

WATER LOSS FROM FOREST AND RANGE LANDS IN CALIFORNIA*

by

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Only a minor portion of the precipitation on a watershed leaves the watershed as streamflow. The annual water loss (difference between precipitation and streamflow) is usually equal to evapotranspiration from the watershed. The reasons for any difference between annual water loss and annual evapotranspiration are storage within the watershed, lack of coincidence between topographic hydrologic drainage divides, or underground outflow.

Watershed experiments have shown that there is a significant difference between the annual evapotranspiration rates of shrubs and trees and those of herbs (Hibbert, 1971; Lewis, 1968; Rowe and Reimann, 1961; Young and Blaney, 1942). Thus the composition of watershed cover should be an important determinant of annual water loss. Such composition is the result of a dynamic process in which forest and shrub lands are converted to herbaceous cover by fire, disease, range improvement, logging, etc., and grass lands (herbaceous cover) are diminished by brush invasion and reforestation. Therefore, the annual precipitation-streamflow relationship can be expected to vary widely with changes in cover composition. The literature also indicates that the physical characteristics of watersheds may affect the precipitation-streamflow relationship (Anderson, 1975; Chang and Boyer, 1977; Jackson, 1967; Julian et al., 1967).

The validity and reliability of predictors of annual water loss must be known to determine the extent to which the results of watershed experiments may be transferred to other areas, to calibrate watershed models, and to estimate the yield of proposed water salvage or reservoir projects in watersheds with little or no streamflow records. Accordingly, a study comparing annual water loss to watershed characteristics was undertaken. It was found that:

- Precipitation explains most of the variation in water loss ($r^2 = 0.76$);
- The precipitation-water loss relationships between Northern and Southern California do not differ discernibly;

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- Precipitation-loss data are skewed towards maximum loss, which is the expected result of the fire exclusion management practiced since the early 1900s;
- Distance from the coast, orientation, latitude, ultrabasic rock, and ratio of mean annual maximum daily precipitation to mean annual precipitation each make a slight (third decimal place) improvement in the coefficient of determination (r^2) over that of precipitation;
- Slope and elevation do not appear to affect water loss; and
- The effect of watershed cover could not be determined from U.S. Forest Service CALVEG map data.

The Study

Annual water loss, annual precipitation, ratio of mean annual maximum daily precipitation to mean annual precipitation, latitude and longitude of the center of the watershed, distance from coast, area of ultrabasic rock, area of herbaceous cover, barren area, orientation, slope, and elevation were determined for 68 watersheds located in California. These watersheds are distributed throughout the shrub- and tree-covered areas of the study area, with a maximum density of one watershed per 30 minutes of latitude and longitude. Watershed locations are shown on Figure 1 and presented with other characteristics in Table 1, at the end of this paper.

Watershed Selection

The watersheds were selected with preference for (1) lack of impairments, (2) quality of record, (3) length of record, and (4) small size. Each watershed is located substantially in the 30-minute quadrangle represented. Watersheds were excluded for which the hydrologic analysis showed a greater-than-normal water loss in dry periods or which exhibited a lack of response of water loss to additional precipitation. The former, with dry-year loss greater than normal, indicates that the isohyetal precipitation is low, or the streamflow is high, with respect to true values. Most of such excluded watersheds were in the North Coast, South Feather-North Yuba rivers, and Big Sur-Arroyo Grande areas. The other test, failure of loss to respond to additional precipitation, indicates the opposite. The test was made by plotting the difference between dry-year and normal-year loss ($L_n - L_d$) against the difference in precipitation ($P_n - P_d$). Watersheds with values of ($L_n - L_d$) of less than $0.26(P_n - P_d) - 0.5$ were eliminated. No geographical clusters of such watersheds were noted.

Data

The data shown in Table 1 are described and analyzed in this section. Latitude and longitude of each watershed were determined at the center, which was located as described under the topic "slope".

Water loss and precipitation were determined for two periods:

- A short (two to seven years) period of below-normal precipitation and stable rainfall-runoff relationship; and
- The entire period of streamflow record ending in September 1980, except for isolated periods of one or two years.

Stability of the rainfall-runoff relationship (P/Q) was determined by double mass plotting of normalized precipitation and streamflow. Periods of approximately constant slope were assumed to have undisturbed watershed cover and to be unaffected by fluctuation of underground storage.

Precipitation (P). The mean annual depth of precipitation in inches on the watershed was estimated for the same study periods as for streamflow. The method used was to determine (1) the mean annual precipitation (MAP) for the watershed from the Rantz (1969) isohyetal map, (2) the ratio of the MAP for the study period recorded by a local climatological station to the MAP for a period of concurrent record with a regional long-record climatological station, and (3) the ratio of the MAP recorded by the regional climatological station for the period of concurrent record with the local station to the MAP for the period of the Rantz map, and then (4) to multiply the three elements together, the watershed MAP times the two ratios.

Streamflow (Q). The mean annual depth of runoff for dry periods and period of record were determined by dividing the mean annual volume of streamflow by the watershed area to secure the same linear units as for precipitation. The annual streamflow data are taken from the U.S. Geological Survey's annual series, "Water Resources Data for California". The recorded flows for several streams with minor impairments were corrected for such impairments.

Water Loss (L). The difference between mean annual precipitation and streamflow ($P - Q$) was determined in inches for the two periods for each watershed.

Precipitation Ratio (R_p). The ratio of mean annual maximum 24-hour precipitation to mean annual precipitation is a measure of the duration and intensity of precipitation. It varies from a value of 0.07 in northwestern California to 0.40 in southeastern California. Values for each watershed were determined from Plate 4 of Calif. Dept. of Water Resources Bulletin 195 (1976) and converted to percent for analysis.

Orientation (A_z). The orientation of each watershed in degrees with respect to north was determined in a downstream direction, as that of a line bisecting the watershed and passing through the gaging station. The least angle from north, either east or west, was measured, providing a potential range of values of 0° to 180° .

Distance from Coast (D_c). The shortest distance from the center of the watershed to the shore of the Pacific Ocean was measured in miles on 1:250,000 or 1:1,000,000 scale maps.

Elevation (E). The average elevation in feet of each watershed was determined as the average of the gaging station, the three ridgetop points used to compute slope, and the center of the watershed.

Slope (S). The average slope in percent of the path of water flow was determined for five points, of which three points are on the watershed divide, one at the center of the watershed, and one at the gage. The first point is the intersection of the bifurcation line used to determine aspect with the ridgetop. The other two ridgetop points were determined by quadrisection, i.e., bisection of the two halves of the watershed with lines normal to the

line used to determine aspect. The center was determined by bisecting the center line between the two quadrisection lines. From these four points, the horizontal distance a drop of water would travel to reach the gaging station was determined on 1:250,000 scale maps. The vertical distances traveled were determined as the difference in elevation between the gaging station and each of the four points. Slope, in percent, was computed for each of the four points and averaged with zero slope at the gage.

Ultrabasic Rock Type (Ub). The area of ultrabasic rocks in percent of watershed area was determined from the California Division of Mines and Geology's 1:250,000 scale map "Geologic Map of California".

Barren (B). The percent of watershed area that is barren of vegetation was determined from U.S. Forest Service CALVEG, First Approximation, 1:250,000 maps.

Herbaceous Cover (Hb). The percent of watershed area covered by herbs in 1976 was determined from U.S. Forest Service CALVEG, First Approximation, 1:250,000 maps.

Results

The data presented in Table 1 were analyzed by 2 and 3 variable linear multiple regression. Of the independent variables tested, only precipitation was significant in explaining variation in loss. The coefficient of determination (r^2) was slightly improved by consideration of orientation, distance from coast, precipitation ratio, latitude, and ultrabasic rock type, in addition to precipitation. The other variables tested did not appear to affect the precipitation-water loss relationship, which is shown in Figures 2 and 3.

<u>Variables</u>	<u>r^2 for Period of Record</u>
Precipitation only	
Straight line	0.7575
Power curve	0.7555
Precipitation and Orientation	0.7577
Precipitation and Distance from Coast	0.7581
Precipitation and Precipitation Ratio	0.7592
Precipitation and Latitude	0.7630
Precipitation and Ultrabasic Rock	0.7657

The statewide equations for precipitation only, maximum loss, normal loss, grassland loss, and Grunsky's Rule (Meyer, 1915) are shown below.

<u>Subject</u>	<u>Equation</u>
Maximum loss	$L_{max} = (182P - P^2 - 25) \div 172$
Normal loss (period of record)	$L_n = 2.32P^{0.66}$
Grassland loss	$L_g = 0.362P + 8.35$
Grunsky's Rule, P = 0 to 50 inches	$L = P - 0.01P^2$

The maximum loss equation is a parabola that is tangent to the line $L = P$ at $P = 5$ inches, the curve $L = 2.34P^{0.714}$, and the line $L = 48$ inches at $P = 91$ inches. The equation $L = 2.34P^{0.714}$ is the curve of best fit ($r^2 = 0.91$) for the 22 watersheds from both the dry and normal period data sets with highest loss relative to precipitation, and a loss greater than 12 inches. A normal maximum, as represented by this curve, was selected because the reliability of the data (or noise) does not warrant use of a true envelope curve. The limit of $L = 48$ inches was selected because it is the lowest round number that exceeds all values of L found in the final data set and among disqualified watersheds.

Normal loss is represented by a power curve, despite the higher r^2 of the straight line, because it fits the high values of L better and because it does not cause L to exceed 48 inches within the normal range of precipitation in California, i.e., less than 98 inches.

The grassland loss equation was derived from data from watershed experiments in Arizona and California (Burgy and Papazafiriou, 1970; Hibbert, 1971; Lewis, 1968; Rowe and Reimann, 1961; Young and Blaney, 1942). The data and curve are shown in Figure 4. The difference between this curve and the maximum loss curve is the amount of water that could be salvaged by conversion of watershed cover from shrubs and trees to herbs.

Grunsky's Rule is significant because it is probably based on pre-fire exclusion data.

The double mass curves used to check stability of the precipitation-streamflow relationship show a slope-bench-slope characteristic that diminishes as precipitation increases, until it requires an event similar to 1977 to produce a bench in the curve for some North Coast streams. This is illustrated in Figure 5.

Discussion

In theory, transpiration should be affected by water availability, energy, and soil fertility. The classification of the independent variables examined with respect to these three factors is shown in the following tabulation.

<u>Water</u>	<u>Energy</u>	<u>Soil Fertility</u>
Precipitation	Orientation	Slope*
Precipitation, Ratio	Distance from Coast	Ultrabasic Rock
Distance from Coast	Elevation*	
Slope*	Latitude	

*No effect on precipitation-loss relationship found.

Figures 2 and 3, which show the precipitation-loss relationship, illustrate a system in which all or nearly all precipitation is lost up to the level of the grassland loss curve at about $P = 14$ inches or $L = 13$ inches; thereafter there is a plume of data points, most of which are above the grassland loss line. The few outliers below the line are high Sierra watersheds with substantial barren areas. Most of the data points are near the maximum loss curve.

The skew of the data toward the maximum is due to selection of forest and range watersheds, with large areas of high water-using (with respect to herbs) shrubs and trees. However, the skew is probably amplified by fire exclusion, which has been practiced since the late 1800s (Parsons, 1977). If Grunsky's Rule is taken to represent the pre-fire exclusion precipitation-streamflow relationship, the difference between the loss derived from the rule and normal loss from this study would be the increase in loss due to fire exclusion. For the 68 watersheds, the average increase in loss is 14 to 17 percent of the average streamflow, as shown in the following tabulation.

<u>Item</u>	<u>Annual Quantities in Inches</u>	
	<u>Dry Periods</u>	<u>Period of Record</u>
Precipitation	21.97	34.71
Loss: Normal	17.83	24.11
Grunsky's Rule	17.14	22.66
Difference, Normal - Grunsky	0.69	1.45
Streamflow	4.14	10.60

The regression equation that includes latitude indicates that loss with respect to precipitation declines as latitudes become higher. This is similar to the decline in solar radiation from south to north. The extraterrestrial radiation at latitude 42 is 90 percent of that at latitude 33 (Calif. Dept. of Water Resources, 1978). For comparison, the water loss for the average precipitation of the normal data set (34.71 inches) at latitude 42 is 87 percent of that at latitude 33. Thus, energy availability appears to explain this phenomenon.

The regression equations that include distance from coast and precipitation ratio show relationships that are contrary to theory. Coastal watersheds should have less loss for a given amount of precipitation than does an inland watershed because fog would reduce energy and supply some of the water for evapotranspiration. Yet, the equation shows a decrease in loss with respect to precipitation as the distance from the coast increases. A high precipitation ratio means fewer days of precipitation and less infiltration than with low values of the ratio. Thus there should be less loss with respect to precipitation with high values of precipitation ratio. Yet the regression equation shows increasing loss as the ratio increases. This is further evidence of the lack of significance of these variables.

Soils derived from serpentinite have notoriously poor fertility. Accordingly, the percent of watershed underlain by ultrabasic rocks appears to have a minor effect on water loss.

The percent of watershed area that was barren or with herbaceous cover according to U.S. Forest Service CALVEG maps, did not explain variation in the precipitation-loss relationship, as it should have. This, and the significance of ultrabasic rock, indicates the need to develop cover data from a source with greater discrimination.

The slope-bench-slope characteristic of the precipitation-streamflow double mass curves for arid and semiarid watersheds indicates an inability of the watershed vegetation to fully respond to greater-than-normal precipitation. This suggests that (1) density of shrub and tree cover is limited by the water available during dry periods, and (2) most of the response comes from herbaceous cover.

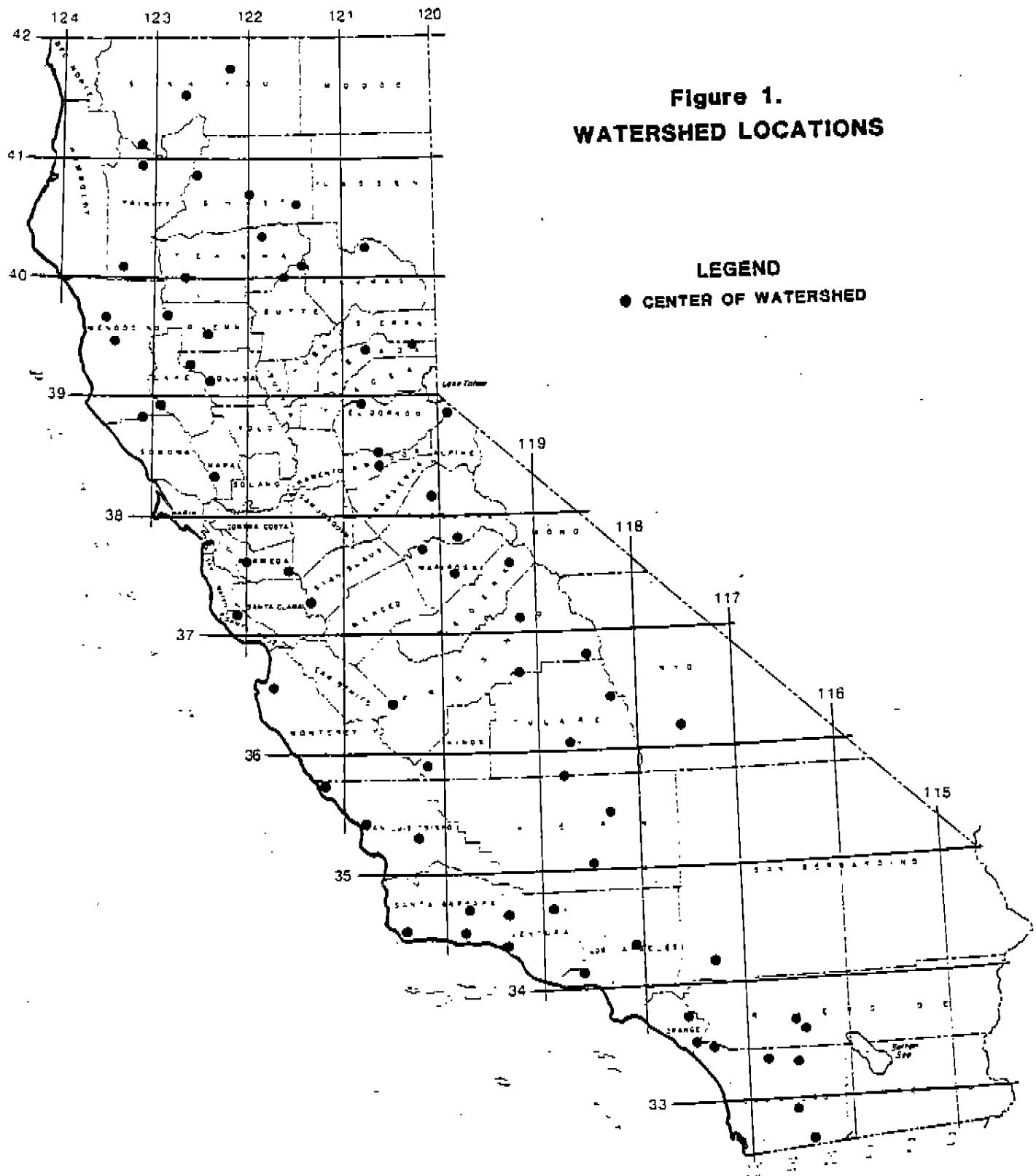
References

- Anderson, H.W. "The Hydrologic Potential of Unit Areas: A Basis for Managing Water Resources", Proceedings 2nd World Congress of Water Resources, International Water Resources Assoc., New Delhi, India, December 12-17, 1975, Vol. 4, pp. 61-69, 1975.
- Burgy, R.H., and Z.G. Papazafiriou. Hydrologic Studies and Watershed Management on Brushlands, Progress Report No. 9, Dept. of Water Science and Engineering, Univ. of Calif., Davis. 31 p., 1970.
- California Department of Water Resources. California Sunshine - Solar Radiation Data. Bulletin 187, 110 p. 1978.
- California Department of Water Resources. Rainfall Analysis for Drainage Design, Vol. 2, Long-Duration Precipitation Frequency Data. Bulletin 195, 382 p., 1976.
- Chang, M., and D.G. Boyer. "Estimates of Low Flows Using Watershed and Climatic Parameters", Water Resources Research, 13/6:997-1001, 1977.
- Hibbert, A.R. "Increases in Streamflow After Converting Chaparral to Grass", Water Resources Research, 7/1:71-80, 1971.
- Jackson, R.J. "The Effect of Slope, Aspect and Albedo on Potential Evapotranspiration from Hillslopes and Catchments", Journal of Hydrology (New Zealand), 6/2 p. 60, 1967.
- Julian, R.W., V. Yevjevich and H.J. Morel-Seytoud. "Prediction of Water Yield in High Mountain Watersheds Based on Physiography", Hydrology Paper No. 22, Colorado State Univ.. 1967.
- Lewis, D.C. "Annual Hydrologic Response to Watershed Conversion from Oak Woodland to Annual Grassland", Water Resources Research, 4(1):59-72, 1968.
- Meyer, A.F. "Computing Run-off From Rainfall and Other Physical Data", with discussions by J.D. Justin, A.M. Strong, E.F. Chandler, C.E. Grunsky, R.E. Hortin, W.G. Hoyt, and A.F. Meyer, Trans. ASCE, 79:1056-1224, 1915.
- Parsons, D.J. "Preservation in Fire-type Ecosystems", Proc. Symp. on the Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems, USDA Forest Service Gen. Tech. Report WO-3; pp. 172-182, 1977.
- Rantz, S.E. "Mean Annual Precipitation in the California Region", Basic Data Compilation M-1969, U.S. Geological Survey, Menlo Park, CA., 5 p., maps, 1969.

Rowe, P.B. Influence of Woodland Chaparral on Water and Soil in Central California, Calif. Dept. of Natural Resources, Div. of Forestry, 70 p., 1948.

Rowe, P.B., and L.F. Reimann. "Water Use by Brush, Grass and Grass-Forb Vegetation", Journal of Forestry, 50(3):175-181, 1961.

Young, A.A. and H.F. Blaney. Use of Water by Native Vegetation, Bulletin No. 50, Div. of Water Resources, Calif. Dept. of Public Works, 154 p., 1942.



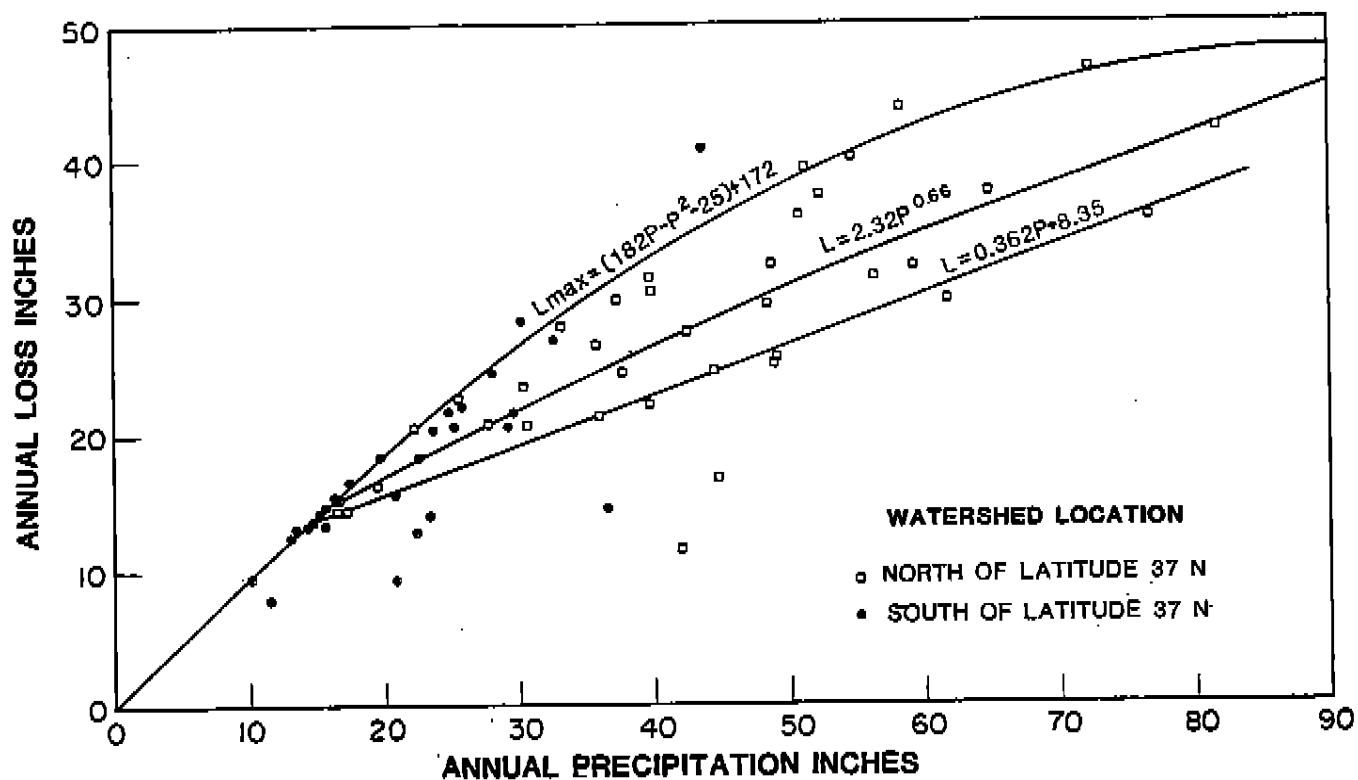


Figure 2. PRECIPITATION - WATER LOSS RELATIONSHIP FOR PERIOD OF RECORD

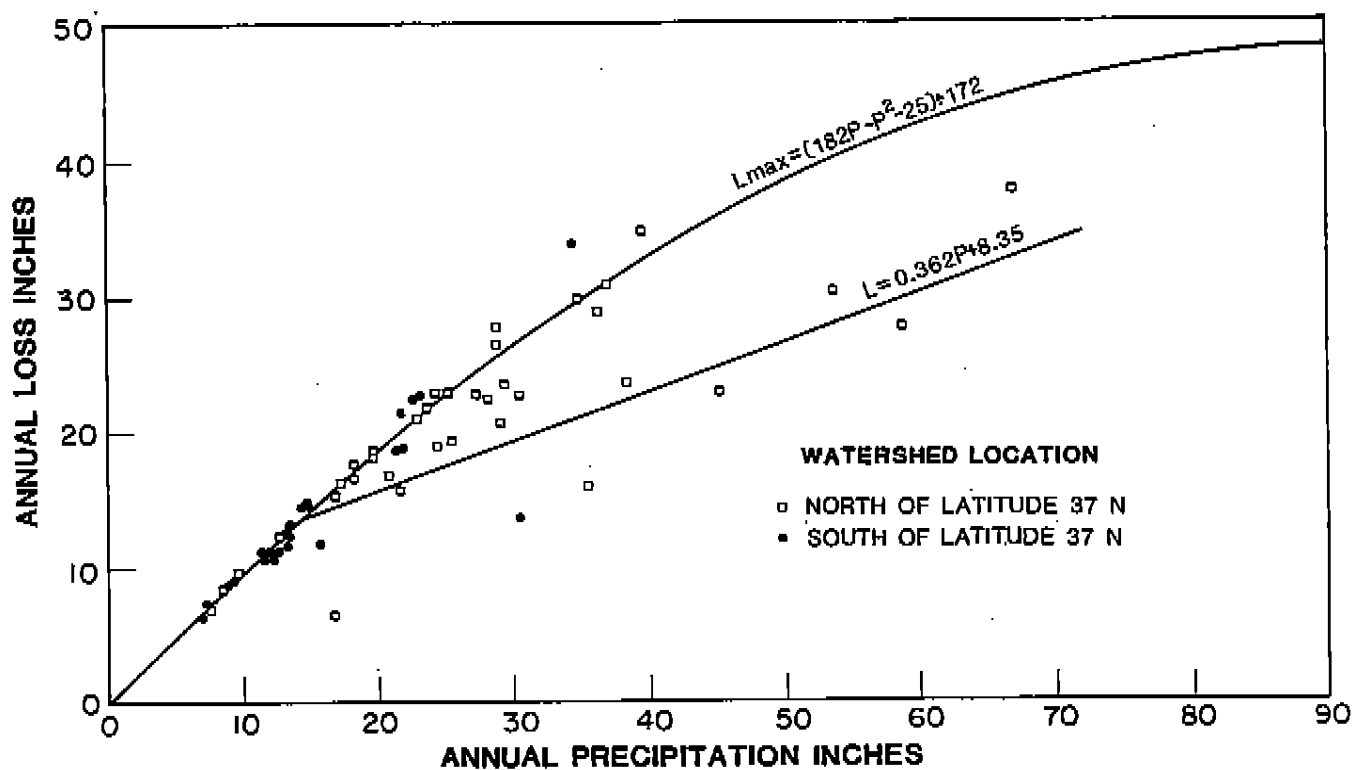


Figure 3. PRECIPITATION - WATER LOSS RELATIONSHIP FOR DRY PERIODS

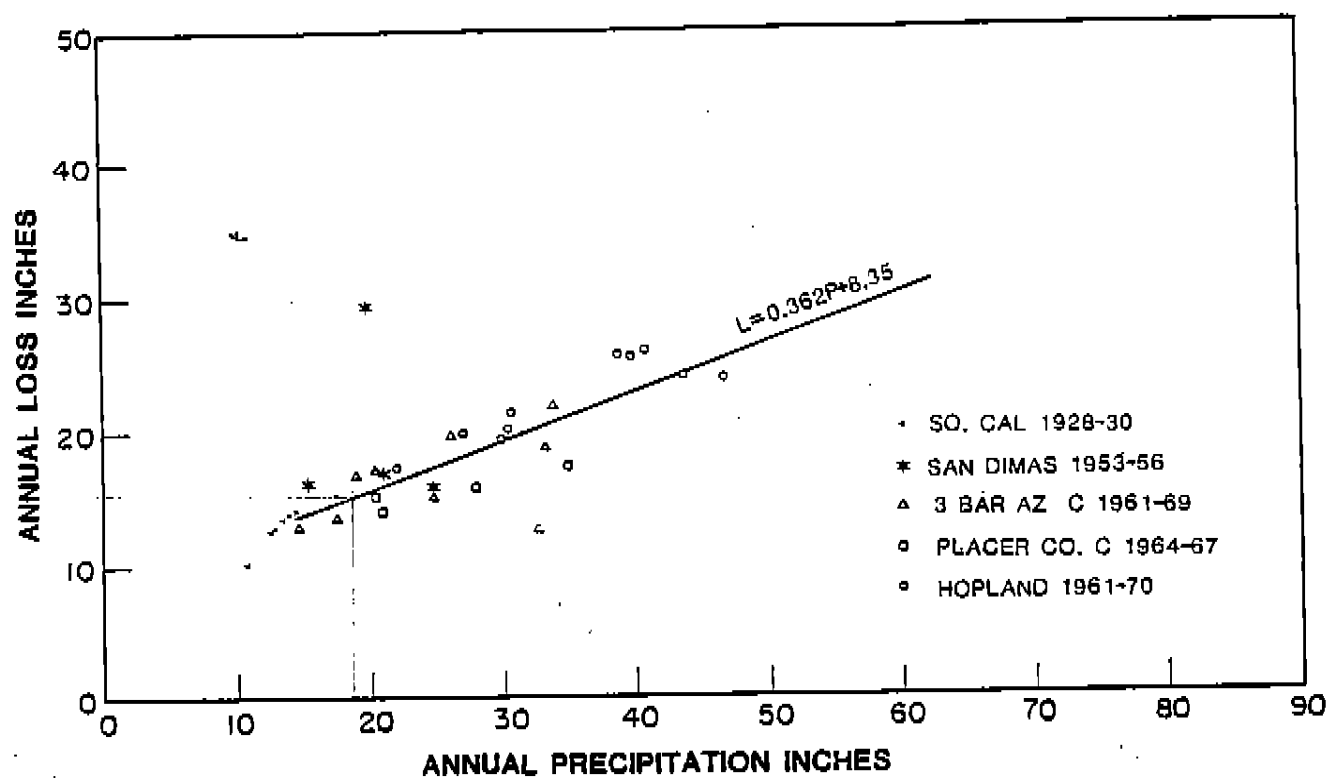


Figure 4. PRECIPITATION - WATER LOSS RELATIONSHIP
FOR GRASS COVERED WATERSHEDS

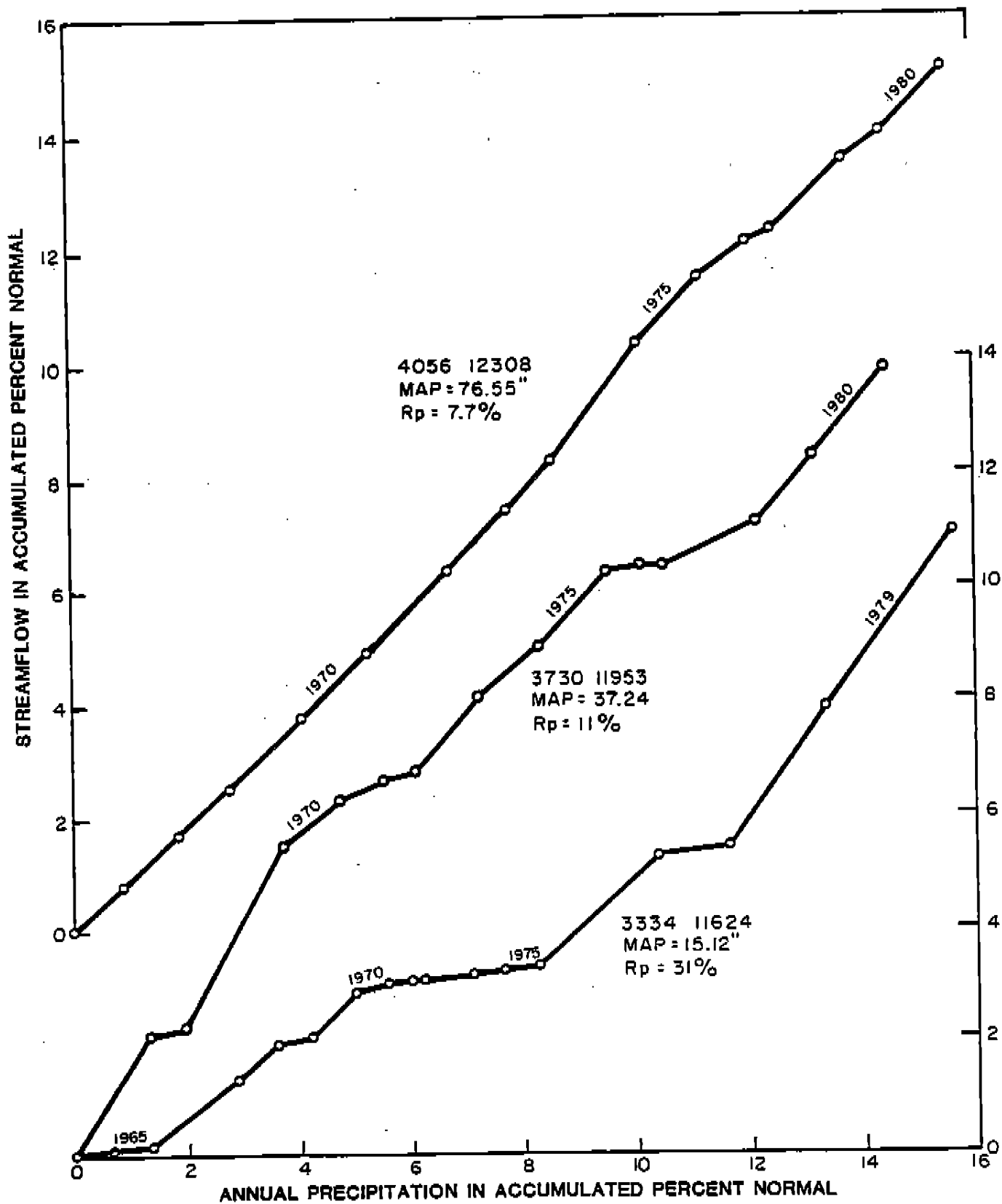


Figure 5. DOUBLE MASS CURVES FOR TYPICAL WATERSHEDS

Table 1
HYDROLOGIC DATA AND WATERSHED CHARACTERISTICS

LOCATION COVER TYPES		DRY PERIOD		PERIOD OF RECORD				R _p %	PHYSICAL CHARACTERISTICS						COVER TYPES	
D-M	D-M	Pd In.	Qd In.	Ld In.	Pr In.	Qr In.	Lr In.		Az Deg.	Do Mi.	E Ft.	S %	Ub %	B %	Hb %	
3239	11625	12.21	0.005	12.20	23.70	0.39	23.31	14.4	122W	42	4155	1.94	0	0	13.6	
3254	11634	22.69	0.190	22.50	30.36	2.22	28.14	13.7	147W	39	4647	2.62	0	0	8.7	
3317	11630	7.43	0.112	7.32	10.01	0.421	9.59	26.0	105E	50	4372	10.35	0	0	0	
3320	11649	34.49	0.631	33.86	43.69	2.92	40.77	18.3	121E	33	4676	6.36	0	0	0	
3327	11719	14.88	0.021	14.86	19.69	1.33	18.36	18.0	176W	14	1456	2.79	0	0	0	
3330	11731	12.59	0.091	12.49	15.47	0.724	14.75	17.9	139W	8	1004	2.79	0	0	0	
3334	11624	8.62	0.162	8.46	15.13	0.858	14.27	31.0	10E	62	4628	7.91	0	0	0	
3339	11631	9.07	0.030	9.04	16.23	0.688	15.54	27.1	7W	59	2968	5.67	0	0	0	
3343	11735	13.21	1.37	11.84	23.32	9.32	14.00	19.2	95W	17	2595	8.74	0	0	0	
3406	11836	11.41	0.44	10.97	22.76	4.53	18.23	19.9	160E	4	1427	5.26	0	0	0	
3413	11717	18.92	1.77	17.15	29.66	7.89	21.77	15.7	161E	55	3641	9.50	0	0	0	
3420	11805	9.14	0.17	8.97	25.90	0.69	23.21	18.2	110W	33	4520	4.53	0	0	0	
3423	11924	21.35	2.79	18.56	29.37	8.76	20.61	18.6	44W	6	2512	7.94	0	0	0	
3430	11949	22.20	7.42	18.78	25.20	4.49	20.71	18.0	3W	5	1811	10.10	0	0	0	
3431	12026	13.38	0.902	12.48	23.46	3.25	20.21	14.8	99W	4	1020	3.99	0	0	30.0	
3437	11921	23.35	0.59	22.76	28.11	3.57	24.54	19.0	112E	18	5020	3.89	0	0	0	
3440	11947	21.79	0.288	21.50	24.94	3.21	21.73	18.3	122W	17	4289	5.57	1.3	0	5.3	
3441	11856	12.18	1.54	10.64	15.41	2.01	13.40	19.3	42W	35	4530	1.94	0	0.5	1.3	
3502	11828	14.25	0.020	14.23	17.35	0.869	16.48	15.0	69E	70	6110	6.72	0	0	0	
3517	12018	6.98	0.478	6.50	11.48	3.54	7.94	15.0	84W	22	2592	2.41	0	0	0	
3525	12047	13.26	0.087	13.17	20.71	5.02	15.69	13.8	128W	5	772	1.63	13.6	0	50.0	
3530	11815	13.07	0.15	12.92	13.29	0.18	13.11	17.1	3W	105	5836	4.16	0	0	0	
3549	11847	14.65	0.358	14.29	20.74	1.43	19.31	13.9	94W	108	3302	3.42	0	0	20.8	
3553	12013	11.33	0.011	11.32	14.64	0.778	13.86	15.9	117E	50	2251	2.54	3.5	0	0	
3602	11843	18.78	1.41	17.38	32.60	5.71	26.89	13.8	85W	127	3948	5.29	0	0	0.9	
3612	11735	11.74	0.02	11.72	13.00	0.03	12.97	27.0	23E	166	5408	3.38	0	0	0	
3623	12033	11.09	0.027	11.06	14.12	0.861	13.26	14.4	81E	60	2936	4.32	11.8	0	0	
3626	11816	15.71	3.79	11.92	22.14	9.20	12.94	12.2	169W	162	10500	4.06	0	0.8	0	
3632	12142	14.61	0.106	14.50	16.30	0.659	15.64	12.4	17W	10	1386	3.26	0	0	0	
3640	11912	13.58	0.032	13.55	16.42	0.137	16.28	12.5	138W	129	1800	2.99	0	0	0	
3648	11833	30.70	17.04	13.66	36.53	21.82	14.71	11.1	86W	163	9332	4.21	0	40.6	0	
3707	11908	30.79	8.13	22.66	48.96	23.58	25.38	10.5	166W	150	7918	6.15	0	6.7	3.8	
3710	12207	28.90	1.45	27.45	58.32	14.70	43.61	12.1	180	10	1542	2.08	0	0	0	

Table 1 (Continued)
HYDROLOGIC DATA AND WATERSHED CHARACTERISTICS

LOCATION		DRY PERIOD			PERIOD OF RECORD			R _p	PHYSICAL CHARACTERISTICS					COVER TYPES		
COVER TYPES	LAT	LONG	Pd	Qd	Ld	Pr	Qr	Lr	Az	Dc	E	S	Ub	B	Hb	
	3717	12120	8.33	0	8.33	16.44	1.59	14.85	80E	39	1413	1.14	0.2	0	25.9	
	3730	11953	24.30	1.40	22.90	37.24	7.40	29.84	178E	117	3036	6.78	0	0	0	
	3732	12134	7.51	0.07	7.44	16.27	1.56	14.71	51W	48	2500	2.74	8.1	0	0	
	3735	11919	17.05	10.34	6.71	42.64	31.25	11.39	142E	148	9180	5.16	0	0	12.8	
	3737	12200	9.66	0.01	9.65	19.23	3.02	16.21	135W	28	977	6.48	1.8	0	33.3	
	3743	12010	16.67	0.35	16.34	30.11	6.75	23.36	120W	108	2958	8.45	0	0	0	
	3749	11949	25.44	2.70	22.74	54.66	14.72	39.94	85W	130	5630	3.60	0	0	0	
	3809	12002	23.86	2.04	21.82	48.69	16.53	32.16	134W	133	5710	3.10	0	0	0	
	3823	12224	24.46	5.81	18.65	42.30	14.96	27.34	122E	32	1220	3.80	0	0	0	
	3827	12037	34.70	5.10	29.60	39.76	8.62	31.14	112W	114	2594	2.07	0	0	0	
	3832	12037	18.27	0.82	17.45	39.70	9.46	30.24	82W	117	3180	1.65	1.6	0	3.0	
	3850	12308	23.09	2.34	20.75	56.36	24.95	31.41	149E	18	1851	2.87	1.5	0	0	
	3852	11956	25.71	6.57	19.14	37.65	13.11	24.54	25W	160	8290	6.30	0	11.1	0	
	3856	12049	20.77	4.09	16.68	48.14	18.80	29.34	86W	127	2660	3.21	5.4	0	0	
	3856	12257	19.72	1.71	18.01	48.96	23.88	25.08	98E	32	2138	4.75	16.7	0	0	
	3906	12226	12.00	0.18	11.82	27.61	6.71	20.90	155E	59	1725	1.01	28.0	0	9.5	
	3916	12237	17.37	1.08	16.29	39.49	17.49	22.00	65E	60	3390	5.17	7.1	0	0	
	3924	12046	53.67	20.64	33.03	81.51	39.43	42.08	141W	146	4789	6.49	14.3	0	0	
	3926	12016	27.24	4.68	22.56	52.44	15.24	37.20	78E	169	7260	5.46	0	0	0	
	3926	12334	37.04	6.22	30.82	64.63	27.15	37.50	91W	13	1643	1.85	0	0	0	
	3931	12227	12.68	0	12.68	22.18	1.74	20.44	62E	71	1215	1.86	0	0	4.9	
	3941	12330	66.93	29.55	37.38	93.43	47.63	45.80	22W	15	1950	0.06	0	0	24.0	
	3945	12246	29.05	8.57	20.48	50.93	14.98	35.95	111E	55	3466	3.53	0.9	0	2.0	
	4000	12240	18.31	1.52	16.79	35.92	14.70	21.22	74W	64	3184	3.63	18.3	0	0	
	4001	12138	28.32	6.10	22.22	59.16	27.15	32.01	157W	117	3060	2.47	0.2	0	0	
	4005	12319	45.12	22.26	22.86	61.89	32.24	29.65	172E	34	3143	1.96	1.0	0	2.8	
	4014	12046	29.50	5.94	23.56	35.94	9.56	26.38	163W	166	5760	4.81	0	0	8.1	
	4019	12156	21.74	5.99	15.75	30.85	10.34	20.51	103W	107	1920	1.55	0	0	10.6	
	4035	12130	36.12	7.26	28.86	51.10	11.72	39.38	27E	137	5900	2.30	0	7.3	0	
	4043	12200	38.28	15.07	23.21	44.31	19.88	24.43	115W	115	2240	3.69	0	0	0	
	4050	12235	39.53	4.81	34.72	71.93	25.39	46.54	164W	82	3304	2.61	0	0	0	
	4056	12308	58.85	31.30	27.55	76.55	38.90	37.65	180	53	5256	4.64	3.5	0	0	
	4108	12306	35.44	19.61	15.83	44.48	27.58	16.90	54W	54	5040	3.52	5.1	0	0	
	4133	12242	19.72	1.12	18.60	25.50	2.78	22.72	23W	72	4598	2.62	7.0	0	0	
	4146	12212	28.88	2.76	26.12	33.27	5.94	27.78	99W	100	5822	5.59	1.1	4.3	0	