Current Changes in Illinois Weather Patterns and their Effect on Hydrologic Analysis

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Presentation Objectives

• Review rainfall analysis milestones to-date
  – TP-40
  – Bulletin 70/71

• Discuss general evolution of detention requirements in northeastern Illinois

• Discuss next steps in rainfall analysis
Pre-TP 40

- Pre-1950s: Yarnell
  - Generalized maps for several durations and return periods
  - Derived from approx 200 gage stations
- More gages added
- 1950s: TP 24 by the USCOE
  - Showed higher amounts of short-duration rainfall
TECHNICAL PAPER NO. 40

RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

for Durations from 30 Minutes to 24 Hours and
Return Periods from 1 to 100 Years

Prepared by
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for
Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

WASHINGTON, D.C.
May 1961
Reprinted and Revised: January 1963

# Table 1: Sources of point rainfall data

<table>
<thead>
<tr>
<th>Duration</th>
<th>No. of stations</th>
<th>Average length of record (yr.)</th>
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<td>30-min. to 24-hr</td>
<td>200</td>
<td>48</td>
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<tr>
<td>Hourly</td>
<td>2081</td>
<td>14</td>
</tr>
<tr>
<td>Daily (recording)</td>
<td>1350</td>
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<tr>
<td>Daily (nonrecording)</td>
<td>3409</td>
<td>15</td>
</tr>
<tr>
<td>Daily (nonrecording)</td>
<td>1426</td>
<td>47</td>
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</tbody>
</table>
Technical Paper No. 40 (1961)

5.8"

– Rainfall was measured for specific durations (6-, 12-, 24-, 96-hours) as opposed to collecting for individual storms.
Pre-Bulletin 70

• TP 40

• Additional analysis during 1960s-70s

• Technical Letter 13
  (predecessor to Bulletin 70)
• Based on an 83-year sample period
  – Including 61 Illinois gages

• Specific needs for study:
  – Frequency relations had not been updated
  – Further study of longer records of data
  – Increased flooding in northern Illinois
  – Seasonal frequency variations
### Table 1. Number of Times the 24-Hour, 100-Year Value from Technical Paper 40 Is Exceeded by State

<table>
<thead>
<tr>
<th></th>
<th>(a) Number of stations</th>
<th>(b) Average length of record</th>
<th>(c) Number of times exceeded</th>
<th>(d) Number of times expected</th>
<th>Ratio (c)/(d)</th>
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<td>Illinois</td>
<td>61</td>
<td>87</td>
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<td>246</td>
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*From Sorrell and Hamilton, 1990*
Bulletin 70

Figure 3. Illinois climatic sections adopted by the National Weather Service
Table 13. Sectional Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years

<table>
<thead>
<tr>
<th>Storm codes</th>
<th>Sectional (zone) codes</th>
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<tbody>
<tr>
<td>1 – 10 days</td>
<td>9 – 3 hours</td>
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<tr>
<td>2 – 5 days</td>
<td>10 – 2 hours</td>
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<tr>
<td>3 – 72 hours</td>
<td>11 – 1 hour</td>
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<tr>
<td>4 – 48 hours</td>
<td>12 – 30 minutes</td>
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<td>5 – 24 hours</td>
<td>13 – 15 minutes</td>
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<td>6 – 18 hours</td>
<td>14 – 10 minutes</td>
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<td>7 – 12 hours</td>
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<td>8 – 6 hours</td>
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<td>2 – Northeast</td>
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<td>4 – Central</td>
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<td>5 – East</td>
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<td>9 – Southeast</td>
</tr>
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<td></td>
<td>10 – South</td>
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</table>

Rainfall (inches) for given recurrence interval

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<th>Zone code</th>
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<th>3-month</th>
<th>4-month</th>
<th>6-month</th>
<th>9-month</th>
<th>1-year</th>
<th>2-year</th>
<th>5-year</th>
<th>10-year</th>
<th>25-year</th>
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<td>7.21</td>
<td>8.45</td>
<td>9.45</td>
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</tr>
</tbody>
</table>
• Findings:
  – Wetter, especially in northeastern Illinois
  – Intensity of rainstorms over the state had increased
  – Rainfall depths revised
    • Not a great difference for events smaller than 10-yr
    • 5.8” → 7.58” for 100-year 24-hour storm in NE IL
### Huff Distribution:

<table>
<thead>
<tr>
<th>Storm Duration (x)</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>(x \leq 6) hrs</td>
<td>1\text{st} Quartile</td>
</tr>
<tr>
<td>(6 &gt; x \geq 12) hrs</td>
<td>2\text{nd} Quartile</td>
</tr>
<tr>
<td>(12 &gt; x \geq 24) hrs</td>
<td>3\text{rd} Quartile</td>
</tr>
<tr>
<td>(x &gt; 24) hrs</td>
<td>4\text{th} Quartile</td>
</tr>
</tbody>
</table>

Rainfall Distribution

- SCS Type II vs. Huff Quartile Distribution
  - SCS Type II distribution intended to be used only with 24-hour events
  - SCS Type II generally more conservative runoff results
Rainfall Distribution

- SCS Type II vs. Huff (continued)
  - Huff distributions designed to represent actual typical rainfall patterns
  - Important to use critical duration with the Huff distribution
Hydrologic Analysis Methodologies

• Pre-1991
  – (Modified) Rational Method
  – TR-55
  – TR-20
  – HEC-1
  – ILLUDAS
  – HSPF (continuous simulation)
Hydrologic Analysis Methodologies

- 1991 – Today
  - TR-55 & TR-20
  - HEC-HMS
  - SWMM
  - HSPF
  - others

Continuous simulation
General Evolution of Detention Ordinances in Northeastern Illinois

- 1970s, Using TP 40 rainfall amounts:
  - MWRD: Rational Method
    - Restrict to 3-year undeveloped
  - DuPage County
    - TR-55 and restrict to 0.1 cfs/acre
General Evolution of Detention Ordinances in Northeastern Illinois

• 1990s
  – ISWS report Bulletin 70
  – Chicagoland’s collar counties generally adopt 0.1 cfs/acre or dual-release rate
  – NIPC reports
General Evolution of Detention Ordinances in Northeastern Illinois

• NIPC Reports – Conclusions:
  – Reality of watershed is a factor.
  – Outlet control needed to limit post-development flooding and erosion.
General Evolution of Detention Ordinances in Northeastern Illinois

• NIPC Reports – Conclusions (continued):
  – Actual storm events vs. theoretical design
  – Net effect of random detention locations in conjunction with the increased flow volume from new development.
General Evolution of Detention Ordinances in Northeastern Illinois

- NIPC Reports – Conclusions (continued):
  - 2-year flow control
    - prevent erosion
    - limit depth fluctuations for more frequent events
  - Wet-bottom basins (+)
  - Dry-bottom basins (–)
General Evolution of Detention Ordinances in Northeastern Illinois

- NIPC Reports – Conclusions (continued):
  - Use Bulletin 70 rainfall & 0.1 cfs/ac.
  - Evaluated hydrologic design methodologies
    - Continuous simulation model on 40 years of data as a benchmark to compare the other methodologies (Upper Salt Creek watershed).
    - Developed “unit area” detention chart for determining required detention based on landuse.

Sources:
- “Unit Area Detention Volumes Based on Continuous Simulation Recommended for Use With the DuPage Countywide Stormwater Management Ordinance”, NIPC, 1997
General Evolution of Detention Ordinances in Northeastern Illinois

• Today
  – Flooding is down, quality is up.
    • Result of ordinance regulations
    • Northeastern Illinois ahead of the national curve
  – BMPs
  – Volume Control
    • Concept of infiltration through extended detention
General Evolution of Detention Ordinances in Northeastern Illinois

- Today (continued)
  - Changes since 1991
    - Progression of technology
    - Additional data
Progressing Technology

- Current Technologies for Gathering Rainfall Data
  - Rain Gage Stations
  - NEXRAD (Next Generation Weather Radar)
    - Weather Surveillance Radar-88 Doppler
Progressing Technology

• Advantages of Radar-Rainfall for Data Collection (over rain gages)
  – Spatial and Temporal Mapping
  – Point rainfall depths are not representative of the spatial distribution of a storm event
  – High Resolution (relative)
  – Real Time Flood Forecasting
Progressing Technology

• Current Disadvantage of Radar-Rainfall Data Usage

  – Oldest recorded data: 1993

  – NEXRAD data must be ground-truthed
Progressing Technology

• Current Technologies for Gathering Hydrologic Data
  – Landsat Thematic Mapper (map inundated areas)
  – Remote Sensing (soil moisture content, elevation, water body inventories, water quality parameters, etc)
Progressing Technology

• Advances in Watershed Modeling

Precipitation → Subcatchment → Overland Flow → Runoff Hydrograph
• Advances in Watershed Modeling (cont’d)
  – Calibration with NEXRAD
  – Digital elevation/terrain models (DEM\text{\textregistered}s)
  – GIS and remote sensed data
  – Database management
  – More powerful processors
Progressing Technology

- Advances in Watershed Modeling (cont’d)
  - GIS link to H & H modeling
Illinois State Water Survey continues to collect precipitation data

- 20 years have passed since last rainfall depths assigned in Bulletin 70
- 1970 to mid-1990s: Northeastern Illinois has experienced a wetter climate.
Thoughts Looking Back

• Is the increase in precipitation an anomaly or a trend?

• What do we do in a period of climate change?

• Everything changes over time.
  – Maybe the rainfall intensities are changing.
• Watershed vs. Regional
  – Watershed characteristics are important.
  – Comprehensive storm water management plans that incorporate calibration and flood forecasting are much simpler now to implement, monitor and update.
Thoughts Moving Forward

• Continuous simulation incorporates weather pattern changes.
  – Calibration of model based on hydrologic parameters

• With technology today, data is quicker, better, and we can do more with it.
Thoughts Moving Forward

• We have more and more accurate and efficient ways for modeling reality.

• We can take advantage of additional data and more progressive modeling that is within our reach to enhance old assumptions.
Conclusion

- Comments / Questions
- Presentation will be available for download: www.eraconsultants.com/downloads.asp