National Precipitation Frequency Standard
NOAA Atlas 14 and Beyond

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Precipitation Frequency Estimates

- Precipitation amounts for a given duration and annual exceedance probability (or average recurrence interval).
  
  Example: X precipitation over 24-hour period with 1% (1/100) probability to occur in given year.

- Precipitation Depth (or Intensity) for a given Duration and Frequency (ARI or AEP)

Depth-Duration-Frequency (DDF) curves

Intensity-Duration-Frequency (IDF) curves
Precipitation Frequency Applications

Infrastructure design and planning under federal, state, and local regulations

- Transportation
- Development and building codes

FEMA National Flood Insurance Program

Comparing observed and forecasted precipitation with threshold precipitation to indicate flooding threats

Estimating severity of historic events

<table>
<thead>
<tr>
<th>Type of structure</th>
<th>Return period (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway culverts</td>
<td></td>
</tr>
<tr>
<td>Low traffic</td>
<td>5–10</td>
</tr>
<tr>
<td>Intermediate traffic</td>
<td>10–25</td>
</tr>
<tr>
<td>High traffic</td>
<td>50–100</td>
</tr>
<tr>
<td>Highway bridges</td>
<td></td>
</tr>
<tr>
<td>Secondary system</td>
<td>10–50</td>
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<tr>
<td>Primary system</td>
<td>50–100</td>
</tr>
<tr>
<td>Farm drainage</td>
<td></td>
</tr>
<tr>
<td>Culverts</td>
<td>5–50</td>
</tr>
<tr>
<td>Ditches</td>
<td>5–50</td>
</tr>
<tr>
<td>Urban drainage</td>
<td></td>
</tr>
<tr>
<td>Storm sewers in small cities</td>
<td>2–25</td>
</tr>
<tr>
<td>Storm sewers in large cities</td>
<td>25–50</td>
</tr>
<tr>
<td>Airfields</td>
<td>5–10</td>
</tr>
</tbody>
</table>
Precipitation Frequency Studies

Early 1950s

• NWS chosen to prepare IDF curves for federal government.
• NWS is independent.
• Does not regulate or design.

NWS Relevant Publications

• Technical Paper 40, 1961
• Technical Paper 49, 1964
• NOAA Atlas 2, 1973
• NOAA Atlas 14, 2004-2023

Today’s De-facto National Standards

• Endorsed by federal water agencies.
• Referenced in many federal, state and local regulations.

Technical Paper 40, 1961:
https://www.weather.gov/media/owp/oh/hdsc/docs/TP40.pdf
https://www.weather.gov/gyx/TP40s.htm
NOAA Atlas 14

Hydrometeorological Design Studies Center (HDSC)

- Since 2003, develops and updates precipitation frequency estimates for the United States and territories
- Part of Office of Water Prediction (NWS, NOAA)

Funding Approach

- Performed At Request Of And Funded By Users - not from NWS budget

Discontinuities at volumes’ boundaries, and irregular update cycle creates issues for users

Volumes

- Volume 1 (2004): Semiarid Southwest
- Volume 11 (2018) : Texas
- Volume 12 (2023) : Montana, Idaho, and Wyoming

https://www.weather.gov/owp/hdsc
**Volume Development (and enhancement to Technical Paper 40)**

- from 5 minutes to 60 days
- recurrence intervals of 1 to 1000 years.
- confidence intervals
- high spatial resolution (~800 m)
- spatial interpolation (account for terrain, coastal proximity, etc.)
- numerous internal consistency checks
- regional approach that allows for the development of rare frequency
- denser rain gauge networks with longer periods of record, and extensive quality control
- online delivery: https://hdsc.nws.noaa.gov/hdsc/pfds/

**Assumptions**

- Assumes stationarity in data and methodology
Sources of Error

Data:
- Period of record
- Missing data
- Quality Control
- Spatial Coverage

Methods:
- Distribution selection
- Parameterization method
- Stationary vs non-stationary methodology
- Regionalization
- Interpolation
- Optimization & consistency checks

Houston Hobby Airport

Preliminary 100-year 24-hour estimate: 17.6”
Nonstationarity Impact on NOAA Atlas 14


- Work done in collaboration with Penn State University, University of Illinois Urbana-Champaign and University of Wisconsin-Madison
- Testing done for Atlas 14 Volume 10 project area (Northeastern States)
- Funding provided by DOT FHWA
A National Analysis Accounting for Nonstationarity

Leverage support from the Bipartisan Infrastructure Law (BIL) FY22-26

- Leverage results and recommendations from the Assessment Report
- Develop a seamless spatial national analysis using a non-stationarity assumption with latest precipitation observations and climate projections
- Replaces current Atlas 14 estimates based on historical data (Historical IDFs) for durations:
  - from 5 minutes to 60 days
  - recurrence intervals of 1 to 1000 years
- Add new product features to account for the future precipitation information (Future IDFs)
- Atlas 15 to be delivered with robust web visualizations and data services
Moving Forward: NOAA Atlas 15

**Volume 1:** Based on historical gages and observed trends

- Integrated terrain information
- Models trend in historical observations (when it exists) to account for short-term non-stationary temporal changes
  - Non-stationary trends represents a major enhancement from Atlas 14

**Volume 2:** Incorporates climate projection adjustment factors

- Future precipitation informed by global climate models, modeled non-stationary temporal changes
- Provides adjustment factors to Volume 1 to calculate future estimates.
Additional Atlas Products

- **Areal Precipitation Frequency Estimates**
  - **BACKGROUND:** Atlas 14 estimates are point estimates. ARFs are used to convert point precipitation to average precipitation over a watershed. Many ARF methods have been proposed, but Weather Bureau’s ARF curves from 1958 are still commonly used.
  - **NEEDS:** Derive regional ARFs and develop web tool to delineate watershed estimates.

- **Design Storm**
  - **BACKGROUND:** Atlas 14 provides precipitation frequency estimates for a given duration, but designers often need information on how precipitation is distributed in time and not just the total amount.
  - **NEEDS:** Develop Atlas 15 design storm product with guidance on how to use the product.

- **Probable Maximum Precipitation (PMP)**
  - **BACKGROUND:** Probable Maximum Precipitation (PMP) estimates provide the maximum depth of precipitation over a given area and duration that is meteorologically possible. NWS studies done at request and funding of various federal agencies. All activities discontinued in 1999 due to lack of funding.
  - **NEEDS:** Develop the new approach and PMP estimates in a changing climate. 

![Diagram](Weather_Bureau's_ARF_curves_(1958).png)