SEMIARID PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 40, Technical Paper No. 49* and *NOAA Atlas 2*

Seventeenth Progress Report

Hydrometeorological Design Studies Center
Hydrology Laboratory

Office of Hydrologic Development
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DISCLAIMER

The data and information presented in this report should be considered as preliminary and are provided only to demonstrate current progress on the various technical tasks associated with this project. Values presented herein are NOT intended for any other use beyond the scope of this progress report. Anyone using any data or information presented in this report for any purpose other than for what it was intended does so at their own risk.

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Meteorologists, statisticians, computer experts and support staff have contributed to the Semiarid Precipitation Frequency Study. This includes, but is not limited to, the following people:

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1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency analysis for the Semiarid Southwestern United States. Current precipitation frequency studies for the Semiarid region are contained in *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" (Hershfield 1961), *Technical Paper No. 49* "Two- to ten-day precipitation for return periods of 2 to 100 years in the contiguous United States" (Miller et al 1964) and *NOAA Atlas 2* "Precipitation-Frequency Atlas of the Western United States." The current study includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual and seasonal precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the Semiarid study area and use accepted statistical methods. In particular, the Semiarid Study is the pilot study in which decisions regarding the methods and format are being made that will affect subsequent studies. The study results will be published as Volumes of *NOAA Atlas 14*. They will also be made available on the internet using web pages with the additional ability to download digital files.

The Semiarid study area includes 4 states completely, Arizona, Nevada, New Mexico, and Utah, and southeastern California. Additional data from 7 bordering states and Mexico (Figure 1) were included for continuity. The core and border states, as well as regions used in the analysis, are shown in Figure 1.

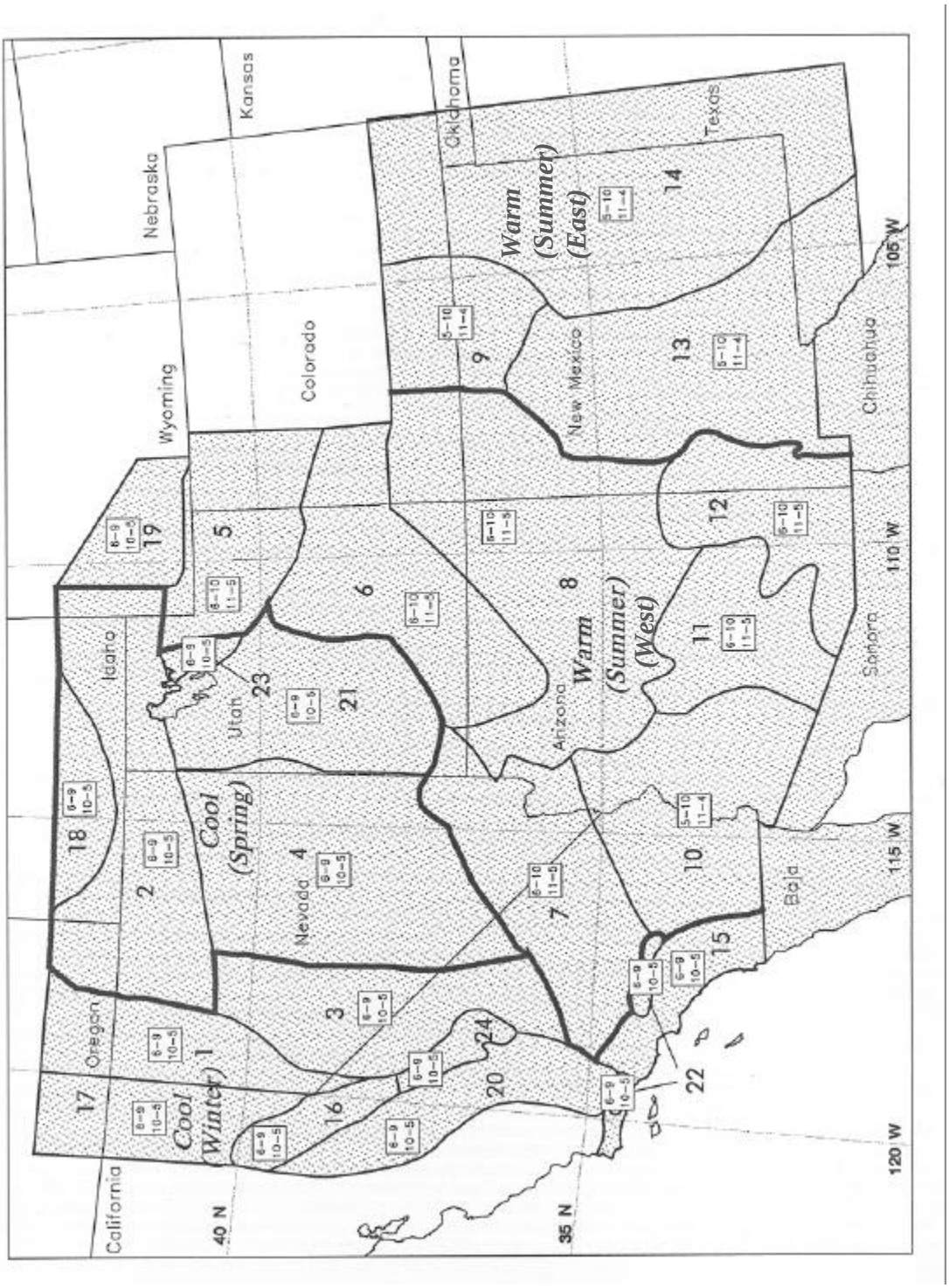

Figure 1. Semiarid Precipitation Frequency study area and region boundaries.

2. Highlights.

Daily and hourly data through December 2000 were added and quality controlled. N-minute data through May 1997 were also added and quality controlled. Additional information is provided in Section 4.1, Update of Data Collection and Quality Control.

Mapping of precipitation frequency values is nearly complete pending results of the updated dataset. The format for the precipitation-frequency maps have been developed. Additional information is provided in Section 4.2, Update of Data Frequency Analysis and Mapping.

Temporal distributions of extreme rainfall are complete. Graphs representative of storm-types and seasons were created. Additional information is provided in Section 4.3, Update of Temporal Distributions.

Work on an Internet-based Precipitation Frequency Data Server is near completion for the Semiarid Southwestern United States Precipitation Frequency Project. Precipitation Frequency Data Server will accommodate future studies for the entire United States. Additional information is provided in Section 4.4, Update of Precipitation Frequency Data Server.

The National Weather Service headquarters has reorganized, and the new management has initiated review of the Hydrometeorological Design Studies Center. Additional information is provided in Section 5.1, Organizational Review by New Management.

3. Status.

3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percentage completed per task. Past status reports should also be referenced for additional information.

Semiarid study checklist [estimated percent complete]:

Data Collection, Formatting and Quality Control [75%]:

- Daily
- Hourly
- N-minute

L-Moment Analysis/Frequency Distribution for 1 hr - 60 days and 2 to 1000 yrs [90%]:

- Daily
- Hourly
- N-minute

Algorithm/Data Plot [85%]

- Establish regions from spatial, topographic and meteorological variables
- Run L-moments for regional growth factors to generate dataset
- Create 2yr-24hr precipitation frequency index map
  - Format dataset
  - Review maps (i.e., station id's, discordancy, elevation, frequency values)
  - Review hand-drawn analysis
  - Perform digitization
  - Rasterization
  - Generate contour rasters for final map
- Create ratio maps - 2yr (1-12) hr/2yr 24hr, 2yr (2-60) day/2yr 24hr
  - Plotting
  - Review hand-drawn analysis
  - Perform digitization
  - Rasterization
- Create regional growth factor maps - 2yr (1-12) hr/2yr 24hr, 2yr (2-60) day/2yr 24hr

Precipitation Frequency Maps [50%]

- Create frequency maps for 1-hour to 60-day durations at return periods 2 to 1000 years (seasonal and annual maximum) by multiplying index map rasters and using appropriate regional growth factor and ratio map rasters
- Create maps and/or relations for durations smaller than 1 hour (5, 10, 15, 30 minute) using index map and appropriate conversion factors
- Perform internal consistency checks (comparing rasters of sequential duration and frequency)

Temporal Distributions of Extreme Rainfall [100%]

- hourly data assembled by quartile of greatest precipitation amount and converted to cumulative rainfall amounts for each region
- graphs of representative storm-types and seasons

Spatial Relations (Depth-Area-Duration Studies) [25%]

- analyze critical storms to determine depth-area-duration relations
- small-area, short-duration relations
- area-depth curves for areas <500 mi^2 and for >500mi^2
- families of mass curves and area-depth curves as a function of duration and area size
- a smoothed set of curves to distinguish between convective, tropical and non-tropical storms (if appropriate)

Deliverables [25%]

- Write hard copy of Final Report
    - Maps of analyzed results
    - Graphical relations to obtain intermediate values
    - Seasonal variation
    - Depth-area distribution
    - Temporal distribution of rainfall in extreme storms
    - Implement peer review
- Prepare data for web delivery
- Prepare documentation for web delivery
- Publish hard copy of Final Report

3.1.1 Data Collection and Quality Control.

The daily and hourly datasets originally included data through December 1992 and now have been updated through December 2000. The n-minute dataset has been updated through May 1997.

Table 1. Information on daily and hourly datasets through December 2000 and n-minute datasets through May 1997.

	Daily	**Hourly**	**N-minute**
No. of stations	1177 (+147 SNOTEL) (+108 in Mexico)	448	25
Longest record length (yrs) (Station ID)	106 (02-8815)	59 (41-2797)	88 (02-6481)
Average record length (yrs)	47*	38	36

*not including SNOTEL or Mexico stations

3.1.2 Frequency Distribution Fitting Analyses:

This task evaluates and selects the frequency distribution which provides the best fit for the data. A comprehensive L-moment statistical analysis (Hosking and Wallis 1997) of goodness-of-fit has been done on both daily and hourly data through December 1992 for all durations and all regions to select a best-fit distribution. The best-fit for the partial duration (PD) series in this project is the Generalized Normal distribution (GNO) for precipitation frequency estimates.

3.1.3 Mapping Analyses:

Precipitation frequencies have been calculated, analyzed and plotted for all durations and return frequencies. These results will be adjusted appropriately for the updated datasets.

HDSC continues to explore the possibility of using spatial interpolation tools such as the Parameter-elevation Regressions on Independent Slopes Model (PRISM). Discussions with the Spatial Climate Analysis Center will determine if there are ways to adapt PRISM technology to precipitation frequency data.

3.1.4 Other Analyses:

Temporal distributions of extreme rainfall in the Semiarid study area have been examined. The results will be presented in graphs representative of different storm-types and seasons. These graphs and accompanying tables are complete.

3.1.5 Documentation and Publication.

The Semiarid study results will be available on the HDSC Precipitation Frequency Data Server, formerly the Graphical User Interface (GUI), once mapping is complete. The Precipitation Frequency Data Server displays precipitation frequency values and intensity-duration-frequency curves and tables. At present, all states can be selected. Where other studies are not yet concluded, information on existing precipitation frequency maps, namely *TP40* (Hershfield 1961) and *NOAA Atlas 2* (Miller et al 1973), is given.

4. Progress since Last Reporting Period.

4.1 Update of Data Collection and Quality Control.

Daily and hourly station data through December 2000 were added to the dataset These data have been quality controlled using a threshold check and the L-moment discordancy check and will be included in the precipitation frequency calculations. The n-minute (i.e., 5-minute, 10-minute, 15-minute, 30-minute) data collection, formatting process and quality control is complete through May 1997. Because there are only 25 n-minute stations in the Semiarid study area, we grouped them into 4 regions. These regions follow seasonal boundaries, Cool (Winter), Cool (Spring), Warm (Summer, East), and Warm (Summer, West) (see Figure 1). In Cool regions, general storms dominate with the maximum in either the Winter or Spring. In Warm regions, convective storms dominate in the Summer.

Thus, the quality control for the daily, hourly, n-minute datasets for the Semiarid Study through December 2000 is complete.

Table 2. Daily and hourly stations used in L-moment analysis (data through December 2000).

Region	Daily stations ≥19 data years	Hourly stations ≥15 data years
1	18	6
2	52	14
3	26	14
4	42	17
5	31	13
6	52	10
7	36	16
8	123	21
9	39	12
10	51	16
11	76	10
12	79	17
13	82	41
14	115	46
15	106	67
16	33	25
17	21	12
18	20	4
19	8	5
20	48	23
21	65	15
22	19	20
23	23	7
24	7	11
Total	**1172**	**442**

Table 3. N-minute stations used in L-moment analysis.

Region	**N-minute stations ≥ 14 data years**
Cool (Winter)	8
Cool (Spring)	4
Warm (Summer, West)	7
Warm (Summer, East)	4
Total	**23**

The discordancy check for the Semiarid data has been completed for all regions. The stations in which the discordancy value is equal to or greater than 5.0 were closely scrutinized for suspicious or unusual data. Methods to examine the suspicious data include, but are not limited to, comparing with other data sources (e.g., microfiche), comparing with hourly data and checking with other stations in the vicinity.

In summary, these analyses show that the quality control for the daily dataset through December 2000 for the Semiarid study has been thorough.

4.2 Update of Frequency Analysis and Mapping

Precipitation frequencies were originally estimated using the Generalized Pareto distribution (GPA). However, critical review of the statistical analysis later demonstrated that the Generalized Normal distribution (GNO) was most appropriate. It was not necessary to re-calculate 2-year values because 2-year return values are essentially equal for all tested distributions. The GNO distribution was used for the return frequencies greater than 2 years.

Mapping is nearly complete pending results of the updated dataset. Hard copies of the final precipitation-frequency maps are currently being prepared and will be submitted for peer review in the upcoming months.

4.3 Update of Temporal Distributions of Extreme Rainfall

In the semiarid study, the temporal distributions were remarkably similar over the entire area (i.e., most storms had intense precipitation occurring during the first quarter of storm time). The data were analyzed in two major areas, the General Storm Area and Convective Storm Area. Time distributions for 12-, 24-, and 72-hour events for each storm area were divided into quartiles, defined here as one-quarter of a storm duration. Semiarid storms are predominantly first-quartile storms regardless of storm type, duration or season (i.e., the greatest percentage of rain typically falls in the first few hours of a storm).

4.4 Update of Precipitation Frequency Data Server

The Internet-based Precipitation Frequency Data Server, which provides point and areal (up to 400 square miles) precipitation frequency data, is nearly complete. Though initiated for the Semiarid study, the Precipitation Frequency Data Server has been designed to accommodate future studies for the entire United States. The Precipitation Frequency Data Server is capable of generating an Intensity-Duration Frequency (IDF) curve and data table on-the-fly.

The Precipitation Frequency Data Server has a point-and-click interface, which allows the user to move their mouse around a shaded relief map while the longitude, latitude and elevation values change in adjacent input boxes. The user also selects the desired units (U.S. or metric), season (warm, cool or all), and data type (Intensity-Duration-Frequency or precipitation frequency). Based on these selections and the latitude/longitude pair, a table and color-coded intensity-duration-frequency (IDF) curve or color-coded precipitation frequency bar graph are displayed. Precipitation Frequency Data Server provides output for the entire duration list (5-min to 10-days) on a single output page. For those wishing to save the table data for further processing in, say a

spreadsheet program, there is an option to save the data in a comma-delimited format. The output graph is a GIF file, which is both printable and savable.

5. Issues.

5.1 Organizational Review by New Management.

The National Weather Service headquarters has reorganized (details can be viewed at http://www.nws.noaa.gov/oh/start.html). The new management has initiated review of the Hydrometeorological Design Studies Center.

5.1.1 Technology

A committee of technical experts from our partners is reviewing the technology we are using for precipitation frequency analysis. The committee members are:

Rocky Durrans, The University of Alabama, Tuscaloosa, AL (Rapporteur)
Greg Johnson, USDA-NRCS National Water and Climate Center, Portland, OR
Lou Schreiner, U.S. Bureau of Reclamation, Lakewood, CO
Jim Angel, Illinois State Water Survey, Champaign, IL (representing the American Association of State Climatologists)
Art DeGaetano, Northeast Regional Climate Center, Ithaca, NY
Will Thomas, Michael Baker Corporation, Alexandria, VA (representing the Transportation Research Board)
David Goldman, U.S. Army Corps of Engineers, Davis, California
Alan McNab, National Climatic Data Center, Ashville, NC
Geoff Bonnin, NWS Office of Hydrologic Development, Silver Spring, MD (Chairman)

The committee is looking at:

1. Data Collection and Quality Control: The committee suggested NWS contract for the data collection and quality control work. To that end, the Northeast Regional Climate Center has submitted a proposal combining the expertise of each of the regional climate centers. Since the data collection and quality control work for the Semiarid Precipitation Frequency Study is complete, there will be no impact on this study.

2. Statistical Analysis Procedure: The committee recommended a panel of recognized experts review the procedures. The NWS is currently responding to the first round of review comments. The NWS expects the statistical analysis procedures to be validated with perhaps minor adjustments. We expect little impact on the Semiarid Precipitation Frequency Study.

3. Spatial Interpolation: The committee recommended discussions with the Spatial Climate Analysis Center to determine if there are ways to adapt PRISM technology to precipitation frequency data.

5.1.2 Funding and Schedule

The technical committee recommended that precipitation frequencies for the entire United States be updated within three years. While the management review is not yet final there is a significant concern about whether the funds available are consistent with these expectations and whether current schedules are realistic.

6. Projected Schedule.

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on in the next quarter are also included in this section.

Data Collection and Quality Control [August 2001]
L-Moment Analysis/Frequency Distribution [September 2001]
Algorithm/Data Plot [November 2001]
Precipitation Frequency Maps [November 2001]
Temporal Distributions of Extreme Rainfall [complete]
Spatial Relations (Depth-Area-Duration Studies) [January 2002]
Implement Precipitation Frequency Data Server [January 2002]
Implement review by peers [January 2002]
Write hard copy of Final Report [January 2002]
Publish hard copy of Final Report [March 2002]

6.1 Data Collection and Quality Control.

Quality control is an iterative process that continues throughout the process. However, threshold checks and discordancy checks of all data are complete.

6.2 L-Moment Analysis/Frequency Distribution.

A comprehensive L-moment statistical analysis will be done on updated daily and hourly datasets for all durations and all regions to select a best-fit distribution. The tasks involved with the statistical analysis will take roughly one month for all 24 regions in the Semiarid study area.

6.3 Precipitation Frequency Maps.

A sophisticated cartographic-map making process has been designed using the latest release of ArcView software. During the next few months the review and revision process will result in a final cartographic-quality map template. This map template will then serve as the basis for all future precipitation frequency maps. The maps will be available both online (as ArcInfo ASCII raster, ArcView GIS shapefile, postscript and JPEG files) and in a hardcopy form with the final reports.

6.4 Precipitation Frequency Data Server.

Once the data and mapping are complete, the precipitation frequency estimates for the Semiarid study will be available from the newly developed HDSC web-based Precipitation Frequency Data Server. The Precipitation Frequency Data Server will display precipitation frequency values, as well as intensity-duration-frequency (IDF) curves and tables. Eventually, all states will be selectable from the opening U.S. map.

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