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ESTIMATES OF MOUNTAIN-FRONT STREAMFLOW AVAILABLE FOR POTENTIAL RECHARGE TO THE TULAROSA BASIN, NEW MEXICO

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 01-4013

Prepared in cooperation with the
CITY OF ALAMOGORDO
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BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

For additional information write to:

District Chief
U.S. Geological Survey
Water Resources Division
5338 Montgomery NE, Suite 400
Albuquerque, NM 87109-1311

Copies of this report can be purchased from:

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch	25.40	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
cubic foot per second	0.02832	cubic meter per second
acre-foot	1,233	cubic meter

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

ESTIMATES OF MOUNTAIN-FRONT STREAMFLOW AVAILABLE FOR POTENTIAL RECHARGE TO THE TULAROSA BASIN, NEW MEXICO

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ABSTRACT

Streamflow in the Tularosa Basin, New Mexico, infiltrates into alluvial-basin aquifers at or near mountain fronts. Streamflow at or near mountain fronts is a substantial component of potential recharge to these aquifers. Streamflow response from precipitation differs substantially between the streams draining the Sacramento Mountains on the eastern side of the basin and those draining the San Andres Mountains on the western side.

Mean annual streamflow at mountain fronts that is available for potential recharge to the Tularosa Basin was estimated using two regional regression methods. The method for estimating mean annual streamflow using basin-climatic characteristics was applied to 46 subbasins in the Tularosa Basin. Drainage areas for the subbasins ranged from 0.87 to 157 square miles, and mean annual precipitation ranged from 11.80 to 24.89 inches. Mean annual streamflow to the basin is estimated to be about 95 cubic feet per second or 68,800 acre-feet using the basin-climatic characteristics method. The method for estimating mean annual streamflow using channel-geometry characteristics was applied to 12 subbasins in the Tularosa Basin. Of the 46 basins, 31 had drainage areas less than 20.7 square miles and 3 had active-channel widths less than 15 feet, which were outside the ranges used to develop the regression equations.

INTRODUCTION

During the 1996 drought in New Mexico, the U.S. Geological Survey, in cooperation with the City of Alamogordo and the Department of the Air Force, began a study to appraise the water resources of the Tularosa Basin (fig. 1). Streamflow at mountain fronts throughout New Mexico is a substantial component of recharge to alluvial aquifers (Kernodle and Scott, 1986). The mean annual streamflow is an estimate of the potential annual recharge to an aquifer that is commonly used in ground-water models (Kernodle and Scott, 1986; Wilkins, 1986; Kernodle and others, 1987).

Two regional regression methods have been developed for southern New Mexico to estimate mean annual streamflow (Waltemeyer, 1993). The basin-climatic characteristics method uses drainage area and mean annual precipitation to estimate mean annual streamflow. The channel-geometry characteristics method uses active-channel width to estimate mean annual streamflow. This report presents estimates of mean annual streamflow available for potential recharge to the Tularosa Basin at or near mountain fronts.

The Tularosa Basin is a closed basin with numerous playa lakes. The basin is bounded on the eastern side by the Sacramento Mountains and on the western side by the San Andres Mountains (fig. 1). The Sacramento Mountains receive about twice as much annual precipitation than the San Andres Mountains mainly because the Sacramento Mountains are higher in altitude (about 9,000 to 10,000 feet) than the San Andres Mountains (about 7,000 feet). Snowmelt in the Sacramento Mountains sustains perennial streamflow at or near mountain fronts. In contrast, precipitation in the San Andres Mountains occurs mostly as rainfall, and the mountains have little or no snowmelt to sustain streamflow. In subbasins adjacent to the San Andres Mountains, streamflow is ephemeral, occurring only in direct response to rainfall.

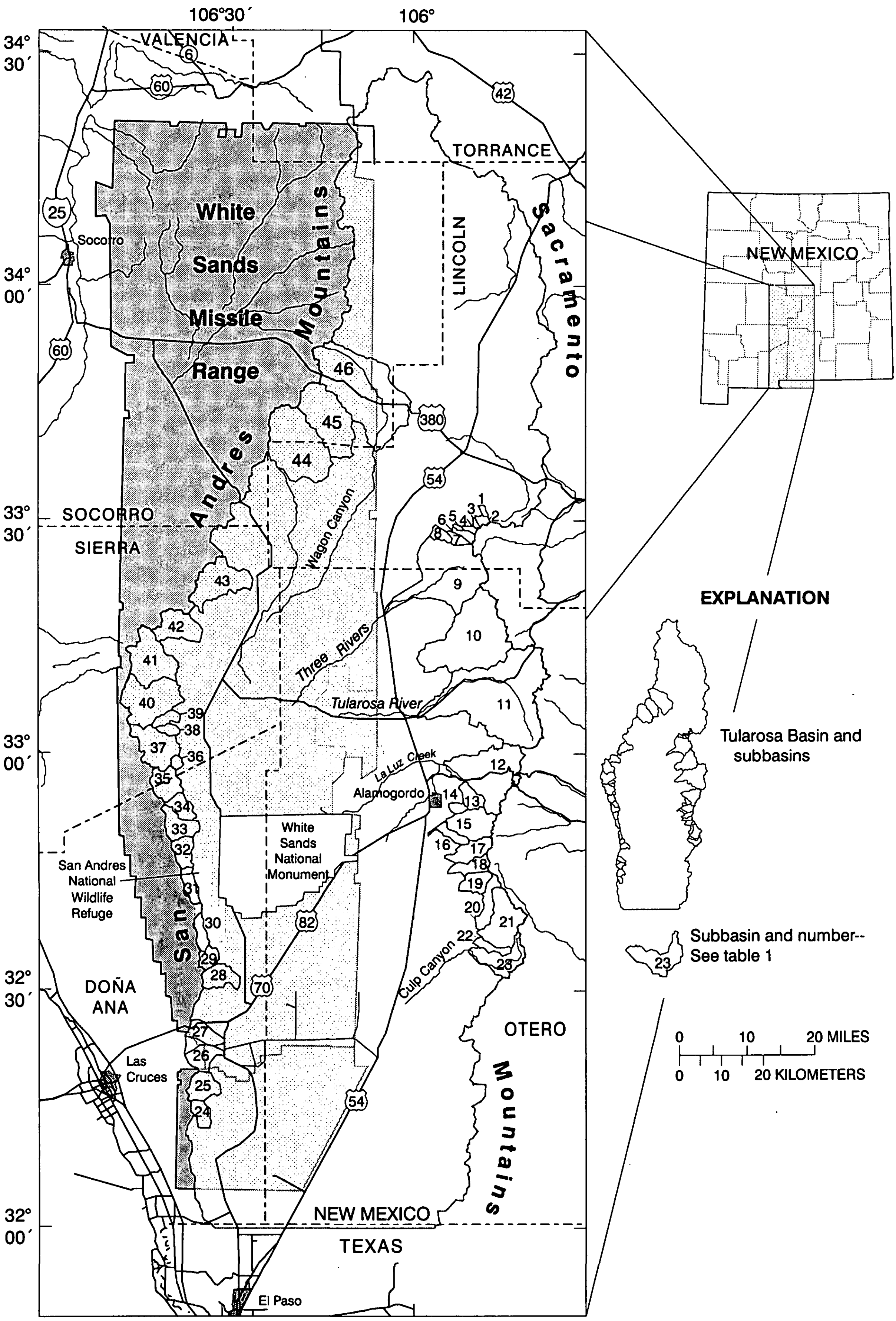

Figure 1. Location of surface-water subbasins at or near mountain fronts.

ESTIMATES OF STREAMFLOW AT SELECTED MOUNTAIN FRONTS

Two regional streamflow regression methods for estimating annual streamflow have been developed for southern New Mexico (Waltemeyer, 1993): the basin-climatic characteristics method and the channel-geometry characteristics method. Typically the standard error of estimate of equations derived from channel-geometry characteristics is less than the standard error of estimate derived from basin-climatic characteristics.

The basin-climatic characteristics method was used to estimate mean annual streamflow in all 46 subbasins (fig. 1) in the Tularosa Basin. Streamflow estimates derived using the channel-geometry characteristics method were not completed in 34 subbasins because of the safety hazard of live munitions in these subbasins, which precluded active channel-width measurements. The streamflow estimates determined by both methods are listed in table 1.

Basin-Climatic Characteristics Method

Drainage area and mean annual precipitation were statistically significant independent variables in the relation with mean annual streamflow at 13 streamflow-gaging stations in southern New Mexico (Waltemeyer, 1993). The equation used to estimate mean annual streamflow at or near mountain fronts in 46 subbasins in the Tularosa Basin is:

$$Q_a = 1.70 \times 10^{-4} A^{1.35} P^{1.65} \quad (1)$$

where Q_a = mean annual streamflow, in cubic feet per second;
A = drainage area, in square miles; and
P = mean annual precipitation, in inches.

The exponents of drainage area and mean annual precipitation in the Waltemeyer (1993) report were reversed.

A geographical information system was used, along with digital elevation models, to obtain drainage areas. A digital line coverage was superimposed over mean annual precipitation (U.S. Weather Bureau, no date) in subbasins in the Tularosa Basin (table 1) for a basin average precipitation (weighted by area). Drainage areas ranged from 0.87 to 157 square miles, and mean annual precipitation ranged from 11.80 to 24.89 inches. Estimated mean annual streamflow available for potential recharge ranged from 0.03 to 24.2 cubic feet per second.

Channel-Geometry Characteristics Method

Active-channel width is a statistically significant independent variable in relation to mean annual streamflow at six streamflow-gaging stations in southern New Mexico (Waltemeyer, 1993). The equation used to estimate mean annual streamflow at mountain fronts in 12 selected subbasins in the Tularosa Basin is:

$$Q_a = 0.04\, W^{1.59} \quad (2)$$

where W = active-channel width, in feet.

Active-channel width ranged from 4 to 56 feet in the 12 subbasins. Mean annual streamflow estimates derived using this method ranged from 0.36 to 24.1 cubic feet per second (table 1).

Comparison of the Results of the Methods

A comparison in 12 subbasins of mean annual streamflow estimates derived using the basin-climatic and channel-geometry characteristics methods is shown in figure 2. The basin-climatic method estimates mean annual streamflows of less than about 1 cubic foot per second for six subbasins that are outside of the recommended drainage area range of the regression model (subbasins 2, 14, 16, 17, 18, and 19) (fig. 2). In comparison, the channel-geometry method estimates larger mean annual streamflows for 11 of the 12 subbasins—except for the largest basin (11,157 square miles), which may be underestimated. In similar investigations having larger data sets (Hedman and Osterkamp, 1982) channel-geometry method relations have less standard error of estimate than the basin-climatic method.

Table 1. Estimates of mean annual streamflow using two regional-regression methods for subbasins in the Tularosa Basin, New Mexico

[ft^3/s, cubic feet per second; mi^2, square miles; --, no data]

Subbasin number (fig. 1)	Stream name	Mean annual streamflow		Drainage area (mi^2)	Mean annual precipitation (inches)	Active-channel width (feet)
		Basin-climatic characteristics method (ft^3/s)	Channel-geometry characteristics method (ft^3/s)			
1	Bear Canyon at mountain front near Nogal	0.05	--	1.39	24.27	--
2	Water Canyon at mountain front near Nogal	.12	0.36	2.50	24.89	4
3	Sanders Canyon at mountain front near Nogal	.03	--	.87	24.67	--
4	Elder Canyon at mountain front near Nogal	.07	--	1.73	24.46	--
5	Unnamed arroyo at mountain front near Nogal	.03	--	.97	22.82	--
6	Unnamed arroyo at mountain front near Nogal	.19	--	3.60	24.42	--
7	Unnamed arroyo at mountain front near Nogal	.19	--	3.77	23.63	--
8	Unnamed arroyo at mountain front near Nogal	.22	--	4.76	21.17	--
9	Three Rivers at mountain front at Three Rivers	11.5	18.8	86.5	22.01	48
10	Rinconada Canyon at mountain front near Tularosa	12.7	24.1	97.5	21.16	56
11	Tularosa River at mountain front near Tularosa	24.2	8.93	157	21.23	30
12	La Luz Creek at La Luz	7.3	16.4	65.2	21.07	44
13	Dry Canyon at High Rolls	.44	--	8.98	19.35	--
14	Marble Canyon at mountain front at Alamogordo	.10	3.62	3.45	17.08	17
15	Alamo Canyon at mountain front at Alamogordo	1.98	17.0	24.9	20.99	45
16	Mule Canyon at Alamogordo	.22	3.62	6.70	16.22	17
17	San Andres Canyon at mountain front near Alamogordo	1.03	2.08	14.8	21.65	12
18	Dog Canyon at Oliver Lee State Park near Valmont	.61	1.09	10.5	20.82	8

Table 1. Estimates of mean annual streamflow using two regional-regression methods for subbasins in the Tularosa Basin, New Mexico--Continued

Subbasin number (fig. 1)	Stream name	Mean annual streamflow: Basin-climatic characteristics method (ft^3/s)	Mean annual streamflow: Channel-geometry characteristics method (ft^3/s)	Drainage area (mi^2)	Mean annual precipitation (inches)	Active-channel width (feet)
19	Escondido Canyon at mountain front near Alamogordo	0.60	3.29	11.0	19.95	16
20	Bug Scuffle Canyon at mountain front near Alamogordo	.68	--	12.3	19.50	--
21	Grapevine Canyon at mountain front near Alamogordo	2.59	--	33.5	19.37	--
22	Pipeline Canyon at mountain front near Alamogordo	.16	--	6.11	14.26	--
23	Culp Canyon at mountain front near Alamogordo	.95	--	23.2	14.29	--
24	Oak Canyon at mountain front near White Sands	.28	--	8.94	14.85	--
25	Soledad Canyon at mountain front near White Sands	.67	--	15.6	15.88	--
26	Sotol Creek at mountain front near White Sands	.44	--	13.1	14.32	--
27	Unnamed arroyo at mountain front near White Sands	.30	--	12.2	11.91	--
28	Bear Canyon at mountain front near White Sands	.40	--	15.4	11.80	--
29	Little San Nicolas Canyon at mountain front near White Sands	.15	--	7.35	12.00	--
30	Ash Canyon at mountain front near White Sands	.20	--	7.60	13.81	--
31	San Andres Canyon at mountain front near White Sands	.30	--	8.90	15.63	--
32	Mayberry Canyon at mountain front near White Sands	.42	--	11.5	15.49	--
33	Deadman Canyon at mountain front near White Sands	.59	--	16.1	14.33	--
34	Lost Man Canyon at mountain front near White Sands	.26	--	10.2	12.88	--
35	Hembrillo Canyon at mountain front near White Sands	.48	--	17.2	12.00	--

Table 1. Estimates of mean annual streamflow using two regional-regression methods for subbasins in the Tularosa Basin, New Mexico--Continued

Subbasin number (fig. 1)	Stream name	Mean annual streamflow		Drainage area (mi^2)	Mean annual precipitation (inches)	Active-channel width (feet)
		Basin-climatic characteristics method (ft^3/s)	Channel-geometry characteristics method (ft^3/s)			
36	Grandview Canyon at mountain front near White Sands	0.04	--	2.82	12.00	--
37	Sulfur Canyon at mountain front near White Sands	1.03	--	30.3	12.04	--
38	Ash Canyon at mountain front near White Sands	.07	--	4.30	12.08	--
39	Workman Canyon at mountain front near White Sands	.13	--	5.99	12.66	--
40	Cottonwood Canyon at mountain front near White Sands	2.21	--	45.3	13.73	--
41	Rhoades Canyon at mountain front near White Sands	2.04	2.97	39.7	14.57	15
42	Good Fortune Canyon at mountain front near White Sands	1.12	--	24.0	15.34	--
43	Thurgood Canyon at mountain front near White Sands	1.70	--	37.2	13.80	--
44	Unnamed arroyo at mountain front near Bingham	5.27	--	73.8	15.61	--
45	Red Canyon at mountain front near Bingham	3.11	--	55.6	14.31	--
46	Wagon Canyon at mountain front near Bingham	7.46	--	120	12.95	--

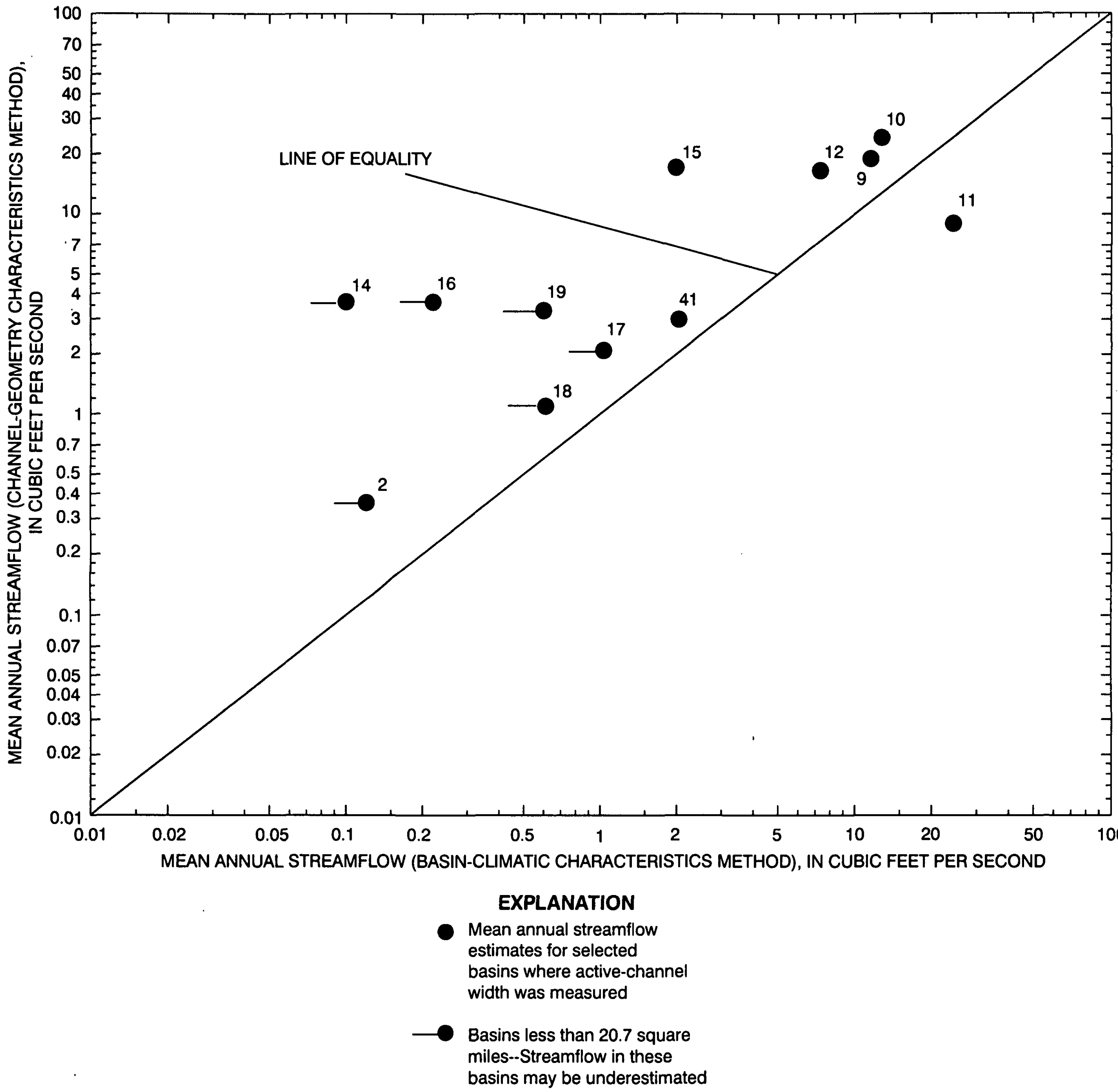

Figure 2. Comparison of estimated mean annual streamflow using two regional regression methods (see figure 1 for location of subbasins and table 1 for stream names).

Total estimated mean annual streamflow available for potential recharge from the Sacramento Mountains to the Tularosa Basin is about 66 cubic feet per second or 47,800 acre-feet. The San Andres Mountains provide an estimated mean annual streamflow of about 29 cubic feet per second or 21,000 acre-feet at the mountain fronts. Therefore, total streamflow assumed to be available for potential recharge to the Tularosa Basin is about 95 cubic feet per second or 68,800 acre-feet for an average year using the basin-climatic characteristics method. Direct recharge from precipitation to the Tularosa Basin is assumed to be lost to evapotranspiration, and mountain-front recharge is potential recharge to the basin.

LIMITATIONS AND ACCURACY OF THE METHODS

Using the two regression equations to estimate mean annual streamflow for the 46 subbasins needs to be limited to specific ranges for the characteristics for which the equations are based (Waltemeyer, 1993). The limitations were (1) drainage area of subbasins ranging from 20.7 to 184 square miles, (2) mean annual precipitation ranging from 6.0 to 25 inches, and (3) active-channel width ranging from 15 to 55 feet. Of 46 subbasins, 31 had drainage areas less than 20.7 square miles and 3 had active-channel widths less than 15 feet. Therefore, comparison of estimates indicates that for basins less than 20.7 square miles and for channel widths less than 15 feet, mean annual streamflow may be less using the basin-climatic method. These subbasins and channel widths are outside the ranges of the basin-climatic variables used to develop the regression model (fig. 2, table 1). Therefore, streamflow estimated using the channel-geometry methods generally produces higher estimates (fig. 2). Thus, estimates derived using channel-geometry methods may be more applicable.

SUMMARY

Streamflow at mountain fronts is a substantial component of potential recharge to the Tularosa Basin in southern New Mexico. Mean annual streamflow at mountain fronts available for potential recharge to the basin was estimated using two regional regression methods. The basin-climatic characteristics method was used in all 46 subbasins to estimate streamflow. Streamflow estimates derived using the channel-geometry characteristics method were not completed in 34 subbasins because a safety hazard of live munitions in these subbasins precluded necessary channel-width measurement data collection. Drainage areas for the subbasins ranged from 0.87 to 157 square miles, and mean annual precipitation ranged from 11.80 to 24.89 inches.

Estimates of streamflow derived by both methods were compared for 12 subbasins. Comparison of estimates indicates that channel-geometry methods generally produces higher estimates. The total estimated mean annual streamflow for potential recharge from the Sacramento Mountains to the Tularosa Basin is about 66 cubic feet per second or 47,800 acre-feet. The San Andres Mountains provide an estimated mean annual streamflow of about 29 cubic feet per second or 21,000 acre-feet at the mountain fronts. Mean annual streamflow at mountain fronts assumed to be available for potential recharge to the basin is about 95 cubic feet per second or 68,800 acre-feet for an average year using the basin-climatic characteristics method.

SELECTED REFERENCES

Hedman, E.R., and Osterkamp, W.R., 1982, Streamflow characteristics related to channel geometry of streams in western United States: U.S. Geological Survey Water-Supply Paper 2653, 16 p.

Kernodle, J.M., Miller, R.S., and Scott, W.B., 1987, Three-dimensional model simulation of transient ground-water flow in the Albuquerque-Belen Basin, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 86-4194, 86 p.

Kernodle, J.M., and Scott, W.B., 1986, Three-dimensional model simulation of steady-state ground-water flow in the Albuquerque-Belen Basin, New Mexico: U.S. Geological Survey Water-Resources Investigations Report 84-4353, 57 p.

U.S. Weather Bureau [n.d.], Normal annual precipitation, 1931-60, State of New Mexico: U.S. Department of Commerce Map, 1 sheet, scale 1:500,000.

Waltemeyer, S.D., 1993, Methods for estimating streamflow at mountain fronts in southern New Mexico: U.S. Geological Survey Water-Resources Investigations Report 93-4213, 17 p.

Wilkins, D.W., 1986, Southwest Alluvial-Basin Regional Aquifer-Systems Study in parts of Colorado, New Mexico, and Texas, *in* Sun, R.J., ed., Regional Aquifer-Systems Analysis Program of the U.S. Geological Survey—Summary of projects, 1978-84: U.S. Geological Survey Circular 1002, p. 107-115.

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