Appendix C

Evaluation of Ungaged Local Mountain Runoff in Centro and Baja Subareas

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1.1 Background and Purpose

Previous studies have identified local mountain runoff as a component of the natural water supply within the Study Area. To date, five studies (DWR, 1967; Hardt, 1971; Lines, 1996; Stamos, et al, 2001; and Wagner and Bonsignore [W&B], 2012) have provided independent estimates of local mountain runoff in the Study Area. Each study addresses the topic differently, utilizing different boundaries, methods of analysis, and data sources. The primary objectives of this evaluation were to:

- document the evolution of knowledge related to ungaged local runoff
- assess the limitations of previous analytical methods
- incorporate previously undocumented streamflow data for one ungaged tributary, Boom Creek, in the Baja Subarea
- present revised estimates of ungaged local runoff based on a consistent methodology using the most current and reliable information
- identify data gaps and needs

For this evaluation, technical reports prepared by the Department of Water Resources (DWR, 1967), USGS (Hedman, 1970; Hardt, 1971; Lines, 1996; and Stamos, et al., 2001), and W&B (2012) were reviewed. A timeline of all key technical reports relevant to ungaged local runoff is presented in **Appendix A**.

1.2 Local Mountain Rainfall

Local runoff is generated by rainfall in the desert mountains, where there are currently no rain gages. As a consequence, the precise orographic effect of the local mountains on local precipitation patterns is uncertain. Previous studies have relied on available rainfall isohyetal maps to estimate local runoff (DWR, 1967; W&B, 2012). **Figure C1** shows four available isohyetal maps that cover the Study Area. The upper left map was used in Bulletin No. 84 (DWR, 1967) and developed by the U.S. Weather Bureau based on WY 1930-31 to WY 1959-60 rainfall data. The upper right map was developed by Rantz (1969) based on rainfall from 1900 to 1960 and was used in the W&B study (2012). The lower left map is a commonly referenced map prepared by James (1992) and is based on rainfall from 1960 to 1991. Finally, the lower right map was developed by the Oregon State University Climate Group (OSU, 2004) based on the Parameter-elevation Regressions on Independent Slopes Model (PRISM) mapping system and is based on rainfall data from 1971 to 2000.

Examination of the four maps indicates significant variability in the estimated rainfall in the local mountains. Variations in rainfall estimates between the DWR, Rantz, and OSU maps are primarily attributable to the contouring methods applied and to a lesser extent to the different time periods represented by each map. Contours in the DWR and Rantz maps were contoured manually, while the OSU map is based on the Parameter-elevation Regressions on Independent Slopes Model (PRISM) mapping system. PRISM uses point measurements of precipitation, temperature, and other climatic

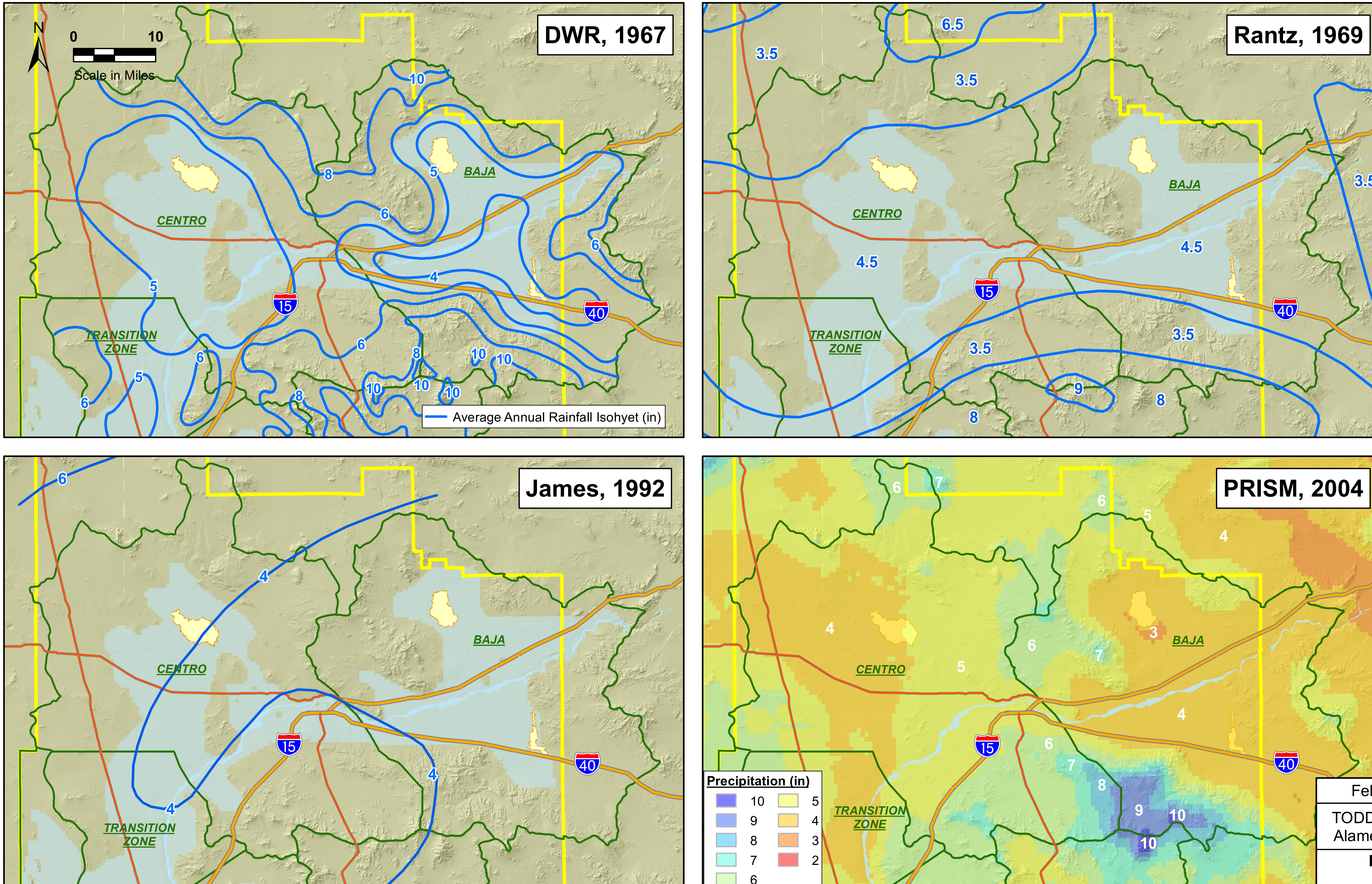

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Figure C1
Rainfall
Isohyetal Maps

factors to account for rain shadows, coastal effects, and temperature inversions. PRISM maps are recognized as the highest-quality spatial datasets currently available and are used by the U.S. Department of Agriculture. Because the PRISM map was developed using the most rigorous method of interpolation and is based on most recent rainfall data (1971 to 2000), it represents the most reliable isohyetal map for the Study Area.

1.3 Review of Previous Studies

1.3.1 Bulletin No. 84 (DWR, 1967)

In Bulletin No. 84 (DWR, 1967), estimates of ungaged local runoff within the Study Area are provided based on a relationship between gaged runoff and precipitation in the Deep Creek watershed adjusted to average annual precipitation in the desert mountains. A rainfall isohyetal map is presented in Plate 1 of the report, from which weighted-average annual rainfall in mountain areas is estimated for the various basin units, subunits, and subareas across the Mojave River region. The upper left map in **Figure C1** shows the isohyetal contours digitized from the DWR report. **Table C1** shows the calculations used in Bulletin No. 84 to estimate mountain local runoff of the various subunits/subareas pertinent to the Study Area. The boundaries of the various DWR basin areas are shown on **Figure C2**.

Table C1
DWR (1967) Estimates of Local Mountain Runoff Estimates
Study Area Subunits/Subareas

Basin	Mountain Area (acres)	Weighted-Average Annual Rainfall (inches)	Runoff Coefficient (% Rainfall)	Local Mountain Runoff (AFY)	Reported Mountain Runoff (AFY)
Middle Mojave Subunit	107,500	6.1	1.0%	546	550
Harper Subunit	100,800	6.7	1.0%	563	550
Lower Mojave Subunit	136,900	6.9	1.0%	787	800
Coyote Unit	66,100	7.8	1.0%	430	450
Caves Subarea	34,000	5.7	1.0%	162	150

Note: Runoff coefficient for Coyote Subarea weighted-average precipitation should be 1.7 percent based on correlation table in report; however reported mountain runoff reflects an applied runoff coefficient of 1.0 percent.

As shown in the table, a runoff coefficient of 1.0 percent is universally applied to all mountain areas within the Study Area. Average annual surface runoff is estimated for mountain areas generally within the Centro Subarea, including the Middle Mojave Subunit (550 AFY) and Harper Subunit (550 AFY), totaling 1,100 AFY. With respect to areas within the Baja Subarea, average annual mountain runoff is estimated for the Lower Mojave Subunit (800 AFY), Coyote Unit (450 AFY), and Caves Subarea (150 AFY), totaling 1,400 AFY. Runoff volumes are assumed to either contribute to Mojave River discharge or to

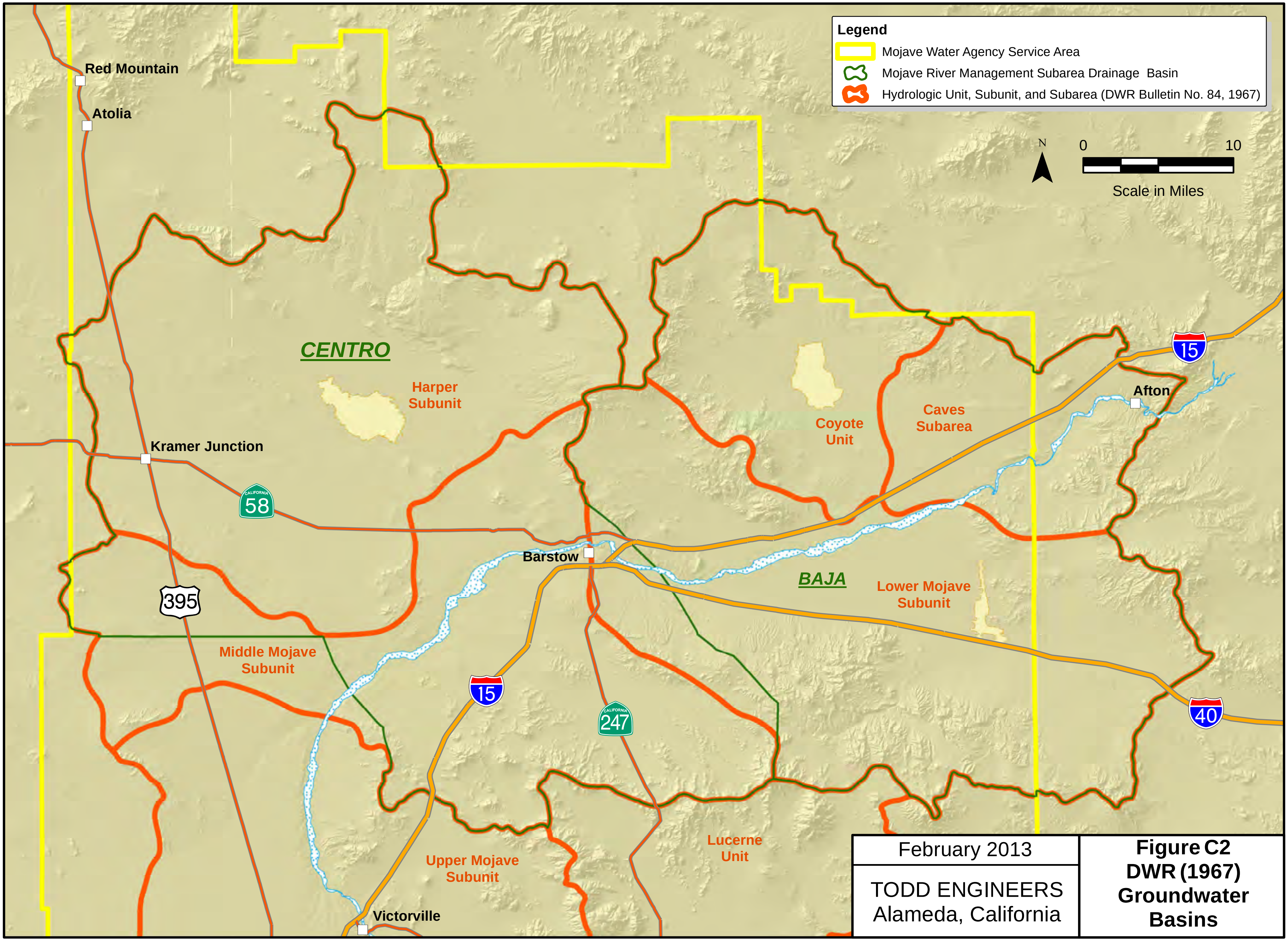

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Figure C2
DWR (1967) Groundwater Basins

groundwater recharge along the basin margins. Implied in both instances is that local mountain runoff is not subject to additional evaporation.

1.3.2 Hardt (1971)

Hardt (1971) estimates local mountain runoff estimates for the Middle Mojave and Lower Mojave subunits. While annual runoff volumes are not documented in the original report, they are cited in the Stamos et al. (2001) report for two years, 1930 and 1963. For these two periods, contributions to groundwater recharge from mountain runoff are estimated for the Middle Mojave Subunit (including Harper Subunit) (1,100 AFY) and Lower Mojave Subunit (350 AFY). While the 1,110 AFY runoff estimate appears to correspond directly to the combined estimate of the Middle Mojave and Harper subunits by DWR, it is not clear from what source the 350 AFY estimate for the Lower Mojave Subunit is derived.

1.3.3 Lines (1996)

Lines (1996) was the first investigator to estimate the contribution of local runoff from specific ephemeral desert washes to Mojave River flows in the Study Area. Because the objective of the Lines study was to estimate local contributions to surface water flow in the Mojave River, local mountain runoff was not considered for areas that drain away from the Mojave River (e.g. watershed areas surrounding Harper Lake, Coyote Lake, and Troy Lake). Watershed areas and discharge points for 22 ephemeral washes along the Mojave River were estimated.

Average annual discharge for specific tributary washes were estimated by Lines using a methodology similar to one applied by Hedman (1970). The Hedman study found a statistically significant correlation between combined channel depth and width to measured mean annual discharge rates in 48 gaged streams across California. Lines compared channel depth and width to stream gage measurements in 29 gaged streams in the Mojave Desert region and developed a correlation (regression model) between channel width (but not depth) and average annual discharge (**Figure C3**). Lines applied the regression model to measured widths of ungaged ephemeral washes in the Basin to estimate average annual discharge.

Lines then applied the weighted-average discharge estimates for specific mapped tributary washes to the entire drainage area of the Mojave River separated into three main reaches (referred to in the report as the Upper, Middle, and Lower stems). The Upper Stem is defined as the reach between the Forks and Lower Narrows stream gage. The Middle Stem is defined as the reach between the Lower Narrows and Barstow stream gages, while the Lower Stem is defined as the reach between the Barstow and Afton stream gages.

To estimate the variability of local runoff on an annual basis, Lines suggested multiplying the average annual discharge of ephemeral washes by the ratio of annual flows recorded at the Barstow gage relative to its respective average (i.e., if annual discharge in the Mojave River at Barstow is 200 percent

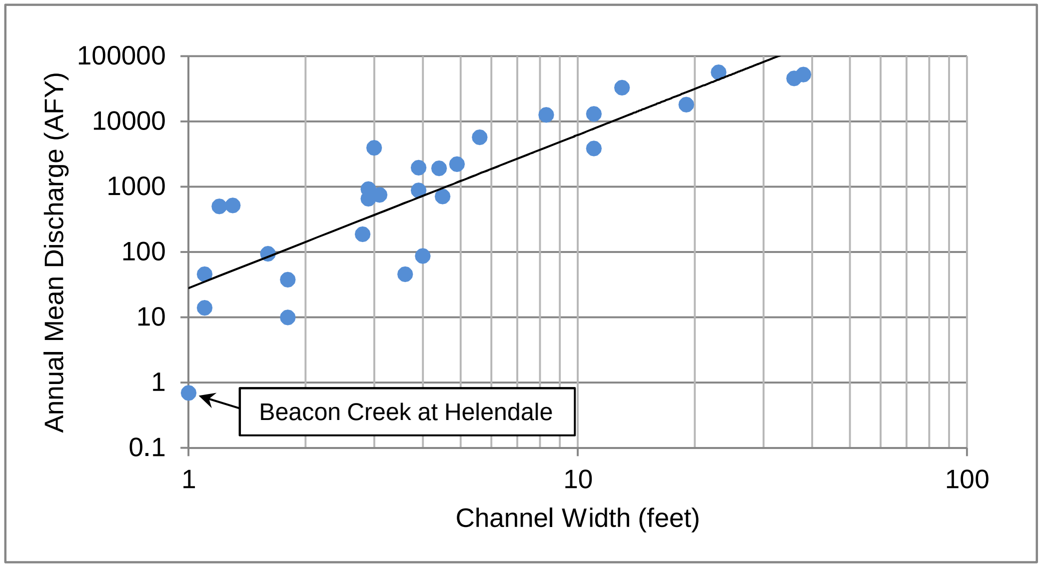

Figure C3.
Lines (1996) Regression Model between Channel Width and Annual Mean Discharge

of its average, then annual flow in each ephemeral wash is assumed to be 200 percent of its respective average). Implied in this suggestion is that the relative magnitude of rainfall on an annual and seasonal basis in the San Bernardino Mountains and on the desert floor is similar.

Of the 22 ungaged ephemeral streams mapped by Lines in the Basin, 11 washes are located within the Study Area. The locations where channel widths were measured for the 11 washes in the Centro and Baja subareas are shown on **Figure C4**. The same site numbers and names presented in the Lines report are used in this report. For the purposes of this evaluation, Fremont Wash and Buckthorn Washes (Sites 12 and 13) are considered to be within the Centro Subarea. Also shown on the figure are the surface water drainage areas for the Middle Stem and Lower Stem of the Mojave River as defined in the Lines report. Also shown on the figure are the drainage areas of the seven ephemeral washes in the Baja Subarea, as mapped by W&B (2012). The drainage areas for all eleven ungaged tributary streams and average annual discharge rates estimated by Lines are presented in **Table C2**.

As shown in the table, Lines estimates that the combined average annual local runoff for mapped ephemeral washes within the Middle Stem and Lower Stem are 1,620 AFY and 1,630 AFY, respectively. The mapped tributary washes represent 549.6 mi^2 (72.5 percent) of the total 758 mi^2 drainage area for the Middle Stem and 180 mi^2 (41.7 percent) of the total 432 mi^2 drainage area of the Lower Stem. Using the area weighted-average runoff of ungaged tributary washes, Lines estimates the maximum total contribution of ungaged runoff to the Middle Stem and Lower Stem of the Mojave River is 2,200 AFY and 3,900 AFY, respectively (the value for the Middle Stem is different from the Lines report, due to the exclusion of an additional wash in the Middle Stem located near the Lower Narrows gage).

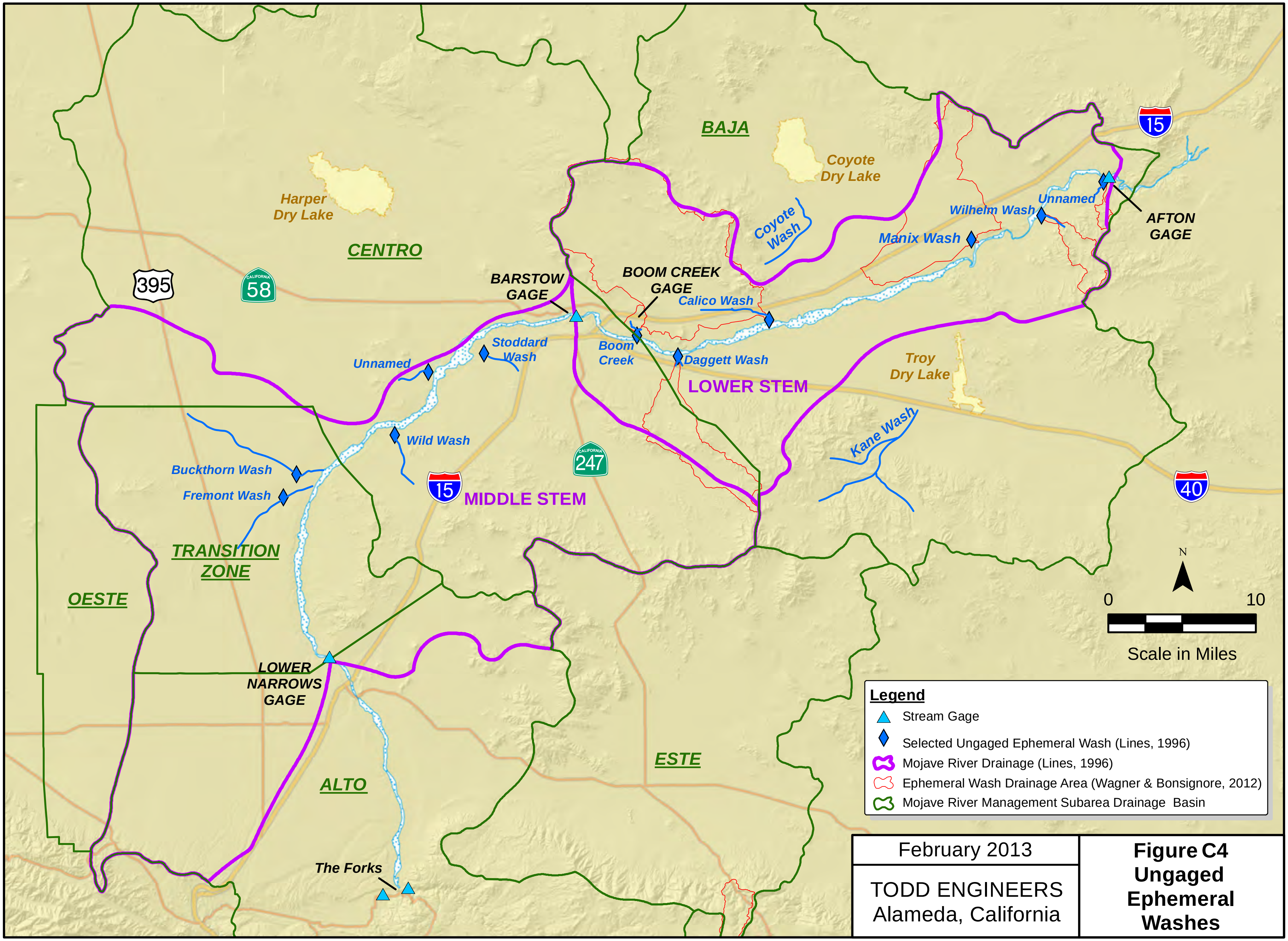

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Figure C4
Ungaged Ephemeral Washes

Table C2
Summary of Ungaged Local Runoff Estimates by Lines (1996)
for Ephemeral Washes in Study Area

Site Number and Name	Drainage Area		Channel Width	Annual Discharge
	mi^2	Acres	ft	AFY
Middle Stem				
Site 12. Fremont Wash	254	162,560	0.8	20
Site 13. Buckthorn Wash	104	66,560	2.9	300
Site 14. Wild Wash	47.7	30,528	2.8	300
Site 15. Unnamed	1.9	1,216	2.5	200
Site 16. Stoddard Wash	142	90,880	4.2	800
Total Site 12-16	**550**	**351,744**		**1,620**
Total Middle Stem[a]	**758**	**540,928**		**2,200**
Lower Stem				
Site 17. Boom Creek	1.6	1,024	1.6	100
Site 18. Daggett Wash	24	15,360	3.0	400
Site 19. Calico Wash	100	64,000	3.2	400
Site 20. Manix Wash	45.2	28,928	3.3	500
Site 21. Wilhelm Wash	7.6	4,864	2.2	200
Site 22. Unnamed	1.6	1,024	1.6	30
Total Sites 17-22	**180**	**115,200**		**1,630**
Total Lower Stem[b]	**432**	**276,480**		**3,900**

[a] Middle Stem = Lower Narrows to Barstow
[b] Lower Stem = Barstow to Afton Canyon

While the Lines study presents a consistent and reproducible methodology, a closer examination of the methodology applied in the study reveals significant limitations. The channel widths of the 29 gaged streams evaluated by Lines range from 1 to 38 feet. As shown in **Figure C3**, while the strength of the correlation between channel width and average annual discharge for gaged streams with channel widths greater than 5 feet is more reasonable, the correlation of gaged streams with channel widths less than 5 feet is poor. The channel widths of the 11 ephemeral washes in the Study Area range from 0.8 to 4.2 feet, with an average of 2.6 feet. Of the gaged reference streams with a channel width between 1 and 3 feet, the range of average annual discharges is significant. As one example, one stream with a channel width of 3.0 feet has an average annual discharge of 3,960 AFY, while another stream with a larger channel width of 3.5 feet has an average annual discharge of about 20 AFY. The wide range in discharge rates for gaged streams indicates that the regression model developed by Lines excludes one or more important factors that affect the annual discharge rate in a desert wash, most notably among the potential factors is the amount of precipitation in the watershed above the gage.

Additionally, the assumption by Lines that annual tributary flows occur at the same relative magnitude as the ephemeral flows recorded at the Barstow gage is not supported by available rainfall and streamflow data. Stormflows in the Mojave River are primarily from winter storms from the Pacific Northwest in the San Bernardino Mountains. Runoff in ephemeral desert washes is primarily from rainfall in the local mountains and along the margins of the Basin and is distributed between winter storms and isolated summer thunderstorms created by monsoonal moisture. This assumption is discussed in further detail in Section 1.4.

1.3.4 Stamos et al. (2001)

In the regional groundwater flow model of the Mojave River Basin, Stamos et al. (2001) applies the average annual runoff estimates by Lines for mapped ephemeral washes to surface flows in the Mojave River. Annual variations in ungaged local runoff are estimated based on the assumption by Lines that local runoff is related to stormflows recorded at the Barstow gage. However, contributions from other areas within the Mojave River surface water drainage basin that are not concentrated in an ephemeral wash are not applied in the USGS model.

Within the USGS model, local mountain runoff is also assigned to areas that drain away from the Mojave River and recharge the groundwater system. Constant recharge of mountain-front recharge was assigned in the northern portion of Coyote Lake (259 AFY) and along the basin margin near Kane Wash (647 AFY) totaling about 906 AFY. No mountain-front recharge is assigned in the Harper Lake area.

Additionally, the USGS model estimates groundwater discharge as evaporation from the three dry lakes in the Study Area. While evaporation at Harper Dry Lake was recorded early in the transient state simulation, evaporation of groundwater at Harper Dry Lake ceased in the mid-1960s due to groundwater level declines as a result of local overproduction of groundwater. Even with recent water level recoveries, evaporation at Harper Dry Lake did not return at the end of the simulation period. Groundwater discharge as evaporation at Troy Dry Lake was less than 10 AFY throughout the transient-state simulation period. Finally, groundwater discharge at Coyote Dry Lake was relatively steady form 1931 to 1999, averaging about 600 AFY in the last 10 years of the simulation period (1990 to 1999).

1.3.5 W&B (2012)

W&B (2012) offer an alternative approach to the Lines study for estimating discharge in the six ephemeral washes in the Baja Subarea. Similar to the Lines study, estimates of runoff are not provided for internally drained areas (e.g. watersheds of Harper Lake, Coyote Lake, and Troy Lake). In the W&B study, seven separate runoff coefficients (termed unit discharges in the report) are calculated for seven different gaged reference streams in the Mojave Desert by comparing the weighted-average annual rainfall from an isohyetal map developed by Rantz (1969) and drainage area to gage records. The Rantz isohyetal map is shown in the upper right corner of **Figure C1**.

Runoff coefficients in the W&B study range from 0.03 to 0.49 percent of rainfall, which are lower than the runoff coefficient uniformly applied within the Study Area by DWR (1.0 percent). As pointed out in the W&B report, the application of the Lines regression model to the seven reference ephemeral washes would provide a total annual average discharge of 1,573 AFY, one order of magnitude higher than the actual total gaged measurements (159 AFY).

The range of runoff coefficients are applied to the six ephemeral washes in the Baja Subarea, for which the drainage area and weighted-average annual rainfall in the drainage area were estimated. The weighted-average rainfall for each of the six washes ranged from 3.5 to 4.5 inches, with an overall average of about 4.25 inches. Results of the analysis are shown in **Table C3** along with the estimates by Lines for comparison. As shown in the table, total discharge for the six ephemeral washes in Baja Subarea range from 11 to 205 AFY. No attempt is made to estimate discharge for the ephemeral washes in Centro Subarea. The W&B study also does not evaluate local runoff from drainage areas outside those of ephemeral streams mapped by Lines.

The method applied in the W&B report is more robust than the method used by Lines to estimate contribution of local runoff concentrated in mapped ephemeral streams. Unlike the Lines study, the W&B study accounts for the amount of precipitation in the drainages of gaged reference streams and Study Area ephemeral washes. The method is also based directly on relationships from several comparable reference streams, and is thus considered more robust than the method used by DWR. One potential limitation of the Wagner method is the use of the Rantz isohyetal map. The Rantz isohyetal map was developed from manual contouring of rainfall data from 1900 to 1960.

Table C3
Summary of Ungaged Local Runoff Estimates
Lines (1996) vs. W&B (2012) Estimates

Site Number and Name	Drainage Area		Lines (1996)	W&B (2012)	
			Annual Discharge	Annual Discharge[a]	
				Low	High
	mi^2	acres	AFY	AFY	AFY
Site 17. Boom Creek	1.6	1,024	100	0.1	2
Site 18. Daggett Wash	24	15,360	400	1	22
Site 19. Calico Wash	100	64,000	400	6	119
Site 20. Manix Wash	45.2	28,928	500	3	52
Site 21. Wilhelm Wash	7.6	4,864	200	0.4	8
Site 22. Unnamed	1.6	1,024	30	0.1	2
Total Sites 17-22	**180**	**115,200**	**1,630**	**11**	**205**

[a] Low represents 0.03 percent runoff;
High represents 0.49 percent runoff

1.4 Comparison of Lines and W&B Estimates to Actual Gaged Flows at Boom Creek

To further evaluate the discharge estimates of ephemeral washes presented in the Lines and W&B reports, historical stream gage data for one of the “ungaged” tributary wash in the Study Area (Site 17. Boom Creek) was obtained through the USGS NWIS database. Mean daily streamflow records for Boom Creek are available for WYs 1967-73. Examination of the Boom Creek record reveals that Boom Creek flowed for a total of 10 days over this seven-year period, as shown in **Table C4**. The total discharge over the seven-year period was 11.6 AF, or 1.7 AFY. It is important to point out that that the drainage area above the Boom Creek gage (154 acres) is much smaller than the drainage area reported by Lines (1,024 acres), which includes additional acreage between the Boom Creek gage and the estimated point of discharge in the Mojave River.

Table C4
Dates of Measurable Discharge in Boom Creek
(WY 1966-67 to WY 1972-73)

Date of Measurable Discharge	Discharge	
	cfs	AF
15-Jul-67	0.2	0.4
07-Jun-68	0.47	0.9
06-Sep-69	0.94	1.9
26-Aug-70	2.2	4.4
02-Jun-72	0.46	0.9
07-Jun-72	1.4	2.8
19-Oct-72	0.02	0.0
20-Oct-72	0.03	0.1
11-Feb-73	0.05	0.1
14-Feb-73	0.06	0.1
Total Discharge(AF)		11.6
Average Annual Discharge(AFY)		1.7
Total Precipitation at Barstow rain gage over 7 years (in)		26.21
Average Annual Precipitation at Barstow rain gage over 7 years (in/yr)		3.74
Boom Creek Discharge (inches)		0.13
Boom Creek Discharge (%) rainfall		3.4%

Boom Creek gage watershed = 154 acres (0.24 mi^2)
Boom creek watershed in Lines (1996) and
W&B (2012) = 1,024 acres (1.6 mi^2)

It is notable that the available record for Boom Creek includes WY 1968-69, one of the wettest years on record in the San Bernardino Mountains, which produced an annual flow in the Mojave River at Barstow of 146,600 AF (representing approximately 900 percent of the average annual flow at Barstow). The application of the Lines regression model and assumption of annual flows to Boom Creek would provide an estimate of about 900 AFY. In fact, no runoff was recorded at the Boom Creek gage during the January and February 1969 winter storms in the San Bernardino Mountains when most of the stormflows were recorded at the Barstow gage. Rainfall at the Barstow gage in January and February of 1969, while above average, were only 1.0 and 2.2 inches, respectively.

Because the drainage area for Boom Creek is relatively small and close to the valley floor, weighted-average rainfall on the watershed is probably represented well by rainfall on the valley floor. Average annual rainfall at Barstow gage during the seven-year period was 3.74 inches (representing 86 percent of the long-term average of 4.37 inches). Based on the 154-acre gage drainage area and 3.74 inches of average rainfall at the Barstow rain gage, the average annual discharge in Boom Creek over the seven-year period represents 3.4 percent of rainfall. While the runoff coefficient for Boom Creek is much higher than previous estimates by DWR and W&B, the average annual gage flow (1.7 AFY) is two orders of magnitude lower than the 100 AFY estimated by Lines. Interestingly, the Boom Creek flows actually resemble Beacon Creek at Helendale, one of the 29 gaged streams used by Lines to develop his regression model. Beacon Creek has a channel width of 1.0 foot, weighted-average annual drainage area precipitation of 4.5 inches per year (based on estimates by W&B, 2012), and an average annual discharge of 0.7 AFY. This data point is labeled in **Figure C3**.

The runoff coefficient for Boom Creek (3.4 percent of rainfall) is larger than those reported for the seven gaged reference ephemeral streams by W&B (0.03 to 0.49 percent of rainfall). However, the difference of actual Boom Creek discharge (1.7 AF) and the upper estimate by W&B (adjusted to the drainage area for the Boom Creek gage) of 0.24 AF is small.

Overall, the historical streamflow record of the Boom Creek provides an important data point within the Study Area that 1) confirms the significant difference in rainfall patterns in the Study Area versus the San Bernardino Mountains, 2) further highlights the limitations in the regression model used by Lines, 3) and suggests that the higher runoff coefficient of the seven reference gages (0.49 percent) by W&B may be more appropriate. Due to the small drainage area for Boom Creek and short period of record, the runoff coefficient from Boom Creek should be viewed cautiously and should not be used to provide estimates of mountain runoff for the entire Study Area.

1.5 Summary of Findings from Previous Studies

The following conclusions can be made based on the evaluation of previous studies on local runoff:

1. Local runoff estimates in the Study Area reported by DWR (1967) are reasonable, but are based on the relationship between rainfall and runoff adjusted to one stream, Deep Creek.

1. Estimates of local runoff concentrated into ephemeral washes by Lines are limited by their dependence on a poor correlation between channel width and annual discharge for narrow washes (less than 5 feet). The poor correlation results from the exclusion of other important factors that control local runoff, most notably the amount of precipitation within the watersheds of referenced gaged streams.

2. The method used by W&B is more robust than the method used by Lines to estimate contribution of local runoff concentrated in mapped ephemeral streams. Unlike the Lines study, the W&B study accounts for the amount of precipitation in the drainages of gaged reference streams and Study Area ephemeral washes. The method is also based directly on relationships from several comparable reference streams, and is thus considered more robust than the method used by DWR.

3. The W&B study does not evaluate local runoff from drainage areas outside those of ephemeral streams mapped by Lines.

1.6 Revised Local Runoff Estimates

While the W&B (2012) study applies the most rigorous method to estimate local runoff, it does not provide estimates for mountain runoff for drainage areas outside those for mapped ephemeral streams. To estimate total contributions from local runoff in the Study Area, the upper runoff coefficient from the W&B study (0.49 percent) was applied to the weighted-average rainfall over contributing areas outside of the Mojave River Basin groundwater flow model area (non-basin areas). **Figure C5** shows the different non-basin regions reflect a combination of areas defined by basin boundaries presented by DWR (1967) and the Centro and Baja subarea boundaries.

Table C5 shows the revised estimates of local runoff for the different contributing non-basin regions across the Study Area.

Table C5
Revised Estimates of Average Annual Recharge from Local Storm Runoff within Study Area

Contributing Non-Basin Area	Area		Weighted-Average Annual Rainfall[a]	Runoff Coefficient	Average Annual Runoff
	acres	mi^2	in/yr	%	AFY
Centro – Mojave River	216,007	338	6.02	0.49%	530
Centro – South Harper Valley	131,867	206	4.70	0.49%	250
Centro – South Harper Lake	48,688	76	4.30	0.49%	85
Centro – North Harper Lake	160,844	251	5.20	0.49%	340
Baja – Mojave River[b]	280,954	439	5.48	0.49%	630
Baja – Coyote	101,167	158	4.98	0.49%	205
Baja – Caves	71,464	112	4.26	0.49%	125

[a]calculated using GIS Spatial Analyst based on PRISM (2004) Isohyetal Map for WYs 1971 to 2000
[b]includes area that drains towards Troy Dry Lake

As shown in **Table C4** and **Figure C5**, total estimated ungaged local runoff within the Centro Subarea is 1,205 AFY. Of this amount, 530 AFY is generated within the Mojave River drainage basin including areas southeast of Hinkley Gap; the remaining 675 AFY is generated in areas that drain towards the Harper Dry Lake drainage basin northeast of Hinkley Gap (including South Harper Valley, South Harper Lake, and North Harper Lake). The estimated total ungaged local runoff within the Baja Subarea is 960 AFY. Of this amount about 755 AFY is generated within the Mojave River drainage basin upstream of the Afton gage with 630 AFY occurring above the Caves area; 205 AFY contributing to groundwater recharge that drains towards Coyote Dry Lake).

All runoff is assumed to infiltrate to recharge the groundwater system (i.e., not subject to further evaporation) beneath ungaged ephemeral washes, the Mojave River channel, or along alluvial margins

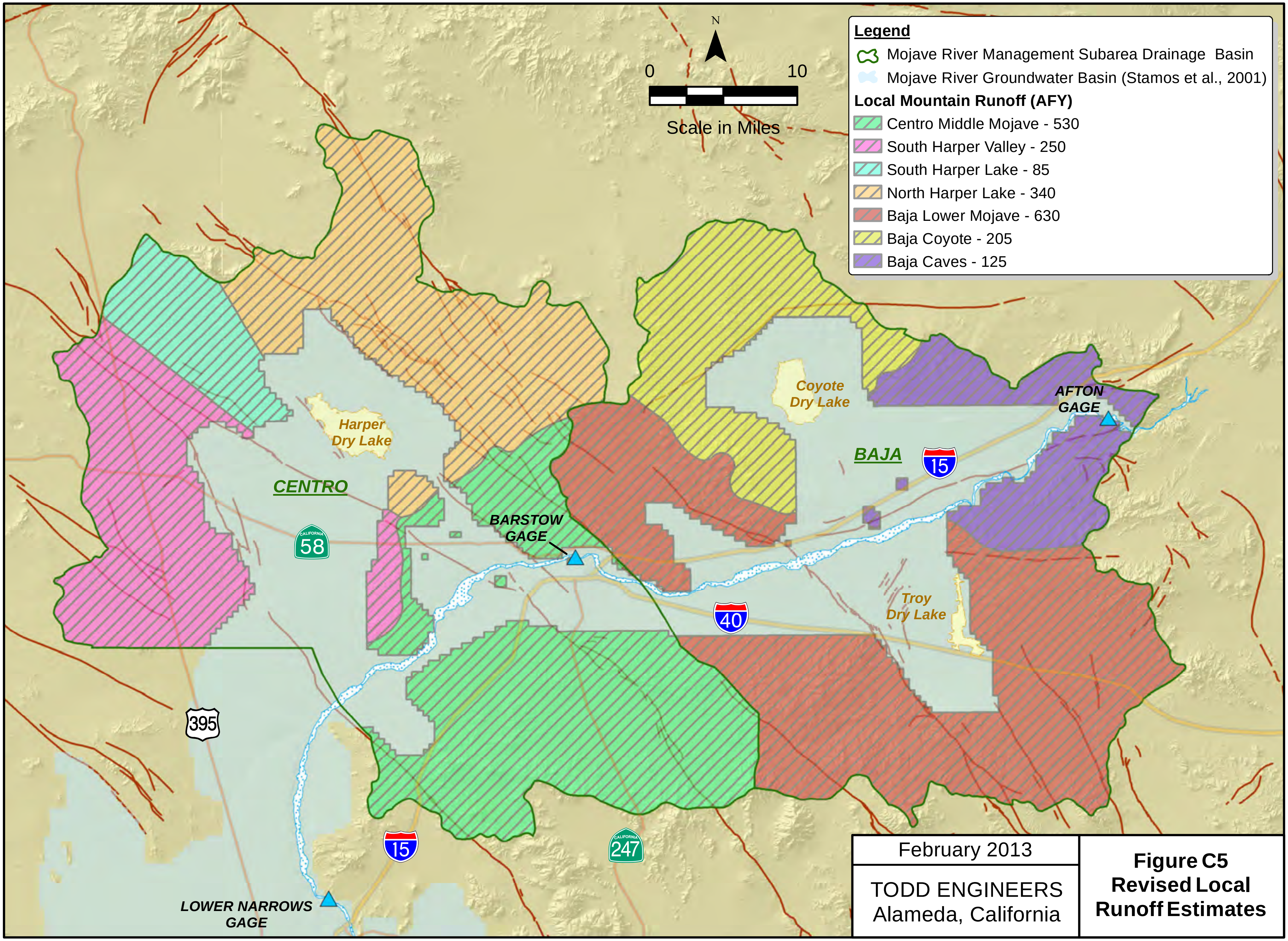

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Figure C5
Revised Local Runoff Estimates

of the basin. Additional field investigations are required to confirm this assumption. It is recognized that local variability in runoff exists across the Study Area due to differences in surficial geology, slope, vegetation coverage, and the range of annual rainfall within each drainage area. However, for the purposes of this study, estimates presented herein are considered reasonable and incorporate the most current and reliable information and data.

1.7 Conclusions

Based on the focused evaluation of local runoff, the following conclusions can be made:

- Examination of gaged flows in Boom Creek for available years indicate that the upper estimate of average annual runoff in Boom Creek by W&B (1.9 AFY), which is two orders of magnitude lower than the estimate reported by Lines (100 AFY), is reasonable.

- Uncertainty in average annual local runoff estimates by Lines for specific ungaged tributary washes in the Study Area is magnified in the extrapolated estimates of local runoff entering the Lower Stem and Middle Stem of the Mojave River.

- Rainfall patterns on the desert floor indicate that the relative magnitude and timing of ungaged local runoff varies significantly from the magnitude and frequency of storms generated in the San Bernardino Mountains.

- Local runoff estimates for specific ephemeral washes reported in W&B (2012) are considered the most reliable estimates of local runoff, because these estimates consider the amount of precipitation in watersheds of numerous gaged reference watersheds and Study Area watersheds.

- Application of W&B of the upper runoff coefficient estimated by Lines for seven reference gages (0.49 percent) to weighted-average rainfall for non-basin areas results in 1,205 AFY of mountain-front recharge in the Centro Subarea (including the Harper Lake area) and 960 AFY in the Baja Subarea (including the Afton/Caves area).

1.8 References

(See master reference list in main report)