Precipitation Characteristics for Landslide Hazard Assessment for the Central Oregon Coast Range

by

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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AN ABSTRACT OF THE THESIS OF

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Arne E. Skaugset, III and Marvin Pyles

Precipitation data from 1988-1995 for 13 rain gauges of the Department of Forest Engineering rain gauge network, and a longer precipitation record, 1976-1995, at Mapleton were analyzed. The objectives were to assess the spatial and temporal distribution of precipitation intensity and antecedent precipitation, and understand the role of these characteristics for triggering debris slides from headwalls in the central Oregon Coast Range.

Frequency distribution curves and recurrence intervals using a partial-duration series were calculated for the maximum 5-minute, 30 minute, 1 hour, 2 hour, 6 hour precipitation durations and antecedent precipitation index (API) for the rain gauge network and the maximum 1 hour and 2 hour precipitation durations for Mapleton. Isohyet lines showing selected 2-year precipitation intensities and API were used to characterize the spatial distribution of precipitation intensity and API across the central Oregon Coast Range. The effect of elevation on this spatial distribution was investigated.

An attempt to quantify the occurrence of high intensity precipitation occurring with high antecedent precipitation, which is hypothesized to trigger debris slides, was done by testing if the highest precipitation intensities (greater than a 1-year recurrence

interval) occurred during the storms with the highest API. API and precipitation intensity were tested for correlation to discern if a particular precipitation duration could be used to predict API, thus make it possible to use a precipitation intensity based threshold to assess the general hazard of landslides.

Precipitation intensities associated with selected recurrence intervals vary considerably over the study area. Precipitation values for selected durations and recurrence intervals could vary as much as 50% or larger for selected rain gauge locations. Precipitation intensities are higher in the central portion of the study area, centered around the ridges of the Siuslaw River watershed, with decreasing intensity toward the northern and southern boundaries possibly due to topographic influences. Higher API values are found more frequent where the high precipitation intensity spatial trends exists. Relationships between short duration precipitation intensities with elevation, and API with elevation, within the rain gauge network could not be determined.

No single precipitation intensity, including total storm precipitation, showed a strong positive correlation with high API for the entire rain gauge network. It appears that any attempts to predict the precipitation characteristics which trigger headwall failure by a precipitation intensity threshold in the central Oregon Coast Range is not possible. Attempts to assess the risk of headwall failure by high API may be possible. High precipitation intensities occurred with high antecedent precipitation conditions and they occur at the highest antecedent precipitation conditions.

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INTRODUCTION

High intensity precipitation which occurs in conjunction with high antecedent precipitation is hypothesized to trigger debris avalanches in headwalls of the central Oregon Coast Range. Rainfall varies greatly in the Coast Range depending on topography, location, and conditions within individual storms, but, little is known regarding the nature of the patterns of these storms (Froehlich, 1988). The interaction of storm paths from the Pacific ocean with the mountainous terrain of western Oregon influences the variability of precipitation amounts in the Coast Range. Differing wind, frontal movement, and terrain effects create areas which receive locally high precipitation while other areas receive appreciably less (Beschta, 1989). Substantial differences in precipitation amounts are common in mountainous terrain, yet, there have been no attempts to quantify these differences in the Oregon Coast Range. Precipitation information does exist and several agencies are increasing efforts to gather more information for the Coast Range. However data collection for these efforts have concentrated mainly along the periphery and at lower elevations (Froehlich, 1988).

In 1989, the Fundamental **C**oastal **O**regon **P**roductivity **E**nhancement (COPE) Program and the Department of Forest Engineering at Oregon State University (OSU) initiated a research project to measure precipitation intensity rates for the central Oregon

Coast Range and relate them to landslide activity (Froehlich, 1988). A network of precipitation intensity gauges was established to collect data for the project.

Precipitation intensity information is useful for many engineering and land management applications. Hydrologic models, road and stream crossing design criteria, and geotechnical assessment require precipitation intensity information. By knowing the characteristics of rainfall patterns and intensities forest resources managers can maintain and locate roads, better design stream crossings, estimate peak streamflows, and evaluate landslide hazards and erosion.

Precipitation information for the mountainous areas of the central Oregon Coast Range has not been previously available. This thesis presents a first analysis of the precipitation intensity of the central Oregon Coast Range based on the precipitation data from the Department of Forest Engineering precipitation intensity rain gauge network. The purpose of this analysis is to better understand the role precipitation plays in triggering debris flows.

The specific objectives of this thesis are to:

- Characterize the spatial and temporal distribution of precipitation intensities for the central Oregon Coast Range.
- Characterize the spatial distribution of antecedent precipitation, as expressed by an antecedent precipitation index, for the central Oregon Coast Range.
- Analyze the precipitation intensity and antecedent precipitation characteristics to better understand an hypothesized model that intense rainfall in conjunction with high

antecedent precipitation trigger debris flows in headwalls of the central Oregon Coast Range.

STUDY AREA

The study area is located in the central Oregon Coast Range. Fourteen rain gauges are located in a narrow band from the Umpqua River in the south to the Alsea River in the north (Figure 1, Table 1). The rain gauges span approximately 50 miles north to south and 20 miles east to west encompassing approximately 1000 square miles.

The climate and precipitation of the Oregon Coast Range is controlled by two systems: the North Pacific High to the south, and the Aleutian Low to the north. In the Northern Hemisphere the wind is from the west both along the northern margin of a high and the southern margin of a low. These westerly flows bring in moist marine air masses which are the predominant precipitation producers of the area (Schultz, 1990).

The other predominant climatic force in the Northwest is the cyclonic storms of winter in which moist subtropical air meets a cold polar front, the air ascends, pressure falls, winds rise, and high precipitation amounts can occur. The surface westerlies intensify to a steady 100 mile-per-hour "jet stream" that tends to drag the cyclones eastward. The result is not only high precipitation amounts, but also powerful winds (Shultz, 1990).

Precipitation in the Coast Range responds to an orographic effect; moist marine air rises over the range resulting in the highest annual precipitation amounts at the higher elevations (Daly et. al., 1993). Annual precipitation varies from 60 to 120 inches per year in the study area, with about 80-90 percent of the annual precipitation occurring from October until April.

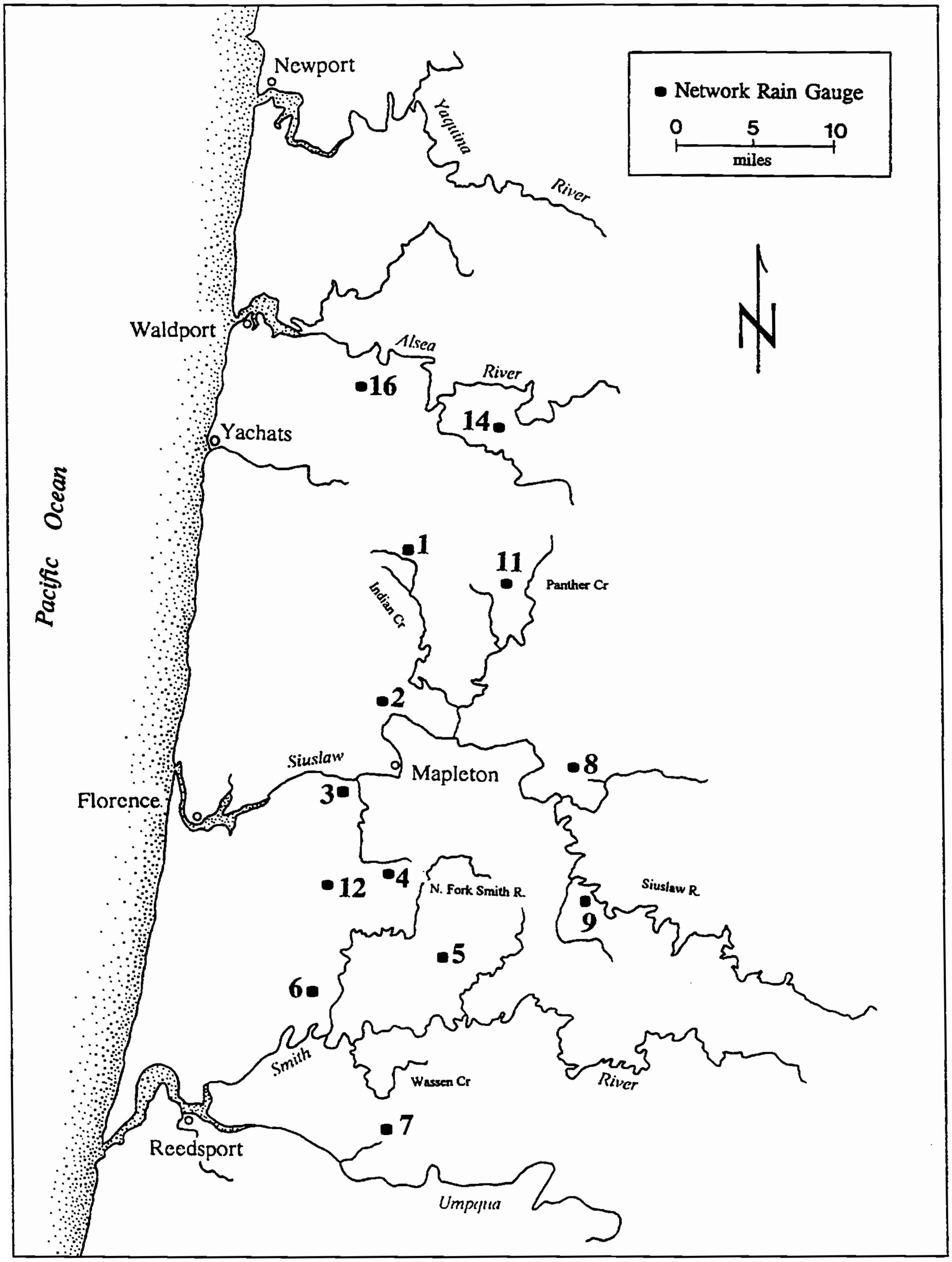


Figure 1. Study Area and Rain Gauge Locations
(for Rain Gauge Descriptions see Table 1)

Table 1. Rain Gauge Descriptions and Locations

Gauge #	Gauge Name	Location (*based on Williamette Meridian*)	Elev. (ft.)
1	Indian Creek	SE 1/4 SE 1/4 Sec. 35, T.15S., R.10W.	1040
2	Thompson Creek	NE 1/4 NW 1/4 Sec. 15, T.17S. R.10W.	780
3	Sweet Creek	SW 1/4 SW1/4 Sec. 17, T.18S. R.10W.	1040
4	South Canyon Creek	SW 1/4 NE 1/4 Sec. 15, T.19S. R.10W.	1640
5	Smith River	SW 1/4 SW 1/4 Sec. 5, T.20S. R.09W.	1220
6	Johnson Creek	NE 1/4 NE 1/4 Sec. 24, T.20S. R.11W.	760
7	Wassen Creek	SE 1/4 SE 1/4 Sec. 34, T.21S. R.10W.	1400
8	Kirk Creek	NE 1/4 SE 1/4 Sec. 3, T.18S. R.08W.	1400
9	Mill Creek	NW 1/4 NW 1/4 Sec. 23, T.19S. R.08W.	1000
11	Panther Creek	NW 1/4 NW 1/4 Sec. 12, T.16S. R.08W.	1120
12	Ryder Creek	SE 1/4 SW 1/4 Sec. 13, T.19S. R.11W.	800
14	Lobster Creek	NE 1/4 NE 1/4 Sec. 27, T.14S. R.09W.	1200
16	Cascade Creek	SW 1/4 SE 1/4 Sec. 29, T.14S. R.10W.	1000
	Mapleton	SE 1/4 Sec. 2. T.18S. R.10W.	40

Most large precipitation events occur as rain, during the winter. Snowfall is not a significant component of winter precipitation, except at the higher elevations. Transient snowpacks may contribute additional moisture to soils during rain-on-snow events, but landslide activity is customarily generated directly from large rainfall events (Beschta, 1989).

The topography of the central Coast Range is characterized by steep slopes (40-100%) and narrow valleys. Elevations vary from 100 feet above sea level at Mapleton to nearly 2,300 feet at the highest point in the study area at Saddle Mountain. Typical hillslopes are finely divided into small unchanneled valleys. An unchanneled valley typically consists of a headwall (hollow) which is bounded by ridges with relatively small side slope areas between the ridge and the headwall. Channels typically form below the headwalls which usually terminate between 30 and 100 meters downslope from the ridge (Dietrich, 1989).

The geology of the study area is composed mainly of older Cenozoic marine and estuarine sedimentary rocks with areas of intrusive igneous rocks. The rocks (sediments and volcanics) were laid down during the early Cenozoic era when the Coast Range and Williamette Valley was covered by a shallow sea. Uplift of the Klamath Mountains to the south brought an influx of sand into the basin. These sands spread out into graded beds, later uplift of this material formed the Coast Range (Baldwin, 1976).

Major geologic formations in the study area are the Tyee and Flourney sandstones. Both the Tyee and Flourney formations are composed of micaceous sandstone beds grading upward into siltstone. Distinction between the two formations is difficult and the contact is only approximately mapped between the Smith and Siuslaw Rivers (Baldwin, 1976).

Soils of the central Coast Range are poorly developed, gravely soils formed from colluvium and residuum derived from the sedimentary and igneous rocks of the area. The three predominant soil series are the Digger, Bohannon, and Preacher. The Digger soil series are Dystic Entrochrepts and are moderately deep, well drained soils derived from sandstone and siltstone. The Bohannon series are Typic Haplumbrepts which are deep, well drained soils derived from sedimentary rocks. The Preacher series are Typic Haplumbrepts which are deep, well drained soils derived from sedimentary rocks.

Vegetation of the central Coast Range consists primarily of conifer forest dominated by Douglas-fir (*Pseudotsuga menziesii*). Western hemlock (*Tsuga heterophylla*), and western red cedar (*Thija plicata*) are present, particularly along stream channels. Red alder (*Alnus rubra*) and big leaf maple (*Acer macrophyllum*) are other common species, generally occupying headwalls, lower slopes, and riparian areas. Understory vegetation includes sword fern (*Polysticum munitum*), vine maple (*Acer circinatum*), huckleberry (*Vaccinium ovatum*), rhododendron (*Rhododendron macrophyllum*), and salmonberry (*Rubus spectabillis*).

LITERATURE REVIEW

Headwalls

Headwalls (zero order basins or hollows) are relatively shallow depressions or concave portions of a slope at the head of incipient channels. The slope of the centerline of the depression ranges from 70 to 120 percent. The spoon shaped depression has no defined channel, but a channel typically forms at the lower end (Froehlich and Andrus, 1989).

Headwalls soils are typically colluvial deposits from slow erosion processes such as soil creep, ravel, windthrow and animal activity. Over time these colluvial deposits fill the headwall's concave depression. As the eroded material deposited in the headwall thickens landslides become more likely because the deposits provide greater mass and become deeper and wider facilitating greater groundwater capacity. After failure has occurred thin deposits can be firmly held by vegetation and the colluvial deposit can again accumulate to critical depth (Dietrich, 1989).

The concave shape of the headwall causes water from upslope subsurface flow to converge. These areas are more prone to develop perched water tables, pore pressures rise more rapidly and higher than other parts of the slope (Pierson, 1980; O'laughlin et. al., 1982; Harr, 1977). The increased height of saturation and accompanying increased pore pressure decreases the soil strength, which is an important triggering mechanism for slope failure (Beschta, 1989). Headwalls are prone to soil mass movements because of their tendency to accumulate groundwater during extreme rainfall and snowmelt events (Sidle, 1987).

A large portion of soil mass movements in the Coast Range that reach stream channels come from headwall failure (Swanson et. al., 1977; Ketcheson and Froehlich, 1978). Soil mass movements which reach stream channels benefit stream habitat by providing inputs of coarse substrate particles and large woody debris. However, an accelerated frequency of soil mass movements, caused from management actions, can adversely affect fish populations and water quality by altering riparian areas, increasing sediment in streams, and changing pool size and number (Froehlich, 1988). A better understanding of the failure potential of headwall areas could lead to management activities which reduce headwall failure risk.

Precipitation and Headwall Failure

Precipitation induced build-up of pore water pressure in hillslope material is widely recognized as a triggering mechanism for rapid, shallow landslides and debris slides (e.g.: Campbell, 1975; Caine, 1980; Reid et. al., 1988). An increase in pore pressure results from the development of a saturated zone that increases in thickness during large rainfall events in areas of convergent topography (such as headwalls) on steep slopes. If the height of the saturated zone extends above a potential failure surface, a decrease in soil shear strength occurs and the potential for slope failure is significantly increased (Beschta, 1989). The height and persistence of the saturated zone depends on the interaction of rainfall with subsurface flow rates (Sidle et. al., 1985). The subsurface flow rate is controlled by the slope steepness and the character of the soil on it (Campbell, 1974). Precipitation modeling efforts have shown that antecedent precipitation is often a significant variable in prediction of either stream runoff (Istok and Boersma, 1986; Fedora, 1987) or groundwater levels in steep hillslopes (Sidle, 1986; Bransom, 1997).

Debris avalanches occur in response to several precipitation characteristics which set them apart from other classes of landslides, such as rotational slumps and block glides. The latter, for example, depend more upon deep percolation of groundwater and may not respond to the effects of precipitation until long after a storm. In contrast, the shallow, headwall failures resulting in debris avalanches, occur during, and only during high intensity rainfall (Campbell, 1974).

Shallow-rapid slides, such as debris avalanches from headwall areas, generally occur during a single storm of either long duration, high intensity or rapid snowmelt. After extended dry periods, additional precipitation prior to an intense precipitation storm is required to generate the necessary antecedent precipitation conditions for soil mass movement (Sidle et. al., 1985). A threshold storm, defined solely on frequency and magnitude information, should not be expected to adequately index precipitation producing mass soil movements (Beschta, 1989). Rather, an assessment of antecedent precipitation along with precipitation frequency and magnitude is needed to assess the potential for mass soil movement.

Campbell (1975) described the precipitation conditions necessary to create debris slides. The conditions he describes are "an initial period of enough rainfall to bring the full thickness of the soil mantle to field capacity (high antecedent conditions),...followed by rainfall intense enough to exceed the infiltration rate of the parent material underlying the soil mantle, and lasting long enough to establish a groundwater table of sufficient thickness to cause failure."

One such use of combined antecedent precipitation and intense rainfall conditions to assess debris flow occurrence is suggested by the United States Geological Survey in the San Francisco Bay Region of California (Cannon and Ellen, 1985). In this region, Cannon and Ellen (1985) showed that greater than 10 to 15 inches of antecedent seasonal rainfall is sufficient to set the stage for debris slides. When large intense rain events closely follow sufficient seasonal antecedent rainfall, abundant debris avalanches occur. A threshold of precipitation characteristics for high landslide occurrence was developed from six large, intense storms on the basis of antecedent precipitation and average rainfall intensity. This threshold allows the USGS and residents of steep, landslide-prone slopes around San Francisco to assess seasonal precipitation characteristics so that times of high debris slide hazard can be predicted.

Other precipitation models have been developed to provide predictions of landslide occurrence. One approach developed a threshold relationship from mean rainfall intensity and duration of a particular storm (Caine, 1980). This method stated that if at any time during the storm the average rainfall intensity exceeds the threshold value (I) shown below then debris slides or debris avalanches are likely to occur.

Caine's Threshold: $\mathrm{I} = 14.82\left(duration(hrs)\right)^{-0.39}$

This threshold relationship may be improved if used in conjunction with rainfall intensity-duration-frequency relationships. The coupling of the two relationships may identify return periods for various combinations of precipitation intensity and duration likely to produce debris slides. A difficulty in the application of this technique is that the threshold is based on soil failures which have occurred with a minimum input of rainfall, i.e., presumably under nearly saturated antecedent conditions. Under dry conditions the rainfall threshold can be exceeded yet debris slides do not generally occur. Antecedent precipitation must be taken into account to index when the soil mantle has become saturated enough to influence slope failure. Further study of these difficulties is needed before this technique could be applied (Sidle et. al., 1985).

Another method for assessing the risk of landslide occurrence in relation to precipitation is a regional prediction model, developed in New Zealand, that takes antecedent rainfall and soil wetness into account (Crozier and Eyles, 1980). This model has considerable data requirements. The data requirements include a detailed history of landslides for the region with the timing of failure confidently assigned to specific dates, daily precipitation, mean temperature, mean windspeed, sunshine hours, and mean vapor pressure. In most landslide research or assessments the variables needed to operate the model are not available making this model ineffective to land managers.

Predicting the occurrence of landslides for a specific site is not generally feasible in landscapes where mass movements are frequent and widespread, such as the Oregon Coast Range. However, prediction of the general hazard of occurrence is possible and useful (Sidle et. al., 1985). The actual timing of failure should be dependent on site conditions and stochastic variations in rainfall with certain combinations of antecedent precipitation and precipitation intensity required for failure (Reneau and Dietrich, 1987).

METHODS

This section presents the methods used to develop the precipitation characteristics which can affect landslide hazard in the central Oregon Coast Range. The Methods section is divided into sub-sections relating to each individual procedure or technique which was used to produce the results. Background information is also provided for the various techniques.

Precipitation Collection

The precipitation data was collected with 13 rain gauges maintained by the Forest Engineering Department of Oregon State University. Data collection began in the Fall of 1988 and has continued through the present. The record length used for analysis is from the date of installation until April, 1995. Only 8 of the rain gauges were installed in 1988, and the remaining 5 rain gauges were added in subsequent years (Table 2). This precipitation database is supplemented by a rain gauge located in Mapleton maintained by the Oregon Climate Service. The Mapleton rain gauge record extends from 1975 until the present, providing a longer term record for the area.

The 13 rain gauges maintained by the Forest Engineering Department are tipping bucket rain gauges manufactured by Sierra Misco, Inc. The tipping bucket rain gauges are standard 8 inch diameter gauges with each bucket tip representing 0.01 of an inch of precipitation. Precipitation data from the rain gauges was recorded on Omnidata

Table 2. Rain Gauge Data Type and Start Date

#	Gauge Name	Type of Data	Record Began
1	Indian Creek	Time recorded every 0.04" precipitation	Dec. 1988
2	Thompson Creek	Time recorded every 0.04" precipitation	Oct. 1988
3	Sweet Creek	Time recorded every 0.04" precipitation	Oct. 1988
4	South Canyon Creek	Time recorded every 0.04" precipitation	Oct. 1988
5	Smith River	Time recorded every 0.04" precipitation	Oct. 1989
6	Johnson Creek	Time recorded every 0.04" precipitation	Dec. 1988
7	Wassen Creek	Time recorded every 0.04" precipitation	Oct. 1988
8	Kirk Creek	Time recorded every 0.04" precipitation	Oct. 1988
9	Mill Creek	Time recorded every 0.04" precipitation	Oct. 1988
11	Panther Creek	Time recorded every 0.04" precipitation	Sept. 1989
12	Ryder Creek	Time recorded every 0.04" precipitation	Sept. 1989
14	Lobster Creek	Time recorded every 0.04" precipitation	Oct. 1990
16	Cascade Creek	Time recorded every 0.04" precipitation	Oct. 1990
	Mapleton	Hourly Precipitation (0.1" resolution)	1976

Datapod event recorders. The Datapod records the date and time at which each 0.04 of an inch of precipitation had accumulated.

The Omnidata event recorders were used on the rain gauges until the Spring of 1995. In 1995, the event recorders were replaced by Unidata Starlogger dataloggers, which are currently in use. The Starlogger dataloggers store data in electronic memory. The data is periodically down-loaded to a lap-top computer with the appropriate Starlogger software. The major change with the use of the Starlogger dataloggers is that date and time is recorded for every 0.01 inch of precipitation, compared to 0.04 of an inch recorded by the Omnidata event recorders. By recording the date and time of every 0.01 of an inch of precipitation greater precision in precipitation intensity measurement is provided for future analysis.

The primary purpose of the Forest Engineering Department rain gauges is to collect precipitation intensity data. By recording the date and time that precipitation occurs, an accurate record of precipitation intensity is observed. The rain gauge record from the Mapleton gauge, maintained by the Oregon Climate Service, records hourly precipitation to a resolution of 0.1 of an inch. This data does not provide the accuracy in precipitation intensity that the Forest Engineering Department rain gauges provide. However, it is the only long term record of precipitation intensity in the area and is useful in some limited comparisons.

Precipitation Gauge Maintenance

Throughout the period of record the precipitation gauges required periodic maintenance and service. Table 3 lists the maintenance schedule I followed. I suggest that this schedule be continued throughout the future precipitation record collection for the Department of Forest Engineering Rain Gauge Network.

Maintenance and care of a long term, rain gauge network entails service by different people over time. The key to keeping high quality maintenance and gauge operation is proper communication among the different people servicing the gauges. A maintenance record and gauge log must be kept for the rain gauge network with complete notes and dates of maintenance recorded. This record must be passed along and understood by all people servicing the gauges over time.

Table 3. Precipitation Gauge Maintenance Schedule

Type of Maintenance	Activity	Frequency
Download of precipitation record from dataloggers	Site visit	Every 1-2 months in Fall/Winter Every 3 months in Spring/Summer
Inspect gauges -levelness -funnel clear of debris -tipping bucket operating and being recorded by datalogger	Site visit	Every 1-2 months in Fall/Winter Every 3 months in Spring/Summer
Inspect dataloggers -batteries have adequate charge -datalogger clean and dry -electrical connections seated	Site visit	Every 1-2 months in Fall/Winter Every 3 months in Spring/Summer
Replace datalogger batteries and desiccant material	Site visit	Annually
Clear brush and trees away from gauges	Site visit	Annually (preferably in Spring)
Adjust tipping bucket to proper measurement amount (0.01")	Bring into lab	Bi-annually , or as needed
Calibrate gauge to varying precipitation intensities	Bring into lab	Prior to any record analysis
Replace precipitation gauges and dataloggers	Site visit	Every 5-10 years as equipment wears out

Precipitation Gauge Calibration

Two methods of tipping bucket rain gauge calibration are commonly used, static and dynamic. In the static calibration method, the rain gauge is leveled and the stop under the bucket is adjusted until application of a specified volume of water causes the bucket to tip (Humphrey et. al., 1996). This procedure is repeated several times with the stop beneath the bucket adjusted such that the bucket tips in correspondence with the volume of water representative of a depth of precipitation (in this case 0.01 inch of precipitation). The static calibration should be done frequently (about every 1-2 years) on tipping bucket rain gauges to ensure proper bucket stop adjustment of the rain gauges.

Static calibration methods assume that the bucket tip volumes are independent of precipitation intensities. The mechanical motion of the tipping buckets are such that the buckets often cannot reposition themselves fast enough after a tip to collect all of the rainfall entering the gauge (referred to as "undercatchment") and results in underestimation of rainfall intensities (Humphrey et. al., 1996). Dynamic calibration methods attempt to account for undercatchment by calibrating the tipping bucket rain gauge while the buckets are in motion. In dynamic calibration, recorded rain gauge rates are compared to actual rainfall rates artificially created from applied flow rates (Humphrey et. al., 1996).

An automated system that dynamically calibrates tipping bucket rain gauges has been developed by Humphrey et. al. (1996). This system calibrates the rain gauges by interfacing them to a computerized pump, datalogger, balance, and computer (Humphrey et. al., 1996). Output from this system provides correction factors for varying precipitation intensities which can be applied to actual field data.

The automated dynamic calibration system (Humphrey et. al., 1996) is performed in two steps: 1) pump calibration and 2) rain gauge calibration. Up to 10 delivery rates can be selected to bracket expected precipitation intensities in the field. Pump calibration ensures precise control of water flow rates delivered to the rain gauge funnel. Rain gauge calibration then takes that precise water flow rate from the pump and runs it through the rain gauge. The resulting bucket tip times observed versus expected bucket tip times for the precise water flow rate provides the amount of variation the tipping bucket rain gauge experiences for the selected rate.

The automated dynamic calibration system (Humphrey et. al., 1996) was used on all of the Department of Forest Engineering rain gauges. All of the gauges were removed from the field during the summer of 1995 for calibration. Five delivery rates were selected which meet and slightly exceed Oregon Coast Range rainfall intensities: 0.25 inch/hour, 0.5 inch/hour, 0.75 inch/hour, 1 inch/hour, and 2 inch/hour.

The resulting calibration curves were used to adjust the actual record of precipitation for the Forest Engineering Department rain gauges. A linear relationship was assumed between the observed calibration rates. An example calibration curve for one of the calibrated rain gauges, Cascade Creek rain gauge, is shown in Figure 2. The calibration adjustments for each of the 5 precipitation intensities rates used in the dynamic calibration are summarized in Table 4.

The percentage adjustments in the preceding table (Table 4) typically vary from about -4 percent to nearly 8 percent. Two of the gauges, Lobster and Cascade Creeks, experienced higher calibration errors. The Cascade Creek gauge was in error as much as 13.5 percent and the Lobster Creek gauge had errors as high as 29 percent. In both cases the stop beneath the tipping buckets, which regulates when a bucket tips, was out of adjustment. The question with these two gauges was how long were the tipping buckets out of adjustment? Once this was determined then only that period of time would be adjusted by the calibration percentages.

Figure 2. Typical Calibration Curve for a Dynamic Calibration, Cascade Creek Rain Gauge

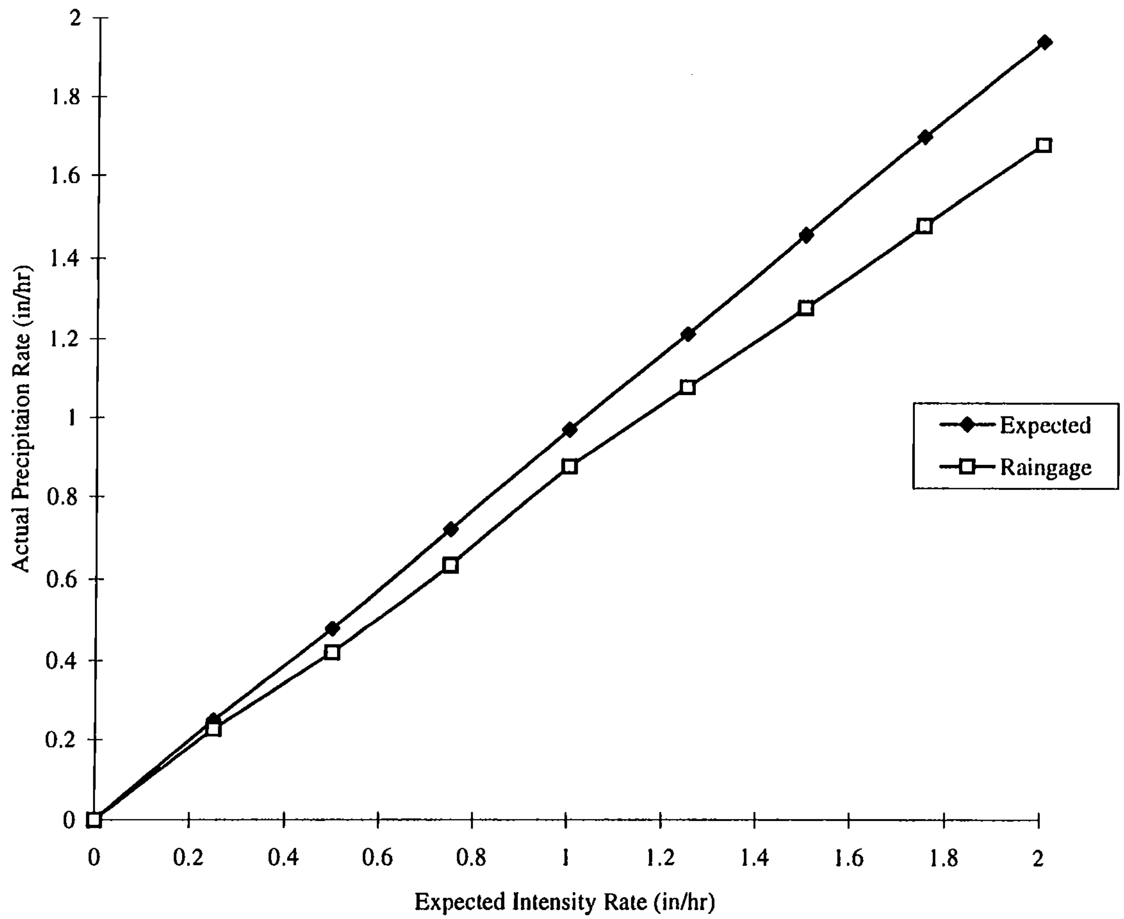


Table 4. Percentage of Adjustment for Each Calibration Rainfall Intensity for the Forest Engineering Rain Gauges, 1995 (percentage of adjustment is the amount the actual field data was increased or decreased according to the rainfall intensity)

		Calibration Rainfall Rate				
Gauge #	**Gauge Name**	**0.25 in/hr**	**0.5 in/hr**	**0.75 in/hr**	**1 in/hr**	**2 in/hr**
1	Indian Creek	-1.30%	3.80%	2.70%	4.40%	3.80%
2	Thompson Creek	7.90%	3%	4.10%	7.50%	6.10%
3	Sweet Creek	0.70%	4.70%	4.20%	2.90%	7.30%
4	South Canyon	-0.02%	1.40%	0.50%	1.70%	4.60%
5	Smith River	2.70%	6.30%	5.20%	6.60%	7.90%
6	Johnson Creek	5.10%	8%	6%	6%	7.30%
7	Wassen Creek	1.60%	-2.60%	0.60%	0.80%	4.60%
8	Kirk Creek	7.90%	3.90%	4.90%	6.60%	7.10%
9	Mill Creek	6.40%	1.80%	3.90%	4.10%	7%
11	Panther Creek	0	4.30%	-1.40%	-2.20%	1.60%
12	Ryder Creek	-4.50%	1.10%	8%	5.90%	5.90%
14	Lobster Creek	26.50%	28.60%	29%	29.30%	27.90%
16	Cascade Creek	9%	12.40%	11.90%	9.50%	13.50%

Both rain gauges were compared to adjacent rain gauges and a relationship between monthly precipitation totals were compared using a double mass curve analysis. In both cases the Lobster and Cascade Creek rain gauges had excellent relationships with adjacent rain gauge records. No deviation of the double mass curve was observed which led to the assumption that the tipping buckets were out of adjustment for the entire period of record.

The calibration percentages shown here (Table 4) are applicable only to the data record from 1988 until 1995. The rain gauges had static calibrations performed on them prior to returning them to the field in the summer of 1995. Each gauge's tipping buckets were adjusted during this static calibration. These gauge adjustments negate the future use of the dynamic calibration percentages presented in this thesis. For future analysis it is suggested that another dynamic calibration be performed and those new adjustment calibrations be used on that data record.

During the summer of 1995, four new rain gauges were installed in the rain gauge network to replace aging and worn gauges. In the next 5 years, or as necessary, the remaining rain gauges will need to be replaced due to normal wear. To determine the best investment for future gauges, two types of rain gauges were purchased. The first type was a Qualimetric tipping bucket rain gauge retailing for about $600 per gauge. The second type was a lower cost gauge made by Fluid Isolation Technology, Inc., retailing for $350 per gauge.

To determine which gauge is most cost effective, the durability and accuracy of the gauges will be observed over time. To assess accuracy of the four gauges a dynamic calibration was performed prior to placing the gauges in the field. The results of this calibration is summarized in Table 5. Future dynamic calibrations of these gauges should be compared to these initial calibration results.

Table 5. Initial Calibration Deviation Percentage for Four New Rain Gauges (Percentages indicate amount rain gage deviated from a controlled intensity flow rate)

Description		**Controlled Intensity Rate**				
Gauge Type	Location in Field	.25 in/hr	.5 in/hr	.75 in/hr	1 in/hr	2 in/hr
Fluid Isolation	Smith River	2%	4%	4%	4%	3%
Fluid Isolation	Indian Creek	-5%	-5%	-4%	0	1%
Qualimetrics	Cascade Creek	18%	20%	19%	22%	17%
Qualimetrics	Sweet Creek	10%	11%	12%	11%	12%

Initial calibration information for the four new rain gauges (Table 5) provides insight into the importance of dynamic calibration of tipping bucket rain gauges. Even with high quality factory calibrated rain gauges, collection rates of the gauges can be substantially different from actual applied rates. The Qualimetric rain gauges, the most expensive, had the largest deviation from the control rate, while the Fluid Isolation Technology gauges had lower errors. The large errors are not a problem provided they are identified, by a dynamic calibration such as was done on these gauges, and the data collected from these gauges corrected according to that dynamic calibration.

Precipitation Data

The parameters of interest from the precipitation record were the maximum, short duration precipitation intensities and the antecedent precipitation conditions. A Qbasic program was developed to correct the precipitation data according to the dynamic calibration, isolate each storm event for each rain gauge, and determine the maximum 5 minute, 30 minute, 1 hour, 2 hour and 6 hour precipitation intensities and the total storm precipitation for each storm. This Qbasic program was called PRECIP and the code is found in Appendix C.

Dynamic calibration information was used to correct the precipitation data. For each rain gauge, a percentage of under- or over-catchment for the five calibrated delivery rates (0.25 inch/hour, 0.5 inch/hour, 0.75 inch/hour, 1 inch/hour and 2 inch/hour) was determined. PRECIP prompted the user to input the percentage difference for each of the calibrated delivery rates. PRECIP calculates the time difference between each 0.04 inches (the rate at which the precipitation record was collected) of precipitation then divides that time interval by 0.04 inches. The resulting precipitation intensity value for that time period was adjusted by the percentage of under- or over-catch for the closest corresponding calibration delivery rate. For example, if the corresponding intensity from the precipitation data had a value of 0.8 inches/hour then the calibration percentage for the delivery rate of 0.75 inches/hour was closest and was applied.

The adjusted precipitation data from the dynamic calibration is then divided into storms by PRECIP. The storms were separated based on a 6 hour break in measured precipitation. This time separation was determined from study of the long term precipitation record at Mapleton and this study's objective of observing short duration precipitation intensity. Clusters of hourly precipitation (hourly precipitation a minimum of 4-6 hours in duration) in the Mapleton data were typically isolated by breaks in precipitation greater than or equal to 6 hours. The objective of this thesis leads to characterization of short duration precipitation intensities, defined as durations shorter than six hours, a six hour break in precipitation was all that was necessary.

For each storm PRECIP calculates the maximum precipitation intensities. Maximum precipitation intensities for 30 minute, 1 hour, 2 hour, and 6 hour durations were used because these are commonly published durations and allow comparison with other areas. A precipitation intensity shorter than a 30 minute duration was of interest to understand the role of brief intense rainfall in storms. The duration chosen was 5 minutes.

The 5 minute intensity duration was chosen after analyzing the 5 minute, 10 minute, 15 minute and 20 minute maximum intensities for one rain gauge record, Wassen Creek. The Wassen Creek rain gauge was used because it is the only rain gauge with a complete record for the entire period of precipitation collection. The 5 minute, 10 minute, 15 minute and 20 minute intensities were tested for correlation with the top 100 antecedent precipitation index (API) events and the top 100 one hour intensity events (a commonly measured short duration intensity) of the Wassen Creek record. All of the precipitation intensities showed similar correlation coefficients with the top 100 API and one hour intensity events (Table 6). The mean of the 5 minute, 10 minute, 15 minute and 20 minute durations for these top 100 events were compared to the mean of the maximum one hour precipitation intensities (Table 6). The mean value of the 5 minute intensity was 26% of the mean one hour intensity value for the top 100 API events, and 23% of the mean one hour intensity value from the top 100 one hour events. The 5 minute duration represented the highest proportion of precipitation on an hourly basis compared to the other durations (i.e. 26 percent at 5 minutes proportions to 312 percent at one hour, while

55 percent at 20 minutes proportions to 165 percent at one hour). Furthermore, the fact that the mean 5 minute intensity represented around one quarter of the mean one hour intensity for the largest storm events is rather spectacular and warranted further study.

Table 6. Correlation Coefficients for the 5 Minute, 10 minute, 15 Minute and 20 Minute Intensities and the Top 100 API and Top 100 One Hour Intensity Storm Events and Percentage of the Mean One Hour Intensity for Wassen Creek Rain Gauge.

	5 Minute	10 Minute	15 Minute	20 Minute
Correlation with API	.28	.26	.28	.3
Correlation with One Hour Intensity	.12	.1	.09	.12
Percentage of One Hour Intensity for Top 100 API Events	26%	35%	44%	55%
Percentage of One Hour Intensity for Top 100 One Hour Intensity Events	23%	31%	39%	48%

In addition to the maximum intensities PRECIP determined the duration, total precipitation, and start time for each storm. The entire record for the rain gauge network was processed with PRECIP. The resulting output was put in tabular form by storm for comparison and analysis.

Antecedent Precipitation Index

An antecedent precipitation index (API) was used to quantify the antecedent moisture conditions for each storm. An antecedent precipitation index assigns a different weight to precipitation occurring prior to a storm than precipitation during the storm. The different weights for the precipitation from previous storms and the current storm lends itself to an interpretation of sequential storm event timing and the soil moisture conditions associated with the current storm.

Antecedent precipitation index has been used as a predictor of storm runoff (Fedora, 1987; Istok and Boersma, 1986), groundwater levels in hillslopes (Sidle, 1986; Bransom, 1997), soil macro-pore discharge (Ziemer and Albright, 1987) and soil thresholds for landslide assessment (Crozier and Eyles, 1980). The antecedent precipitation index is used in this study to represent the sequential storm event timing and relative soil moisture conditions for each rain gauge location. A recession coefficient (C) is used to decay the importance of individual rainfall observations through time to formulate an antecedent index at any time (API_t) (Fedora, 1987) (Equation 1).

$$API_t = API_{t-\Delta t} * C + P_t \qquad (1)$$

Where:

API_t = Antecedent Precipitation Index at time t (inches).

$API_{t-\Delta t}$ = Time interval of precipitation observations (hours).

C = Recession coefficient (dimensionless).

P_t = Precipitation volume during one Δt ending at time t (inches).

Values of API at any time are dependent on all precipitation occurring prior to that time. Observations of precipitation during a time interval, Δt, contribute fully to the API value, while previously fallen precipitation is decayed through time. API at any time considers completely that precipitation which occurred during the most recent time interval, a partial consideration of precipitation that has fallen a short time ago, and only slight consideration of precipitation that occurred a long time ago (Fedora, 1987).

Variation in the amounts and timing of precipitation raise or lower the API; higher API values occur when greater precipitation amounts occur over a long time period. For this reason, API is a good indicator of the magnitude and timing of storms which influence soil moisture, triggering landslides.

Equation 1 can only be used when the time interval of precipitation observations and the time interval used to derive the recession coefficient are equal. The equation can be adjusted for any time interval of precipitation observations or any time interval of soil water drainage observations used to derive C (Fedora, 1987) (Equation 2).

$$C(a) = C(b)^{(\Delta t(a)/\Delta t(b))} \qquad (2)$$

Where:

C(a)	=	Recession coefficient based on time interval Δt(a).
C(b)	=	Recession coefficient based on time interval Δt(b).
t(a)	=	Time interval of precipitation observations.
t(b)	=	Time interval used to derive recession coefficient.

Equation 2 becomes:

$$API_t = API_{t-\Delta t} * C(a) + P_t \qquad (3)$$

The precipitation data used in this study was collected at variable time intervals. Because of this variable time interval equation 3 was used to predict API for all of the rain gauge records.

The decay coefficient C(b) was determined from piezometric well observations from a representative Coast Range headwall site (Bransom, 1997). Bransom's values for C(b) were determined to be between 0.99 and 0.985, based on hourly observations. This value varied by storm and hillslope position (Bransom, 1997). A decay coefficient of

0.985 was used in this study because it is the lowest value, providing a more conservative analysis. The variability in decay coefficients observed by Bransom (1997) emphasize the fact that API values are not absolute values of soil moisture conditions over the entire Coast Range. They must be interpreted as an index of site factors which can influence soil moisture and will vary according to soil properties, geology, and topography.

API was calculated for each 0.04 inches of precipitation using equation 3 with a decay coefficient of 0.985. API was reset to zero at August 1 due to low summer precipitation. When the precipitation record was interrupted at a gauge, due to equipment maintenance or malfunction, the API from the nearest adjacent gauge was used to begin the API calculations for the interrupted record. API decays so rapidly with 0.985 decay, by hour, that a weighted relationship between adjacent gauges was not considered necessary for API calculations after an interruption of gauge precipitation collection.

A Qbasic program was developed that isolated each storm for each rain gauge and the corresponding maximum API for that storm. The isolation of storms used the same algorithm for storm isolation as PRECIP, thus producing the maximum API for storms which PRECIP had calculated precipitation intensities for. This Qbasic program was called API and the code is in Appendix C.

Frequency Analysis

Frequency analysis was performed to assess the temporal variation of precipitation intensities and antecedent precipitation. Frequency analysis provides a method by which the uncertainty in hydrologic data may be quantified and presented in a standard probabilistic framework (Bedient and Huber, 1992). Natural hydrologic phenomena are highly variable and stochastic in nature, therefore amenable to statistical interpretation and probability analysis (Chow, 1964).

Frequency analysis consists of establishing a frequency distribution that fits a random sample in a data series. A theoretical distribution for the population of events is established and the statistical parameters of that distribution are computed from the sample data (Kite, 1977). The probability distribution allows the prediction of the probability of exceedance of hydrologic events both within and outside the range of the data being used. Most of the frequency distributions used in hydrologic analysis can be represented by equation 4 (Chow, 1964):

$$Q_p = \overline{Q} + \sigma_p * K \qquad (4)$$

Where: Q_p = event that will be exceeded by with a probability, p.

$\overline{Q}$ = mean of the sample data series.

σ_p = standard deviation of the sample data series.

K = frequency factor for probability, p, from the distribution used.

Random hydrologic variables, such as precipitation intensity or API values, can be used to predict the required design variable (i.e. the 50 year event) from a frequency analysis in two ways. These are the annual series and the partial-duration series (Kite, 1977).

An annual series takes the largest event from each year of the record. A disadvantage of the annual series is that the second or third, etc., largest events in a particular year may be larger than the maximum event in another year and yet be totally disregarded. In the partial-duration series method, all events above a base threshold are included in the analysis. This threshold is generally selected such that at least one event in each year is included. Each event included in the partial-duration series must be separate and distinct, i.e.; including two consecutive daily hydrologic events caused by the same storm is not valid (Kite, 1977).

The recurrence interval of events, defined by a partial-duration series, is the average length of time between events. This interval is probabilistic and contains no inference of periodicity. The recurrence intervals of an annual series and partial-duration series have different meanings. In the annual series the recurrence interval represents the average number of years between the occurrence of an event of a given magnitude (Kite, 1977). In the partial-duration series the recurrence interval represents the average number of events occurring annually. For example, if on average there are 3 events per year in the partial-duration series, then each recurrence interval would represent 0.33 years. Yet in any given 0.33 year period the probability of a event occurring is not going to be the same. In the summer when there is little precipitation the probability of the event occurring would be lower. The recurrence interval in a partial-duration series does not represent the probability of an event occurring in any given period of time, but represents the probability of the average number of events occurring over a year. To express the partial-duration series data on an annual basis the recurrence interval is divided by the average number of events in a year in the partial-duration series. Though the recurrence interval is expressed on an annual basis, any particular event may not be that annual maximum.

The decision to use a partial-duration or an annual series depends on the use to which the frequency analysis will be put. Some types of designs, for example erosion protection works, are susceptible not particularly to one peak event but more to closely repeated high events and so a partial-duration series analysis might be more suitable. If the design event is likely to have low recurrence interval, then again the partial-duration series may be more suitable because of the smaller recurrence interval than the annual maximum series (Kite, 1977).

In this project a partial-duration series was selected because landslide occurrence associated with high antecedent precipitation and high precipitation intensity are likely to occur from events that happen more than once a year or occur closely together. The short data record also required a partial-duration series be used to increase the number of events for statistical interpretations. The base threshold for the partial-duration series was the smallest annual maximum event from the record of each individual rain gauge.

A partial-duration series compared to an annual series of the same data set yields different results. This difference must be considered when interpreting the frequency analysis information. A theoretical relationship between the partial-duration and the annual series (Chow, 1964) and their recurrence intervals are compared in Table 7 (Dalrymple, 1960). The difference between the annual and partial-duration series amounts to about 10% when the recurrence interval is 5 years and about 5% when the recurrence interval is 10 years. The distinction is only of importance at low recurrence intervals.

Table 7. Comparison of Recurrence Intervals for Annual and Partial-Duration Series (Dalrymple, 1960).

Recurrence Intervals (years)	
Partial-duration	Annual Series
0.5	1.16
1	1.58
1.44	2
2	2.54
5	5.52
10	10.5
20	20.5
50	50.5
100	100.5

Distribution Fit

To test the best fit of a probability distribution to the precipitation data the Kolmogorov-Smirnov Test (K-S test) and a graphical comparison were used. Developed in 1933, the K-S test is a goodness of fit test used for assessing distribution fit. The test statistic, D_n, is based on deviations of the sample distribution function P(x) from the completely specified continuous hypothetical distribution function $P_o(x)$, such that:

$$D_n = \max \left| P(x) - P_o(x) \right| \tag{5}$$

The values of P(x) are obtained as n_j/n where n_j is the cumulative number of sample events at probability density function class limits j, and n is the total number of events. $P_o(x)$ is then 1/k, 2/k, etc. where k is the number of class intervals. The test requires that the values of D_n computed from the sample distribution be less than the tabulated value of D_n at the required confidence intervals (Kite, 1977). The distribution which has the smallest D_n, below the tabular values of D_n at the required confidence interval, is considered the distribution which best fits the data.

This test was performed using the statistical software package Statgraphics by Statistical Graphics Corporation, which tests 18 separate probability distributions for goodness of fit. One other probability distribution was tested, which was not included in Statgraphics, the Extreme Value Type I Distribution (Gumbel, 1958). To test goodness of fit of the data to the Extreme Value Type I Distribution a graphical comparison was used. The data fitted to the Extreme Value Type I Distribution was compared graphically to the same data fitted to the distribution selected from the K-S test analysis (Figure 3).

The long term record from the Mapleton rain gauge record was used to analyze the goodness of fit. This long term record was assumed to have a frequency distribution representative of the study area. The frequency distribution chosen from the Mapleton record by the K-S test was checked for goodness of fit with a sample of other rain gauge records to ensure that the distribution was appropriate for the rain gauge network.

The results of the K-S test showed a lognormal distribution to best fit both the Mapleton rain gauge and a sample of rain gauges from the rain gauge network. To provide a more accurate fit to the lognormal distribution, a skew coefficient (C) was used from the Log Pearson Type III distribution:

$$C = \frac{n\sum(\log Q_{peak} - \overline{\log Q_{peak}})^3}{(n-1)(n-2)(\sigma_{\log Qpeak})^3} \quad (6)$$

Where: Q_{peak} = The precipitation intensity or API series being analyzed.

The frequency factor (K) for the distribution was selected based on the data's skew coefficient (C). A graphical comparison of the Log Pearson Type III distribution and the Extreme Value Type I distribution showed the Extreme Value Type I distribution fit the precipitation data the best (Figure 3). Plotting positions for the graphical comparison were calculated using Gringorton's equation (Equation 7):

$$p = \frac{m-a}{n+1-2a} \quad (7)$$

Where: p = Probability of exceedance

m = Rank of the peak flow event.

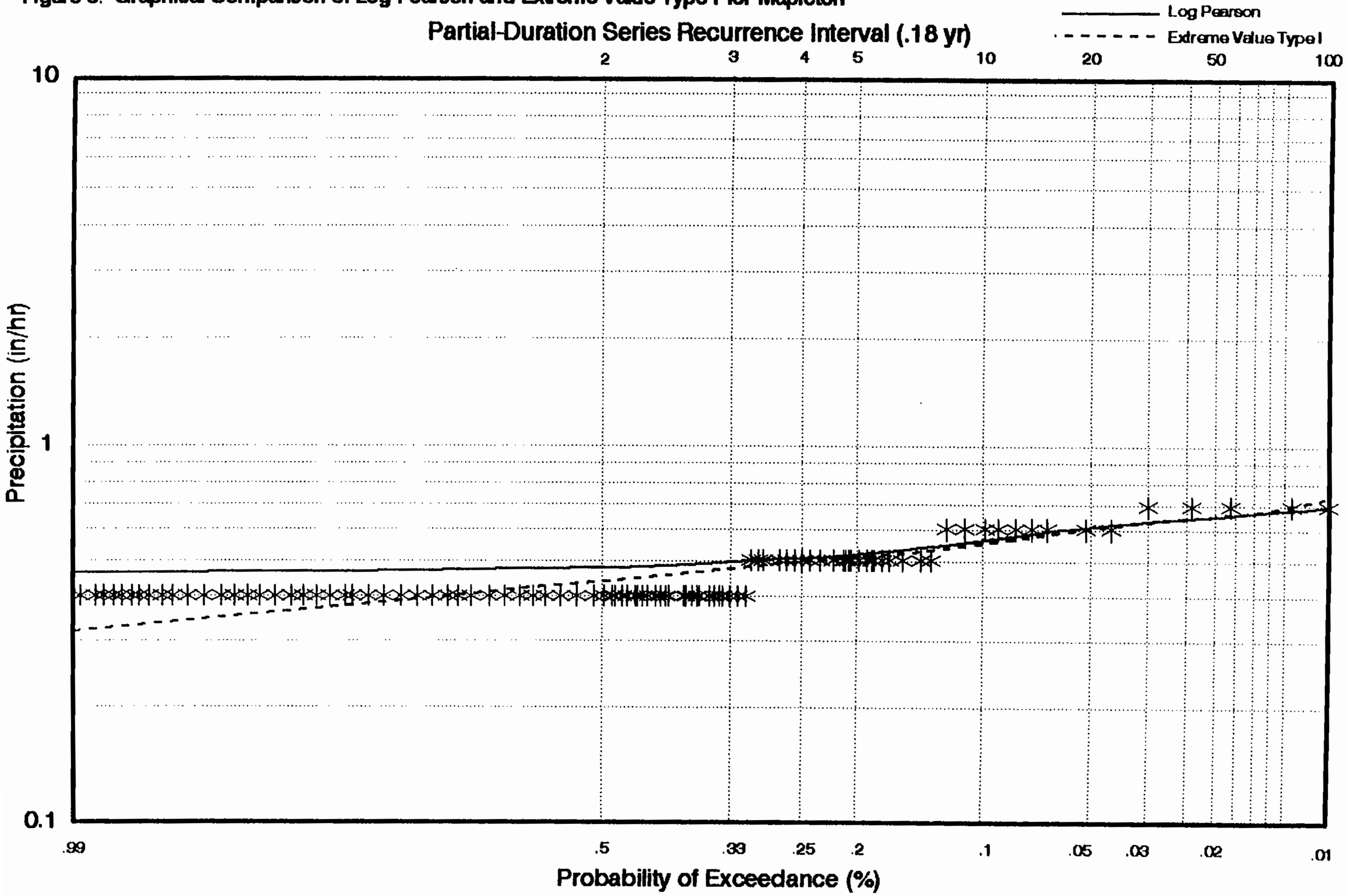
n = Number of events in record.

a = Distribution coefficient

(0.375 for lognormal, 0.44 for the Extreme Value Type I Distribution).

The Extreme Value Type I distribution was selected for the frequency distribution of the precipitation data for this study. The probability of exceedance of precipitation intensity and antecedent precipitation were calculated using equation 4 (Chow, 1964).

Figure 3. Graphical Comparison of Log Pearson and Extreme Value Type I for Mapleton



The frequency factor (K) for the Extreme Value Type I distribution for that equation is calculated by equation 8 (Bedient and Huber, 1992):

$$K = -0.7797\{0.5772 + \ln(\ln(T/T-1))\} \quad (8)$$

Where: K = Frequency factor for the Extreme Value Type I distribution.

T = Return interval.

Frequency curves were developed for each of the rain gauges using the Extreme Value Type I distribution. The Extreme Value Type I distribution frequency curves plot as a straight line on "Gumbel probability paper". The template for the "Gumbel probability paper" is made following the instructions in Powell (1943).

Precipitation Characteristics for Landslide Hazard Analysis

The hypothesized mechanism that triggers debris slides in headwalls is high antecedent precipitation in conjunction with high precipitation intensity (Reneau and Dietrich, 1987). Based on this hypothesized mechanism, the highest API values and precipitation intensities for the central Coast Range were tested for correlation and likelihood of occurrence with each other. If high antecedent storm conditions are correlated with one of the calculated precipitation intensities it may be possible to establish a threshold precipitation intensity which has a high probability of initiating debris slides.

To test for correlation between maximum precipitation intensities and API, Pearson's product moment coefficient of correlation, r, was used (Equation 9).

$$r = \frac{SS_{xy}}{\sqrt{SS_{xx} SS_{yy}}} \qquad (9)$$

Where: r = Correlation coefficient, a number between -1 and 1.

SS_{xy} = Sum of squares of errors between x and y.

SS_{xx} = Sum of square of errors of x.

SS_{xy} = Sum of square of errors of y.

Pearson's product moment coefficient of correlation, r, is a measure of the strength of the linear relationship between two random variables, x and y. In this work x is high precipitation intensity and y, the dependent variable, is API. The stronger the positive relationship between x and y, the closer the correlation coefficient will be to 1. A strong positive relationship suggests that as the maximum short duration precipitation intensity increases so does the maximum API.

The largest API storms were tested for correlation with the maximum short duration precipitation intensities and total storm precipitation. The largest API storms are those storms in the API partial-duration series data set, storms with API values greater than the lowest annual maximum API in each rain gauge record. Correlation was also tested between short duration precipitation intensity and total storm precipitation for the API storms that were greater than a one year recurrence interval. This was to assess if

API values greater than a one year recurrence give a better correlation than the API values used from the partial-duration series data set.

It may also be possible to use the recurrence interval values of API and peak precipitation intensities (i.e. the two year events) to evaluate the spatial distribution of the highest hazard areas for precipitation which may trigger debris slides. For example, an overlay of the spatial distribution of the two year API event and the two year precipitation intensity can be made. Those areas where the highest API and precipitation intensities overlap would represent the highest hazard areas for debris slides. This approach is only viable if API and precipitation intensities also occur together in the same storms. If the peak API storms do not coincide with maximum precipitation intensities, then this overlay approach is not valid.

To test whether maximum precipitation intensities occur in storms with high API, the percent of occurrence of the largest short duration precipitation intensities, defined as greater than a one year recurrence interval, was calculated for the largest API storms (storms of the API partial-duration series and the storms with API greater than a one year recurrence interval). If a high percentage of occurrence is found then it can be concluded that the maximum precipitation intensities do occur with the maximum antecedent precipitation.

Spatial Distribution

The spatial distribution of precipitation intensities and antecedent precipitation across the study area are shown with maps of isohyet lines of precipitation intensity and

API. Isohyets are lines on a map which designate or contour areas of equal precipitation or API. The isohyet line plots were created using Surfer for Windows software by Golden Software.

The isohyet lines drawn consisted of each gauge's short duration precipitation intensity's and API's two year recurrence interval. The precipitation record in the rain gauge network varied in length from five to seven years. Theoretically, the highest recurrence interval which should be interpreted confidently for this length of record is five to seven years (same as record length). However, a more conservative approach is to interpret a recurrence interval about half of the length of record being analyzed (in this case two to three years)(George Taylor, pers. comm. 1995). The two year recurrence was chosen based on this conservative approach and from results of a comparison between recurrence intervals calculated by a annual and partial-duration series comparison for Indian Creek rain gauge (shown in Results section of this thesis).

A relationship between elevation and the short duration precipitation intensities and API in the rain gauge network was tested to discover if there was topographic effect on precipitation intensities and API. The two year recurrence interval of precipitation intensity and API, and several precipitation intensities from isolated storms were regressed against elevation. If a positive relationship was discovered then that relationship would be used to more accurately predict the spatial distribution.

The two year recurrence values and the location of the corresponding rain gauge were inserted into Surfer for Windows. The isohyet lines for the two year recurrence of the precipitation intensities and API were first estimated by hand drawing the lines. Various fitting functions in Surfer were used to see which function most closely fit isohyet lines relative to the estimated hand drawn lines. The Kriging function in Surfer provided the best representation.

RESULTS AND DISCUSSION

Frequency Analysis

The frequency distribution curves for the partial-duration series analysis from each rain gauge in the rain gauge network and the Mapleton rain gauge are presented in alphabetical order in figures 4 - 17. The Extreme Value Type I frequency (Gumbel) distribution curves plot as a straight line when the template for the Extreme Value Type I frequency distribution is used. There are five duration curves plotted on each graph. The graphs are used by finding the precipitation amount of interest on the ordinate and locating that value on the duration curve of interest. The annual probability of precipitation per duration being equaled or exceeded is read off the bottom abscissa. The top abscissa gives the inverse of the probability of being equaled or exceeded, the recurrence interval in years.

The precipitation intensity and API for selected recurrence intervals are presented for each rain gauge in table 8. The Extreme Value Type I frequency distribution provided the best fit to the partial-duration series data of the rain gauge network. The frequency distribution curves (Figures 4-17) over-estimate the smaller recurrence intervals and under-estimate the higher recurrence intervals when compared to the calculated values (Table 8).

The frequency distribution curves were calculated up to a 25 year recurrence interval. The precipitation records from the rain gauges go up to 7 years, with the exception of Mapleton which is 19 years in length. Only a 7 year recurrence interval can

Figure 4. Frequency Distribution Curves for Cascade Creek Rain Gauge

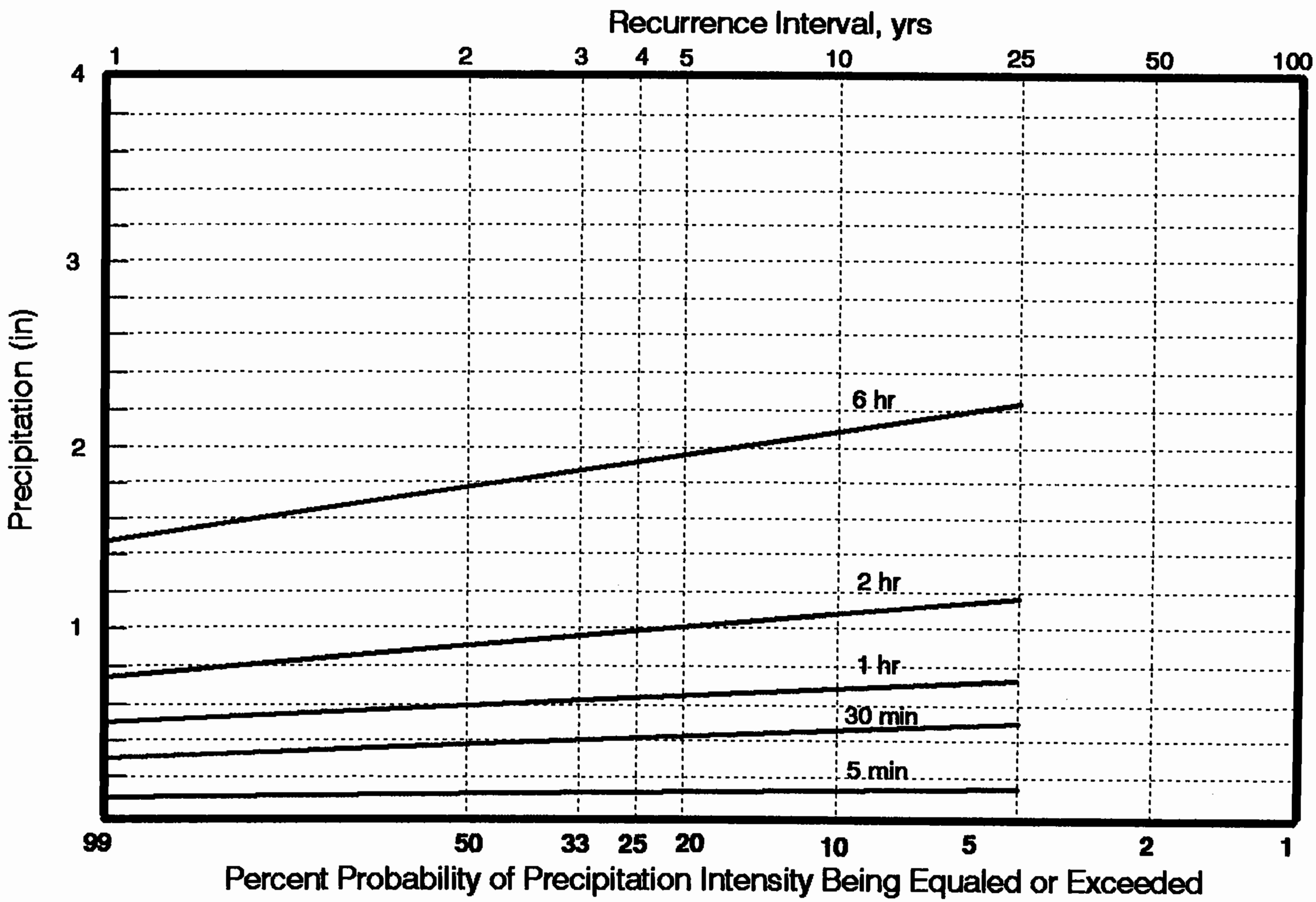


Figure 5. Frequency Distribution Curves for Indian Creek Rain Gauge

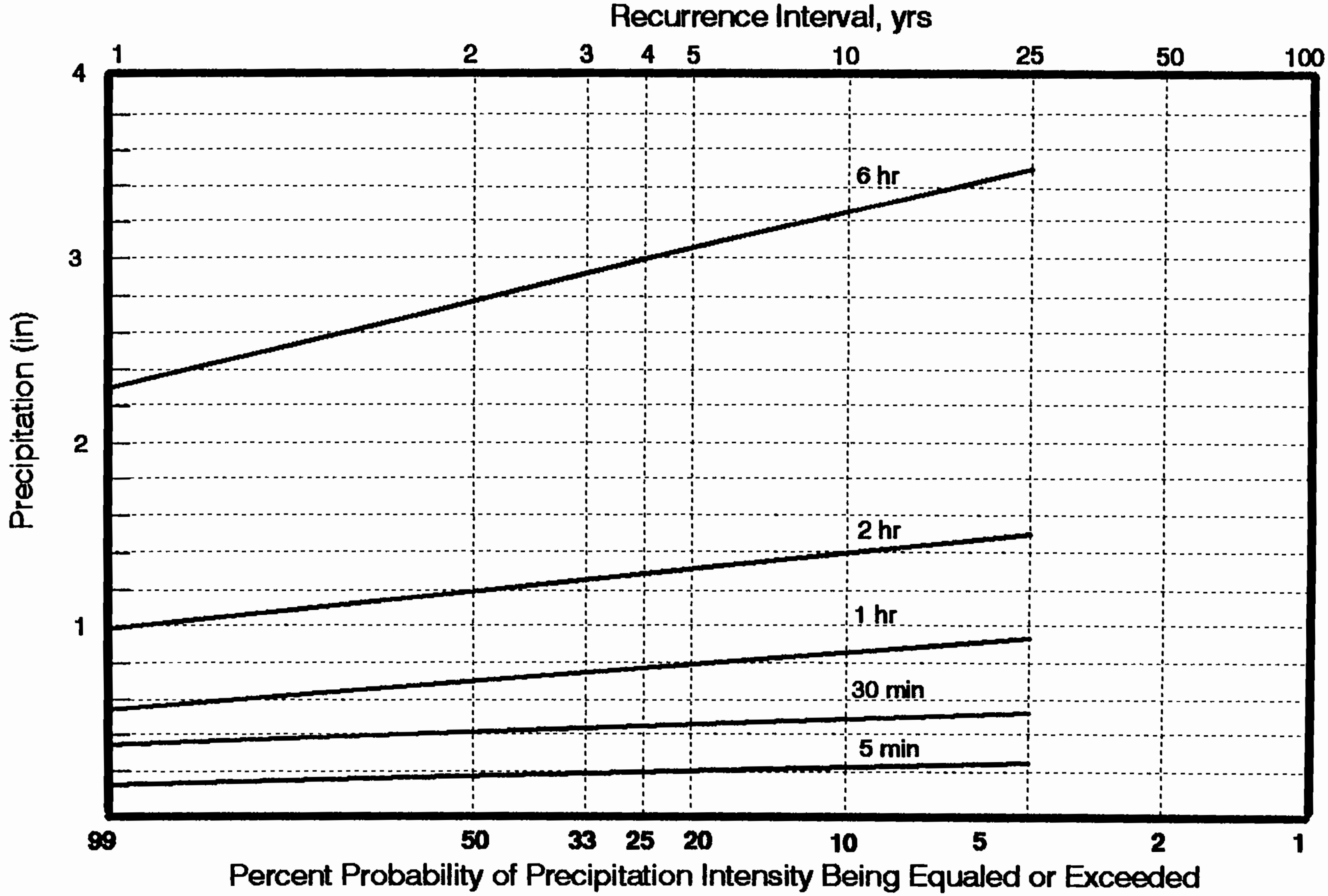


Figure 6. Frequency Distribution Curves for Johnson Creek Rain Gauge

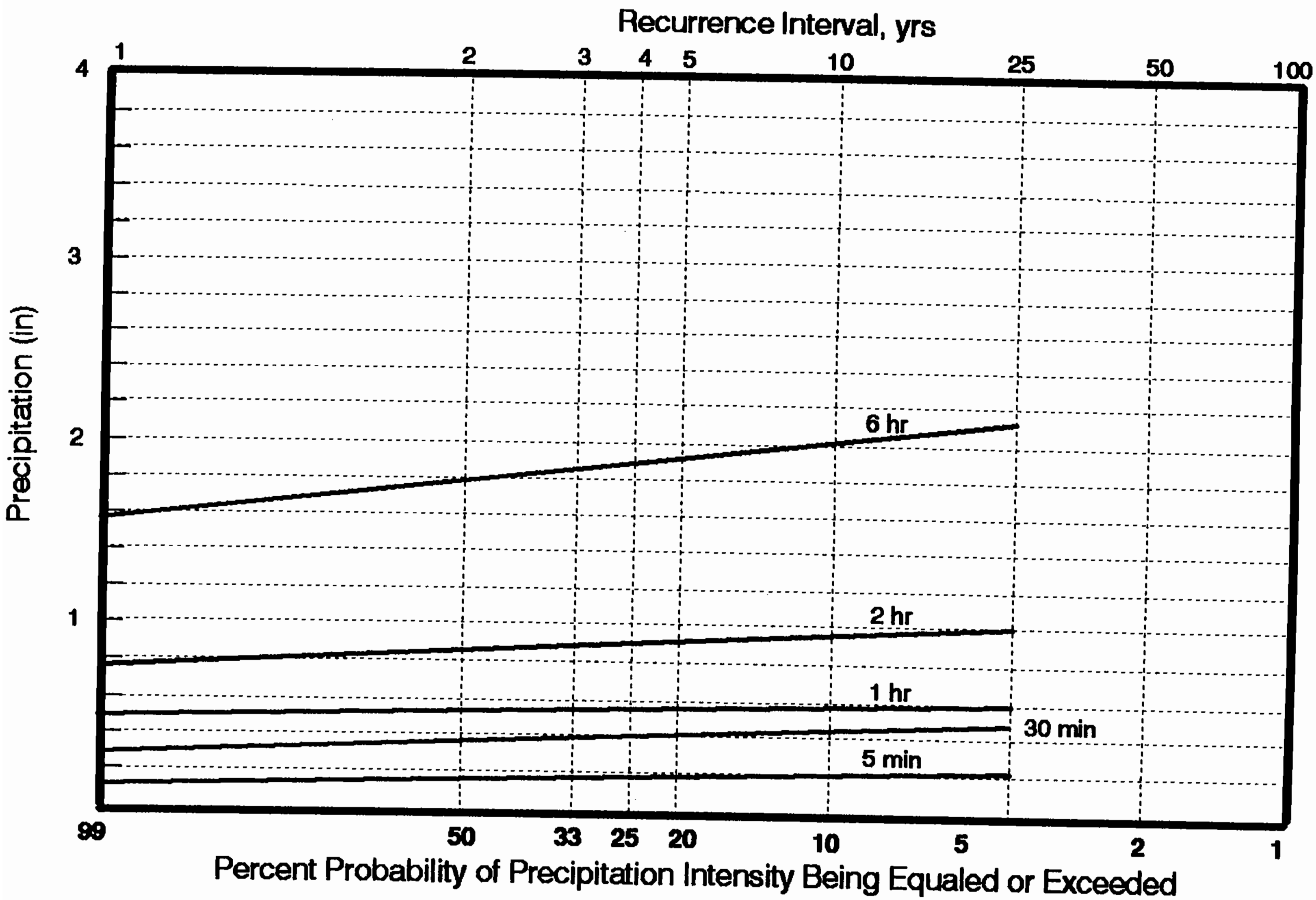


Figure 7. Frequency Distribution Curves for Kirk Creek Rain Gauge

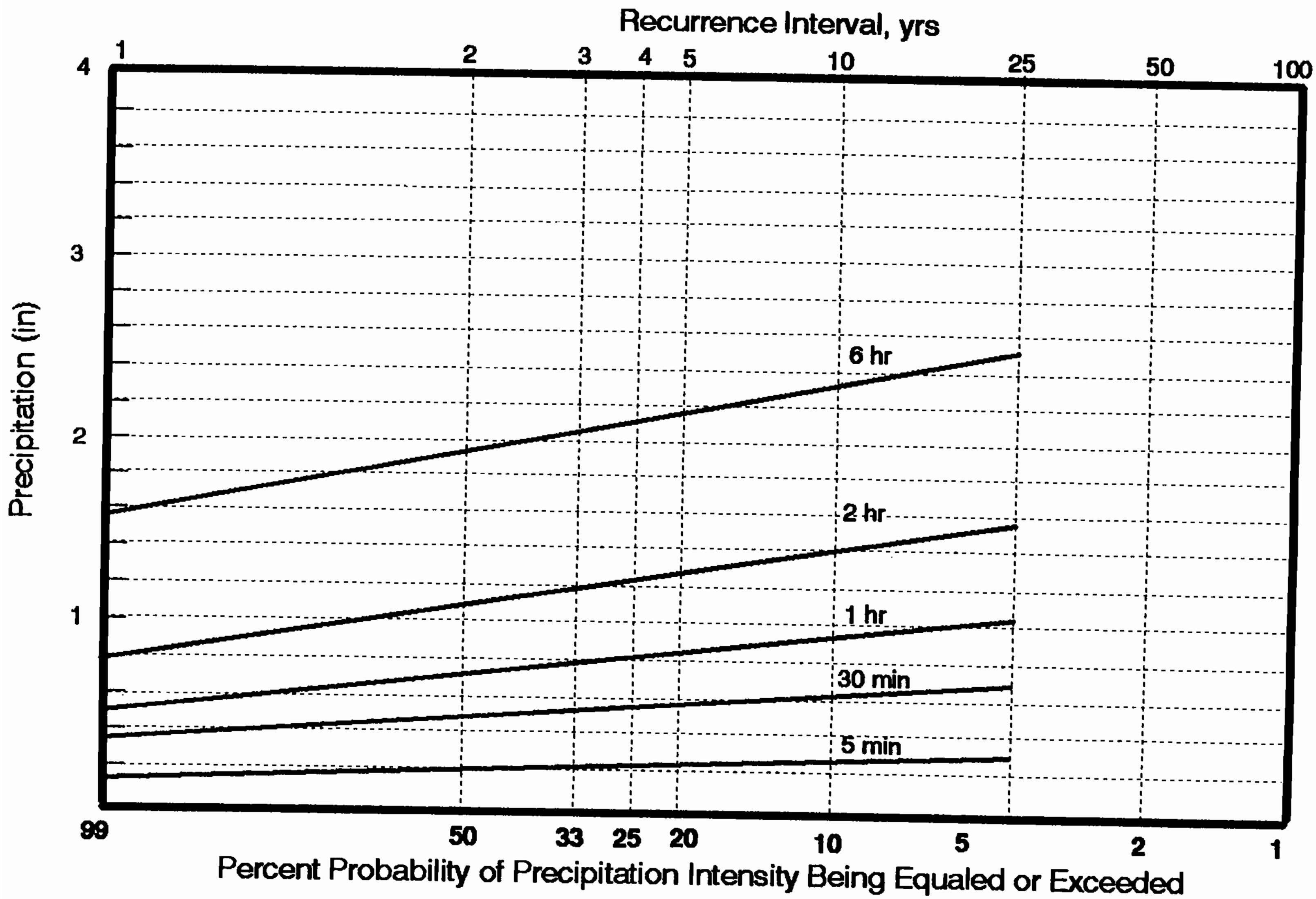


Figure 8. Frequency Distribution Curves for Lobster Creek Rain Gauge

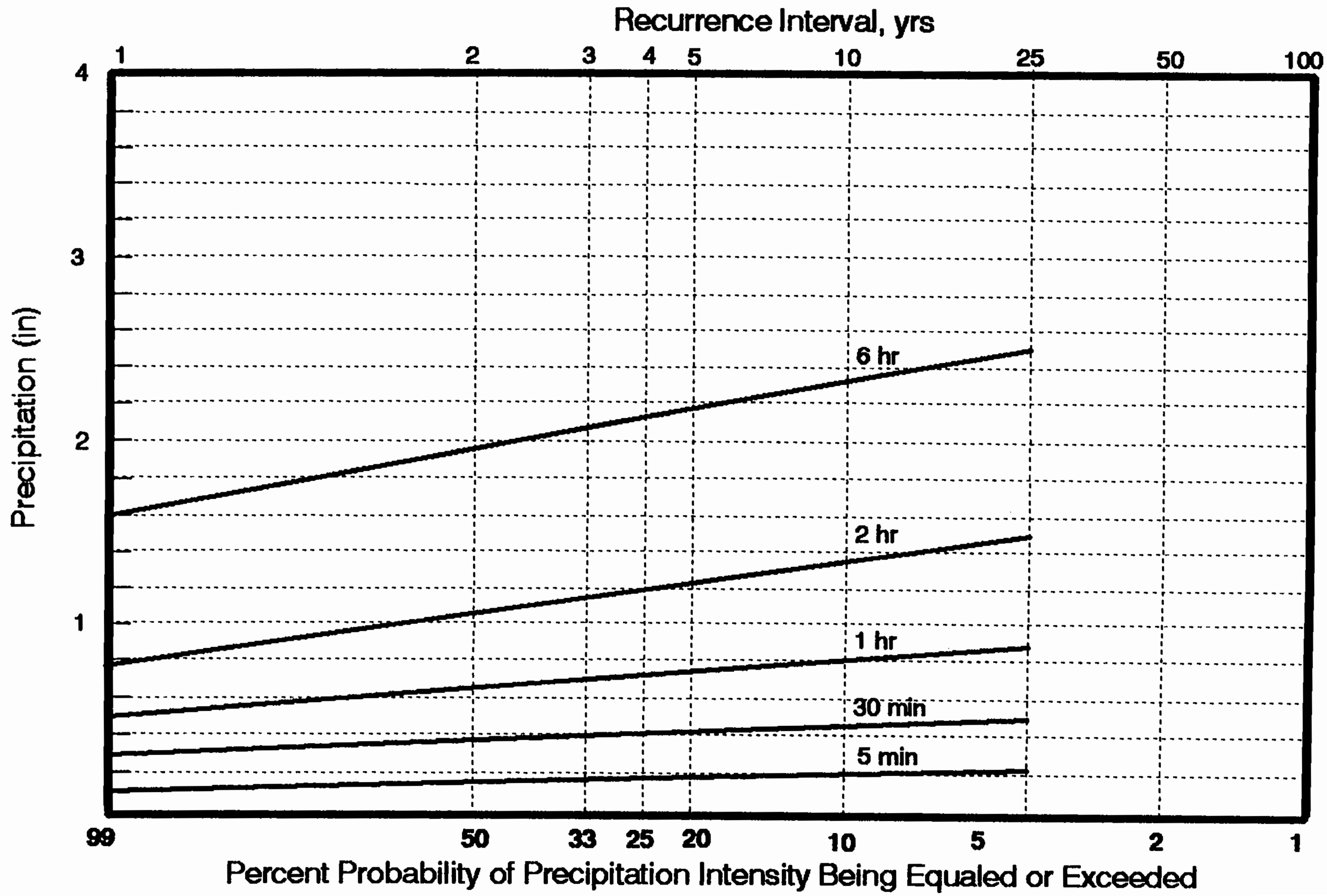


Figure 9. Frequency Distribution Curves for Mapleton Rain Gauge
Record Period: 1976-1994

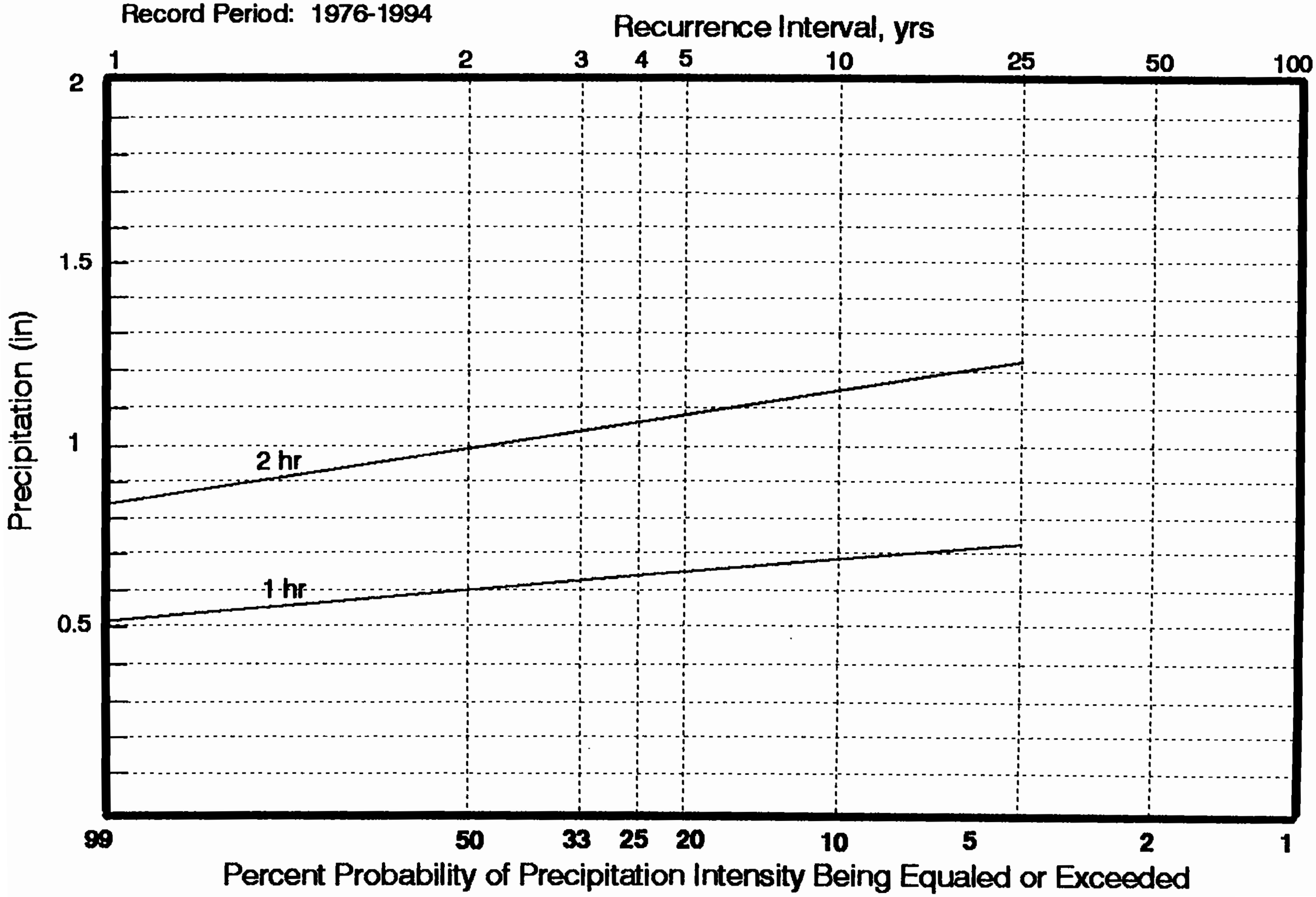


Figure 10. Frequency Distribution Curves for Mill Creek Rain Gauge

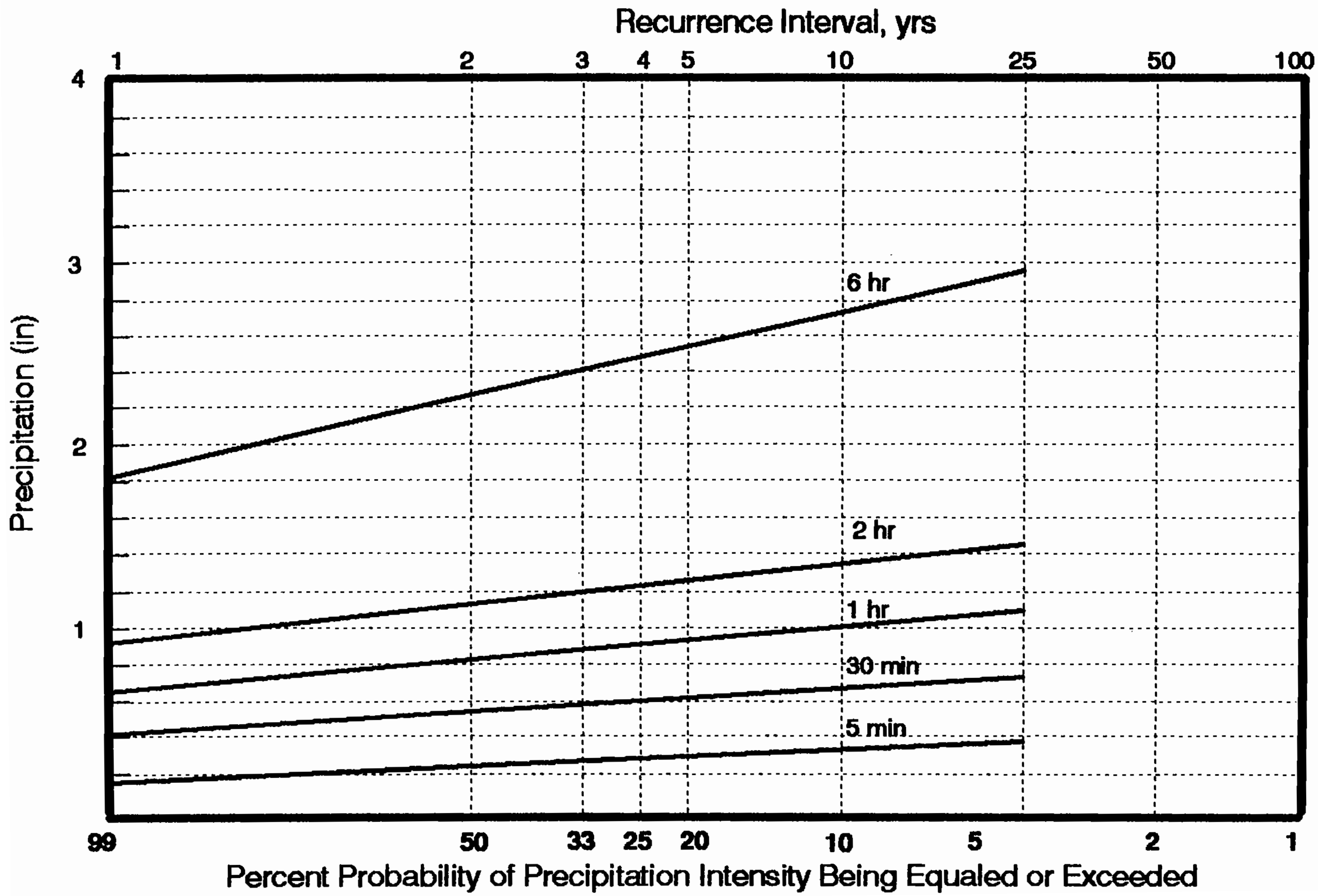


Figure 11. Frequency Distribution Curves for Panther Creek Rain Gauge

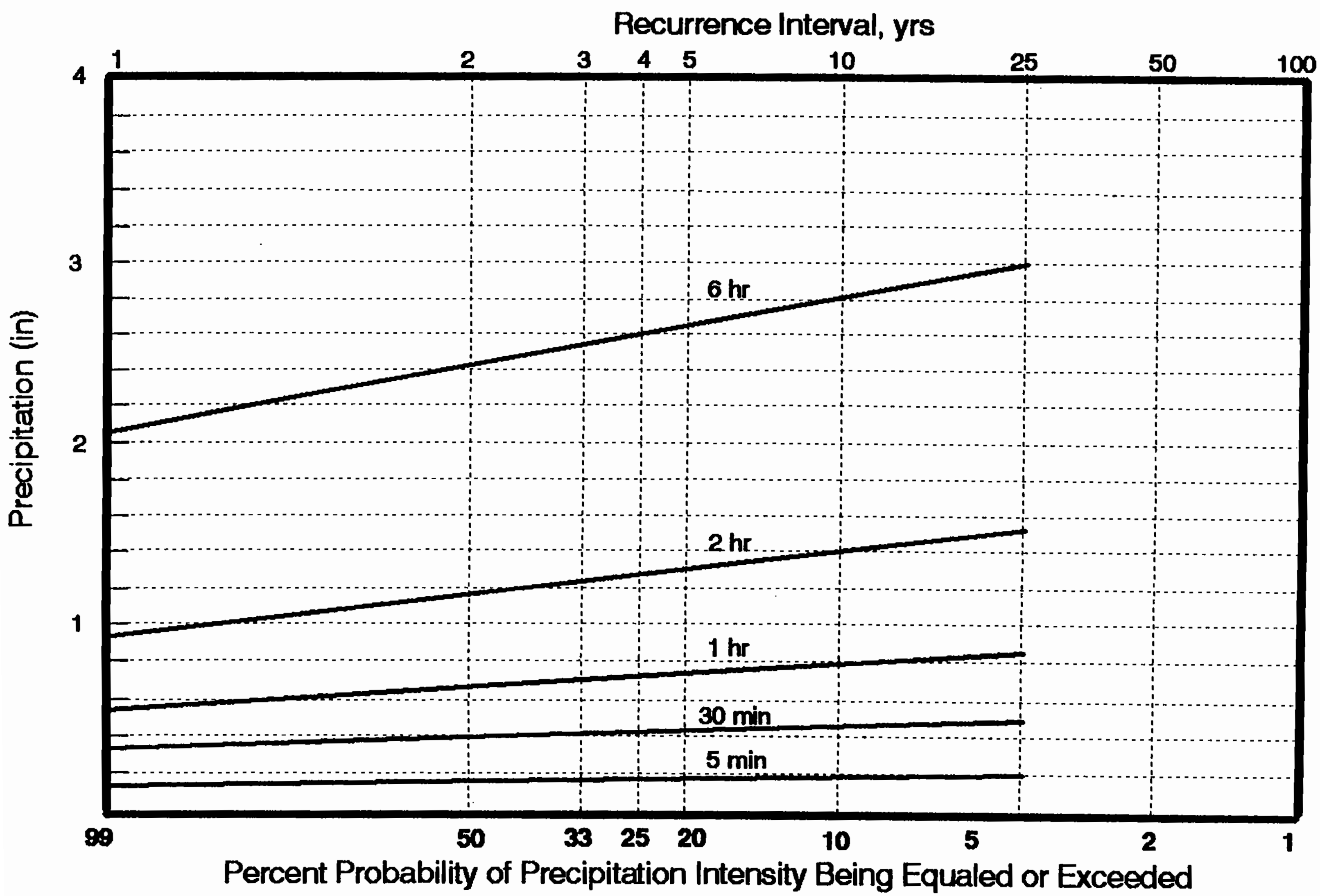


Figure 12. Frequency Distribution Curves for Ryder Creek Rain Gauge

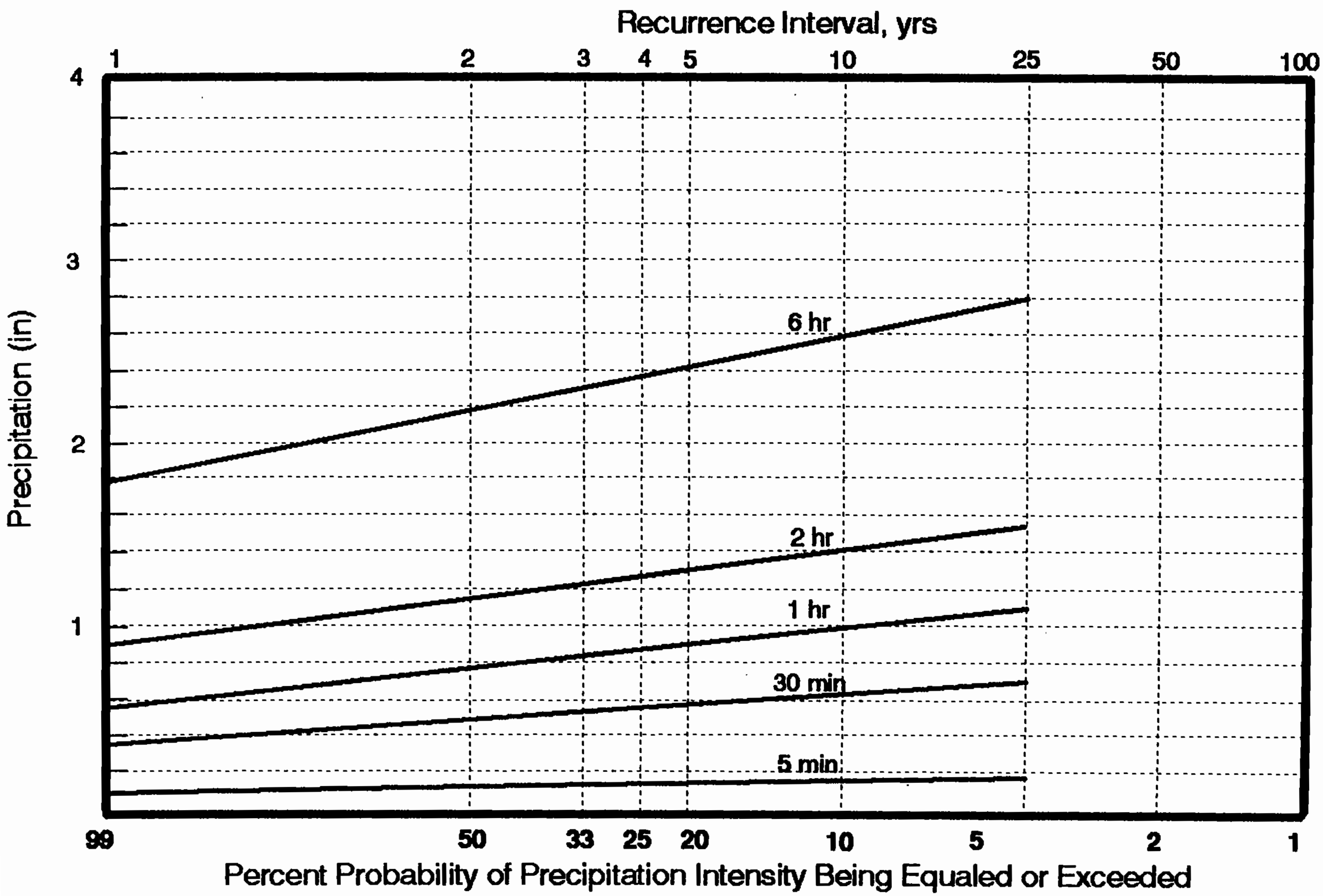


Figure 13. Frequency Distribution Curves for Smith River Rain Gauge

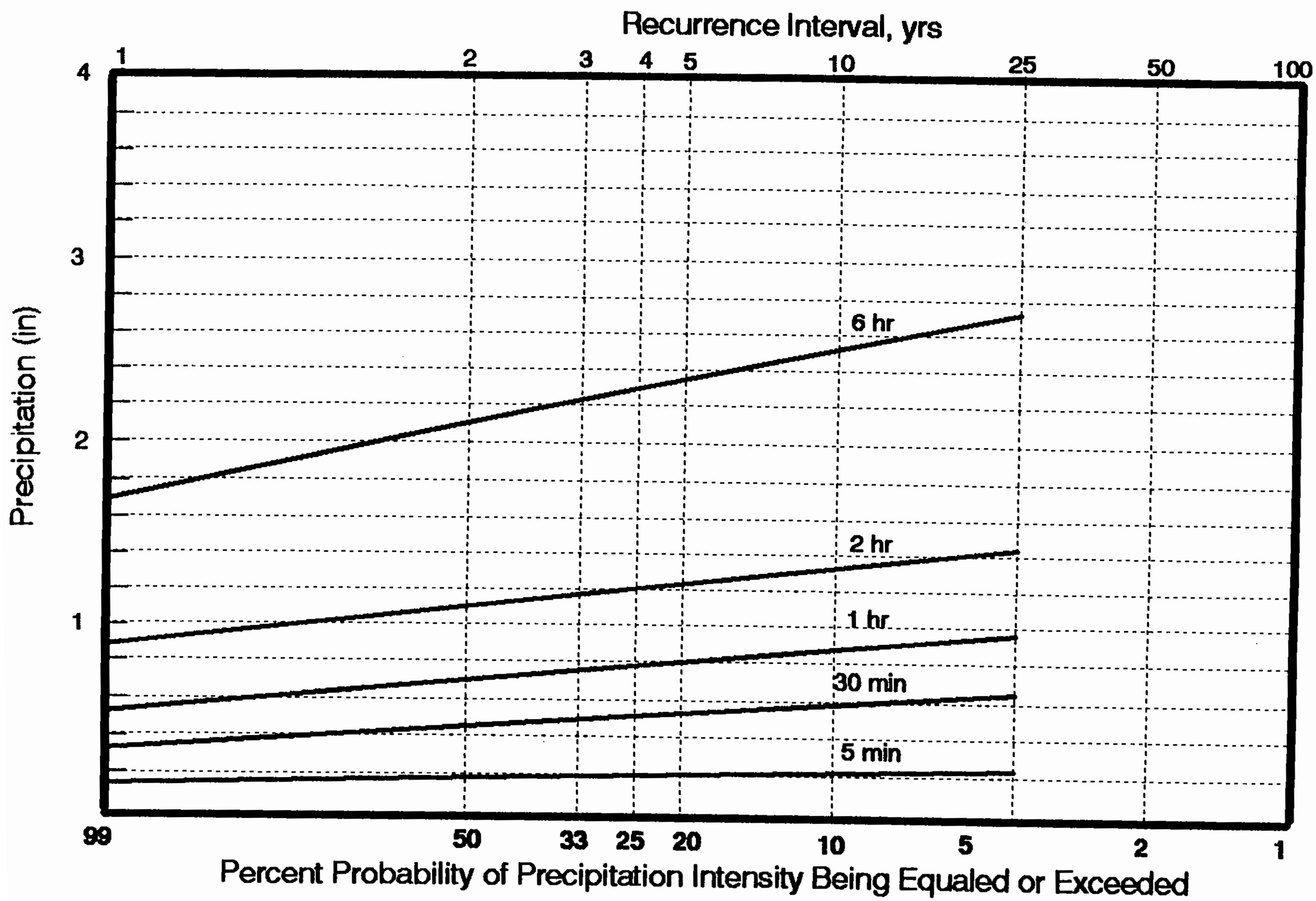


Figure 14. Frequency Distribution Curves for South Canyon Rain Gauge

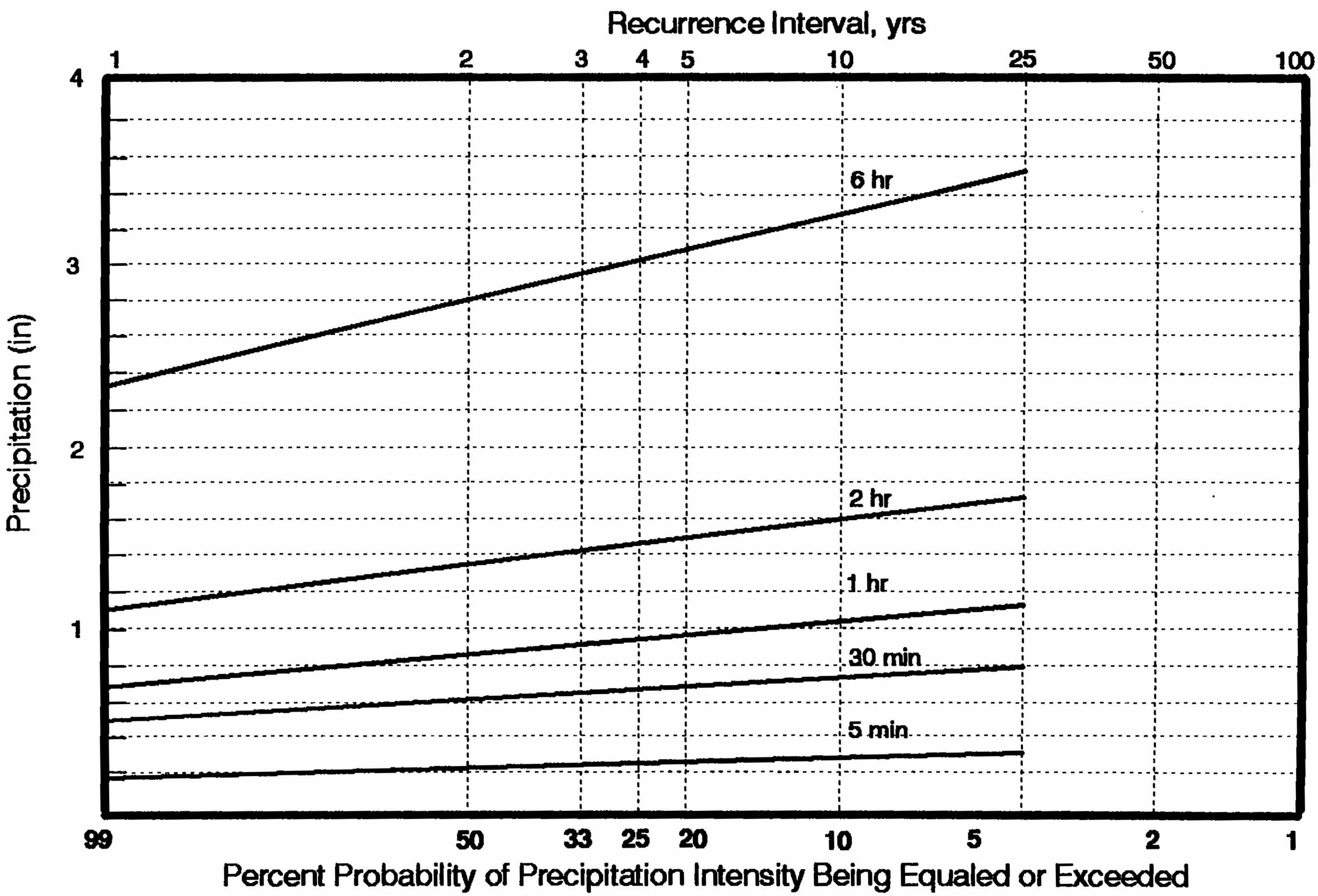


Figure 15. Frequency Distribution Curves for Sweet Creek Rain Gauge

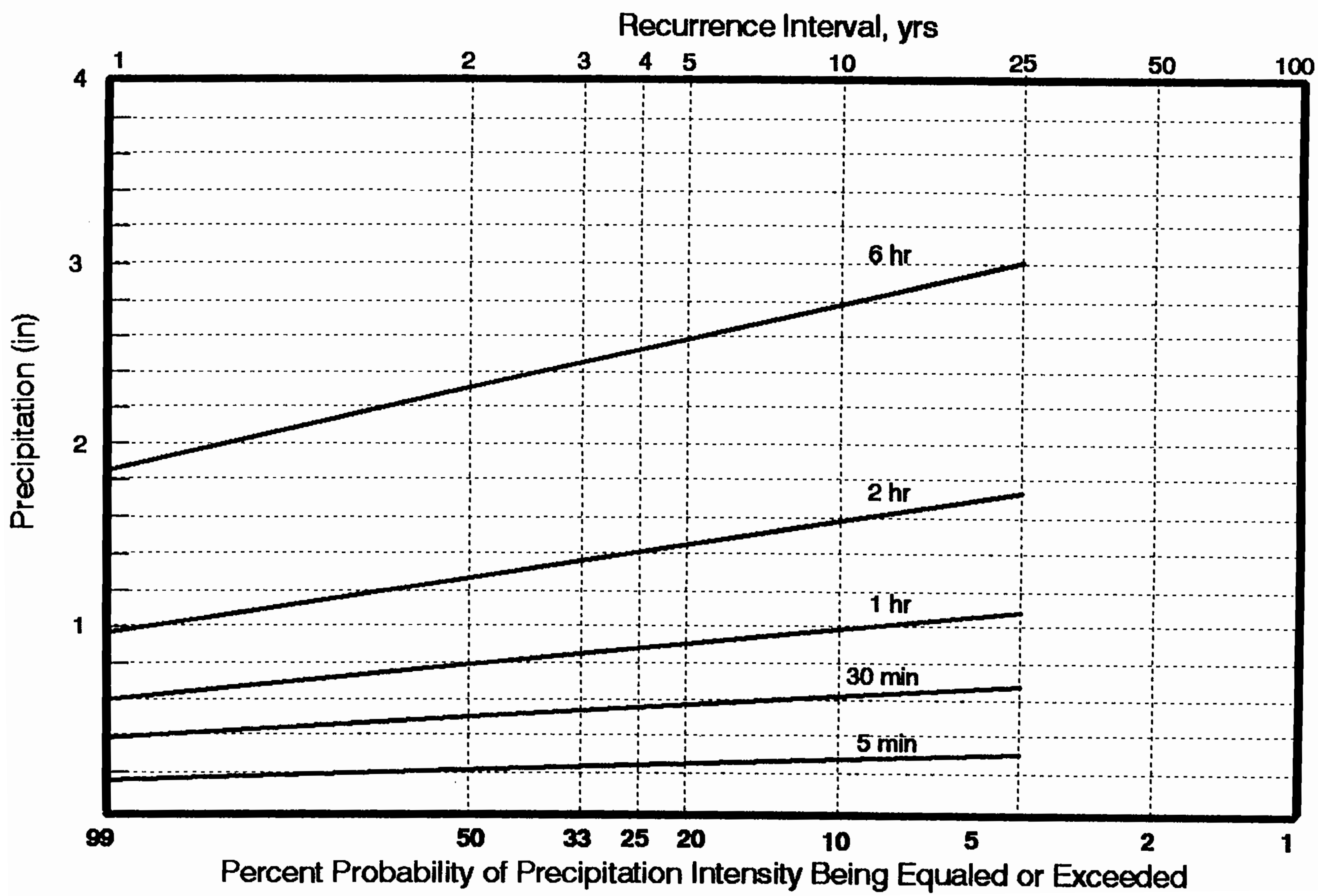


Figure 16. Frequency Distribution Curves for Thompson Creek Rain Gauge

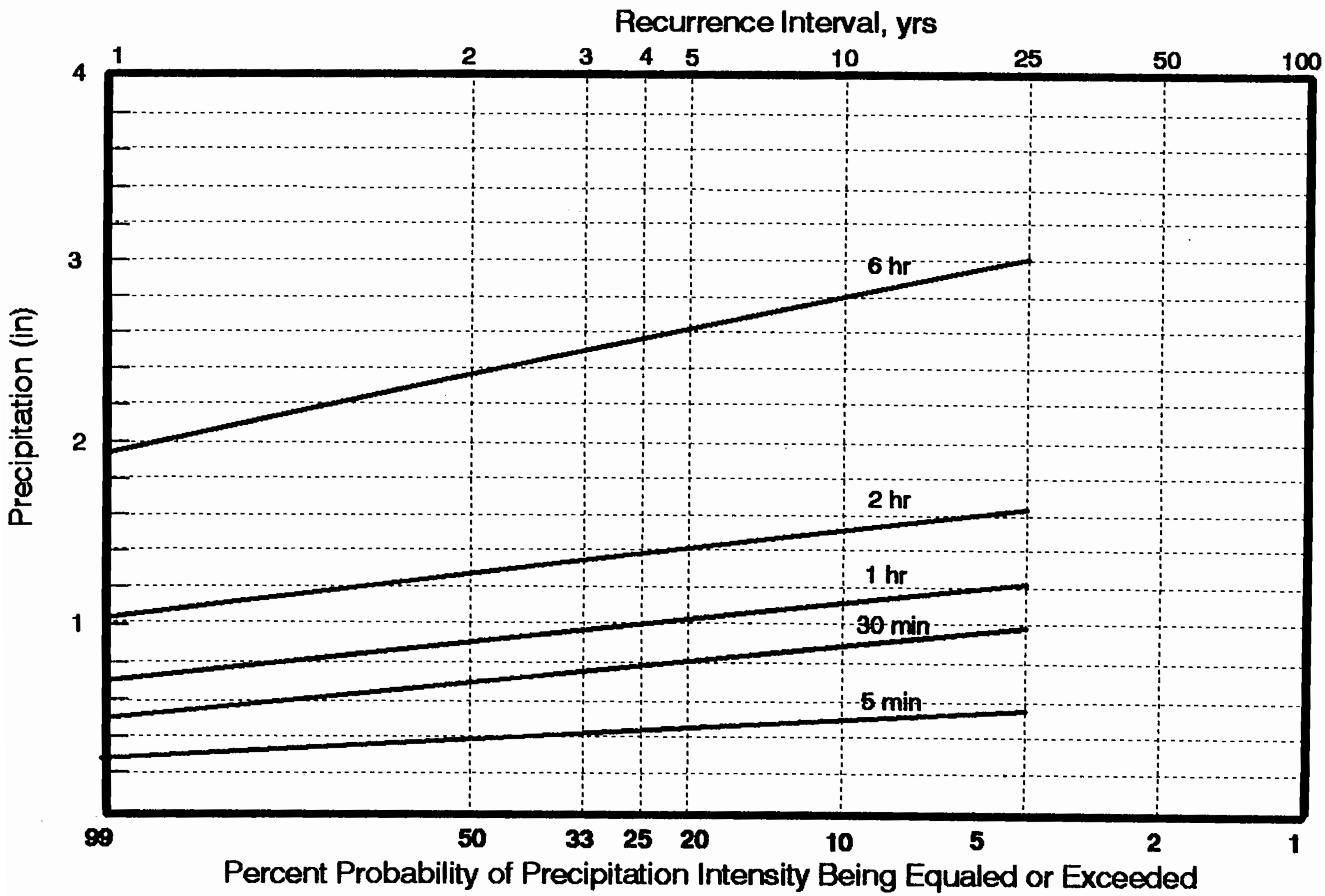


Figure 17. Frequency Distribution Curves for Wassen Creek Rain Gauge

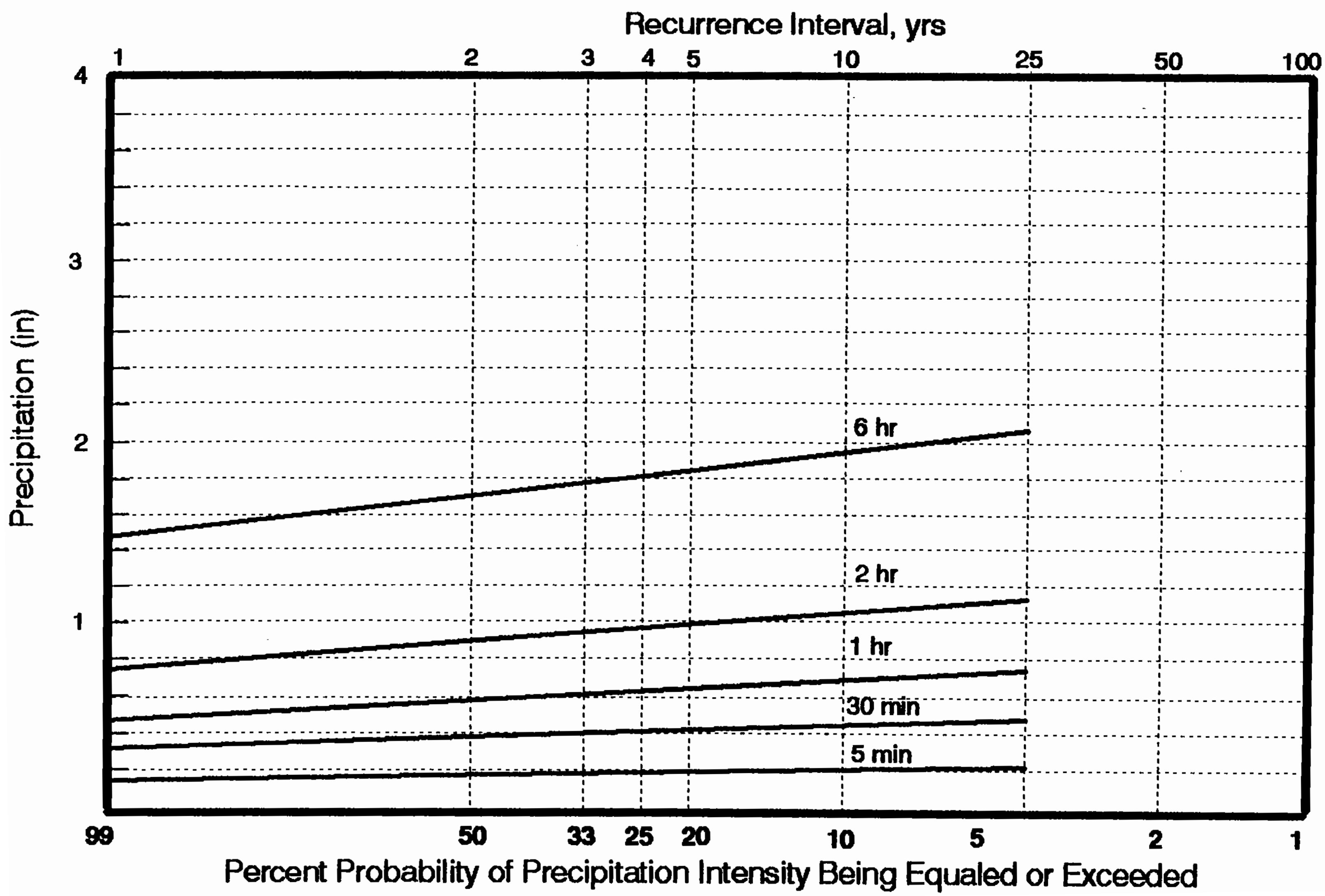


Table 8. Precipitation Amounts and Antecedent Precipitation Index for Selected Durations and Recurrence Intervals for the Central Oregon Coast Range.

Cascade Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.10	0.11	0.12	0.12	0.13	0.14	0.15
0.5 hr. (in./0.5hr.)	0.31	0.35	0.37	0.39	0.40	0.45	0.50
1 hr. (in./hr.)	0.47	0.54	0.57	0.60	0.62	0.67	0.75
2 hr. (in./2 hrs.)	0.77	0.87	0.93	0.97	1.00	1.10	1.23
6 hr. (in./6 hrs.)	1.55	1.72	1.82	1.88	1.93	2.08	2.28
api (in.)	3.88	4.25	4.47	4.62	4.73	5.09	5.56

Indian Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.15	0.17	0.19	0.20	0.21	0.23	0.26
0.5 hr. (in./0.5hr.)	0.38	0.41	0.43	0.45	0.46	0.50	0.54
1 hr. (in./hr.)	0.58	0.68	0.72	0.75	0.78	0.85	0.94
2 hr. (in./2 hrs.)	1.05	1.15	1.21	1.24	1.27	1.36	1.47
6 hr. (in./6 hrs.)	2.36	2.65	2.81	2.92	3.01	3.27	3.61
api (in.)	5.61	6.16	6.48	6.70	6.87	7.41	8.11

Johnson Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.12	0.14	0.16	0.16	0.17	0.19	0.21
0.5 hr. (in./0.5hr.)	0.32	0.36	0.38	0.39	0.40	0.44	0.48
1 hr. (in./hr.)	0.49	0.52	0.53	0.54	0.55	0.57	0.59
2 hr. (in./2 hrs.)	0.78	0.83	0.86	0.88	0.90	0.94	1.00
6 hr. (in./6 hrs.)	1.62	1.76	1.83	1.87	1.91	2.01	2.14
api (in.)	4.08	4.39	4.56	4.67	4.76	5.03	5.38

Kirk Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.16	0.20	0.22	0.23	0.25	0.28	0.32
0.5 hr. (in./0.5hr.)	0.37	0.45	0.49	0.52	0.55	0.62	0.71
1 hr. (in./hr.)	0.52	0.64	0.71	0.75	0.79	0.90	1.04
2 hr. (in./2 hrs.)	0.82	1.00	1.10	1.16	1.21	1.37	1.57
6 hr. (in./6 hrs.)	1.59	1.83	1.95	2.04	2.11	2.32	2.59
api (in.)	4.59	5.16	5.48	5.71	5.88	6.43	7.14

Table 8. (continued) Precipitation Amounts and Antecedent Precipitation Index for Selected Durations and Recurrence Intervals for the Central Oregon Coast Range.

Lobster Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.13	0.15	0.17	0.17	0.18	0.20	0.23
0.5 hr. (in./0.5hr.)	0.33	0.36	0.39	0.40	0.41	0.45	0.50
1 hr. (in./hr.)	0.52	0.60	0.65	0.68	0.70	0.78	0.88
2 hr. (in./2 hrs.)	0.83	0.99	1.08	1.14	1.18	1.32	1.50
6 hr. (in./6 hrs.)	1.63	1.85	1.98	2.06	2.12	2.32	2.58
api (in.)	4.52	4.98	5.25	5.44	5.58	6.03	6.62

Mapleton Rain Gauge

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
1 hr (in./hr.)	0.53	0.57	0.60	0.62	0.63	0.67	0.73
2 hr (in./2 hrs.)	0.86	0.94	0.99	1.03	1.05	1.13	1.23

Mill Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.17	0.22	0.25	0.26	0.28	0.32	0.37
0.5 hr. (in./0.5hr.)	0.42	0.50	0.54	0.57	0.59	0.66	0.76
1 hr. (in./hr.)	0.64	0.76	0.82	0.86	0.90	1.00	1.14
2 hr. (in./2 hrs.)	0.93	1.06	1.13	1.18	1.21	1.33	1.48
6 hr. (in./6 hrs.)	1.82	2.08	2.23	2.33	2.42	2.67	3.00
api (in.)	4.91	5.44	5.73	5.94	6.11	6.60	7.25

Panther Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.15	0.16	0.17	0.18	0.18	0.20	0.21
0.5 hr. (in./0.5hr.)	0.34	0.38	0.40	0.42	0.43	0.47	0.51
1 hr. (in./hr.)	0.55	0.62	0.65	0.68	0.70	0.76	0.84
2 hr. (in./2 hrs.)	0.97	1.10	1.18	1.23	1.27	1.38	1.54
6 hr. (in./6 hrs.)	2.06	2.30	2.43	2.52	2.59	2.80	3.07
api (in.)	5.32	5.82	6.09	6.27	6.41	6.84	7.40

Table 8. (continued) Precipitation Amounts and Antecedent Precipitation Index for Selected Durations and Recurrence Intervals for the Central Oregon Coast Range.

Ryder Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.12	0.14	0.14	0.15	0.15	0.17	0.18
0.5 hr. (in./0.5hr.)	0.38	0.46	0.51	0.54	0.56	0.63	0.73
1 hr. (in./hr.)	0.60	0.73	0.81	0.85	0.89	1.01	1.16
2 hr. (in./2 hrs.)	0.93	1.07	1.15	1.21	1.25	1.38	1.56
6 hr. (in./6 hrs.)	1.81	2.05	2.18	2.27	2.34	2.56	2.85
api (in.)	4.37	4.81	5.06	5.24	5.38	5.81	6.38

Smith River Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.14	0.16	0.17	0.18	0.18	0.20	0.22
0.5 hr. (in./0.5hr.)	0.35	0.42	0.46	0.49	0.51	0.58	0.66
1 hr. (in./hr.)	0.54	0.64	0.70	0.74	0.77	0.86	0.97
2 hr. (in./2 hrs.)	0.87	1.01	1.08	1.13	1.17	1.28	1.44
6 hr. (in./6 hrs.)	1.70	1.94	2.07	2.16	2.23	2.45	2.73
api (in.)	4.58	5.19	5.53	5.78	5.96	6.54	7.29

South Canyon Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.19	0.22	0.23	0.25	0.26	0.28	0.32
0.5 hr. (in./0.5hr.)	0.48	0.56	0.60	0.63	0.66	0.73	0.82
1 hr. (in./hr.)	0.71	0.81	0.87	0.91	0.94	1.03	1.15
2 hr. (in./2 hrs.)	1.13	1.28	1.36	1.42	1.46	1.60	1.77
6 hr. (in./6 hrs.)	2.35	2.63	2.79	2.91	2.99	3.25	3.60
api (in.)	6.27	7.01	7.43	7.73	7.95	8.66	9.58

Sweet Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.17	0.21	0.23	0.24	0.25	0.29	0.33
0.5 hr. (in./0.5hr.)	0.40	0.47	0.50	0.53	0.55	0.61	0.69
1 hr. (in./hr.)	0.62	0.73	0.79	0.84	0.87	0.98	1.11
2 hr. (in./2 hrs.)	0.99	1.19	1.29	1.37	1.42	1.60	1.83
6 hr. (in./6 hrs.)	1.85	2.14	2.30	2.42	2.50	2.77	3.13
api (in.)	4.87	5.30	5.55	5.72	5.85	6.26	6.79

Table 8. (continued) Precipitation Amounts and Antecedent Precipitation Index for Selected Durations and Recurrence Intervals for the Central Oregon Coast Range.

Thompson Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.28	0.34	0.37	0.40	0.42	0.47	0.55
0.5 hr. (in./0.5hr.)	0.52	0.63	0.69	0.73	0.77	0.87	1.00
1 hr. (in./hr.)	0.74	0.86	0.92	0.97	1.01	1.12	1.27
2 hr. (in./2 hrs.)	1.06	1.20	1.27	1.32	1.36	1.49	1.65
6 hr. (in./6 hrs.)	2.05	2.28	2.42	2.51	2.58	2.80	3.09
api (in.)	5.96	6.60	6.96	7.22	7.41	8.02	8.82

Wassen Creek Raingage

	Recurrence Interval (yrs.)						
Precipitation Duration	**1**	**2**	**3**	**4**	**5**	**10**	**25**
5 min. (in./ min.)	0.15	0.16	0.17	0.18	0.19	0.20	0.23
0.5 hr. (in./0.5hr.)	0.33	0.36	0.38	0.40	0.41	0.44	0.49
1 hr. (in./hr.)	0.50	0.56	0.59	0.61	0.63	0.69	0.76
2 hr. (in./2 hrs.)	0.78	0.86	0.90	0.94	0.96	1.04	1.14
6 hr. (in./6 hrs.)	1.49	1.65	1.74	1.80	1.84	1.99	2.18
api (in.)	4.33	4.84	5.14	5.34	5.50	6.00	6.65

be interpreted from a 7 year length of record when not fitting the data series to a frequency distribution. By using the extreme value distribution, recurrence intervals can be extrapolated to a 10 - 15 year recurrence from a 7 year record. Interpretation of return intervals beyond this length of time are provided, but the level of confidence in these interpretations is low.

Precipitation intensities associated with selected recurrence intervals varied considerably over the study area. The Thompson Creek and South Canyon rain gauges had the greatest precipitation for short durations, less than or equal to 2 hours. South Canyon and Indian Creek rain gauges had the greatest precipitation for the longer, 6 hour duration. Precipitation values for selected durations and recurrence could vary as much as 50% or larger for selected rain gauge locations. For example, the one year - 6 hour precipitation for Cascade Creek is 1.55 inches for Indian Creek it is 2.36 inches, 52 percent larger.

The tremendous variability of precipitation intensities across the study area substantiates the problems associated with using one rain gauge in some central location, to represent precipitation across the mountainous terrain of the central Coast Range. In the Thompson Creek and Cascade Creek example, the 1 hour, 1 year precipitation intensity recurrence is 52% greater at Thompson Creek than at Cascade Creek. This variability occurs within 25 miles. If one rain gauge is used to interpret this area the possibility of under or over predicting a precipitation intensity is high.

The high variability in precipitation must be considered when selecting precipitation inputs for engineering or management decisions. With precipitation so variable across the central Coast Range the criteria for the correct design precipitation intensity will vary based on location of the project. For example, a 1 hour precipitation intensity for a twenty five year recurrence interval at Wassen Creek is 0.76 inches. At the Thompson Creek rain gauge this amount equates to a 1 year recurrence interval.

The safest design approach to this precipitation variability would be to be utilize the highest precipitation intensities as a basis for design across the entire region. However, expense in implementing this conservative design criteria may be impractical. Use of a rain gauge network, such as the one described in this study, could help identify areas which would require a higher design storm standard than those that are not as high.

Partial-Duration and Annual Series Comparison

Partial-duration series frequency analysis was used for the precipitation and antecedent precipitation index data for the rain gauge network. Partial-duration series was used due to the small sample size of events, which would result from an annual series, and because landslide producing storms can occur more than once per year, as an annual series would suggest. As an indicator of accuracy of the partial-duration series analysis, an annual series was calculated for one rain gauge, Indian Creek, and the results compared with the partial-duration series in Table 9.

Comparing precipitation intensities for selected recurrence intervals for the annual and partial-duration series data for the Indian Creek rain gauge (Table 9) showed similar results. The 1 year recurrence interval for the 5 minute, 2 hour and 6 hour intensities were

Table 9. Comparison of Precipitation Amounts and API between Partial-Duration and Annual Series Frequency Analysis for Selected Durations and Recurrence Intervals for the Indian Creek Rain Gauge.

Partial Series Returns

	Recurrence Interval (yrs)						
Duration	1	2	3	4	5	10	25
5 min	0.15	0.17	0.19	0.20	0.21	0.23	0.26
.5 hr	0.38	0.41	0.43	0.45	0.46	0.50	0.54
1 hr	0.58	0.68	0.72	0.75	0.78	0.85	0.94
2 hr	1.05	1.15	1.21	1.24	1.27	1.36	1.47
6 hr	2.36	2.65	2.81	2.92	3.01	3.27	3.61
API	5.61	6.16	6.48	6.70	6.87	7.41	8.11

Annual Series Returns

	Recurrence Interval (yrs)						
Duration	1	2	3	4	5	10	25
5 min	0.08	0.18	0.20	0.22	0.23	0.26	0.31
.5 hr	0.35	0.43	0.45	0.46	0.47	0.49	0.52
1 hr	0.56	0.67	0.69	0.71	0.72	0.76	0.80
2 hr	0.84	1.15	1.22	1.27	1.30	1.40	1.53
6 hr	1.97	2.70	2.86	2.97	3.05	3.29	3.59
API	5.51	6.53	6.76	6.91	7.03	7.36	7.78

Percent Difference of Annual Series vs. Partial Series

	Recurrence Interval (yrs)						
Duration	1	2	3	4	5	10	25
5 min	-92%	3%	7%	9%	10%	13%	14%
.5 hr	-7%	3%	2%	2%	1%	-1%	-4%
1 hr	-4%	-1%	-4%	-6%	-8%	-12%	-17%
2 hr	-24%	0%	1%	2%	2%	3%	3%
6 hr	-20%	2%	2%	2%	1%	1%	0%
API	-2%	6%	4%	3%	2%	-1%	-4%

not close in predictions, but all other precipitation intensities recurrence intervals less than
10 years were within 10 percent of each other. This seems to be a reasonable result given the short record length used (5 - 7 years). Even for recurrence intervals beyond the 10 years, only two of the intensity durations, the 5 minute and the 1 hour, were greater than 10 percent different.

From analysis of the Indian Creek rain gauge annual and partial-duration series, the precipitation amounts for selected recurrence intervals using partial-duration series frequency analysis are concluded to be accurate. The exceptions being the precipitation amounts below a 2 year recurrence interval, and the events greater than or equal to a 10 year recurrence. These values should be used with caution. The two year recurrence interval used to plot the spatial distributions of precipitation in this thesis are virtually the same whether calculated by annual or partial-duration series.

Spatial Distribution

The spatial distribution of the two-year 5 minute, 30 minute, 1 hour, 2 hour, 6 hour precipitation intensities and API for the rain gauge network are presented in Figures 18 - 23. The figures show rain gauge locations on the map (for the rain gauge name and location see Figure 1 and Table 1 in the Study Area section of this thesis). Isohyets, or lines of equal precipitation, are drawn on the map. The precipitation amount or API value is the number adjacent to the isohyet. For the precipitation maps the number value

Figure 18. 2-Year - 5 Minute Precipitation Amount

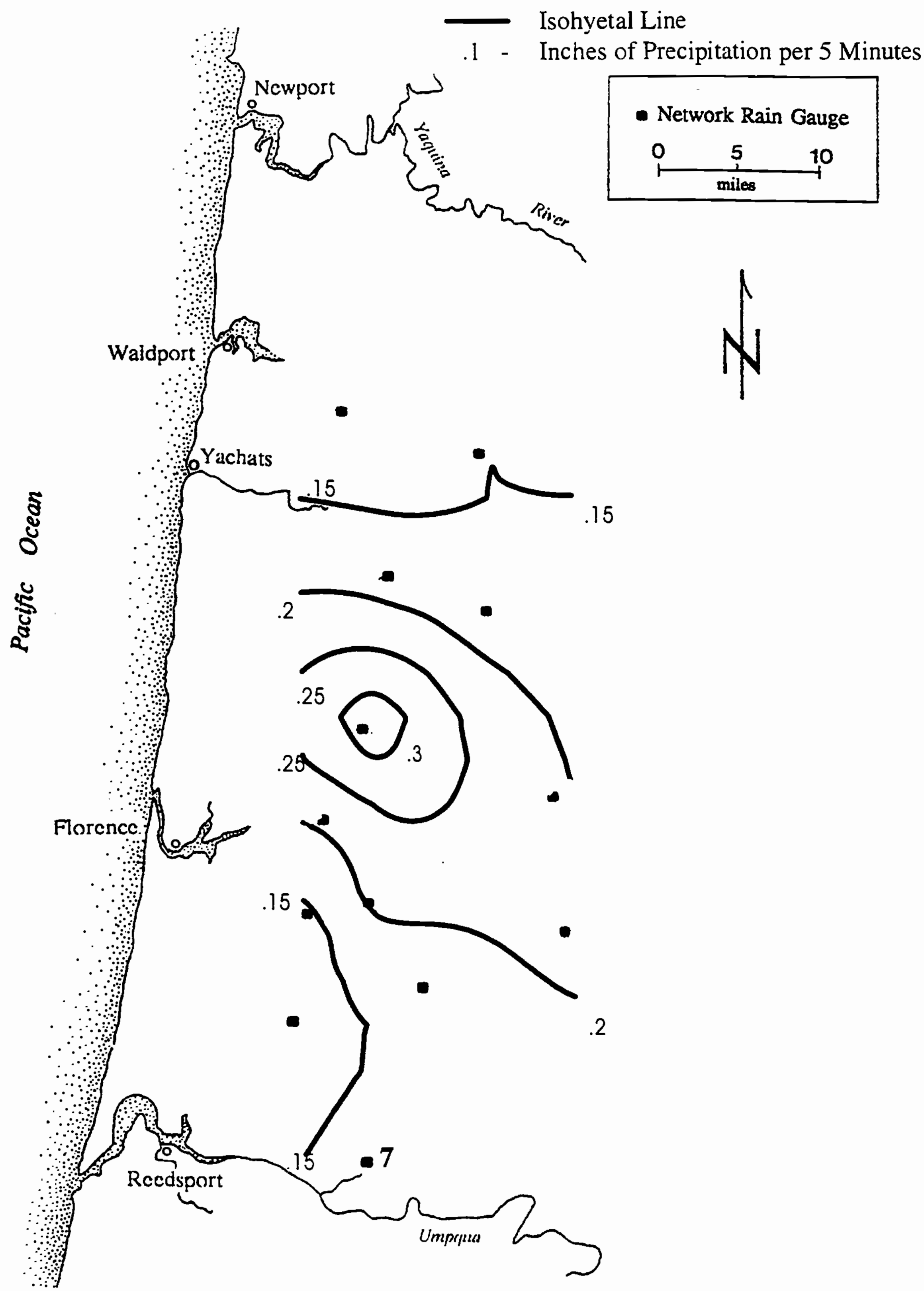


Figure 19. 2-Year - 30 Minute Precipitation Amount

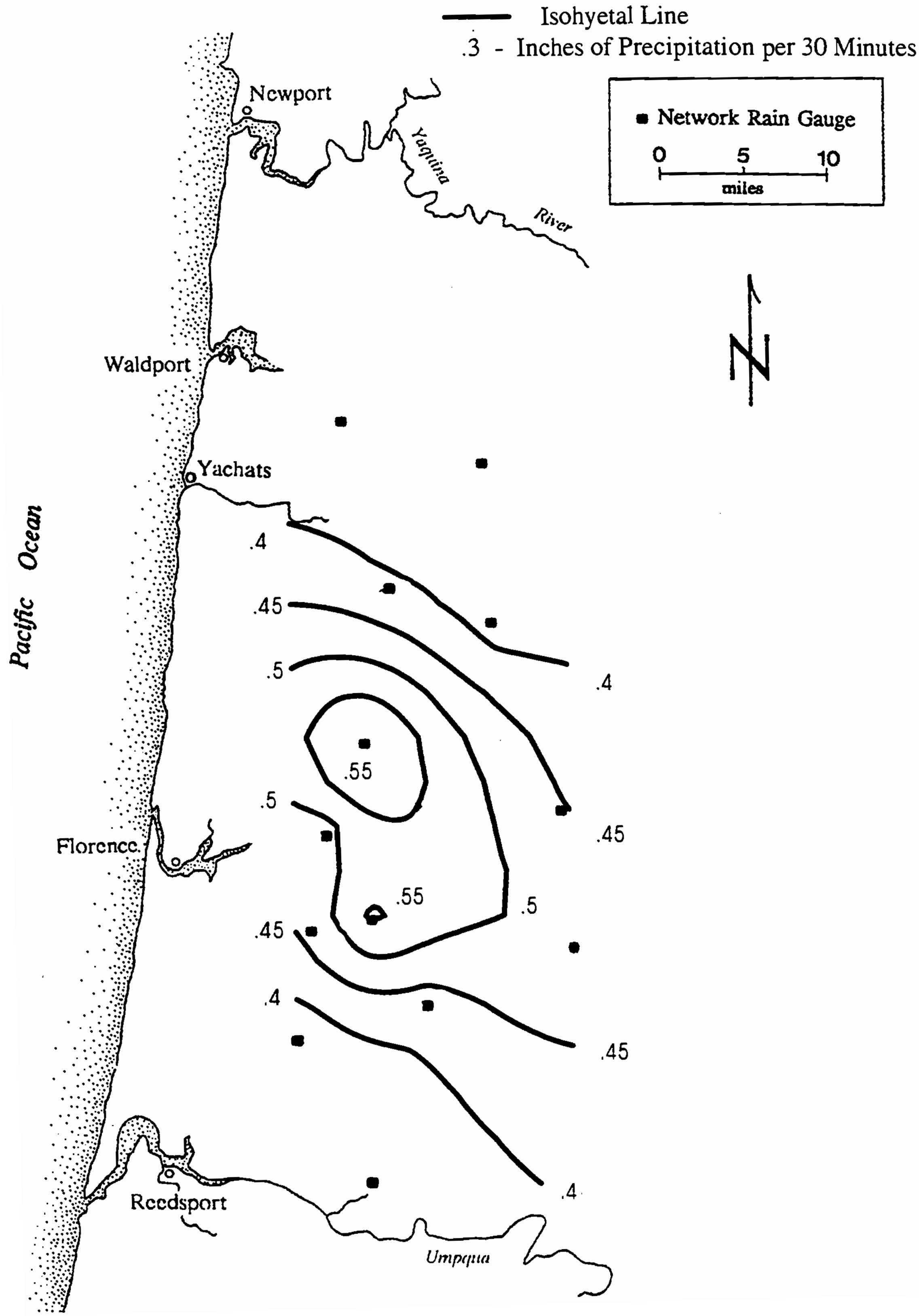


Figure 20. 2-Year - 1 Hour Precipitation Amount

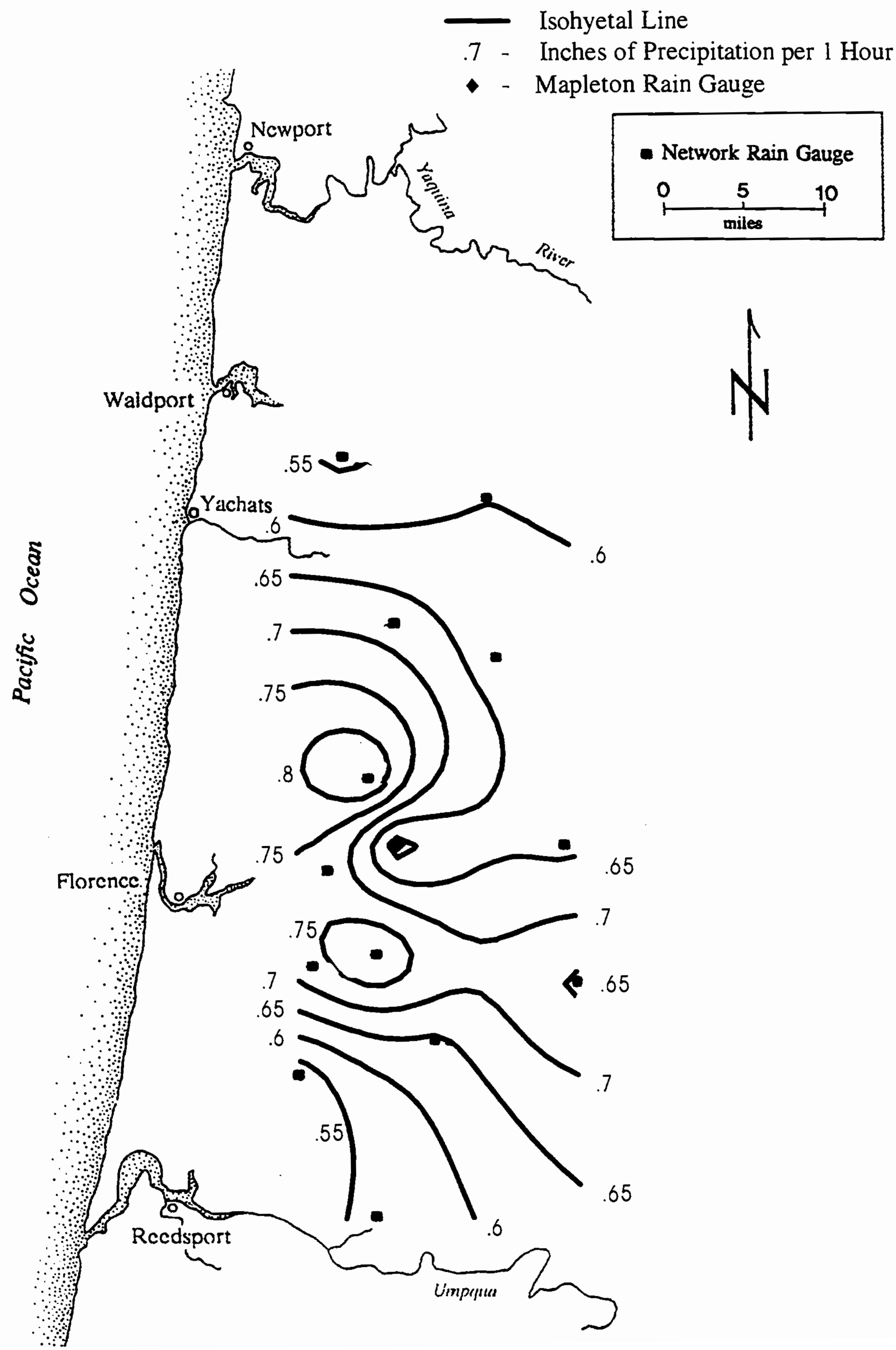


Figure 21. 2-Year - 2 Hour Precipitation Amount

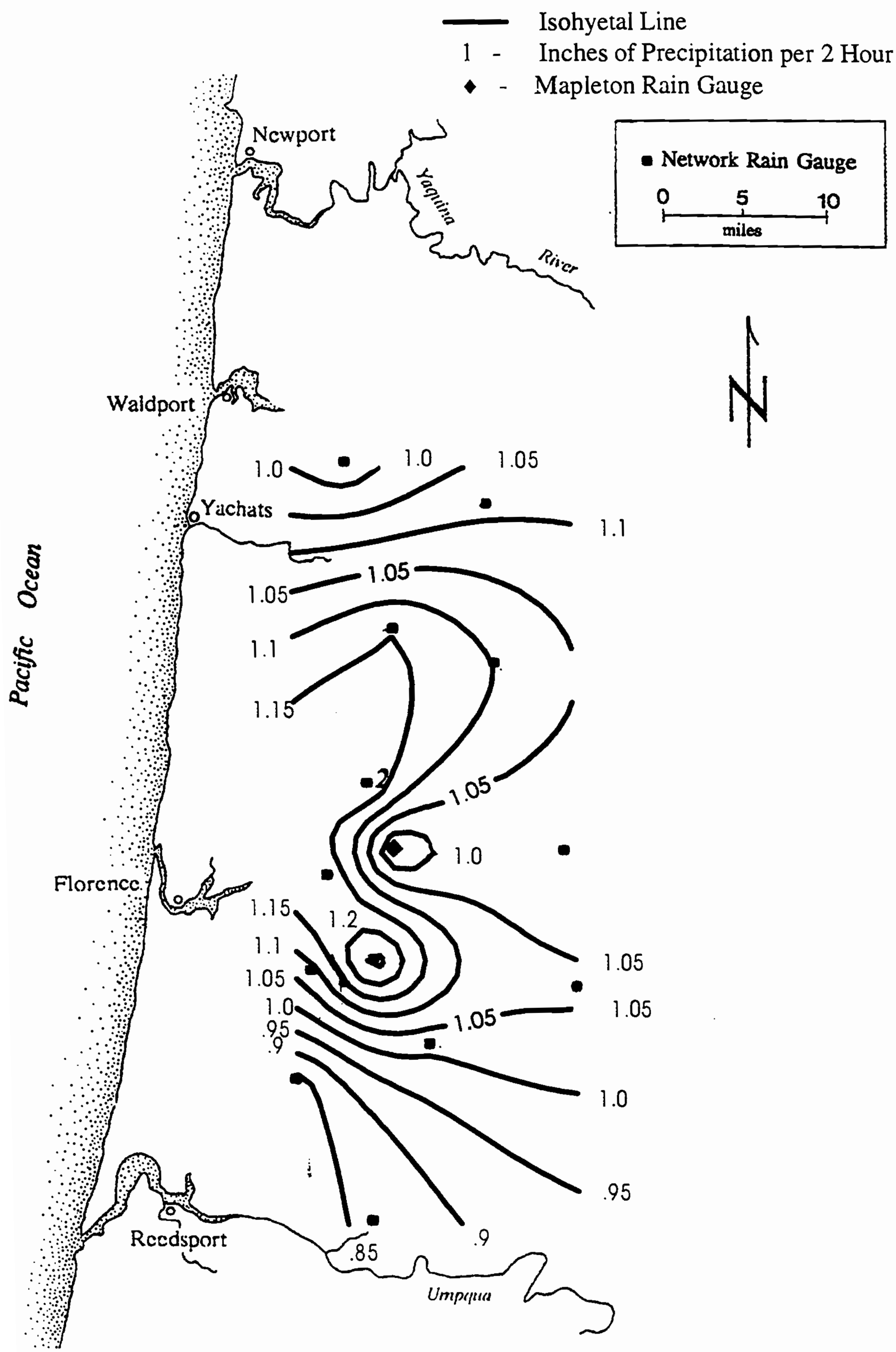


Figure 22. 2-Year - 6 hour Precipitation Amount

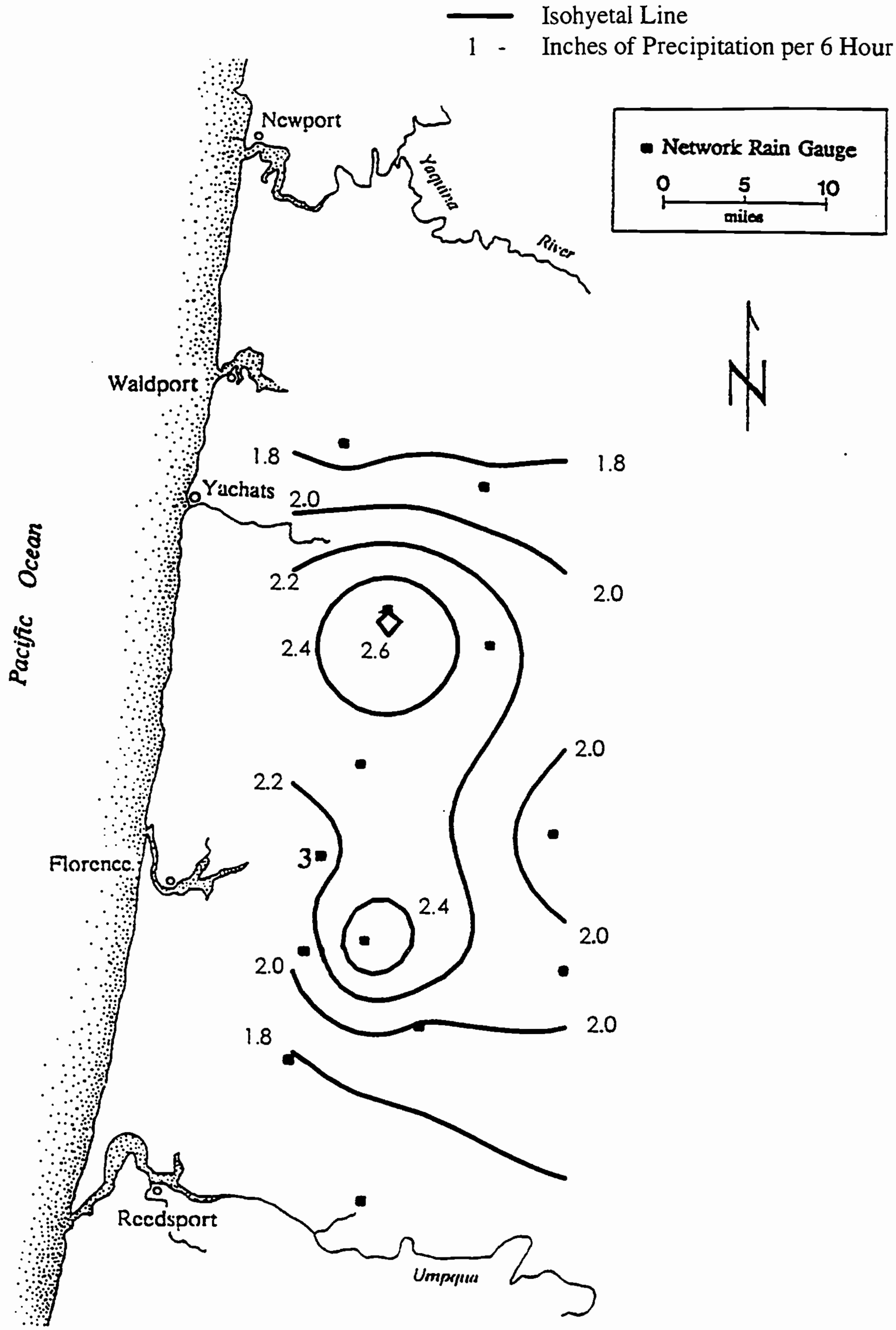
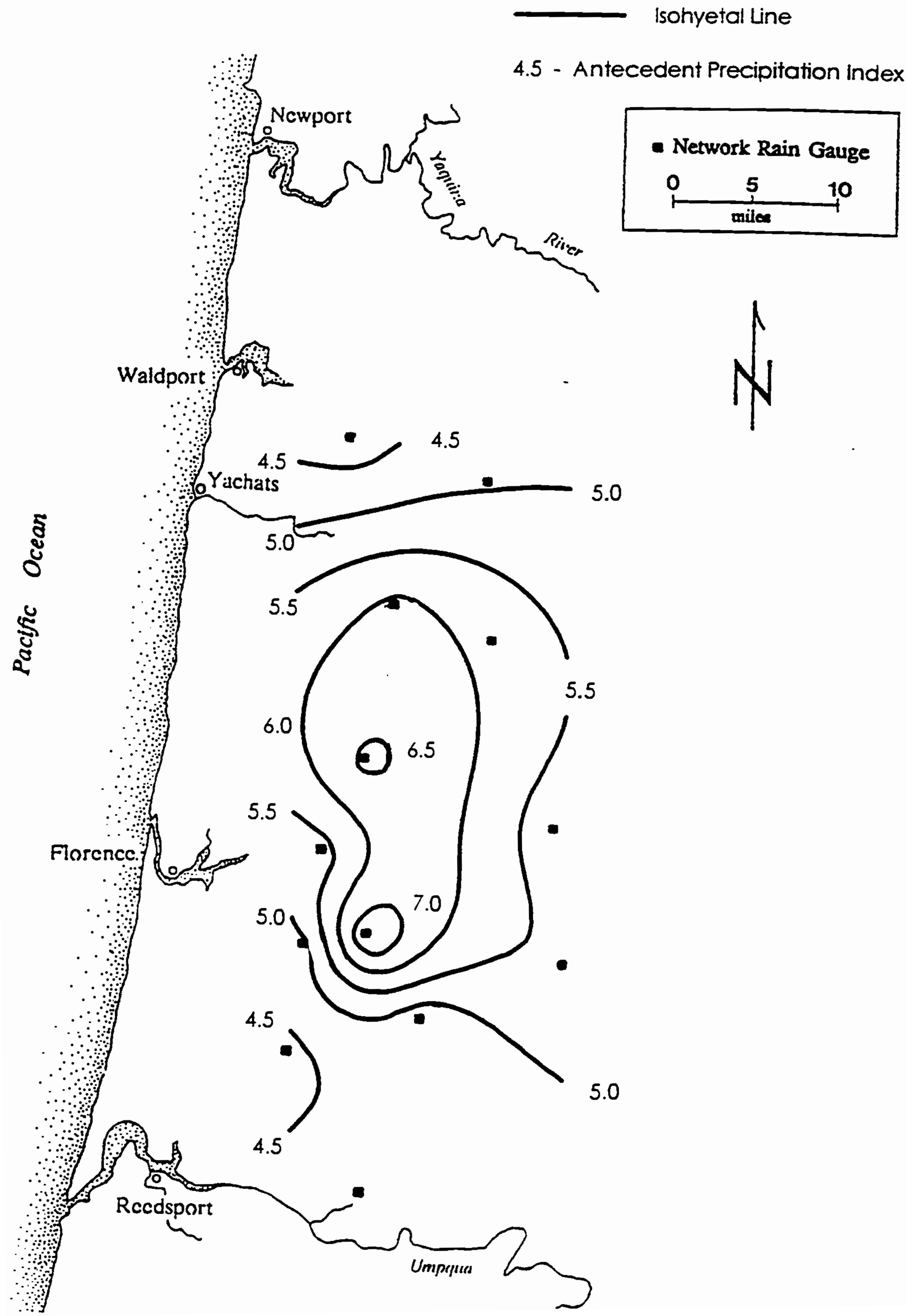


Figure 23. 2-Year - Antecedent Precipitation Index



represents the amount of precipitation for that selected time duration with a two year recurrence interval or an annual probability of being equaled or exceeded of 50 percent.

A definite trend is observed in the two-year precipitation intensities across the central Oregon Coast Range. Precipitation intensities are higher in the central portion of the study area with decreasing intensity toward the northern and southern boundaries. The highest precipitation intensities for the durations, less than or equal to 2 hours, are at the Thompson Creek and South Canyon rain gauges. These rain gauges are north and south of the town of Mapleton, respectively. The highest precipitation amount, for the 6 hour duration, is at the Indian Creek rain gauge. The 6 hour precipitation amount is also high at the Thompson Creek, South Canyon and Panther Creek rain gauges. The Mapleton rain gauge is located between the Thompson Creek and South Canyon rain gauges in the Siuslaw River valley near the city of Mapleton. Though centered in this area of higher precipitation intensity, it has lower values than the ridge top rain gauges of Thompson Creek, Indian Creek and South Canyon.

It appears that winter storms which usually track inland from the southwest, travel up the Siuslaw River valley. When they reach the first high elevation ridges of the Siuslaw River watershed, the ridges that the Thompson Creek and South Canyon rain gauges are located on, the highest 2 hour and shorter duration precipitation intensities occur. As storms track across the Siuslaw River watershed, they must get slowed at the farthest northern boundaries of the watershed by the northern ridges. The highest 6 hour precipitation intensities are most frequent here.

North and south of the Siuslaw River watershed, the precipitation intensities decrease, possibly due to topographic influences. A possibility could be that the northern rain gauges, Cascade Creek and Lobster Creek, are in a rain shadow from the higher ridges of the northern Siuslaw River watershed. As storms track from the southwest during winter the northern ridges of the Siuslaw River watershed may reduce precipitation that reaches those northern rain gauges. This rain shadow effect cannot be argued for the southern rain gauges located in the Smith River and Umpqua River watersheds. Some topographic influence or less intense storm cells that track through these southern areas may create this lower intensity spatial trend.

This spatial pattern is not always followed in individual storms (see Appendix A for partial-duration series storm data). It is not uncommon for the peak precipitation intensity of any particular storm to occur at any location in the network. But, the dominate high intensity trends are given by the isohyetal maps.

Higher API values are found more frequent where the high precipitation intensity trends exists, centered around the ridges of the Mapleton area. API values are lower toward the northern and southern boundaries of the study area. Maximum API values are found at the Thompson Creek and South Canyon rain gauges, with API decreasing to the north and south of these sites.

Elevational Characteristics

The effect of changes in elevation on precipitation is known as orographics. In Oregon the orographic effect alters mean annual precipitation throughout the state. Mean annual precipitation increases along an elevation gradient with the highest mean annual precipitation at the highest elevations (Daly and Taylor, 1993).

Of interest is whether short duration precipitation intensities or API, in the central Oregon Coast Range, are similarly influenced by elevation. The spatial analysis shows a trend in the distribution of precipitation intensities and API. The interpretation of this spatial distribution could be strengthened if elevation is found to correlate with the precipitation intensities. If an elevational trend can be observed and quantified, then rain gauge information collected at low elevations could be used to predict high elevation, un-gauged areas.

The correlation of precipitation intensity and API with elevation are presented in Figures 24 - 29. The 2-year 5 minute, 30 minute, 1 hour, 2 hour, 6 hour precipitation intensities and API do not have a statistically significant correlation with elevation. The 2-year 5 minute and 30 minute precipitation intensities have non-significant negative correlations (Figures 24 and 25), with p values of 0.59 and 0.96 respectively. The 2-year 1 hour, 2 hour, 6 hour and API regression analysis show non-significant positive correlations (Figures 26 - 29), with p values of 0.54, 0.38, 0.78, and 0.32 respectively.

The 1 hour and 2 hour precipitation duration plots include the Mapleton rain gauge. This data point defines the lower limit of the regression line in the 1 and 2 hour duration regression plots. This occurs because the Mapleton rain gauge is at a location with lower precipitation intensities relative to many of the other rain gauges of the network. However, when viewing the scatter of the points in the regression plot, if the Mapleton rain gauge was excluded a better correlation would not be produced.

The correlation between elevation and precipitation intensity or API was conducted using the 2-year event. The 2-year precipitation intensities will occur on

Figure 24. Graph of 2-Year, 5 minute Precipitation Intensity versus Elevation

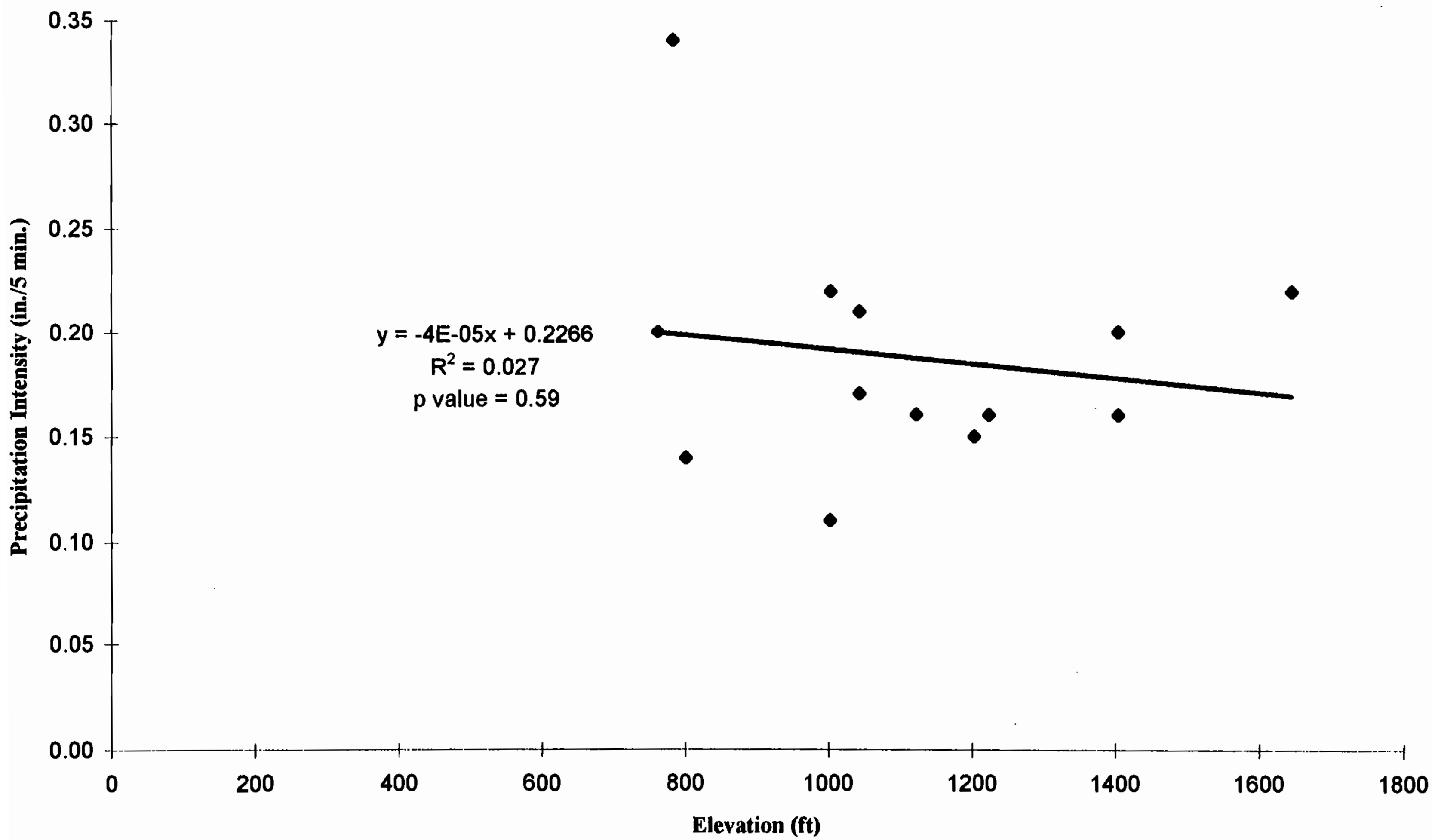


Figure 25. Graph of 2-Year, 30 Minute Precipitation Intensity versus Elevation

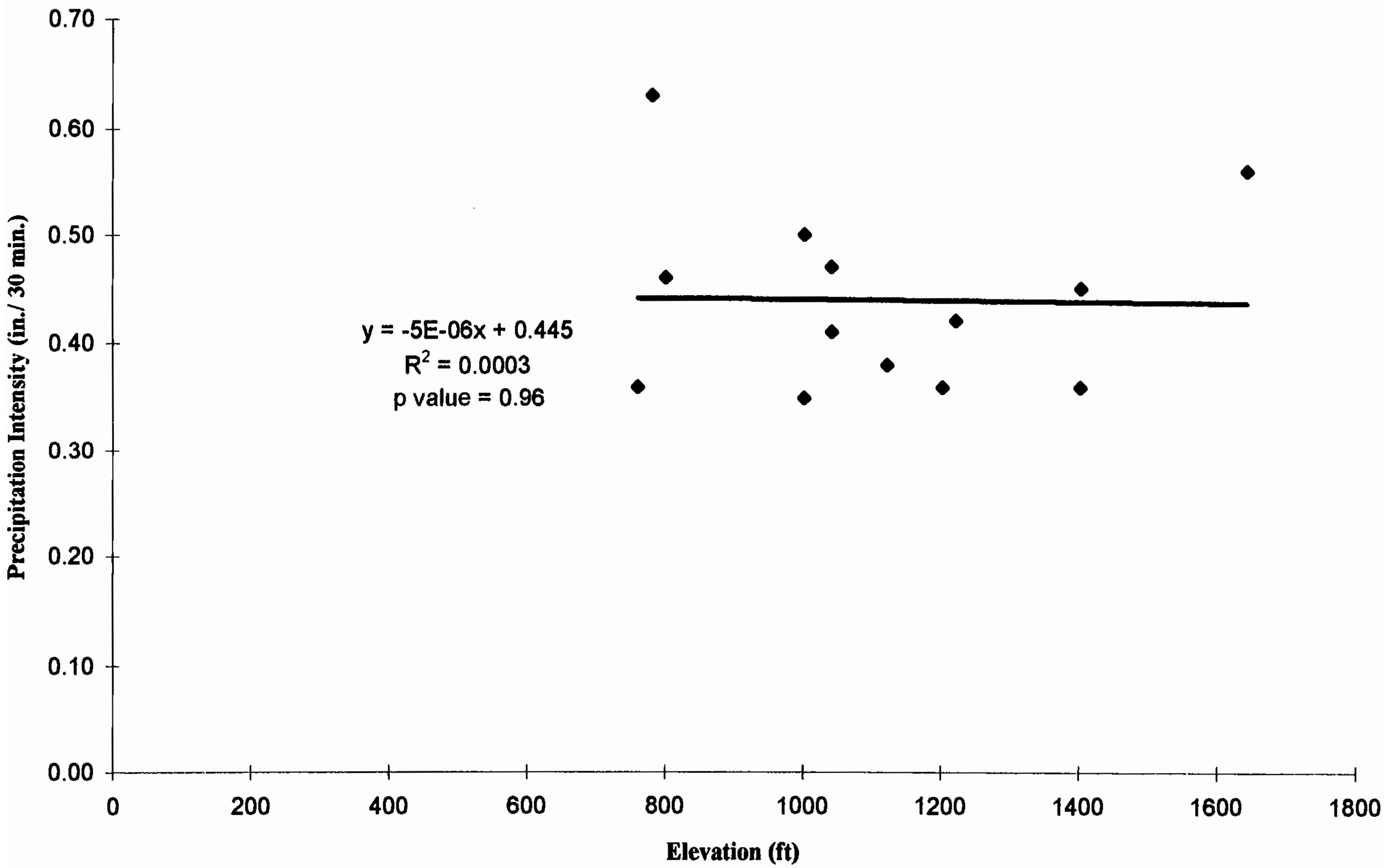


Figure 26. Graph of 2-Year, 1 Hour Precipitation Intensity versus Elevation

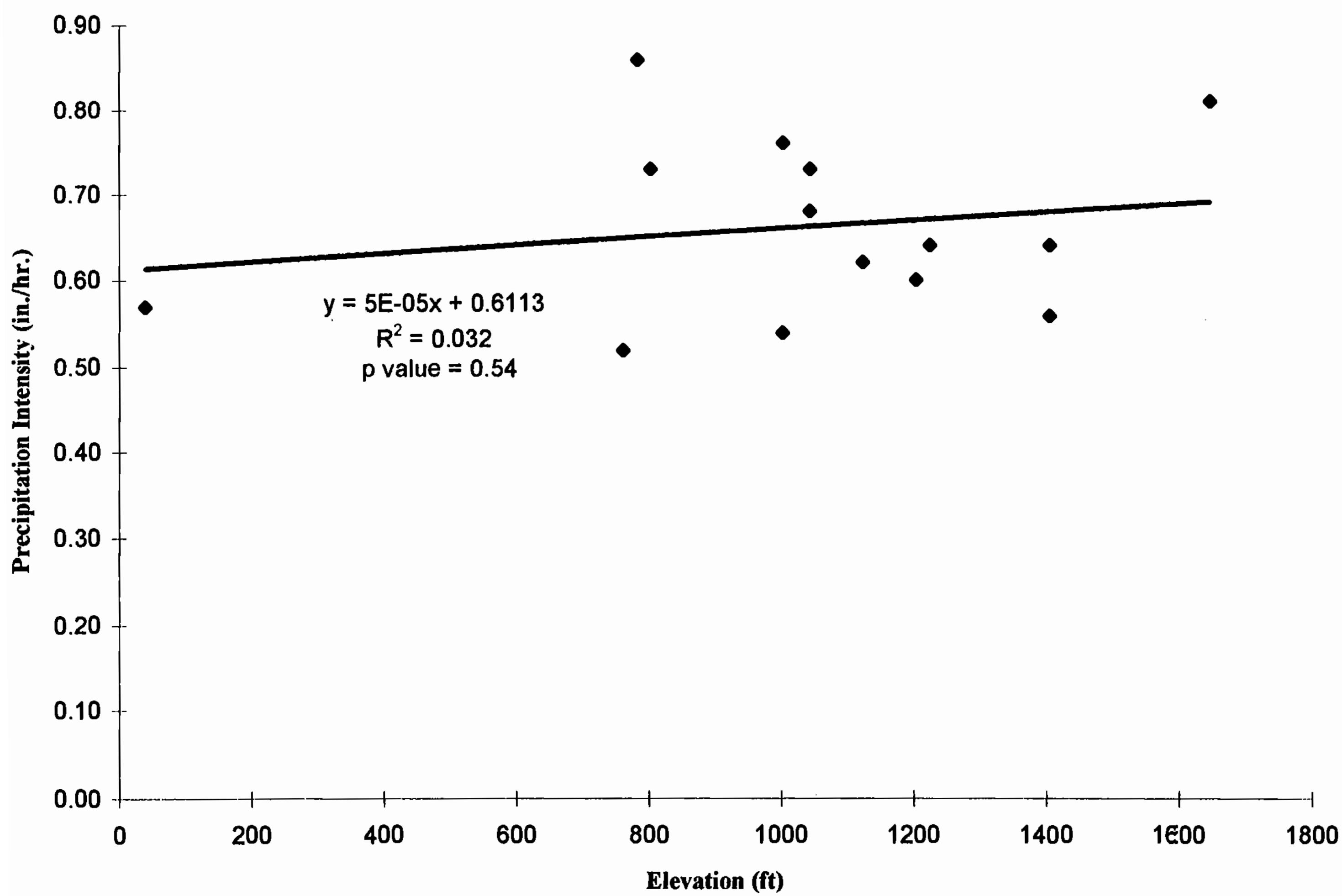


Figure 27. Graph of 2-Year, 2 Hour Precipitation Intensity versus Elevation

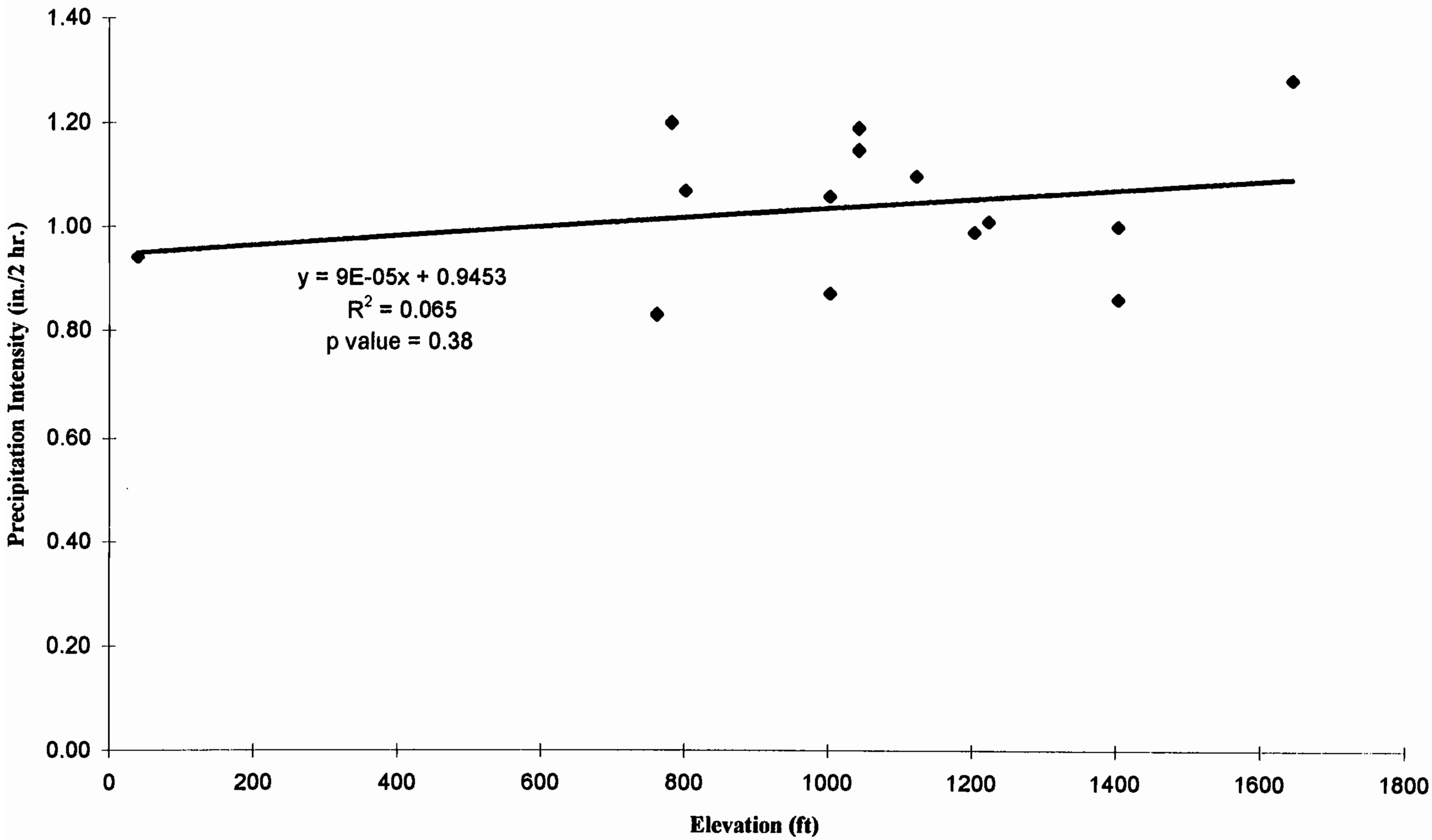


Figure 28. Graph of 2-Year, 6 Hour Precipitation Intensity versus Elevation

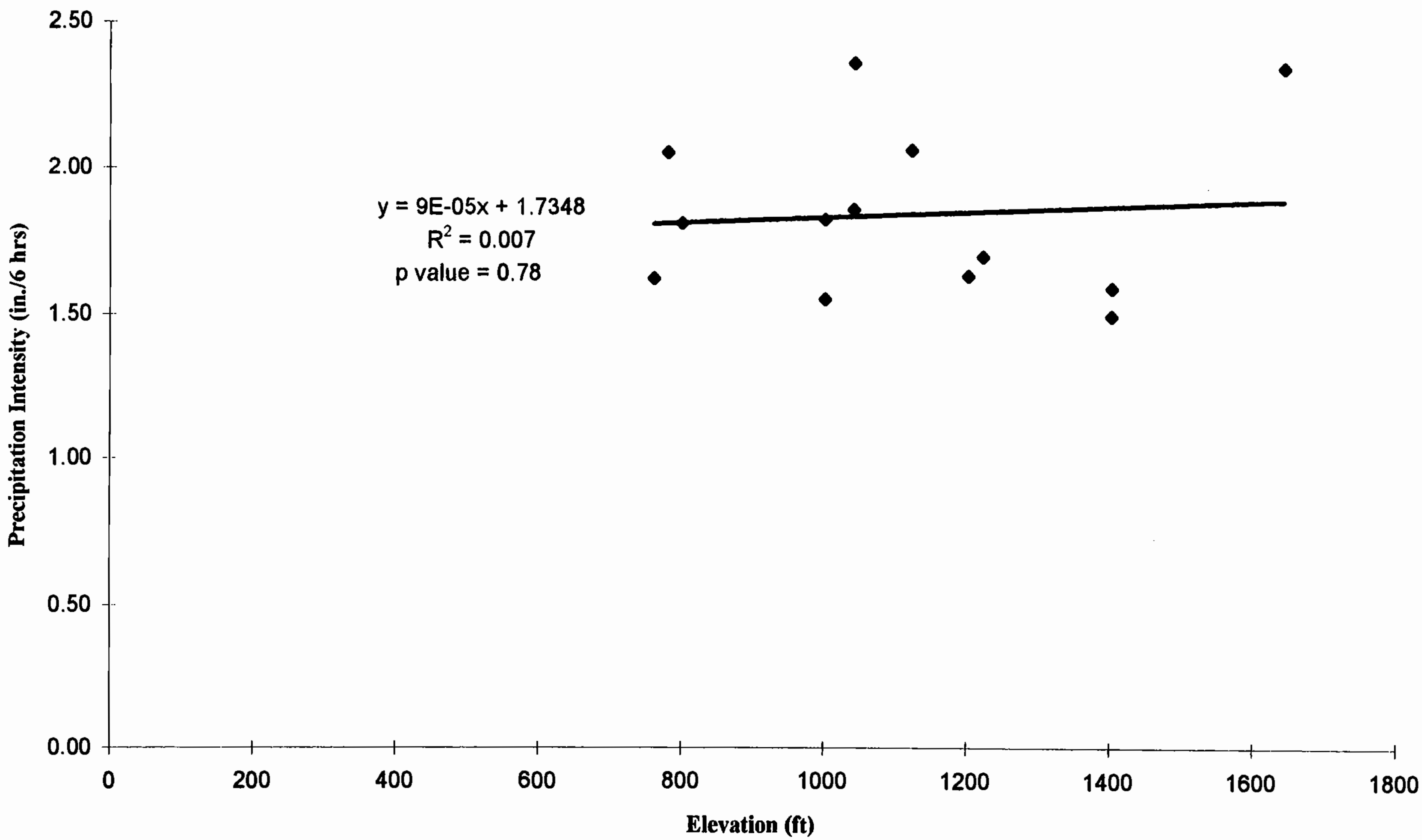
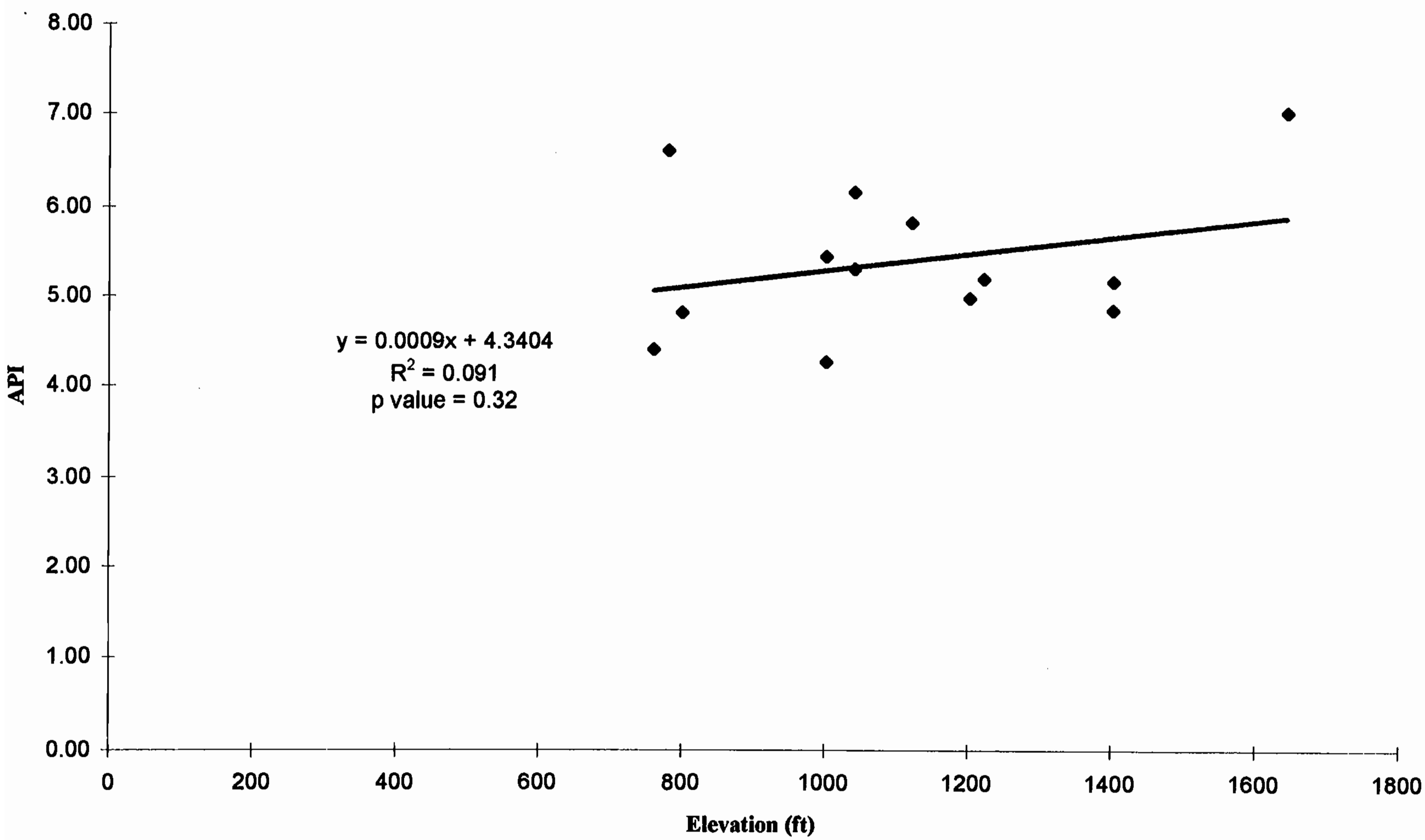


Figure 29. Graph of 2-Year Antecedent Precipitation Index versus Elevation



average every 2 years at each of the rain gauges but it is unlikely these magnitudes would occur during the same storm event across the network. To investigate the relationship of precipitation intensity and API with elevation during storm events, two separate storms were analyzed. One storm, which occurred April 15, 1992, was a short duration, high intensity storm which covered the entire rain gauge network. The other storm, which occurred January 29, 1995, was a long duration, low intensity storm which also covered the entire rain gauge network. A sub-sample of precipitation intensities, the 5 minute and 1 hour duration and API were checked for correlation with elevation using linear regression. The resulting regression slope, intercept, p value and coefficient of determination for these storm events are presented in Table 10.

Table 10. Precipitation Intensity and API Relationship with Elevation for 2 Isolated Storm Events.

1/29/95 Storm		**Regression Line Slope**	**Intercept**	**P Value**	**Coefficient of Determination (r^2)**
	5 Minute Intensity	0.0000004	0.07	0.99	0.00003
	1 Hour Intensity	-0.00009	0.051	0.56	0.04
	API	0.0015	0.759	0.35	0.11
4/15/92 Storm					
	5 Minute Intensity	-0.00002	0.1	0.65	0.02
	1 Hour Intensity	0.000007	0.27	0.82	0.0003
	API	0.0002	2.24	0.80	0.007

As with the 2-year precipitation intensities, the precipitation intensity and API values show no statistically significant correlation with elevation for the isolated storms.

The slope of the regression lines varies from positive to negative with different precipitation intensities and the r^2 is low in all cases.

The 2-year precipitation intensities and the isolated storm precipitation intensities show extremely poor correlation with elevation. The p values ranged from 0.32 to an upper level of 0.96. The r^2 values ranged from as low as $3*10^{-5}$ to an upper level of 0.06. Relationships between short duration precipitation intensities with elevation, and API with elevation, within the rain gauge network cannot be determined.

Precipitation Characteristics for Landslide Hazard Analysis

The actual timing of headwall failure, should be dependent on site conditions and stochastic variations in rainfall, exhibited by certain combinations of antecedent precipitation and storm intensity (Reneau and Dietrich, 1987). What combination of antecedent precipitation and storm intensity creates the greatest likelihood of headwall failure? If a combination of antecedent precipitation and storm intensity can be identified, then does one easily measurable variable, such as precipitation intensity provide a prediction of headwall failure likelihood?

This thesis does not examine the question of what combination of antecedent precipitation and precipitation intensity creates the greatest likelihood of headwall failure. This would require field observations of headwall characteristics, failure potential of the headwalls, information on headwall failure timing coupled with an examination of the precipitation characteristics associated with that failure. This thesis examines the characteristics of precipitation hypothesized to create conditions conducive to increased headwall pore pressures, decreasing the soil shear strength, thus creating a greater hazard for headwall failure.

If the hypothesized model of high antecedent precipitation combined with high intensity precipitation is needed to create headwall failure, then high intensity precipitation will occur when high antecedent precipitation exists. The data set of precipitation intensities and antecedent precipitation indices for individual storms for the central Oregon Coast Range was analyzed to see if high intensity precipitation events occur in storms with high antecedent precipitation. The number of high intensity precipitation events, defined as precipitation intensities with greater than or equal to a 1-year recurrence interval, was counted in the storms with high antecedent precipitation, defined by high API. The number of high intensity events, which occurred in storms of high API, was expressed as a percent of the total possible number of precipitation intensity events greater than or equal to a 1-year recurrence interval. This was done for selected precipitation durations with two API data series. The first series was API storms which were used for the API partial-duration series. The second data set was API storms with an API greater than or equal to a 1-year recurrence interval (Tables 11 and 12).

The results presented in Tables 11 and 12, show that high precipitation intensities do occur in storms with high API, but results are variable. There is not one precipitation duration which occurs most frequently with high API at all rain gauges.

The percentages of precipitation intensities which have a recurrence interval greater than or equal to 1-year indicate the proportion of high precipitation intensity events in the two API data sets (Tables 11 and 12). Large proportions of high precipitation intensities in the API partial-duration series data indicate that high intensity precipitation events occur frequently with high antecedent precipitation conditions (Table 11). Proportions of the high precipitation intensities occur in the API events with greater than a 1-year recurrence interval in the majority of selected durations and rain gauges (Table 12). This suggests that not only do the high precipitation intensities occur in storms with high antecedent precipitation conditions but occur in storms with the highest antecedent precipitation conditions (see Appendix B for actual API series data).

High intensity precipitation, though infrequent, is observed to occur with high API. But, can a particular precipitation intensity duration correlate with API? If a correlation is found then it may be possible to use that duration as a predictor for precipitation characteristics with the greatest potential to trigger headwall failures.

Precipitation intensities and API for individual storms were analyzed to see if high intensity precipitation or total storm precipitation correlated with high API. The same two API data sets were used from the previous analysis of percentage of occurrence of high intensity precipitation and high API. These are the data sets of API storms which made up the API partial-duration series and storms with an API greater than a 1-year recurrence interval (Tables 13 and 14).

Precipitation intensity and total storm precipitation had correlation coefficients which varied greatly with high API. In both API data sets correlation coefficients varied from negative to positive correlations. No single precipitation intensity, including total storm precipitation, show a strong positive correlation with high API for the entire rain gauge network. It appears that any attempts to predict the precipitation characteristics with the greatest potential to trigger headwall failure by a threshold of a particular precipitation intensity duration is not possible in the central Oregon Coast Range.

Table 11. Occurrence of High Intensity Precipitation (greater than 1 year recurrence) and API for the Partial-Duartion Series API Storms.

	Number of Precipitation Intensities by Duration. (> or = 1-Year Recurrence Interval)					Percent of Possible Precipitation Intensities by Duration. (> or = 1-Year Recurrence Interval)				
Rain Gauge	5 min.	30 min.	1 hr.	2 hr.	6 hr.	5 min.	30 min.	1 hr.	2 hr.	6 hr.
Cascade Creek	2	3	4	5	5	40%	60%	80%	100%	100%
Indian Creek	1	3	4	2	1	14%	43%	57%	29%	14%
Johnson Creek	0	0	1	0	2	0%	0%	14%	0%	29%
Kirk Creek	2	4	5	6	6	29%	57%	71%	86%	86%
Lobster Creek	0	2	1	2	4	0%	29%	14%	29%	57%
Mill Creek	1	2	2	2	1	25%	50%	50%	50%	25%
Panther Creek	0	3	4	5	4	0%	50%	67%	83%	67%
Ryder Creek	5	2	2	5	6	83%	33%	33%	83%	100%
Smith River	6	3	4	6	6	86%	43%	57%	86%	86%
South Canyon	4	4	5	3	6	57%	57%	71%	43%	86%
Sweet Creek	2	7	5	4	4	29%	100%	71%	57%	57%
Thompson Creek	5	5	6	7	4	71%	71%	86%	100%	57%
Wassen Creek	2	4	5	5	6	29%	57%	71%	71%	86%

Table 12. Occurrence of High Intensity Precipitation (greater than 1 year recurrence) and API for Storms with API Greater Than a 1 Year Recurrence Interval.

	Number of Precipitation Intensities by Duration. (> or = 1-Year Recurrence Interval)					Percent of Possible Precipitation Intensities by Duration. (> or = 1-Year Recurrence Interval)				
Rain Gauge	5 min.	30 min.	1 hr.	2 hr.	6 hr.	5 min.	30 min.	1 hr.	2 hr.	6 hr.
Cascade Creek	0	1	0	1	1	0%	14%	0%	14%	14%
Indian Creek	0	1	1	1	1	0%	14%	14%	14%	14%
Johnson Creek	0	0	0	0	1	0%	0%	0%	0%	14%
Kirk Creek	2	3	4	4	5	29%	43%	57%	57%	71%
Lobster Creek	0	1	1	1	3	0%	14%	14%	14%	43%
Mill Creek	0	1	1	1	1	0%	25%	25%	25%	25%
Panther Creek	0	2	3	4	3	0%	33%	50%	67%	50%
Ryder Creek	0	0	0	1	1	0%	0%	0%	14%	14%
Smith River	2	2	2	4	3	29%	29%	29%	57%	43%
South Canyon	4	2	3	2	5	57%	29%	43%	29%	71%
Sweet Creek	1	3	2	1	2	14%	43%	29%	14%	29%
Thompson Creek	2	2	3	4	3	29%	29%	43%	57%	43%
Wassen Creek	0	2	3	3	3	0%	29%	43%	43%	43%

A precipitation intensity threshold, such as Caine's threshold (Caine, 1980), which relates high landslide failure hazard with high intensity precipitation alone appears inappropriate for the central Oregon Coast Range. High precipitation intensities occur both with and without conditions of high antecedent precipitation in the central Oregon Coast Range. A potential landslide hazard threshold, based on precipitation intensity alone, could show storms with precipitation intensity high enough to exceed Caine's threshold, while lacking the high antecedent precipitation conditions necessary for failure.

Attempts to assess the risk of headwall failure by high API may be possible for the central Oregon Coast Range. To predict some API threshold is appropriate for assessing headwall failure risk would assume that the precipitation characteristics for triggering headwall failures are inherent in the API measurement. High API storms do have high precipitation intensities associated with them. The API partial-duration series data set show a high percentage of precipitation intensities greater than or equal to a 1-year recurrence interval (Table 11). High precipitation intensities also occur in the API events with greater than a 1-year recurrence interval in the majority of selected durations and rain gauges (Table 12). Not only do the high precipitation intensities occur with high antecedent precipitation conditions but they occur at the highest antecedent precipitation conditions (Tables 11 and 12).

With a longer record of precipitation in the rain gauge network, a greater number of large precipitation events can be observed compared to the current data. Better correlations of the combined precipitation characteristics that are needed to meet the hypothesized conditions to trigger headwall failure could be observed. If the relationships and observed characteristics of the current data set are assumed to be

Table 13. Correlation of Precipitation Intensity and High API for the Partial-Duration Series API Storms.

Rain Gauge	Correlation Coefficients for Precipitation Intensity Associated with High API (API Partial Series)					
	5 min.	30 min.	1 hr.	2 hr.	6 hr.	Storm Total
Cascade Creek	0.26	0.49	0.54	0.56	0.52	-0.58
Indian Creek	-0.10	0.03	0.09	0.15	0.15	0.27
Johnson Creek	-0.05	0.22	0.26	0.27	0.36	0.65
Kirk Creek	0.67	0.55	0.48	0.49	0.48	0.50
Lobster Creek	0.32	0.43	0.46	0.50	0.50	0.55
Mill Creek	0.28	0.48	0.52	0.56	0.69	0.65
Panther Creek	0.27	0.47	0.39	0.41	0.34	0.14
Ryder Creek	0.14	0.21	0.24	0.26	0.30	0.51
Smith River	0.43	0.52	0.54	0.50	0.47	0.50
South Canyon	0.59	0.61	0.62	0.63	0.65	0.58
Sweet Creek	0.54	0.45	0.41	0.28	0.44	0.39
Thompson Creek	0.47	0.48	0.50	0.56	0.55	0.49
Wassen Creek	0.39	0.44	0.44	0.45	0.48	0.45

Table 14. Correlation of Precipitation Intensity and High API for Storms with API Greater Than 1-Year Recurrence Interval.

Rain Gauge	Correlation Coefficients for Precipitation Intensity Associated with High API (> 1 Year API Events)					
	5 min.	30 min.	1 hr.	2 hr.	6 hr.	Storm Total
Cascade Creek	-0.07	0.25	0.53	0.72	0.48	0.59
Indian Creek	0.03	0.13	0.14	0.15	0.03	0.09
Johnson Creek	-0.35	-0.04	-0.03	-0.16	-0.13	0.52
Kirk Creek	0.85	0.46	0.34	0.35	0.41	0.53
Lobster Creek	0.56	0.59	0.58	0.52	0.40	0.44
Mill Creek	0.84	0.82	0.76	0.69	0.80	0.75
Panther Creek	0.61	0.79	0.76	0.68	0.40	-0.18
Ryder Creek	0.25	0.32	0.30	0.36	0.51	-0.04
Smith River	0.18	0.13	0.20	0.36	0.50	0.13
South Canyon	0.03	0.08	0.23	0.38	0.51	0.42
Sweet Creek	0.79	0.82	0.89	0.86	0.89	0.31
Thompson Creek	0.09	-0.05	-0.07	0.14	0.24	0.33
Wassen Creek	0.83	0.57	0.31	0.31	0.27	0.66

representative of the central Coast Range over a longer length of time, then it is doubtful, even with a longer data record, that precipitation intensity alone would be identified as a trigger for headwall failure. From this analysis, the best method to assess the headwall failure risk from precipitation is to consider the occurrence of high API with high precipitation intensity. When this assessment is combined with a knowledge of the sites most prone to failure (i.e. high risk headwalls) a general assessment of headwall failure risk and its location spatially may be possible.

CONCLUSIONS

This thesis presented the first analysis of precipitation data from the Department of Forest Engineering rain gauge network along with the long-term precipitation record at Mapleton. The purpose of the analysis was to assess the spatial and temporal distribution of precipitation intensity and antecedent precipitation and understand the precipitation characteristics which trigger debris slides in headwalls in the central Oregon Coast Range. The specific points learned from this thesis are summarized below:

- Precipitation intensities associated with selected recurrence intervals varied considerably over the study area. The variability of precipitation intensities across the study area substantiates the problems associated with using one rain gauge in some central location, to represent precipitation across the mountainous terrain of the central Coast Range. Precipitation values for selected durations and recurrence could vary as much as 50% or larger for selected rain gauge locations. For example, the 1 hour, 1-year precipitation intensity recurrence is 52% greater at the Thompson Creek rain gauge than at the Cascade Creek rain gauge. This variability occurs within 25 miles. Not only does the amount of precipitation across the Coast Range vary, but the probability or risk of a selected precipitation amount occurring varies as well. For example, a 1 hour precipitation intensity for a twenty five year recurrence interval at Wassen Creek is 0.76 inches. At the Thompson Creek rain gauge this amount equates to a 1 year recurrence interval.

- A definite spatial trend is observed in the two-year precipitation intensities across the central Oregon Coast Range. Precipitation intensities are higher in the central portion of the study area with decreasing intensity toward the northern and southern boundaries. As storms track across the Siuslaw River watershed, they must get slowed at the farthest northern boundaries of the watershed by the northern ridges. North and south of the Siuslaw River watershed, the precipitation intensities decrease, possibly due to topographic influences. A possibility could be a rain shadow from the higher ridges of the northern Siuslaw River watershed. This rain shadow effect cannot be argued for the southern rain gauges located in the Smith River and Umpqua River watersheds. Some topographic influence or less intense storm cells that track through these southern areas may create this lower intensity spatial trend.
- Higher API values are found more frequent where the high precipitation intensity spatial trends exists, centered around the ridges of the Mapleton area. API values are lower toward the northern and southern boundaries of the study area.
- Dynamic calibration of tipping bucket rain gauges, as presented by Humphrey et. al. (1996), is important for determining rain gauge accuracy. New factory calibrated rain gauges showed collection rates substantially different from actual applied rates. Collection deviations ranged from 5 -20 percent. The large errors would result in inaccuracy of the data collected if they were not identified, by a dynamic calibration.
- The 2-year precipitation intensities and the isolated storm precipitation intensities showed no statistically significant correlation with elevation and low r^2 values. The 2-year 5 minute, 30 minute, 1 hour, 2 hour, 6 hour and API regression analysis had p values of 0.59, 0.96, 0.54, 0.38, 0.78 and 0.32, respectively. Relationships between

short duration precipitation intensities with elevation, and API with elevation, within the rain gauge network could not be determined.

- High precipitation intensities do occur in storms with high API, but results are variable.
- No single precipitation intensity, including total storm precipitation, show a strong positive correlation with high API for the entire rain gauge network. It appears that any attempts to predict the precipitation characteristics with the greatest potential to trigger headwall failure by a threshold of a particular precipitation intensity duration is not possible in the central Oregon Coast Range.
- Attempts to assess the risk of headwall failure by high API may be possible for the central Oregon Coast Range. Not only do the high precipitation intensities occur with high antecedent precipitation conditions but they occur at the highest antecedent precipitation conditions.

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APPENDICES

APPENDIX A

PRECIPITATION INTENSITY PARTIAL SERIES DATA

Cascade Creek Storm Start Time	5 minute Intensity (in.)	Annual Return
12/29/94 16:34	0.14	8.20
11/20/92 21:49	0.11	3.15
10/20/90 23:45	0.11	1.95
10/31/90 5:45	0.11	1.41
5/7/93 6:57	0.11	1.11
11/17/91 4:41	0.10	0.91
3/8/95 0:49	0.10	0.77
10/25/91 19:57	0.10	0.67
11/4/91 8:00	0.09	0.59
2/21/92 18:36	0.09	0.53

Cascade Creek Storm Start Time	30 minute Intensity (in.)	Annual Return
11/20/92 21:49	0.52	8.12
10/20/92 0:54	0.35	3.12
2/21/92 18:36	0.32	1.93
1/19/93 2:42	0.31	1.40
12/9/92 19:45	0.30	1.10
11/17/91 4:41	0.27	0.90
11/19/91 12:51	0.27	0.77
1/27/92 2:20	0.26	0.67
2/17/92 0:59	0.25	0.59
3/5/92 13:43	0.25	0.53
1/8/95 16:00	0.24	0.48
11/16/91 7:21	0.24	0.44
3/8/95 0:49	0.24	0.40
11/4/91 8:00	0.24	0.37
10/25/91 19:57	0.23	0.35
3/17/95 19:52	0.22	0.32
10/29/90 16:33	0.22	0.31

Cascade Creek Storm Start Time	1 Hour Intensity (in.)	Annual Return
11/20/92 21:49	0.67	8.10
10/20/92 0:54	0.64	3.12
1/19/93 2:42	0.55	1.93
12/9/92 19:45	0.51	1.40
1/27/92 2:20	0.48	1.09
2/17/92 0:59	0.46	0.90
11/19/91 12:51	0.46	0.76
3/8/95 0:49	0.41	0.66
11/4/91 8:00	0.39	0.59
1/8/95 16:00	0.39	0.53
2/21/92 18:36	0.39	0.48
1/10/95 14:31	0.39	0.44
11/16/91 7:21	0.36	0.40
1/29/95 6:06	0.35	0.37
2/16/95 17:24	0.34	0.35
3/17/95 19:52	0.33	0.32
11/17/91 4:41	0.32	0.30
11/30/92 0:27	0.32	0.29
12/1/91 4:22	0.32	0.27
10/29/90 16:33	0.31	0.26

Cascade Creek Storm Start Time	2 Hour Intensity (in.)	Annual Return
10/20/92 0:54	1.02	8.10
11/20/92 21:49	1.00	3.11
12/9/92 19:45	0.99	1.93
1/19/93 2:42	0.86	1.40
2/17/92 0:59	0.85	1.09
1/27/92 2:20	0.78	0.90
11/19/91 12:51	0.71	0.76
11/4/91 8:00	0.65	0.66
3/8/95 0:49	0.65	0.59
1/10/95 14:31	0.65	0.53
1/8/95 16:00	0.63	0.48
2/16/95 17:24	0.61	0.44
12/1/91 4:22	0.58	0.40
1/29/95 6:06	0.56	0.37
11/25/91 1:26	0.54	0.35
11/18/92 20:59	0.52	0.32
11/6/92 15:23	0.51	0.30
12/5/91 1:25	0.51	0.29
2/21/92 18:36	0.51	0.27
3/19/95 18:24	0.50	0.26
10/29/90 16:33	0.50	0.25

Cascade Creek Storm Start Time	6 Hour Intensity (in.)	Annual Return
12/9/92 19:45	2.13	8.12
11/20/92 21:49	1.73	3.12
1/19/93 2:42	1.72	1.93
2/17/92 0:59	1.64	1.40
1/8/95 16:00	1.60	1.10
10/20/92 0:54	1.59	0.90
11/19/91 12:51	1.54	0.77
2/16/95 17:24	1.51	0.67
1/27/92 2:20	1.43	0.59
1/29/95 6:06	1.40	0.53
11/4/91 8:00	1.36	0.48
1/10/95 14:31	1.31	0.44
3/8/95 0:49	1.18	0.40
11/25/91 1:26	1.17	0.37
12/1/91 4:22	1.16	0.35
12/5/91 1:25	1.12	0.32
10/20/90 23:45	1.05	0.31

Indian Creek Precipitation Intensity Partial-Duration Series Data

Indian Creek Storm Start Time	5 minute Intensity (in.)	Annual Return
6/29/89 5:43	0.30	11.28
5/27/93 16:19	0.22	4.34
5/25/89 1:11	0.20	2.68
8/21/89 16:27	0.19	1.94
5/22/89 15:17	0.16	1.52
12/6/93 7:02	0.14	1.25
12/10/93 5:36	0.13	1.06
10/25/91 5:34	0.12	0.92
10/25/94 15:53	0.11	0.82
12/6/91 23:30	0.11	0.73
6/5/94 9:24	0.11	0.66
3/4/89 10:21	0.10	0.61
4/29/92 12:04	0.10	0.56
5/2/93 23:39	0.10	0.52
4/8/93 2:26	0.10	0.48
4/16/93 16:35	0.10	0.45
2/1/91 16:33	0.09	0.42
5/19/93 6:37	0.09	0.40
1/29/95 4:33	0.09	0.38
1/24/92 22:14	0.09	0.36
4/28/92 21:43	0.09	0.34
4/15/92 19:22	0.09	0.33
1/7/89 9:55	0.09	0.31
10/20/89 22:26	0.09	0.30
10/31/94 2:40	0.09	0.29
3/17/95 18:06	0.09	0.28
12/9/92 19:01	0.09	0.26
3/3/91 1:28	0.09	0.26
4/6/91 1:42	0.09	0.25
10/20/92 0:05	0.09	0.24
3/9/89 3:31	0.09	0.23
11/23/89 1:48	0.09	0.22
10/28/92 10:14	0.09	0.22
1/3/93 6:23	0.08	0.21
2/16/92 22:53	0.08	0.20
1/27/92 1:44	0.08	0.20
1/27/90 20:50	0.08	0.19

Indian Creek Storm Start Time	30 minute Intensity (in.)	Annual Return
10/25/94 15:53	0.50	11.31
5/22/89 15:17	0.46	4.35
6/29/89 5:43	0.46	2.69
12/6/91 23:30	0.43	1.95
10/31/94 2:40	0.41	1.53
10/20/92 0:05	0.40	1.26
8/21/89 16:27	0.38	1.07
11/19/91 12:55	0.37	0.93
3/4/89 10:21	0.36	0.82
1/29/95 4:33	0.35	0.73
12/6/93 7:02	0.34	0.67
12/3/89 13:02	0.34	0.61
1/27/92 1:44	0.33	0.56
2/16/92 22:53	0.33	0.52

5/25/89 1:11	0.32	0.48
2/16/95 13:04	0.32	0.45
1/7/89 9:55	0.31	0.43
12/9/92 19:01	0.30	0.40
11/20/92 19:19	0.29	0.38
11/30/93 12:26	0.29	0.36
1/19/93 0:22	0.29	0.34
3/1/91 11:56	0.29	0.33
11/8/94 12:16	0.29	0.31
3/3/91 1:28	0.29	0.30
4/6/91 1:42	0.29	0.29
12/4/90 4:32	0.28	0.28

Indian Creek Storm Start Time	1 Hour Intensity (in.)	Annual Return
10/25/94 15:53	0.79	11.45
10/20/92 0:05	0.70	4.41
10/31/94 2:40	0.69	2.73
1/29/95 4:33	0.69	1.97
11/19/91 12:55	0.64	1.55
1/27/92 1:44	0.63	1.27
2/16/95 13:04	0.60	1.08
5/22/89 15:17	0.60	0.94
2/16/92 22:53	0.57	0.83
11/30/94 9:35	0.56	0.74
12/4/90 4:32	0.55	0.67

Indian Creek Storm Start Time	2 Hour Intensity (in.)	Annual Return
10/25/94 15:53	1.49	11.36
10/20/92 0:05	1.30	4.37
10/31/94 2:40	1.23	2.71
2/16/95 13:04	1.08	1.96
11/19/91 12:55	1.07	1.54
12/16/94 11:12	1.05	1.26
1/29/95 4:33	1.03	1.07
1/7/89 9:55	0.99	0.93
11/30/94 9:35	0.99	0.82
3/4/89 10:21	0.98	0.74
11/20/92 19:19	0.96	0.67
11/30/93 12:26	0.95	0.61
11/11/89 19:20	0.95	0.56
2/16/92 22:53	0.93	0.52
1/27/92 1:44	0.93	0.49
12/3/89 13:02	0.92	0.45
10/21/90 3:15	0.91	0.43

Indian Creek Storm Start Time	6 Hour Intensity (in.)	Annual Return
10/25/94 15:53	3.46	11.34
10/31/94 2:40	3.09	4.36
12/16/94 11:12	2.84	2.70
2/16/95 13:04	2.63	1.96
11/30/94 9:35	2.60	1.53
11/20/92 19:19	2.35	1.26
1/29/95 4:33	2.35	1.07

1/27/92 1:44	2.30	0.93
1/7/89 9:55	2.24	0.82
11/19/91 12:55	2.24	0.74
4/4/91 2:16	2.14	0.67
11/30/93 12:26	2.08	0.61
4/26/90 18:31	2.06	0.56
8/1/89 10:14	2.05	0.52
3/4/89 10:21	1.96	0.48
10/21/90 3:15	1.82	0.45
10/25/89 22:43	1.78	0.43
12/9/92 19:01	1.77	0.40
2/16/92 22:53	1.77	0.38
1/19/93 0:22	1.76	0.36

Johnson Creek Storm Start Time	5 minute Intensity (in.)	Annual Return
5/13/93 2:11	0.27	11.31
10/21/89 0:41	0.14	4.35
12/9/92 3:11	0.12	2.69
5/24/93 12:14	0.12	1.95
10/25/89 23:40	0.11	1.53
3/6/92 14:50	0.11	1.26
5/22/89 14:47	0.11	1.07
8/21/89 6:21	0.11	0.93
4/29/92 15:25	0.11	0.82
10/28/92 10:46	0.11	0.73
5/15/94 1:06	0.11	0.67
10/24/94 18:04	0.10	0.61
11/26/92 19:33	0.10	0.56
12/5/93 5:24	0.10	0.52
3/1/92 23:16	0.10	0.48
10/20/92 1:04	0.10	0.45
11/24/89 0:17	0.10	0.43
10/25/90 7:10	0.10	0.40
12/20/88 4:00	0.10	0.38
2/4/91 7:22	0.10	0.36
11/11/91 19:00	0.10	0.34
10/28/92 23:53	0.10	0.33
11/14/94 21:46	0.10	0.31
5/29/93 7:13	0.09	0.30
3/3/91 1:32	0.09	0.29
3/12/95 17:32	0.09	0.28

Johnson Creek Storm Start Time	30 minute Intensity (in.)	Annual Return
10/21/89 0:41	0.49	11.30
5/15/94 10:10	0.40	4.34
10/20/92 7:23	0.39	2.69
4/29/92 15:25	0.36	1.95
12/3/89 13:02	0.35	1.53
10/25/90 7:10	0.33	1.26
11/30/92 1:01	0.32	1.07
11/29/93 13:13	0.31	0.93
5/22/89 14:47	0.30	0.82
5/25/93 14:51	0.29	0.73
1/8/95 16:20	0.29	0.66
10/25/94 16:19	0.27	0.61
3/7/95 22:50	0.27	0.56
4/8/92 7:02	0.27	0.52
8/21/89 6:21	0.27	0.48
10/29/92 20:12	0.27	0.45
11/30/94 10:58	0.26	0.42
10/21/90 5:09	0.26	0.40
10/28/92 23:53	0.25	0.38
12/5/93 15:17	0.25	0.36
2/16/92 2:18	0.25	0.34
7/15/89 22:59	0.25	0.33
11/24/89 0:17	0.24	0.31
6/5/90 16:38	0.24	0.30
11/17/90 7:37	0.24	0.29
1/29/95 4:21	0.24	0.28

10/25/89 23:40	0.23	0.27
12/9/92 16:20	0.23	0.26
3/3/91 1:32	0.23	0.25

Johnson Creek Storm Start Time	**1 Hour Intensity (in.)**	**Annual Return**
10/21/89 0:41	0.56	11.40
10/20/92 7:23	0.55	4.38
12/3/89 13:02	0.52	2.71
11/29/93 13:13	0.52	1.97
1/8/95 16:20	0.52	1.54
5/15/94 10:10	0.51	1.27
10/21/90 5:09	0.51	1.08
11/30/94 10:58	0.50	0.93
11/30/92 1:01	0.49	0.83
5/22/89 14:47	0.49	0.74
3/7/95 22:50	0.45	0.67
10/25/90 7:10	0.45	0.61
2/16/92 2:18	0.44	0.56
3/1/91 12:19	0.44	0.52

Johnson Creek Storm Start Time	**2 Hour Intensity (in.)**	**Annual Return**
12/3/89 13:02	0.93	11.35
5/22/89 14:47	0.92	4.36
10/21/90 5:09	0.91	2.70
11/29/93 13:13	0.84	1.96
11/30/94 10:58	0.83	1.53
3/7/95 22:50	0.79	1.26
4/26/90 18:51	0.77	1.07
1/8/95 16:20	0.77	0.93
10/25/94 16:19	0.74	0.82
8/21/89 6:21	0.74	0.74
11/11/89 22:32	0.74	0.67
7/15/89 22:59	0.73	0.61
3/4/89 22:19	0.72	0.56
2/16/92 2:18	0.72	0.52
1/19/93 2:59	0.71	0.48
11/30/92 1:01	0.71	0.45
10/21/89 0:41	0.70	0.43
2/7/90 12:52	0.67	0.40
3/3/91 1:32	0.67	0.38

Johnson Creek Storm Start Time	**6 Hour Intensity (in.)**	**Annual Return**
4/26/90 18:51	2.02	11.45
11/29/93 13:13	2.00	4.41
1/8/95 16:20	1.82	2.73
11/30/94 10:58	1.81	1.97
10/21/90 5:09	1.68	1.55
8/1/89 10:28	1.65	1.27
1/19/93 2:59	1.62	1.08
11/4/91 9:41	1.57	0.94
7/15/89 22:59	1.56	0.83
2/7/90 12:52	1.55	0.74
4/8/92 7:02	1.47	0.67

Kirk Creek Precipitation Intensity Partial-Duration Series Data

Kirk Creek Storm Start Time	5 Minute Intensity (in.)	Annual Return
11/21/88 1:36	0.27	11.35
2/6/89 13:17	0.27	4.36
4/12/92 13:40	0.25	2.70
11/5/88 13:45	0.22	1.96
3/2/89 9:00	0.19	1.53
5/26/89 18:55	0.17	1.26
11/9/88 5:52	0.15	1.07
11/27/88 0:37	0.15	0.93
11/2/88 4:39	0.14	0.82
6/29/89 5:05	0.14	0.74
11/7/88 20:07	0.13	0.67
9/10/94 15:36	0.12	0.61
3/13/95 23:47	0.11	0.56
10/25/94 17:38	0.10	0.52
8/26/90 20:10	0.10	0.48
11/7/89 10:59	0.10	0.45
12/3/89 17:43	0.10	0.43
12/3/93 20:36	0.10	0.40
2/4/91 7:36	0.10	0.38

Kirk Creek Storm Start Time	30 Minute Intensity (in.)	Annual Return
11/5/88 13:45	0.86	11.30
11/21/88 1:36	0.46	4.35
2/6/89 13:17	0.41	2.69
11/9/88 5:52	0.40	1.95
4/12/92 13:40	0.39	1.53
11/2/88 4:39	0.39	1.26
11/27/88 0:37	0.33	1.07
11/1/88 8:11	0.32	0.93
3/2/89 9:00	0.31	0.82
4/8/92 9:22	0.30	0.73
5/26/89 18:55	0.30	0.66
10/25/94 17:38	0.29	0.61
11/11/88 18:50	0.27	0.56
5/22/89 15:33	0.26	0.52
12/3/89 17:43	0.24	0.48
3/24/95 10:12	0.24	0.45
3/5/95 10:34	0.24	0.42
11/14/88 20:56	0.24	0.40
2/4/91 7:36	0.23	0.38
10/25/90 14:23	0.23	0.36
1/5/90 21:15	0.23	0.34
1/10/95 20:09	0.23	0.33
9/10/94 15:36	0.22	0.31
1/12/91 21:49	0.22	0.30
11/12/89 0:04	0.22	0.29
1/30/95 17:02	0.22	0.28
3/20/94 15:48	0.22	0.27
11/30/93 12:31	0.22	0.26

Kirk Creek Precipitation Intensity Partial-Duration Series Data

Kirk Creek Storm Start Time	1 Hour Intensity (in.)	Annual Return
11/5/88 13:45	1.20	11.36
11/2/88 4:39	0.62	4.37
11/1/88 8:11	0.58	2.70
11/21/88 1:36	0.55	1.96
10/25/94 17:38	0.53	1.53
11/27/88 0:37	0.53	1.26
2/6/89 13:17	0.49	1.07
11/9/88 5:52	0.48	0.93
12/3/89 17:43	0.46	0.82
5/22/89 15:33	0.46	0.74
4/8/92 9:22	0.42	0.67
4/12/92 13:40	0.41	0.61
11/30/93 12:31	0.40	0.56
1/5/90 21:15	0.39	0.52
11/12/89 0:04	0.38	0.49
2/4/91 7:36	0.35	0.45
11/30/94 11:05	0.35	0.43
1/30/95 17:02	0.35	0.40

Kirk Creek Storm Start Time	2 Hour Intensity (in.)	Annual Return
11/5/88 13:45	1.64	11.36
11/2/88 4:39	1.24	4.37
11/21/88 1:36	0.97	2.71
10/25/94 17:38	0.89	1.96
11/1/88 8:11	0.87	1.54
11/27/88 0:37	0.85	1.26
11/9/88 5:52	0.82	1.07
5/22/89 15:33	0.75	0.93
11/12/89 0:04	0.75	0.82
12/3/89 17:43	0.73	0.74
11/30/93 12:31	0.69	0.67
1/5/90 21:15	0.66	0.61
11/30/94 11:05	0.60	0.56
11/4/91 10:23	0.58	0.52
11/8/88 13:09	0.57	0.49
4/8/92 9:22	0.57	0.45
1/30/95 17:02	0.57	0.43

Kirk Creek Storm Start Time	6 Hour Intensity (in.)	Annual Return
11/5/88 13:45	2.51	11.34
11/21/88 1:36	2.19	4.36
11/2/88 4:39	2.07	2.70
11/27/88 0:37	1.87	1.96
1/5/90 21:15	1.70	1.53
10/25/94 17:38	1.60	1.26
11/1/88 8:11	1.50	1.07
11/30/93 12:31	1.46	0.93
5/22/89 15:33	1.42	0.82
1/8/89 9:24	1.41	0.74
1/8/95 18:00	1.33	0.67
11/4/91 10:23	1.29	0.61
1/30/95 17:02	1.28	0.56

11/30/94 11:05	1.28	0.52
11/12/89 0:04	1.27	0.48
12/16/94 11:50	1.26	0.45
11/9/88 5:52	1.23	0.43
10/21/90 7:41	1.21	0.40
11/14/88 20:56	1.20	0.38
4/8/92 9:22	1.19	0.36

Lobster Creek Storm Start Time	5 Minute Intensity (in.)	Annual Return
9/10/94 11:10	0.24	9.70
3/5/92 12:59	0.18	3.73
4/20/93 19:08	0.17	2.31
12/18/93 11:47	0.13	1.67
10/25/91 19:32	0.13	1.31
8/19/93 22:33	0.13	1.08
10/25/94 16:07	0.12	0.92
5/25/93 14:32	0.10	0.80
11/19/91 13:24	0.09	0.70
11/19/94 11:15	0.09	0.63
10/28/92 14:38	0.09	0.57
2/21/92 17:38	0.09	0.52
1/2/94 8:03	0.09	0.48
11/26/91 5:47	0.09	0.44
10/20/92 1:55	0.09	0.41
11/18/92 22:10	0.09	0.39
11/16/91 6:47	0.09	0.36
4/3/92 22:59	0.09	0.34
1/21/93 13:30	0.09	0.33
4/8/93 2:25	0.09	0.31
2/15/95 3:48	0.09	0.29
11/24/94 17:22	0.08	0.28
1/19/93 5:46	0.08	0.27
10/25/90 9:34	0.08	0.26

Lobster Creek Storm Start Time	30 Minute Intensity (in.)	Annual Return
10/25/94 16:07	0.54	9.66
1/2/94 8:03	0.38	3.72
10/20/92 5:57	0.37	2.30
9/10/94 11:10	0.37	1.67
11/16/91 6:47	0.33	1.31
11/24/94 17:22	0.32	1.07
12/18/93 11:47	0.31	0.91
3/5/92 12:59	0.31	0.79
1/19/93 5:46	0.30	0.70
5/25/93 14:32	0.30	0.63
4/20/93 19:08	0.28	0.57
11/30/93 12:46	0.28	0.52
12/3/92 9:08	0.27	0.48
2/21/92 17:38	0.27	0.44
10/25/91 19:32	0.27	0.41
1/3/92 8:23	0.25	0.39
1/29/95 2:59	0.24	0.36
1/30/95 15:07	0.24	0.34
5/2/93 22:19	0.24	0.32
4/8/93 2:25	0.23	0.31
10/30/92 3:57	0.23	0.29
2/16/95 12:22	0.23	0.28
3/5/95 7:43	0.23	0.27
11/19/94 11:15	0.23	0.26
1/27/92 2:30	0.23	0.25
1/21/93 13:30	0.23	0.24
2/21/94 11:34	0.23	0.23

1/10/95 18:10	0.23	0.22
10/31/94 4:46	0.22	0.21
2/17/92 0:57	0.22	0.20
6/12/92 20:18	0.22	0.20
1/8/95 3:02	0.22	0.19
10/1/92 3:35	0.22	0.19
1/2/93 13:39	0.22	0.18
8/19/93 22:33	0.22	0.17
10/29/92 3:19	0.21	0.17
3/19/94 8:51	0.21	0.16
11/19/91 13:24	0.20	0.16
3/7/95 21:57	0.20	0.16
10/21/90 2:24	0.20	0.15

Lobster Creek Storm Start Time	**1 Hour Intensity (in.)**	**Annual Return**
10/25/94 16:07	0.98	9.70
10/20/92 5:57	0.70	3.73
11/16/91 6:47	0.52	2.31
1/19/93 5:46	0.49	1.67
11/30/93 12:46	0.49	1.31
12/3/92 9:08	0.47	1.08
2/21/92 17:38	0.46	0.92
1/3/92 8:23	0.45	0.80
1/2/94 8:03	0.44	0.70
10/31/94 4:46	0.43	0.63
11/24/94 17:22	0.42	0.57
9/10/94 11:10	0.41	0.52
1/30/95 15:07	0.39	0.48
4/8/93 2:25	0.39	0.45
1/27/92 2:30	0.39	0.41
2/16/95 12:22	0.39	0.39
11/19/91 13:24	0.38	0.36
1/8/95 3:02	0.37	0.34
2/12/94 19:19	0.37	0.33
3/5/92 12:59	0.36	0.31
1/29/95 2:59	0.36	0.29
3/7/95 21:57	0.36	0.28
10/21/90 2:24	0.36	0.27

Lobster Creek Storm Start Time	**2 Hour Intensity (in.)**	**Annual Return**
10/25/94 16:07	1.50	9.75
10/20/92 5:57	1.29	3.75
12/3/92 9:08	0.86	2.32
11/30/93 12:46	0.84	1.68
1/3/92 8:23	0.81	1.32
1/19/93 5:46	0.75	1.08
10/31/94 4:46	0.74	0.92
11/16/91 6:47	0.73	0.80
2/16/95 12:22	0.72	0.71
1/27/92 2:30	0.71	0.63
2/21/92 17:38	0.68	0.57
2/12/94 19:19	0.65	0.52
1/8/95 3:02	0.63	0.48
12/18/93 11:47	0.63	0.45

10/30/92 3:57	0.63	0.42
10/21/90 2:24	0.62	0.39

Lobster Creek Storm Start Time	6 Hour Intensity (in.)	Annual Return
10/25/94 16:07	2.67	9.74
2/16/95 12:22	1.99	3.75
1/27/92 2:30	1.75	2.32
1/19/93 5:46	1.68	1.68
12/3/92 9:08	1.67	1.32
10/20/92 5:57	1.64	1.08
10/31/94 4:46	1.54	0.92
1/8/95 3:02	1.53	0.80
11/30/93 12:46	1.52	0.71
1/3/92 8:23	1.51	0.63
1/30/95 15:07	1.41	0.57
11/21/92 3:19	1.32	0.52
11/16/91 6:47	1.31	0.48
2/21/92 17:38	1.30	0.45
1/10/95 18:10	1.25	0.42
12/6/93 14:41	1.24	0.39
10/21/90 2:24	1.19	0.37

Mapleton Precipitation Intensity Partial-Duration Series Data

Mapleton Rank	1 Hour Intensity (in.)	Annual Return
1	0.7	30.76
2	0.7	11.83
3	0.7	7.32
4	0.7	5.30
5	0.6	4.16
6	0.6	3.42
7	0.6	2.90
8	0.6	2.52
9	0.6	2.23
10	0.6	2.00
11	0.6	1.81
12	0.6	1.65
13	0.6	1.52
14	0.5	1.41
15	0.5	1.31
16	0.5	1.23
17	0.5	1.16
18	0.5	1.09
19	0.5	1.03
20	0.5	0.98
21	0.5	0.93
22	0.5	0.89
23	0.5	0.85
24	0.5	0.81
25	0.5	0.78
26	0.5	0.75
27	0.5	0.72
28	0.5	0.70
29	0.5	0.67
30	0.5	0.65
31	0.5	0.63
32	0.5	0.61
33	0.5	0.59
34	0.5	0.57
35	0.5	0.56
36	0.5	0.54
37	0.5	0.52
38	0.5	0.51
39	0.5	0.50
40	0.5	0.49
41	0.5	0.47
42	0.5	0.46
43	0.5	0.45
44	0.5	0.44
45	0.5	0.43
46	0.5	0.42
47	0.5	0.41
48	0.4	0.40
49	0.4	0.40
50	0.4	0.39
51	0.4	0.38
52	0.4	0.37
53	0.4	0.37
54	0.4	0.36
55	0.4	0.35
56	0.4	0.35

57	0.4	0.34
58	0.4	0.33
59	0.4	0.33
60	0.4	0.32
61	0.4	0.32
62	0.4	0.31
63	0.4	0.31
64	0.4	0.30
65	0.4	0.30
66	0.4	0.29
67	0.4	0.29
68	0.4	0.28
69	0.4	0.28
70	0.4	0.28
71	0.4	0.27
72	0.4	0.27
73	0.4	0.26
74	0.4	0.26
75	0.4	0.26
76	0.4	0.25
77	0.4	0.25
78	0.4	0.25
79	0.4	0.24
80	0.4	0.24
81	0.4	0.24
82	0.4	0.24
83	0.4	0.23
84	0.4	0.23
85	0.4	0.23
86	0.4	0.22
87	0.4	0.22
88	0.4	0.22
89	0.4	0.22
90	0.4	0.21
91	0.4	0.21
92	0.4	0.21
93	0.4	0.21
94	0.4	0.21
95	0.4	0.20
96	0.4	0.20
97	0.4	0.20
98	0.4	0.20
99	0.4	0.19
100	0.4	0.19
101	0.4	0.19
102	0.4	0.19
103	0.4	0.19
104	0.4	0.19
105	0.4	0.18
106	0.4	0.18
107	0.4	0.18

Mapleton Rank	2 Hour Intensity (in.)	Annual Return
1	1.3	31.00
2	1.2	11.92
3	1.1	7.38
4	1.1	5.35

Mapleton Precipitation Intensity Partial-Duration Series Data

5	1	4.19
6	1	3.44
7	1	2.92
8	1	2.54
9	1	2.25
10	1	2.01
11	0.9	1.82
12	0.9	1.67
13	0.9	1.53
14	0.9	1.42
15	0.9	1.32
16	0.9	1.24
17	0.9	1.17
18	0.9	1.10
19	0.9	1.04
20	0.9	0.99
21	0.8	0.94
22	0.8	0.90
23	0.8	0.86
24	0.8	0.82
25	0.8	0.79
26	0.8	0.76
27	0.8	0.73
28	0.8	0.70
29	0.8	0.68
30	0.8	0.65
31	0.8	0.63
32	0.7	0.61
33	0.7	0.59
34	0.7	0.58
35	0.7	0.56
36	0.7	0.54
37	0.7	0.53
38	0.7	0.52
39	0.7	0.50
40	0.7	0.49
41	0.7	0.48
42	0.7	0.47
43	0.7	0.45
44	0.7	0.44
45	0.7	0.43
46	0.7	0.42
47	0.7	0.42
48	0.7	0.41
49	0.7	0.40
50	0.7	0.39
51	0.7	0.38
52	0.7	0.38
53	0.7	0.37
54	0.7	0.36
55	0.7	0.35
56	0.7	0.35
57	0.7	0.34
58	0.7	0.34
59	0.7	0.33
60	0.7	0.32

61	0.7	0.32
62	0.7	0.31
63	0.7	0.31

Mill Creek Precipitation Intensity Partial-Duration Serie Data

Mill Creek Storm Start Time	5 Minute Intensity (in.)	Annual Return
11/5/88 14:42	0.35	6.52
7/31/89 12:50	0.27	2.51
4/12/92 16:49	0.14	1.55
10/28/92 23:39	0.14	1.12
11/19/88 6:43	0.14	0.88
4/15/92 22:34	0.14	0.72
11/21/88 1:03	0.14	0.62
8/22/89 20:15	0.11	0.53
11/19/91 14:29	0.11	0.47
11/9/88 7:16	0.10	0.42
11/11/88 18:50	0.10	0.38
11/2/88 4:49	0.10	0.35
10/29/90 18:21	0.10	0.32

Mill Creek Storm Start Time	30 Minute Intensity (in.)	Annual Return
11/5/88 14:42	0.77	6.46
7/31/89 12:50	0.57	2.49
11/21/88 1:03	0.51	1.54
11/2/88 4:49	0.34	1.11
4/3/92 5:01	0.32	0.87
5/22/89 15:34	0.32	0.72
11/19/88 6:43	0.31	0.61
1/5/90 18:25	0.31	0.53
11/14/88 20:11	0.31	0.47
11/7/88 17:29	0.29	0.42
11/9/88 7:16	0.28	0.38
5/17/89 22:27	0.28	0.35
8/22/89 20:15	0.26	0.32
11/27/88 7:10	0.26	0.30
4/29/92 0:17	0.25	0.28
6/6/90 23:02	0.25	0.26
11/1/88 9:05	0.25	0.24
11/11/88 18:50	0.24	0.23
2/16/92 8:21	0.24	0.22
5/5/90 15:29	0.23	0.21
12/4/89 7:07	0.22	0.20
11/26/90 20:51	0.22	0.19
2/8/92 10:57	0.22	0.18
10/28/92 23:39	0.21	0.17
12/12/91 14:53	0.21	0.16

Mill Creek Storm Start Time	1 Hour Intensity (in.)	Annual Return
11/5/88 14:42	1.16	6.48
11/21/88 1:03	0.84	2.49
7/31/89 12:50	0.61	1.54
5/22/89 15:34	0.60	1.12
11/14/88 20:11	0.53	0.88
1/5/90 18:25	0.53	0.72
5/17/89 22:27	0.46	0.61
11/27/88 7:10	0.46	0.53
11/19/88 6:43	0.44	0.47
12/4/89 7:07	0.44	0.42

11/26/90 20:51	0.44	0.38
11/1/88 9:05	0.43	0.35
11/7/88 17:29	0.42	0.32
4/3/92 5:01	0.41	0.30
2/16/92 8:21	0.41	0.28
11/2/88 4:49	0.41	0.26
11/9/88 7:16	0.40	0.24
11/8/90 19:59	0.39	0.23
12/12/91 14:53	0.39	0.22

Mill Creek Storm Start Time	2 Hour Intensity (in.)	Annual Return
11/5/88 14:42	1.31	6.51
11/21/88 1:03	1.27	2.50
5/22/89 15:34	1.07	1.55
11/27/88 7:10	0.82	1.12
1/5/90 18:25	0.78	0.88
11/1/88 9:05	0.78	0.72
7/31/89 12:50	0.77	0.61
12/4/89 7:07	0.76	0.53
11/26/90 20:51	0.76	0.47
11/2/88 4:49	0.72	0.42
11/19/88 6:43	0.71	0.38
11/14/88 20:11	0.71	0.35
2/16/92 8:21	0.69	0.32
11/8/90 19:59	0.67	0.30
12/12/91 14:53	0.67	0.28

Mill Creek Storm Start Time	6 Hour Intensity (in.)	Annual Return
11/21/88 1:03	3.53	6.44
11/5/88 14:42	1.79	2.48
11/27/88 7:10	1.78	1.53
1/5/90 18:25	1.62	1.11
5/22/89 15:34	1.61	0.87
1/8/89 7:32	1.51	0.72
11/12/91 22:49	1.46	0.61
12/25/91 6:32	1.46	0.53
2/7/90 18:38	1.42	0.47
11/8/90 19:59	1.40	0.42
11/1/88 9:05	1.40	0.38
11/2/88 4:49	1.29	0.35
11/14/88 20:11	1.27	0.32
4/17/90 8:24	1.26	0.30
10/24/91 23:29	1.26	0.28
10/14/90 16:33	1.19	0.26
11/19/88 6:43	1.17	0.24
8/9/91 4:07	1.16	0.23
11/11/88 18:50	1.08	0.22
12/3/91 1:47	1.07	0.21
3/5/89 3:24	1.06	0.20
8/28/91 18:23	1.05	0.19
10/3/90 9:52	1.04	0.18
12/1/91 17:35	1.00	0.17
1/11/91 10:09	1.00	0.16
11/7/88 17:29	0.99	0.16

7/31/89 12:50	0.99	0.15
12/4/89 7:07	0.98	0.15
11/26/90 20:51	0.98	0.14
2/16/88 23:42	0.96	0.14
2/15/89 23:42	0.96	0.13
11/9/88 7:16	0.95	0.13
6/16/91 4:29	0.95	0.12
2/20/90 5:33	0.95	0.12
1/13/90 16:06	0.88	0.12
12/7/89 21:27	0.87	0.11
12/1/90 5:41	0.87	0.11
6/12/92 7:47	0.86	0.11

Panther Creek Precipitation Intensity Partial-Duration Series

Panther Creek Storm Start Time	5 Minute Intensity (in.)	Annual Return
10/21/92 7:40	0.22	9.77
6/29/92 10:52	0.17	3.76
4/12/92 13:18	0.17	2.33
10/20/92 1:40	0.14	1.68
11/20/92 20:24	0.14	1.32
5/19/93 11:31	0.14	1.09
5/25/93 11:16	0.14	0.92
5/26/93 16:33	0.14	0.80
12/10/93 5:31	0.14	0.71
1/2/94 3:07	0.14	0.63
1/27/90 23:44	0.13	0.57
3/9/95 0:17	0.13	0.53
11/23/89 3:50	0.13	0.48
11/19/91 13:25	0.13	0.45

Panther Creek Storm Start Time	30 Minute Intensity (in.)	Annual Return
10/25/94 16:15	0.48	9.71
1/7/90 11:14	0.45	3.73
2/7/90 15:34	0.41	2.31
12/2/89 19:20	0.37	1.67
11/23/89 3:50	0.36	1.31
1/27/90 23:44	0.33	1.08
11/12/90 23:48	0.32	0.92
10/31/94 4:31	0.32	0.80
11/19/91 13:25	0.30	0.70
10/21/92 7:40	0.29	0.63
10/20/92 1:40	0.29	0.57
1/5/90 15:52	0.29	0.52
9/23/92 0:40	0.28	0.48
3/9/95 0:17	0.28	0.45
6/29/92 10:52	0.28	0.41
12/16/94 11:38	0.28	0.39
1/10/95 15:09	0.28	0.37
4/15/92 22:51	0.26	0.34
4/12/92 13:18	0.25	0.33
2/21/92 17:25	0.25	0.31
11/23/90 16:19	0.25	0.29
12/10/93 5:31	0.25	0.28

Panther Creek Storm Start Time	1 Hour Intensity (in.)	Annual Return
2/7/90 15:34	0.77	9.72
10/25/94 16:15	0.71	3.74
1/7/90 11:14	0.70	2.31
12/2/89 19:20	0.63	1.68
10/31/94 4:31	0.58	1.31
10/20/92 1:40	0.53	1.08
12/16/94 11:38	0.52	0.92
11/19/91 13:25	0.51	0.80
1/5/90 15:52	0.51	0.70
11/23/89 3:50	0.48	0.63
11/23/90 16:19	0.46	0.57
4/15/92 22:51	0.46	0.52

1/27/90 23:44	0.45	0.48
11/12/90 23:48	0.43	0.45
11/30/94 10:04	0.43	0.42
11/11/89 20:08	0.43	0.39
3/9/95 0:17	0.43	0.37
1/30/95 4:45	0.42	0.34
1/10/95 15:09	0.42	0.33
11/30/93 13:12	0.41	0.31

Panther Creek Storm Start Time	**2 Hour Intensity (in.)**	**Annual Return**
2/7/90 15:34	1.37	9.76
10/25/94 16:15	1.30	3.75
12/2/89 19:20	1.17	2.32
1/7/90 11:14	1.16	1.68
10/31/94 4:31	1.01	1.32
1/5/90 15:52	1.00	1.08
11/23/89 3:50	0.90	0.92
12/16/94 11:38	0.89	0.80
11/23/90 16:19	0.87	0.71
11/19/91 13:25	0.82	0.63
11/30/94 10:04	0.82	0.57
11/11/89 20:08	0.76	0.52
1/10/95 15:09	0.76	0.48
11/30/93 13:12	0.74	0.45
10/20/92 1:40	0.69	0.42

Panther Creek Storm Start Time	**6 Hour Intensity (in.)**	**Annual Return**
2/7/90 15:34	2.65	9.77
10/31/94 4:31	2.53	3.49
10/25/94 16:15	2.51	2.16
12/2/89 19:20	2.29	1.57
12/16/94 11:38	2.22	1.23
1/7/90 11:14	2.21	1.01
1/5/90 15:52	2.17	0.86
11/30/94 10:04	2.11	0.74
11/23/90 16:19	1.89	0.66
11/30/93 13:12	1.80	0.59
12/26/94 3:54	1.69	0.53
1/10/95 15:09	1.62	0.49
11/20/92 20:24	1.60	0.45
11/19/91 13:25	1.57	0.42

Ryder Creek Precipitation Intensity Partial-Duration Series

Ryder Creek Storm Start Time	5 Minute Intensity (in.)	Annual Return
10/30/94 5:23	0.18	9.69
10/25/94 15:03	0.14	3.73
10/19/92 0:57	0.13	2.31
12/8/92 17:45	0.13	1.67
4/6/93 3:36	0.13	1.31
5/19/93 2:09	0.13	1.08
4/5/94 10:04	0.13	0.91
12/3/89 7:57	0.12	0.79
10/25/89 23:29	0.12	0.70
3/15/95 1:15	0.12	0.63
1/27/90 4:19	0.11	0.57
10/29/90 17:13	0.11	0.52
10/29/92 5:45	0.10	0.48
10/30/92 1:55	0.10	0.44
11/19/92 18:28	0.10	0.41
11/29/92 0:14	0.10	0.39
12/18/92 12:28	0.10	0.36
1/18/93 1:40	0.10	0.34
5/3/93 0:14	0.10	0.33
5/7/93 7:12	0.10	0.31
11/30/93 3:36	0.10	0.29
2/13/94 7:55	0.10	0.28
2/22/94 15:21	0.10	0.27
6/13/92 10:10	0.10	0.26
1/8/95 14:43	0.10	0.25
1/18/95 3:16	0.10	0.24
2/4/91 7:19	0.09	0.23

Ryder Creek Storm Start Time	30 Minute Intensity (in.)	Annual Return
10/25/94 15:03	0.71	9.75
10/30/94 5:23	0.66	3.75
5/26/93 14:52	0.41	2.32
10/21/90 4:05	0.34	1.68
11/4/91 8:58	0.33	1.32
10/25/90 9:46	0.33	1.08
1/27/90 4:19	0.32	0.92
10/19/92 0:57	0.32	0.80
10/29/90 17:13	0.31	0.71
11/6/89 9:10	0.31	0.63
12/3/89 7:57	0.30	0.57
11/11/89 21:54	0.30	0.52
4/26/90 19:13	0.30	0.48
12/14/94 20:40	0.29	0.45
6/13/92 0:23	0.28	0.42
1/29/95 3:23	0.28	0.39

Ryder Creek Storm Start Time	1 Hour Intensity (in.)	Annual Return
10/25/94 15:03	1.19	9.74
10/30/94 5:23	0.96	3.75
12/3/89 7:57	0.64	2.32
10/19/92 0:57	0.58	1.68
10/21/90 4:05	0.58	1.32

11/4/91 8:58	0.57	1.08
11/11/89 21:54	0.53	0.92
4/26/90 19:13	0.52	0.80
2/15/90 10:43	0.47	0.71
12/14/94 20:40	0.46	0.63
10/25/90 9:46	0.46	0.57
12/1/90 3:59	0.45	0.52
1/27/90 4:19	0.43	0.48
5/26/93 14:52	0.43	0.45
10/29/90 17:13	0.43	0.42
11/6/89 9:10	0.43	0.39
1/29/95 3:23	0.41	0.37

Ryder Creek Storm Start Time	2 Hour Intensity (in.)	Annual Return
10/30/94 5:23	1.42	9.71
10/25/94 15:03	1.41	3.73
10/21/90 4:05	1.04	2.31
12/3/89 7:57	1.02	1.67
4/26/90 19:13	1.02	1.31
11/4/91 8:58	1.00	1.08
11/11/89 21:54	0.91	0.92
11/30/93 3:36	0.82	0.80
2/15/90 10:43	0.77	0.70
12/14/94 20:40	0.74	0.63
1/5/90 16:13	0.73	0.57
2/12/91 10:58	0.71	0.52
2/7/90 13:20	0.71	0.48
10/19/92 0:57	0.71	0.45
11/30/94 10:42	0.67	0.41
3/1/91 12:32	0.67	0.39
1/18/93 1:40	0.67	0.37
10/29/90 17:13	0.63	0.34
11/29/92 0:14	0.62	0.33
11/24/90 3:15	0.61	0.31
4/8/92 5:49	0.60	0.29
1/30/95 16:15	0.60	0.28

Ryder Creek Storm Start Time	6 Hour Intensity (in.)	Annual Return
4/26/90 19:13	2.70	9.70
10/25/94 15:03	2.27	3.73
11/30/93 3:36	2.22	2.31
11/4/91 8:58	2.19	1.67
10/21/90 4:05	1.99	1.31
10/30/94 5:23	1.94	1.08
11/30/94 10:42	1.66	0.92
1/5/90 16:13	1.57	0.80
1/18/93 1:40	1.57	0.70
2/7/90 13:20	1.45	0.63
2/12/91 10:58	1.42	0.57
2/15/90 10:43	1.41	0.52
12/14/94 20:40	1.40	0.48
2/16/92 22:48	1.40	0.44
1/27/92 2:59	1.39	0.41
11/3/90 9:24	1.39	0.39

3/1/91 12:32	1.35	0.36
12/5/91 10:51	1.35	0.34
11/24/90 3:15	1.34	0.33
11/11/89 21:54	1.33	0.31
4/8/92 5:49	1.32	0.29
3/9/90 8:04	1.28	0.28
12/6/93 3:36	1.26	0.27
3/4/95 4:38	1.20	0.26

Smith River Storm Start Time	5 Minute Intensity (in.)	Annual Return
4/18/91 17:09	0.20	11.29
11/5/88 13:42	0.19	4.34
11/22/93 11:45	0.14	2.69
11/29/93 13:26	0.14	1.95
11/7/88 19:31	0.14	1.53
11/19/88 6:56	0.14	1.25
11/21/88 1:35	0.14	1.07
11/2/88 5:02	0.14	0.93
9/7/94 3:40	0.12	0.82
1/28/90 4:30	0.11	0.73
10/21/92 6:14	0.10	0.66
10/29/92 0:00	0.10	0.61
11/30/92 0:57	0.10	0.56
12/7/92 23:31	0.10	0.52
4/25/93 22:48	0.10	0.48
12/17/93 12:28	0.10	0.45
5/29/90 12:53	0.10	0.42
11/9/88 6:58	0.10	0.40
11/11/88 20:15	0.10	0.38
11/27/88 4:47	0.10	0.36
4/15/92 22:07	0.10	0.34
5/22/89 15:08	0.10	0.33
11/17/91 4:46	0.10	0.31
9/23/92 15:17	0.10	0.30
11/16/91 7:40	0.10	0.29
1/8/95 16:11	0.09	0.28
5/21/90 9:36	0.09	0.27
11/14/88 20:00	0.09	0.26
11/19/91 14:06	0.09	0.25
11/30/94 11:07	0.09	0.24
3/14/95 1:54	0.08	0.23

Smith River Storm Start Time	30 Minute Intensity (in.)	Annual Return
11/5/88 13:42	0.76	11.33
11/2/88 5:02	0.46	4.36
11/21/88 1:35	0.44	2.70
11/19/88 6:56	0.34	1.95
11/9/88 6:58	0.33	1.53
11/24/88 13:31	0.33	1.26
2/7/90 18:24	0.32	1.07
11/11/88 20:15	0.32	0.93
3/3/91 1:29	0.30	0.82
11/14/88 20:00	0.30	0.74
11/27/88 4:47	0.30	0.67
5/22/89 15:08	0.29	0.61
11/1/88 8:33	0.27	0.56
11/22/93 11:45	0.26	0.52
11/29/93 13:26	0.26	0.48
9/7/94 3:40	0.25	0.45
11/19/91 14:06	0.25	0.43
11/30/94 11:07	0.25	0.40
1/29/95 4:12	0.24	0.38
12/16/94 11:29	0.24	0.36
4/8/92 7:02	0.24	0.34

Smith River Storm Start Time	1 Hour Intensity (in.)	Annual Return
11/5/88 13:42	1.08	11.36
11/21/88 1:35	0.68	4.37
2/7/90 18:24	0.62	2.70
11/24/88 13:31	0.59	1.96
11/2/88 5:02	0.58	1.53
11/1/88 8:33	0.51	1.26
5/22/89 15:08	0.51	1.07
11/27/88 4:47	0.50	0.93
11/14/88 20:00	0.49	0.82
11/29/93 13:26	0.46	0.74
1/5/90 17:17	0.44	0.67
3/3/91 1:29	0.43	0.61
12/3/89 13:44	0.43	0.56
11/30/94 11:07	0.43	0.52
11/30/92 0:57	0.42	0.49
11/11/88 20:15	0.42	0.45
12/16/94 11:29	0.41	0.43
3/8/95 2:30	0.40	0.40

Smith River Storm Start Time	2 Hour Intensity (in.)	Annual Return
11/5/88 13:42	1.50	11.33
11/21/88 1:35	1.10	4.36
2/7/90 18:24	1.04	2.70
11/24/88 13:31	0.97	1.95
5/22/89 15:08	0.96	1.53
11/27/88 4:47	0.92	1.26
11/29/93 13:26	0.84	1.07
11/2/88 5:02	0.83	0.93
11/30/94 11:07	0.83	0.82
11/1/88 8:33	0.80	0.74
1/5/90 17:17	0.76	0.67
12/16/94 11:29	0.74	0.61
12/3/89 13:44	0.73	0.56
11/11/89 21:41	0.70	0.52
3/8/95 2:30	0.68	0.48
1/30/90 13:04	0.67	0.45
11/19/88 6:56	0.64	0.43
11/4/91 9:26	0.64	0.40
11/14/88 20:00	0.63	0.38
3/3/91 1:29	0.63	0.36
11/30/92 0:57	0.62	0.34

Smith River Storm Start Time	6 Hour Intensity (in.)	Annual Return
11/21/88 1:35	2.67	11.34
11/5/88 13:42	2.36	4.36
11/27/88 4:47	2.10	2.70
11/29/93 13:26	1.93	1.96
2/7/90 18:24	1.91	1.53
11/30/94 11:07	1.72	1.26
1/5/90 17:17	1.64	1.07
12/16/94 11:29	1.54	0.93
11/2/88 5:02	1.51	0.82

5/22/89 15:08	1.44	0.74
11/24/88 13:31	1.40	0.67
11/4/91 9:26	1.40	0.61
4/26/90 21:21	1.40	0.56
11/1/88 8:33	1.36	0.52
10/25/94 16:05	1.34	0.48
1/10/95 19:36	1.34	0.45
1/8/95 16:11	1.32	0.43
1/19/93 0:28	1.31	0.40
12/5/93 22:04	1.31	0.38
4/8/92 7:02	1.31	0.36

South Canyon Precipitation Intensity Partial-Duration Series Data

South Canyon Storm Start Time	5 Minute Intensity (in.)	Annual Return
11/2/88 4:05	0.34	11.25
5/19/93 2:24	0.30	4.33
4/12/92 12:50	0.26	2.68
11/21/88 0:22	0.23	1.94
11/9/88 6:59	0.20	1.52
11/5/88 13:07	0.19	1.25
11/11/88 18:27	0.18	1.06
10/20/92 4:33	0.18	0.92
12/6/93 6:14	0.18	0.81
10/24/91 23:29	0.18	0.73
8/17/90 12:49	0.18	0.66
11/1/88 7:45	0.14	0.60
10/25/89 23:16	0.14	0.56
11/20/92 20:24	0.14	0.52
5/7/93 4:33	0.14	0.48
5/25/93 12:43	0.14	0.45
5/28/93 5:45	0.14	0.42
10/15/93 7:26	0.14	0.40
11/30/93 13:26	0.14	0.38
12/3/93 21:21	0.14	0.36
12/10/93 6:00	0.14	0.34
11/7/88 19:15	0.13	0.33
10/24/94 17:09	0.13	0.31
1/27/90 5:29	0.13	0.30
11/27/88 4:41	0.12	0.29
10/13/94 13:49	0.11	0.27
12/3/89 16:30	0.11	0.26
1/28/90 5:16	0.10	0.25
11/14/88 19:40	0.10	0.25
12/28/88 22:03	0.10	0.24
4/29/92 13:15	0.10	0.23
7/5/90 9:55	0.10	0.22
2/11/91 7:52	0.10	0.22
10/29/92 0:14	0.10	0.21
10/30/92 20:09	0.10	0.20
11/30/92 1:26	0.10	0.20
12/7/92 23:45	0.10	0.19
12/9/92 18:14	0.10	0.19
12/19/92 2:24	0.10	0.18
1/3/93 6:43	0.10	0.18
1/19/93 1:40	0.10	0.17
1/20/93 16:33	0.10	0.17
4/6/93 3:36	0.10	0.16
4/8/93 20:38	0.10	0.16
5/2/93 23:45	0.10	0.16
5/20/93 13:55	0.10	0.15
6/10/93 22:04	0.10	0.15
12/31/93 14:38	0.10	0.15
1/2/94 3:21	0.10	0.14
2/13/94 8:09	0.10	0.14
3/2/94 6:57	0.10	0.14
3/21/94 11:31	0.10	0.14
4/6/94 8:09	0.10	0.13
11/24/88 14:21	0.09	0.13

10/30/94 5:37	0.09	0.13
9/23/92 14:39	0.09	0.13
10/21/89 0:50	0.09	0.12
10/25/90 7:11	0.09	0.12
12/1/90 4:24	0.09	0.12
3/4/89 9:42	0.09	0.12
12/17/94 13:46	0.09	0.12
1/29/95 4:12	0.09	0.11

South Canyon Storm Start Time	**30 Minute Intensity (in.)**	**Annual Return**
11/5/88 13:07	0.80	11.30
11/2/88 4:05	0.76	4.35
11/1/88 7:45	0.58	2.69
10/24/94 17:09	0.57	1.95
11/11/88 18:27	0.56	1.53
11/21/88 0:22	0.44	1.26
10/30/94 5:37	0.44	1.07
11/27/88 4:41	0.42	0.93
10/24/91 23:29	0.42	0.82
11/9/88 6:59	0.42	0.73
4/12/92 12:50	0.38	0.66
10/25/90 7:11	0.38	0.61
10/20/92 4:33	0.37	0.56
1/8/89 6:08	0.36	0.52
1/27/90 5:29	0.36	0.48
10/21/89 0:50	0.34	0.45
12/3/89 16:30	0.34	0.42
5/19/93 2:24	0.33	0.40
12/3/93 21:21	0.33	0.38
11/11/89 22:31	0.33	0.36
11/14/88 19:40	0.33	0.34
11/6/89 9:16	0.32	0.33
11/7/88 19:15	0.32	0.31
12/17/94 13:46	0.32	0.30
11/19/88 6:14	0.31	0.29
12/14/94 5:15	0.31	0.28
1/10/95 18:44	0.31	0.27

South Canyon Storm Start Time	**1 Hour Intensity (in.)**	**Annual Return**
11/1/88 7:45	1.08	11.30
11/5/88 13:07	1.07	4.35
10/24/94 17:09	0.89	2.69
11/2/88 4:05	0.85	1.95
11/27/88 4:41	0.73	1.53
10/30/94 5:37	0.71	1.26
11/11/88 18:27	0.68	1.07
11/21/88 0:22	0.68	0.93
12/3/89 16:30	0.67	0.82
1/27/90 5:29	0.62	0.73
11/9/88 6:59	0.62	0.66
1/8/89 6:08	0.62	0.61
11/11/89 22:31	0.59	0.56
10/20/92 4:33	0.57	0.52
11/24/88 14:21	0.56	0.48

4/27/90 18:51	0.56	0.45
10/21/90 4:13	0.55	0.42
11/7/88 19:15	0.54	0.40
11/30/94 10:47	0.53	0.38
1/5/90 19:58	0.52	0.36
12/14/94 5:15	0.51	0.34
1/8/95 2:41	0.51	0.33
11/14/88 19:40	0.50	0.31
10/25/90 7:11	0.49	0.30
12/3/93 21:21	0.49	0.29
11/30/93 13:26	0.49	0.28
3/1/91 12:51	0.47	0.27

South Canyon Storm Start Time	2 Hour Intensity (in.)	Annual Return
11/5/88 13:07	1.92	11.31
11/1/88 7:45	1.42	4.35
10/24/94 17:09	1.28	2.69
11/27/88 4:41	1.23	1.95
10/30/94 5:37	1.10	1.53
11/21/88 0:22	1.09	1.26
4/27/90 18:51	1.07	1.07
1/8/89 6:08	1.05	0.93
11/11/89 22:31	1.05	0.82
12/3/89 16:30	1.05	0.73
11/2/88 4:05	1.04	0.67
11/24/88 14:21	1.00	0.61
10/21/90 4:13	0.99	0.56
1/5/90 19:58	0.97	0.52
1/27/90 5:29	0.94	0.48
11/30/93 13:26	0.94	0.45
11/30/94 10:47	0.91	0.43
11/9/88 6:59	0.91	0.40
12/14/94 5:15	0.89	0.38
1/29/95 4:12	0.83	0.36
11/11/88 18:27	0.82	0.34
1/8/95 2:41	0.82	0.33
11/4/91 9:49	0.80	0.31
10/25/89 23:16	0.78	0.30
10/30/92 20:09	0.78	0.29

South Canyon Storm Start Time	6 Hour Intensity (in.)	Annual Return
11/5/88 13:07	3.52	11.30
4/27/90 18:51	2.83	4.35
1/8/89 6:08	2.71	2.69
11/27/88 4:41	2.63	1.95
11/21/88 0:22	2.60	1.53
11/24/88 14:21	2.54	1.26
11/1/88 7:45	2.51	1.07
11/30/93 13:26	2.40	0.93
10/24/94 17:09	2.34	0.82
1/5/90 19:58	2.30	0.73
10/21/90 4:13	2.16	0.66
10/25/89 23:16	2.05	0.61
11/30/94 10:47	1.99	0.56

1/8/95 2:41	1.96	0.52
10/30/94 5:37	1.92	0.48
11/2/88 4:05	1.92	0.45
11/4/91 9:49	1.91	0.42
12/14/94 5:15	1.88	0.40
11/9/88 6:59	1.80	0.38
11/23/90 17:38	1.71	0.36
11/11/89 22:31	1.70	0.34
2/12/91 7:20	1.70	0.33
1/27/90 5:29	1.69	0.31
12/3/89 16:30	1.65	0.30
1/19/93 1:40	1.64	0.29
2/7/90 16:44	1.58	0.28
1/29/95 4:12	1.57	0.27
4/8/92 6:07	1.56	0.26

Sweet Creek Precipitation Intensity Partial-Duration Series Data

Sweet Creek Storm Start Time	5 Minute Intensity (in.)	Annual Return
6/29/89 5:07	0.34	11.40
5/22/89 14:33	0.23	4.38
11/5/88 13:10	0.22	2.71
8/21/89 16:19	0.21	1.97
6/29/92 6:43	.0.18	1.54
11/9/88 7:12	0.18	1.27
11/19/91 13:34	0.16	1.08
11/11/88 19:22	0.14	0.93
5/26/93 15:21	0.14	0.83
2/13/94 7:55	0.14	0.74
4/8/94 23:02	0.14	0.67
11/2/88 4:30	0.14	0.61
1/31/90 14:08	0.14	0.56
1/10/95 13:45	0.14	0.52

Sweet Creek Storm Start Time	30 Minute Intensity (in.)	Annual Return
1/31/90 14:08	0.63	11.29
11/5/88 13:10	0.61	4.34
5/22/89 14:33	0.54	2.69
11/7/88 17:10	0.47	1.95
6/29/89 5:07	0.46	1.53
11/9/88 7:12	0.44	1.25
11/19/91 13:34	0.43	1.06
11/2/88 4:30	0.41	0.93
10/25/94 16:06	0.40	0.82
8/21/89 16:19	0.34	0.73
12/3/89 12:16	0.34	0.66
11/4/91 8:59	0.30	0.61
1/29/95 4:19	0.30	0.56
1/7/90 10:38	0.30	0.52
11/30/94 10:21	0.29	0.48
5/17/89 11:49	0.28	0.45
10/20/89 23:39	0.27	0.42
3/19/95 17:09	0.27	0.40
4/26/90 19:44	0.27	0.38
6/5/94 8:26	0.27	0.36
11/1/88 7:33	0.27	0.34
2/13/90 12:23	0.26	0.33
3/12/95 17:15	0.26	0.31
1/10/95 13:45	0.26	0.30
5/26/93 15:21	0.26	0.29
3/7/95 22:46	0.25	0.28
1/8/89 7:52	0.25	0.26
2/18/95 19:58	0.25	0.26
1/30/95 16:20	0.25	0.25
2/13/94 7:55	0.25	0.24
4/8/93 2:52	0.25	0.23
4/15/92 22:16	0.24	0.22

Sweet Creek Precipitation Intensity Partial-Duration Series Data

Sweet Creek Storm Start Time	1 Hour Intensity (in.)	Annual Return
1/31/90 14:08	1.16	11.31
11/5/88 13:10	0.95	4.35
11/2/88 4:30	0.81	2.69
10/25/94 16:06	0.67	1.95
5/22/89 14:33	0.62	1.53
11/7/88 17:10	0.61	1.26
12/3/89 12:16	0.58	1.07
11/4/91 8:59	0.57	0.93
11/1/88 7:33	0.51	0.82
6/29/89 5:07	0.51	0.73
8/21/89 16:19	0.50	0.67
11/9/88 7:12	0.50	0.61
5/17/89 11:49	0.49	0.56
4/26/90 19:44	0.48	0.52
1/29/95 4:19	0.45	0.48
11/30/94 10:21	0.43	0.45
10/20/89 23:39	0.43	0.43
10/30/94 6:12	0.41	0.40
3/19/95 17:09	0.41	0.38
11/29/93 12:28	0.41	0.36
11/19/91 13:34	0.40	0.34
11/11/89 22:14	0.40	0.33
2/13/90 12:23	0.39	0.31
1/8/89 7:52	0.39	0.30
2/15/90 10:36	0.39	0.29
4/8/92 9:13	0.38	0.28

Sweet Creek Storm Start Time	2 Hour Intensity (in.)	Annual Return
1/31/90 14:08	2.19	11.30
11/5/88 13:10	1.19	4.35
5/22/89 14:33	1.12	2.69
11/4/91 8:59	1.00	1.95
10/25/94 16:06	0.96	1.53
11/2/88 4:30	0.96	1.26
5/17/89 11:49	0.96	1.07
12/3/89 12:16	0.93	0.93
11/1/88 7:33	0.93	0.82
4/26/90 19:44	0.92	0.73
11/30/94 10:21	0.82	0.66
11/7/88 17:10	0.78	0.61
10/20/89 23:39	0.78	0.56
8/21/89 16:19	0.77	0.52
11/11/89 22:14	0.73	0.48
11/9/88 7:12	0.70	0.45
11/29/93 12:28	0.70	0.42
2/15/90 10:36	0.65	0.40
1/29/95 4:19	0.64	0.38
11/19/91 13:34	0.63	0.36
1/10/95 13:45	0.61	0.34
1/5/90 16:17	0.61	0.33
10/30/94 6:12	0.61	0.31
3/4/89 9:31	0.59	0.30
1/7/90 10:38	0.59	0.29

3/19/95 17:09	0.59	0.28
3/7/95 22:46	0.59	0.27
4/8/92 9:13	0.58	0.26

Sweet Creek Storm Start Time	**6 Hour Intensity (in.)**	**Annual Return**
11/5/88 13:10	3.10	11.28
1/31/90 14:08	2.77	4.34
4/26/90 19:44	2.40	2.69
11/4/91 8:59	2.34	1.94
11/30/94 10:21	1.98	1.52
11/1/88 7:33	1.97	1.25
5/22/89 14:33	1.82	1.06
10/25/94 16:06	1.82	0.92
11/2/88 4:30	1.68	0.82
11/29/93 12:28	1.47	0.73
1/5/90 16:17	1.46	0.66
4/8/92 9:13	1.40	0.61
11/9/88 7:12	1.38	0.56
2/7/90 11:26	1.35	0.52
1/8/89 7:52	1.30	0.48
12/7/89 20:58	1.29	0.45
1/8/95 15:24	1.29	0.42
11/19/91 13:34	1.28	0.40
7/15/89 22:55	1.27	0.38
12/3/89 12:16	1.27	0.36
11/11/89 22:14	1.27	0.34
2/15/90 10:36	1.26	0.33
1/7/90 10:38	1.24	0.31
5/17/89 11:49	1.24	0.30
10/30/94 6:12	1.23	0.29
3/4/89 9:31	1.21	0.28
3/9/90 6:58	1.20	0.26
1/30/95 16:20	1.19	0.26
8/21/89 16:19	1.19	0.25
4/15/92 22:16	1.17	0.24
6/29/89 5:07	1.17	0.23
11/7/88 17:10	1.15	0.22
11/26/91 4:46	1.12	0.22
10/20/89 23:39	1.12	0.21
4/1/93 4:33	1.11	0.20

Thompson Creek Precipitation Intensity Partial-Duration Series Data

Thompson Creek Storm Start Time	5 Minute Intensity (in.)	Annual Return
11/5/88 13:55	0.50	8.07
11/2/88 4:33	0.45	3.10
11/11/88 19:40	0.41	1.92
11/9/88 5:45	0.32	1.39
11/14/88 20:24	0.28	1.09
11/21/88 0:14	0.19	0.90
11/27/88 4:48	0.19	0.76
5/2/93 23:16	0.19	0.66
5/19/93 6:57	0.19	0.58
12/4/91 10:23	0.19	0.52
11/12/90 23:35	0.19	0.47
1/25/90 10:51	0.19	0.43
11/7/88 17:16	0.15	0.40
11/25/88 12:14	0.15	0.37
6/21/93 17:31	0.15	0.34
11/23/89 21:38	0.15	0.32
11/19/91 13:16	0.15	0.30
12/29/88 4:00	0.15	0.29
2/7/90 13:34	0.15	0.27
11/17/91 4:59	0.15	0.26
12/3/89 9:57	0.15	0.24
2/16/93 0:37	0.15	0.23
11/29/90 7:49	0.14	0.22
11/1/88 7:40	0.11	0.21
4/8/93 2:38	0.11	0.20
8/19/93 22:48	0.11	0.20
10/22/91 4:51	0.11	0.19
12/25/92 16:45	0.11	0.18

Thompson Creek Storm Start Time	30 Minute Intensity (in.)	Annual Return
11/5/88 13:55	0.83	8.10
11/2/88 4:33	0.79	3.12
11/11/88 19:40	0.74	1.93
11/9/88 5:45	0.62	1.40
11/14/88 20:24	0.62	1.09
11/27/88 4:48	0.44	0.90
11/12/90 23:35	0.41	0.76
6/29/89 5:17	0.36	0.66
6/21/93 17:31	0.35	0.59
2/16/93 0:37	0.33	0.53
12/4/91 10:23	0.33	0.48
11/21/88 0:14	0.31	0.44
5/2/93 23:16	0.31	0.40
11/17/91 4:59	0.31	0.37
11/29/90 7:49	0.31	0.35
1/25/90 10:51	0.30	0.32
11/23/89 21:38	0.30	0.30
12/3/89 9:57	0.30	0.29
4/26/90 18:16	0.30	0.27
10/23/92 17:51	0.30	0.26

Thompson Creek Precipitation Intensity Partial-Duration Series Data

Thompson Creek Storm Start Time	1 Hour Intensity (in.)	Annual Return
11/11/88 19:40	1.06	8.07
11/5/88 13:55	1.03	3.11
11/2/88 4:33	0.99	1.92
11/14/88 20:24	0.92	1.39
11/9/88 5:45	0.83	1.09
11/27/88 4:48	0.74	0.90
11/12/90 23:35	0.58	0.76
4/26/90 18:16	0.56	0.66
2/7/90 13:34	0.54	0.59
12/4/91 10:23	0.54	0.52
11/21/88 0:14	0.53	0.47
1/7/89 20:25	0.53	0.43
12/3/89 9:57	0.52	0.40
1/7/90 10:47	0.51	0.37
11/23/89 21:38	0.51	0.35
2/16/93 0:37	0.50	0.32
11/1/88 7:40	0.49	0.30
11/7/88 17:16	0.44	0.29
8/1/89 10:26	0.44	0.27
10/21/90 3:42	0.43	0.26
1/11/91 9:43	0.43	0.24
11/19/91 13:16	0.43	0.23
1/25/90 10:51	0.42	0.22
1/12/91 21:22	0.42	0.21
11/4/91 8:50	0.42	0.20
11/29/90 7:49	0.41	0.20
10/23/92 17:51	0.40	0.19

Thompson Creek Storm Start Time	2 Hour Intensity (in.)	Annual Return
11/27/88 4:48	1.36	8.08
11/11/88 19:40	1.28	3.11
11/5/88 13:55	1.27	1.92
11/2/88 4:33	1.26	1.39
11/14/88 20:24	1.23	1.09
4/26/90 18:16	1.07	0.90
11/9/88 5:45	1.06	0.76
2/7/90 13:34	0.96	0.66
1/7/89 20:25	0.94	0.59
2/16/93 0:37	0.92	0.52
11/21/88 0:14	0.85	0.48
12/3/89 9:57	0.84	0.43
10/21/90 3:42	0.83	0.40
11/1/88 7:40	0.80	0.37
11/23/89 21:38	0.80	0.35
8/1/89 10:26	0.79	0.32
11/12/90 23:35	0.76	0.30
1/11/91 9:43	0.76	0.29
11/23/90 20:06	0.73	0.27
1/7/90 10:47	0.72	0.26
11/4/91 8:50	0.71	0.24
11/19/91 13:16	0.69	0.23
11/7/88 17:16	0.67	0.22
1/25/90 10:51	0.65	0.21
4/8/92 12:47	0.64	0.21

Thompson Creek Precipitation Intensity Partial-Duration Series Data

Thompson Creek Storm Start Time	6 Hour Intensity (in.)	Annual Return
11/27/88 4:48	2.76	8.06
4/26/90 18:16	2.74	3.10
11/5/88 13:55	2.46	1.92
1/7/89 20:25	2.32	1.39
11/14/88 20:24	1.96	1.09
8/1/89 10:26	1.92	0.90
10/21/90 3:42	1.88	0.76
11/23/90 20:06	1.83	0.66
11/21/88 0:14	1.81	0.58
11/11/88 19:40	1.79	0.52
2/7/90 13:34	1.78	0.47
11/2/88 4:33	1.75	0.43
11/4/91 8:50	1.72	0.40
4/8/92 12:47	1.64	0.37
11/1/88 7:40	1.60	0.34
1/5/90 16:26	1.52	0.32
11/9/88 5:45	1.49	0.30
4/4/91 17:07	1.49	0.29
11/23/89 21:38	1.47	0.27
12/24/92 1:35	1.47	0.26
11/12/90 23:35	1.46	0.24
12/3/89 9:57	1.46	0.23
1/7/90 10:47	1.41	0.22
11/13/92 18:19	1.40	0.21
5/7/91 6:10	1.38	0.20
7/15/89 22:44	1.35	0.20
12/7/89 20:42	1.34	0.19
11/19/91 13:16	1.31	0.18
2/12/91 4:14	1.31	0.18
1/11/91 9:43	1.30	0.17
1/25/90 10:51	1.27	0.16
2/15/89 23:35	1.27	0.16
2/16/93 0:37	1.27	0.15

Wassen Creek Precipitation Intensity Partial-Duration Series Data

Wassen Creek Storm Start Time	5 Minute Intensity (in.)	Annual Return
11/2/88 4:53	0.22	11.29
6/29/89 4:18	0.18	4.34
1/23/93 9:50	0.18	2.69
2/1/91 17:51	0.18	1.95
10/24/91 23:00	0.15	1.53
11/19/88 4:40	0.14	1.25
10/30/92 22:04	0.14	1.06
1/2/93 10:33	0.14	0.93
12/5/93 22:19	0.14	0.82
12/9/93 6:14	0.14	0.73
11/20/91 11:05	0.14	0.66
9/23/92 15:18	0.13	0.61
4/29/92 15:51	0.13	0.56
11/10/88 6:09	0.13	0.52
11/21/88 1:35	0.13	0.48
11/11/88 22:20	0.12	0.45
11/14/88 20:14	0.11	0.42
10/25/90 19:32	0.10	0.40
11/1/88 8:43	0.10	0.38
11/7/88 20:01	0.10	0.36
11/27/88 7:21	0.10	0.34
12/5/91 13:10	0.10	0.33
10/20/92 7:40	0.10	0.31
5/3/93 0:14	0.10	0.30
5/19/93 11:45	0.10	0.29
5/20/93 18:57	0.10	0.28
5/28/93 8:38	0.10	0.26
11/29/93 18:57	0.10	0.26
12/31/93 0:14	0.10	0.25
2/13/94 8:52	0.10	0.24
1/8/95 14:38	0.10	0.23
1/12/95 4:33	0.10	0.22

Wassen Creek Storm Start Time	30 Minute Intensity (in.)	Annual Return
2/1/91 17:51	0.45	11.25
11/10/88 6:09	0.42	4.33
11/2/88 4:53	0.39	2.68
10/24/91 23:00	0.38	1.94
11/21/88 1:35	0.37	1.52
11/30/91 5:34	0.37	1.25
4/29/92 15:51	0.36	1.06
11/1/88 8:43	0.34	0.92
11/27/88 7:21	0.31	0.82
11/20/91 11:05	0.30	0.73
1/2/93 10:33	0.29	0.66
12/9/93 6:14	0.29	0.60
5/27/89 16:56	0.29	0.56
6/29/89 4:18	0.28	0.52
11/14/88 20:14	0.28	0.48
10/27/89 4:37	0.28	0.45
3/3/91 1:24	0.27	0.42
5/22/89 14:35	0.27	0.40
11/16/90 6:47	0.26	0.38

11/9/88 2:38	0.26	0.36
12/4/89 5:39	0.25	0.34
10/30/92 22:04	0.25	0.33
1/23/93 9:50	0.25	0.31
12/5/93 22:19	0.25	0.30
11/19/88 4:40	0.25	0.29
4/12/92 13:01	0.25	0.27
11/7/88 20:01	0.25	0.26
11/24/89 1:07	0.25	0.25
5/17/89 12:50	0.25	0.25
3/9/90 14:03	0.24	0.24
10/20/92 7:40	0.24	0.23
11/24/89 15:01	0.24	0.22
9/23/92 15:18	0.23	0.22
4/26/90 17:41	0.23	0.21
1/5/90 17:31	0.23	0.20
1/11/91 9:48	0.22	0.20
11/11/88 22:20	0.22	0.19
12/5/91 13:10	0.22	0.19
5/20/93 18:57	0.21	0.18
5/28/93 8:38	0.21	0.18
11/29/93 18:57	0.21	0.17
12/31/93 0:14	0.21	0.17
1/8/95 14:38	0.21	0.16
10/25/90 19:32	0.21	0.16
5/21/90 13:15	0.21	0.16
4/4/92 1:04	0.21	0.15
1/25/90 15:27	0.21	0.15
1/7/89 10:37	0.20	0.15
1/18/95 5:16	0.20	0.14
1/29/95 4:36	0.20	0.14
11/24/88 22:37	0.20	0.14
11/11/89 21:46	0.19	0.14
3/1/91 14:56	0.19	0.13
4/4/91 22:47	0.19	0.13
1/30/95 16:33	0.19	0.13
3/12/90 7:54	0.19	0.13
1/8/94 5:31	0.18	0.12

Wassen Creek Storm Start Time	**1 Hour Intensity (in.)**	**Annual Return**
11/10/88 6:09	0.82	11.25
10/24/91 23:00	0.56	4.33
11/27/88 7:21	0.55	2.68
11/30/91 5:34	0.55	1.94
1/2/93 10:33	0.54	1.52
11/1/88 8:43	0.52	1.25
11/21/88 1:35	0.51	1.06
5/22/89 14:35	0.51	0.92
4/29/92 15:51	0.51	0.82
2/1/91 17:51	0.50	0.73
11/2/88 4:53	0.47	0.66
11/14/88 20:14	0.47	0.60
12/9/93 6:14	0.46	0.56
4/26/90 17:41	0.44	0.52
11/16/90 6:47	0.42	0.48

1/5/90 17:31	0.42	0.45
6/29/89 4:18	0.42	0.42
12/4/89 5:39	0.42	0.40
9/23/92 15:18	0.41	0.38
11/9/88 2:38	0.41	0.36
3/3/91 1:24	0.41	0.34
5/17/89 12:50	0.40	0.33
10/27/89 4:37	0.39	0.31
1/30/95 16:33	0.38	0.30
1/11/91 9:48	0.38	0.29
12/5/93 22:19	0.38	0.27
11/29/93 18:57	0.38	0.26
1/7/89 10:37	0.37	0.25
11/11/89 21:46	0.37	0.25
11/11/88 22:20	0.36	0.24
3/1/91 14:56	0.36	0.23
4/4/91 22:47	0.35	0.22
4/8/92 9:05	0.34	0.22
10/30/92 22:04	0.34	0.21
12/31/93 0:14	0.34	0.20
12/5/91 13:10	0.32	0.20
1/29/95 4:36	0.32	0.19
5/27/89 16:56	0.32	0.19
1/25/90 15:27	0.32	0.18
11/4/91 11:11	0.32	0.18
1/23/93 9:50	0.31	0.17
10/26/89 0:25	0.31	0.17
11/7/88 20:01	0.31	0.16
2/7/90 15:11	0.31	0.16
11/24/89 15:01	0.31	0.16
3/8/95 5:30	0.30	0.15
1/27/92 1:34	0.30	0.15
3/5/95 11:10	0.30	0.15
11/19/90 13:24	0.30	0.14
10/20/92 7:40	0.29	0.14
1/8/95 14:38	0.29	0.14
1/3/93 9:07	0.29	0.14
5/3/93 0:14	0.29	0.13
12/2/93 21:21	0.29	0.13
2/13/94 8:52	0.29	0.13

Wassen Creek Storm Start Time	**2 Hour Intensity (in.)**	**Annual Return**
11/1/88 8:43	1.01	11.26
11/10/88 6:09	0.99	4.33
11/27/88 7:21	0.90	2.68
5/22/89 14:35	0.89	1.94
1/2/93 10:33	0.87	1.52
11/14/88 20:14	0.87	1.25
11/30/91 5:34	0.82	1.06
4/26/90 17:41	0.78	0.92
5/17/89 12:50	0.77	0.82
3/3/91 1:24	0.75	0.73
11/21/88 1:35	0.72	0.66
1/7/89 10:37	0.71	0.61
12/4/89 5:39	0.69	0.56

1/5/90 17:31	0.69	0.52
11/11/89 21:46	0.68	0.48
11/11/88 22:20	0.68	0.45
12/9/93 6:14	0.67	0.42
1/30/95 16:33	0.66	0.40
10/24/91 23:00	0.65	0.38
3/1/91 14:56	0.65	0.36
11/2/88 4:53	0.64	0.34
1/8/95 14:38	0.63	0.33
1/3/93 9:07	0.63	0.31
11/9/88 2:38	0.61	0.30
4/4/91 22:47	0.60	0.29
11/29/93 18:57	0.59	0.27
3/8/95 5:30	0.59	0.26
4/29/92 15:51	0.58	0.25
11/16/90 6:47	0.57	0.25
2/1/91 17:51	0.56	0.24
1/19/93 5:31	0.55	0.23
9/23/92 15:18	0.55	0.22
3/14/95 0:37	0.55	0.22
6/5/90 19:20	0.53	0.21
10/26/89 0:25	0.53	0.20
2/7/90 15:11	0.53	0.20
3/19/95 16:43	0.52	0.19
12/5/93 22:19	0.51	0.19
1/27/92 1:34	0.51	0.18
1/12/95 4:33	0.51	0.18
10/22/89 18:20	0.51	0.17
6/29/89 4:18	0.50	0.17
5/3/93 0:14	0.50	0.17
1/11/91 9:48	0.49	0.16
3/9/90 14:03	0.49	0.16
1/29/95 4:36	0.48	0.15
11/24/89 15:01	0.48	0.15
2/13/94 8:52	0.48	0.15

Wassen Creek Storm Start Time	**6 Hour Intensity (in.)**	**Annual Return**
11/27/88 7:21	1.85	11.26
4/26/90 17:41	1.84	4.33
1/7/89 10:37	1.80	2.68
11/14/88 20:14	1.74	1.94
1/8/95 14:38	1.67	1.52
11/1/88 8:43	1.58	1.25
11/21/88 1:35	1.58	1.06
11/9/88 2:38	1.45	0.92
11/10/88 6:09	1.45	0.82
4/4/91 22:47	1.44	0.73
2/7/90 15:11	1.43	0.66
5/22/89 14:35	1.41	0.61
12/9/93 6:14	1.38	0.56
11/29/93 18:57	1.38	0.52
1/5/90 17:31	1.38	0.48
11/30/91 5:34	1.36	0.45
4/29/92 15:51	1.36	0.42
1/3/93 9:07	1.34	0.40

1/12/95 4:33	1.30	0.38
11/2/88 4:53	1.21	0.36
1/2/93 10:33	1.20	0.34
10/24/91 23:00	1.18	0.33
3/1/91 14:56	1.18	0.31
1/19/93 5:31	1.14	0.30
11/11/88 22:20	1.11	0.29
2/1/91 17:51	1.10	0.27
11/16/90 6:47	1.10	0.26
3/19/95 16:43	1.09	0.25
3/3/91 1:24	1.07	0.25
3/9/90 14:03	1.07	0.24
1/27/92 1:34	1.06	0.23
11/11/89 21:46	1.05	0.22
3/8/95 5:30	1.04	0.22
9/23/92 15:18	1.04	0.21
4/8/92 9:05	1.04	0.20
6/5/90 19:20	1.03	0.20
4/1/93 7:12	1.02	0.19
11/19/91 15:56	1.00	0.19
1/30/95 16:33	1.00	0.18
2/16/95 21:42	0.97	0.18
12/4/89 5:39	0.93	0.17
11/19/90 13:24	0.93	0.17
2/12/91 11:28	0.92	0.17
12/5/91 13:10	0.90	0.16
3/18/94 4:04	0.89	0.16

APPENDIX B

ANTECEDENT PRECIPITATION INDEX PARTIAL SERIES AND ASSOCIATED STORM CHARACTERISTCS

Cascade Creek

Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	API Partial Series: Peak API (in.)	API Partial Series: API Annual Return
	Peak Precipitation Intensities Assoc. w/API partial series — Boxed Events Indicate >= 1 Yr. Return							
2/17/92 0:59	0.06	0.25	0.46	0.85	1.64	7.47	4.92	7.86
1/10/95 14:31	0.05	0.21	0.39	0.65	1.31	8.60	4.62	3.02
2/21/92 18:36	0.09	0.32	0.39	0.51	0.82	1.06	4.27	1.87
2/20/92 22:40	0.03	0.10	0.15	0.28	0.53	0.70	4.25	1.35
1/29/95 6:06	0.06	0.20	0.35	0.56	1.40	5.15	3.96	1.06
2/16/95 17:24	0.05	0.18	0.34	0.61	1.51	3.97	3.81	0.87
1/27/92 2:20	0.08	0.26	0.48	0.78	1.43	3.95	3.78	0.74
12/5/91 1:25	0.03	0.16	0.31	0.51	1.12	3.75	3.55	0.64
11/20/92 21:49	0.11	0.52	0.67	1.00	1.73	3.95	3.53	0.57
2/1/95 7:06	0.02	0.11	0.17	0.27	0.43	0.48	3.48	0.51
1/8/95 16:00	0.05	0.24	0.39	0.63	1.60	3.45	3.48	0.46
2/18/95 5:29	0.03	0.13	0.22	0.40	0.85	1.40	3.48	0.42
12/9/92 19:45	0.08	0.30	0.51	0.99	2.13	2.74	3.47	0.39
1/19/93 2:42	0.07	0.31	0.55	0.86	1.72	4.60	3.42	0.36
12/6/91 22:51	0.03	0.09	0.11	0.15	0.07	0.22	3.23	0.34
11/19/91 12:51	0.06	0.27	0.46	0.71	1.54	2.41	3.21	0.31
3/12/95 19:29	0.06	0.16	0.26	0.49	1.02	2.66	3.19	0.30
3/8/95 0:49	0.10	0.24	0.41	0.65	1.18	4.07	3.18	0.28
3/10/95 12:15	0.03	0.14	0.24	0.38	0.64	1.70	3.14	0.26
1/17/95 8:29	0.05	0.10	0.16	0.28	0.62	1.61	3.08	0.25
1/28/92 20:46	0.01	0.03	0.05	0.09	0.08	0.17	3.06	0.24
11/20/91 8:08	0.08	0.10	0.10	0.12	0.23	0.61	3.01	0.23
1/21/93 13:16	0.05	0.15	0.23	0.27	0.51	1.00	3.00	0.22
1/17/95 0:30	0.00	0.00	0.00	0.00	0.00	0.04	2.98	0.21
12/7/91 7:43	0.02	0.07	0.09	0.10	0.08	0.17	2.97	0.20
3/19/95 18:24	0.07	0.18	0.30	0.50	0.98	3.05	2.85	0.19
11/26/91 5:24	0.03	0.12	0.19	0.34	0.85	1.70	2.85	0.18
2/2/95 4:36	0.00	0.00	0.00	0.00	0.00	0.04	2.83	0.18
12/11/92 1:42	0.00	0.00	0.00	0.00	0.00	0.04	2.72	0.17
3/22/95 4:22	0.01	0.04	0.05	0.08	0.04	0.13	2.57	0.17
12/11/92 11:08	0.05	0.12	0.16	0.20	0.37	0.57	2.56	0.16
3/15/95 2:32	0.01	0.02	0.03	0.07	0.12	0.17	2.54	0.16
1/30/92 23:34	0.03	0.12	0.17	0.29	0.62	1.00	2.50	0.15
11/4/91 8:00	0.09	0.24	0.39	0.65	1.36	2.93	2.49	0.15
11/25/91 1:26	0.05	0.19	0.29	0.54	1.17	1.49	2.46	0.14
4/1/93 8:09	0.07	0.14	0.23	0.33	0.65	3.01	2.36	0.14
1/30/92 1:18	0.02	0.09	0.15	0.27	0.56	0.65	2.35	0.13
3/22/95 13:49	0.00	0.00	0.00	0.00	0.00	0.04	2.33	0.13
10/31/92 3:43	0.03	0.11	0.20	0.32	0.73	1.96	2.31	0.13
11/27/91 16:33	0.00	0.00	0.00	0.00	0.00	0.04	2.27	0.12
10/31/90 5:45	0.11	0.16	0.19	0.20	0.43	0.52	2.22	0.12

Cascade Creek

Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)
	Peak Precipitation Intensities Assoc. w/API > Annual Event — Boxed Events Indicate >= 1 Yr. Return						
2/17/92 0:59	0.05	0.21	0.39	0.65	1.31	8.60	4.62
1/10/95 14:31	0.09	0.32	0.39	0.51	0.82	1.06	4.27
2/21/92 18:36	0.03	0.10	0.15	0.28	0.53	0.70	4.25
2/20/92 22:40	0.06	0.20	0.35	0.56	1.40	5.15	3.96

Indian Creek

Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)	API Annual Return
	Peak Precipitation Intensities Assoc. w/API partial series; Boxed Events Indicate >= 1 Yr. Return						API Partial Series	
12/25/94 8:15	0.03	0.15	0.29	0.50	0.60	0.60	7.43	11.25
10/25/94 15:53	0.11	0.50	0.79	1.49	3.46	3.46	6.88	4.25
2/16/92 22:53	0.08	0.33	0.57	0.93	1.77	1.77	6.87	2.63
2/14/95 13:01	0.01	0.04	0.08	0.12	0.09	0.09	6.76	1.90
10/28/94 0:50	0.00	0.00	0.00	0.00	0.00	0.00	6.59	1.49
1/27/95 17:12	0.03	0.12	0.22	0.40	1.11	1.11	6.13	1.23
1/11/91 6:57	0.06	0.21	0.37	0.62	1.26	1.26	5.68	1.04
12/10/94 3:45	0.02	0.10	0.17	0.30	0.57	0.57	5.63	0.91
1/7/89 9:55	0.09	0.31	0.54	0.99	2.24	2.24	5.24	0.80
4/4/91 2:16	0.06	0.24	0.45	0.85	2.14	2.14	5.23	0.72
11/23/90 14:07	0.07	0.26	0.44	0.75	1.72	1.72	5.17	0.65
1/14/89 13:47	0.03	0.16	0.31	0.59	1.64	1.64	4.95	0.59
11/29/93 2:20	0.03	0.14	0.20	0.23	0.33	0.33	4.95	0.55
12/4/93 16:03	0.03	0.01	0.01	0.00	0.00	0.00	4.91	0.51
4/26/90 18:31	0.05	0.23	0.43	0.85	2.06	2.06	4.90	0.47
11/20/92 19:19	0.06	0.29	0.54	0.96	2.35	2.35	4.62	0.44
10/28/94 10:13	0.02	0.07	0.04	0.02	0.01	0.01	4.61	0.42
2/7/90 11:42	0.04	0.19	0.37	0.66	1.52	1.52	4.51	0.39
1/19/93 0:22	0.07	0.29	0.46	0.82	1.76	1.76	4.50	0.37
12/5/91 9:09	0.05	0.17	0.32	0.56	1.33	1.33	4.49	0.35
12/6/91 23:30	0.11	0.43	0.48	0.53	0.69	0.69	4.49	0.33
11/26/94 9:47	0.02	0.10	0.18	0.30	0.63	0.63	4.47	0.32
11/29/93 16:45	0.01	0.01	0.01	0.02	0.03	0.03	4.46	0.31
4/6/91 1:42	0.09	0.29	0.33	0.37	0.87	0.87	4.44	0.29
12/31/93 11:44	0.05	0.21	0.38	0.55	0.79	0.79	4.43	0.28
1/13/91 21:21	0.05	0.17	0.28	0.49	1.10	1.10	4.43	0.27
2/16/94 6:54	0.03	0.11	0.17	0.23	0.53	0.53	4.40	0.26
1/27/92 1:44	0.08	0.33	0.63	0.93	2.30	2.30	4.35	0.25
3/4/89 10:21	0.10	0.36	0.53	0.98	1.96	1.96	4.33	0.24
12/3/93 21:20	0.07	0.20	0.34	0.51	1.16	1.16	4.31	0.23
1/7/90 10:30	0.05	0.20	0.32	0.60	1.19	1.19	4.31	0.23
4/28/90 3:16	0.01	0.02	0.04	0.06	0.04	0.04	4.29	0.22
11/19/91 12:55	0.07	0.37	0.64	1.07	2.24	2.24	4.26	0.21
1/11/89 1:18	0.01	0.01	0.02	0.04	0.02	0.02	4.20	0.21
3/3/91 1:28	0.09	0.29	0.40	0.65	1.03	1.03	4.10	0.20
10/28/92 10:14	0.09	0.27	0.47	0.68	1.30	1.30	3.93	0.19
2/18/94 11:36	0.03	0.09	0.11	0.18	0.37	0.37	3.88	0.19
12/29/88 3:05	0.07	0.22	0.35	0.63	1.14	1.14	3.81	0.18
1/5/90 17:04	0.04	0.19	0.36	0.62	1.36	1.36	3.78	0.18
11/29/94 3:01	0.01	0.06	0.10	0.20	0.45	0.45	3.76	0.17
4/1/93 7:49	0.06	0.19	0.28	0.50	1.15	1.15	3.74	0.17
4/8/91 11:47	0.04	0.16	0.31	0.56	1.09	1.09	3.73	0.17
12/14/94 3:25	0.03	0.11	0.19	0.34	0.78	0.78	3.73	0.16
3/12/89 0:11	0.05	0.16	0.24	0.38	0.81	0.81	3.71	0.16
5/22/89 15:17	0.16	0.46	0.60	0.84	1.51	1.51	3.68	0.15
4/8/93 2:26	0.10	0.28	0.43	0.66	1.40	1.40	3.66	0.15
11/20/91 21:21	0.02	0.09	0.10	0.11	0.21	0.21	3.65	0.15
11/1/92 12:36	0.06	0.17	0.28	0.38	0.54	0.54	3.58	0.14
11/26/90 13:11	0.02	0.10	0.14	0.20	0.32	0.32	3.55	0.14
12/9/92 19:01	0.09	0.30	0.52	0.87	1.77	1.77	3.54	0.14
2/4/91 7:12	0.08	0.17	0.29	0.46	1.08	1.08	3.53	0.14
1/9/90 16:23	0.03	0.14	0.26	0.42	0.70	0.70	3.52	0.13
3/5/95 8:20	0.02	0.09	0.10	0.13	0.13	0.13	3.51	0.13

Intensities Assoc. w/API partial series					API Partial Series	
ed Events Indicate >= 1 Yr. Return				Storm	Peak	API Annual
Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Total (in.)	API (in.)	Return
.18	0.31	0.50	1.20	8.92	5.42	11.36
.23	0.43	0.77	2.02	4.68	4.69	4.37
.20	0.33	0.62	1.26	2.45	4.58	2.70
.25	0.44	0.72	1.38	6.95	4.45	1.96
.17	0.30	0.55	1.38	5.21	4.11	1.53
.21	0.37	0.67	1.55	6.19	4.07	1.26
.19	0.32	0.54	1.35	3.83	4.06	1.07
.20	0.37	0.66	1.44	4.00	4.02	0.93
.29	0.52	0.77	1.82	3.93	3.85	0.82
.01	0.01	0.02	0.03	0.08	3.84	0.74
.17	0.29	0.55	1.38	4.71	3.83	0.67
.12	0.16	0.22	0.40	0.55	3.77	0.61
.15	0.27	0.45	0.75	1.51	3.74	0.56
.00	0.00	0.00	0.00	0.04	3.66	0.52
.19	0.30	0.57	1.13	4.25	3.63	0.49
.15	0.23	0.37	1.00	2.44	3.61	0.45
.20	0.37	0.59	1.05	3.50	3.60	0.43
.27	0.42	0.74	1.45	3.79	3.58	0.40

Intensities Assoc. w/API > Annual Event					
ed Events Indicate >= 1 Yr. Return				Storm	Peak
Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Total (in.)	API (in.)
.18	0.31	0.50	1.20	8.92	5.42
.23	0.43	0.77	2.02	4.68	4.69
.20	0.33	0.62	1.26	2.45	4.58
.25	0.44	0.72	1.38	6.95	4.45
.17	0.30	0.55	1.38	5.21	4.11
.21	0.37	0.67	1.55	6.19	4.07
.19	0.32	0.54	1.35	3.83	4.06

Kirk Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API partial series — Boxed Events Indicate >= 1 Yr. Return: 5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	API Partial Series: Peak API (in.)	API Annual Return
11/21/88 1:36	0.27	0.46	0.55	0.97	2.19	11.56	6.64	11.27
11/5/88 13:45	0.22	0.86	1.20	1.64	2.51	3.67	5.74	4.33
11/27/88 0:37	0.15	0.33	0.53	0.85	1.87	3.80	5.67	2.68
11/25/88 12:13	0.07	0.18	0.19	0.21	0.42	0.64	5.35	1.94
11/28/88 7:27	0.01	0.01	0.02	0.04	0.09	0.13	5.19	1.52
11/2/88 4:39	0.14	0.39	0.62	1.24	2.07	6.91	5.18	1.25
1/5/90 21:15	0.05	0.23	0.39	0.66	1.70	6.25	4.74	1.06
11/9/88 5:52	0.15	0.40	0.48	0.82	1.23	3.89	4.64	0.92
1/10/95 20:09	0.05	0.23	0.29	0.49	1.14	8.84	4.53	0.82
1/8/90 14:30	0.03	0.11	0.16	0.31	0.47	0.60	4.29	0.73
1/8/89 9:24	0.05	0.17	0.31	0.56	1.41	5.35	4.22	0.66
11/28/88 23:21	0.00	0.00	0.00	0.00	0.00	0.04	4.19	0.61
11/14/88 20:56	0.09	0.24	0.34	0.51	1.20	5.11	4.05	0.56
11/7/88 6:02	0.00	0.00	0.00	0.00	0.00	0.04	3.99	0.52
11/11/88 18:50	0.06	0.27	0.33	0.49	0.88	1.45	3.96	0.48
1/9/90 16:48	0.03	0.13	0.18	0.28	0.69	1.51	3.80	0.45
11/7/88 20:07	0.13	0.21	0.32	0.41	0.55	0.69	3.62	0.42
10/25/94 17:38	0.10	0.29	0.53	0.89	1.60	4.64	3.57	0.40
2/7/90 20:42	0.02	0.12	0.24	0.45	1.14	3.71	3.56	0.38
12/10/93 5:16	0.09	0.20	0.33	0.48	1.13	3.28	3.53	0.36
11/8/88 13:09	0.05	0.21	0.31	0.57	0.43	0.64	3.49	0.34
3/3/91 1:17	0.03	0.14	0.24	0.47	0.88	3.19	3.30	0.33
1/11/89 5:25	0.00	0.00	0.00	0.00	0.00	0.04	3.29	0.31
1/16/95 16:04	0.00	0.00	0.00	0.00	0.00	0.05	3.28	0.30
1/10/90 22:12	0.00	0.00	0.00	0.00	0.00	0.04	3.25	0.29
1/30/95 17:02	0.04	0.22	0.35	0.57	1.28	3.71	3.22	0.27
10/31/94 5:55	0.05	0.15	0.26	0.49	1.00	2.97	3.19	0.26
12/5/91 10:19	0.03	0.13	0.22	0.39	0.92	3.32	3.01	0.25
1/8/95 18:00	0.05	0.15	0.29	0.49	1.33	2.98	3.01	0.25
3/4/91 19:29	0.00	0.00	0.00	0.00	0.00	0.04	2.98	0.24
2/1/90 4:15	0.03	0.13	0.23	0.41	0.98	2.24	2.97	0.23
12/12/93 3:41	0.00	0.00	0.00	0.00	0.00	0.04	2.90	0.22
11/30/93 12:31	0.05	0.22	0.40	0.69	1.46	2.84	2.86	0.22
12/6/91 22:31	0.03	0.11	0.14	0.17	0.35	0.73	2.86	0.21
1/10/95 0:28	0.02	0.08	0.10	0.15	0.20	0.33	2.81	0.20
11/13/88 11:33	0.01	0.05	0.10	0.09	0.03	0.17	2.80	0.20
5/22/89 15:33	0.09	0.26	0.46	0.75	1.42	3.76	2.79	0.19
2/16/95 16:19	0.04	0.12	0.23	0.42	1.03	2.85	2.77	0.19
1/11/91 9:13	0.05	0.15	0.23	0.40	0.77	2.50	2.76	0.18
11/1/94 21:10	0.01	0.06	0.12	0.15	0.23	0.30	2.76	0.18
1/17/95 6:28	0.03	0.15	0.20	0.29	0.49	1.40	2.71	0.17
4/8/92 9:22	0.07	0.30	0.42	0.57	1.19	3.10	2.65	0.17

Kirk Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API > Annual Event — Boxed Events Indicate >= 1 Yr. Return: 5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)
11/21/88 1:36	0.27	0.46	0.55	0.97	2.19	11.56	6.64
11/5/88 13:45	0.22	0.86	1.20	1.64	2.51	3.67	5.74
11/27/88 0:37	0.15	0.33	0.53	0.85	1.87	3.80	5.67
11/25/88 12:13	0.07	0.18	0.19	0.21	0.42	0.64	5.35
11/28/88 7:27	0.01	0.01	0.02	0.04	0.09	0.13	5.19
11/2/88 4:39	0.14	0.39	0.62	1.24	2.07	6.91	5.18
1/5/90 21:15	0.05	0.23	0.39	0.66	1.70	6.25	4.74

Lobster Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API partial series 5 Min. (in.)	Boxed Events Indicate >= 1 Yr. Return 30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	API Partial Series Peak API (in.)	API Annual Return
10/25/94 16:07	0.12	0.54	0.98	1.50	2.67	7.66	5.99	9.65
1/10/95 18:10	0.08	0.23	0.34	0.59	1.25	10.23	5.69	3.71
2/16/95 12:22	0.06	0.23	0.39	0.72	1.99	7.60	5.20	2.30
10/28/94 6:38	0.00	0.00	0.00	0.00	0.00	0.05	5.02	1.66
10/31/94 4:46	0.05	0.22	0.43	0.74	1.54	4.30	4.78	1.30
2/17/92 0:57	0.06	0.22	0.32	0.59	1.19	8.05	4.63	1.07
1/27/92 2:30	0.06	0.23	0.39	0.71	1.75	4.92	4.56	0.91
2/21/92 17:38	0.09	0.27	0.46	0.68	1.30	1.73	4.55	0.79
10/28/94 14:52	0.04	0.01	0.00	0.00	0.00	0.10	4.53	0.70
1/30/95 15:07	0.06	0.24	0.39	0.57	1.41	4.10	4.27	0.63
12/27/94 10:51	0.03	0.10	0.18	0.35	0.58	1.15	4.23	0.57
10/28/92 14:38	0.09	0.23	0.34	0.63	0.90	6.69	4.02	0.52
12/6/93 14:41	0.04	0.20	0.35	0.62	1.24	10.12	3.95	0.48
1/28/92 20:41	0.01	0.03	0.04	0.08	0.14	0.20	3.86	0.44
1/21/93 13:30	0.09	0.23	0.34	0.56	1.04	1.57	3.78	0.41
1/19/93 5:46	0.08	0.30	0.49	0.75	1.68	4.91	3.77	0.39
1/17/95 5:37	0.08	0.15	0.22	0.33	0.80	2.03	3.66	0.36
2/22/94 16:11	0.03	0.10	0.20	0.38	0.91	3.54	3.59	0.34
1/8/95 3:02	0.08	0.22	0.37	0.63	1.53	4.05	3.58	0.32
10/29/94 7:34	0.00	0.00	0.00	0.00	0.00	0.05	3.57	0.31
11/1/92 17:51	0.04	0.16	0.18	0.27	0.09	0.35	3.51	0.29
11/20/92 20:56	0.06	0.19	0.33	0.56	1.32	3.54	3.48	0.28
11/2/94 7:35	0.00	0.00	0.00	0.00	0.00	0.05	3.41	0.27
1/22/93 11:23	0.00	0.00	0.00	0.00	0.00	0.05	3.34	0.26
11/30/93 12:46	0.06	0.28	0.49	0.84	1.52	3.35	3.33	0.25
3/22/93 6:16	0.04	0.15	0.25	0.43	1.18	3.14	3.30	0.24
3/16/93 1:25	0.05	0.14	0.23	0.39	0.96	3.49	3.29	0.23
3/10/95 9:21	0.06	0.15	0.28	0.47	0.73	4.40	3.29	0.22
3/21/95 6:29	0.05	0.20	0.31	0.49	0.81	1.22	3.19	0.21
11/26/91 5:47	0.09	0.13	0.19	0.35	0.85	2.18	3.16	0.20
1/2/94 8:03	0.09	0.38	0.44	0.58	0.83	5.12	3.16	0.20
3/7/95 21:57	0.06	0.20	0.36	0.58	1.00	4.10	3.10	0.19
12/5/91 9:58	0.04	0.15	0.24	0.39	1.01	3.14	3.09	0.18
4/8/93 2:25	0.09	0.23	0.39	0.56	1.18	5.27	3.05	0.18
11/19/91 13:24	0.09	0.20	0.38	0.56	1.16	2.89	2.96	0.17
12/6/91 23:22	0.06	0.13	0.18	0.20	0.30	0.51	2.93	0.17
3/14/95 12:36	0.00	0.00	0.00	0.00	0.00	0.05	2.93	0.16
11/2/94 19:05	0.00	0.00	0.00	0.00	0.00	0.05	2.92	0.16
3/19/95 15:15	0.06	0.17	0.30	0.56	1.14	2.53	2.86	0.16
11/30/94 9:09	0.03	0.11	0.22	0.40	1.11	2.43	2.83	0.15
2/25/94 8:29	0.00	0.00	0.00	0.00	0.00	0.05	2.79	0.15
10/30/94 2:18	0.01	0.05	0.09	0.13	0.10	0.20	2.79	0.14
11/23/92 2:11	0.00	0.00	0.00	0.00	0.00	0.05	2.69	0.14
11/27/91 13:12	0.00	0.00	0.00	0.00	0.00	0.05	2.69	0.14
10/31/90 6:15	0.06	0.16	0.27	0.28	0.46	0.66	2.69	0.14

Lobster Creek

Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)
	Peak Precipitation Intensities Assoc. w/API > Annual Event; Boxed Events Indicate >= 1 Yr. Return						
10/25/94 16:07	0.12	0.54	0.98	1.50	2.67	7.66	5.99
1/10/95 18:10	0.08	0.23	0.34	0.59	1.25	10.23	5.69
2/16/95 12:22	0.06	0.23	0.39	0.72	1.99	7.60	5.20
10/28/94 6:38	0.00	0.00	0.00	0.00	0.00	0.05	5.02
10/31/94 4:46	0.05	0.22	0.43	0.74	1.54	4.30	4.78
2/17/92 0:57	0.06	0.22	0.32	0.59	1.19	8.05	4.63
1/27/92 2:30	0.06	0.23	0.39	0.71	1.75	4.92	4.56

Mill Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API partial series: 5 Min. (in.)	Boxed Events Indicate >= 1 Yr. Return: 30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	API Partial Series: Peak API (in.)	API Annual Return
11/21/88 1:03	0.14	0.51	0.84	1.27	3.53	12.70	7.39	6.47
11/25/88 11:49	0.03	0.18	0.26	0.29	0.51	0.98	5.41	2.49
11/27/88 7:10	0.07	0.26	0.46	0.82	1.78	3.08	5.26	1.54
1/5/90 18:25	0.06	0.31	0.53	0.78	1.62	6.82	4.77	1.12
11/5/88 14:42	0.35	0.77	1.16	1.31	1.79	2.91	4.64	0.87
2/7/90 18:38	0.03	0.17	0.31	0.56	1.42	4.51	4.32	0.72
11/14/88 20:11	0.09	0.31	0.53	0.71	1.27	5.57	4.27	0.61
11/2/88 4:49	0.10	0.34	0.41	0.72	1.29	5.90	4.12	0.53
11/26/88 20:35	0.00	0.00	0.00	0.00	0.00	0.04	3.97	0.47
11/9/88 7:16	0.10	0.28	0.40	0.57	0.95	3.26	3.92	0.42
2/17/92 0:57	0.05	0.18	0.26	0.50	1.00	6.76	3.89	0.38
1/27/92 2:30	0.05	0.19	0.33	0.59	1.46	4.11	3.83	0.35
2/21/92 17:38	0.07	0.22	0.38	0.56	1.07	1.43	3.82	0.32
1/9/90 16:45	0.03	0.11	0.19	0.35	0.66	1.28	3.73	0.30
11/19/88 6:43	0.14	0.31	0.44	0.71	1.17	2.62	3.72	0.28
11/17/88 21:39	0.00	0.00	0.00	0.00	0.00	0.04	3.71	0.26
11/29/88 0:49	0.00	0.00	0.00	0.00	0.00	0.04	3.71	0.24
2/9/90 12:33	0.01	0.05	0.09	0.17	0.32	0.47	3.65	0.23
11/11/88 18:50	0.10	0.24	0.34	0.44	1.08	1.48	3.58	0.22
11/7/88 17:29	0.10	0.29	0.42	0.51	0.99	1.64	3.53	0.21
1/8/89 7:32	0.04	0.19	0.35	0.61	1.51	4.21	3.41	0.20
1/11/91 10:09	0.04	0.19	0.34	0.56	1.00	2.93	3.32	0.19

Mill Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API > Annual Event: 5 Min. (in.)	Boxed Events Indicate >= 1 Yr. Return: 30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)
11/21/88 1:03	0.14	0.51	0.84	1.27	3.53	12.70	7.39
11/25/88 11:49	0.03	0.18	0.26	0.29	0.51	0.98	5.41
11/27/88 7:10	0.07	0.26	0.46	0.82	1.78	3.08	5.26
1/5/90 18:25	0.06	0.31	0.53	0.78	1.62	6.82	4.77

Panther Creek

	Peak Precipitation Intensities Assoc. w/API partial series						API Partial Series	
		Boxed Events Indicate >= 1 Yr. Return				Storm	Peak	API Annual
Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Total (in.)	API (in.)	Return
1/7/90 11:14	0.11	0.45	0.70	1.16	2.21	4.76	6.96	9.76
10/25/94 16:15	0.13	0.48	0.71	1.30	2.51	8.34	6.44	3.75
1/9/90 12:40	0.04	0.16	0.30	0.57	1.14	2.08	5.80	2.32
10/31/94 4:31	0.07	0.32	0.58	1.01	2.53	5.94	5.76	1.68
1/5/90 15:52	0.06	0.29	0.51	1.00	2.17	6.17	5.71	1.32
1/10/95 15:09	0.09	0.28	0.42	0.76	1.62	9.95	5.51	1.08
10/28/94 7:16	0.01	0.01	0.02	0.03	0.03	0.08	5.32	0.92
2/16/92 22:48	0.05	0.18	0.32	0.62	1.42	8.81	5.24	0.80
2/17/95 15:34	0.07	0.21	0.34	0.60	1.49	7.34	4.86	0.71
11/23/90 16:19	0.05	0.25	0.46	0.87	1.89	4.82	4.85	0.63
2/7/90 15:34	0.09	0.41	0.77	1.37	2.65	6.33	4.66	0.57
2/21/92 17:25	0.09	0.25	0.26	0.39	0.87	1.13	4.48	0.52
11/30/93 13:12	0.10	0.21	0.41	0.74	1.80	4.84	4.46	0.48
1/30/95 4:45	0.05	0.24	0.42	0.63	1.39	6.83	4.44	0.45
1/11/91 8:06	0.06	0.20	0.36	0.65	1.29	4.25	4.44	0.42

Panther Creek

	Peak Precipitation Intensities Assoc. w/API > Annual Event						
		Boxed Events Indicate >= 1 Yr. Return				Storm	Peak
Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Total (in.)	API (in.)
1/7/90 11:14	0.11	0.45	0.70	1.16	2.21	4.76	6.96
10/25/94 16:15	0.13	0.48	0.71	1.30	2.51	8.34	6.44
1/9/90 12:40	0.04	0.16	0.30	0.57	1.14	2.08	5.80
10/31/94 4:31	0.07	0.32	0.58	1.01	2.53	5.94	5.76
1/5/90 15:52	0.06	0.29	0.51	1.00	2.17	6.17	5.71
1/10/95 15:09	0.09	0.28	0.42	0.76	1.62	9.95	5.51

Ryder Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API partial series — Boxed Events Indicate >= 1 Yr. Return: 5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	API Partial Series: Peak API (in.)	API Annual Return
4/26/90 19:13	0.07	0.30	0.52	1.02	2.70	6.02	6.10	9.63
4/28/90 3:01	0.00	0.00	0.00	0.00	0.00	0.04	5.36	3.70
1/10/95 14:25	0.09	0.21	0.44	0.60	1.05	9.51	5.15	2.29
2/16/92 22:48	0.05	0.18	0.31	0.60	1.40	8.42	5.00	1.66
4/28/90 9:09	0.00	0.00	0.00	0.00	0.00	0.04	4.92	1.30
2/7/90 13:20	0.05	0.22	0.39	0.71	1.45	6.82	4.62	1.07
1/5/90 16:13	0.07	0.22	0.38	0.73	1.57	6.00	4.54	0.91
2/21/92 17:25	0.09	0.25	0.26	0.40	0.91	1.10	4.30	0.79
10/25/94 15:03	0.14	0.71	1.19	1.41	2.27	4.51	4.16	0.70
1/8/90 12:14	0.03	0.11	0.20	0.28	0.44	0.69	4.04	0.63
12/5/91 10:51	0.07	0.24	0.33	0.60	1.35	4.45	3.88	0.57
1/8/95 14:43	0.10	0.37	0.54	0.78	1.68	3.77	3.82	0.52
2/22/92 13:12	0.00	0.00	0.00	0.00	0.00	0.04	3.79	0.48
12/7/91 0:05	0.09	0.22	0.26	0.32	0.41	0.58	3.68	0.44
2/22/94 15:21	0.10	0.20	0.34	0.51	0.99	4.09	3.67	0.41
10/27/94 5:48	0.01	0.01	0.02	0.04	0.02	0.08	3.61	0.39
4/2/93 1:40	0.06	0.12	0.24	0.44	1.07	3.40	3.60	0.36
1/9/90 16:09	0.04	0.14	0.18	0.30	0.65	1.23	3.56	0.34
10/30/94 5:23	0.18	0.66	0.96	1.42	1.94	3.39	3.51	0.32
1/18/93 1:40	0.10	0.24	0.39	0.67	1.57	4.09	3.44	0.31
11/30/93 3:36	0.10	0.20	0.39	0.82	2.22	3.02	3.40	0.29
1/30/95 16:15	0.07	0.27	0.38	0.60	1.11	3.31	3.38	0.28
10/29/90 17:13	0.11	0.31	0.43	0.63	1.19	3.79	3.35	0.27
11/30/94 10:42	0.05	0.21	0.37	0.67	1.66	2.31	3.34	0.25
11/4/91 8:58	0.07	0.33	0.57	1.00	2.19	3.90	3.34	0.24
1/18/95 3:16	0.10	0.24	0.32	0.41	0.62	0.82	3.30	0.23
1/17/95 3:45	0.02	0.08	0.13	0.25	0.60	0.96	3.24	0.23
4/29/90 14:42	0.02	0.02	0.01	0.00	0.00	0.08	3.21	0.22
12/9/93 5:16	0.02	0.07	0.11	0.20	0.55	3.59	3.20	0.21
4/8/92 5:49	0.06	0.23	0.38	0.60	1.32	3.50	3.20	0.20
1/12/91 22:40	0.09	0.19	0.28	0.44	0.90	2.69	3.20	0.20
3/3/91 1:00	0.04	0.16	0.29	0.46	0.74	2.83	3.19	0.19
1/11/91 9:25	0.07	0.17	0.28	0.50	0.90	2.26	3.13	0.18
11/26/91 4:38	0.03	0.13	0.25	0.40	0.99	2.10	3.12	0.18
1/19/93 16:48	0.06	0.12	0.20	0.33	0.68	1.53	3.11	0.17
4/3/93 21:21	0.00	0.00	0.00	0.00	0.00	0.04	3.03	0.17
2/11/90 9:53	0.01	0.05	0.08	0.11	0.17	0.23	3.02	0.16
12/6/93 3:36	0.06	0.16	0.28	0.52	1.26	3.48	2.99	0.16
2/25/94 2:38	0.01	0.03	0.06	0.09	0.14	0.42	2.99	0.16
1/10/90 17:55	0.00	0.00	0.00	0.00	0.00	0.04	2.98	0.15
1/27/92 2:59	0.05	0.21	0.36	0.58	1.39	3.00	2.98	0.15
12/27/94 9:15	0.07	0.26	0.32	0.49	0.75	1.59	2.91	0.14
11/6/91 5:16	0.01	0.05	0.09	0.11	0.18	0.23	2.90	0.14
12/8/92 17:45	0.13	0.24	0.35	0.55	1.18	1.95	2.88	0.14
12/1/94 20:18	0.05	0.13	0.22	0.37	0.52	0.93	2.85	0.13
12/1/94 12:57	0.00	0.00	0.00	0.00	0.00	0.04	2.80	0.13
4/10/92 1:32	0.00	0.00	0.00	0.00	0.00	0.04	2.78	0.13
2/12/91 10:58	0.06	0.19	0.34	0.71	1.42	3.14	2.74	0.13
12/8/93 5:02	0.01	0.02	0.03	0.05	0.13	0.23	2.71	0.12
10/31/90 21:06	0.00	0.00	0.00	0.00	0.00	0.04	2.70	0.12
10/21/90 4:05	0.08	0.34	0.58	1.04	1.99	2.37	2.70	0.12
3/11/95 15:19	0.09	0.22	0.28	0.46	0.64	2.58	2.68	0.12
2/16/95 16:01	0.04	0.11	0.18	0.32	0.84	2.64	2.65	0.11

12/8/91 5:01	0.00	0.00	0.00	0.00	0.00	0.04	2.65	0.11
3/8/95 0:23	0.06	0.23	0.38	0.59	0.98	3.30	2.63	0.11
10/30/92 1:55	0.10	0.20	0.32	0.48	1.06	2.25	2.63	0.11
11/24/90 3:15	0.05	0.17	0.30	0.61	1.34	2.46	2.58	0.11
11/2/94 23:18	0.05	0.19	0.26	0.43	0.78	1.34	2.58	0.10
12/14/94 20:40	0.07	0.29	0.46	0.74	1.40	2.89	2.54	0.10
3/20/95 18:01	0.05	0.10	0.15	0.24	0.64	2.10	2.53	0.10
3/10/95 9:13	0.03	0.09	0.11	0.19	0.33	0.99	2.51	0.10
11/12/90 23:54	0.07	0.22	0.31	0.51	1.12	2.78	2.50	0.10
11/3/90 9:24	0.06	0.18	0.36	0.50	1.39	1.96	2.47	0.10
11/6/91 21:29	0.01	0.01	0.02	0.03	0.02	0.08	2.47	0.09
12/2/93 21:36	0.06	0.12	0.20	0.36	0.88	1.41	2.46	0.09
11/19/92 18:28	0.10	0.16	0.24	0.39	0.76	2.02	2.44	0.09
1/29/95 3:23	0.08	0.28	0.41	0.57	0.94	2.12	2.41	0.09
3/14/95 14:59	0.01	0.02	0.03	0.04	0.01	0.08	2.41	0.09
1/11/90 9:13	0.00	0.00	0.00	0.00	0.00	0.04	2.41	0.09
3/5/91 8:45	0.01	0.05	0.09	0.10	0.09	0.15	2.40	0.09
1/29/90 16:24	0.06	0.17	0.24	0.39	0.74	1.54	2.39	0.09
2/3/90 4:19	0.03	0.14	0.27	0.50	0.96	1.45	2.39	0.08
1/28/92 21:19	0.01	0.02	0.03	0.05	0.05	0.11	2.38	0.08
10/25/89 23:29	0.12	0.22	0.33	0.47	1.09	2.10	2.38	0.08

Ryder Creek

	Peak Precipitation Intensities Assoc. w/API > Annual Event						
	Boxed Events Indicate >= 1 Yr. Return					Storm	Peak
Storm Start	**5 Min. (in.)**	**30 Min. (in.)**	**1 Hr. (in.)**	**2 Hr. (in.)**	**6 Hr. (in.)**	**Total (in.)**	**API (in.)**
4/26/90 19:13	0.07	0.30	0.52	1.02	2.70	6.02	6.10
4/28/90 3:01	0.00	0.00	0.00	0.00	0.00	0.04	5.36
1/10/95 14:25	0.09	0.21	0.44	0.60	1.05	9.51	5.15
2/16/92 22:48	0.05	0.18	0.31	0.60	1.40	8.42	5.00
4/28/90 9:09	0.00	0.00	0.00	0.00	0.00	0.04	4.92
2/7/90 13:20	0.05	0.22	0.39	0.71	1.45	6.82	4.62

Smith River

Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)	API Annual Return
	Peak Precipitation Intensities Assoc. w/API partial series — Boxed Events Indicate >= 1 Yr. Return						API Partial Series	
11/21/88 1:35	0.14	0.44	0.68	1.10	2.67	9.94	6.94	11.28
11/24/88 13:31	0.07	0.33	0.59	0.97	1.40	2.00	6.48	4.34
11/27/88 4:47	0.10	0.30	0.50	0.92	2.10	3.65	5.68	2.68
11/25/88 11:58	0.05	0.18	0.23	0.30	0.45	0.83	5.48	1.94
11/5/88 13:42	0.19	0.76	1.08	1.50	2.36	3.60	5.31	1.52
1/10/95 19:36	0.06	0.19	0.31	0.54	1.34	8.65	5.09	1.25
11/14/88 20:00	0.09	0.30	0.49	0.63	1.04	5.78	4.51	1.06
1/5/90 17:17	0.07	0.22	0.44	0.76	1.64	6.39	4.51	0.92
11/9/88 6:58	0.10	0.33	0.36	0.56	1.04	3.36	4.08	0.82
11/2/88 5:02	0.14	0.46	0.58	0.83	1.51	5.37	3.98	0.73
11/19/88 6:56	0.14	0.34	0.38	0.64	1.16	2.82	3.85	0.66
11/11/88 20:15	0.10	0.32	0.42	0.61	0.95	1.70	3.81	0.61
11/29/93 13:26	0.14	0.26	0.46	0.84	1.93	3.70	3.64	0.56
11/29/88 7:05	0.00	0.00	0.00	0.00	0.00	0.04	3.63	0.52
2/7/90 18:24	0.07	0.32	0.62	1.04	1.91	5.18	3.61	0.48
11/30/94 11:07	0.09	0.25	0.43	0.83	1.72	3.31	3.56	0.45
1/9/90 16:32	0.03	0.12	0.21	0.34	0.59	1.23	3.48	0.42
4/1/93 7:55	0.06	0.13	0.26	0.43	1.07	4.23	3.45	0.40
11/11/88 5:59	0.00	0.00	0.00	0.00	0.00	0.04	3.44	0.38
11/7/88 19:31	0.14	0.23	0.32	0.41	0.60	1.16	3.43	0.36
1/30/95 16:17	0.05	0.18	0.32	0.55	1.04	3.50	3.31	0.34
10/25/94 16:05	0.05	0.17	0.32	0.61	1.34	3.70	3.31	0.33
3/3/91 1:29	0.07	0.30	0.43	0.63	0.90	3.02	3.30	0.31
11/18/88 7:09	0.00	0.00	0.00	0.00	0.00	0.04	3.29	0.30
4/26/90 21:21	0.03	0.17	0.31	0.56	1.40	3.25	3.21	0.29
1/17/95 5:11	0.02	0.07	0.13	0.26	0.70	1.11	3.11	0.28
11/26/91 4:48	0.04	0.16	0.25	0.38	0.99	2.06	3.02	0.26
1/8/95 16:11	0.09	0.22	0.28	0.51	1.32	3.13	3.00	0.26
12/7/93 6:43	0.02	0.09	0.17	0.31	0.59	1.31	2.98	0.25
1/18/95 4:39	0.03	0.11	0.15	0.25	0.41	0.66	2.96	0.24
4/3/93 20:38	0.00	0.00	0.00	0.00	0.00	0.04	2.96	0.23
5/22/89 15:08	0.10	0.29	0.51	0.96	1.44	3.83	2.92	0.22
1/20/93 17:02	0.06	0.15	0.20	0.32	0.56	1.77	2.87	0.22
1/19/93 0:28	0.06	0.17	0.34	0.60	1.31	3.25	2.85	0.21
12/5/93 22:04	0.06	0.17	0.34	0.60	1.31	2.55	2.84	0.20
12/16/94 11:29	0.05	0.24	0.41	0.74	1.54	2.07	2.84	0.20
11/20/92 20:24	0.06	0.17	0.30	0.49	1.03	2.83	2.82	0.19

Smith River

Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)
	Peak Precipitation Intensities Assoc. w/API > Annual Event — Boxed Events Indicate >= 1 Yr. Return						
11/21/88 1:35	0.14	0.44	0.68	1.10	2.67	9.94	6.94
11/24/88 13:31	0.07	0.33	0.59	0.97	1.40	2.00	6.48
11/27/88 4:47	0.10	0.30	0.50	0.92	2.10	3.65	5.68
11/25/88 11:58	0.05	0.18	0.23	0.30	0.45	0.83	5.48
11/5/88 13:42	0.19	0.76	1.08	1.50	2.36	3.60	5.31
1/10/95 19:36	0.06	0.19	0.31	0.54	1.34	8.65	5.09
11/14/88 20:00	0.09	0.30	0.49	0.63	1.04	5.78	4.51

South Canyon

	Peak Precipitation Intensities Assoc. w/API partial series						API Partial Series	
		Boxed Events Indicate >= 1 Yr. Return				Storm	Peak	API Annual
Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Total (in.)	API (in.)	Return
11/21/88 0:22	0.23	0.44	0.68	1.09	2.60	10.18	8.65	11.26
11/5/88 13:07	0.19	0.80	1.07	1.92	3.52	5.23	7.87	4.33
11/24/88 14:21	0.09	0.30	0.56	1.00	2.54	5.11	7.42	2.68
11/27/88 4:41	0.12	0.42	0.73	1.23	2.63	4.95	7.24	1.94
4/27/90 18:51	0.07	0.29	0.56	1.07	2.83	6.60	6.77	1.52
11/9/88 6:59	0.20	0.42	0.62	0.91	1.80	6.03	6.73	1.25
11/2/88 4:05	0.34	0.76	0.85	1.04	1.92	7.96	6.69	1.06
1/8/89 6:08	0.09	0.36	0.62	1.05	2.71	8.86	6.64	0.92
11/6/88 18:44	0.00	0.00	0.00	0.00	0.00	0.04	6.45	0.82
1/5/90 19:58	0.07	0.28	0.52	0.97	2.30	9.34	6.32	0.73
1/10/95 18:44	0.09	0.31	0.44	0.64	1.43	11.84	6.28	0.66
11/11/88 18:27	0.18	0.56	0.68	0.82	1.30	2.38	6.01	0.61
11/14/88 19:40	0.10	0.33	0.50	0.65	1.23	6.97	5.75	0.56
2/7/90 16:44	0.04	0.19	0.34	0.66	1.58	8.23	5.47	0.52
1/29/95 4:12	0.09	0.29	0.46	0.83	1.57	8.52	5.33	0.48
1/11/91 9:33	0.06	0.23	0.36	0.62	1.37	7.76	5.29	0.45
11/7/88 19:15	0.13	0.32	0.54	0.72	1.14	1.89	5.25	0.42
10/24/94 17:09	0.13	0.57	0.89	1.28	2.34	7.33	5.04	0.40
1/9/90 19:59	0.05	0.14	0.24	0.41	0.86	1.60	4.96	0.38
2/22/94 5:45	0.06	0.17	0.25	0.46	1.12	5.59	4.88	0.36
1/16/95 13:37	0.00	0.00	0.00	0.00	0.00	0.04	4.80	0.34
11/30/93 13:26	0.14	0.29	0.49	0.94	2.40	4.47	4.54	0.33
4/1/93 7:12	0.06	0.17	0.33	0.62	1.55	5.63	4.52	0.31
12/10/93 6:00	0.14	0.21	0.37	0.66	1.44	4.23	4.37	0.30
3/3/91 1:19	0.07	0.18	0.33	0.57	0.99	3.80	4.34	0.29
1/7/95 10:57	0.02	0.08	0.13	0.17	0.32	0.40	4.27	0.27
1/20/93 16:33	0.10	0.25	0.41	0.67	0.80	2.16	4.23	0.26
1/17/95 5:29	0.02	0.09	0.18	0.34	0.88	1.36	4.20	0.25
1/19/93 1:40	0.10	0.25	0.45	0.73	1.64	4.71	4.19	0.25
12/5/91 10:29	0.05	0.15	0.26	0.49	1.25	4.95	4.19	0.24
1/10/90 21:25	0.01	0.03	0.02	0.01	0.01	0.08	4.16	0.23
11/13/88 11:25	0.03	0.08	0.12	0.06	0.02	0.16	4.15	0.22
1/18/95 4:37	0.05	0.17	0.25	0.37	0.64	0.84	4.10	0.22
10/30/94 5:37	0.09	0.44	0.71	1.10	1.92	4.77	4.07	0.21
11/23/90 17:38	0.05	0.25	0.45	0.77	1.71	4.28	4.07	0.20
2/16/95 15:50	0.05	0.17	0.27	0.50	1.32	4.28	4.05	0.20
1/14/89 14:15	0.05	0.17	0.33	0.62	1.55	5.07	4.05	0.19
2/25/94 3:07	0.01	0.05	0.07	0.11	0.21	0.64	4.02	0.19
11/19/88 6:14	0.07	0.31	0.38	0.45	0.77	2.44	3.91	0.18
1/10/95 0:23	0.01	0.05	0.08	0.14	0.15	0.28	3.86	0.18
11/26/91 4:28	0.05	0.17	0.29	0.50	1.23	2.40	3.84	0.17
1/18/95 20:10	0.00	0.00	0.00	0.00	0.00	0.04	3.76	0.17
4/30/90 12:33	0.02	0.03	0.06	0.07	0.02	0.12	3.74	0.17
10/30/92 20:09	0.10	0.25	0.45	0.78	1.52	3.35	3.73	0.16

South Canyon

Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)
	Peak Precipitation Intensities Assoc. w/API > Annual Event Boxed Events Indicate >= 1 Yr. Return						
11/21/88 0:22	0.23	0.44	0.68	1.09	2.60	10.18	8.65
11/5/88 13:07	0.19	0.80	1.07	1.92	3.52	5.23	7.87
11/24/88 14:21	0.09	0.30	0.56	1.00	2.54	5.11	7.42
11/27/88 4:41	0.12	0.42	0.73	1.23	2.63	4.95	7.24
4/27/90 18:51	0.07	0.29	0.56	1.07	2.83	6.60	6.77
11/9/88 6:59	0.20	0.42	0.62	0.91	1.80	6.03	6.73
11/2/88 4:05	0.34	0.76	0.85	1.04	1.92	7.96	6.69

Sweet Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API partial series — Boxed Events Indicate >= 1 Yr. Return: 5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	API Partial Series: Peak API (in.)	API Annual Return
11/5/88 13:10	0.22	0.61	0.95	1.19	3.10	4.06	6.31	11.32
11/2/88 4:30	0.14	0.41	0.81	0.96	1.68	6.71	5.48	4.35
4/26/90 19:44	0.08	0.27	0.48	0.92	2.40	5.41	5.43	2.69
11/9/88 7:12	0.18	0.44	0.50	0.70	1.38	4.04	5.26	1.95
1/10/95 13:45	0.14	0.26	0.38	0.61	1.11	9.87	5.21	1.53
1/7/90 10:38	0.09	0.30	0.34	0.59	1.24	2.92	4.73	1.26
4/28/90 3:15	0.01	0.02	0.03	0.05	0.11	0.16	4.72	1.07
5/22/89 14:33	0.23	0.54	0.62	1.12	1.82	5.74	4.45	0.93
1/16/95 5:04	0.00	0.00	0.00	0.00	0.00	0.04	4.45	0.82
10/25/94 16:06	0.12	0.40	0.67	0.96	1.82	4.74	4.27	0.73
2/7/90 11:26	0.05	0.16	0.28	0.55	1.35	6.12	4.26	0.67
1/5/90 16:17	0.05	0.19	0.37	0.61	1.46	4.54	4.21	0.61
11/7/88 17:10	0.12	0.47	0.61	0.78	1.15	1.83	4.12	0.56
1/9/90 15:59	0.03	0.13	0.21	0.40	0.86	1.63	4.02	0.52
11/11/88 19:22	0.14	0.18	0.33	0.34	0.74	0.94	3.96	0.48
11/4/91 8:59	0.09	0.30	0.57	1.00	2.34	4.43	3.87	0.45
1/31/90 14:08	0.14	0.63	1.16	2.19	2.77	3.75	3.83	0.43
11/8/88 22:58	0.00	0.00	0.00	0.00	0.00	0.04	3.79	0.40
4/28/90 22:08	0.00	0.00	0.00	0.00	0.00	0.04	3.68	0.38
1/8/89 7:52	0.06	0.25	0.39	0.55	1.30	4.38	3.65	0.36
5/25/89 5:02	0.00	0.00	0.00	0.00	0.00	0.04	3.63	0.34
4/1/93 4:33	0.10	0.17	0.25	0.46	1.11	4.49	3.60	0.33
3/11/89 23:40	0.05	0.15	0.24	0.41	0.91	3.74	3.58	0.31
4/8/92 9:13	0.06	0.22	0.38	0.58	1.40	4.32	3.49	0.30

Sweet Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API > Annual Event — Boxed Events Indicate >= 1 Yr. Return: 5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)
11/5/88 13:10	0.22	0.61	0.95	1.19	3.10	4.06	6.31
11/2/88 4:30	0.14	0.41	0.81	0.96	1.68	6.71	5.48
4/26/90 19:44	0.08	0.27	0.48	0.92	2.40	5.41	5.43
11/9/88 7:12	0.18	0.44	0.50	0.70	1.38	4.04	5.26
1/10/95 13:45	0.14	0.26	0.38	0.61	1.11	9.87	5.21
1/7/90 10:38	0.09	0.30	0.34	0.59	1.24	2.92	4.73
4/28/90 3:15	0.01	0.02	0.03	0.05	0.11	0.16	4.72

Thompson Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API partial series — Boxed Events Indicate >= 1 Yr. Return: 5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	API Partial Series: Peak API (in.)	API Annual Return
11/27/88 4:48	0.19	0.44	0.74	1.36	2.76	5.44	7.73	8.06
11/21/88 0:14	0.19	0.31	0.53	0.85	1.81	13.34	7.59	3.10
11/5/88 13:55	0.50	0.83	1.03	1.27	2.46	4.36	6.78	1.92
11/25/88 12:14	0.15	0.23	0.28	0.45	0.68	1.17	6.61	1.39
4/26/90 18:16	0.11	0.30	0.56	1.07	2.74	6.04	6.18	1.09
1/7/90 10:47	0.11	0.26	0.51	0.72	1.41	4.19	5.90	0.90
11/14/88 20:24	0.28	0.62	0.92	1.23	1.96	7.29	5.57	0.76
11/9/88 5:45	0.32	0.62	0.83	1.06	1.49	4.10	5.42	0.66
11/29/88 3:07	0.00	0.00	0.00	0.00	0.00	0.04	5.31	0.58
11/2/88 4:33	0.45	0.79	0.99	1.26	1.75	6.91	5.29	0.52
4/28/90 4:22	0.01	0.02	0.03	0.06	0.11	0.17	5.27	0.47
1/9/90 15:54	0.06	0.21	0.30	0.55	1.07	1.98	5.20	0.43
1/5/90 16:26	0.10	0.20	0.33	0.57	1.52	5.20	5.17	0.40
11/11/88 19:40	0.41	0.74	1.06	1.28	1.79	2.63	5.02	0.37
1/7/89 20:25	0.11	0.29	0.53	0.94	2.32	6.38	4.85	0.34
2/15/92 23:12	0.10	0.19	0.31	0.57	1.23	7.97	4.81	0.32
2/7/90 13:34	0.15	0.27	0.54	0.96	1.78	6.96	4.73	0.30
12/4/91 10:23	0.19	0.33	0.54	0.62	1.23	5.34	4.51	0.29
11/11/88 3:36	0.00	0.00	0.00	0.00	0.00	0.04	4.42	0.27
1/11/91 9:43	0.11	0.24	0.43	0.76	1.30	2.96	4.37	0.26
11/7/88 17:16	0.15	0.27	0.44	0.67	0.83	0.95	4.36	0.24
1/12/91 21:22	0.11	0.28	0.42	0.60	1.17	3.35	4.28	0.23
11/18/88 3:36	0.00	0.00	0.00	0.00	0.00	0.04	4.18	0.22
4/28/90 22:38	0.00	0.00	0.00	0.00	0.00	0.04	4.15	0.21
1/15/91 9:05	0.00	0.00	0.00	0.00	0.00	0.04	3.93	0.20
11/23/90 20:06	0.10	0.26	0.40	0.73	1.83	3.77	3.89	0.20
1/11/90 5:22	0.01	0.01	0.02	0.03	0.02	0.09	3.88	0.19
11/13/88 6:43	0.02	0.06	0.01	0.09	0.11	0.17	3.86	0.18
11/8/88 11:16	0.06	0.14	0.23	0.30	0.47	0.65	3.86	0.18
4/8/92 12:47	0.11	0.21	0.40	0.64	1.64	4.38	3.83	0.17
2/20/92 18:57	0.11	0.18	0.20	0.26	0.51	0.60	3.79	0.16
3/3/91 1:34	0.05	0.16	0.30	0.48	0.85	3.40	3.72	0.16
3/11/89 23:38	0.11	0.19	0.30	0.38	0.93	4.57	3.60	0.15
4/1/93 7:55	0.06	0.14	0.27	0.50	1.12	4.27	3.47	0.15

Thompson Creek

Storm Start	Peak Precipitation Intensities Assoc. w/API > Annual Event — Boxed Events Indicate >= 1 Yr. Return: 5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)
11/27/88 4:48	0.19	0.44	0.74	1.36	2.76	5.44	7.73
11/21/88 0:14	0.19	0.31	0.53	0.85	1.81	13.34	7.59
11/5/88 13:55	0.50	0.83	1.03	1.27	2.46	4.36	6.78
11/25/88 12:14	0.15	0.23	0.28	0.45	0.68	1.17	6.61
4/26/90 18:16	0.11	0.30	0.56	1.07	2.74	6.04	6.18
1/7/90 10:47	0.11	0.26	0.51	0.72	1.41	4.19	5.90
11/14/88 20:24	0.28	0.62	0.92	1.23	1.96	7.29	5.57

Wassen Creek

Storm Start	5 Min. (in.)	30 Min. (in.)	1 Hr. (in.)	2 Hr. (in.)	6 Hr. (in.)	Storm Total (in.)	Peak API (in.)	API Annual Return
	Peak Precipitation Intensities Assoc. w/API partial series; Boxed Events Indicate >= 1 Yr. Return						API Partial Series	
11/21/88 1:35	0.13	0.37	0.51	0.72	1.58	8.55	6.04	11.24
11/14/88 20:14	0.11	0.28	0.47	0.87	1.74	6.47	5.34	4.32
11/10/88 6:09	0.13	0.42	0.82	0.99	1.45	1.70	5.25	2.68
1/12/95 4:33	0.10	0.17	0.29	0.51	1.30	7.48	4.99	1.94
11/27/88 7:21	0.10	0.31	0.55	0.90	1.85	3.09	4.97	1.52
11/24/88 22:37	0.09	0.20	0.29	0.36	0.79	2.26	4.95	1.25
11/9/88 2:38	0.07	0.26	0.41	0.61	1.45	2.26	4.69	1.06
11/7/88 20:01	0.10	0.25	0.31	0.42	0.74	1.62	4.46	0.92
11/11/88 22:20	0.12	0.22	0.36	0.68	1.11	1.73	4.40	0.81
11/18/88 3:30	0.00	0.00	0.00	0.00	0.00	0.04	4.32	0.73
11/11/88 5:45	0.00	0.00	0.00	0.00	0.00	0.04	4.31	0.66
1/7/89 10:37	0.05	0.20	0.37	0.71	1.80	6.07	4.20	0.60
2/7/90 15:11	0.05	0.18	0.31	0.53	1.43	4.22	4.01	0.56
1/8/95 14:38	0.10	0.21	0.29	0.63	1.67	3.70	3.93	0.52
12/9/93 6:14	0.14	0.29	0.46	0.67	1.38	4.02	3.78	0.48
1/5/90 17:31	0.05	0.23	0.42	0.69	1.38	4.90	3.77	0.45
11/2/88 4:53	0.22	0.39	0.47	0.64	1.21	4.65	3.65	0.42
11/29/88 1:47	0.00	0.00	0.00	0.00	0.00	0.04	3.64	0.40
1/10/95 1:26	0.02	0.07	0.10	0.17	0.09	0.24	3.61	0.38
2/9/90 6:51	0.02	0.07	0.12	0.20	0.46	0.73	3.55	0.36
4/26/90 17:41	0.05	0.23	0.44	0.78	1.84	3.39	3.47	0.34
1/8/90 11:49	0.02	0.08	0.13	0.17	0.31	0.37	3.39	0.32
3/3/91 1:24	0.07	0.27	0.41	0.75	1.07	3.15	3.29	0.31
11/13/88 7:26	0.04	0.10	0.16	0.18	0.26	0.32	3.28	0.30
1/10/95 18:43	0.06	0.13	0.16	0.31	0.53	1.50	3.21	0.29
2/10/90 3:11	0.00	0.00	0.00	0.00	0.00	0.04	3.05	0.27
4/8/92 9:05	0.06	0.17	0.34	0.47	1.04	3.89	3.05	0.26
1/17/95 6:28	0.02	0.07	0.10	0.16	0.35	0.57	3.03	0.25
11/19/88 4:40	0.14	0.25	0.26	0.27	0.44	0.97	2.99	0.25
1/3/93 9:07	0.06	0.17	0.29	0.63	1.34	2.72	2.98	0.24
10/24/91 23:00	0.15	0.38	0.56	0.65	1.18	2.78	2.98	0.23
1/30/95 16:33	0.05	0.19	0.38	0.66	1.00	2.96	2.96	0.22
1/18/95 5:16	0.06	0.20	0.25	0.39	0.54	0.77	2.88	0.22
4/28/90 8:05	0.01	0.02	0.04	0.07	0.03	0.12	2.88	0.21
5/22/89 14:35	0.07	0.27	0.51	0.89	1.41	4.39	2.83	0.20
1/9/90 16:46	0.02	0.07	0.12	0.22	0.49	0.98	2.83	0.20
3/4/91 22:27	0.00	0.00	0.00	0.00	0.00	0.04	2.82	0.19
5/27/89 16:56	0.09	0.29	0.32	0.38	0.63	0.76	2.78	0.19
10/30/92 22:04	0.14	0.25	0.34	0.39	0.73	2.93	2.72	0.18
12/5/91 13:10	0.10	0.22	0.32	0.46	0.90	3.16	2.71	0.18
1/19/93 5:31	0.06	0.13	0.25	0.55	1.14	2.84	2.65	0.17
11/14/88 4:18	0.00	0.00	0.00	0.00	0.00	0.04	2.63	0.17
11/20/88 12:12	0.00	0.00	0.00	0.00	0.00	0.04	2.63	0.16
3/11/89 23:55	0.06	0.17	0.25	0.31	0.71	3.77	2.55	0.16
11/26/90 5:47	0.07	0.10	0.15	0.28	0.68	1.74	2.52	0.16
12/5/93 22:19	0.14	0.25	0.38	0.51	0.77	2.84	2.51	0.15
11/29/93 18:57	0.10	0.21	0.38	0.59	1.38	2.19	2.51	0.15
2/3/90 12:25	0.02	0.07	0.10	0.16	0.11	0.24	2.50	0.15
2/4/91 7:17	0.10	0.16	0.27	0.42	0.79	1.87	2.49	0.14
12/5/90 9:58	0.03	0.12	0.19	0.31	0.81	2.52	2.48	0.14
11/20/92 19:12	0.02	0.09	0.17	0.30	0.79	2.89	2.48	0.14
4/28/90 21:30	0.01	0.04	0.02	0.01	0.00	0.08	2.48	0.14
5/26/89 18:41	0.04	0.16	0.27	0.42	0.85	1.34	2.47	0.13

3/5/91 8:47	0.01	0.02	0.04	0.02	0.01	0.08	2.46	0.13
1/11/91 9:48	0.05	0.22	0.38	0.49	0.70	2.10	2.46	0.13
3/8/95 5:30	0.05	0.18	0.30	0.59	1.04	2.67	2.44	0.13
2/16/95 21:42	0.03	0.15	0.27	0.39	0.97	2.07	2.40	0.12
1/28/90 6:43	0.04	0.07	0.14	0.25	0.63	4.83	2.39	0.12
4/1/93 7:12	0.06	0.13	0.24	0.42	1.02	3.82	2.37	0.12
11/19/90 13:24	0.07	0.16	0.30	0.45	0.93	2.31	2.37	0.12
12/6/90 23:22	0.05	0.10	0.14	0.16	0.24	0.41	2.35	0.12
4/11/92 2:33	0.04	0.10	0.13	0.17	0.37	0.65	2.34	0.11
3/6/91 0:38	0.03	0.14	0.24	0.31	0.50	0.73	2.33	0.11
3/14/95 0:37	0.09	0.18	0.27	0.55	0.74	0.81	2.31	0.11
10/26/91 23:19	0.02	0.05	0.07	0.07	0.15	0.20	2.30	0.11
3/24/89 13:36	0.05	0.17	0.24	0.37	0.83	2.19	2.30	0.11
12/20/88 4:14	0.04	0.13	0.23	0.35	0.48	4.06	2.29	0.11
1/20/93 17:31	0.01	0.05	0.07	0.13	0.33	1.38	2.29	0.10
3/16/89 19:47	0.06	0.18	0.28	0.39	0.88	1.54	2.27	0.10
3/9/95 23:06	0.00	0.00	0.00	0.00	0.00	0.04	2.26	0.10
1/14/91 23:06	0.05	0.13	0.26	0.38	0.66	0.77	2.25	0.10
12/7/91 14:45	0.00	0.00	0.00	0.00	0.00	0.04	2.23	0.10
3/21/95 8:01	0.04	0.17	0.29	0.37	0.57	0.61	2.23	0.10
1/5/93 10:33	0.01	0.03	0.06	0.09	0.06	0.16	2.20	0.10
2/22/94 1:40	0.02	0.09	0.13	0.21	0.41	2.15	2.18	0.09

Wassen Creek

	Peak Precipitation Intensities Assoc. w/API > Annual Event						
		Boxed Events Indicate >= 1 Yr. Return				Storm	Peak
Storm Start	**5 Min. (in.)**	**30 Min. (in.)**	**1 Hr. (in.)**	**2 Hr. (in.)**	**6 Hr. (in.)**	**Total (in.)**	**API (in.)**
11/21/88 1:35	0.13	0.37	0.51	0.72	1.58	8.55	6.04
11/14/88 20:14	0.11	0.28	0.47	0.87	1.74	6.47	5.34
11/10/88 6:09	0.13	0.42	0.82	0.99	1.45	1.70	5.25
1/12/95 4:33	0.10	0.17	0.29	0.51	1.30	7.48	4.99
11/27/88 7:21	0.10	0.31	0.55	0.90	1.85	3.09	4.97
11/24/88 22:37	0.09	0.20	0.29	0.36	0.79	2.26	4.95
11/9/88 2:38	0.07	0.26	0.41	0.61	1.45	2.26	4.69

APPENDIX C

PRECIP Q-BASIC CODE

The following is the Q basic code for Precip.

```
                    "********************"
                     "***   PRECIP   ***"
                    "********************"
                      " By Chris Surfleet"

    A program to automate the isolation of storm and peak precipitation"
                intensities from data collected from the"
                  Department of Forest Engineering"
                          raingage network"

INPUT "Press <return> to continue"; ans$
CLS

'This section inputs the file and counts the number of time records and opens 2
'output files

INPUT "Enter the precipitation file name"; file1$
PRINT
INPUT "Enter output file name for storm data"; file2$
PRINT
PRINT "Enter output file name for corrected precipitation data"
INPUT " (you must type something here, you can erase these files later)"; file3$
PRINT
DIM x#(1500), y#(1500), yy#(1500), w#(6000), z#(6000), storm(1000)
DIM intensity#(200), peak#(200)
DIM hrs#(4), inrate#(4), Length#(4), total#(200)

OPEN file1$ FOR INPUT AS #1
OPEN file2$ FOR OUTPUT AS #2
OPEN file3$ FOR OUTPUT AS #4
n = 0
WHILE NOT EOF(1)
     n = n + 1
     INPUT #1, x#(n), y#(n)
WEND
CLS

'This section asks user for the program variables

PRINT
PRINT "What is the Precipitation amount per time period"
INPUT "  (enter either 0.04 or 0.01)"; ppt
```

```
PRINT
PRINT "What is the time period that defines storm separation"
INPUT "  (enter in hours, e.g. for 2 days enter 48)"; sp#
sep# = sp# / 24
PRINT
PRINT "You may now enter four peak intensity time periods to be calculated"
PRINT
INPUT "What is the first intensity time rate"; hrs#(1)
inrate#(1) = hrs#(1) / 24
INPUT "What is the second intensity time rate"; hrs#(2)
inrate#(2) = hrs#(2) / 24
INPUT "What is the third intensity time rate"; hrs#(3)
inrate#(3) = hrs#(3) / 24
INPUT "What is the fourth intensity time rate"; hrs#(4)
inrate#(4) = hrs#(4) / 24
CLS

'This section asks the user if calibration data is available
'and adjusts the data according to calibration parameters.

PRINT "Is there calibration information?"
DO
INPUT "(enter Y or N)"; ans$
  IF (ans$ <> "y") AND (ans$ <> "n") THEN
      BEEP
      PRINT
      PRINT "You must enter a Y or N"
      PRINT "Please try again...."
  ELSE
      IF (ans$ = "y") THEN GOTO az
      IF (ans$ = "n") THEN
        FOR p = 1 TO n
         yy#(p) = y#(p)
         WRITE #4, x#(p), yy#(p)
        NEXT p
        GOTO ab
        END IF
        END IF
LOOP UNTIL ((ans$ = "y") OR (ans$ = "n"))
CLS
PRINT
az: PRINT "Enter the calibration factor after the calibration rates below"
PRINT "(enter as a correction factor, e.g. enter 1.1 to correct for a 10% undercatch):"
PRINT
```

```
INPUT "0.25 in/hr"; cal1#
INPUT "0.5 in/hr"; cal2#
INPUT "0.75 in/hr"; cal3#
INPUT "1.0 in/hr"; cal4#
INPUT "2.0 in/hr"; cal5#
PRINT
f# = 0
rate1# = .37
rate2# = .63
rate3# = .88
rate4# = 1.5

FOR p = 1 TO n
  dn# = (ABS(x#(p) - x#(p + 1))) * 24
  IF dn# = 0 THEN
   dn# = 1
  ELSE
  END IF
  f# = (ppt / dn#)
     IF x#(p + 1) = 0 THEN
          yy#(p) = 1 * y#(p)
     ELSEIF f# <= rate1# THEN
          yy#(p) = cal1# * y#(p)
     ELSEIF ((f# > rate1#) AND (f# <= rate2#)) THEN
          yy#(p) = cal2# * y#(p)
     ELSEIF ((f# > rate2#) AND (f# <= rate3#)) THEN
          yy#(p) = cal3# * y#(p)
     ELSEIF ((f# > rate3#) AND (f# <= rate4#)) THEN
          yy#(p) = cal4# * y#(p)
     ELSEIF f# > rate4# THEN
          yy#(p) = cal5# * y#(p)
     END IF
  WRITE #4, x#(p), yy#(p)
NEXT p

'This section isolates, counts and prints beginning time of each storm occurance,
'storm total ppt, and total storm duration

ab:
v# = 0
k = 0
WRITE #2, "Storm data"
WRITE #2, "Storm #", "Start time", "PPT Amt. (in)", "Length (hrs)"
```

```
FOR i = 1 TO n
      IF (ABS(x#(i) - x#(i + 1))) <= sep# THEN
           storm(k) = storm(k) + 1
           total# = (yy#(i) + v#)
      ELSE
           k = k + 1
           total# = (yy#(i) + v#)
            IF k = 1 THEN
             Length# = (ABS(x#(i)) - (x#(1))) * 24
             WRITE #2, k, x#(1), total#, Length#
             start# = (x#(i + 1))
            ELSE
             Length# = (ABS((x#(i)) - (start#))) * 24
             WRITE #2, k, start#, total#, Length#
             start# = x#(i + 1)
            END IF
           v# = 0
           total# = 0
      END IF
         v# = total#
NEXT i
CLS

'converts data files with .01" ppt. per time record from x#, yy# to
'w#, z# format

g = 1
IF (ppt = .01) THEN
  FOR r = 1 TO n
      w#(g) = x#(r)
      z#(g) = yy#(r)
      g = g + 1
  NEXT r
  GOTO ad
ELSE GOTO ac
END IF

'calculates exactly 1/4, 1/2, and 3/4
'of each time record and the next time record in order
'then counts each new variable in the list as w#
'also separates each ppt. amt. into 1/4 increments which are called z#
'this program is only used for ppt. amts. of 0.04 inch per time record

ac: g = 1
FOR l = 1 TO n
```

```
  w#(g) = x#(l)
  z#(g) = (ABS(yy#(l)) * (1 / 4))
  g = g + 1
 IF x#(l + 1) > 0 THEN
  first# = ((ABS((x#(l)) - (x#(l + 1)))) * (1 / 4)) + (x#(l))
  second# = ((ABS((x#(l)) - (x#(l + 1)))) * (1 / 2)) + (x#(l))
  third# = ((ABS((x#(l)) - (x#(l + 1)))) * (3 / 4)) + (x#(l))
  firsty# = (ABS(yy#(l)) * (1 / 4))
  secondy# = (ABS(yy#(l)) * (1 / 4))
  thirdy# = (ABS(yy#(l)) * (1 / 4))
  xx#(1) = first#
  xx#(2) = second#
  xx#(3) = third#
  yyy#(1) = firsty#
  yyy#(2) = secondy#
  yyy#(3) = thirdy#
    FOR j = 1 TO 3
     w#(g) = xx#(j)
     z#(g) = yyy#(j)
     g = g + 1
    NEXT j
 ELSE
 END IF
NEXT l

ad:
CLS
FOR sz = 1 TO 4
WRITE #2, "Storm#", "Peak", hrs#(sz), "Hr. Intensity"

k = 0
counter = 1
counter2 = 0
counter3 = 0

FOR u = 1 TO n
      IF ((ABS(x#(u) - x#(u + 1))) <= sep#) THEN
         storm(k) = storm(k) + 1
      ELSE
        k = k + 1
          IF x#(u) = startw# THEN
          GOTO azy
          ELSE
          END IF
        q = u + ((u - 1) * 3)
```

```
         s = counter
         FOR ch = s TO q
            startw# = w#(ch)
            FOR f = ch TO q
                  a# = (ABS((startw#) - w#(f)))
                        IF a# = 0 THEN
                          sum# = 0
                          GOTO zxz
                        ELSE
                        END IF
                  sum# = (z#(f) + i#)
                  i# = sum#
                  counter3 = counter3 + 1
                   IF a# = inrate#(sz) THEN
                     counter2 = counter2 + 1
                     intensity# = sum#
                     sum# = 0
                     i# = 0
                     GOTO zxxz
                   ELSE
                   END IF
                   IF a# > inrate#(sz) THEN
                      dnm# = (w#(f) - w#(f - 1))
                      aa# = (ABS(inrate#(sz) - dnm#))
                         IF dnm# = 0 THEN
                           dnm# = 1
                         ELSE
                         END IF
                       ab# = aa# / dnm#
                       ac# = ab# * (ABS(z#(f) - z#(f - 1)))
                            counter2 = counter2 + 1
                       intensity# = ac# + sum#
                       sum# = 0
                       i# = 0
                   ELSE
                   END IF
zxxz:           IF (intensity# > peak#) THEN
                 peak# = intensity#
               ELSE
               END IF
                  dnm# = 0
                  intensity# = 0
zxz:            NEXT f
                  IF (counter3 > 2) AND (peak# = 0) THEN
                     ba# = a# / inrate#(sz)
```

```
                intensity# = ba# * sum#
              ELSE
              END IF

          IF (intensity# > peak#) THEN
            peak# = intensity#
            ELSE
            END IF
                counter = counter + 1
                sum# = 0
                i# = 0
                intensity# = 0
    NEXT ch
azy:          WRITE #2, k, peak#
           counter = counter + 3
           sum# = 0
           i# = 0
           counter2 = 0
           peak# = 0
           counter3 = 0
           intensity# = 0
      END IF
NEXT u
NEXT sz
CLOSE #1
END
```

APPENDIX D

API Q-BASIC CODE

The following code is for the Qbasic program API. Previously calibrated precipitation data must be used, this program does not adjust for rain gauge calibration.

```
'This section inputs the file and counts the number of time records and opens 1
'output file
INPUT "Enter the API file name"; file1$
PRINT
INPUT "Enter output file name for API data"; file2$
PRINT


DIM file1$(1), file2$(1)

OPEN file1$ FOR INPUT AS #1
OPEN file2$ FOR OUTPUT AS #2

n = 0
WHILE NOT EOF(1)
      n = n + 1
      INPUT #1, x#(n), y#(n)
WEND
CLS
CLS
DIM x#(1500), y#(1500), z#(1500), k(1500)
DIM start#(100), Length#(100), total#(100), api#(200), storm(200)
CLS
PRINT
sep# = .25

OPEN file1$ FOR INPUT AS #1
OPEN file2$ FOR OUTPUT AS #2
n = 0
WHILE NOT EOF(1)
      n = n + 1
      INPUT #1, x#(n), y#(n), z#(n)
WEND

'isolates, counts and prints beginning time of each storm occurance,
'storm total ppt, total storm duration and Peak API per storm.
api# = 0
k = 0
WRITE #2, "API Storm Data"
WRITE #2, "Storm #", "Start time", "Length (hrs)", "Total PPT (in)", "Peak API"
```

```
FOR i = 1 TO n
      IF (ABS(x#(i) - x#(i + 1))) <= sep# THEN
        storm(k) = storm(k) + 1
        total# = (y#(i) + v#)
          IF z#(i) > api# THEN
            api# = z#(i)
          ELSE
          END IF

      ELSE
          k = k + 1
          total# = (y#(i) + v#)

          IF z#(i) > api# THEN
            api# = z#(i)
          ELSE
          END IF

            IF k = 1 THEN
              Length# = (ABS(x#(i)) - (x#(1))) * 24
              WRITE #2, k, x#(1), Length#, total#, api#
              start# = (x#(i + 1))
            ELSE
              Length# = (ABS((x#(i)) - (start#))) * 24
              WRITE #2, k, start#, Length#, total#, api#
              start# = x#(i + 1)
            END IF
            v# = 0
            total# = 0
            api# = 0
      END IF
       v# = total#
NEXT i
CLS
CLOSE
NEXT xt
CLOSE
END
```