ARIZONA STATEWIDE PROBABLE MAXIMUM PRECIPITATION, REPLACING HMR 49

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USSD 2013 Annual Meeting & Conference

February 11-15, 2013 Phoenix, AZ

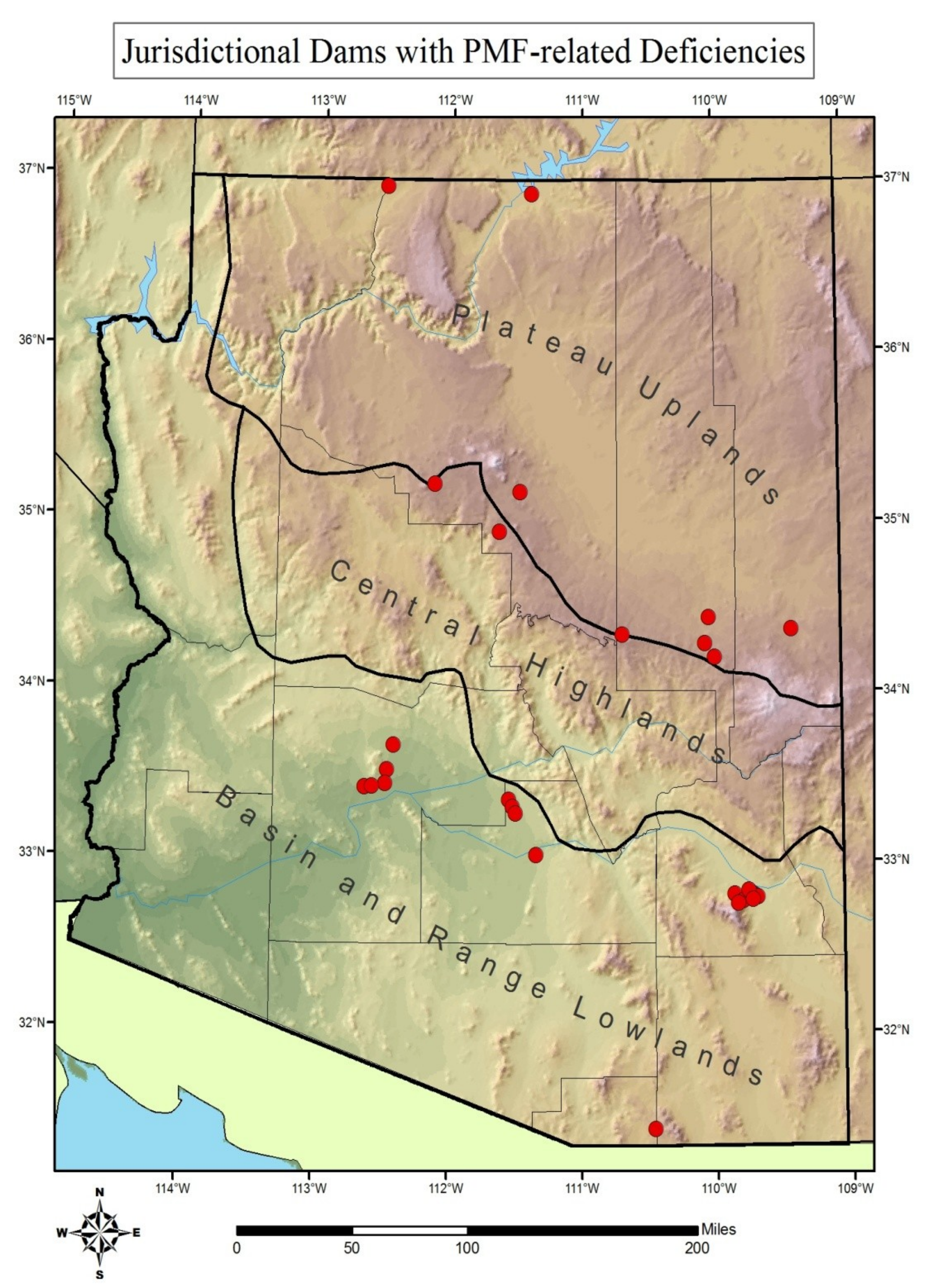
Reasons For Study

Deficient Dams:
29 state-regulated

>$75,000,000 estimated upgrade costs

State-of-practice data and understanding

Regulator/Owner confidence in results/applications



Reasons For Study

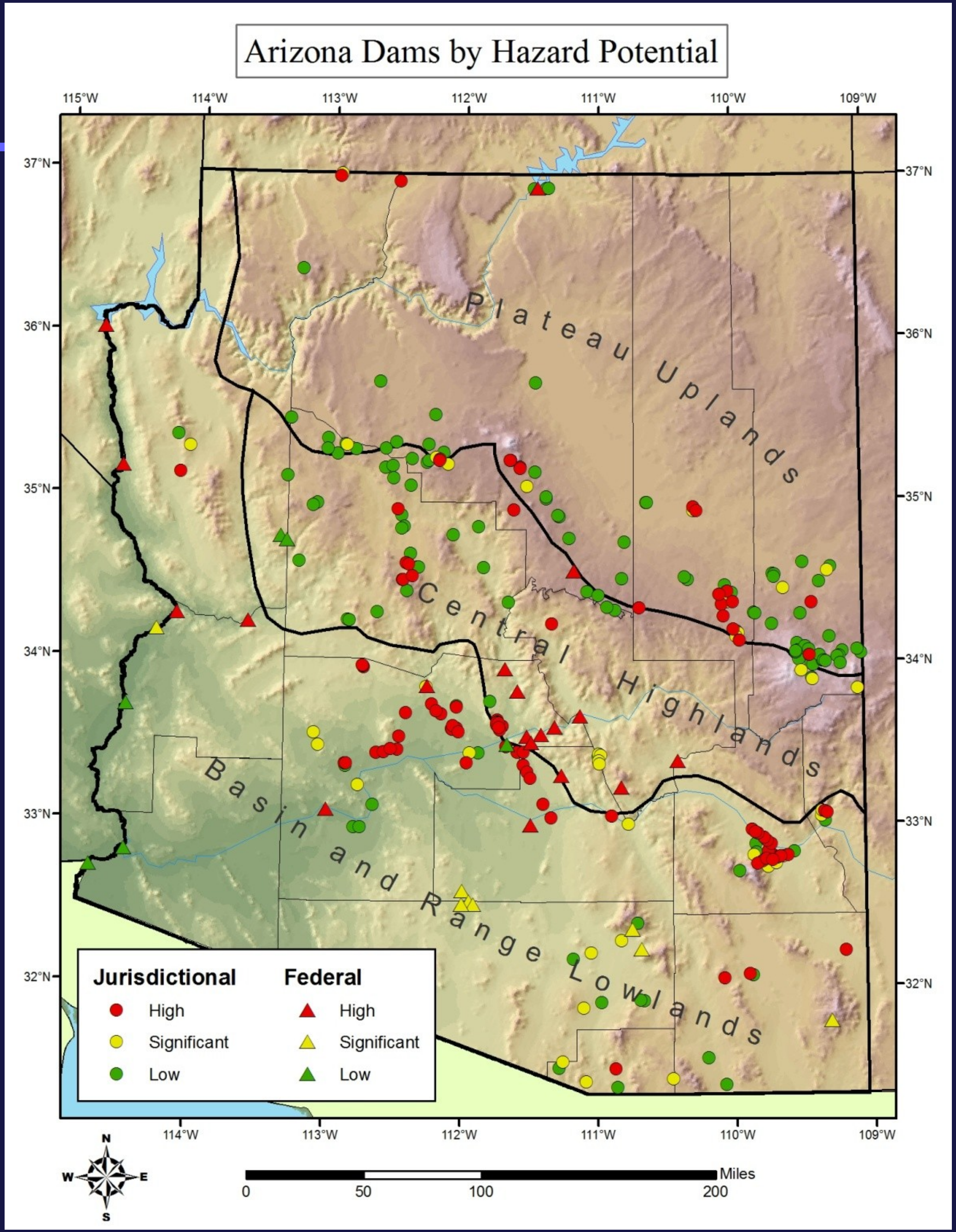
"Hazard creep"

In past 3 years:

17 dams reclassified

More than half deficient

156 more could be reclassified in the future



Cooperative Efforts

- Funding/Cooperating Partners
  - Arizona Department of Water Resources
  - Arizona Game & Fish Department
  - Maricopa County FCD
  - Navajo County FCD
  - 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
  - $15M to $30M est. cost savings over 20 yrs
- Reclaimed Opportunity Costs
  - Flood protection
  - Storage capacities
  - Operational availability

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Background

- HMR 49-Published in 1977
  - The oldest of the HMRs currently in use
  - Based on outdated methods and techniques
    - Subsequently been improved
      - Better understanding of meteorology
      - Updated datasets
      - Improved spatial analysis
    - Methods and techniques updated in newer HMRs
- Major issues with HMR 49
  - Lack of storm data used to develop the PMP values
    - Only a handful of storms were investigated
    - None were analyzed using individual storm Depth-Area-Duration (DAD) values
  - Covers a widely varying region
    - Climatologically/Topographically

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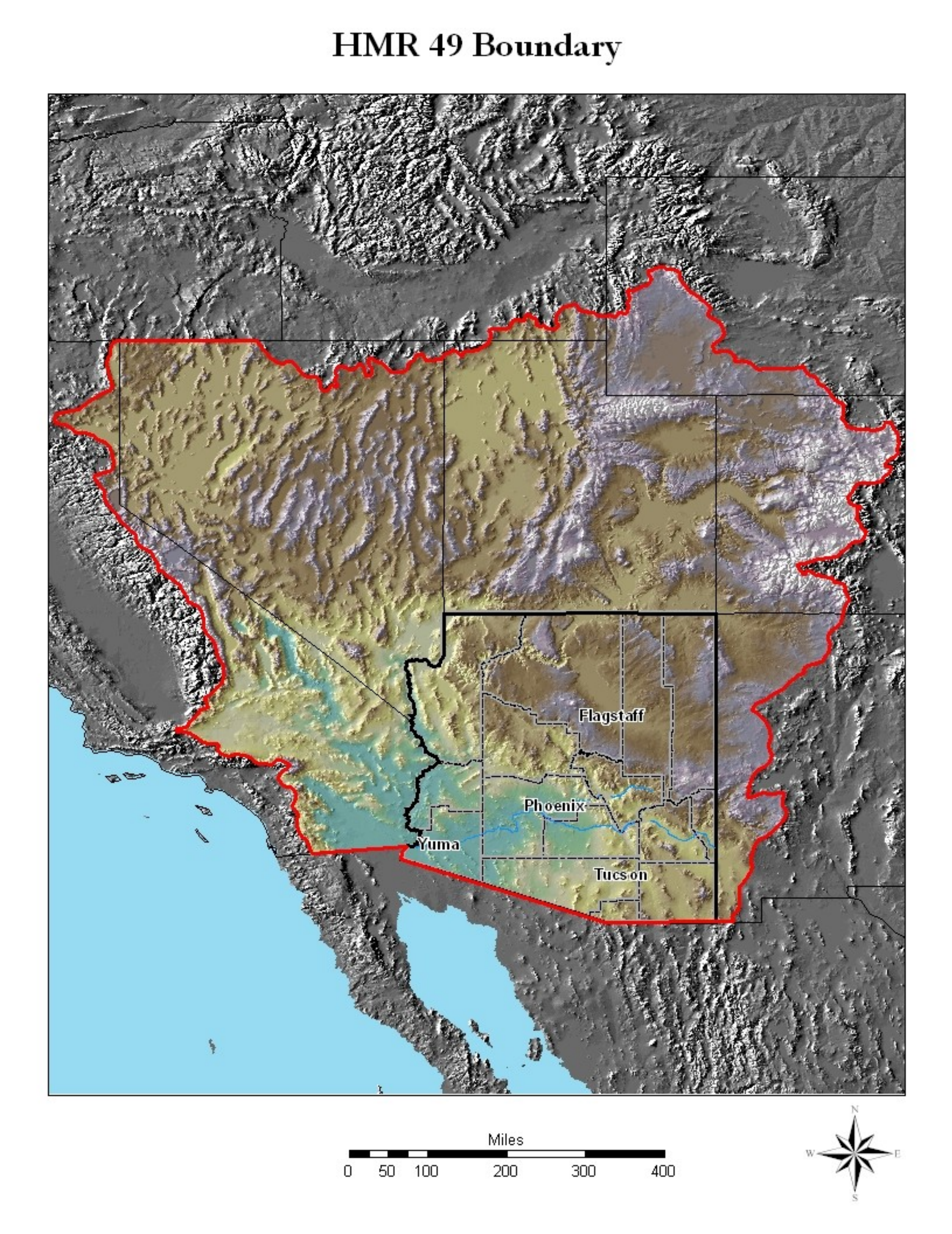
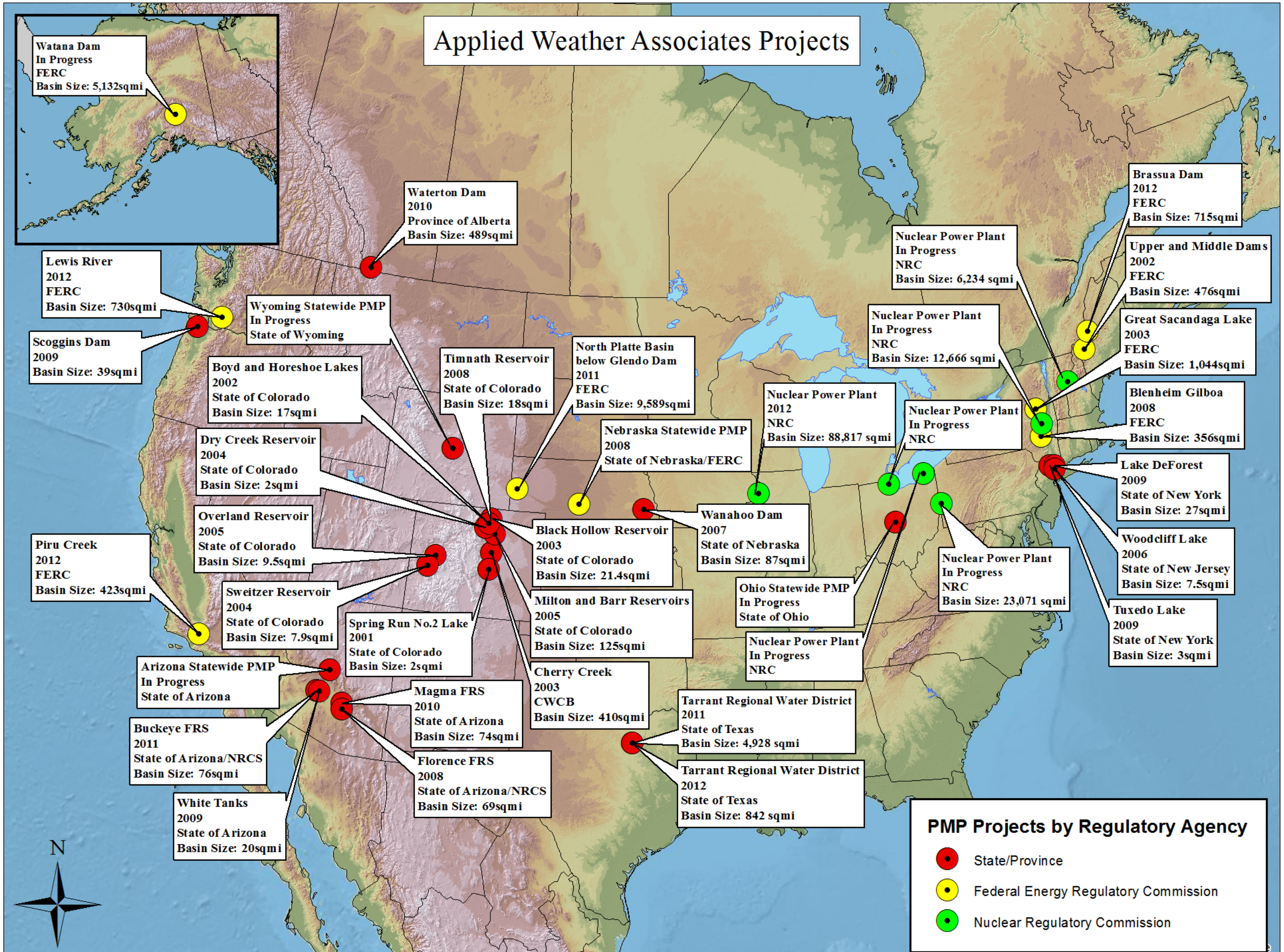
HMR 49 Domain



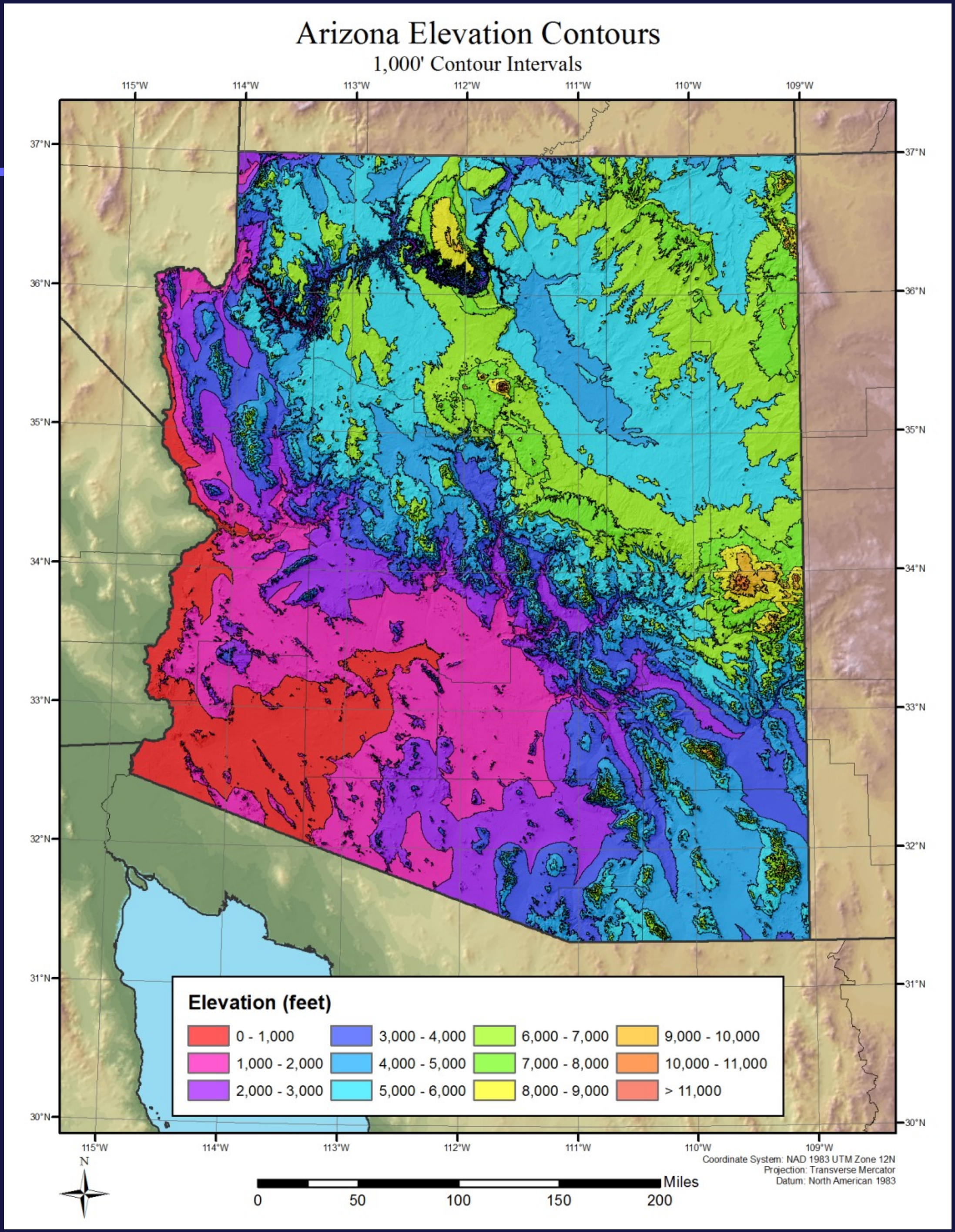
How Did We Compute PMP?

- Storm Based Approach
  - Similar to HMR/WMO procedures
  - Deterministic
- Maintain consistency with AWA PMP studies
  - Improvements in understanding
  - Expanded data base
  - Use of computer technologies
  - Use of NEXRAD weather radar
  - Better understanding of meteorology

Not Our First PMP Study



Elevations Across Arizona, 1,000 Foot Interval



Updating PMP-What Did We Do

- Storm Search
  - Update the storm database
  - Identify the most extreme rainfall events
    - Throughout the state
    - Surrounding regions
  - Identify Storm Types
    - Local Convective
    - Remnant Tropical
    - General Frontal

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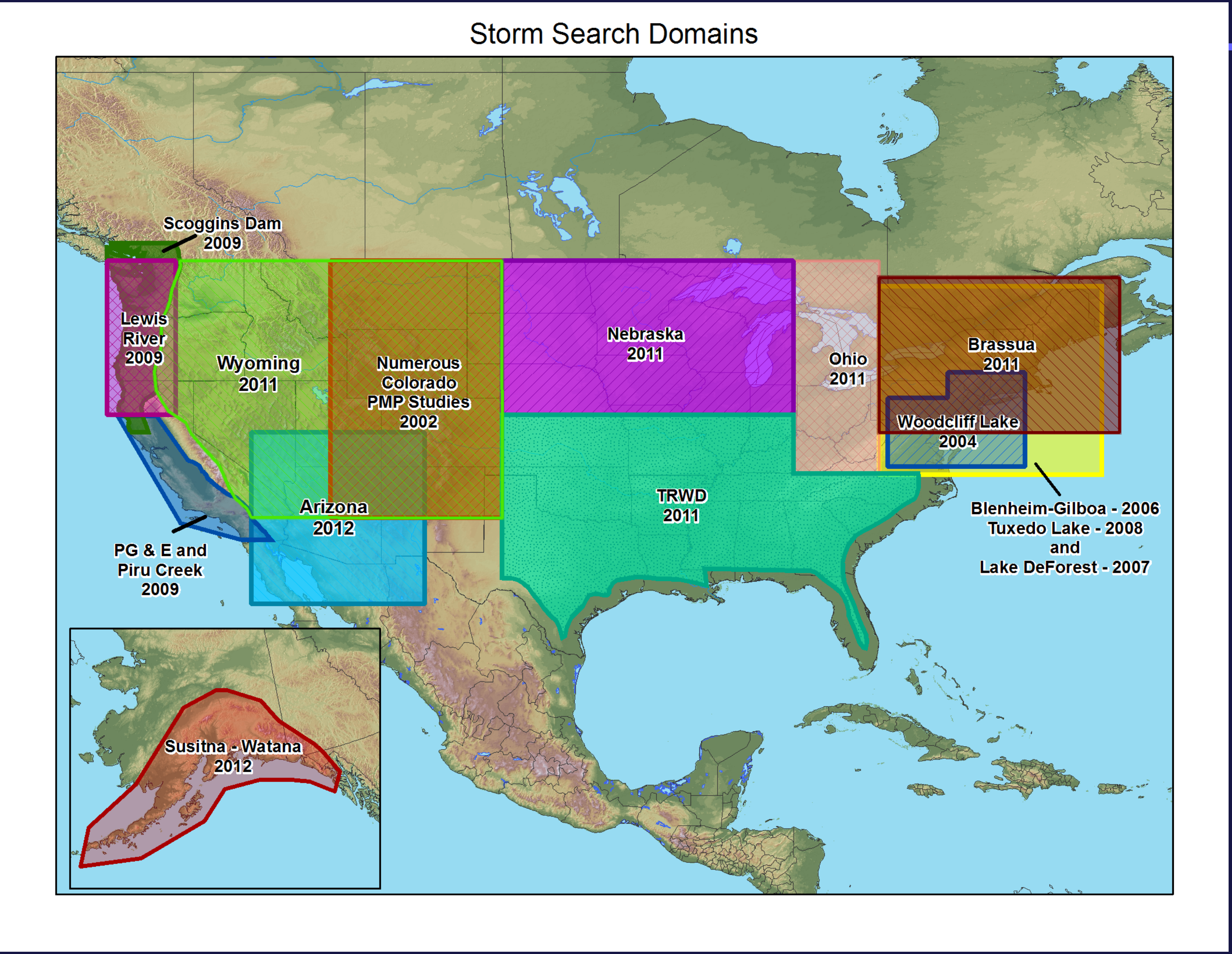
AWA Storm Search Domains



Updating PMP-Storm Search

- 1000's of storms initially captured
- Grouped by storm type
  - Local Convective, tropical, Frontal
  - Location
  - Duration
- Storms used in HMRs included
- Ensure no potential PMP storms missed
- Storms must be transpositionable
  - Meteorological and topographical similar characteristics

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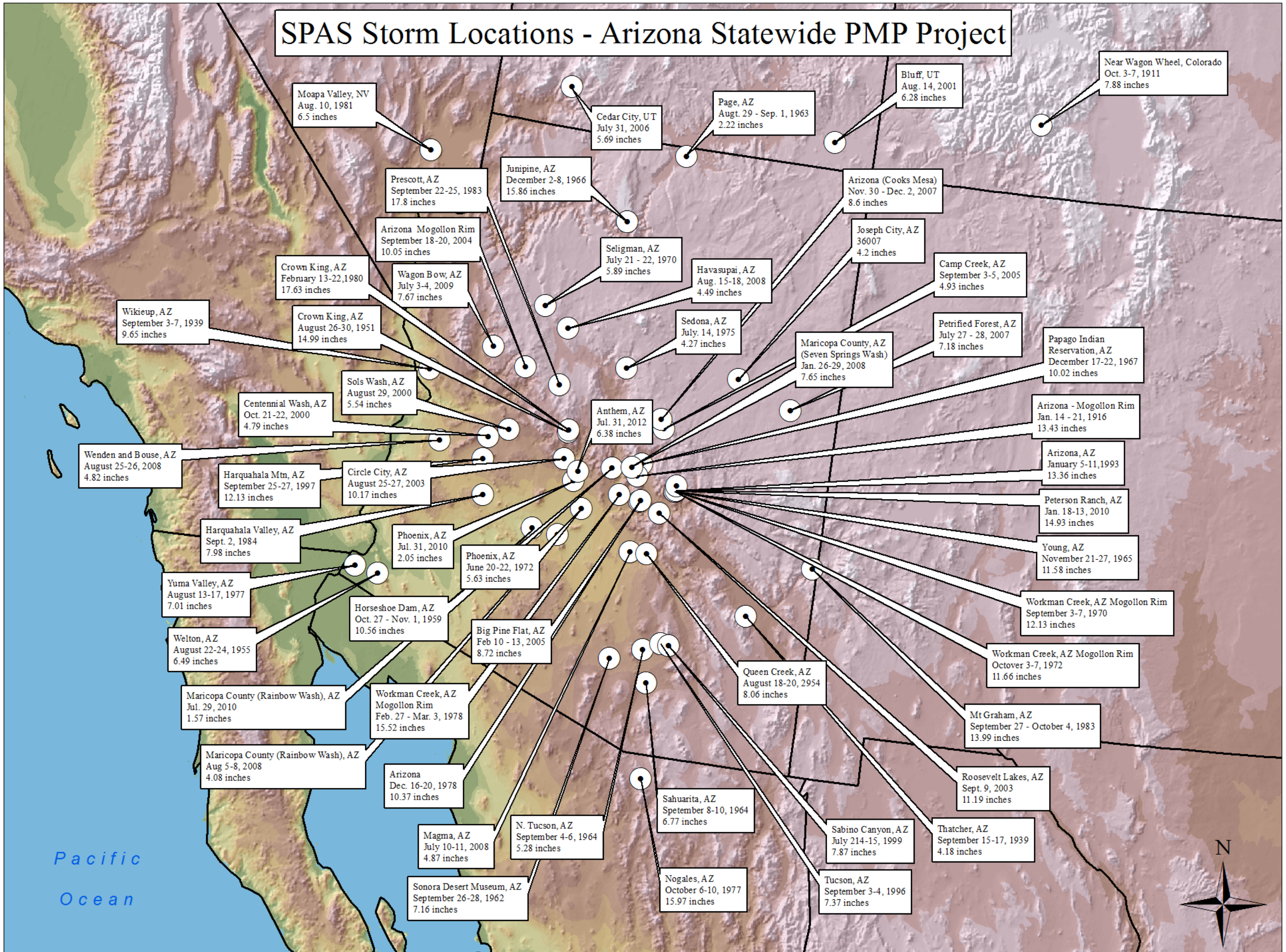
Short List Storm Locations



Updating PMP-Storm Analysis

- Storm Precipitation Analysis System (SPAS)
  - Depth-Area-Duration
  - Mass Curves
  - Storm Isohyetal
  - Hourly (5-minute rainfall) at 1/3rd square mile
  - Dynamically adjusted radar and/or basemap for spatial interpolation

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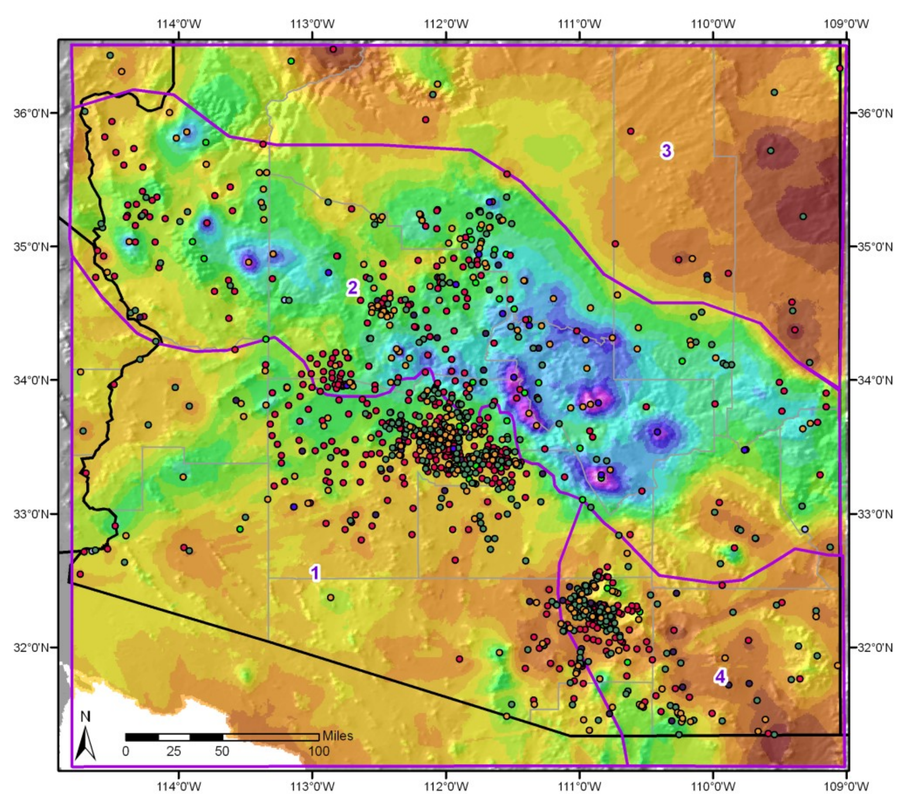
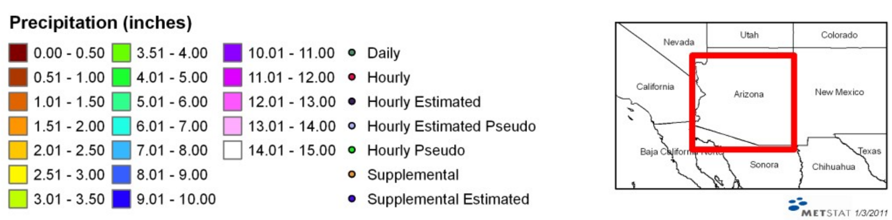
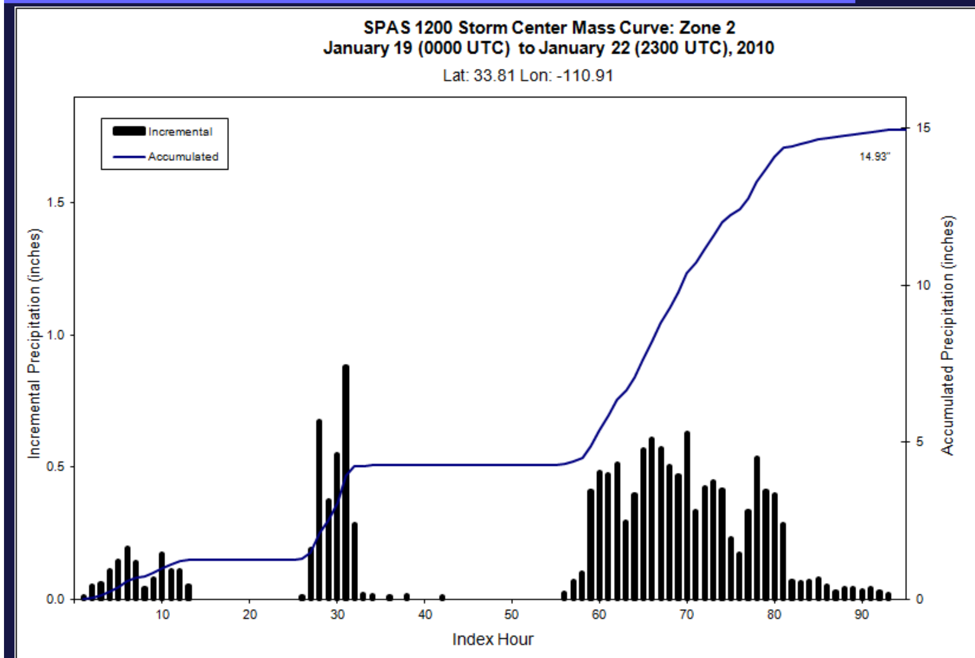
SPAS Storm Analysis Results



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





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

Area (mi^2)	Duration (hours) 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

How Did We Compute PMP?

- Each storm maximized
  - Make it as big as physically possible
  - Storm rainfall = dynamics + moisture
    - Can't quantify dynamics, can quantify moisture
    - Assume most efficient storm dynamics
    - Only moisture varies
  - Use surface dew points or SST for maximization
- Determine moisture which fed the storm = fuel
- Ratio: climatological maximum moisture to actual storm moisture = in-place maximization factor

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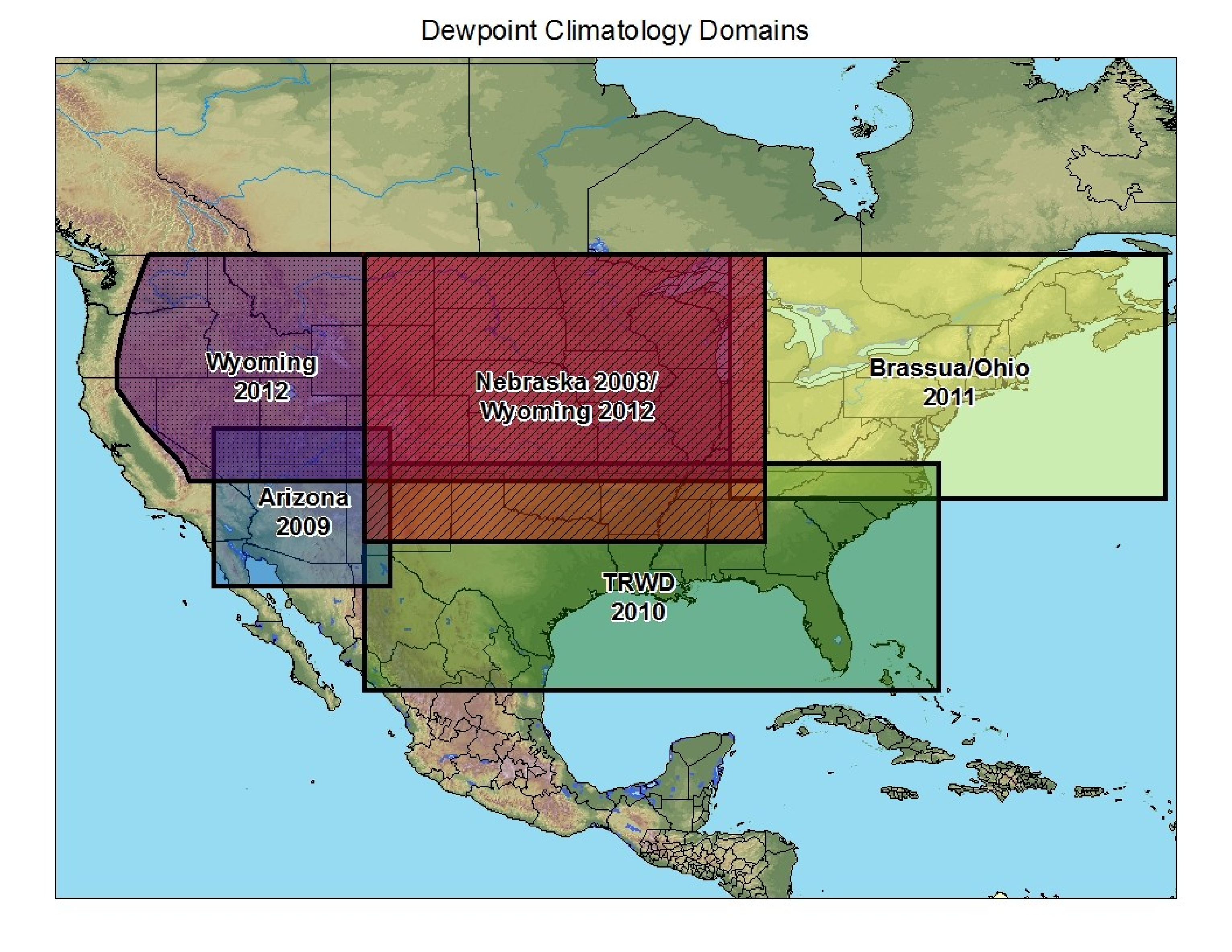
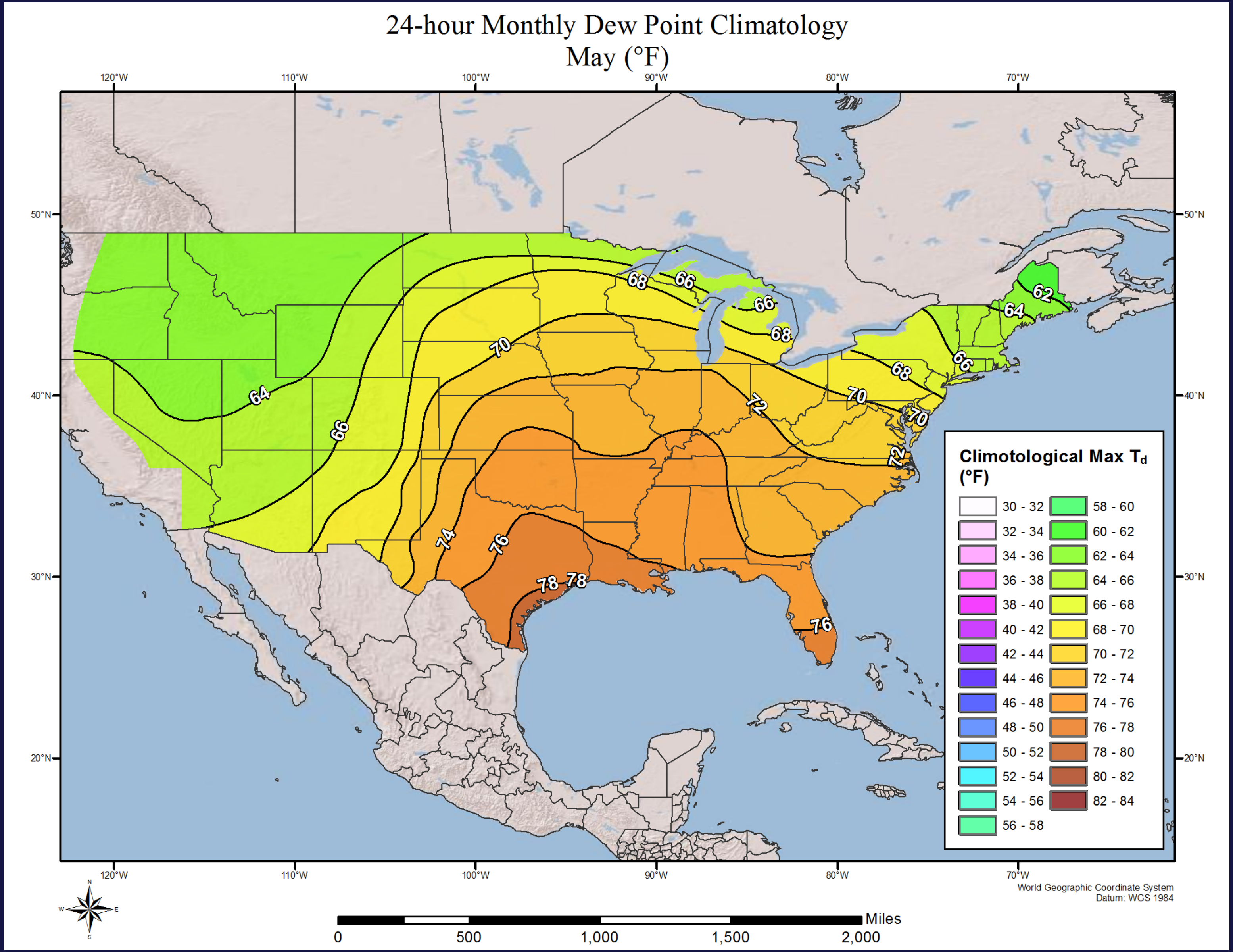
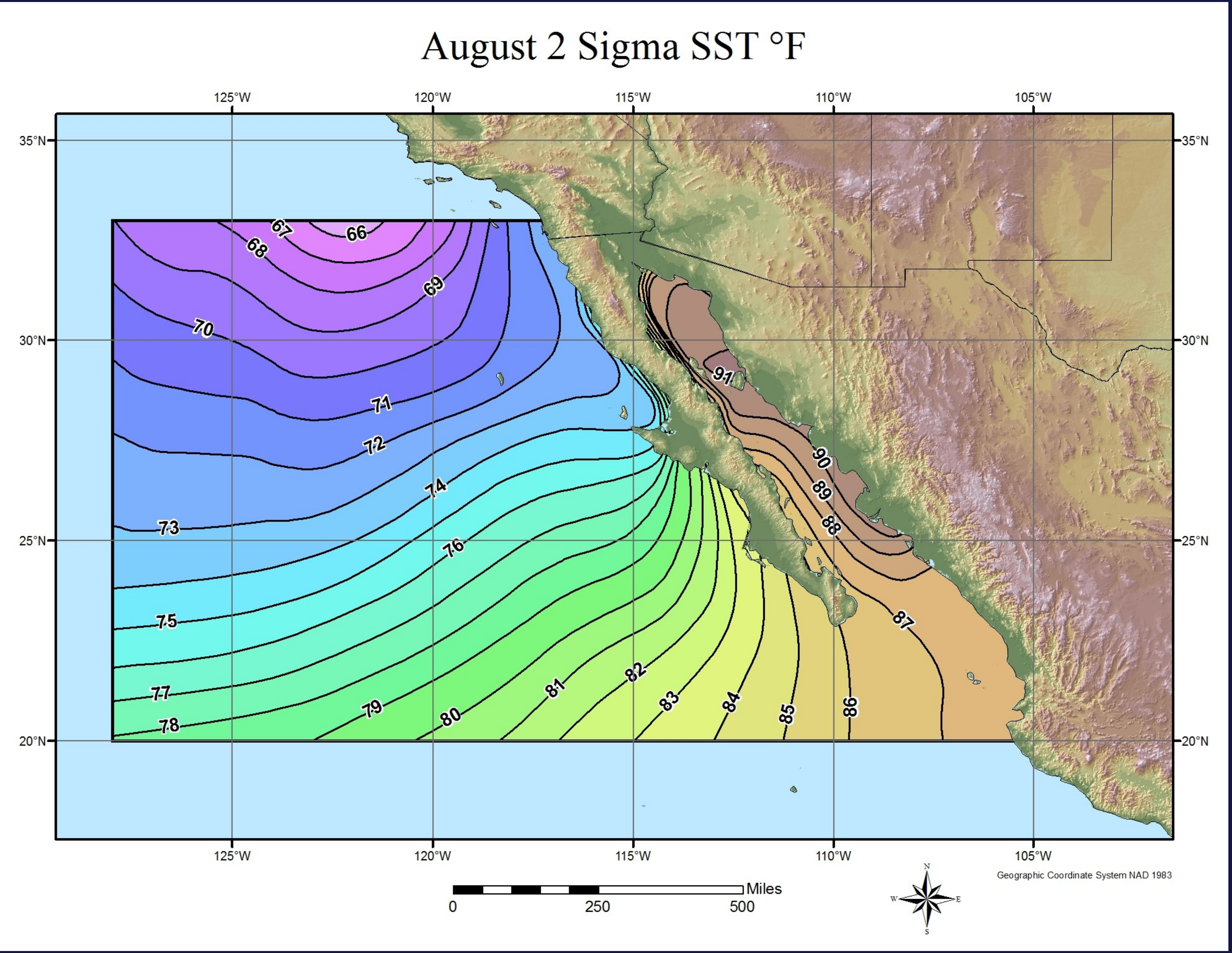
Maximum Dew Point Climatologies



Dew Point Map, May 24-hr 100-yr



Sea Surface Temp, August +2-sigma



How Did We Compute PMP?

- PMP on a ~2.5mi^2 grid
  - 64,103 grid cells-that's a lot of data!
- Move maximized storms to each grid
- Account for differences in moisture and elevation
- Calculate the Orographic Transposition Factor (OTF)
  - Uses Precip Frequency-NOAA Atlas 14
  - Difference between source and target location
- OTF-Quantifiable/Reproducible
  - Replaces HMR SSM, K-Factor
    - Highly subjective
    - Not reproducible
- Results in total adjustment factor
- Apply to the DAD values

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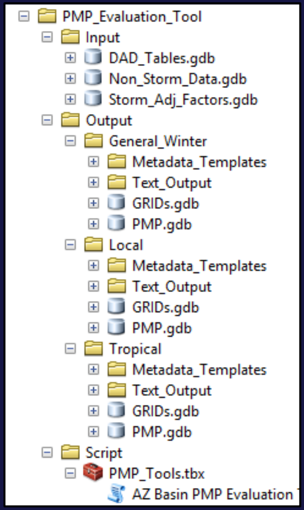
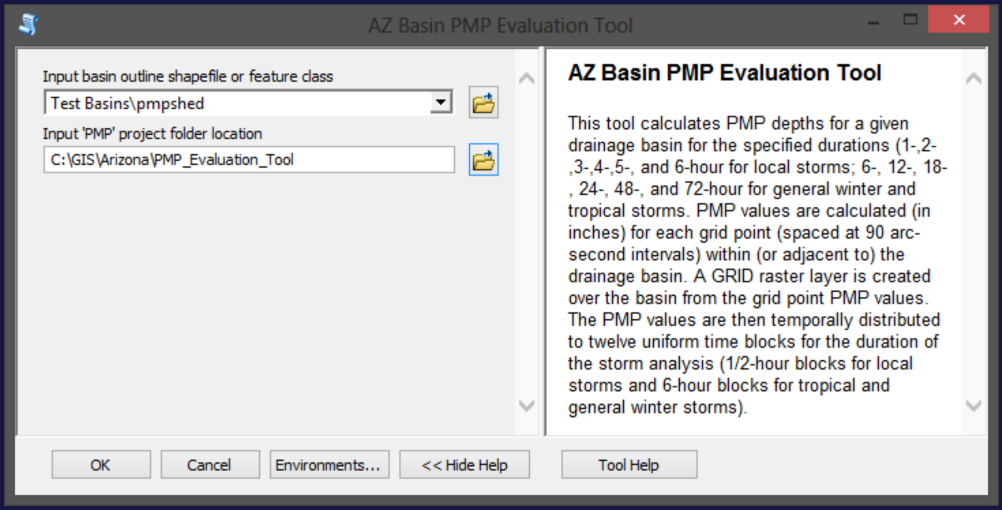
PMP Evaluation Tool (PET)

- Calculates gridded PMP for a user-defined drainage basin
- Custom Python-based scripted tool
  - Designed to be used within the ArcGIS environment
  - Flexible for future updates/enhancements
- Iterates through a storm database
  - Currently 93 maximized historical DAD tables
  - Adjusted to each grid cell
- Produces temporally distributed PMP output in both vector and raster GIS file formats for the basin spatial extent





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Example PMP Results

Tool Running on 8 Basins

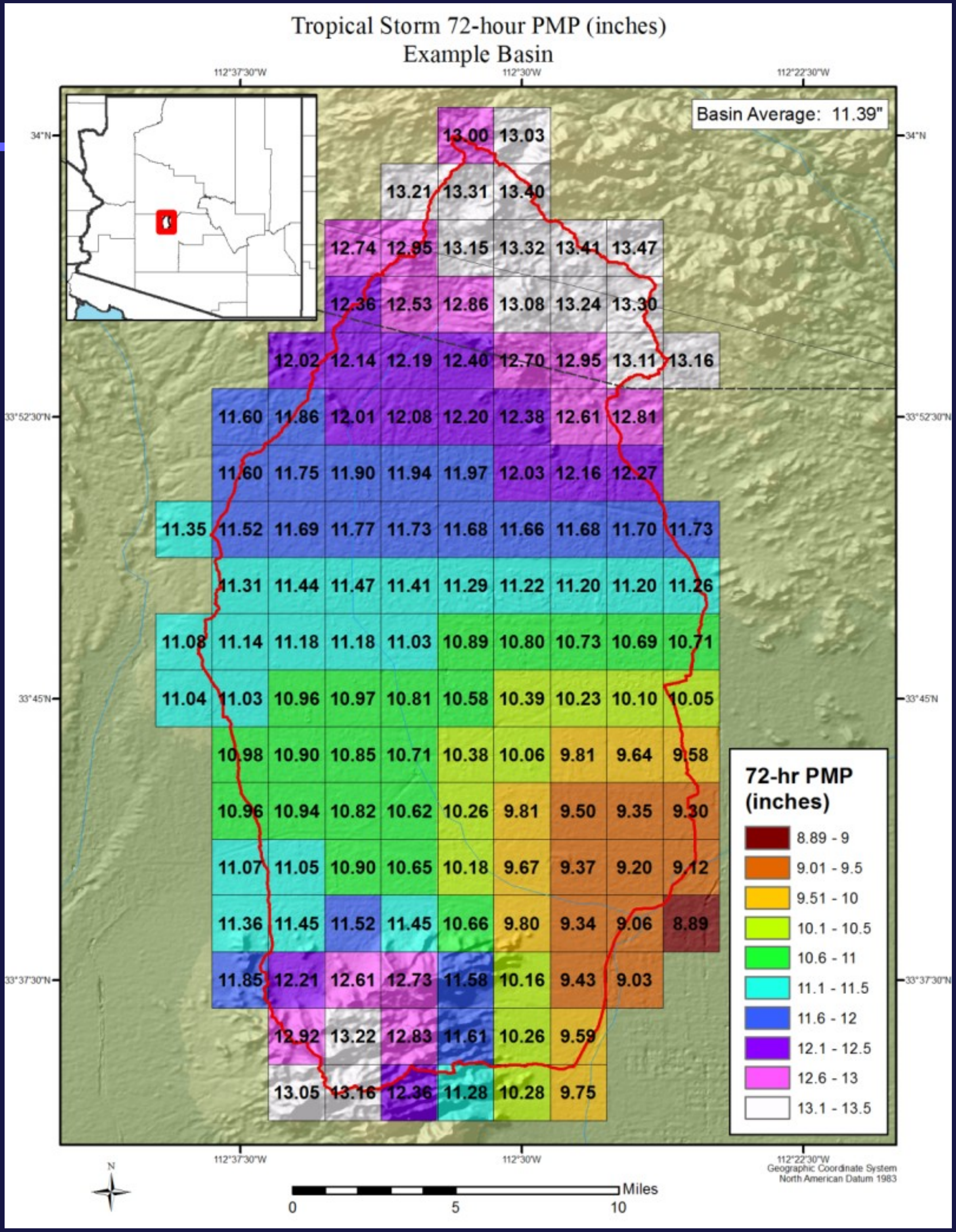
Different Regions, Different Area Sizes

Example PMP Results

72-hour tropical storm PMP values

Provide basin, sub basin, or grid values/average

Associated with storm type temporal timing

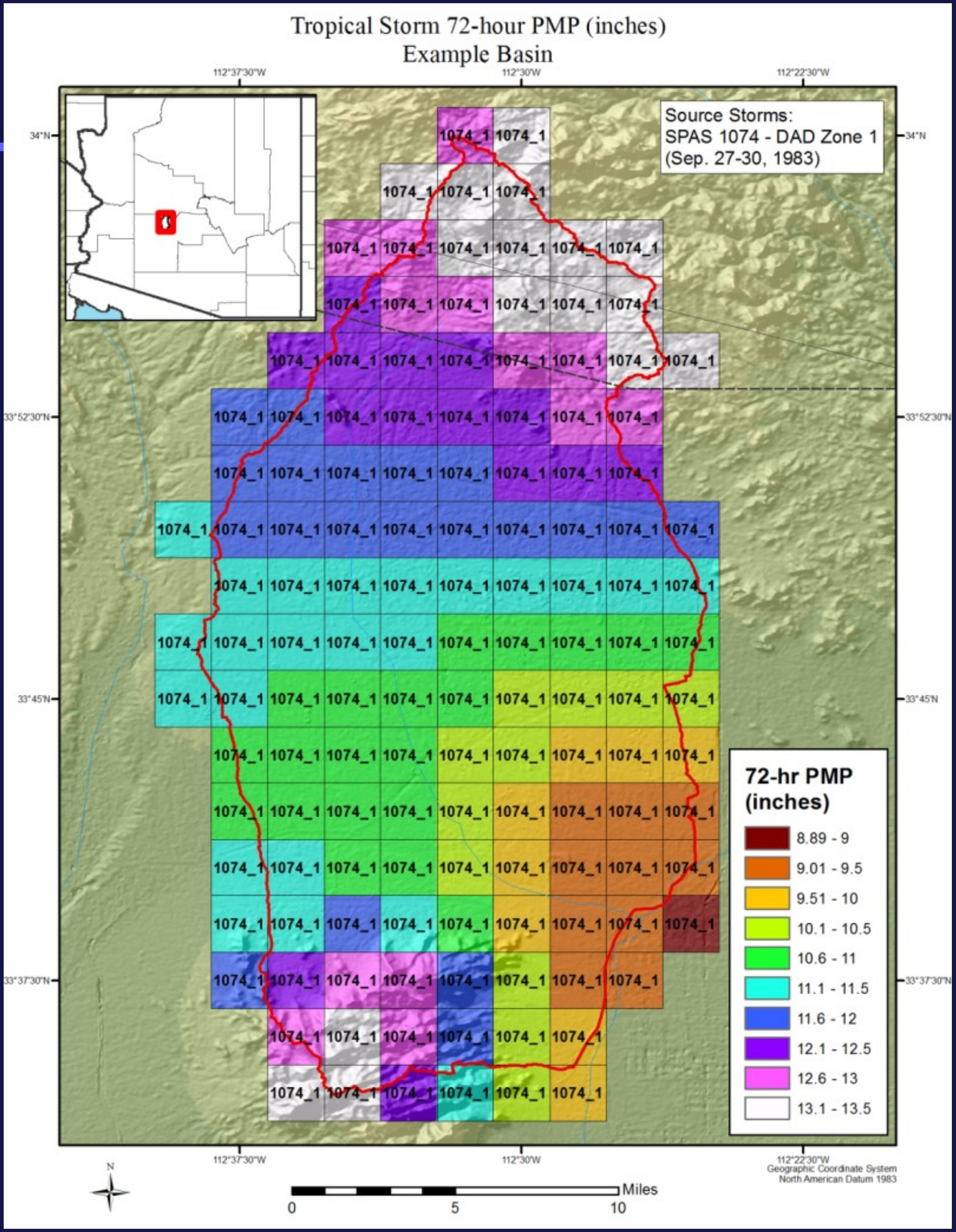


Example PMP Results

72-hour tropical storm PMP

Source storm ID by SPAS storm number

Allows for back calculation and verification



Summary

- Storm based and reproducible
  - Ability to consider site-specific characteristics
- Higher confidence in results/data
- Significant cost savings
  - Properly sized spillways
  - Infrastructure not overbuilt
- PMP study produces updated/reliable values
  - PMP values for any point within Arizona
  - Developed using the most current methods and data available

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QUESTIONS

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EXTRA SLIDES

Arizona Statewide PMP Study

A multi-agency study to improve understanding of public risk and reduce infrastructure costs

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Presentation Outline

- Reason for the study
- Regulator Perspective
- PMP Development Process
- Storm based approach
  - 49 new storms analyzed!
  - Updated dew point/SST climatologies
  - Explicitly Address orographics
- Results/findings
  - Quantifiable/Reproducible
  - No black box

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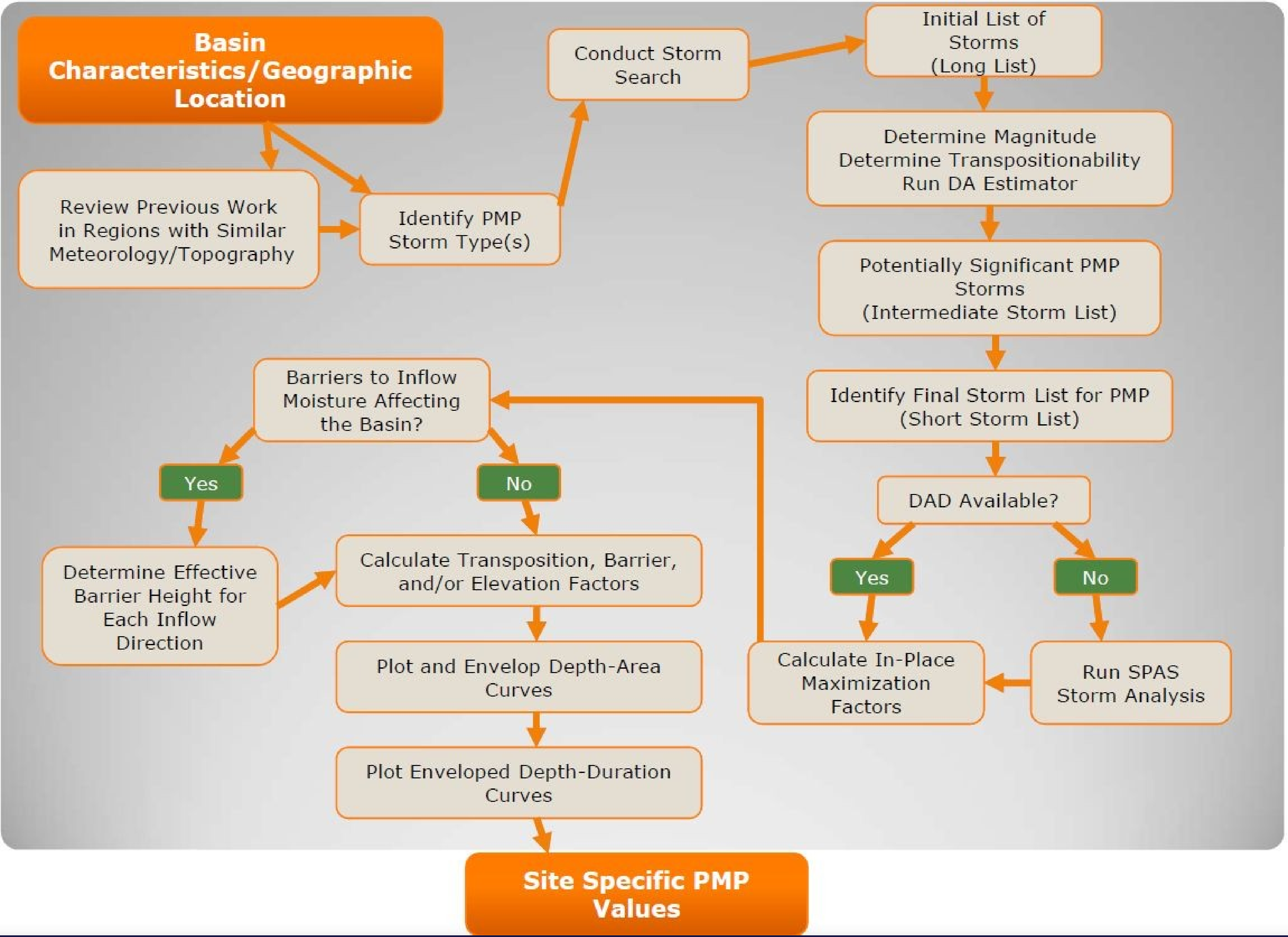
2008 Feasibility Study

- HMR 49 is overdue for updating
- HMR 49 PMP values are unreliable
- HMRs developed using similar methods have been replaced


Basin Characteristics/Geographic Location
Review Previous Work in Regions with Similar Meteorology/Topography
Identify PMP Storm Type(s)
Conduct Storm Search
Initial List of Storms (Long List)
Determine Magnitude
Determine Transpositionability
Run DA Estimator
Potentially Significant PMP Storms (Intermediate Storm List)
Identify Final Storm List for PMP (Short Storm List)
DAD Available?
Yes
No
Calculate In-Place Maximization Factors
Run SPAS Storm Analysis
Barriers to Inflow Moisture Affecting the Basin?
Yes
No
Determine Effective Barrier Height for Each Inflow Direction
Calculate Transposition, Barrier, and/or Elevation Factors
Plot and Envelop Depth-Area Curves
Plot Enveloped Depth-Duration Curves
Site Specific PMP Values

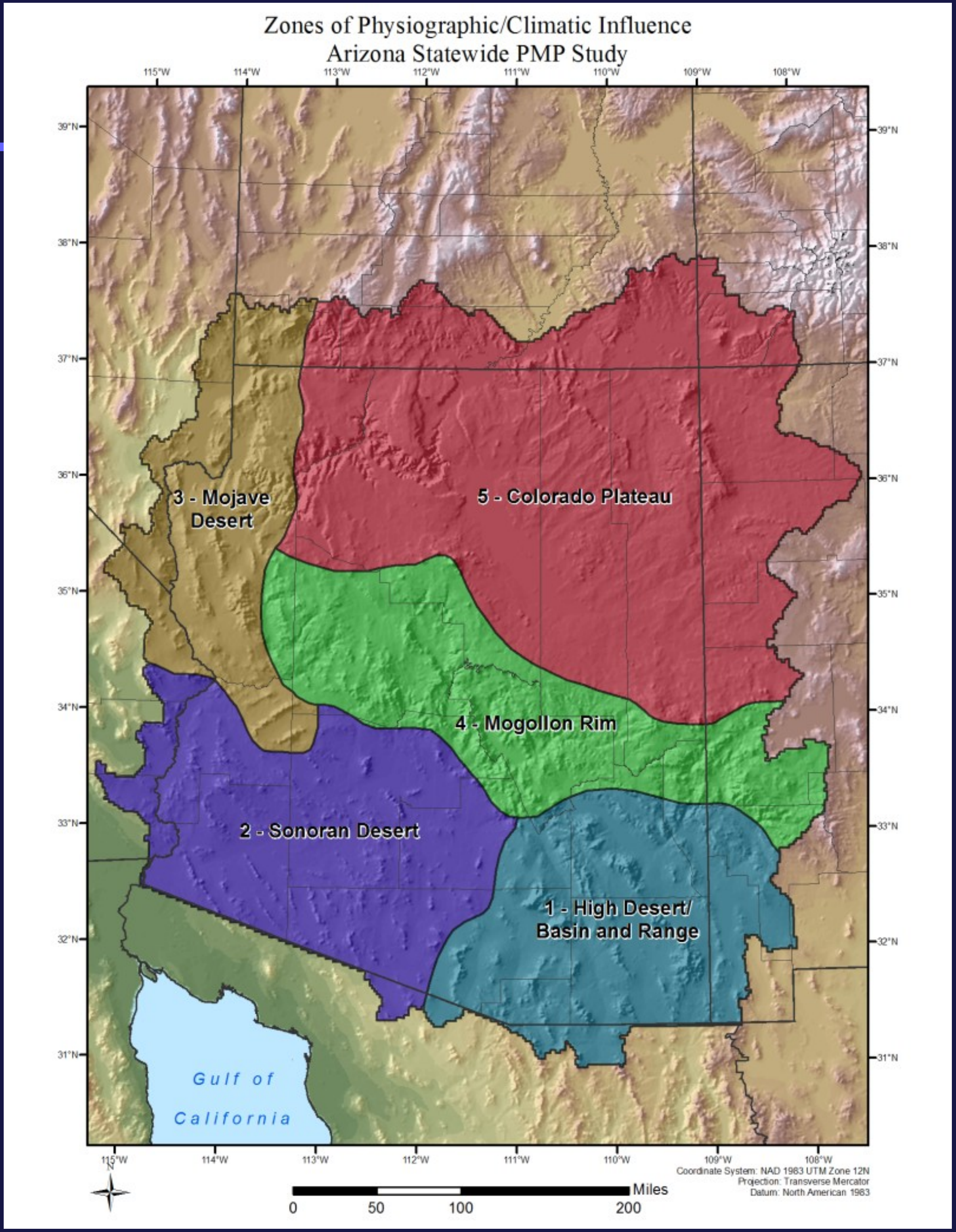
Unique Issues in Arizona

- Terrain and orographics
- How much can it rain at high elevations?
- Lack of data for large areas
- Rain on snow
- Transition between climate regions

Transposition Zones

Provide spatial transposition constraints for each storm

1. High Desert/Basin and Range
2. Sonoran Desert
3. Mojave Desert
4. Mogollon Rim
5. Colorado Plateau



Summary

- HMR 49
  - Out of date
  - Inadequate for use in deriving PMP values
- Hydrological implementation manual
  - For application of the PMP values
  - Based on state regulator's needs
- PMP study produces updated/reliable values for PMF modeling
  - PMP values for any point within Arizona
  - Developed using the most current methods and data available

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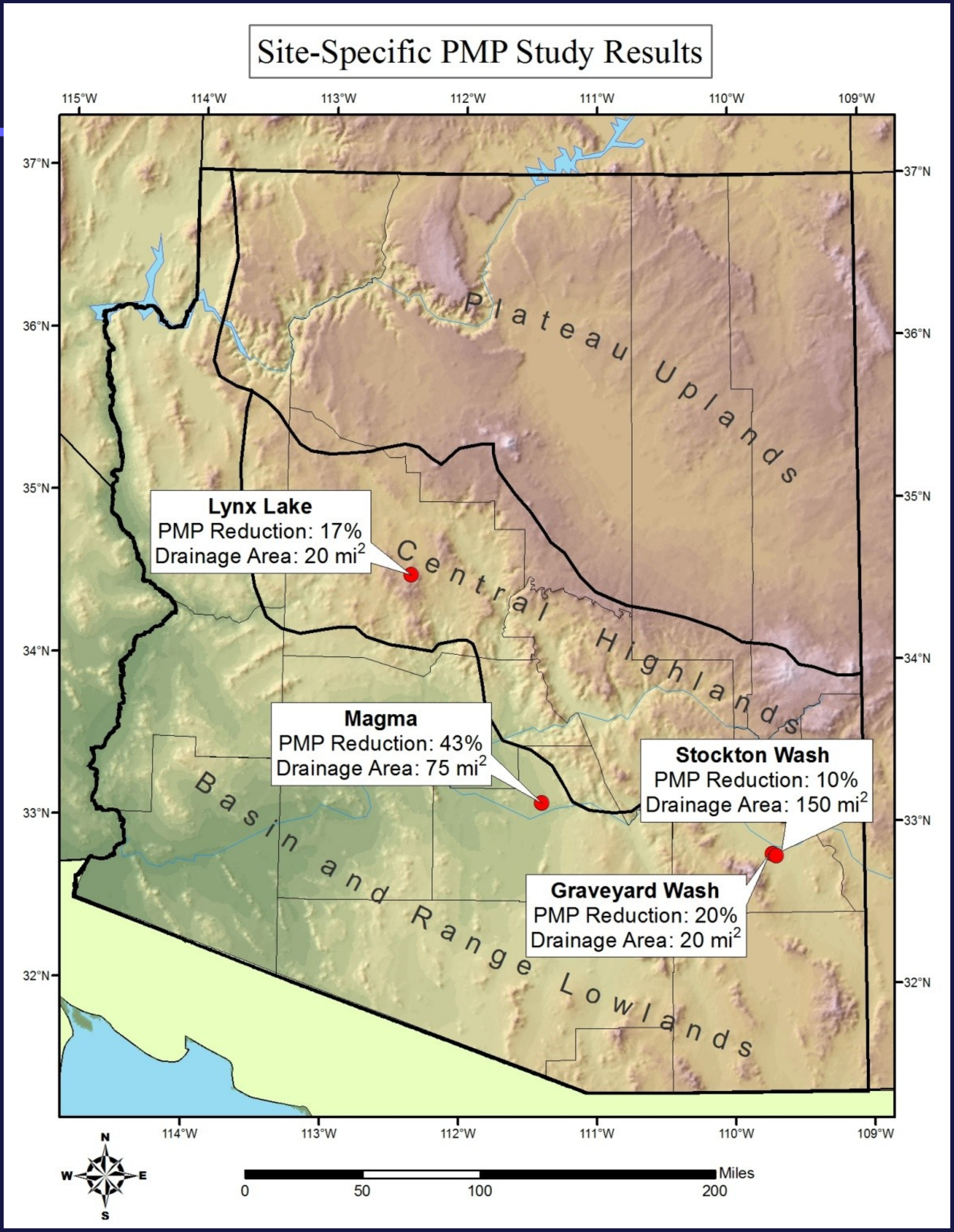
Problems with HMR 49 – overly conservative?

1996: Lynx Lake Dam, cost savings to AGFD

2008: Magma FRS, > $5M cost savings

2008: NRCS-Funded Safford Regional PMP

2009: Florence Dam, > $5M cost savings



Deliverables for Arizona

- Updated storm database
  - 51 new storm analyses using SPAS
  - 3 PMP storm types
- Enormous amount of data
- PMF hydrologic implementation parameters
  - Temporal distributions
  - Basin specific distributions
- One PMP process using state-of-the-science understanding and techniques