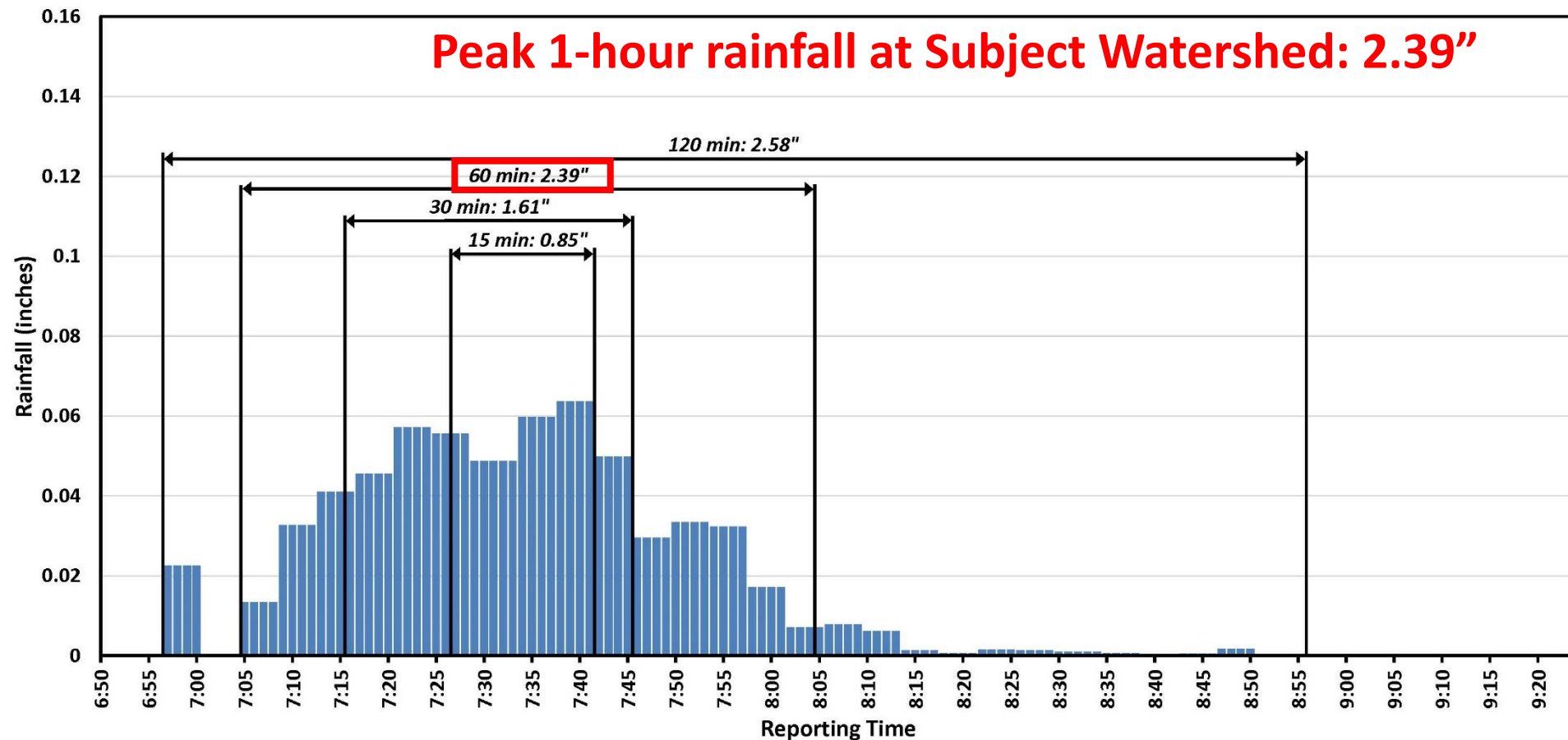
1H Comparison	50 mi <sup>2</sup>	100 mi <sup>2</sup>
8/25/2013 (KNKX)	0.99	0.89
9/7/2014 (KESX)	0.87	0.78
8/25/2013 (KSOX)	0.84	0.63
4/13/2012 (KEYX)	0.83	0.73
8/25/2013 (KYUX -La Quinta Storm 1)	0.82	0.73
8/13/2004 (KESX)	0.80	0.65
Riverside County Manual (NOAA Atlas 2)	0.80	0.73
9/19/2004 (KESX)	0.79	0.73
9/8/2014 (KYUX - La Quinta Storm 2)	0.78	0.61
9/11/2004 (KESX)	0.71	0.53
Nevada 90% DOT (Vieux)	0.68	0.55
10/15/2015 (KEYX-Palmdale)	0.61	0.46
12/22/2010 (KSOX-Highland)	0.51	0.42
San Bernardino County Depth Area Curve	0.50	0.40

# La Quinta Storm-2 Totals

9/8/14

Peak Duration RADAR Rainfall - Area Averaged

(1-minute data)





# NVDOT Study (Vieux & Associates) 2015

## Radar Analysis for Design Storm Application

Baxter E. Vieux, Vieux & Associates, Inc.

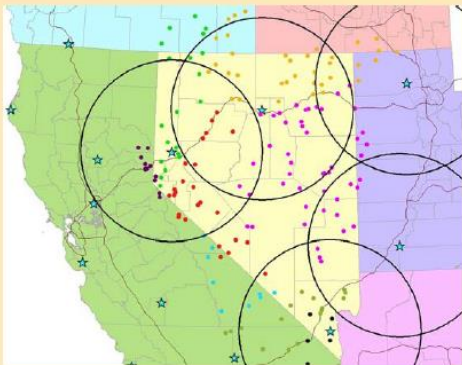
Annjanette Dodd, Kimley-Horn, Inc.

Brian Wilson, Nevada Department of  
Transportation

## WSR-88D Stations

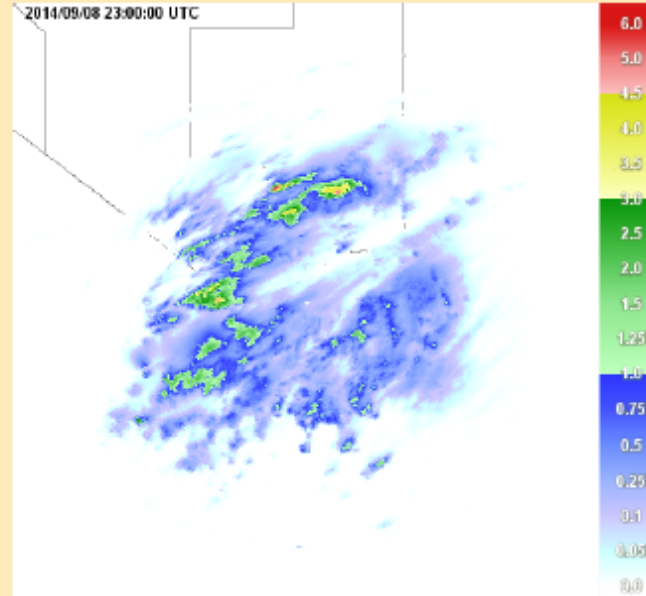
Radar Stations and Data  
(2005 – 2014)

- KRGX (Reno, NV)
- KLRX (Elko, NV)
- KESX (Las Vegas, NV)
- KICX (Cedar City, UT)

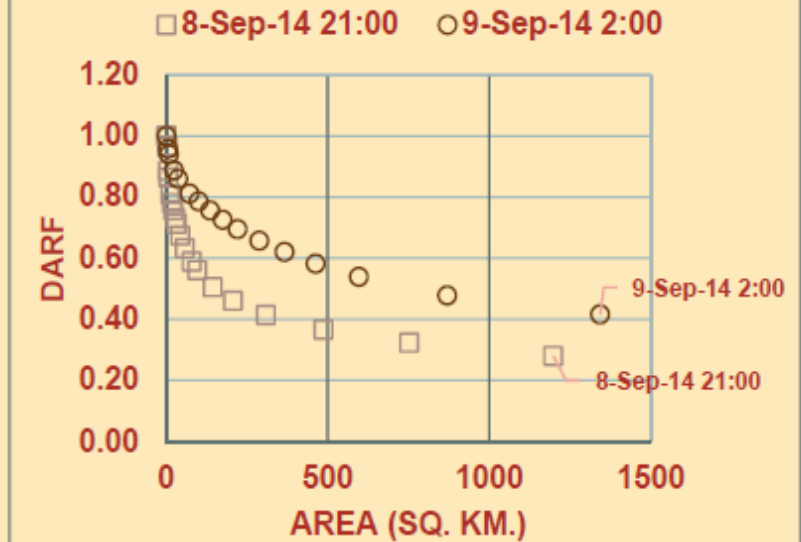


# Depth-Area North American Monsoon 2014

## Storm Total - 6-hr Aggregations from 8-Sep-14 to 9-Sep-14



## SOUTHERN NEVADA 6-HR DURATION



37th Conference on Radar Meteorology  
Norman Oklahoma  
14 – 18 September 2015 Norman, OK

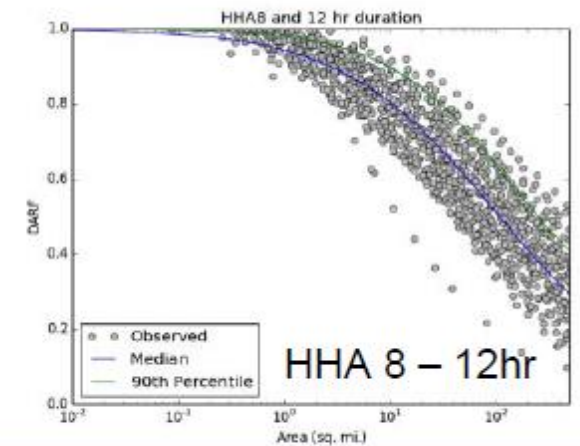
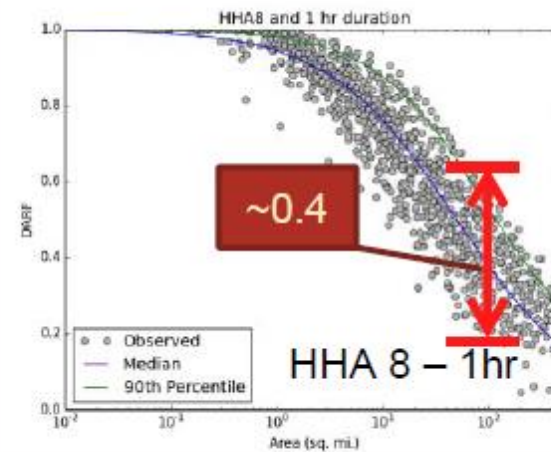
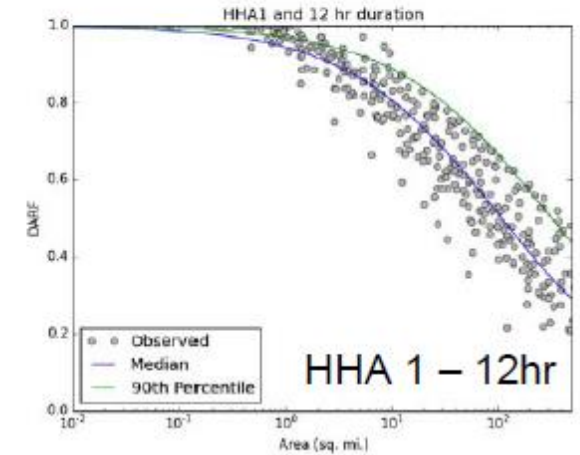
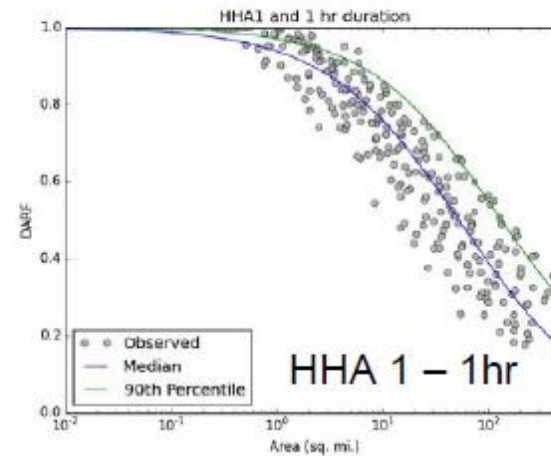
## Radar Analysis for Design Storm Application

Baxter E. Vieux, Vieux & Associates, Inc.

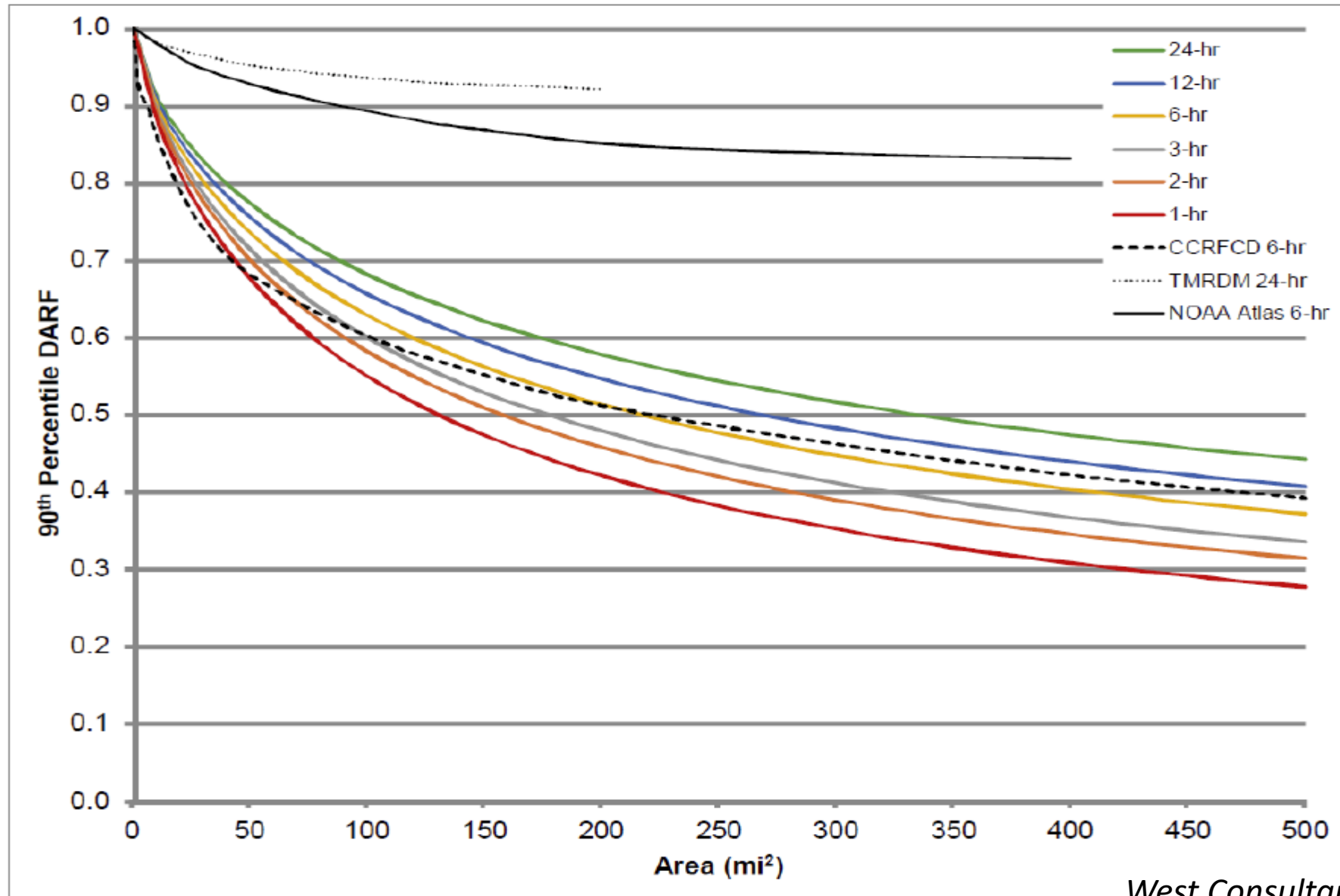
Annjanette Dodd, Kimley-Horn, Inc.

Brian Wilson, Nevada Department of  
Transportation

## DARFs at 90<sup>th</sup> and 50<sup>th</sup> Percentile

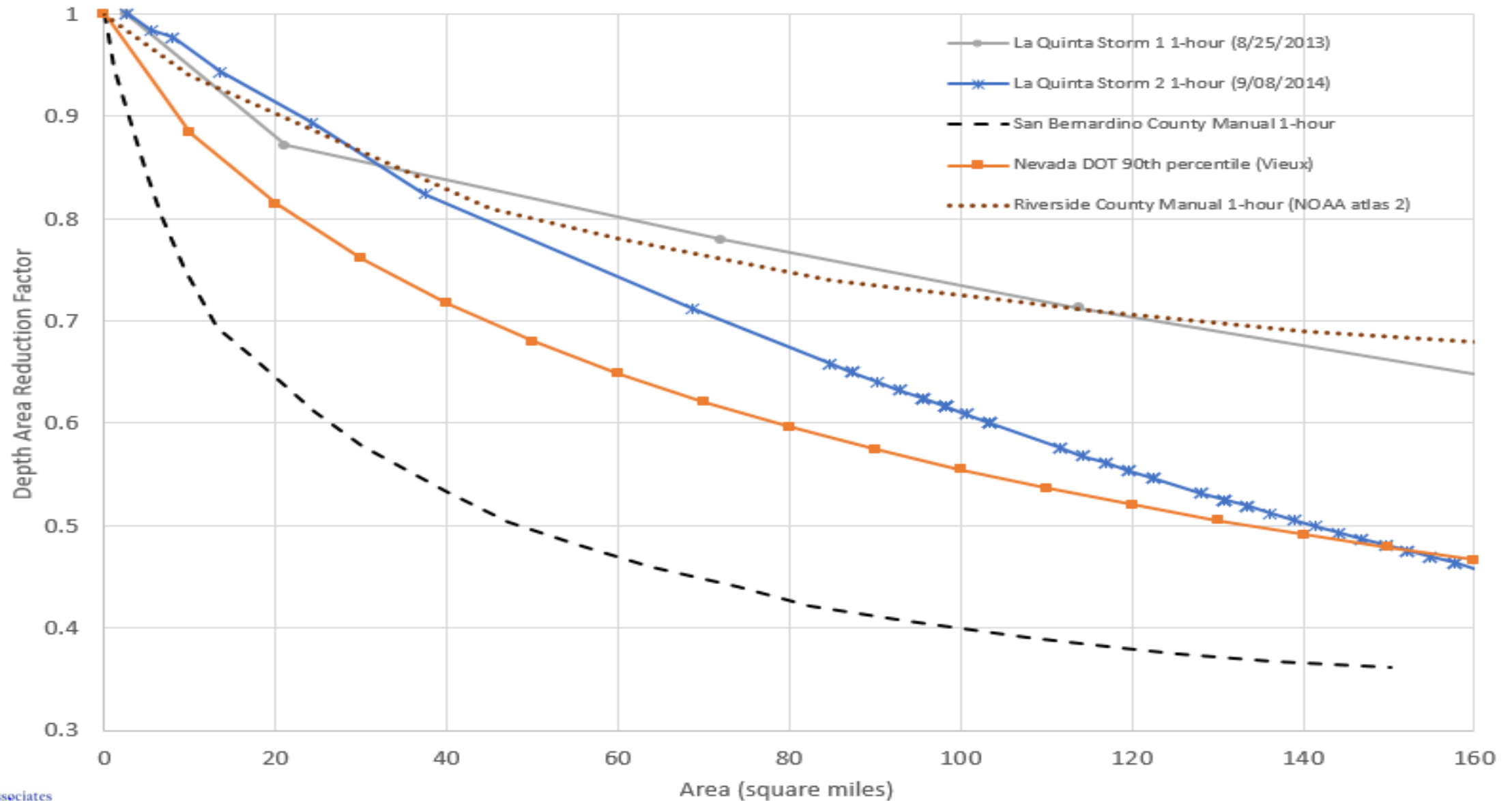


# NVDOT/Imperial County Manual DARF



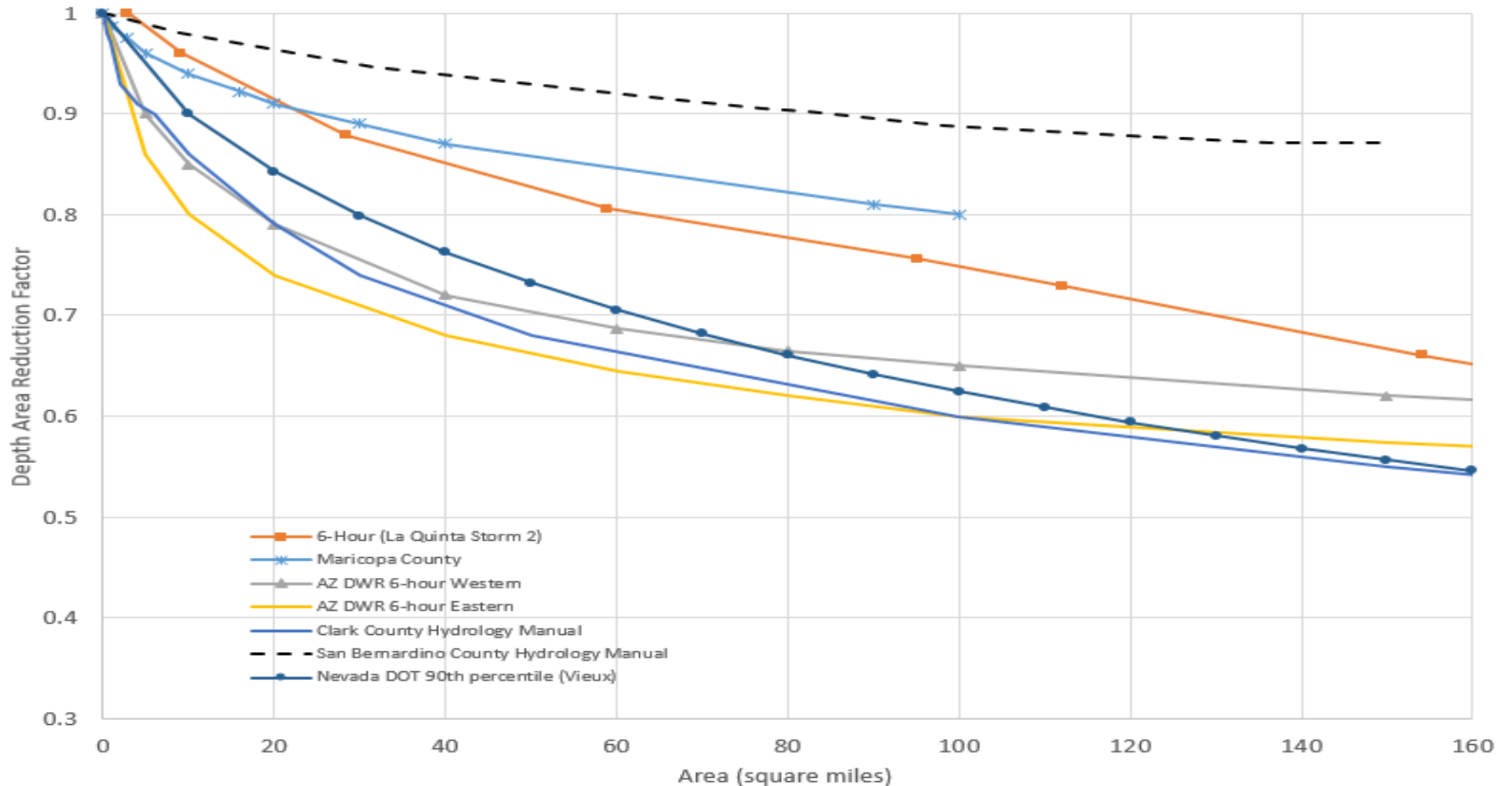
West Consultants, Imperial County

# Comparison of 1 hour DARF and Uncalibrated DARF curves

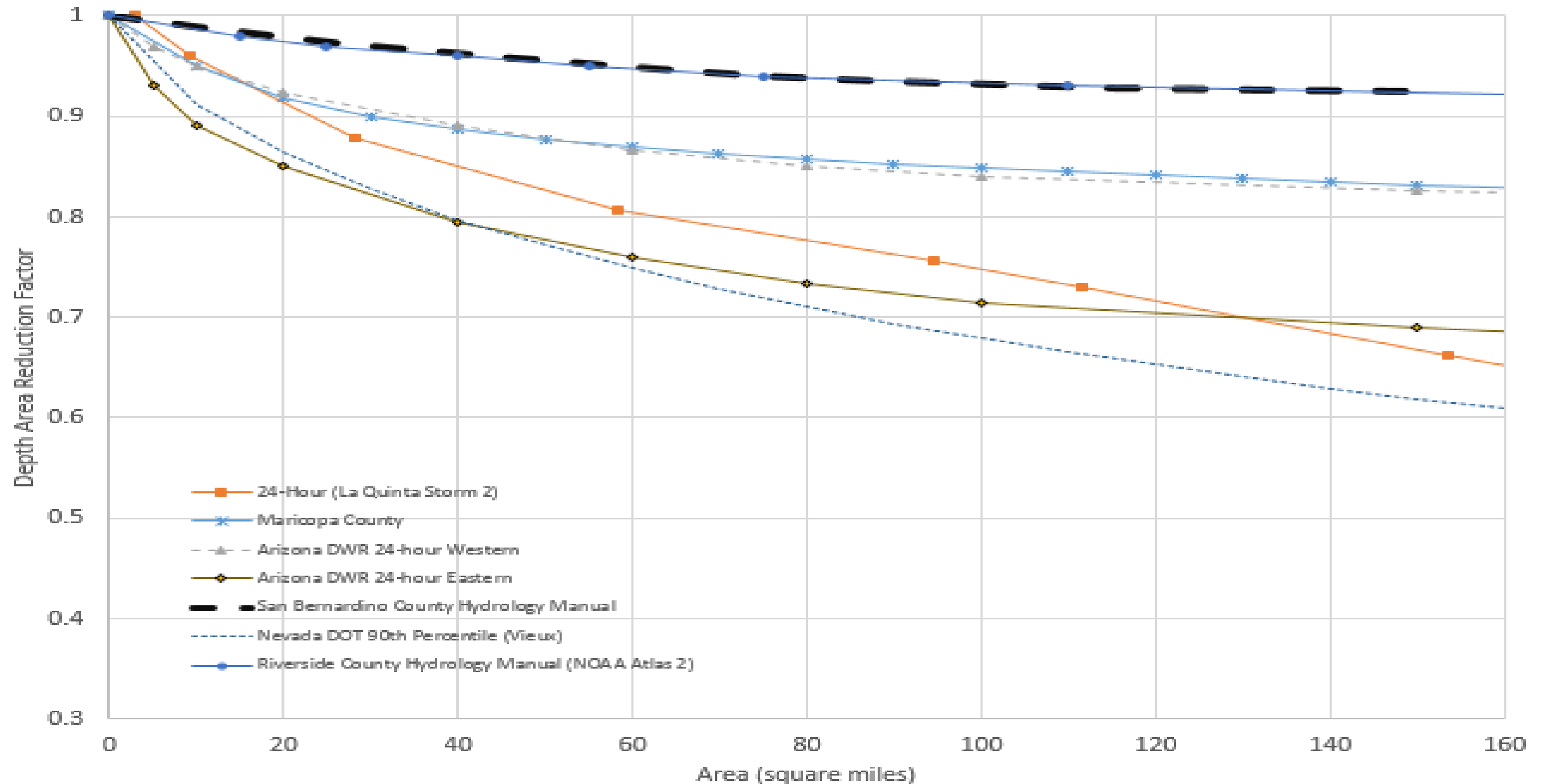




# Comparison of 6 hour DARF and Uncalibrated DARF curves



# Comparison of 24 Hour DARF and Uncalibrated DARF Curves



# Hurricane Norbert Remnants

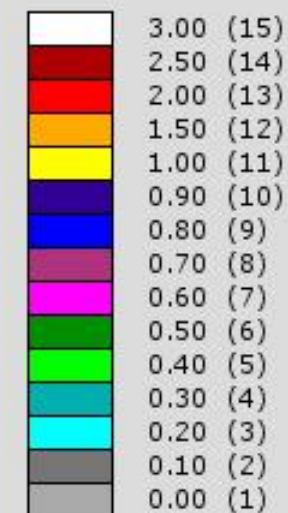
September 2014



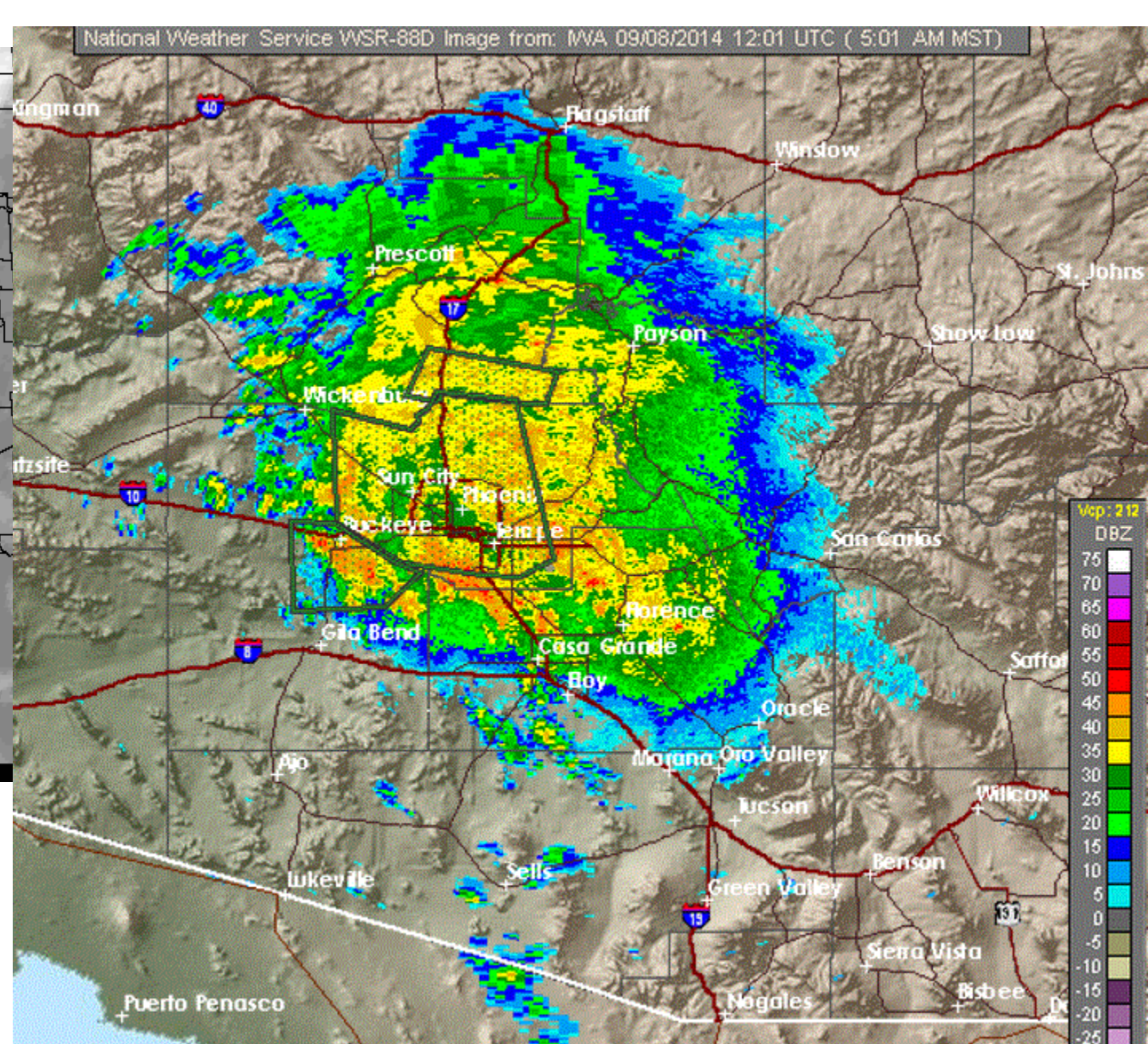
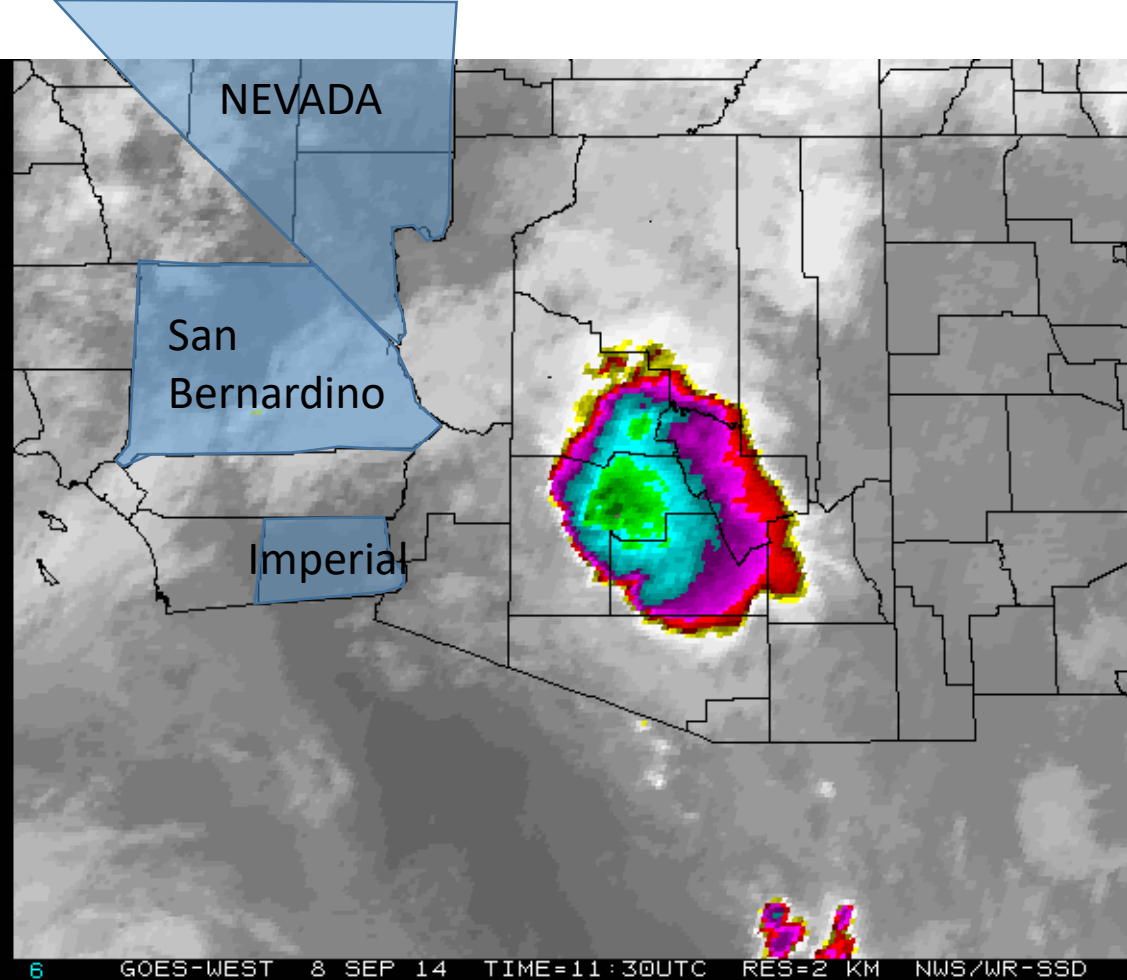
NEXRAD LEVEL-III  
ONE HOUR PRECIP  
KESX - LAS VEGAS, NV  
09/08/2014 12:03:36 GMT  
LAT: 35/42/03 N  
LON: 114/53/27 W  
ELEV: 4948 FT  
MODE/VCP: A / 212

MAX: 0.40 IN  
END: 09/08/2014 12:05

Legend: IN (Category)

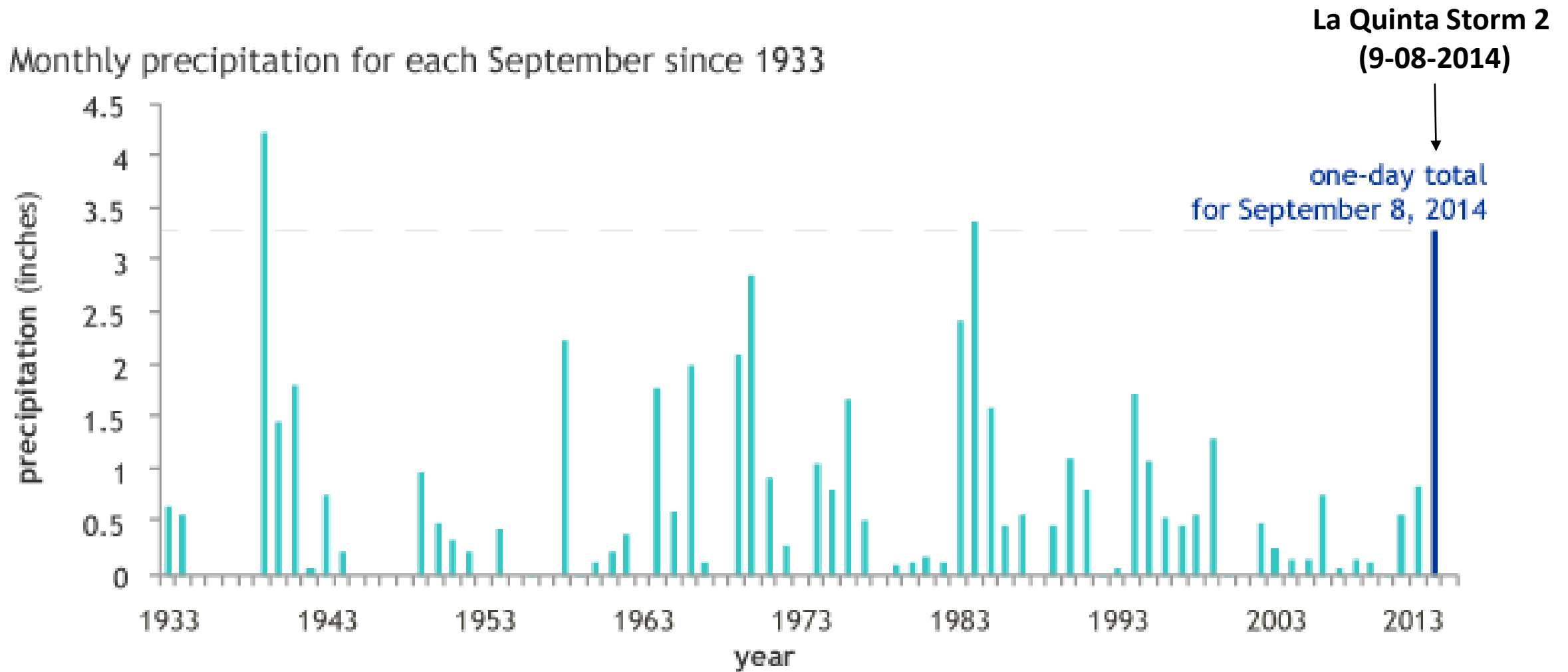








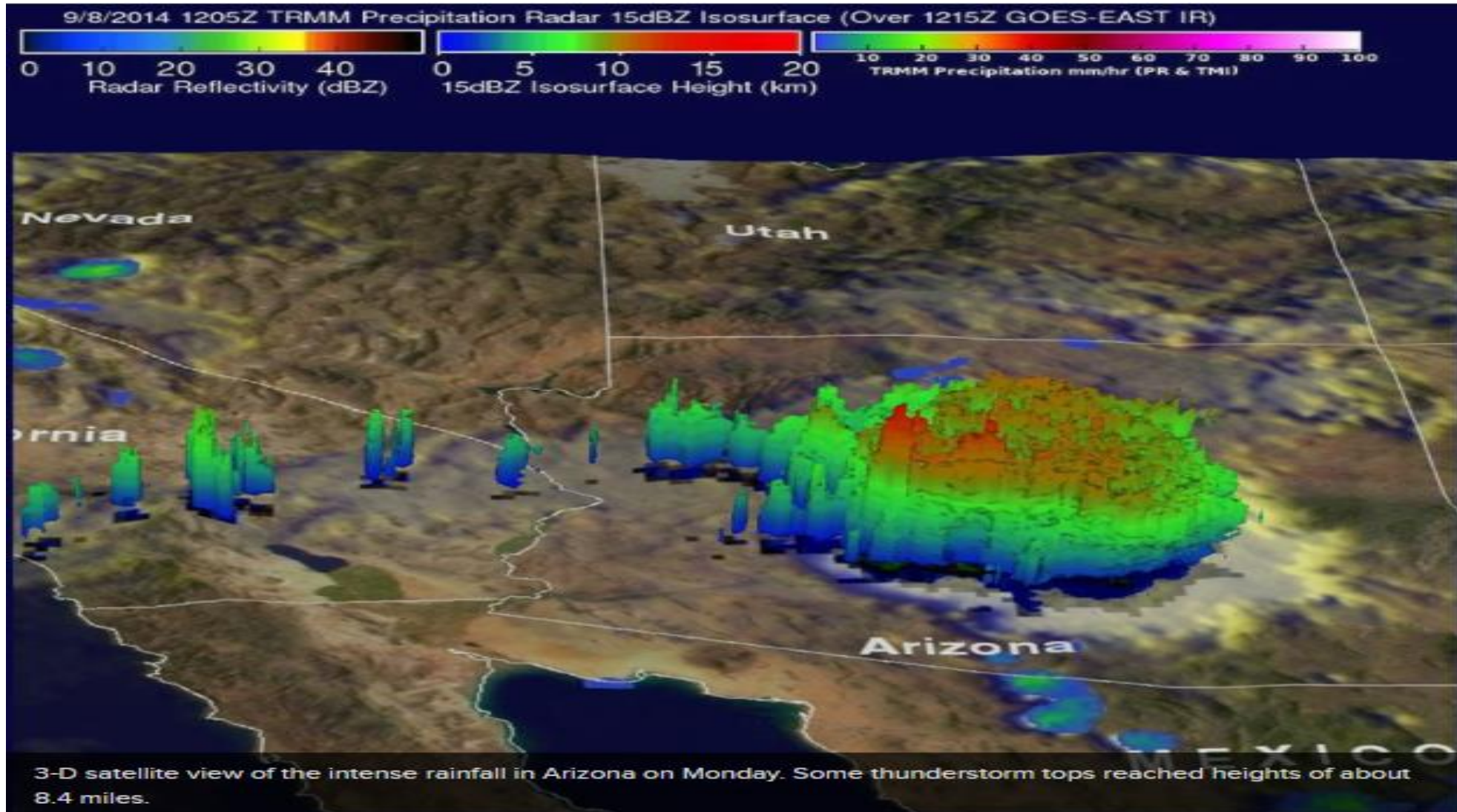
# Rainfall in Phoenix



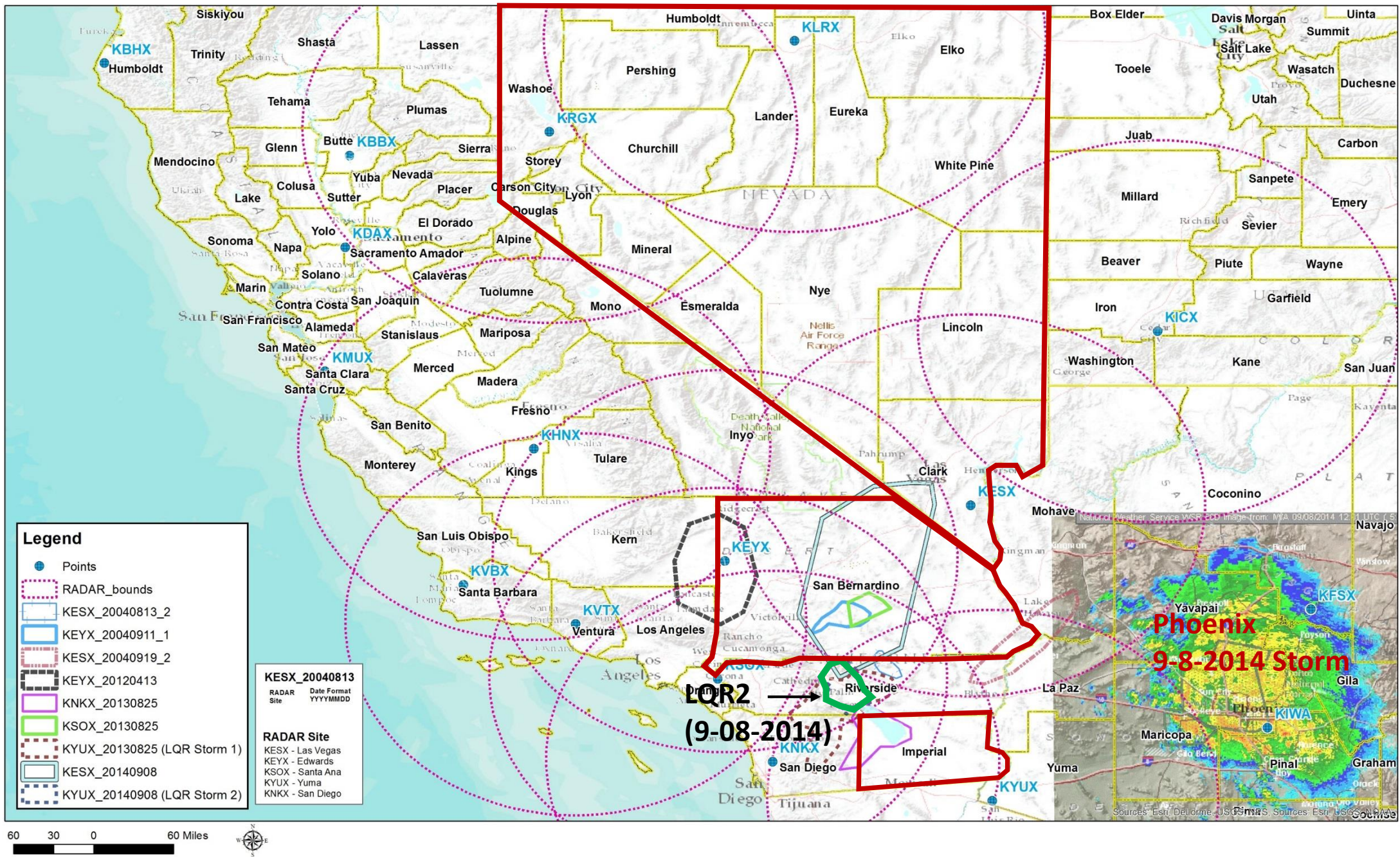
# Path of Hurricane Nobert



# Thunderstorms produced by the remnants of Hurricane Norbert







# Acknowledgements

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The authors would like to thank Rene Perez for his help in identifying key storms and for developing the animations/visuals; Hany Peters and Ken Eke for their insights as the work matured, and Howard McInvale for reviewing the document.

# Sponsors Note

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The county's participation in the funding of this research was an academic exercise to understand the relationship between radar data and rainfall rates and must not be used for design considerations in the County of San Bernardino. The District has embarked on an aggressive program to install more rain gages in the arid regions of the County of San Bernardino which will provide more localized rainfall data for a future research project.