New NOAA Precipitation-Frequency Atlas for Wisconsin

Presentation to the

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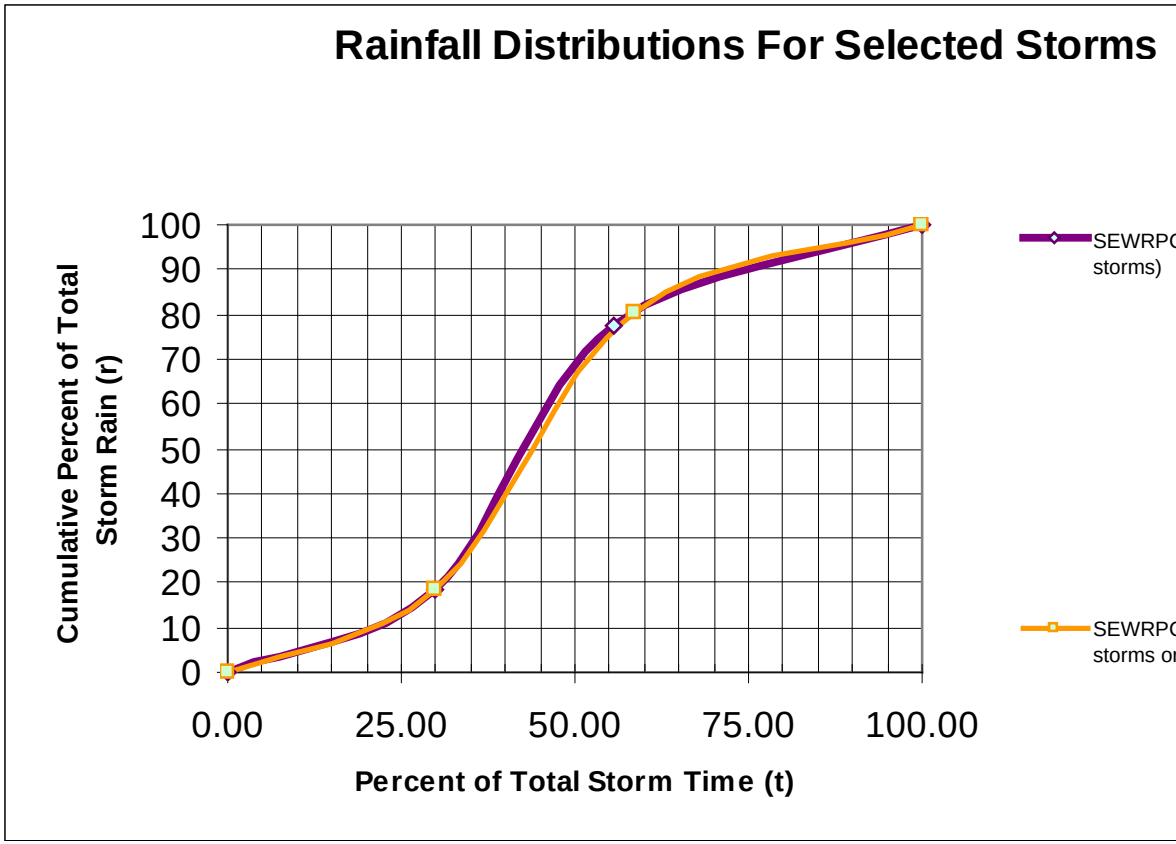
Overview

- Past precipitation frequency studies
- Introduce NOAA Atlas 14, *Precipitation-Frequency Atlas of the United States*, Volume 8, Version 2.0: Midwestern States
  - Precipitation frequency information
  - Temporal storm distributions
- Compare precipitation frequency and temporal distribution information from various commonly-used sources with Atlas 14
- Proposed USDA Natural Resources Conservation Service approach to applying Atlas 14
- Status regarding use of Atlas 14 for regulatory projects in Wisconsin

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

What Is a Design Storm ?

- Design storm is a hypothetical distribution of rainfall over time
- Individual design storms are developed for a given rainfall frequency and duration
  - Storm depth for a given frequency and duration is distributed over time
- Design storm is applied in a hydrologic model to estimate rates and volumes of runoff
  - Generally analyze storms of several durations for a given frequency
  - Results in "critical" (maximum) flow
- Hydrologic model results are used to size stormwater and floodland management facilities and for determining flood hazard areas



Sources of Design Rainfall Estimates

- 1961: U.S. Weather Bureau TP-40
- 1990: SEWRPC
- 1992: Illinois State Water Survey Bulletin 71
- 2000: SEWRPC
- 2013: NOAA Atlas 14 for Midwestern States

Sources of Design Rainfall Estimates

NOAA Atlas 14, *Precipitation-Frequency Atlas of the United States*, Volume 8, Version 2.0: Midwestern States, 2013

- NWS is currently revising throughout the country, applying a region-by-region approach
- WDNR, WisDOT, and SEWRPC jointly funded the Wisconsin portion of the project

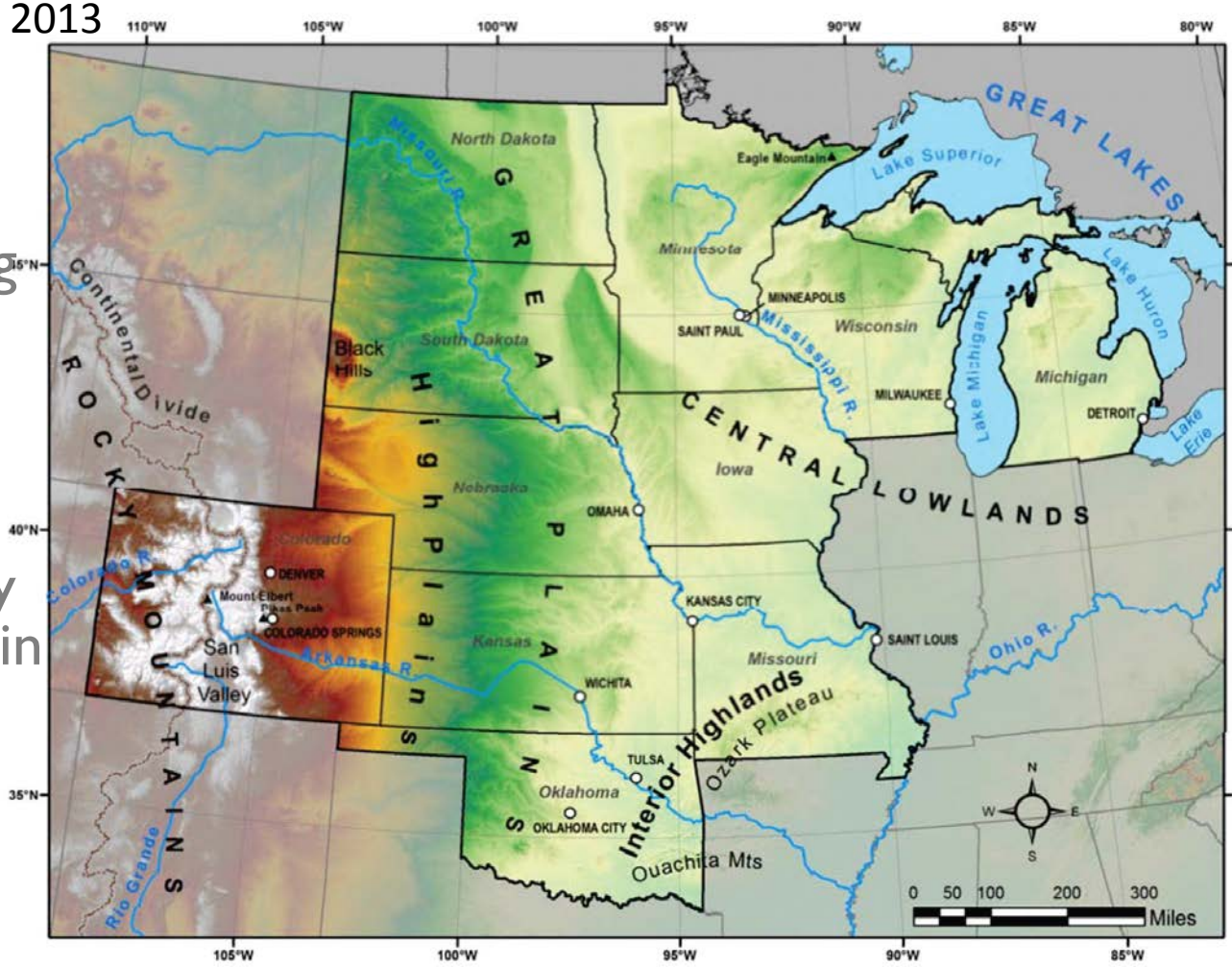


Figure 4.1.1. Project area for NOAA Atlas 14 Volume 8.
(The shaded relief was obtained from USGS EROS Data Center.)

NOAA Atlas 14

- Analyzed data from 16,227 U.S. Federal, Environment Canada, state, and local stations
  - One-day: 11,918
  - One-hour: 2,657
  - 15-minutes, or variable: 1,652
  - In general, only stations with >= 30 years of data were considered, but for hourly stations >= 20 years

NOAA Atlas 14

- Low outliers were typically removed
- High outliers: Compared with nearby concurrent depths, and also reviewed observation forms, monthly reports, and historical publications

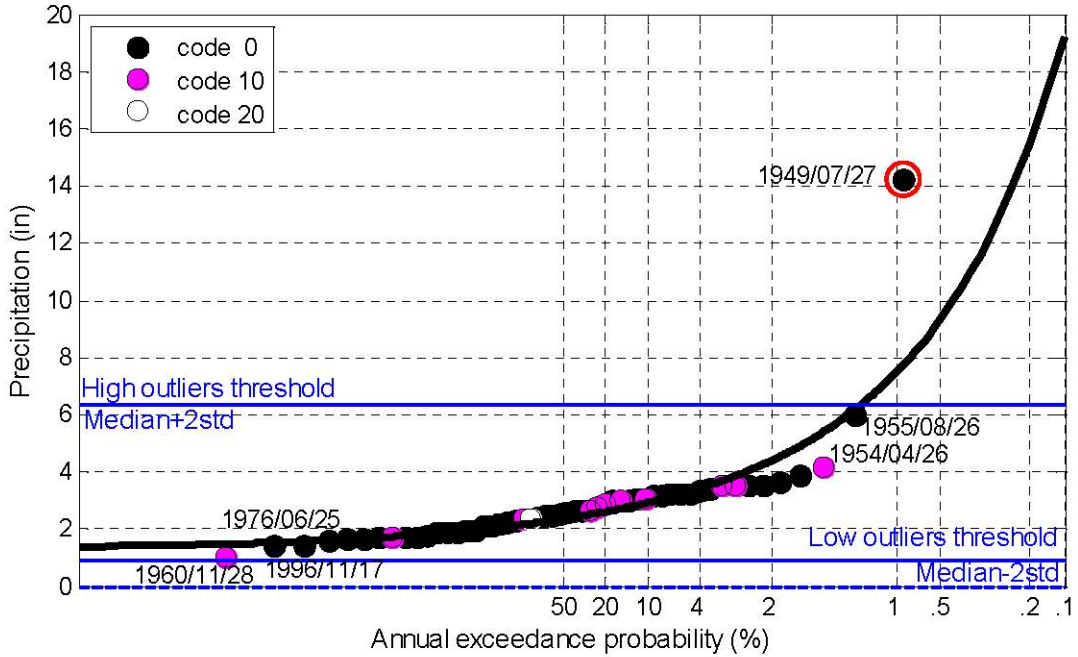


Figure 4.5.1. Outlier tests for 24-hour AMS at station 21-0826. Data quality codes were assigned to annual maxima during the extraction process (Section 4.3).

NOAA Atlas 14

- Parametric and non-parametric statistical tests were made on annual mean series to evaluate climate stationarity (Appendix 2)
- Conclusion: Accepted assumption of stationarity
- Research being conducted to represent IDF relationships under non-stationary climate (ASCE Journal of Hydrologic Engineering, October 2013)

NOAA Atlas 14: Gridded Precipitation-Frequency

- Developed gridded precipitation-frequency estimates at 30 arc-seconds resolution
- Station mean annual maximum (MAM) precipitation for 17 durations from 15 minutes through 60 days was interpolated to produce grid

NOAA Atlas 14: Gridded Precipitation-Frequency

- Strong linear relationships between:
  - MAM and two-year precip and
  - Precip-freq relationships for consecutive frequencies

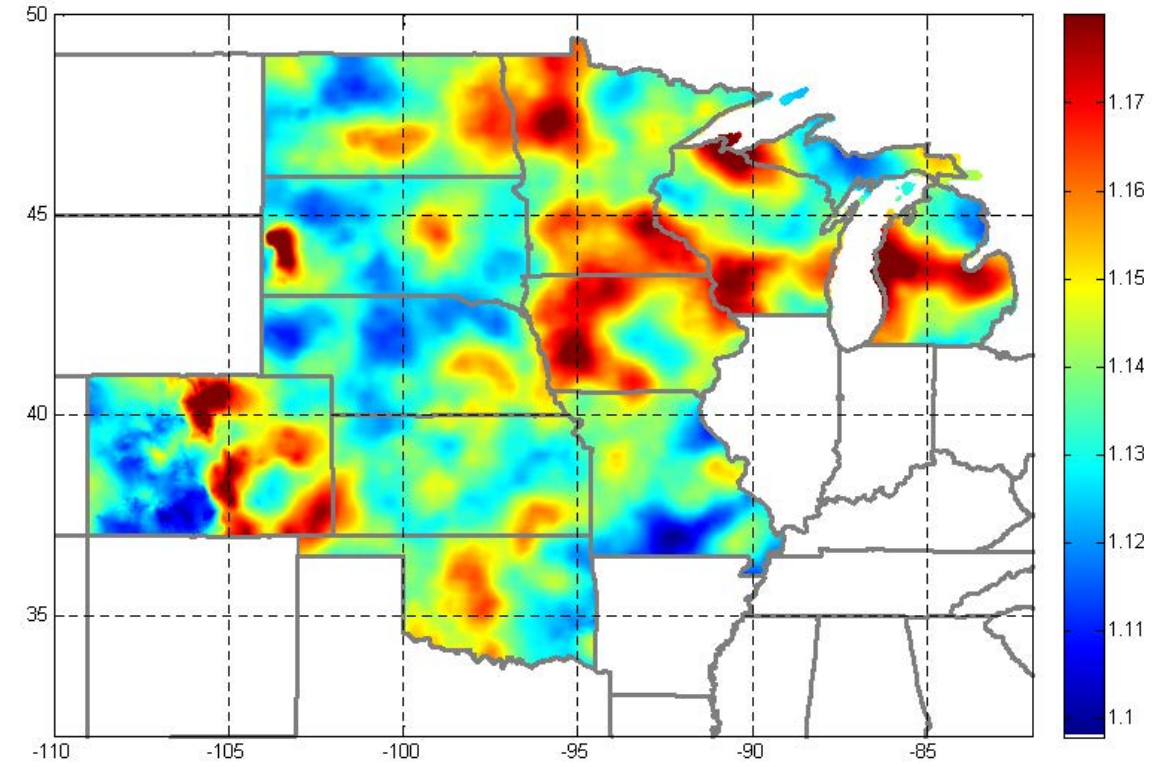
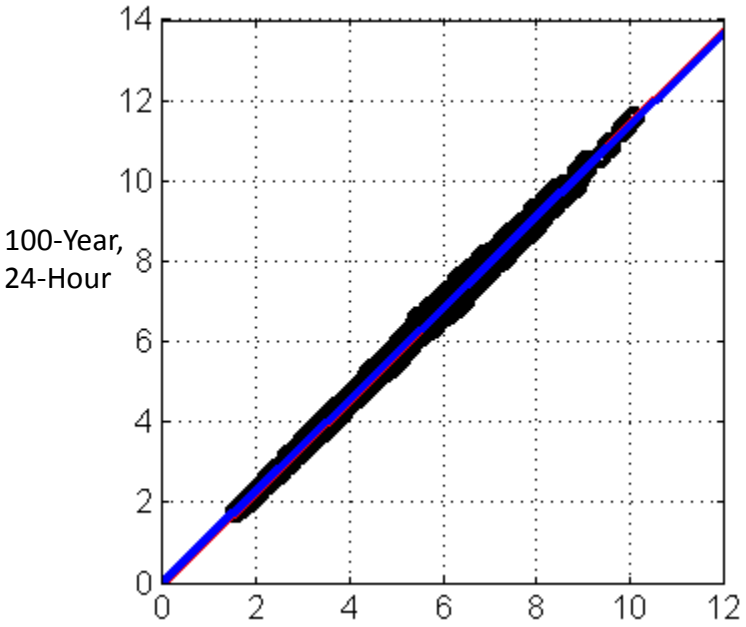
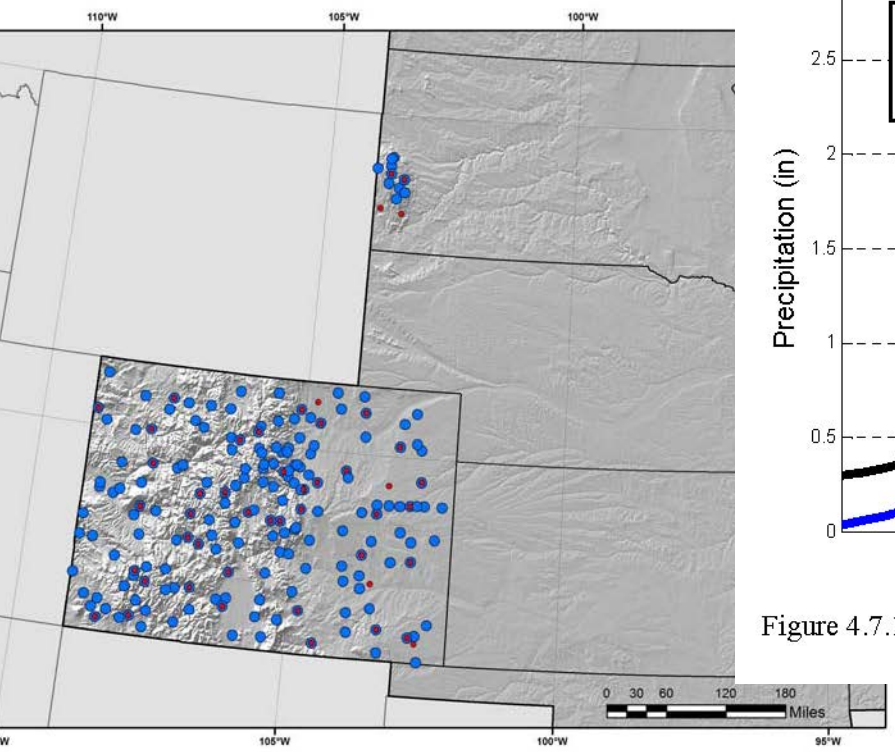


Figure 4.8.2. Spatially interpolated ratios used to calculate 24-hour 100-year precipitation frequency grid from the 24-hour 50-year grid.



NOAA Atlas 14: Rain vs. Total Precipitation

- Precipitation-frequency relationships were developed using both liquid and frozen precipitation (liquid equivalent)
- Trivial difference between using rain and using total precipitation except at high altitudes in Colorado and South Dakota



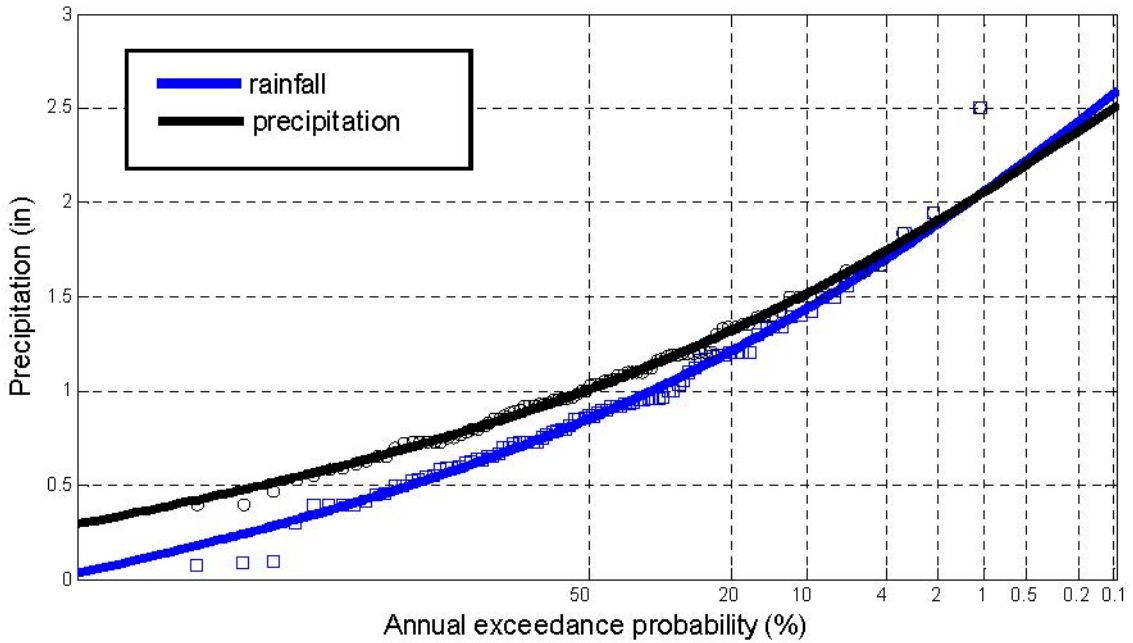
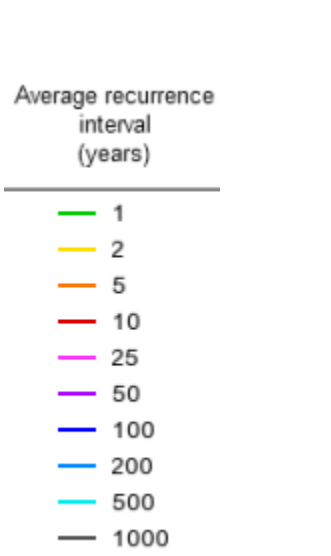
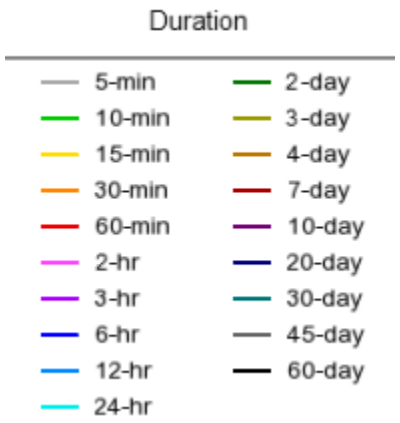
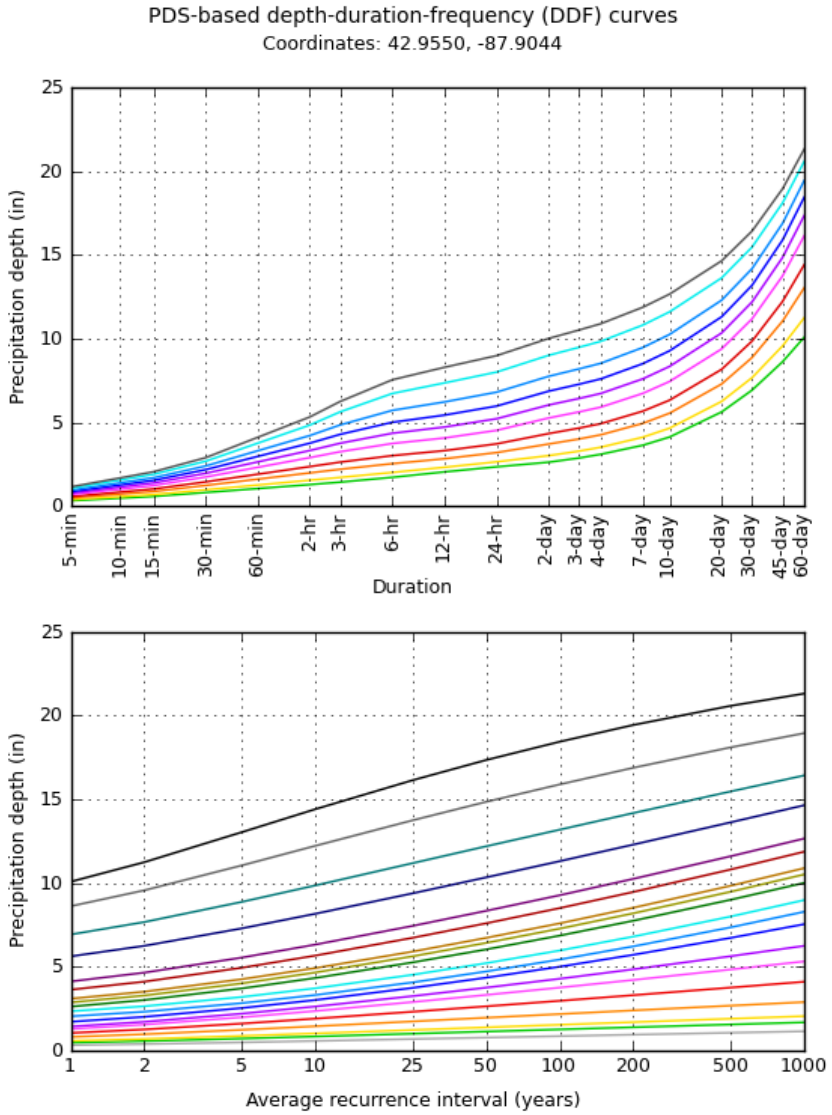


Figure 4.7.1. Probability distributions for the 24-hour rainfall and precipitation annual maximum series at station 05-1071 (elevation 7,946 ft).

Depth-duration frequency curves: Milwaukee, WI







NOAA/NWS/OHD/HDSC

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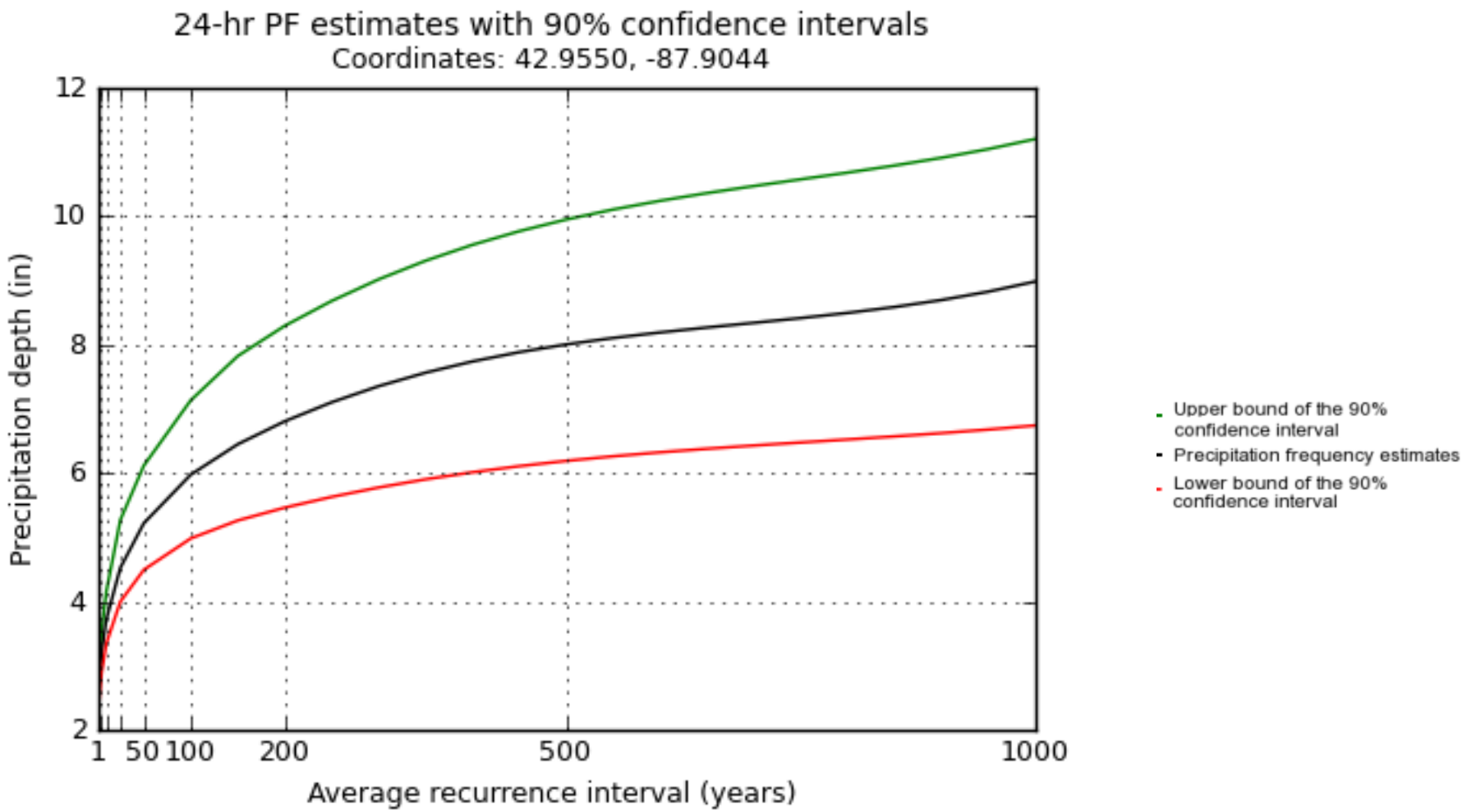
90 % Confidence Intervals: Milwaukee, WI



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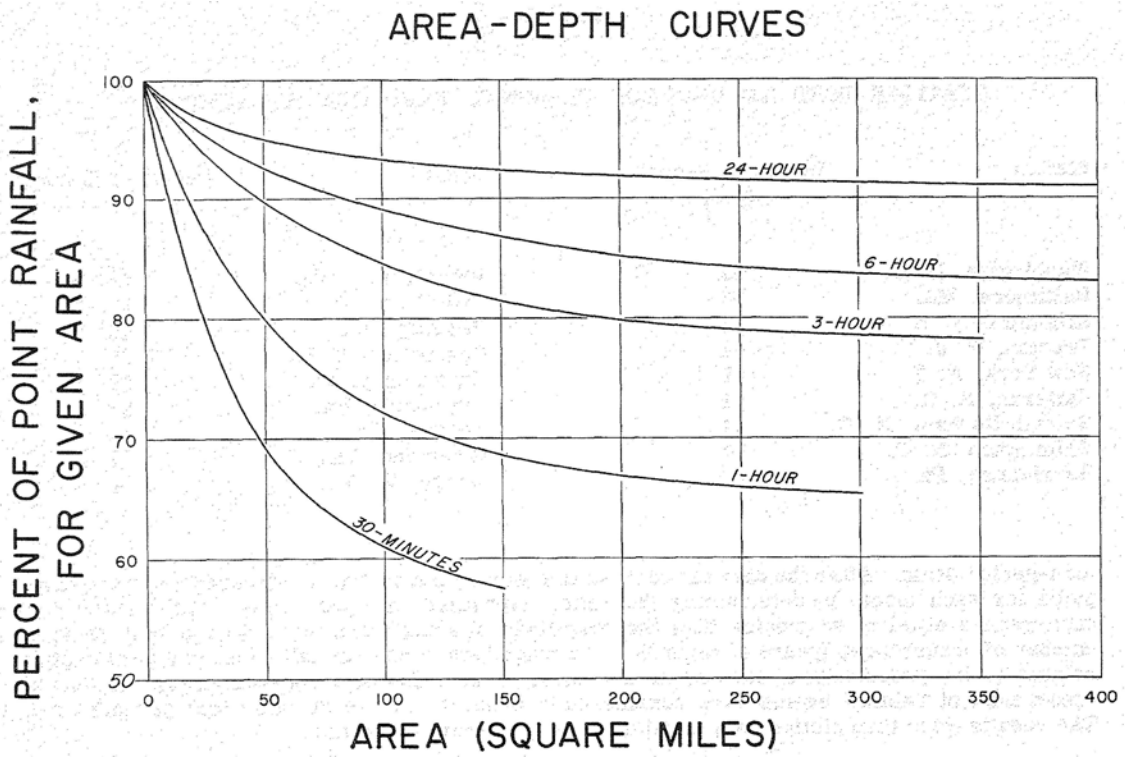
NOAA Atlas 14: Areal Reduction Factors (ARF)

- Point precipitation-frequency estimates
  - Areal reduction factors: Atlas 14 recommends using 1960 U.S. Weather Bureau TP 29
  - NOAA is working on development of new areal reduction factors
  - Possible approach: Use gridded precipitation to average over subwatershed, then apply ARF for entire watershed area studied

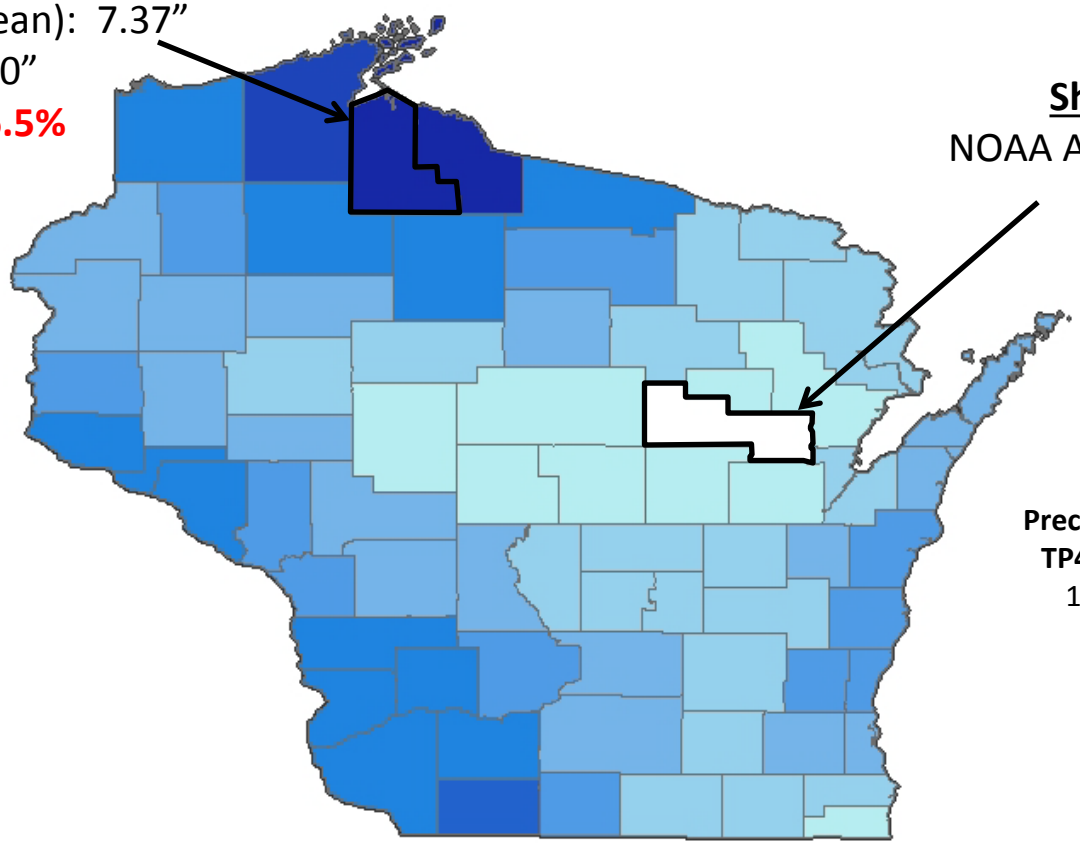


NOAA Atlas 14 Versus TP40 Precipitation Depths

100-Yr, 24-Hr Precipitation Depths
Percent Change From TP40 to NOAA Atlas 14 (Mean)

Ashland County:
NOAA Atlas 14 (Mean): 7.37”
TP40: 5.40”
Increase 36.5%

Shawano County:
NOAA Atlas 14 (Mean): 5.40”
TP40: 5.40”
No Change



Precipitation Depth Change From TP40 to NOAA Atlas 14 (Mean)
100-Year, 24-hour (Percent)

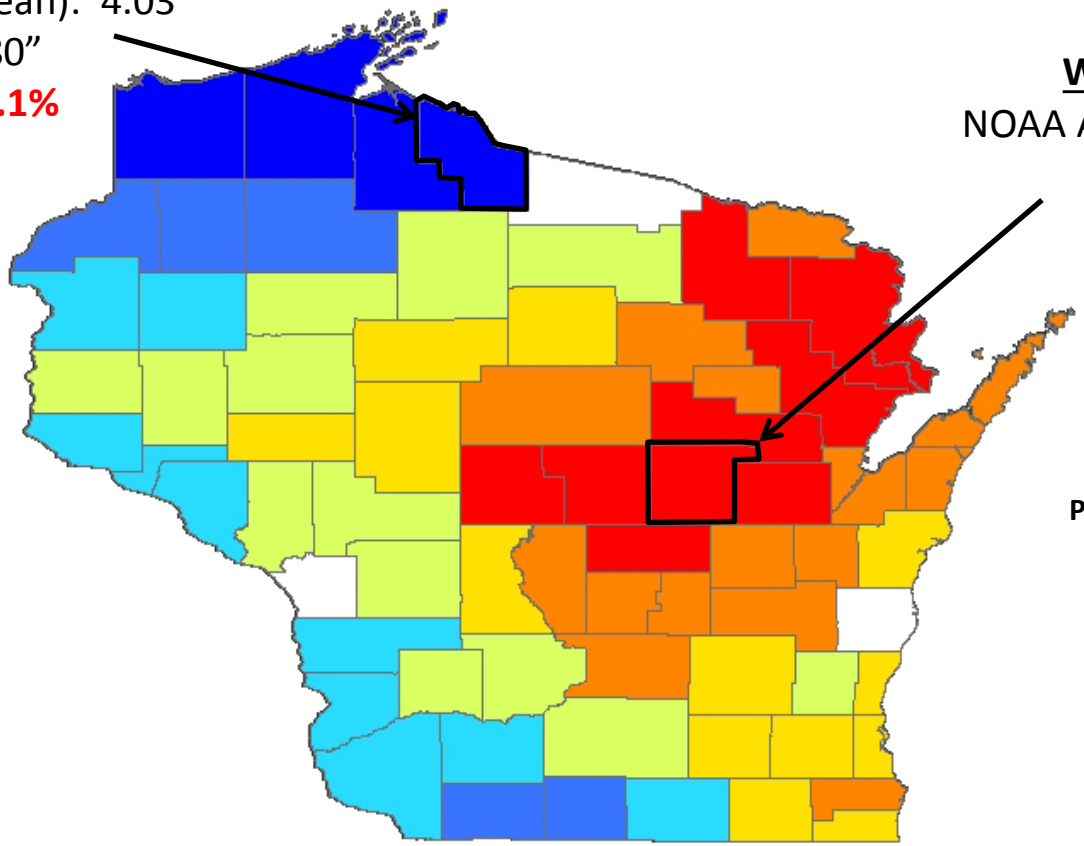
- 0
- 0.01 - 5
- 5 – 10
- 10 – 15
- 15 – 20
- 20 – 25
- 25 – 30
- 30 – 35
- 35 – 40

NOAA Atlas 14 Versus TP40 Precipitation Depths

10-Yr, 24-Hr Precipitation Depths
Percent Change From TP40 to NOAA Atlas 14 (Mean)

Iron County:
NOAA Atlas 14 (Mean): 4.03”
TP40: 3.80”
Increase 6.1%

Waupaca County:
NOAA Atlas 14 (Mean): 3.57”
TP40: 3.90”
Decrease 8.5%



Precipitation Depth Change From TP40 to NOAA Atlas 14 (Mean)
10-Year, 24-hour (Percent)

- -8.5 to -7.5
- -7.5 to -5.0
- -5.0 to -2.5
- -2.5 to -0.01
- 0.0
- 0.01 to 2.5
- 2.5 to 5.0
- 5.0 to 7.5

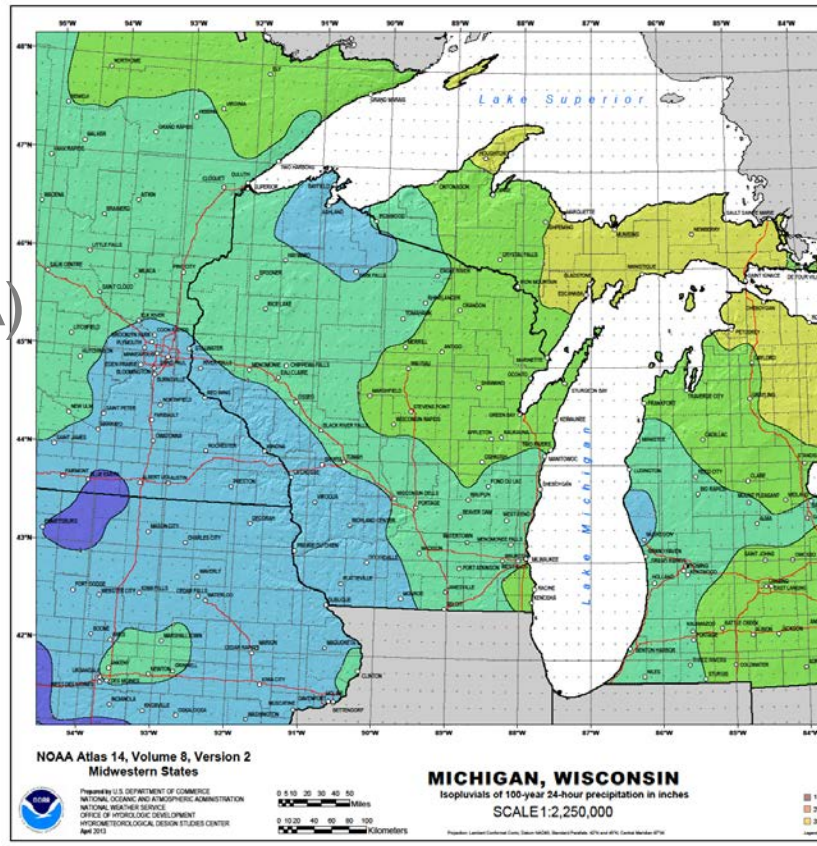
Rainfall Depths for MMSD Planning Area

- Comparison of 100-year, 24-hour rain depths:
  - Weather Bureau TP-40: 5.44 inches
  - ISWS Bulletin 71: 6.24 inches
  - SEWRPC 1990: 5.50 inches
  - SEWRPC 2000: 5.88 inches
  - NOAA Atlas 14: 5.98 inches (GMIA)

5 to 6 inches

6 to 7 inches

7 to 8 inches



Rainfall Depths for MMSD Planning Area

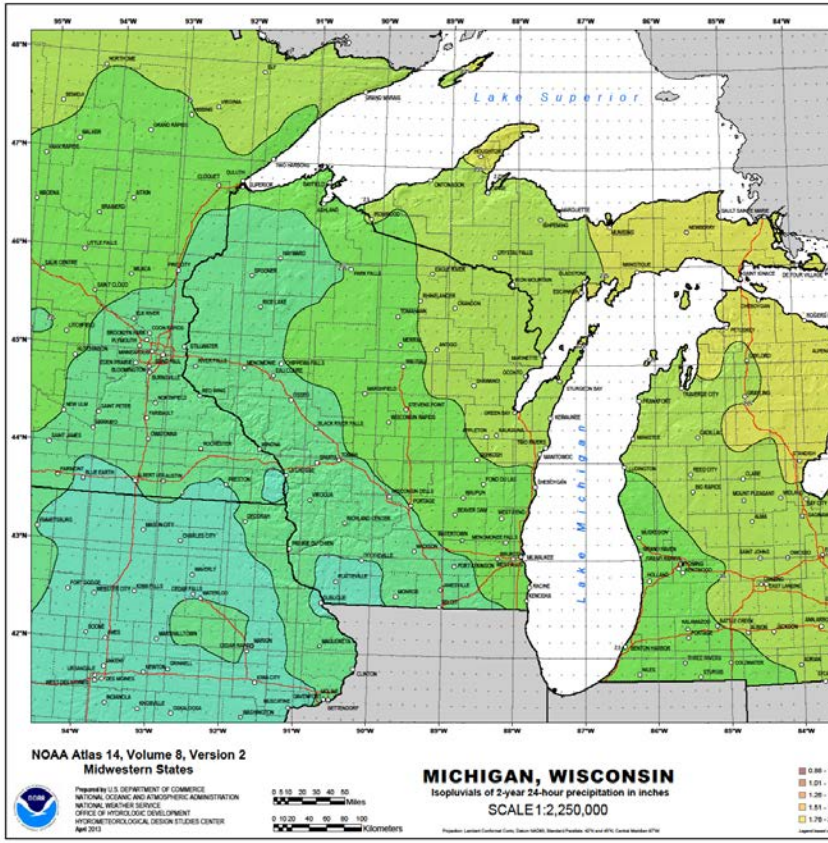
- Comparison of two-year, 24-hour rain depths:
  - Weather Bureau TP-40: 2.6 inches
  - ISWS Bulletin 71: 2.70 inches
  - SEWRPC 1990: 2.4 inches
  - SEWRPC 2000: 2.57 inches
  - NOAA Atlas 14: 2.65 inches

2.26 to 2.50 inches

2.51 to 2.75 inches

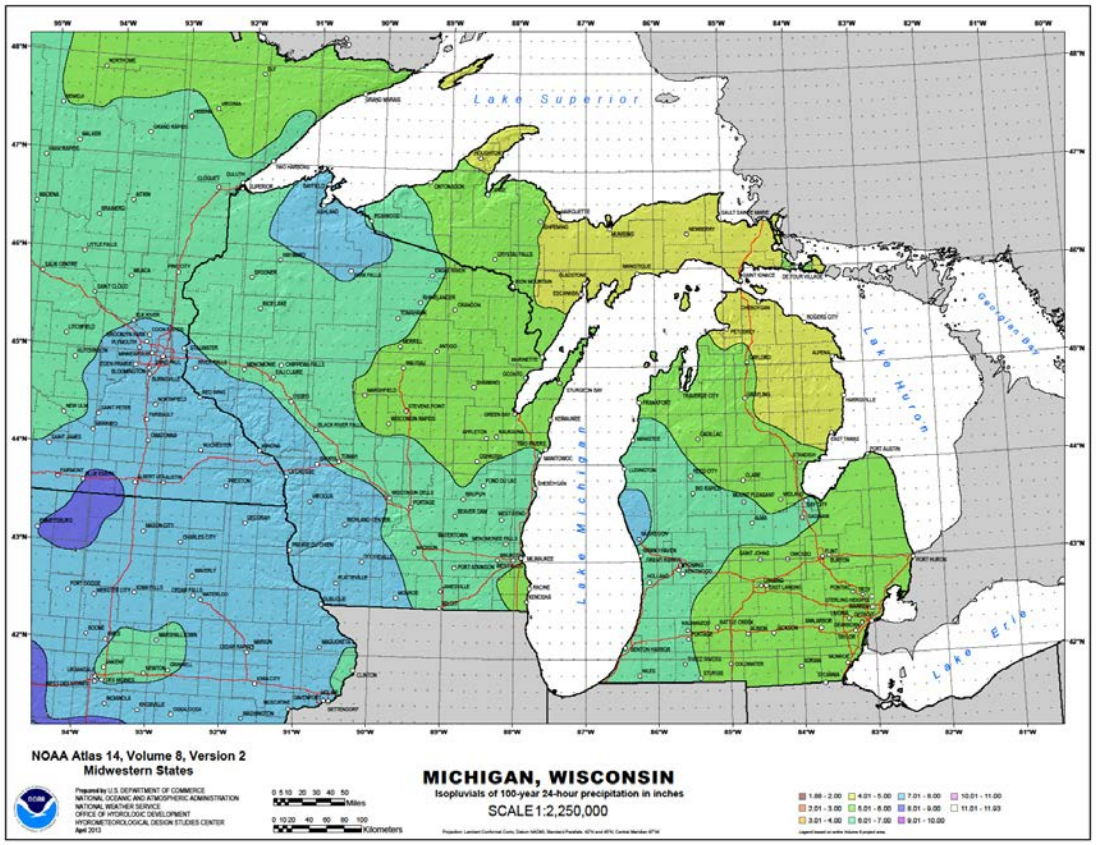
2.76 to 3.00 inches

3.01 to 3.25 inches



Accessing Precipitation-Frequency Information

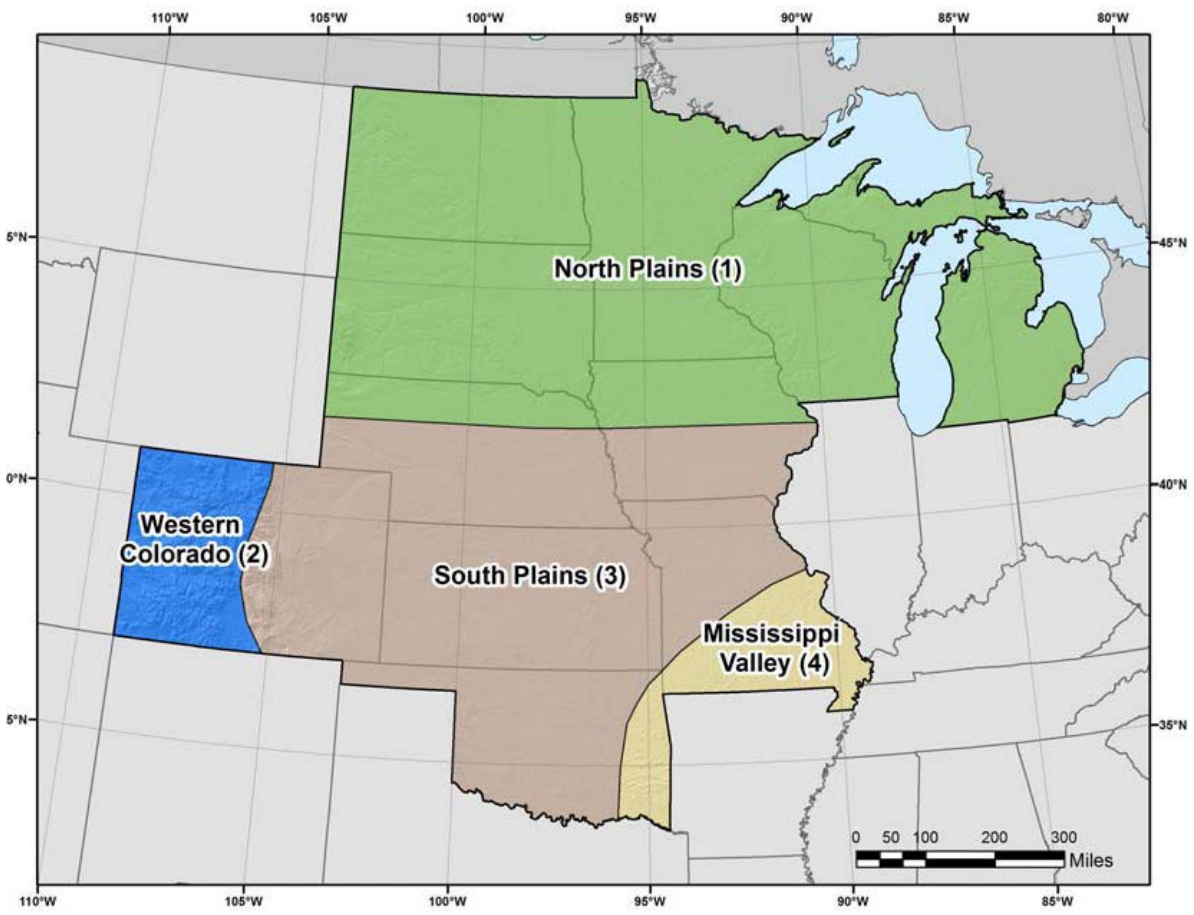
- NOAA recommends using Precipitation Frequency Data Server (PFDS), or ASCII grids, rather than cartographic maps



Atlas 14 Temporal Distributions

- Methodology similar to Illinois State Water Survey "Huff distributions"

- Distributions for 1st, 2nd, 3rd, and 4th quartile storms (i.e., storms with most rain in first quarter, second quarter, etc.)
- 10th through 90th percentile distributions for each quartile
- "Event" was defined as the precipitation pattern over a specific duration
- Temporal distribution curves do not necessarily represent individual storms
- Events always start with precipitation, but do not necessarily end with precipitation, therefore, more "front–loaded" 1st quartile cases



Atlas 14 Temporal Distributions

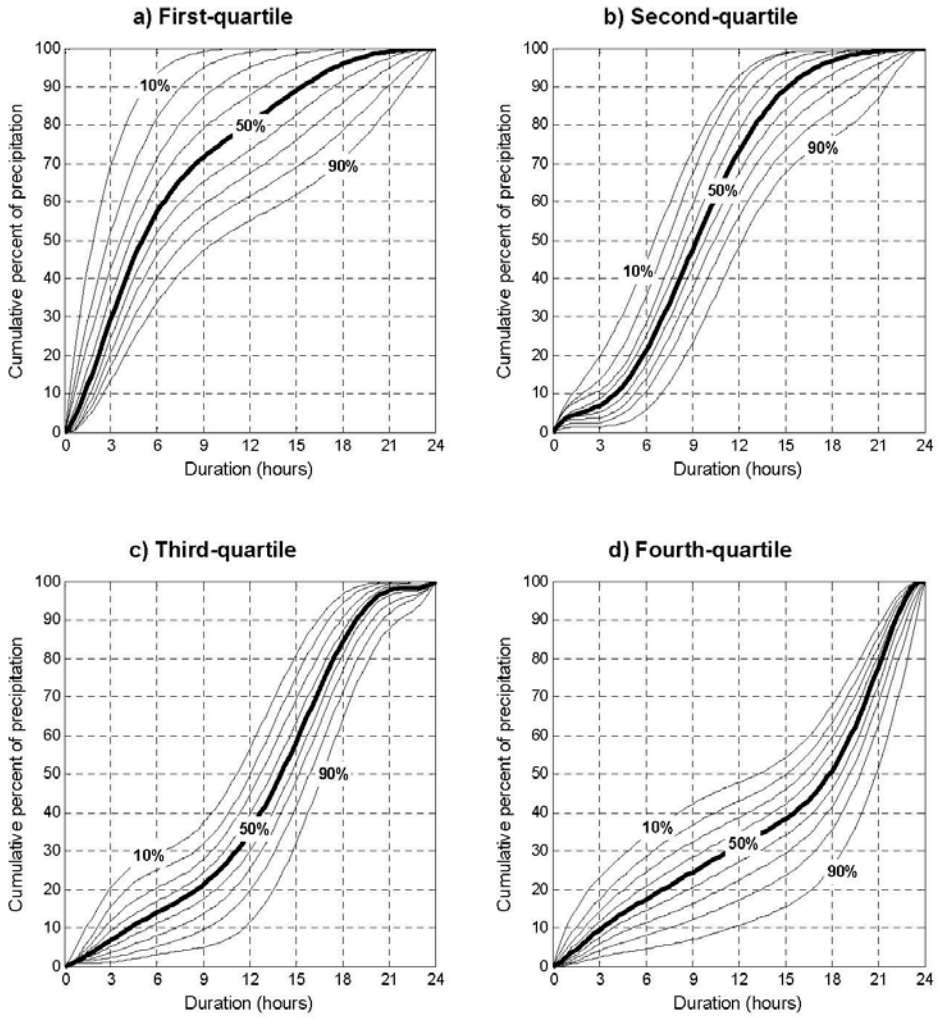


Figure A.5.4. 24-hour temporal distribution curves for the Mississippi Valley region (region 4): a) first-quartile, b) second-quartile, c) third-quartile, and d) fourth-quartile cases.

NRCS Work to Implement NOAA Atlas 14

General Overview:

- NRCS Work and Priorities at a National and State Level
- NRCS Development of Generalized Precipitation Depths (by County)
- NRCS Development of Temporal Storm Distributions (by County) based on NOAA Atlas 14 Data

These will be made available in:

- NRCS Engineering Field Handbook, WI Supplements (Online)
- NRCS Hydrology Computer Programs

NRCS Temporal Distributions

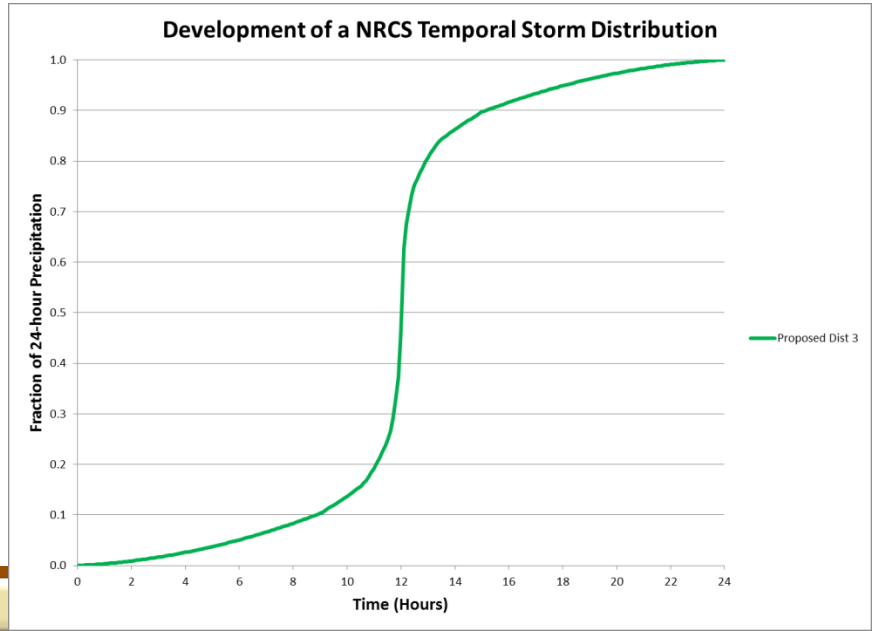
NRCS Temporal Distributions:

- Are generally 24 hours in duration
- Assumes that the precipitation values for all durations (5-minute, through 24-hour) are imbedded within the same design storm for a given frequency (e.g. ,25-yr).
- Are centered around the 12-hour time period (conservative)
- Rainfall Distributions used by NRCS have historically been developed using ratios of the shorter duration storms (e.g. 1-hour) to the 24-hour rainfall for a given storm frequency.
- These rainfall distributions are meant to be conservative for design purposes, and not meant to duplicate actual storm events.

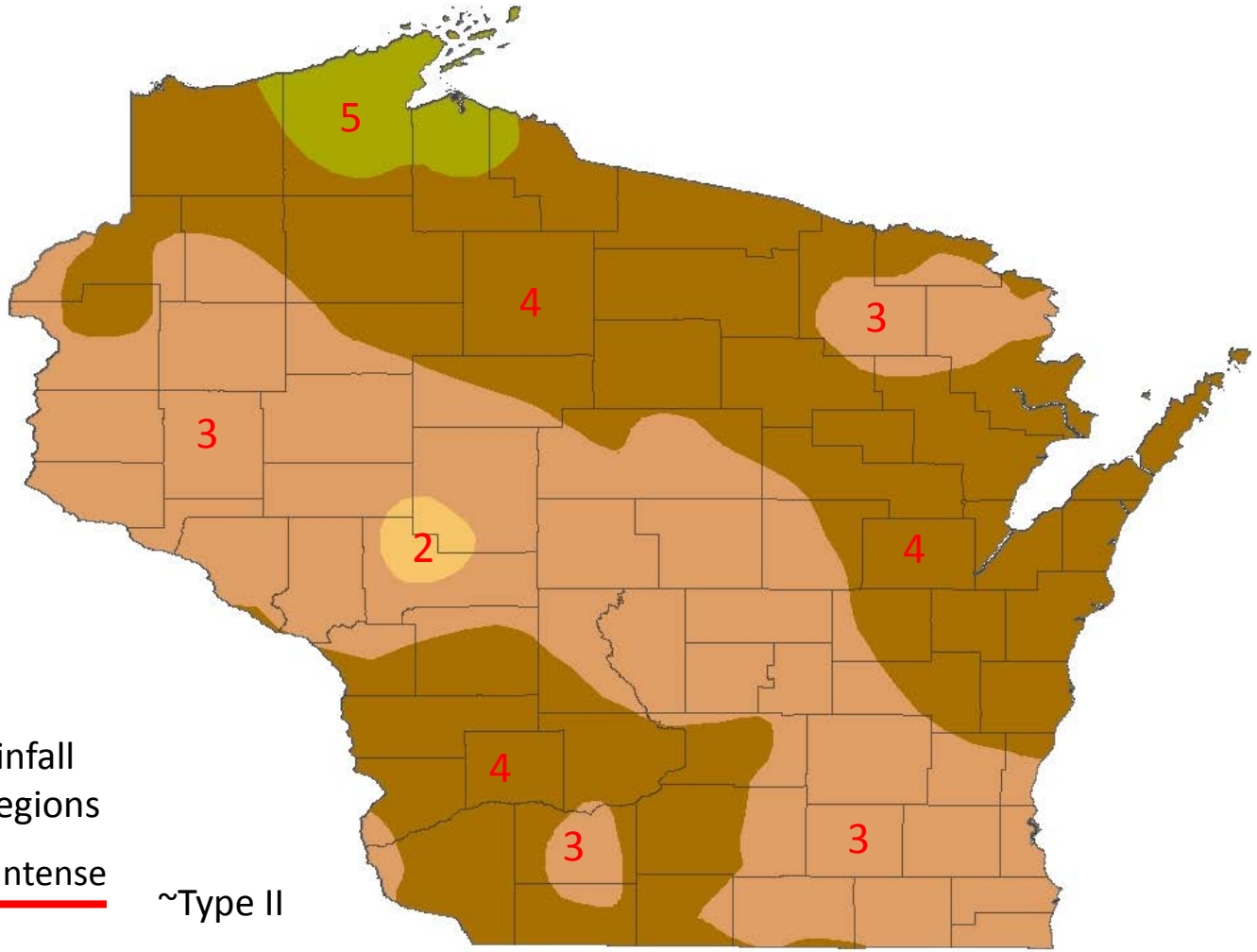
NRCS Temporal Distributions

NRCS Purpose in Nesting All Durations within the 24-hr Temporal Distribution:

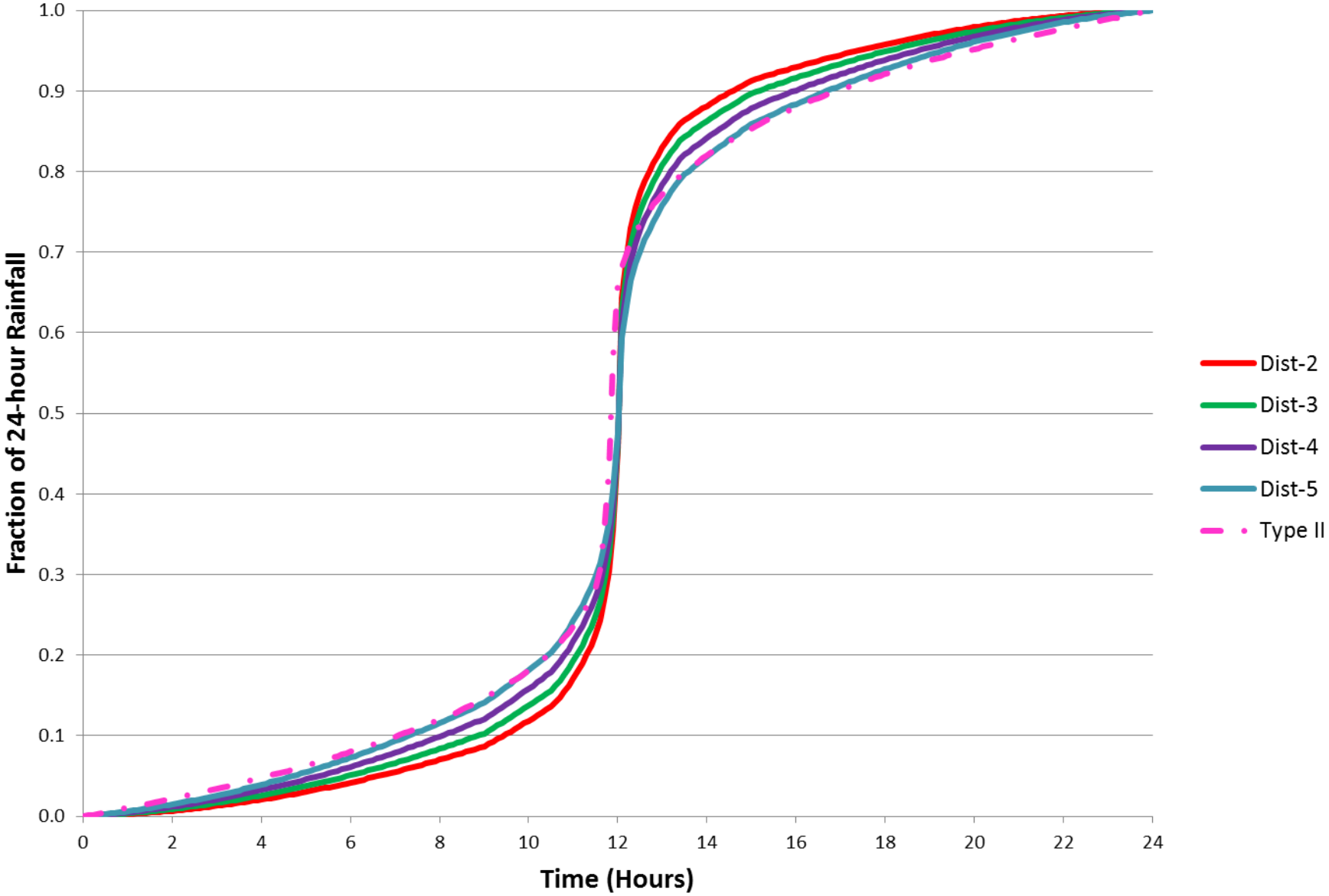
- The storm duration producing the largest peak discharge is generally approximately equal to the time of concentration of the watershed to the design point (NRCS NEH Ch 4)
- Thus, the NRCS 24-hour Temporal Distribution is applicable to any watershed with a Tc less than 24 hours



NRCS NWQQ Team Rainfall Distribution Regions - WI



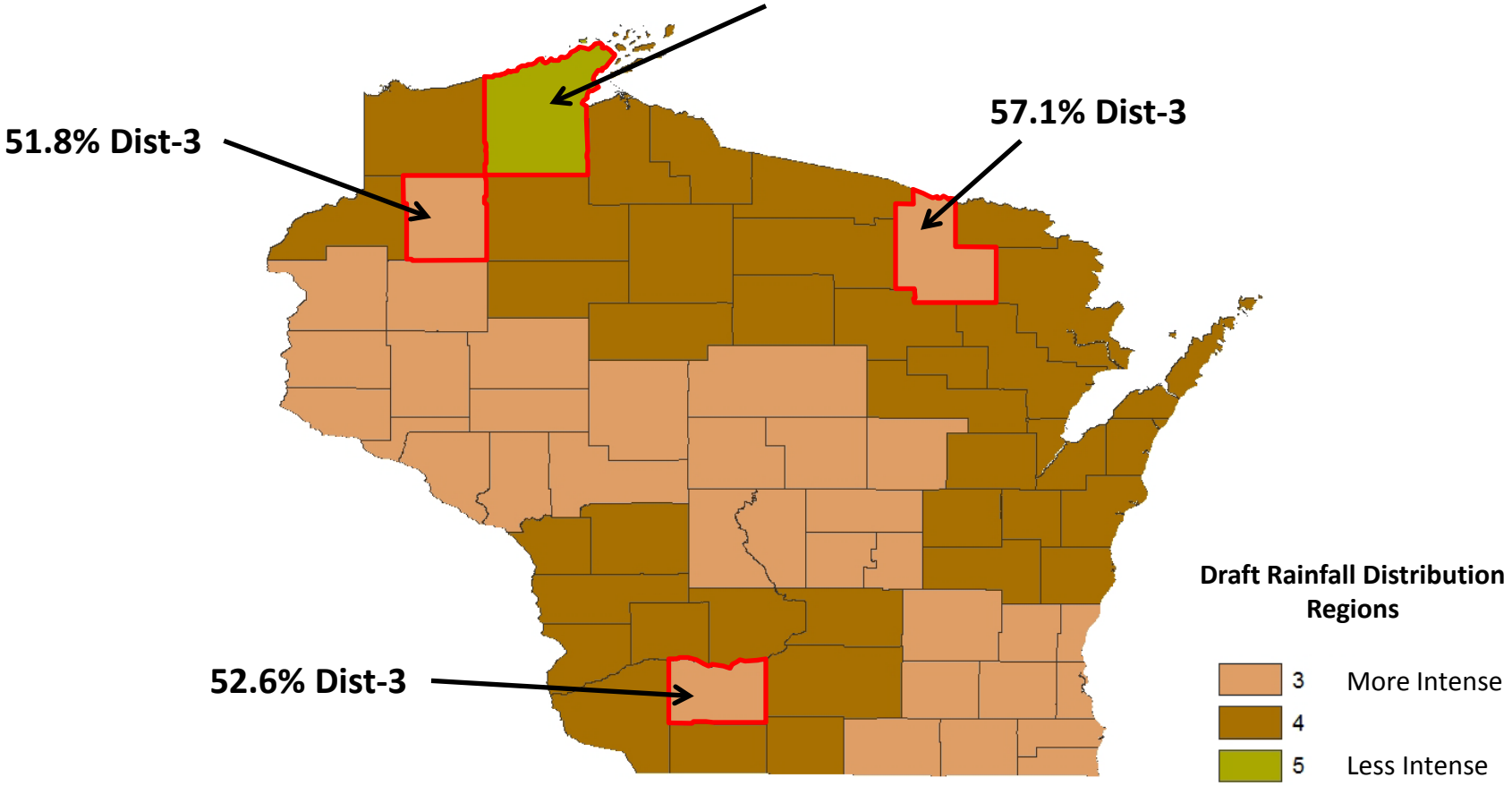
NRCS Storm Distributions



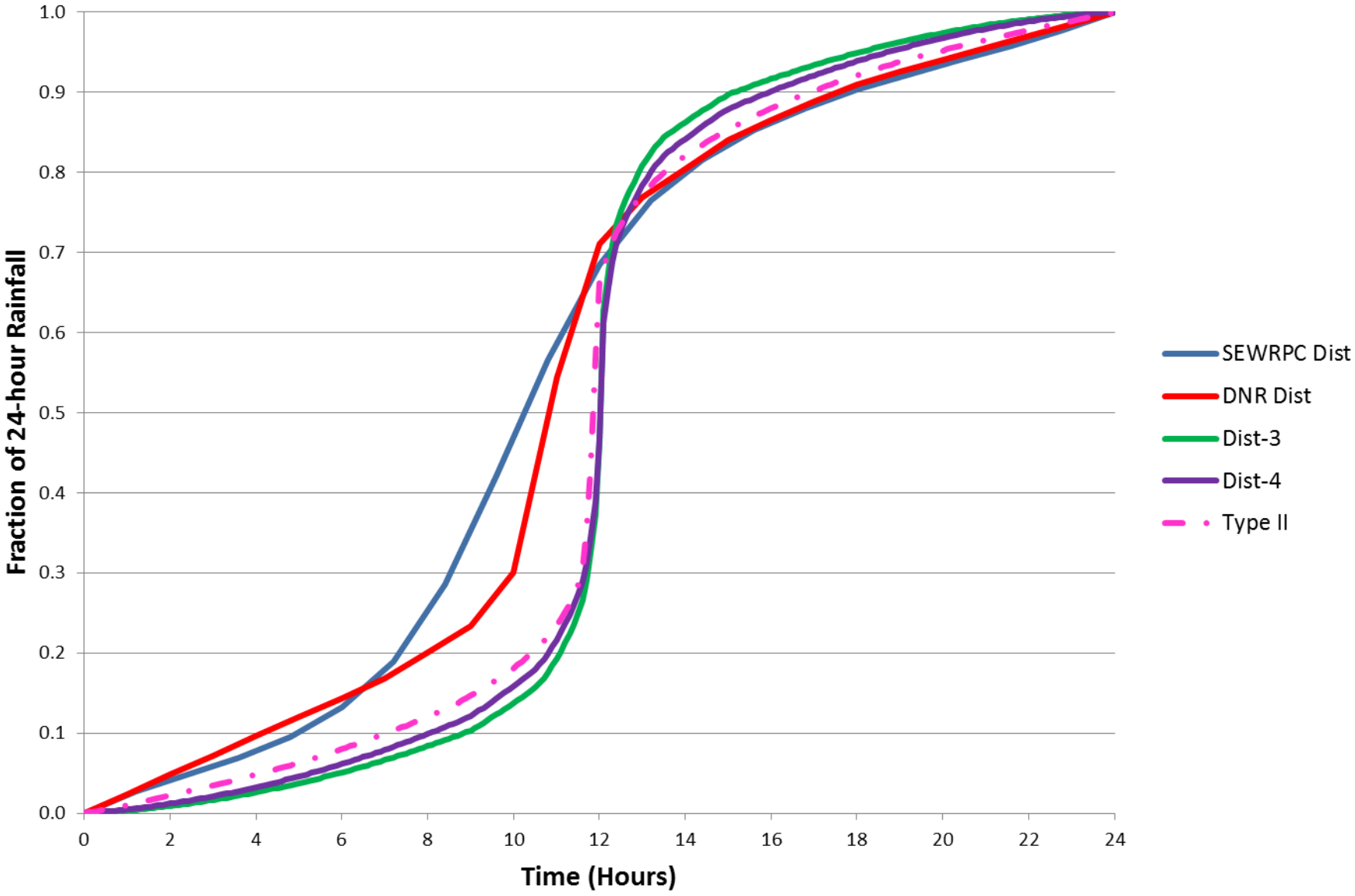
NRCS WI Proposed Rainfall Distributions

Initial Simplified Rainfall Distribution Regions

Based on Dominant (>50%) Distribution for Each County



Comparison of Storm Distributions



Temporal Distributions

- For studies to delineate regulatory floodplain limits, WDNR will accept critical duration analyses for peak flow determinations using Atlas 14 precipitation and:
  - The WDNR State distribution,
  - The SEWRPC 2006 distribution for the Southeastern Wisconsin Region, or
  - The new NRCS distributions.
- WDNR will not accept Atlas 14 precipitation with the NRCS Type II distribution

Accessing Precipitation-Frequency Information

- http://hdsc.nws.noaa.gov/hdsc/pfds/