Department of Agronomy and Range Science
UNIVERSITY OF CALIFORNIA, DAVIS

RANGE SCIENCE REPORT

Agricultural Experiment Station Cooperative Extension

NO. 36 April 1999

Rainfall Depth, Duration, and Return Frequency Information for Typical California Annual Rangelands

Kenneth W. Tate and Edward R. Atwill
Rangeland Watershed Specialist, Agronomy and Range Science, University of California, Davis, and Environmental Health Specialist, School of Vet. Med., University of California, Davis.

Introduction

Hydrologists, managers, planners, and engineers are often interested in estimating the amount and return frequency of probable future rainfall events. Unfortunately, the occurrence of future rainfall events such as the 100-year, 24 hour storm is inherently random and thus unpredictable. We know it will happen, we do not know when (see UC RWP Fact Sheet No. 35, *Exactly What is a 100-Year Event?*).

With varying degrees of confidence, we can employ frequency analysis to predict the depth of rainfall expected for a specific storm event from historic rainfall data. The amount of confidence we have in our estimate depends in large part upon the duration of the historic record. We would be fairly confident in estimating the 5-year, 2 hour storm from 50 years of record. However, we would be less confident predicting the 25 or 50-year, 2 hour storm from that same record.

Basing the design of hydrologic structures, such as road culverts, upon probabilistic estimates of storm size allows an engineer or planner to assign some level of risk (probability) of the failure of that structure.

The amount (concentration or load) of a nonpoint source pollutant (sediment, nutrients, pathogens, etc.) generated and transported during rainfall events can be examined under storm events of various magnitudes. This allows us to assign some probability (risk) that a certain load or concentration will be exceeded under certain conditions. For example, we are using rainfall depth estimates for the 2-year and 50-year return frequency, 4 hour duration storm at Brown's Valley, CA to design simulated rainfall events to examine the hydrologic transport of *Cryptosporidium parvum* oocycts (eggs) from cattle fecal deposits on annual rangeland.

We will soon be utilizing this information in the design of simulated storm events in a field study of the relationship between ground cover by herbaceous vegetation and erosion.

Objective

The objective of this Range Science Report was to synthesize existing rainfall data to characterize precipitation patterns at four

representative California annual range / oak woodland locations. Making this information readily available for planning of future research.

Depth-Duration-Frequency Rainfall Information

Precipitation patterns at rainfall dominated locations, such as California's annual rangelands, are traditionally defined in terms of rainfall depth-duration-frequency (DDF). In developing DDF information, historic rainfall records are utilized to estimate the Depth (in) of rainfall one can expect from a storm of a given Duration (hours) occurring on a given Frequency (years) for the location.

Hershfield (1961) analyzed historical records and developed DDF information for much of the continental United States. He developed DDF information for storm durations of 0.5, 1, 2, 3, 6, and 12 hours with return frequencies of 1, 2, 5, 25, 50, 75, and 100 years. Hershfield presents this information in the form of a series of atlases of the continental United States with isohyetal lines connecting locations of equal rainfall depth for a specific combination of duration and frequency.

Although a bit dated, the document still serves as the most used reference of its kind for the western United States. Hershfield's set of atlases represents a significant effort. One which is unlikely to be updated, or expanded on a National scale again. Where available, the longest, most consistent local rainfall records should be employed when specific DDF information is required.

DDF Information for CA Annual Rangelands

For this report we compiled DDF rainfall information from Hershfield (1961) for four representative sites within California's annual rangelands. The sites were chosen to represent southern Sierra foothill, northern Sierra Nevada foothill, north coast, and central coast annual rangelands. In that order, the sites selected were: 1. USFS San Joaquin Experimental Range (SJER) in Madera County; 2. UC Sierra Foothill Research and Extension Center (SFREC); 3. UC Hopland Research and Extension Center (HREC) in Mendocino County; and 4. Paso Robles, CA (Paso R.) in San Luis Obispo County.

For each location, the expected depth (in) of the 1, 2, 3, 6, 12, and 24 hour duration 1, 2, 5, 10, 25, 50, and 100 year return frequency storm was compiled. This information is listed in Tables 1 through 4. It is also presented graphically in Figure 1. The expected rainfall depth (y-axis) for a given duration (x-axis) storm for a given return frequency (plotted lines) can be read for each location.

Figure 2 is a plot of rainfall depth for the 100-year return frequency 1 hour, 6 hour and 24 hour storms across locations. Note that an average of the four locations has been plotted with the data. The plots are nearly identical for all 4 locations for the 100-year, 1 hour storm. SJER separates out from the other three sites for the 100-year 6 and 24 hour storms. It is also interesting how similar precipitation patterns are for SFREC, HREC, and Paso Robles across all three storms. It is important to point out that this similarity is in individual storm characteristics, and not annual rainfall amount (the number of storms).

Literature Cited

Hershfield, D.M. 1961. Rainfall frequency altas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. Technical Paper No. 40. U.S. Weather Bureau.

Table 1. Rainfall (in) Depth-Duration-Frequency Data for SJER.

	Duration (Hr)					
Frequency (Yr)	1	2	3	6	12	24
1	0.50	0.60	0.80	1.00	1.50	1.70
2	0.60	0.75	1.00	1.30	1.75	2.00
5	0.90	1.00	1.25	1.75	2.20	2.50
10	1.00	1.25	1.50	2.20	3.00	3.50
25	1.20	1.50	1.75	2.75	3.50	4.20
50	1.40	1.75	2.00	3.00	4.00	5.00
100	1.50	2.00	2.25	3.25	5.00	6.20

Table 2. Rainfall (in) Depth-Duration-Frecuency Data for SFREC.

	Duration (Hr)					
Frequency (Yr)	1	2	3	6	12	24
1	0.60	1.00	1.25	2.00	3.00	3.50
2	0.70	1.10	1.60	2.50	3.50	4.00
5	0.80	1.30	1.80	3.00	4.00	4.75
10	1.00	1.60	2.10	3.50	5.00	6.00
25	1.15	2.00	2.50	4.25	5.50	7.00
50	1.25	2.20	2.80	5.00	6.50	8.00
100	1.50	2.35	3.00	5.50	8.00	10.00

Table 3. Rainfall (in) Depth-Duration-Frequency Data for HREC.

	Duration (Hr)					
Frequency (Yr)	1	2	3	6	12	24
1	0.60	1.00	1.20	2.20	3.25	3.75
2	0.70	1.20	1.50	2.80	3.50	4.15
5	0.80	1.40	1.80	3.20	4.00	5.20
10	1.00	1.60	2.25	3.50	4.50	6.00
25	1.15	1.80	2.50	4.00	5.25	7.00
50	1.35	2.10	2.75	4.50	5.75	8.00
100	1.55	2.40	3.00	5.00	6.50	9.00

Table 4. Rainfall (in) Depth-Duration-Frequency Data for Paso Robles.

	Duration (Hr)					
Frequency (Yr)	1	2	3	6	12	24
1	0.50	0.75	1.00	1.50	2.10	3.00
2	0.60	1.00	1.30	2.00	3.00	4.00
5	0.80	1.25	1.75	3.00	4.00	5.00
10	1.00	1.50	2.25	4.00	5.00	6.00
25	1.20	1.80	2.50	4.50	6.00	7.00
50	1.40	2.00	2.75	5.00	7.00	8.50
100	1.50	2.50	3.20	6.00	8.00	10.00

Figure 1

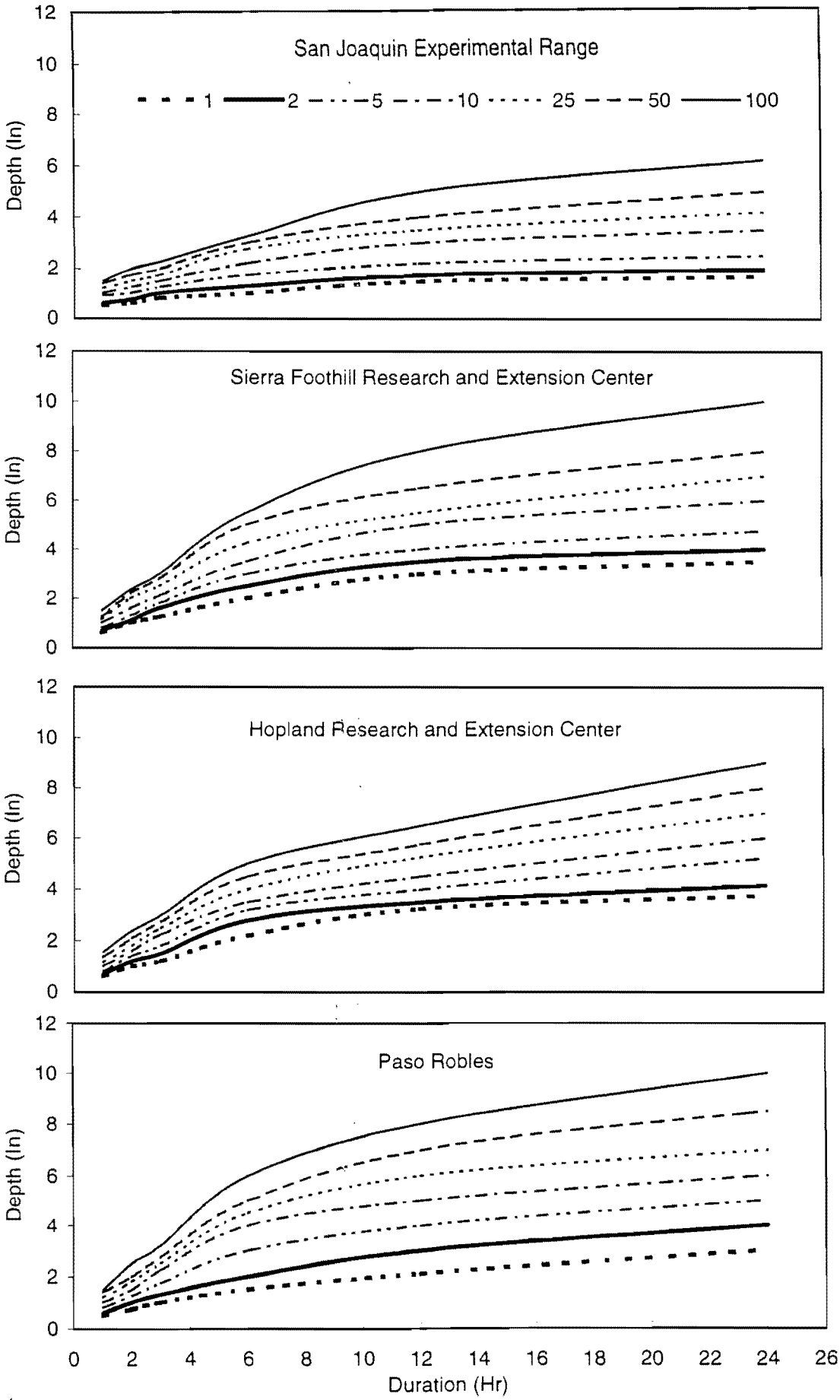
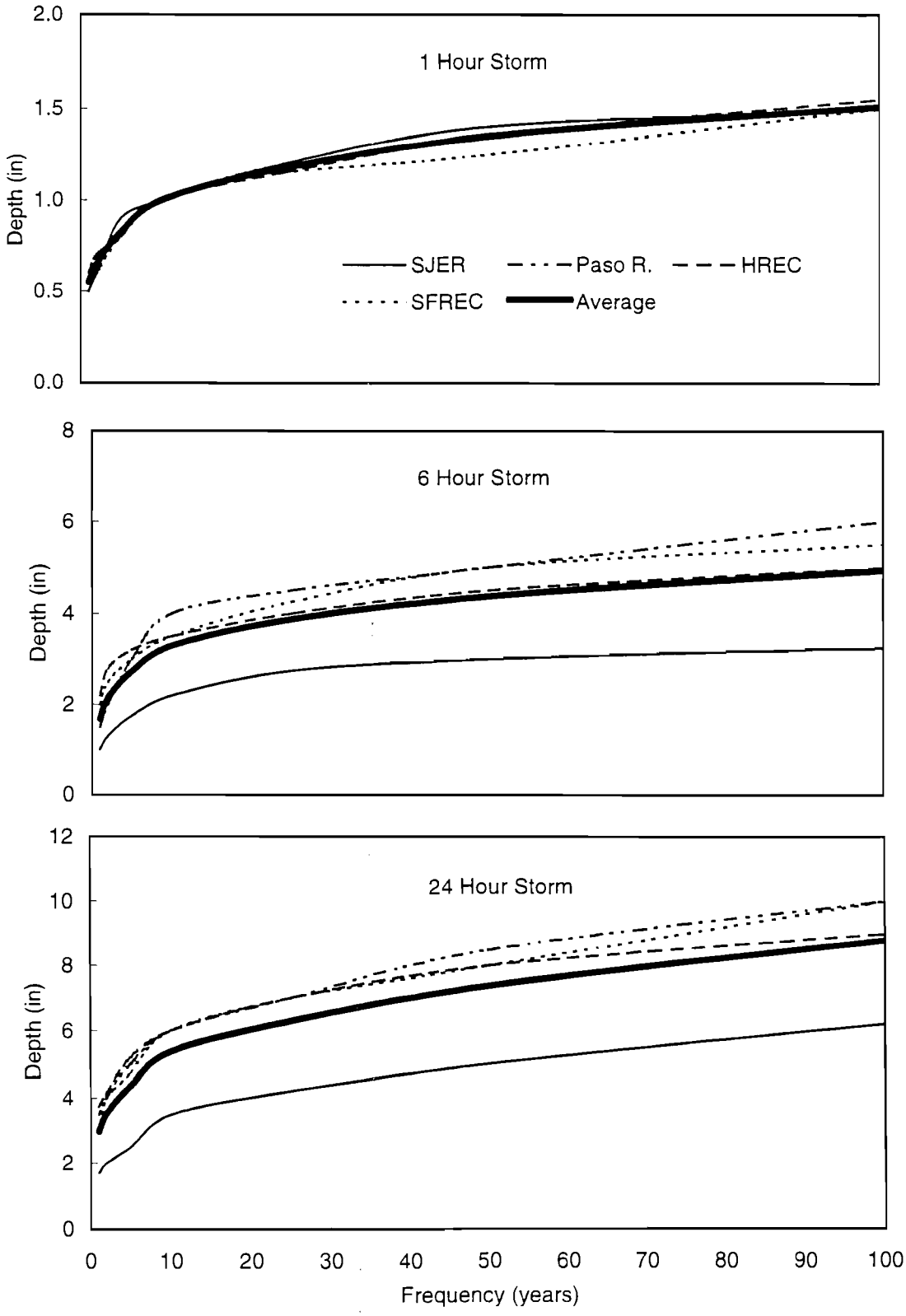

San Joaquin Experimental Range
1
2
5
10
25
50
100
Depth (In)
Sierra Foothill Research and Extension Center
Hopland Research and Extension Center
Paso Robles
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Duration (Hr)

Figure 2


1 Hour Storm
Depth (in)
2.0
1.5
1.0
0.5
0.0
SJER
Paso R.
HREC
SFREC
Average
6 Hour Storm
Depth (in)
8
6
4
2
0
24 Hour Storm
Depth (in)
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
90
100
Frequency (years)