# Statewide and Site-Specific PMP, An Overview

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NMWDOC Spring Workshop

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# Probable Maximum Precipitation

- **Definition:** The ***theoretically*** greatest depth of precipitation for a given duration that is ***physically possible*** over a given storm area at a particular ***geographic location*** at a certain time of year (HMR 59, 1999)
- Types of PMP studies:
  - Generalized (Hydrometeorological Reports)
    - Provides PMP values for a region
    - HMR 51 - East of the 105th Meridian from Canada to Mexico
  - Regional/Statewide
    - Provide PMP values over regions with varying topography
    - Individual basins are included in the regional/statewide results
  - Site-Specific
    - Provides PMP values for individual drainage basins
    - Considers unique meteorology and topography

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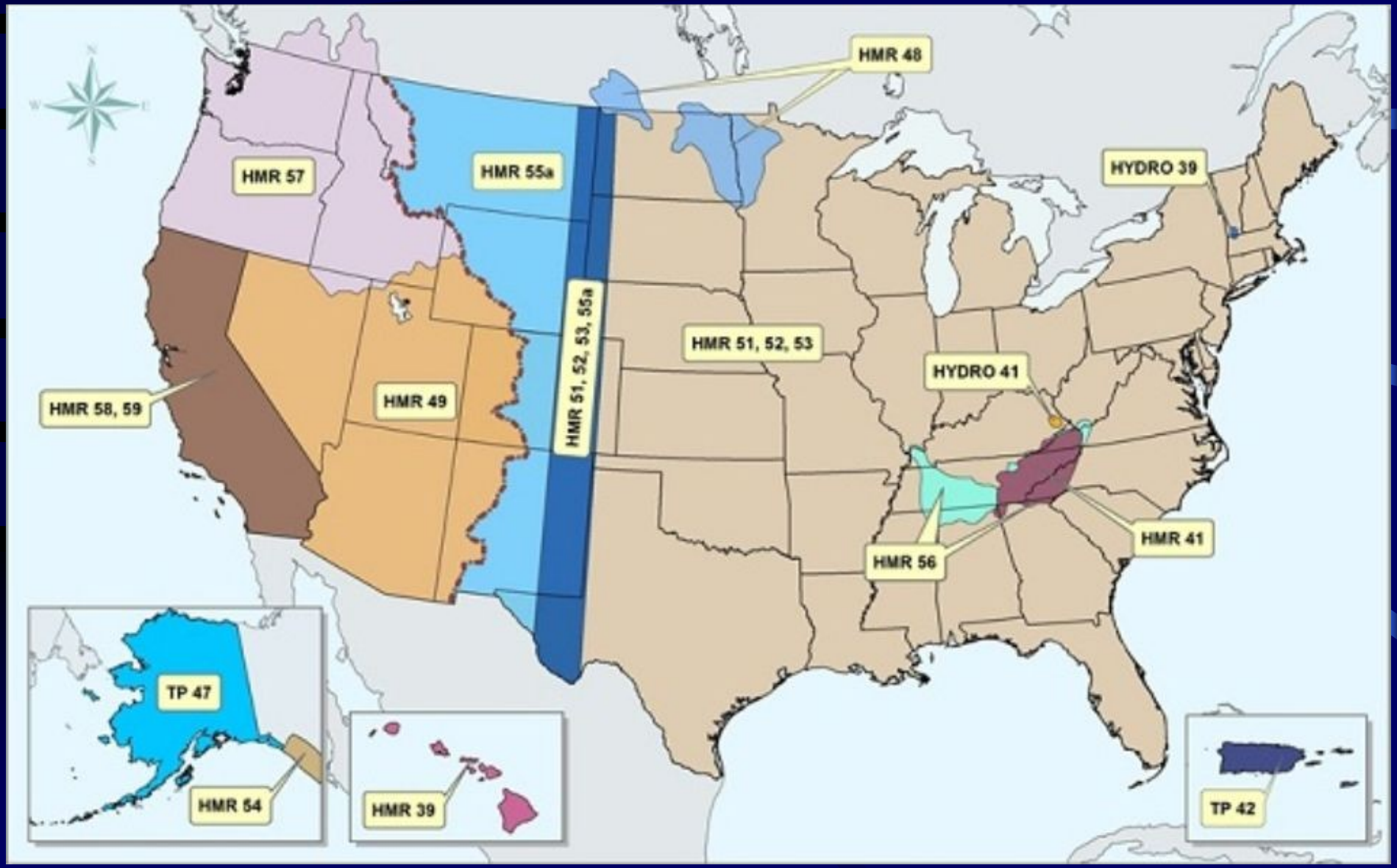
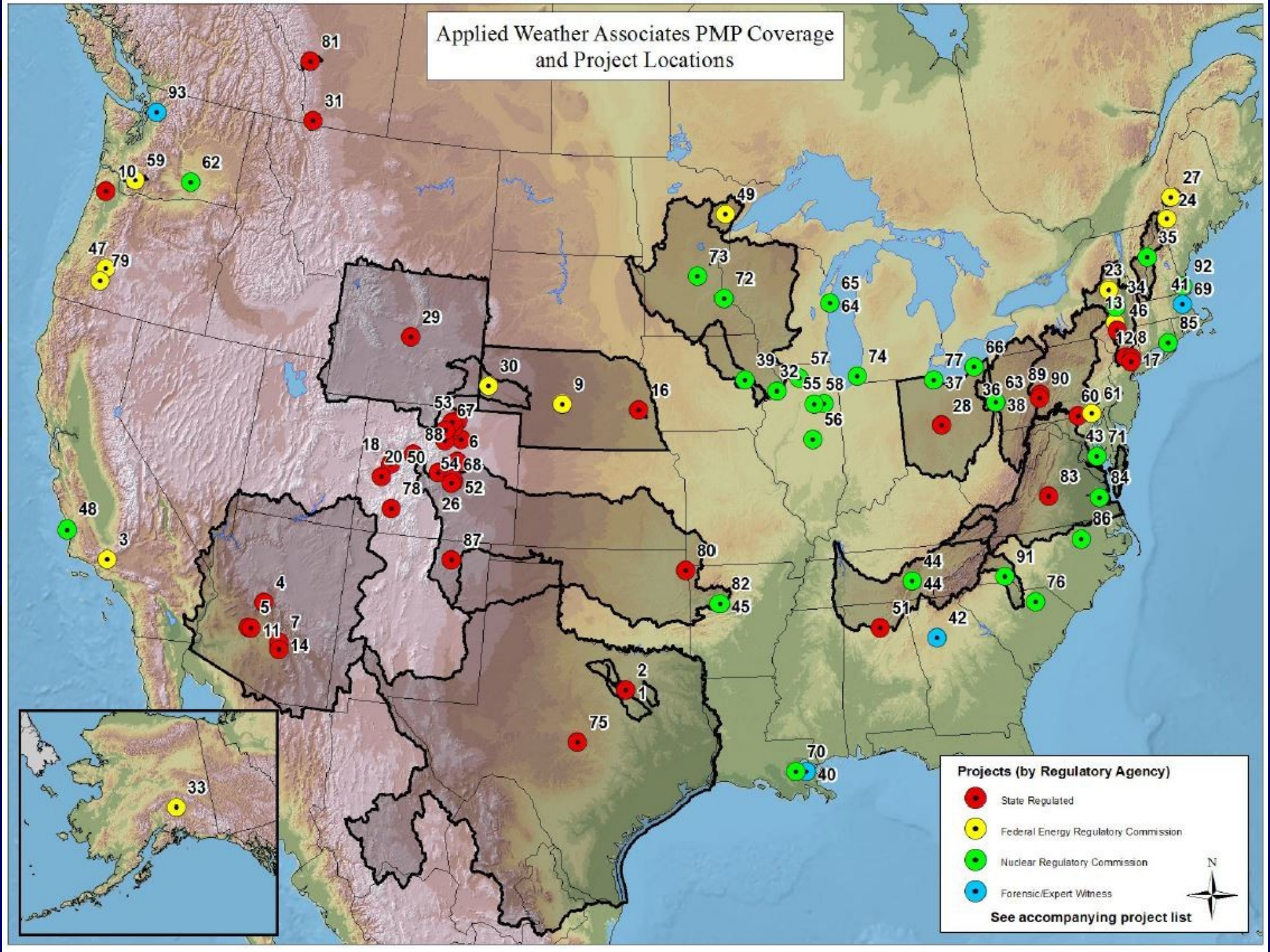
# Coverage of HMRs




Applied Weather Associates PMP Coverage and Project Locations
Projects (by Regulatory Agency)
State Regulated
Federal Energy Regulatory Commission
Nuclear Regulatory Commission
Forensic/Expert Witness
See accompanying project list
N

# How Do Site-Specific, Statewide, Regional PMP Studies Provide Improved PMP Values?

- More storms considered
- New technologies used
- Problems/Unknowns in the HMRs corrected
- Topographic features addressed
- Updated climatologies used

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# Method for Computing PMP Values

- **O**bserved extreme rainfall events are used
  - Storm based approach
- **I**dentify extreme storms in Texas and regions that are considered transpositionable
  - **I**dentify recent extreme storms since publication of the appropriate HMRs
  - **R**eview older rainfall data records
- **I**dentify extreme storm types
  - **Local storms (thunderstorms/MCC)**
  - **General storms (frontal systems)**
  - **Hurricanes/Tropical Systems**

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# Method for Computing PMP Values

- Identify unique topography
  - Precipitation enhancement/decrease
    - -orographics
  - Effects on rainfall center location
    - -physically possible storm centering/orientation
- Review HMR/Hydro/Tech Memo procedures
  - Identify inconsistent assumptions
  - Apply new technologies and data
  - Apply new/updated methods

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# Probable Maximum Precipitation Study for Texas

## Project Overview-TEXAS

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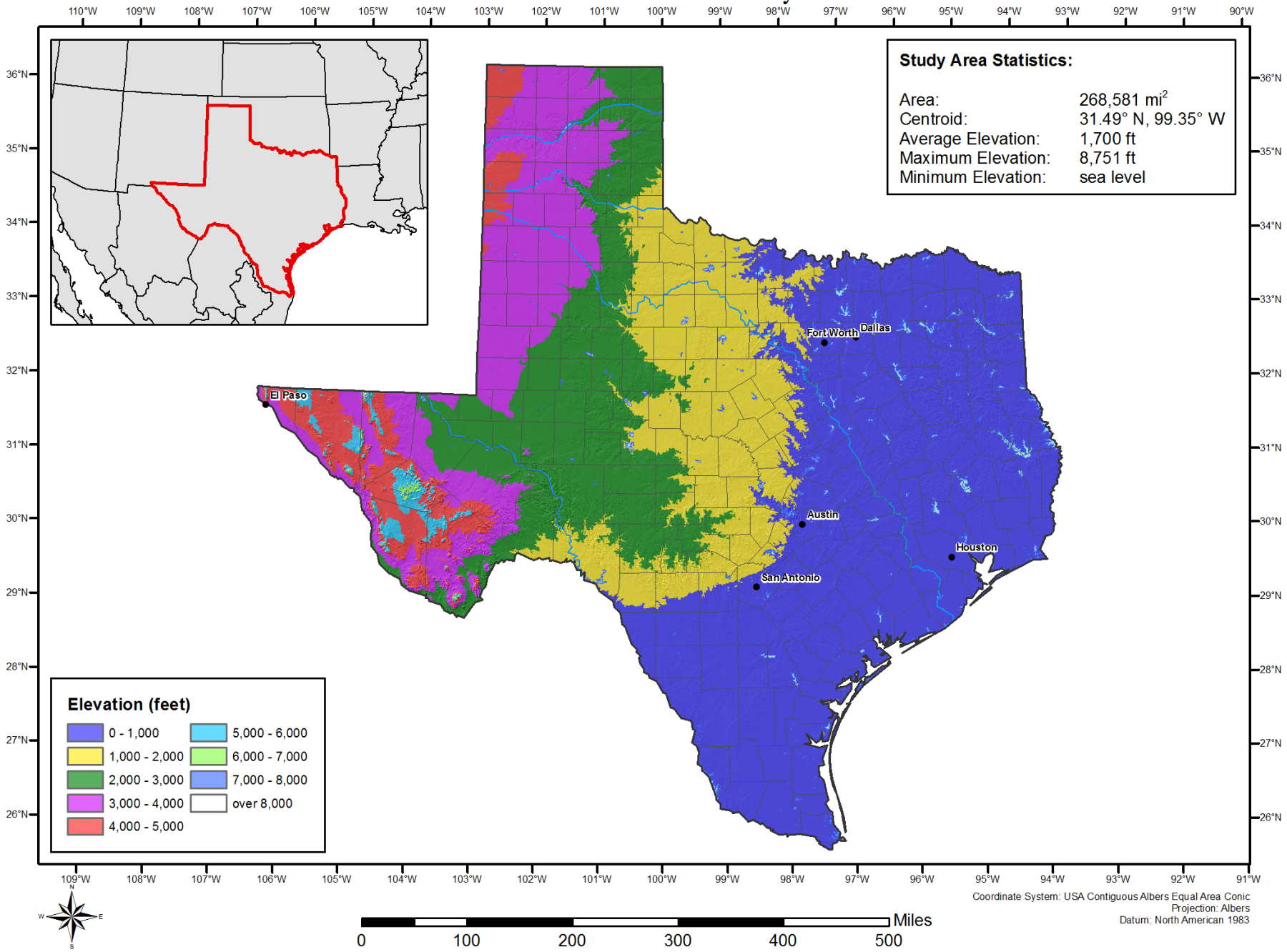
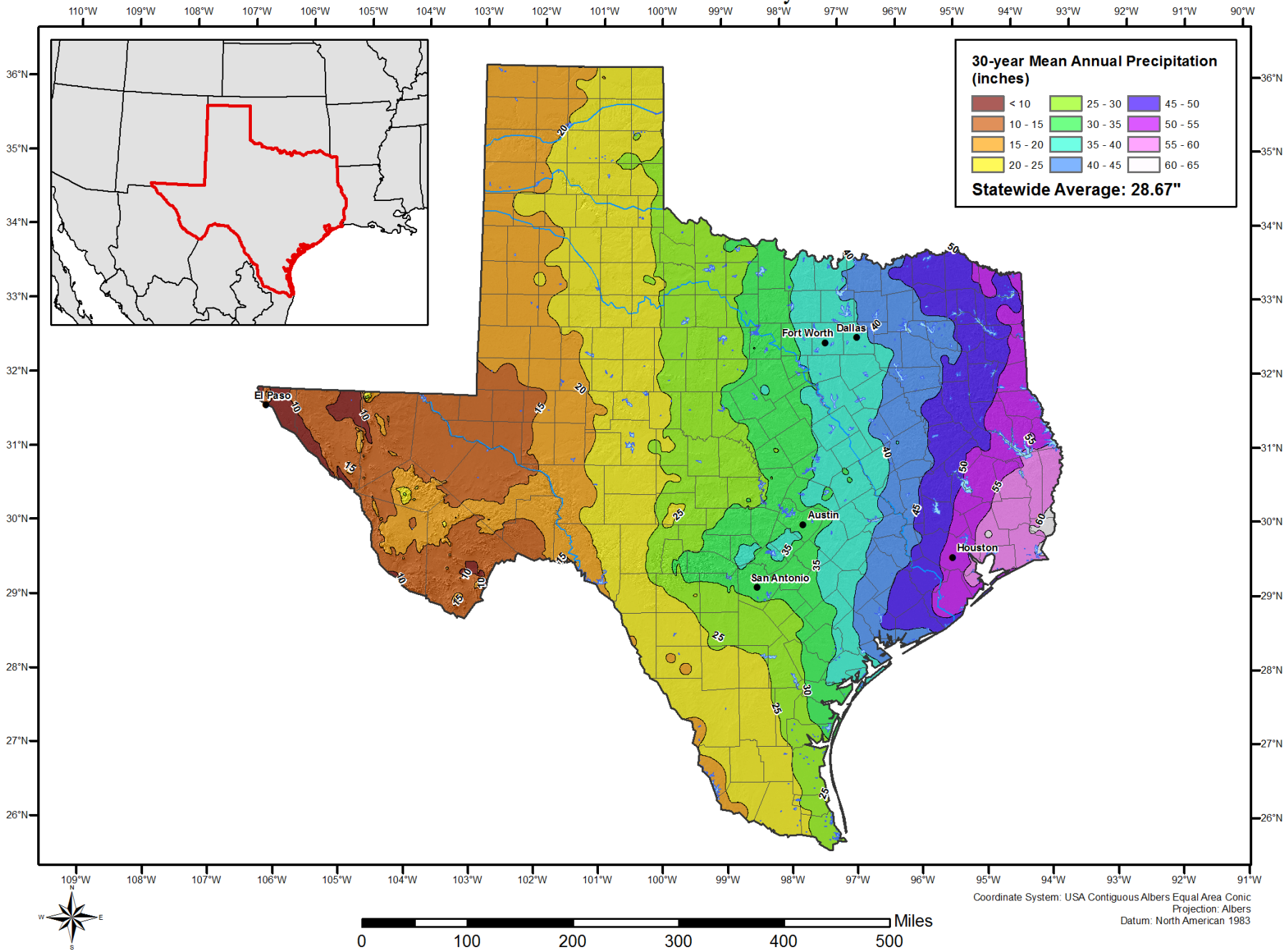
# Elevation Statistics
# Texas Statewide PMP Study

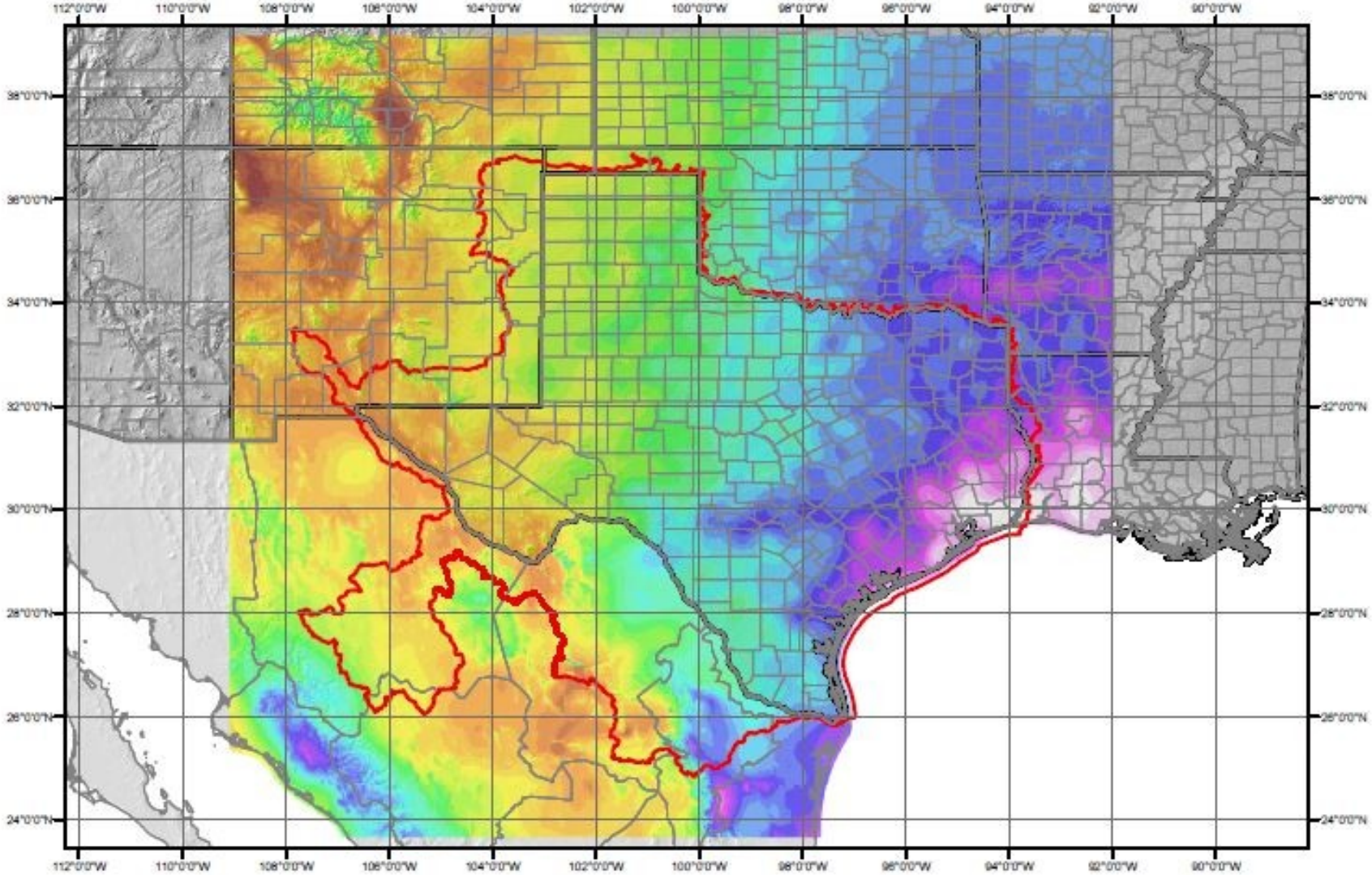


# 30-year Mean Annual Precipitation (1981-2010) in Inches
## Texas Statewide PMP Study



# Proposed PMP Analysis Domain
# Texas PMP Study

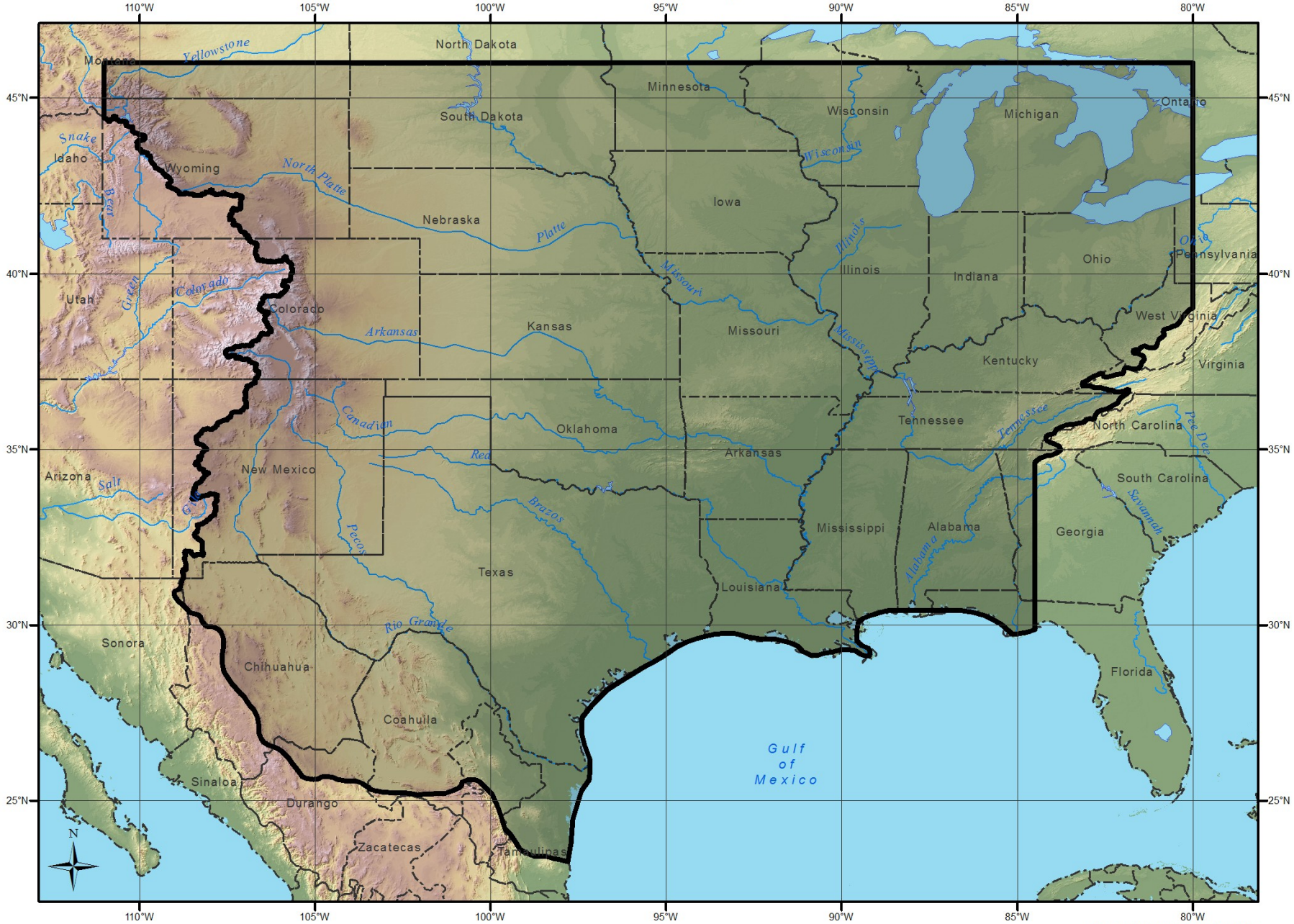

Coordinate System: GCS WGS 1984
Datum: WGS 1984




**24-hour 100-year Precipitation Frequency Estimates (inches)**

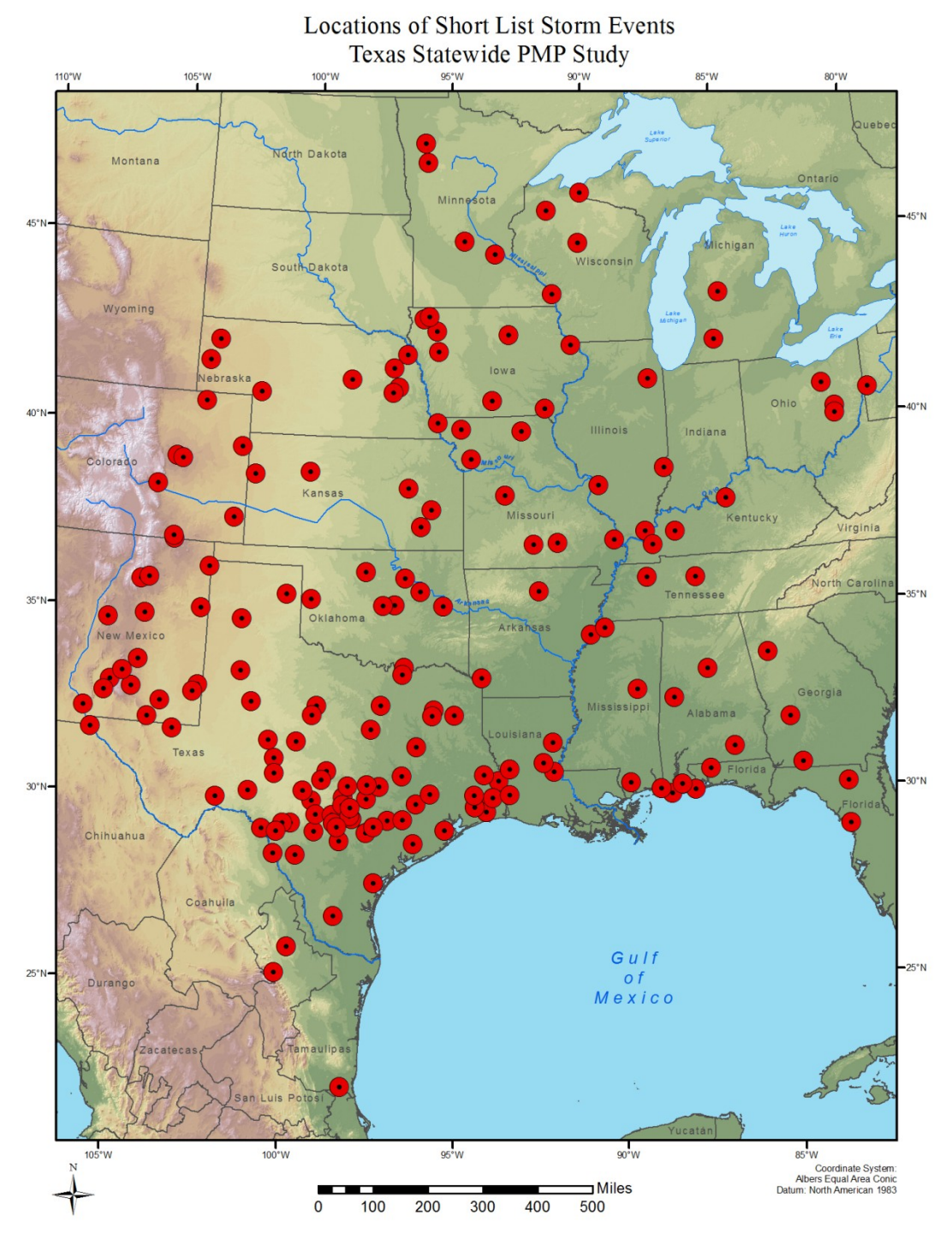
| | | | | | |
|---|---|---|---|---|---|
| 1.34 - 2.00 | 4.01 - 4.50 | 6.51 - 7.00 | 9.01 - 9.50 | 11.51 - 12.00 | 14.01 - 15.00 |
| 2.01 - 2.50 | 4.51 - 5.00 | 7.01 - 7.50 | 9.51 - 10.00 | 12.01 - 12.50 | |
| 2.51 - 3.00 | 5.01 - 5.50 | 7.51 - 8.00 | 10.01 - 10.50 | 12.51 - 13.00 | |
| 3.01 - 3.50 | 5.51 - 6.00 | 8.01 - 8.50 | 10.51 - 11.00 | 13.01 - 13.50 | |
| 3.51 - 4.00 | 6.01 - 6.50 | 8.51 - 9.00 | 11.01 - 11.50 | 13.51 - 14.00 | |

# Storm Search Domain
# Texas PMP Study




Coordinate System: GCS WGS 1984
Datum: WGS 1984

# Intermediate Storm List-All Storms



# Probable Maximum Precipitation

## Project Overview-Arizona

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# Reasons For Study

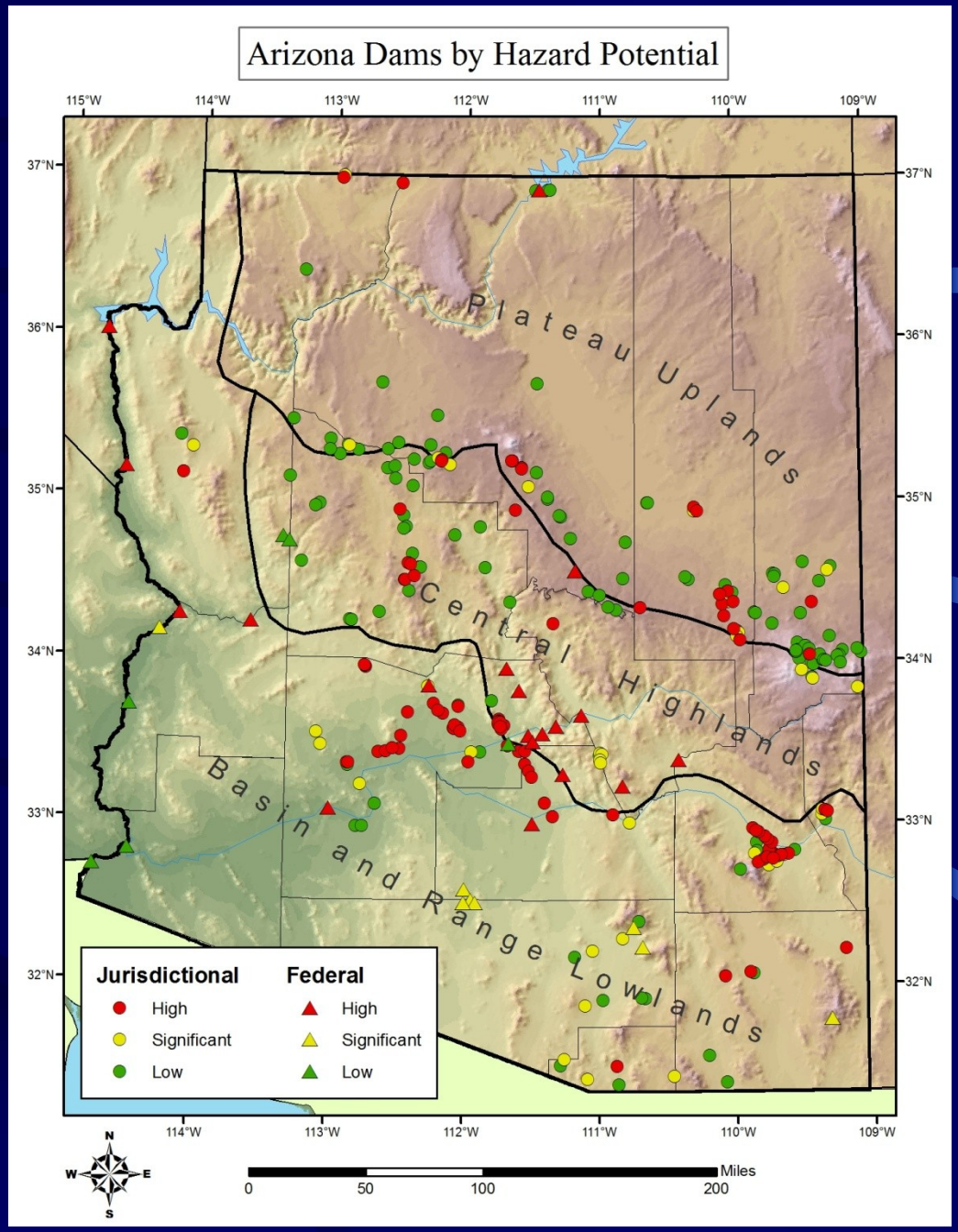
**"Hazard creep"**

In past 3 years:

17 dams reclassified

More than half deficient

156 more could be reclassified in the future



# Cooperative Efforts-AZ

- Funding/Cooperating Partners
  - Arizona Department of Water Resources
  - Arizona Game & Fish Department
  - FCD (Maricopa, Navajo)
  - NRCS
  - FEMA (NDSP State Assistance Grant)
- Working together all partners achieve desired results
- State/Users benefit at a reduced cost

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# Expected Project Benefits

- Reduced Construction Costs
  - New Dams
- Reduced Rehabilitation Costs
  - Remove need for rehabilitation
  - Millions in cost savings during useful lifetime
- Reclaimed Opportunity Costs
  - Flood protection
  - Storage capacities
  - Operational availability

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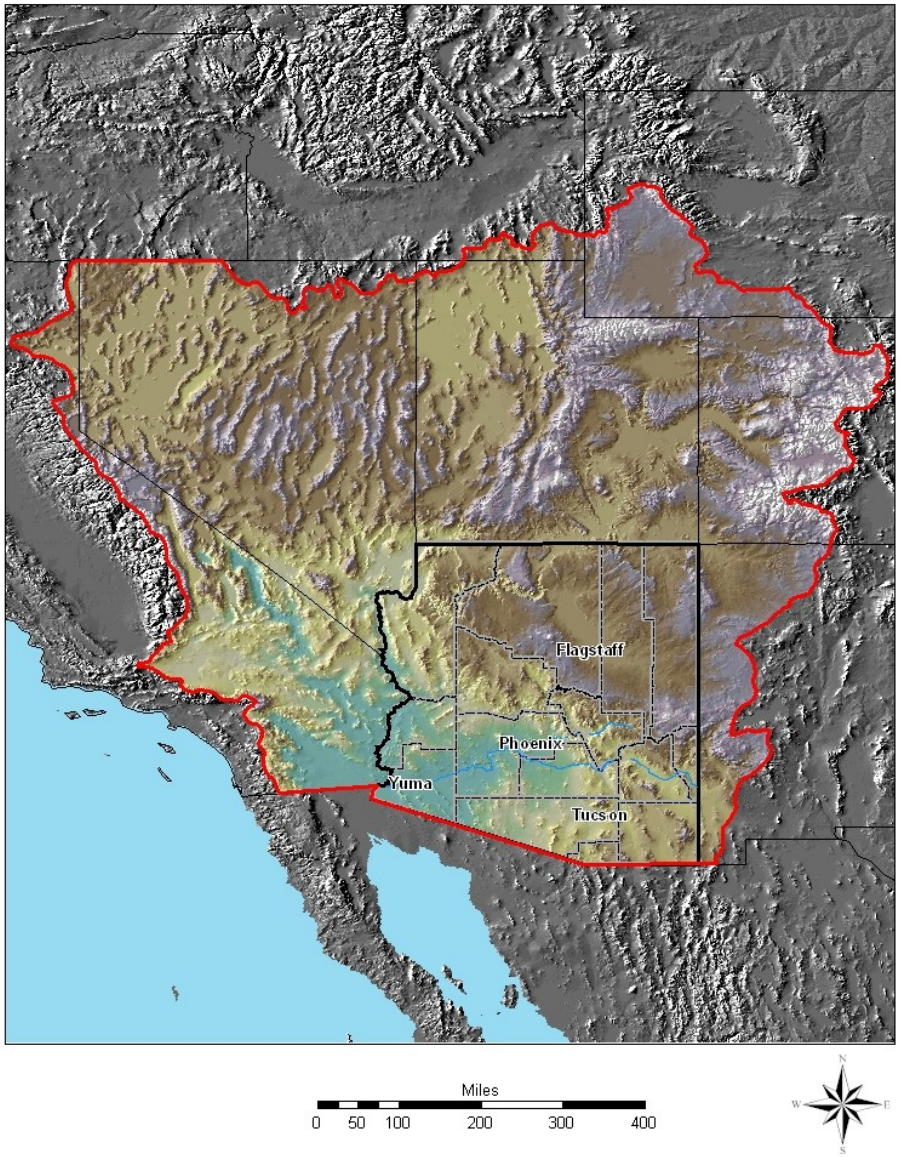
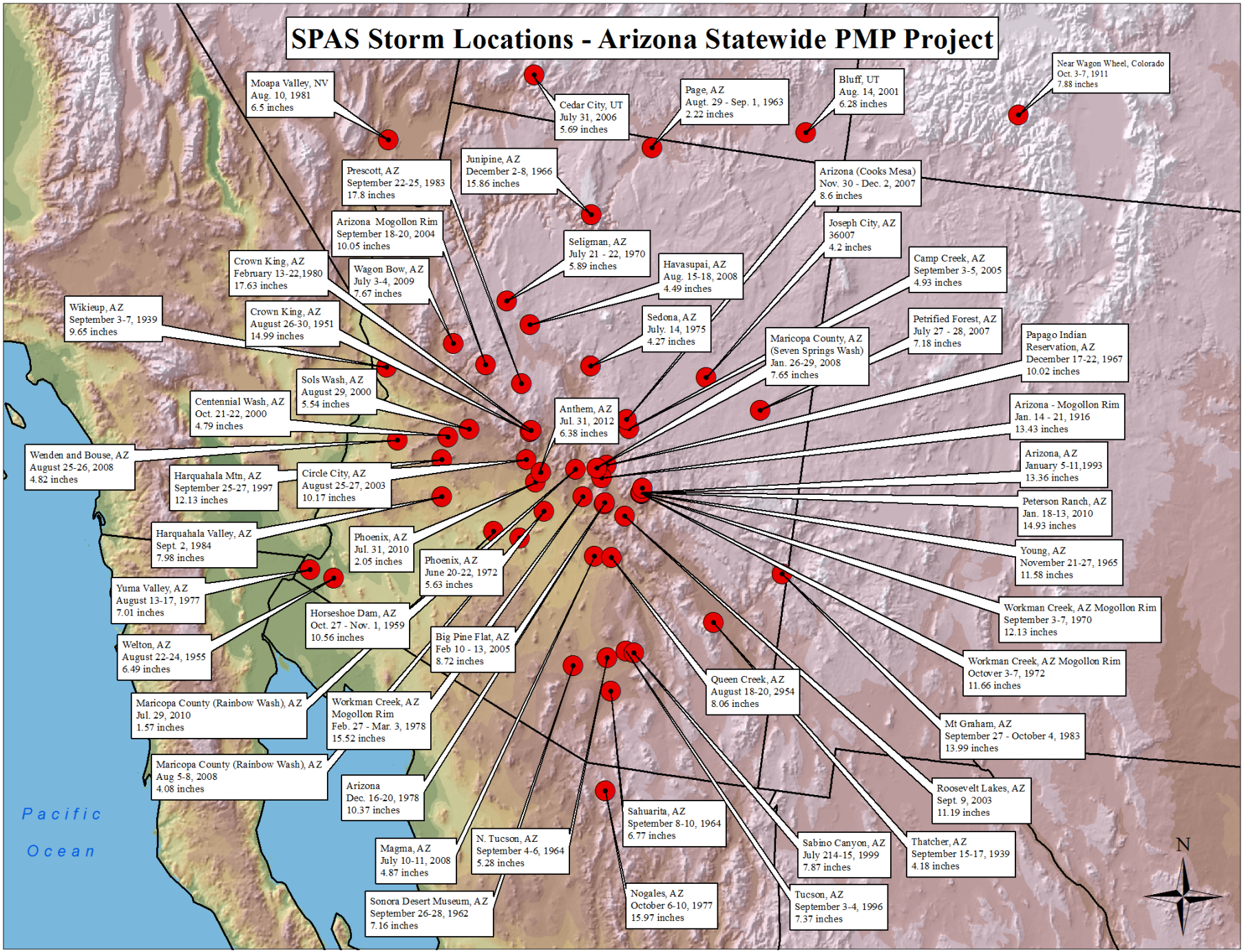
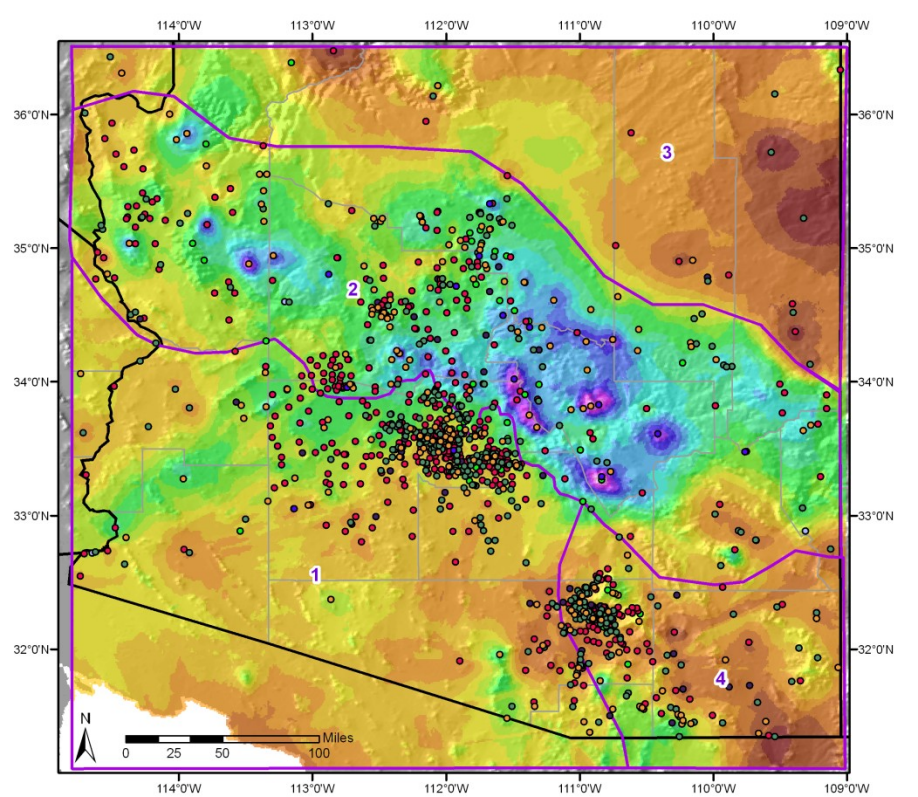
# HMR 49 Domain




SPAS Storm Locations - Arizona Statewide PMP Project
Moapa Valley, NV
Aug. 10, 1981
6.5 inches
Cedar City, UT
July 31, 2006
5.69 inches
Page, AZ
Augt. 29 - Sep. 1, 1963
2.22 inches
Bluff, UT
Aug. 14, 2001
6.28 inches
Near Wagon Wheel, Colorado
Oct. 3-7, 1911
7.88 inches
Prescott, AZ
September 22-25, 1983
17.8 inches
Junipine, AZ
December 2-8, 1966
15.86 inches
Arizona (Cooks Mesa)
Nov. 30 - Dec. 2, 2007
8.6 inches
Arizona Mogollon Rim
September 18-20, 2004
10.05 inches
Seligman, AZ
July 21 - 22, 1970
5.89 inches
Joseph City, AZ
36007
4.2 inches
Crown King, AZ
February 13-22,1980
17.63 inches
Wagon Bow, AZ
July 3-4, 2009
7.67 inches
Havasupai, AZ
Aug. 15-18, 2008
4.49 inches
Camp Creek, AZ
September 3-5, 2005
4.93 inches
Wikieup, AZ
September 3-7, 1939
9.65 inches
Crown King, AZ
August 26-30, 1951
14.99 inches
Sedona, AZ
July. 14, 1975
4.27 inches
Petrified Forest, AZ
July 27 - 28, 2007
7.18 inches
Maricopa County, AZ
(Seven Springs Wash)
Jan. 26-29, 2008
7.65 inches
Papago Indian
Reservation, AZ
December 17-22, 1967
10.02 inches
Sols Wash, AZ
August 29, 2000
5.54 inches
Centennial Wash, AZ
Oct. 21-22, 2000
4.79 inches
Anthem, AZ
Jul. 31, 2012
6.38 inches
Arizona - Mogollon Rim
Jan. 14 - 21, 1916
13.43 inches
Wenden and Bouse, AZ
August 25-26, 2008
4.82 inches
Arizona, AZ
January 5-11,1993
13.36 inches
Harquahala Mtn, AZ
September 25-27, 1997
12.13 inches
Circle City, AZ
August 25-27, 2003
10.17 inches
Peterson Ranch, AZ
Jan. 18-13, 2010
14.93 inches
Harquahala Valley, AZ
Sept. 2, 1984
7.98 inches
Phoenix, AZ
Jul. 31, 2010
2.05 inches
Young, AZ
November 21-27, 1965
11.58 inches
Phoenix, AZ
June 20-22, 1972
5.63 inches
Yuma Valley, AZ
August 13-17, 1977
7.01 inches
Workman Creek, AZ Mogollon Rim
September 3-7, 1970
12.13 inches
Horseshoe Dam, AZ
Oct. 27 - Nov. 1, 1959
10.56 inches
Big Pine Flat, AZ
Feb 10 - 13, 2005
8.72 inches
Welton, AZ
August 22-24, 1955
6.49 inches
Workman Creek, AZ Mogollon Rim
Octover 3-7, 1972
11.66 inches
Queen Creek, AZ
August 18-20, 2954
8.06 inches
Maricopa County (Rainbow Wash), AZ
Jul. 29, 2010
1.57 inches
Workman Creek, AZ
Mogollon Rim
Feb. 27 - Mar. 3, 1978
15.52 inches
Mt Graham, AZ
September 27 - October 4, 1983
13.99 inches
Maricopa County (Rainbow Wash), AZ
Aug 5-8, 2008
4.08 inches
Arizona
Dec. 16-20, 1978
10.37 inches
Roosevelt Lakes, AZ
Sept. 9, 2003
11.19 inches
Pacific
Ocean
Sahuarita, AZ
Spetember 8-10, 1964
6.77 inches
Magma, AZ
July 10-11, 2008
4.87 inches
N. Tucson, AZ
September 4-6, 1964
5.28 inches
Sabino Canyon, AZ
July 214-15, 1999
7.87 inches
Thatcher, AZ
September 15-17, 1939
4.18 inches
Nogales, AZ
October 6-10, 1977
15.97 inches
Sonora Desert Museum, AZ
September 26-28, 1962
7.16 inches
Tucson, AZ
September 3-4, 1996
7.37 inches
N

# SPAS Storm Analysis Results

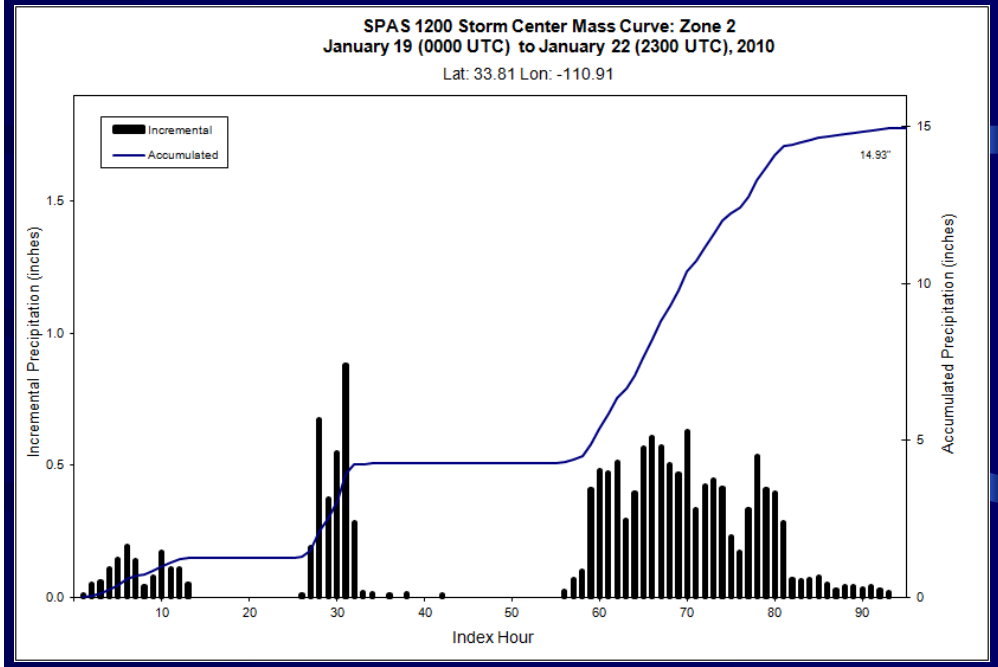



**Hourly and daily station data extraction information:**
**SPAS storm number: 1200**
**Begin: 01/19/2010 0000Z**
**End: 01/22/2010 2359Z**
**Domain: 36.5 -114.8 31.1 -109.0**

**Precipitation (inches)**

| | | | |
|---|---|---|---|
| 0.00 - 0.50 | 3.51 - 4.00 | 10.01 - 11.00 | Daily |
| 0.51 - 1.00 | 4.01 - 5.00 | 11.01 - 12.00 | Hourly |
| 1.01 - 1.50 | 5.01 - 6.00 | 12.01 - 13.00 | Hourly Estimated |
| 1.51 - 2.00 | 6.01 - 7.00 | 13.01 - 14.00 | Hourly Estimated Pseudo |
| 2.01 - 2.50 | 7.01 - 8.00 | 14.01 - 15.00 | Hourly Pseudo |
| 2.51 - 3.00 | 8.01 - 9.00 | | Supplemental |
| 3.01 - 3.50 | 9.01 - 10.00 | | Supplemental Estimated |

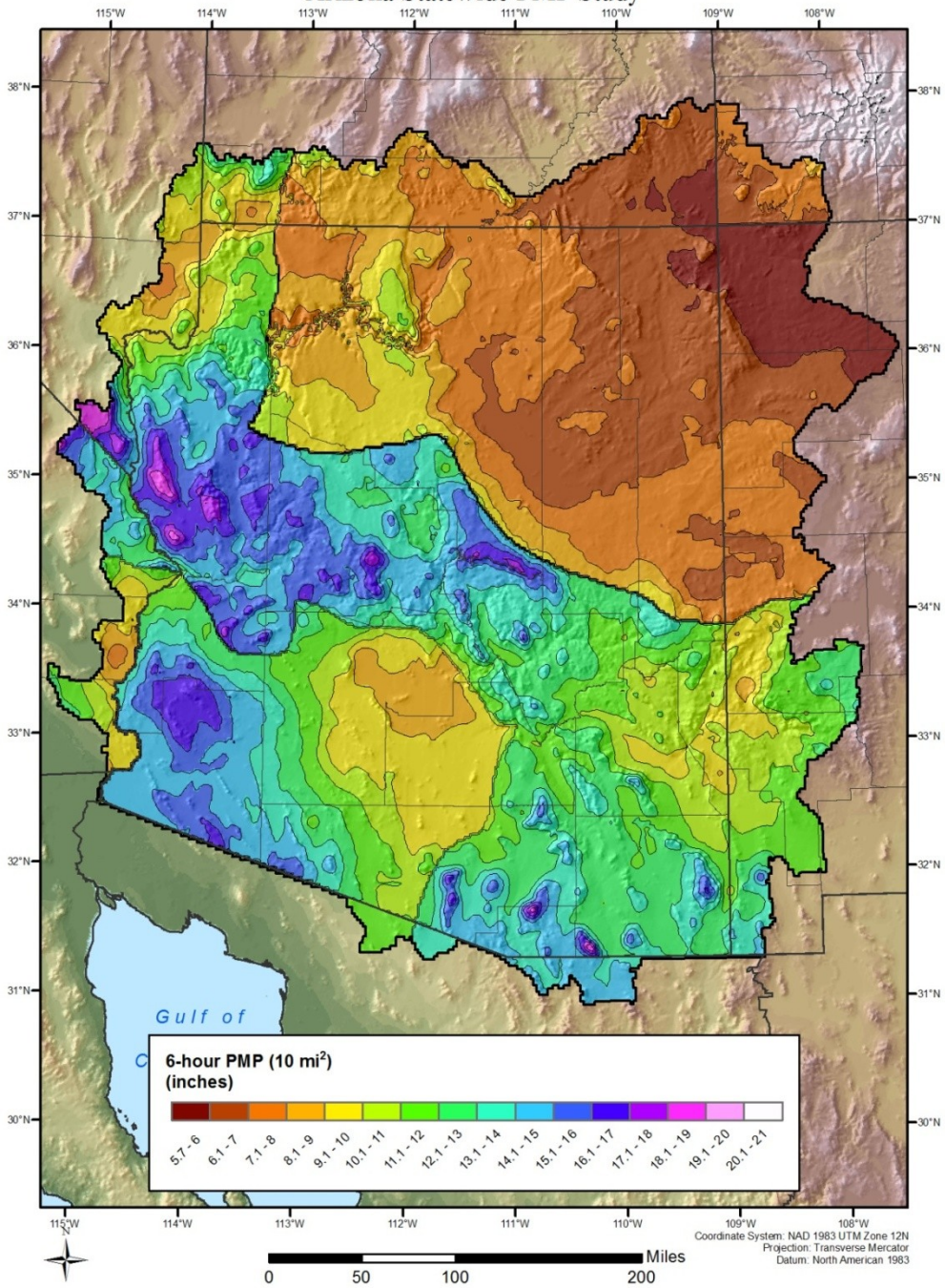

METSTAT 1/3/2011



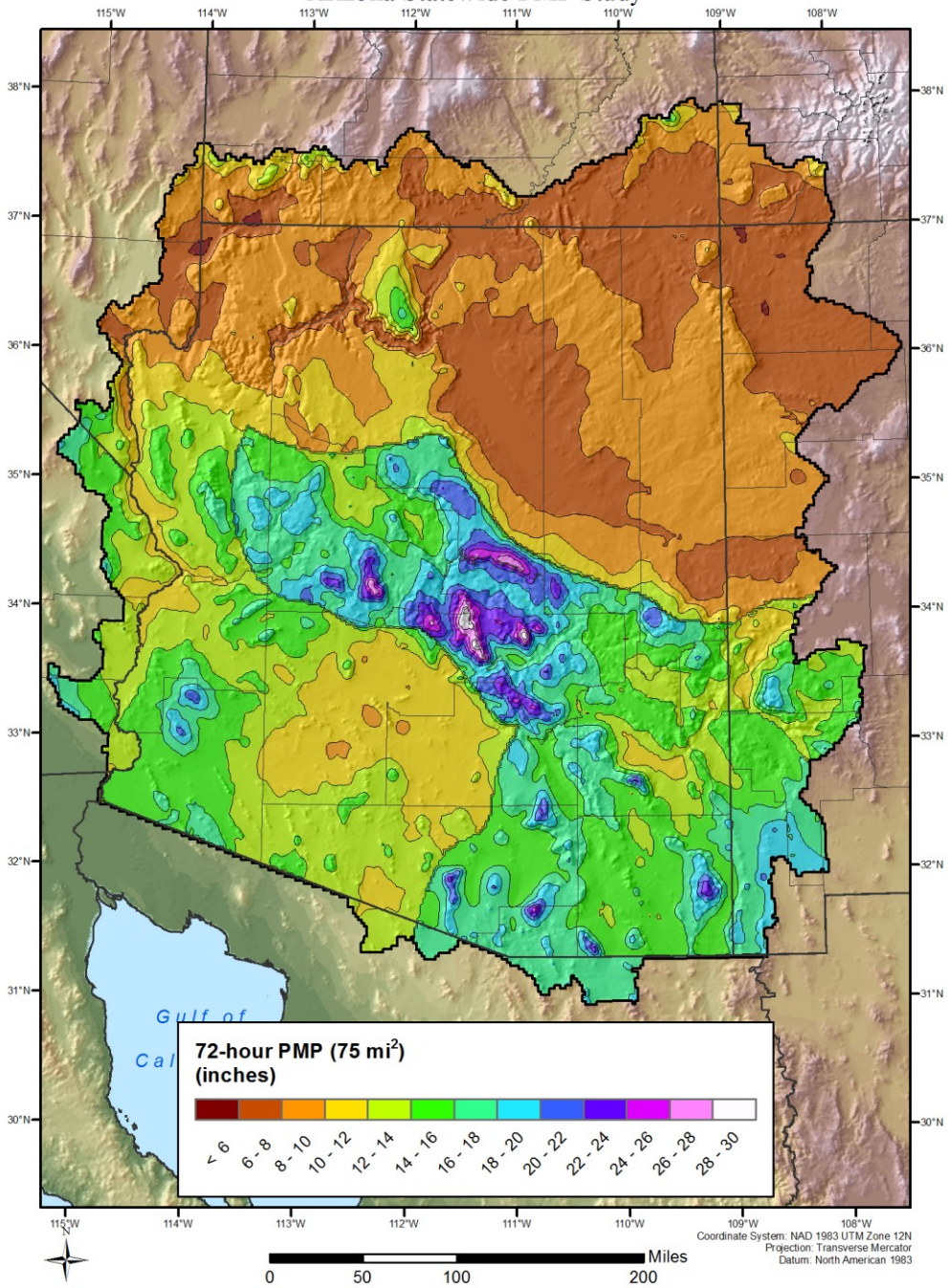

**Storm 1200 - January 19, 2010 (0000 UTC) - January 22, 2010 (0400 UTC)**
**MAXIMUM AVERAGE DEPTH OF PRECIPITATION (INCHES)**

| | Duration (hours) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Area ($mi^2$) | 1 | 3 | 6 | 12 | 18 | 24 | 36 | 48 | 72 | 95 | Total |
| 0 | 1.15 | 2.33 | 3.8 | 6.03 | 8.09 | 9.98 | 10.6 | 10.99 | 13.66 | 14.93 | 14.93 |
| 1 | 1.1 | 2.26 | 3.71 | 5.81 | 7.92 | 9.72 | 10.39 | 10.7 | 13.43 | 14.57 | 14.57 |
| 10 | 1.04 | 2.09 | 3.64 | 5.75 | 7.56 | 9.1 | 9.94 | 10.27 | 12.95 | 14.52 | 14.52 |
| 25 | 0.96 | 2.01 | 3.54 | 5.56 | 7.31 | 8.7 | 9.62 | 9.89 | 12.53 | 13.99 | 13.99 |
| 50 | 0.88 | 1.97 | 3.39 | 5.38 | 7.02 | 8.46 | 9.33 | 9.51 | 12.16 | 13.44 | 13.44 |
| 100 | 0.85 | 1.89 | 3.31 | 5.09 | 6.84 | 8.05 | 8.98 | 9.15 | 11.67 | 12.82 | 12.82 |
| 150 | 0.82 | 1.83 | 3.21 | 4.86 | 6.57 | 7.95 | 8.79 | 8.9 | 11.34 | 12.44 | 12.44 |
| 200 | 0.8 | 1.79 | 3.14 | 4.72 | 6.53 | 7.7 | 8.56 | 8.73 | 11.18 | 12.18 | 12.18 |
| 300 | 0.73 | 1.72 | 3.02 | 4.58 | 6.26 | 7.57 | 8.36 | 8.52 | 10.89 | 11.79 | 11.79 |
| 400 | 0.72 | 1.66 | 2.94 | 4.48 | 6.04 | 7.36 | 8.14 | 8.31 | 10.6 | 11.51 | 11.51 |
| 500 | 0.71 | 1.61 | 2.87 | 4.4 | 5.76 | 7.1 | 7.97 | 8.12 | 10.29 | 11.28 | 11.28 |
| 1,000 | 0.62 | 1.34 | 2.34 | 4 | 5.53 | 6.37 | 7.05 | 7.51 | 8.75 | 10.48 | 10.48 |
| 2,000 | 0.52 | 1.29 | 2.28 | 3.6 | 4.95 | 5.93 | 6.64 | 6.64 | 8.51 | 9.78 | 9.78 |
| 5,000 | 0.43 | 1.08 | 1.93 | 2.92 | 4.4 | 5.1 | 5.78 | 5.78 | 7.49 | 8.6 | 8.60 |
| 10,000 | 0.39 | 0.9 | 1.59 | 2.77 | 3.78 | 4.39 | 5.04 | 5.21 | 6.57 | 7.58 | 7.58 |
| 20,000 | 0.28 | 0.71 | 1.29 | 2.32 | 2.88 | 3.53 | 4.28 | 4.59 | 5.51 | 6.37 | 6.37 |
| 40,231 | 0.19 | 0.53 | 1.02 | 1.74 | 2.35 | 2.77 | 3.23 | 3.43 | 4.36 | 4.74 | 4.74 |

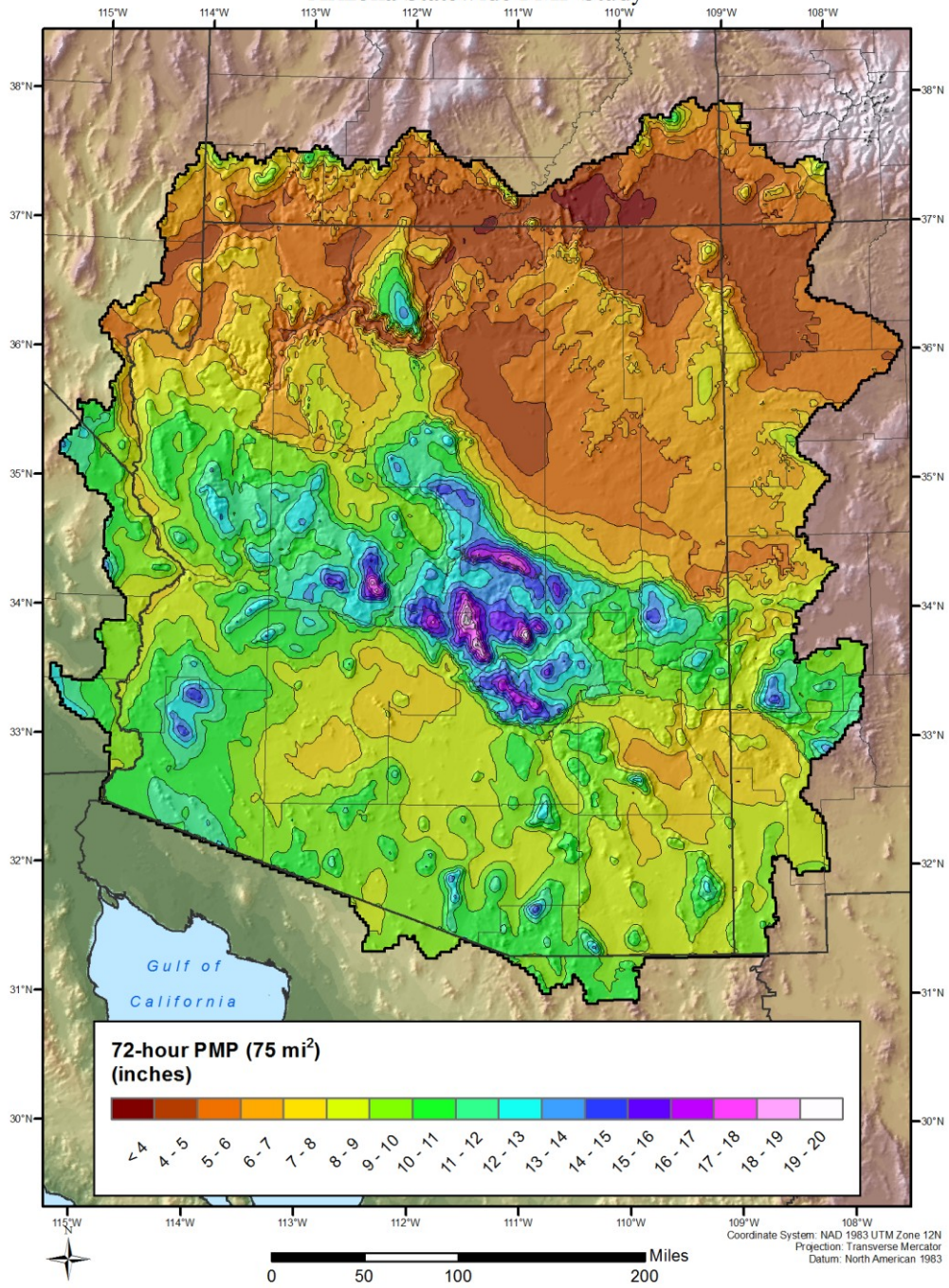
Local Storm 6-hour Probable Maximum Precipitation (at 10 mi$^2$)
Arizona Statewide PMP Study



Tropical Storm 72-hour Probable Maximum Precipitation (at 75 mi$^2$)
Arizona Statewide PMP Study



General Frontal Storm 72-hour Probable Maximum Precipitation (at 75 mi$^2$)
Arizona Statewide PMP Study



# Probable Maximum Precipitation

## Project Overview-WYOMING

- Four HMRs in one state

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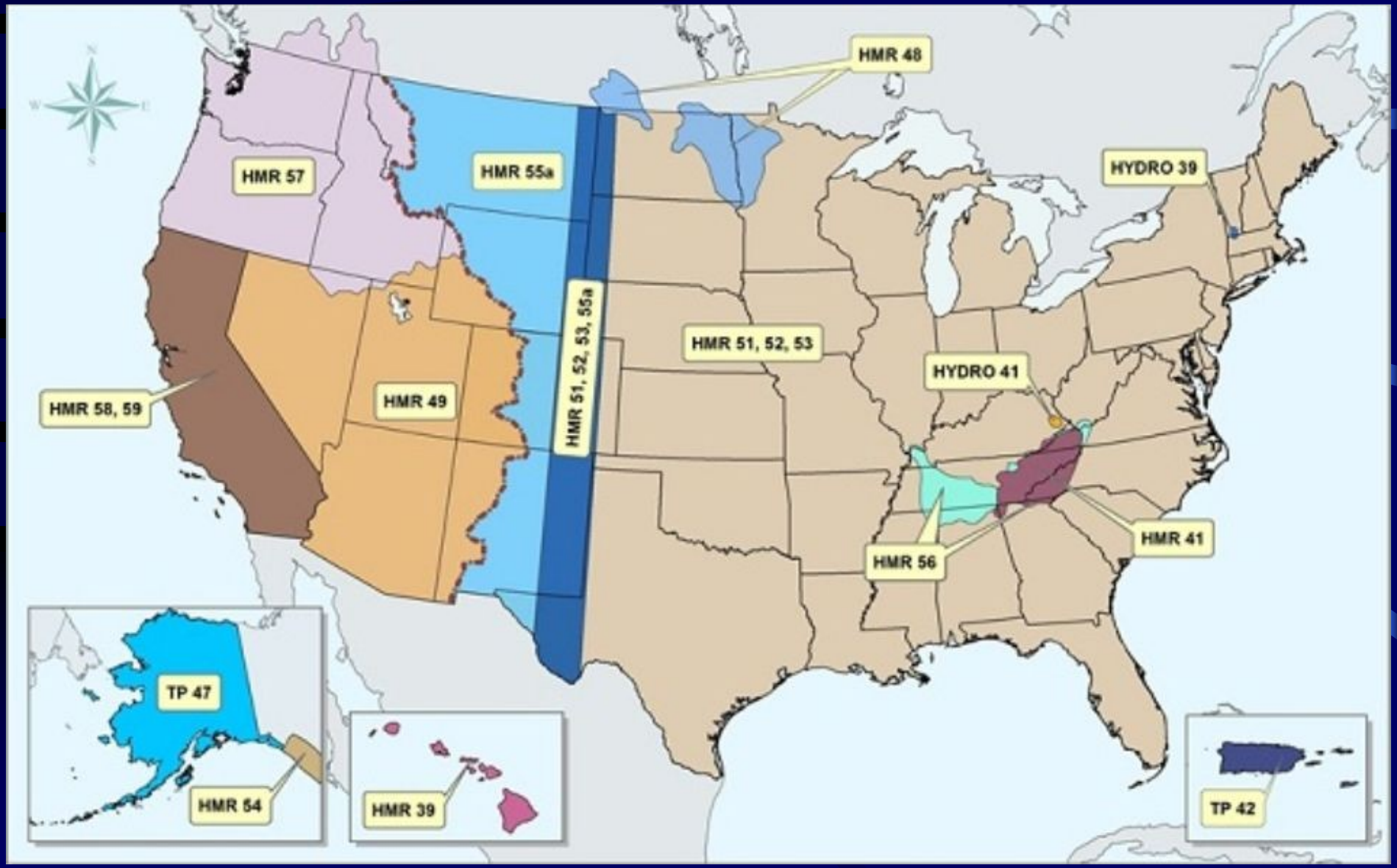
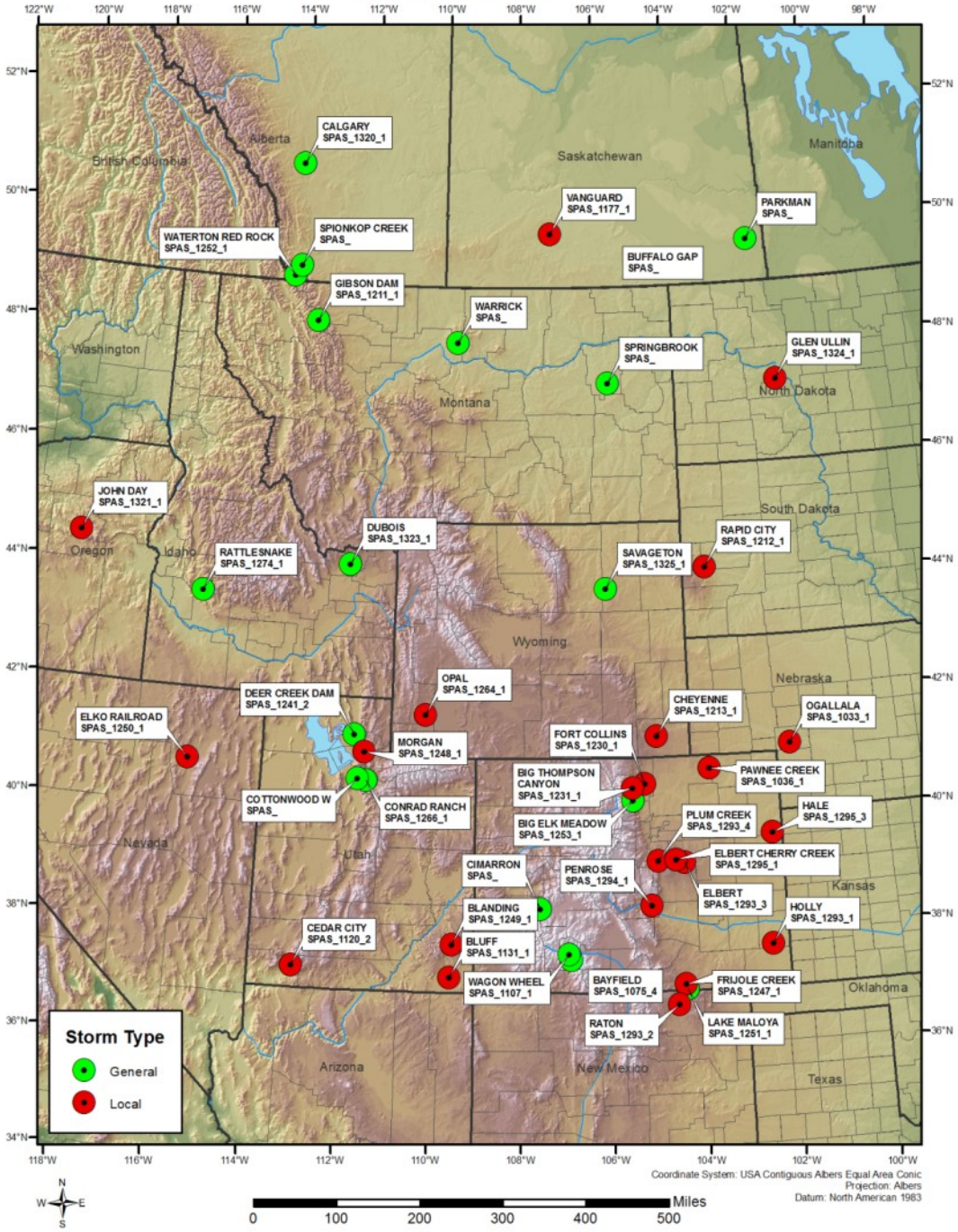
# Coverage of HMRs



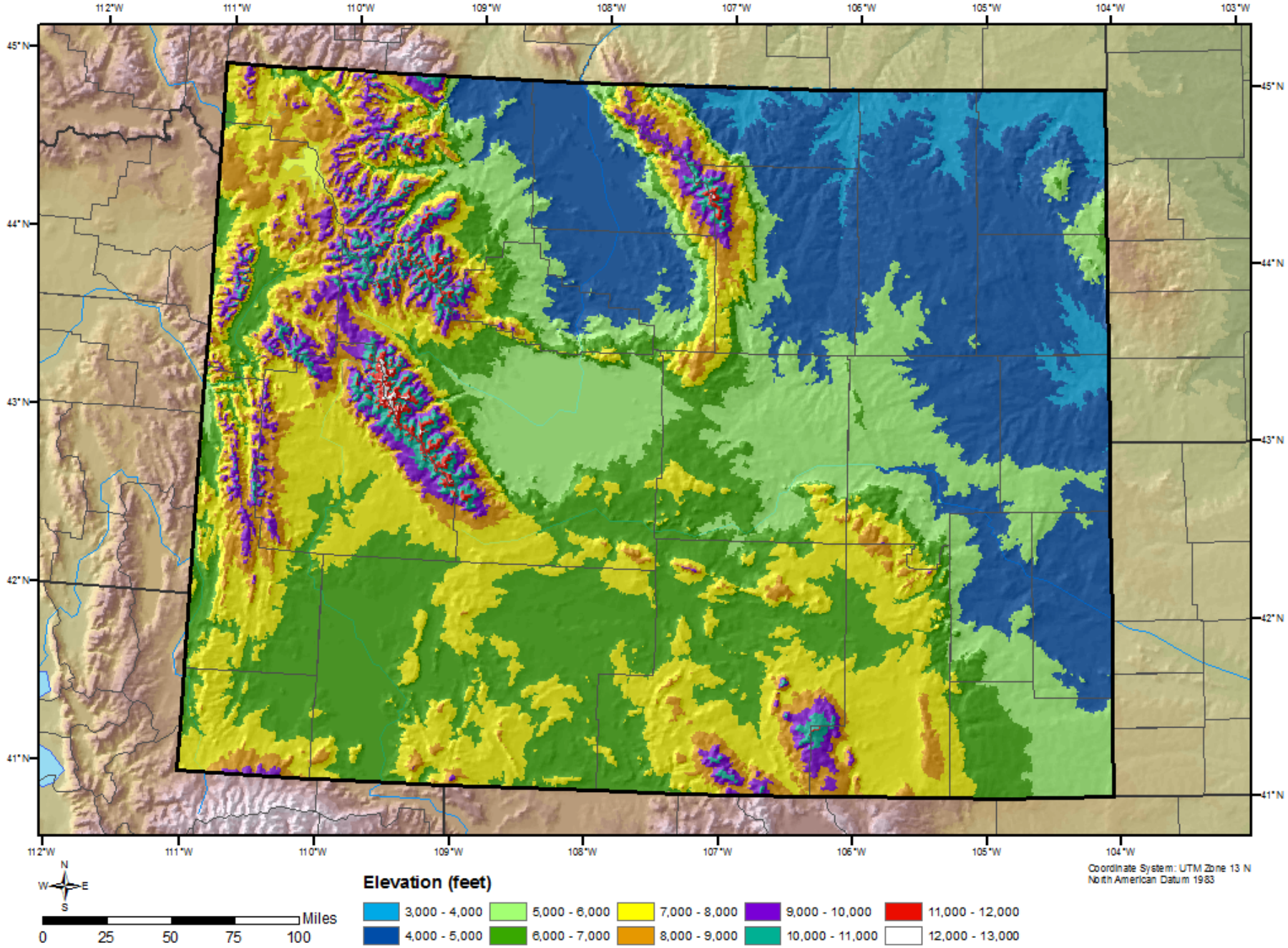
# Locations of Short List Storm Events - All Season

Wyoming Statewide PMP Study



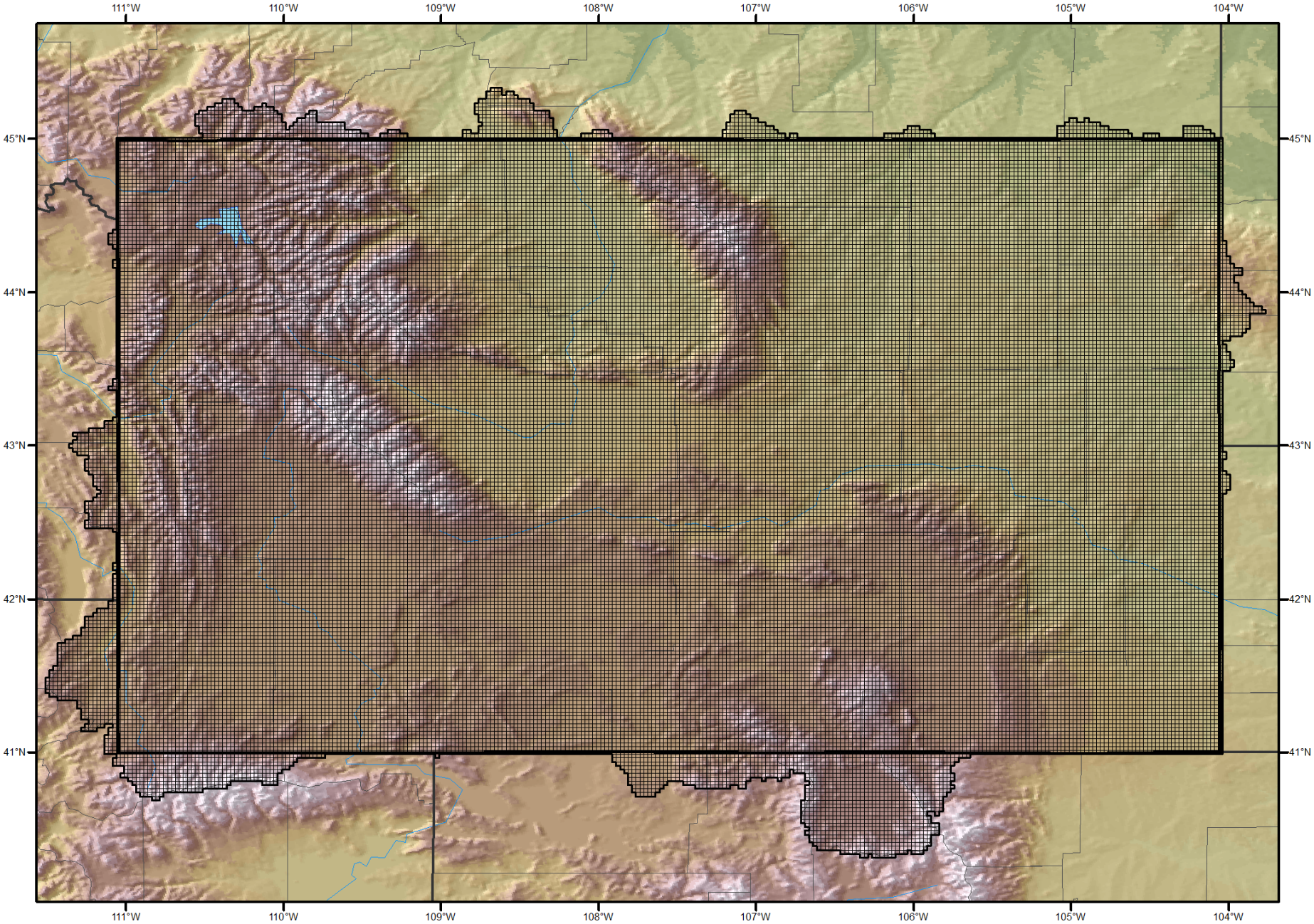
# Wyoming Elevation Contours

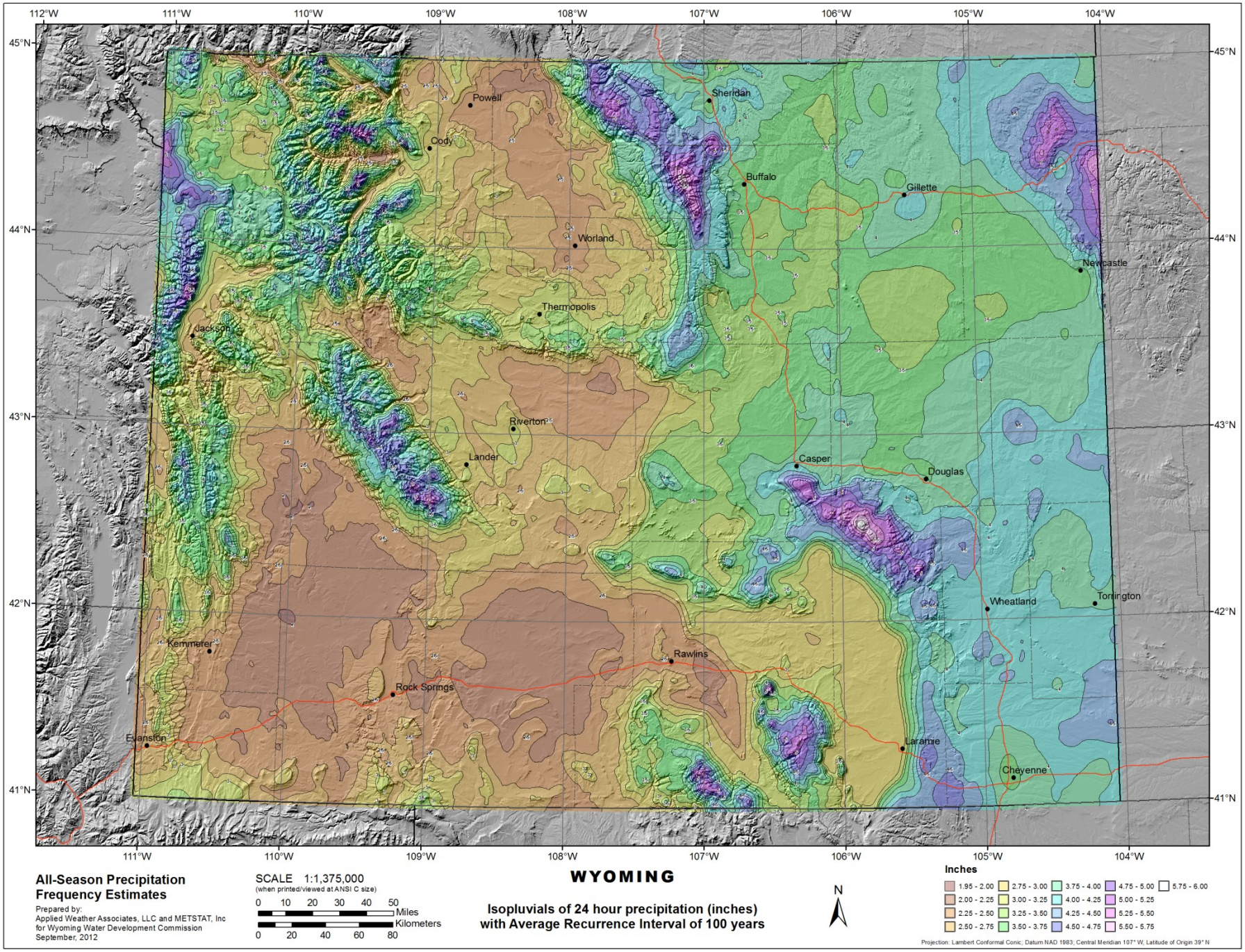
1,000' Intervals

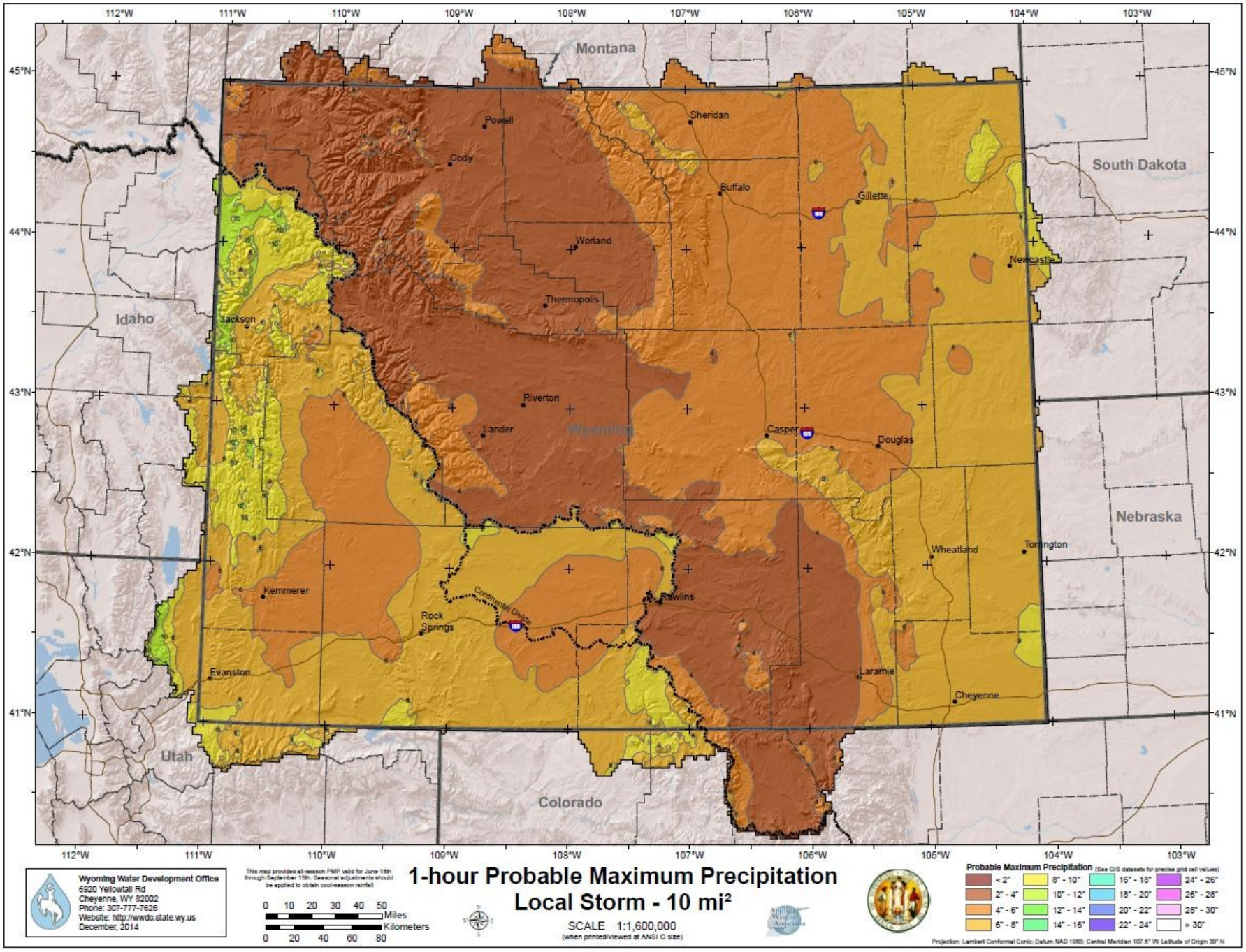


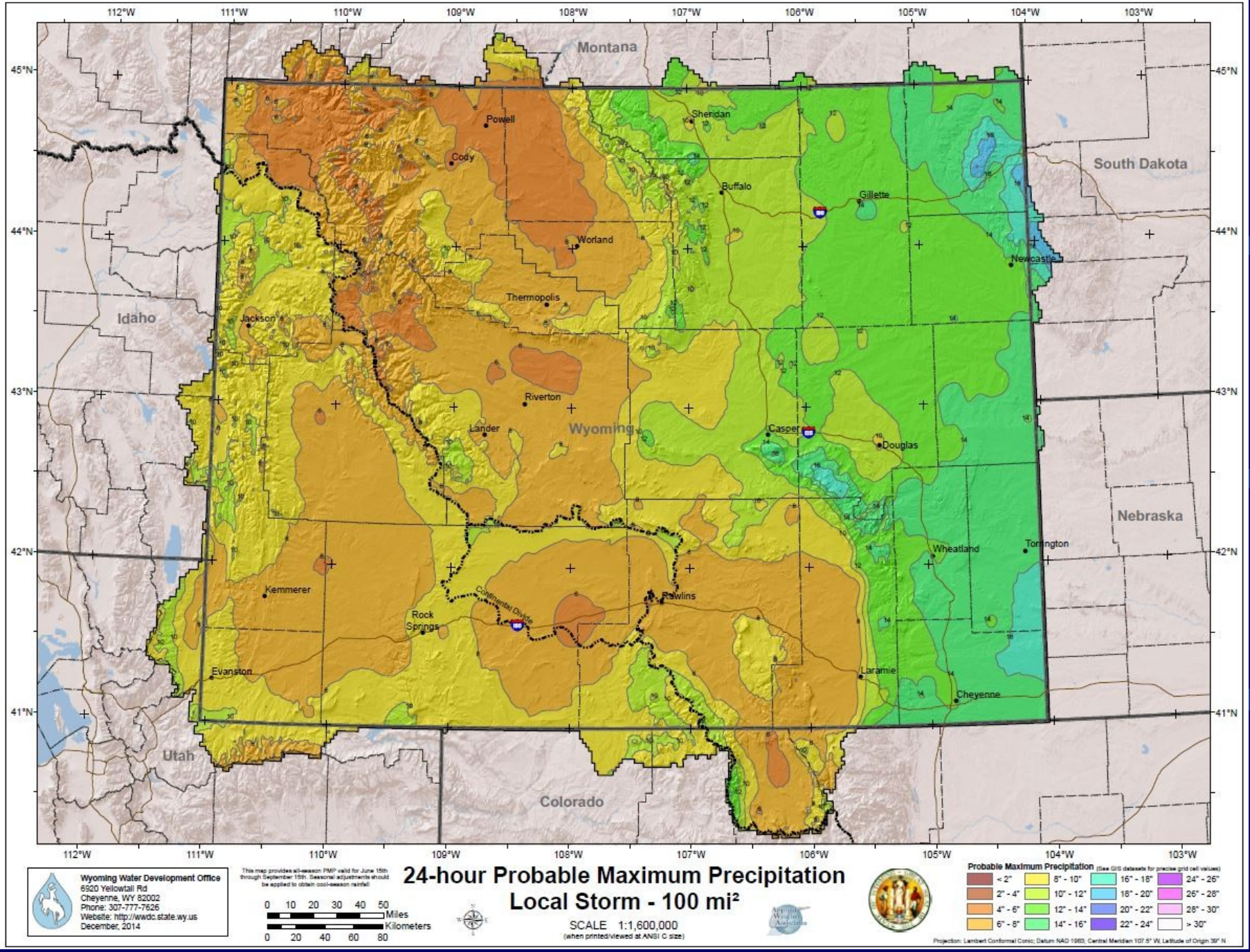
# Gridded PMP Analysis Domain - 90 arc-second

Wyoming Statewide PMP




112°W
111°W
110°W
109°W
108°W
107°W
106°W
105°W
104°W
45°N
44°N
43°N
42°N
41°N
Powell
Cody
Sheridan
Buffalo
Gillette
Worland
Newcastle
Thermopolis
Jackson
Riverton
Lander
Casper
Douglas
Wheatland
Torrington
Kemmerer
Rawlins
Rock Springs
Evanston
Laramie
Cheyenne
All-Season Precipitation Frequency Estimates
Prepared by:
Applied Weather Associates, LLC and METSTAT, Inc
for Wyoming Water Development Commission
September, 2012
SCALE 1:1,375,000
(when printed/viewed at ANSI C size)
0 10 20 30 40 50 Miles
0 20 40 60 80 Kilometers
WYOMING
Isopluvials of 24 hour precipitation (inches)
with Average Recurrence Interval of 100 years
N
Inches
1.95 - 2.00
2.00 - 2.25
2.25 - 2.50
2.50 - 2.75
2.75 - 3.00
3.00 - 3.25
3.25 - 3.50
3.50 - 3.75
3.75 - 4.00
4.00 - 4.25
4.25 - 4.50
4.50 - 4.75
4.75 - 5.00
5.00 - 5.25
5.25 - 5.50
5.50 - 5.75
5.75 - 6.00
Projection: Lambert Conformal Conic, Datum NAD 1983, Central Meridian 107° W, Latitude of Origin 39° N


Montana
South Dakota
Idaho
Nebraska
Utah
Colorado
Wyoming
Powell
Cody
Sheridan
Buffalo
Gillette
Worland
Newcastle
Thermopolis
Jackson
Riverton
Lander
Casper
Douglas
Wheatland
Torrington
Kemmerer
Rock Springs
Rawlins
Continental Divide
Evanston
Laramie
Cheyenne
112°W
111°W
110°W
109°W
108°W
107°W
106°W
105°W
104°W
103°W
45°N
44°N
43°N
42°N
41°N
Wyoming Water Development Office
5920 Yellowtail Rd
Cheyenne, WY 82002
Phone: 307-777-7626
Website: http://wwdc.state.wy.us
December, 2014
This map provides all-season PMP valid for June 15th through September 15th. Seasonal adjustments should be applied to obtain cool-season rainfall
0 10 20 30 40 50 Miles
0 20 40 60 80 Kilometers
1-hour Probable Maximum Precipitation
Local Storm - 10 mi²
SCALE 1:1,600,000
(when printed/viewed at ANSI C size)
Probable Maximum Precipitation (See GIS datasets for precise grid cell values)
< 2"
2" - 4"
4" - 6"
6" - 8"
8" - 10"
10" - 12"
12" - 14"
14" - 16"
16" - 18"
18" - 20"
20" - 22"
22" - 24"
24" - 26"
26" - 28"
28" - 30"
> 30"
Projection: Lambert Conformal Conic; Datum NAD 1983; Central Meridian 107.5° W; Latitude of Origin 39° N


24-hour Probable Maximum Precipitation
Local Storm - 100 mi²
SCALE 1:1,600,000
(when printed/viewed at ANSI C size)
Wyoming Water Development Office
6920 Yellowtail Rd
Cheyenne, WY 82002
Phone: 307-777-7626
Website: http://wwdc.state.wy.us
December, 2014
Miles
Kilometers
Probable Maximum Precipitation
< 2"
2" - 4"
4" - 6"
6" - 8"
8" - 10"
10" - 12"
12" - 14"
14" - 16"
16" - 18"
18" - 20"
20" - 22"
22" - 24"
24" - 26"
26" - 28"
28" - 30"
> 30"
Montana
South Dakota
Idaho
Wyoming
Nebraska
Utah
Colorado
Powell
Cody
Sheridan
Buffalo
Gillette
Worland
Newcastle
Thermopolis
Jackson
Riverton
Lander
Casper
Douglas
Wheatland
Torrington
Kemmerer
Rock Springs
Rawlins
Continental Divide
Evanston
Laramie
Cheyenne

# Probable Maximum Precipitation

## Site-Specific for Springer Dam

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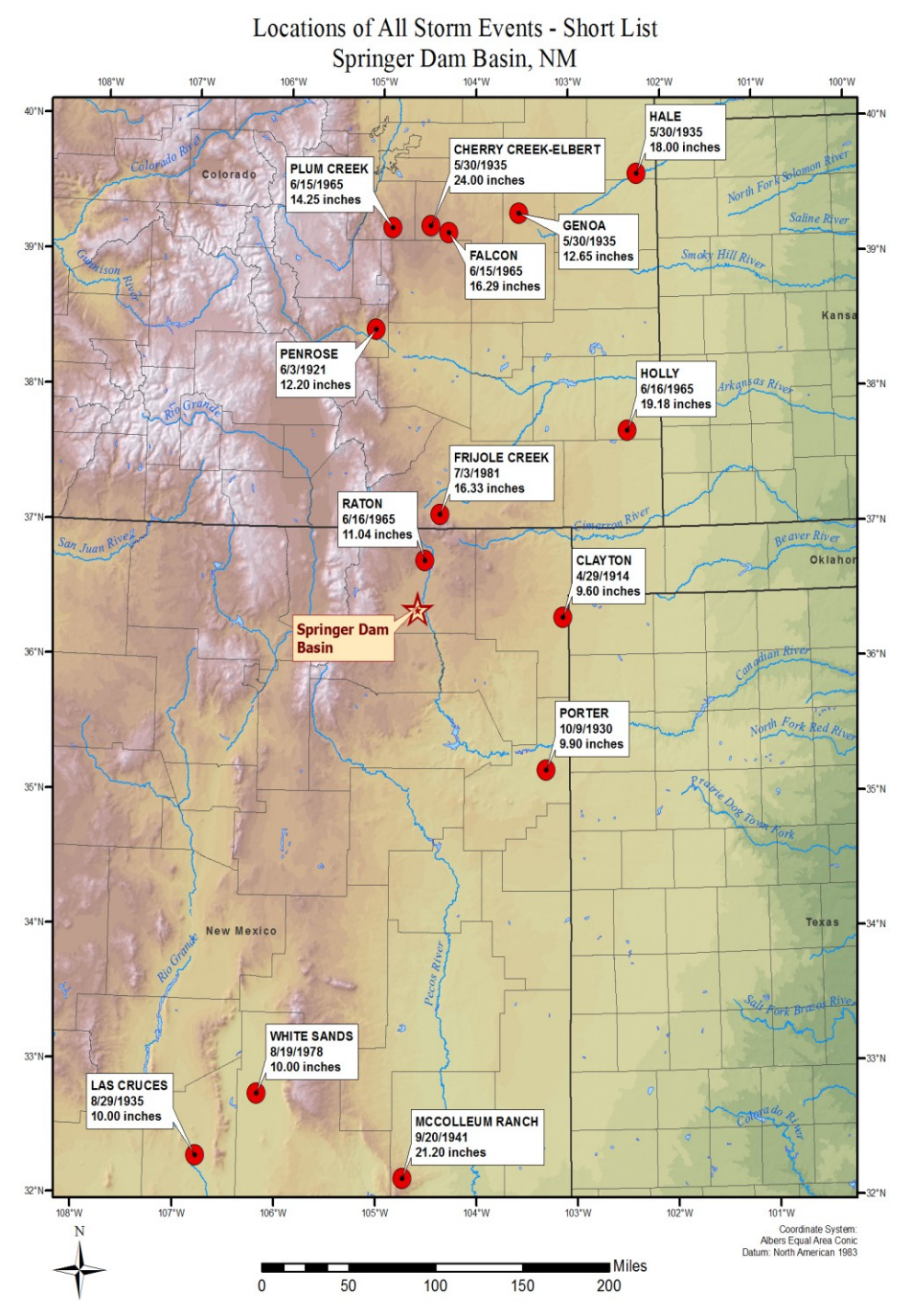
# Storms Used in PMP Development



# PMP Results Compared to HMR 55A

| | Local Storm PMP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1/4-hour | 1/2-hour | 3/4-hour | 1-hour | 2-hour | 3-hour | 4-hour | 5-hour | 6-hour |
| HMR 55A (1 $mi^2$) | 8.05 | 10.28 | 11.35 | 12.08 | 14.01 | 15.01 | 15.62 | 16.10 | 16.47 |
| AWA (1 $mi^2$) | 5.79 | 7.32 | 8.00 | 8.51 | 12.77 | 15.16 | 16.87 | 16.88 | 16.88 |
| % change from HMR 55A | -28% | -29% | -30% | -30% | -9% | 1% | 8% | 5% | 3% |

| | General Storm PMP | | | |
|---|---|---|---|---|
| | 1-hour | 6-hour | 24-hour | 72-hour |
| HMR 55A (10 $mi^2$) | 15.00 | 25.00 | 32.10 | 37.20 |
| AWA (1 $mi^2$) | 8.15 | 21.52 | 28.92 | 28.92 |
| % change from HMR 55A | -46% | -14% | -10% | -22% |

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## What About New Mexico

- Would expect similar results as adjacent studies
- Follow the same process
- Build off previous and ongoing work
- Consistency in development
- Understanding of values
- Reproducible results
- Higher confidence in data

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# Extra Slides

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