Development of Site-Specific PMP and PMFs for Dam Safety Evaluations

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Defining Probable Maximum Precipitation (PMP)

- PMP is “the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year”. – American Meteorological Society, 1959
- Values of PMP are always estimates based upon extreme storms that have occurred in the past.
- Estimates of PMP are typically made based upon guidelines given in the various Hydrometeorological Reports published by the National Weather Service.

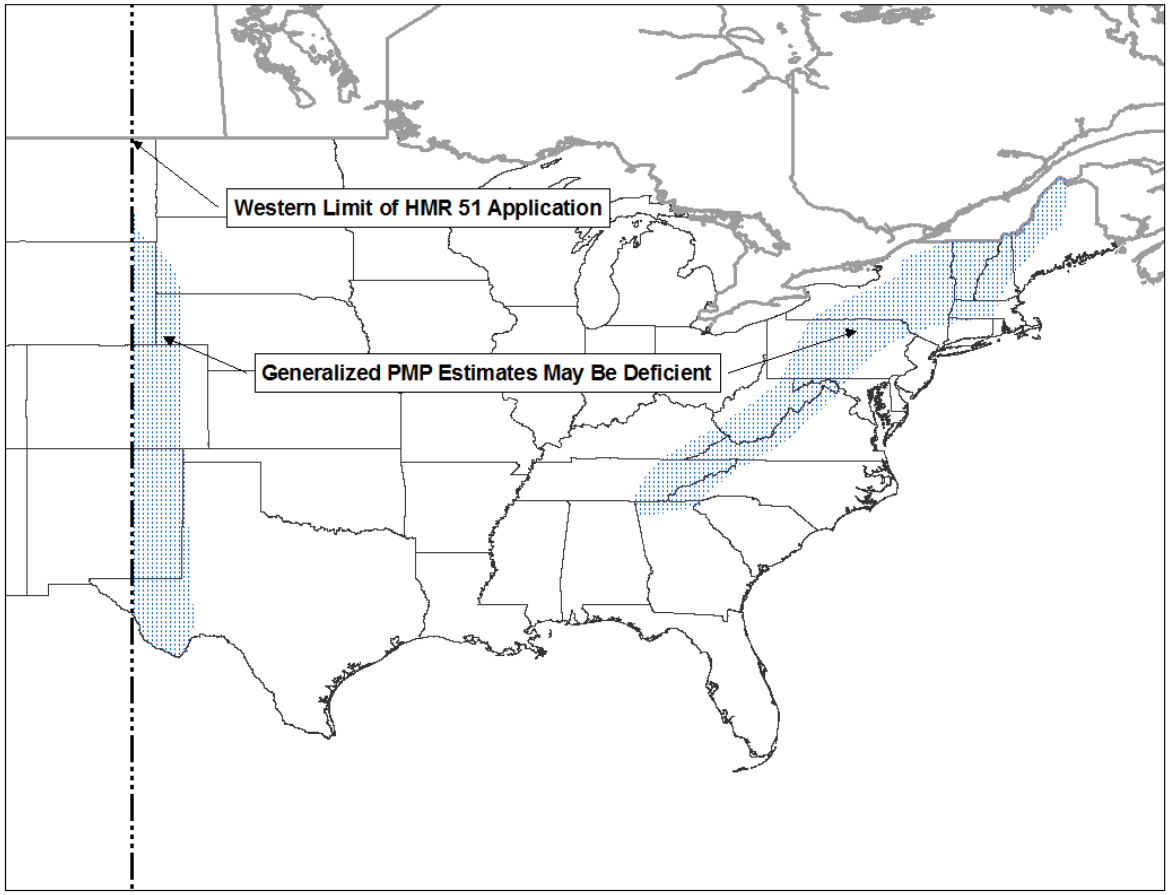
Defining Probable Maximum Flood (PMF)

- Probable Maximum Flood (PMF): The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the drainage basin under study.

HMR No. 51 Values

- HMR No. 51 was published in 1978 and includes storm evaluations that are several decades old. Hurricane Agnes (June 1972) was the latest significant storm to be worked up for the northeast.
- Modern computer modeling methods are being used to develop more accurate PMP estimates
  - Geographic Information System (GIS) software
  - Improved understanding of the meteorological processes
- Estimates of PMP values within the stippled regions of HMR No. 51 "might be deficient because detailed terrain effects have not been evaluated."

Areas of Uncertainty in HMR 51 Generalized Estimates of PMP



When to Consider a Site-Specific PMP Study

- You want to better assess the risk of your project.
- The current PMP does not have the required back-up
- The project discharge capacity is insufficient to pass the current PMF and expected remediation is costly.
- The project lies within the “stippled area”
- There is a significant topographic barrier between the drainage basin and the expected moisture sources.

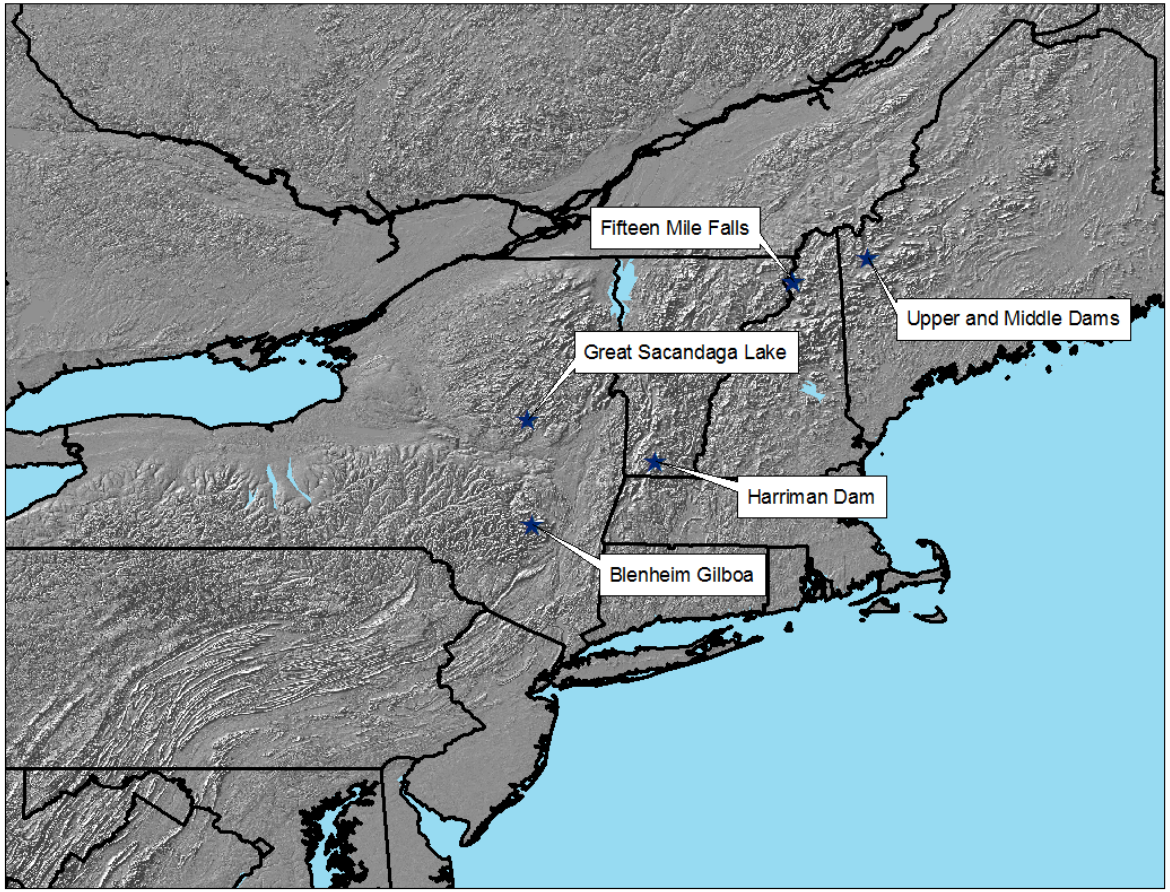
Site-Specific PMP vs. HMR No. 51 Values

- Both use the same basic rainfall adjustment procedures.
- The July 17-18, 1942 Smethport, PA storm was included in HMR 51 and likely influenced values across NY and New England. MCCs were excluded from eastern NY and New England site-specific PMPs, as not considered transpositionable to this region.
- HMR 51 did not address topographic effects.

Site-Specific PMP vs. HMR No. 51 Values

- Site-Specific Studies Included:
  - Barrier Moisture Depletion
  - Storm Elevation Adjustments
  - In Basin Orographic Adjustments
  - Analysis of New Storms
  - Re-analysis of Moisture Source/Storm Maximization for Select Storms
  - NEXRAD Radar Used to Assist in Rainfall Evaluation

Site-Specific PMP Studies



Sample Basin Comparison of Site-Specific PMP vs HMR 51						
Site-Specific PMP		Duration				
	Area (mi^2)	6 hour	12 hour	24 hour	48 hour	72 hour
	10	8.1	10.5	13.4	16.2	16.3
	200	6.8	9.2	12.2	15.0	15.1
	1000	5.5	7.9	10.8	13.4	13.5
	5000	3.9	6.4	8.8	11.1	11.6
	10000	3.2	5.8	7.6	10.0	10.5
	20000	2.4	5.0	6.4	8.7	9.2
HMR 51		Duration				
	Area (mi^2)	6 hour	12 hour	24 hour	48 hour	72 hour
	10	20.3	23.3	25.5	29.0	29.5
	200	13.5	16.4	18.7	21.2	22.5
	1000	9.6	12.4	14.9	17.6	18.0
	5000	6.1	8.7	10.9	13.3	14.4
	10000	4.6	7.4	9.5	11.5	12.6
	20000	3.5	5.9	7.9	10.3	11.3
Percent Reduction		Duration				
	Area (mi^2)	6 hour	12 hour	24 hour	48 hour	72 hour
	10	60%	55%	47%	44%	45%
	200	50%	44%	35%	29%	33%
	1000	43%	36%	28%	24%	25%
	5000	36%	26%	19%	17%	19%
	10000	30%	22%	20%	13%	17%
	20000	31%	15%	19%	16%	19%

Sample Basin Comparison of Site-Specific PMP vs HMR 51 For Basins from 356 - 1635 sq. mi.			
Percent Reduction		Duration	
	Area (mi^2)	6 hour	72 hour
	10	50-65%	45-50%
	200	35-54%	33-40%
	1000	30-47%	25-34%
	5000	14-38%	15-29%
	10000	9-32%	11-34%
	20000	21-31%	11-42%

Site-Specific PMP Estimation

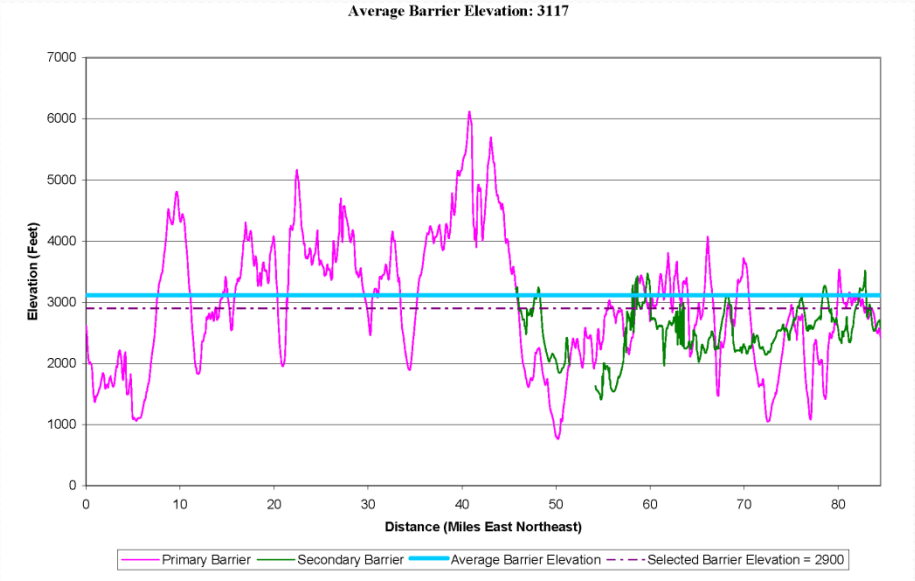
- Identify historic extreme storms that could occur within basin of interest
- Identify topographic features which can dilute or enhance the moisture content of the storm
- Evaluate meteorological conditions for transposition and maximization of storm
- Envelope transposed and maximized storms

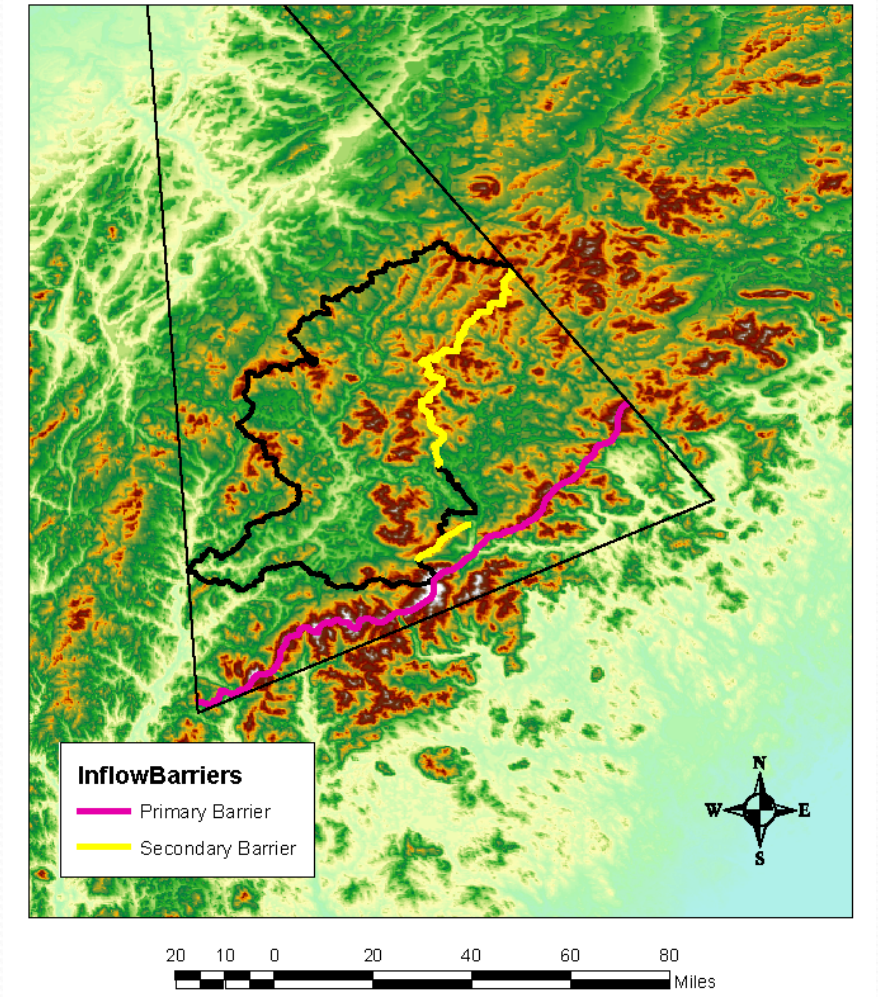
Storm Adjustments for PMP Estimation

- In-Place Maximization
- Transposition
- Elevation Adjustment
- Barrier Adjustment
- In-Basin Orographic Adjustment

Meteorological Storm Adjustments

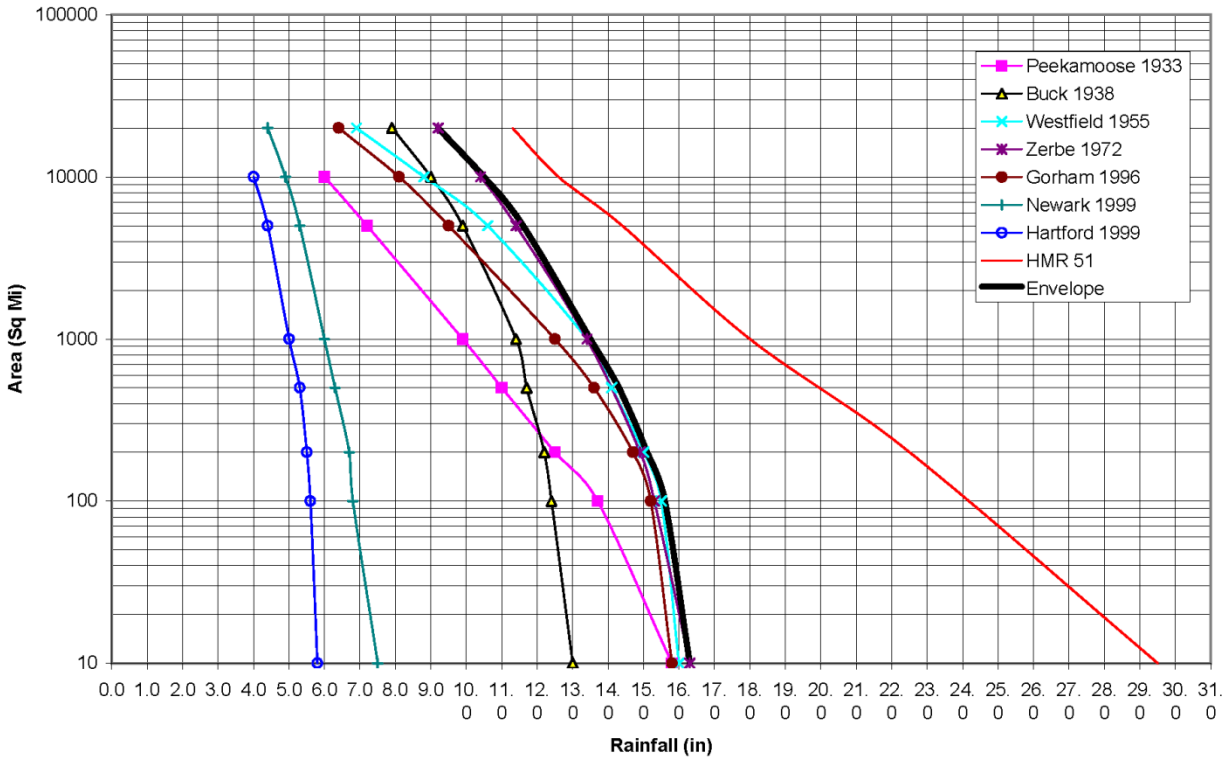
Topographic Storm Adjustments



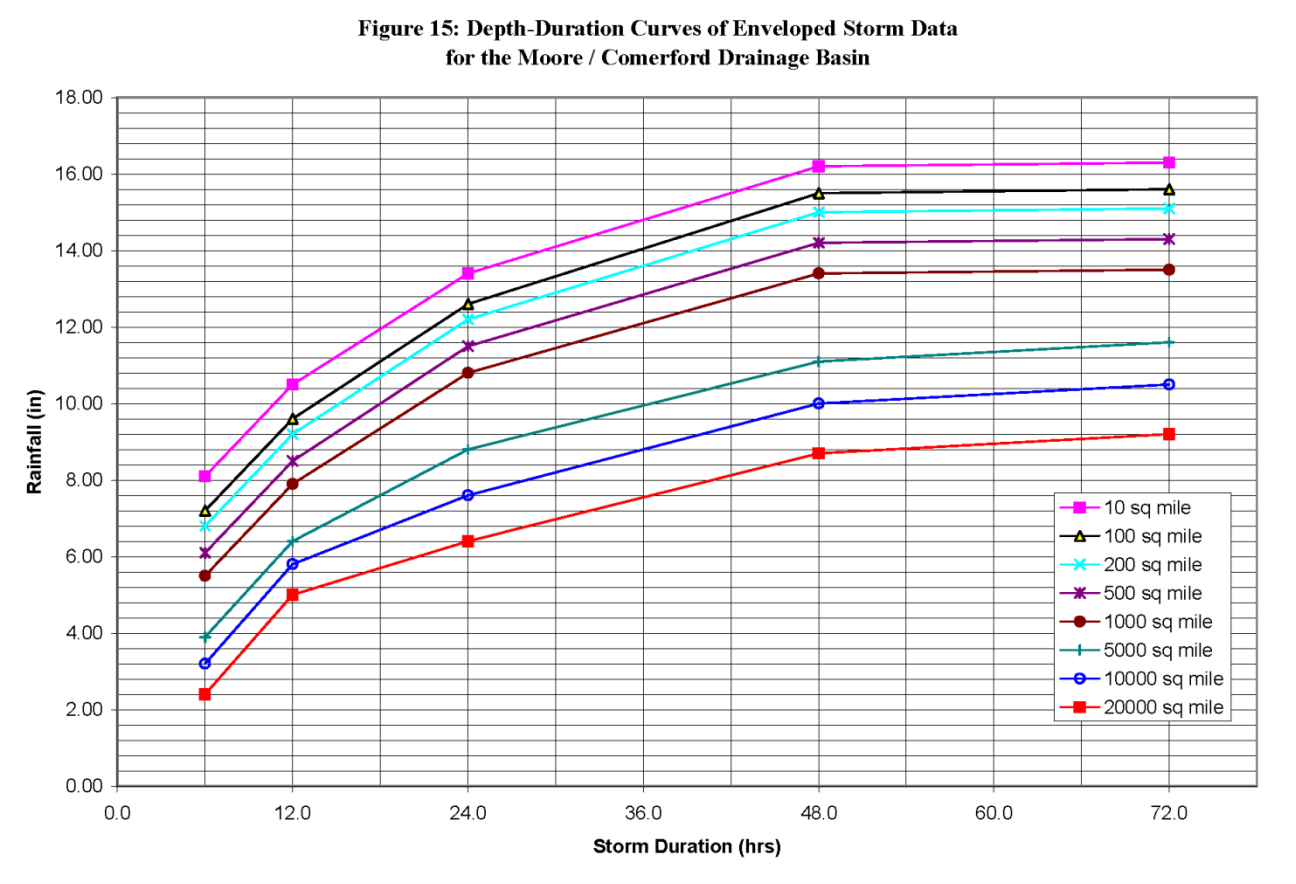


Depth-Area Envelope

Figure 14: 72-Hour Depth Area Curves for Storm Events Maximized and Transposed to Moore / Comerford Basin



Depth-Duration Curves



Applying Site-Specific PMP for PMF Estimation

- Warm-Season Procedure
  - Prepare/Calibrate hydrologic model
    - Compile rain and flow gage records
    - Evaluate existing project discharge curves
    - Initial estimates of unit hydrograph and baseflow parameters
    - Calibrate model for unit hydrograph parameters and loss rates
  - Model PMF
    - Estimate antecedent moisture, baseflow and reservoir stage

Applying Site-Specific PMP for PMF Estimation

- Cold-Season Procedure
  - Screening level analysis
    - Estimate 100-year snowpack
  - Full rain on snow analysis
    - Re-calibrate hydrologic model – additional data needed
      - Temperature, dewpoint, snow water content, wind, solar radiation, albedo
    - Maximum wind and temperature series
    - Seasonally adjusted PMP

Potential Challenges

- Data deficiencies
  - Out of date data storage methods – lack of equipment to read stream flow records
  - Infrequent rainfall data – daily recordings only
  - Lack of snow water equivalence data – lack of monitoring sites and low frequency of measurements
  - Temperature measurements only taken once daily at most NOAA stations
  - Dewpoint and windspeed only measured at first order NOAA stations – typically only at airports – data often recorded only during daylight hours

New Data Sources

- National Center for Environmental Prediction – North American Regional Reanalysis (NCEP NARR)
  - Estimates of environmental variables based on analysis/forecast model
  - 4 hour frequency, 0.3 degree spatial grid (approximately 20 mi.)
    - Temperature, wind, dewpoint, rainfall, snowpack, radiation, evaporation, pressure, etc.
  - Most data available from 1979 to present

New Data Sources

- MesoWest – University of Utah
  - Similar to NOAA Cooperative Network stations
  - Typically collect rainfall, temperature and dewpoint, may have wind pressure and solar radiation measurements
  - Only recent data – since early 2000's at most stations in the northeast
  - Add additional stations to traditional NOAA stations

Additional Considerations

- Incremental Dambreak/IDF Study
- Review/Update of Project Discharge Capacity Curves
- Review of Operational Procedures/Constraints

Follow-up Questions?

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July 17-18, 1942 Smethport, PA Storm

- For the northeast region of the United States, the controlling historical storm event is the July 17-18, 1942 Smethport, Pennsylvania storm
- During this storm, it was estimated that a world record 30.8 inches of rain fell in a 4.5 hour period
- This rainfall intensity is significantly more than all of the other hundreds of historical storms used to develop PMP estimates for the East Coast
- Therefore, this storm alone drives the PMP envelope for a large portion of the northeastern U.S.
- Recent investigations question the Depth-Area-Duration values for Smethport.

July 17-18, 1942 Smethport, PA Storm

- It is the current opinion of meteorologists that Smethport was the result of a Mesoscale Convective Complex (MCC)
- It is the current opinion of meteorologists that it is not appropriate to transposition strong MCCs north and/or east of western PA and possibly western NY.