CHAMP Phase III, San Miguel County, Colorado
Hydrologic Analyses Report

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List of Abbreviations

CDOT	Colorado Department of Transportation
CHAMP	Colorado Hazard Mapping Program
CWCB	Colorado Water Conservation Board
DEM	Digital Elevation Model
EMA	Expected Moments Algorithm
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
HEC-HMS	Hydrologic Engineering Center – Hydrologic Modeling Software
HEC-SSP	Hydrologic Engineering Center – Statistical Software Package
LOMA	Letter of Map Amendment
LPIII	Log-Pearson Type III
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
USDA	United States Department of Agriculture
USGS	United States Geological Survey

Introduction

Amec Foster Wheeler is working with the Colorado Water Conservation Board (CWCB) to develop data in the Flood Risk Project for the Colorado Hazard Mapping (CHAMP) Phase III project for the Federal Emergency Management Agency (FEMA) that may or may not result in new or updated Flood Insurance Rate Maps (FIRM) and Flood Insurance Study (FIS) reports.

Scope

New detailed and approximate hydrology was developed for several streams within San Miguel County. Detailed hydrology was developed for the Zone AE (detailed study) sections of the San Miguel River through the communities of Sawpit, Placerville and Telluride, Fall Creek near the community of Sawpit, and Leopard Creek near the community of Placerville. The detailed hydrology for the San Miguel River through the communities of Sawpit and Placerville was developed using Bulletin 17C flood frequency analysis (FFA) methods using Hydrologic Engineering Center – Statistical Software Package (HEC-SSP). Bulletin 17C FFA methods were also used for the Zone A (approximate study) sections of the San Miguel River due to continuous flows between the Zone A reaches and the Zone AE reach. The detailed hydrology for the San Miguel River upstream of the community of Telluride, in addition to Fall Creek and Leopard Creek, was developed using Hydrologic Engineering Center – Hydrologic Modeling Software (HEC-HMS) procedures. Regression equations were used to determine the hydrology for all remaining Zone A reaches in the county. A summary of the Zone AE reaches is shown in Table 1. The scoped Zone A and Zone AE reaches in San Miguel County are displayed in

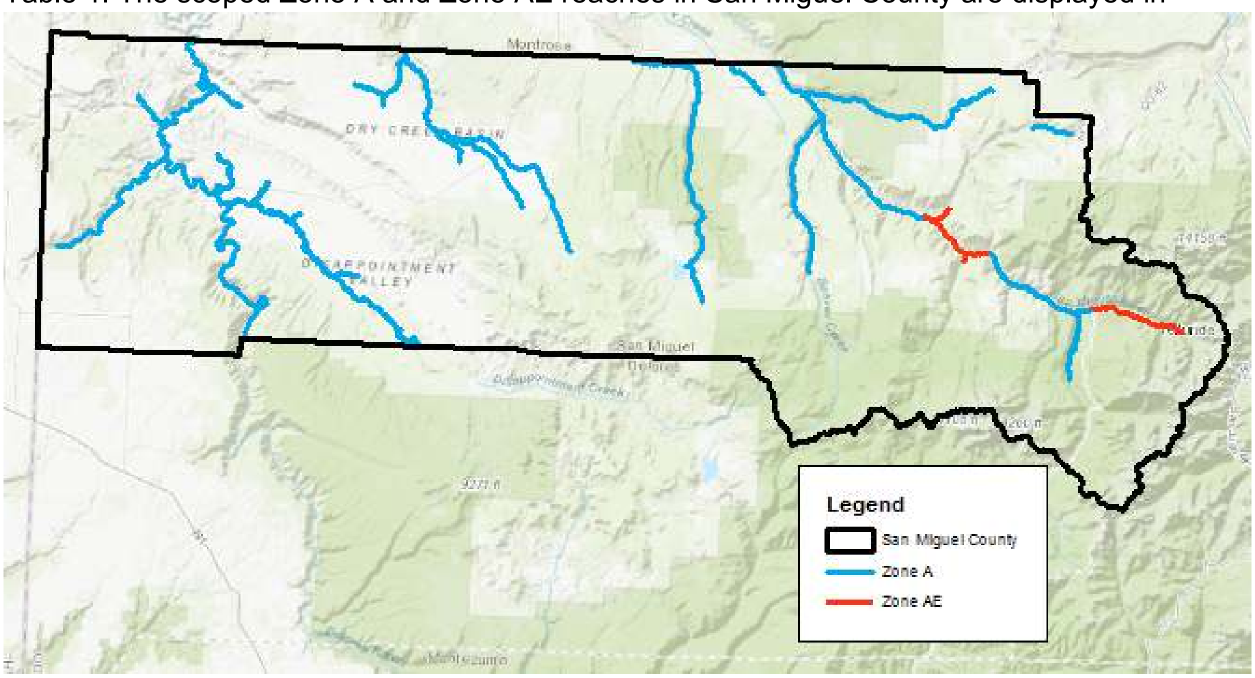

Figure ***1***.

Table 1 – Detailed Study Summary of Methods

Flooding Source	Reach	Stream Miles	Hydrologic Methodology

San Miguel River Reach 2	From approximately 4,500 feet downstream of the confluence of Leopard Creek to approximately 8,500 feet upstream of the confluence with Fall Creek	5.5	Bulletin 17C Stream Gage Analysis
San Miguel River Reach 4	From approximately 5,000 feet downstream of Highway 145 to the confluence of Marshall Creek	6.5	HEC-HMS
Fall Creek	From the confluence with the San Miguel River to approximately 3,050 feet upstream of the mouth	0.6	HEC-HMS
Leopard Creek Reach 1	From the confluence with the San Miguel River to approximately 7,500 feet upstream of the mouth	1.4	HEC-HMS

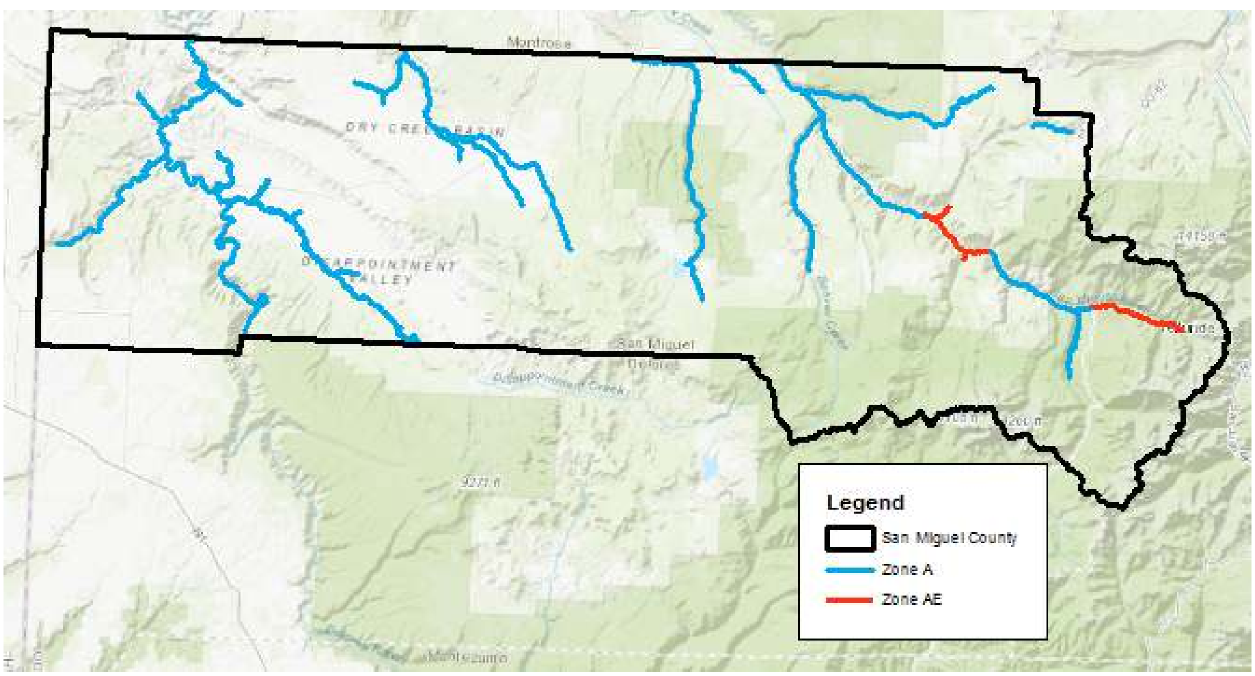

Figure 1 – Zone A and Zone AE reaches in San Miguel County

Existing Hydrology

Flood Insurance Study

San Miguel, Colorado currently has a countywide FIS, published in 1992. This includes the Towns of Sawpit and Telluride and Unincorporated San Miguel County. The FIS shows that Zone AE detailed were performed for the San Miguel River at Placerville and near Telluride, Fall Creek, and Leopard Creek. For the rest of the county, various Zone A areas have been delineated.

Letters of Map Change

There are eleven letters of map change within San Miguel County. Three of these are Letters of Map Revision (LOMR) and eight are Letters of Map Amendment (LOMA). All three of the LOMRs provide updated hydraulics for portions of the San Miguel. No hydrology appears to have been updated.

Proposed Hydrology

Method Selection

Several hydrologic methodologies were used in determining the hydrology for San Miguel County. Bulletin 17C stream gage analysis was used to determine the hydrology for all reaches of the San Miguel River except the most upstream reach beginning near the Town of Telluride. HEC-HMS models (Version 4.2.1) were constructed to determine the hydrology for the remaining San Miguel River reach, in addition to Fall Creek, and both detailed and approximate portions of Leopard Creek. Bulletin 17C stream gage analysis was also used to determine the hydrology for all Zone A reaches of the Dolores River within the County. Regression analyses were used for the hydrology for all remaining Zone A reaches.

Bulletin 17C Stream Gage Analysis using Log-Pearson Type III and EMA

Gages were evaluated in HEC-SSP Version 2.1.1 using Log-Pearson Type III (LPIII) and Expected Moments Algorithm (EMA) outlined in Bulletin 17C. The annual peak flow data was extracted directly from the USGS websites when performing the HEC-SSP Bulletin 17C analysis. Skew is a measure of the asymmetry of the probability distribution of a real-valued random variable about its mean. The station skew option is based solely on computing a skew from the data points contained in the dataset. Station skew was chosen due to the significant record length at the gage.

Two gages were used to develop/verify the flows for the San Miguel River Reaches:

- USGS gaging station – San Miguel River near Placerville (09172500)
- USGS gaging station – San Miguel River at Naturita (09175500)

Four gages were used to develop/verify the flows for the Dolores River Reach:

- Department of Water Resources (DWR) gage at the outlet of McPhee Reservoir
- USGS gaging station – Dolores River near Slick Rock (09168730)
- USGS gaging station – Dolores River at Bedrock (09169500)
- USGS gaging station – Dolores River near Bedrock (09171100)

More detail on how these gages were used in the Bulletin 17C analysis is provided below.

USGS Qualification Codes

Qualification codes were available for the Dolores River near Slick Rock, at Bedrock, and near Bedrock gages as well as the San Miguel River Near Placerville. Table 2 shows the codes encountered within the data.

Table 2 - USGS Qualification Codes and Approach

Code #	Description	Approach
1	Discharge is a Maximum Daily Average	No change in approach.
2	Discharge is an Estimate	Added 25% error bounds for the low and high flow thresholds.
3	Discharge affected by Dam Failure	Peak flow as recorded was used. Set low flow threshold to zero and high flow threshold equal to recorded flow.

Gage Projection

The methodology outlined in the Water Resources Investigations Report 99-4190 “Analysis of the Magnitude and Frequency of Floods in Colorado” was consulted to project gage results to locations on the same stream. The San Miguel River watershed is located within the Southwest Region so an exponent (x) of 0.71 as used in Equation (3) from the Water Resources Investigations Report.

$$Q_{T(u)} = Q_{T(g)}(A_u/A_g)^x$$

Equation (3): Peak Discharge Projection

Where $Q_{T(u)}$ is the peak discharge, in cubic feet per second, at the ungaged site for T-year recurrence interval; $Q_{T(g)}$ is the weighted peak discharge, in cubic feet per second, at the gaged site for T-year recurrence interval; A_u is the drainage area, in square miles, at the ungaged site; A_g is the drainage area, in square miles, at the gaged site; and x is the average exponent for drainage area.

San Miguel River Flows

The peak discharge projection was used to project the Bulletin 17C flows from the San Miguel River near Placerville gage to various locations in both the Zone A and Zone AE reaches. This projection is limited to 0.5 to 1.5 times the drainage area at the projected gage. For this analysis, the projection was extended downstream to 1.58 times the drainage area to reach the bottom of the Zone A reach. The next downstream gage (09174000 San Miguel River near Nucla) only had 9 records and was not analyzed. The next gage (09175500 San Miguel River at Naturita) was examined, however the projected flows were lower than the flows from the near Placerville gage, so that gage was used instead. At the upstream end, the Placerville gage was projected up to 0.5 times the drainage area and those calculated flows were then applied for all parts of the San Miguel River Reach 3 below the confluence of South Fork San Miguel River. This was done to be conservative with the flows for this reach and to also tie into flows from the HMS analysis of San Miguel River Reach 4.

Dolores River Flows

Flows for this reach were developed using a combination of gages. The primary gage used was the Dolores River near Slick Rock (09168730). This gage had 16 years of record but had a gap in data between the years 2004 and 2007. To fill this gap in data, flows from the DWR gage below the McPhee reservoir outlet were added to the Slick Rock records for the years 1990-1996 and 2004-2007. These records represent the minimum flow which would be at the Slick Rock gage as this was the flow leaving McPhee Reservoir and were based on a calculated maximum of the daily peak flows reported at the gage using an Excel pivot table. These values were used as both the peak points and low flow points in the FFA. For the high flow points, flows from the downstream gage at Bedrock (09169500) were used to create interval data for the missing flows. This combined gage analysis was run and then compared to projected flows for the same years from the two gages around Bedrock and was within 3% of both of those projected gaged flows. The flows from this combined gage at Slick Rock was then projected upstream to the study area. Table 3 shows the projected flows from the Bulletin 17C Analysis and resulting flow projection. The calculations for this gage are included in the Supplemental _Data folder of the Gage_Watersheds Deliverable. These flows were projected to various locations along the Zone A Reach.

Table 3 – Bulletin 17C Stream Gage Analysis

Gage/Location		Drainage Area [2] (mi^2)	Projection Ratio	Peak Discharge (cfs)					
Number	Name			10%	4%	2%	1%	1% Plus	0.2%
	San Miguel River Reach 1 at San Miguel and Montrose County line	489	1.58	3,080	3,640	4,130	4,640	5,490	6,040
	San Miguel River Reach 1 below confluence of Beaver Creek	426	1.38	2,790	3,300	3,740	4,210	4,970	5,480
	San Miguel River Reach 1 below confluence of Saltado Creek	333	1.08	2,340	2,770	3,140	3,530	4,180	4,600
09172500	San Miguel River near Placerville, CO	309		2,220	2,630	2,980	3,350	3,960	4,360
	San Miguel River Reach 1 above confluence of Specie Creek	295	0.95	2,150	2,540	2,880	3,240	3,830	4,220
	San Miguel River Reach 2 above confluence of Leopard Creek	223	0.72	1,760	2,090	2,360	2,660	3,140	3,460
	San Miguel River Reach 2 above confluence of Fall Creek	176	0.57	1,490	1,760	2,000	2,250	2,660	2,920
	San Miguel River Reach 3 above confluence of Bear Creek	146	0.47	1,300	1,540	1,750	1,970	2,330	2,560
	San Miguel River Reach 3 below confluence of South Fork San Miguel River [2]	108	0.35	1,300	1,540	1,750	1,970	2,330	2,560
	Dolores River at county line of San Miguel and Montrose	1,640	1.14	4,480	5,570	6,270	6,860	9,030	7,970
	Dolores River approximately 5,500ft upstream of County Road S8	1,490	1.04	4,180	5,200	5,860	6,410	8,440	7,450
09168730	Dolores River Near Slick Rock, CO	1,434	-	4,070	5,060	5,700	6,240	8,210	7,250
	Dolores River below confluence of Dolores and Disappointment Creek	1,040	0.73	3,240	4,030	4,540	4,970	6,540	5,770

[1] Per WRIR 99-4190 - Coefficient for the Southwest Region for projecting gaging stations on the same stream is 0.71 and is ideally applicable when drainage areas are between 0.5 and 1.5 times the drainage area of the projected gage.

[2] Rather than projecting below the 0.5 threshold, flows below the South Fork San Miguel River Confluence were set equal to the flows projected above the confluence of Bear Creek.

Regression Equation Methodology

The regression equation method was used for all Zone A streams within San Miguel County not studied by other methods. The regression equations are taken from the Scientific Investigations Report (SIR) 2009-5136 titled "*Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado*". Additionally, for low-lying areas near the Utah border, regression equations from the SIR Report 2007-5158 titled "*Methods for Estimating Magnitude and Frequency of Peak Flows for Natural Streams in Utah"* were used. The regional regression equations developed in these reports are derived from statistical relationships between stream flow records and applicable station, basin and climatic characteristics. Regional regression equations along with predicted uncertainty are generally a reliable and cost-effective means for estimating streamflow statistics at ungagged sites.

The USGS online modeling program, StreamStats, was used to delineate the watershed, generate supporting shapefiles and produce the USGS regression equation peak flow outputs for each stream. StreamStats allows the user to obtain streamflow statistics for both gaged and ungaged sites by selecting a specific stream location on a map interface. If user selects the location of a USGS stream gage, the user will receive previously published information for the stream gage from a database. If the location of interest lacks a stream gage, StreamStats delineates the basin upstream from the selected location, computes basin and climatic characteristics, and provides estimates of the streamflow statistics using the latest regional regression equations for that area, providing a weighted average if the basin falls within multiple hydraulic regions.

Flow change locations along each stream were delineated at regular intervals from the outlet up the streams. A flow change location was determined by finding the location on the stream where an approximate 8% reduction in the 100-year peak flow occurs compared to the outlet. From the first point after the outlet on, the user delineated up the stream until an approximate 10% reduction in the 100-year peak flow from the previously determined point was found and determined to be the next flow change location.

San Miguel County is located entirely within the Southwest Hydrologic Region. The regression equations for the Southwest Region are shown in Figure 2 below. For the areas using the Utah regression equations, the area in question was assumed to be in Region 6. The regression equations for Region 6 are shown in Figure 3 below.

Peak Streamflow Equations for Southwest Region

Generalized least-squares (GLS) regression, 78 stations

Approximate range of predictor variables

A: 1–4,390 square miles and A_{7500}: 0–100 percent

$Q_2 = 10^{1.67} A^{0.64} A_{7500}^{-0.10}$	√	$SEP = 90$,	pseudo$R^2 = 70$,	$SME = 87$,
$Q_5 = 10^{2.13} A^{0.62} A_{7500}^{-0.19}$	√	$SEP = 71$,	pseudo$R^2 = 75$,	$SME = 69$,
$Q_{10} = 10^{2.36} A^{0.61} A_{7500}^{-0.23}$	√	$SEP = 67$,	pseudo$R^2 = 77$,	$SME = 64$,
$Q_{25} = 10^{2.61} A^{0.60} A_{7500}^{-0.27}$	√	$SEP = 66$,	pseudo$R^2 = 78$,	$SME = 63$,
$Q_{50} = 10^{2.77} A^{0.59} A_{7500}^{-0.30}$	√	$SEP = 67$,	pseudo$R^2 = 78$,	$SME = 63$,
$Q_{100} = 10^{2.91} A^{0.59} A_{7500}^{-0.33}$	√	$SEP = 69$,	pseudo$R^2 = 78$,	$SME = 65$,
$Q_{200} = 10^{3.04} A^{0.58} A_{7500}^{-0.36}$	√	$SEP = 71$,	pseudo$R^2 = 77$,	$SME = 67$, and
$Q_{500} = 10^{3.21} A^{0.58} A_{7500}^{-0.39}$	√	$SEP = 75$,	pseudo$R^2 = 77$,	$SME = 70$.

Figure 2 – Peak Streamflow Equations for the Southwest Hydrologic Region

[SEP, standard error prediction; SME standard model error]

Regression equation for given recurrence interval (2- to 500-year)	Average standard error of prediction, in percent	Model error, in percent	Equivalent years of record
Region 6 (equation based on data from 99 streamflow-gaging stations)			
PK2 = 4,150 DRNAREA$^{0.553}$ (ELEV/1,000)$^{-2.45}$	108	106	1.44
PK5 = 13,100 DRNAREA$^{0.479}$ (ELEV/1,000)$^{-2.44}$	80	78	3.01
PK10 = 24,700 DRNAREA$^{0.444}$ (ELEV/1,000)$^{-2.47}$	70	68	5.06
PK25 = 49,500 DRNAREA$^{0.411}$ (ELEV/1,000)$^{-2.51}$	62	60	8.43
PK50 = 77,400 DRNAREA$^{0.391}$ (ELEV/1,000)$^{-2.54}$	60	58	10.95
PK100 = 115,000 DRNAREA$^{0.391}$ (ELEV/1,000)$^{-2.58}$	61	58	12.97
PK200 = 166,000 DRNAREA$^{0.361}$ (ELEV/1,000)$^{-2.61}$	62	60	14.42
PK500 = 258,000 DRNAREA$^{0.344}$ (ELEV/1,000)$^{-2.65}$	66	63	15.40

Figure 3 – Peak Streamflow Equations for the Utah Region 6 Hydrologic Region

Most of the Zone A areas within San Miguel County are forked tributaries from other Zone A areas until the downstream tributary ultimately reaches its confluence with the Colorado River. Watersheds for these tributaries are delineated by specifying drainage points at tributaries just upstream of their confluences with the downstream tributary in StreamStats. In many cases to be conservative, the highest flows obtained from within the basin were applied to the entire reach.

In the cases of Big Gypsum Creek, Nicholas Wash, West Fork Dry Creek, Dolores River Tributary 1, and the upper most part of Dolores River Tributary 2 (Summit Canyon Creek) the southwester regression equations were not applicable. Due to either an upstream decrease in watershed area above 7,500 feet, or a total watershed area above 7,500 feet of zero square miles, the Southwest Regression equations resulted in higher flows upstream than downstream or were producing unreasonably high flows which did not make sense. To account for this, the peak flow values were derived using the Utah regression equations for Utah's region 6 defined in *USGS Scientific Investigations Report 2007-5158.* These flows were compared to downstream flows derived from the Southwest Colorado regression equations and found to be more reasonable for these particular streams.

Table 4 shows a summary of the regression equation results as well as the error bounds for the expected values. Rows highlighted in grey are the reaches which used the Utah Regression equations. The drainage areas listed reflect the location of the point, however the peak discharges listed reflect the highest flows on the reach being applied.

Table 4 – Regression Analysis Parameters and Results

Location	Drainage Area (mi^2)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
Beaver Creek, confluence with San Miguel River	76.8	1130 (373-1,890) 67% Error	1600 (544-2,660) 66% Error	1920 (634-3,210) 67% Error	2310 (716-3,900) 69% Error	3,900	3360 (975-6,830) 75% Error
Beaver Creek 11,400 ft downstream of confluence with Turner Creek	67.5	1030 (340-1,720) 67% Error	1470 (500-2,440) 66% Error	1770 (584-2,960) 67% Error	2130 (660-3,600) 69% Error	3,600	3090 (900-6,300) 75% Error
Beaver Creek Above confluence with Turner Creek	61.1	974 (321-1,630) 67% Error	1380 (469-2,290) 66% Error	1670 (551-2,790) 67% Error	2010 (623-3,400) 69% Error	3,400	2910 (850-5,950) 75% Error
Beaver Creek 5,700 ft upstream of confluence with Turner Creek	51.1	873 (288-1,460) 67% Error	1240 (422-2,060) 66% Error	1500 (495-2,510) 67% Error	1810 (561-3,060) 69% Error	3,060	2630 (765-5,360) 75% Error
Big Gypsum Creek at confluence with Dolores River	44.5	1450 (435-2,470) 70% Error	2380 (904-3,860) 62% Error	3270 (1,310-5,230) 60% Error	4510 (1,760-7,260) 61% Error	7,260	7450 (2,470-12,100) 66% Error
Dead Horse Creek at confluence with Dry Creek	12.1	559 (184-934) 67% Error	869 (295-1,440) 66% Error	1130 (373-1,890) 67% Error	1440 (446-2,430) 69% Error	2,430	2370 (608-4,250) 75% Error
Dead Horse Creek 450 ft downstream of Monogram Rd.	11.0	517 (171-863) 67% Error	802 (273-1,330) 66% Error	1040 (343-1,740) 67% Error	1320 (409-2,230) 69% Error	2,230	2170 (558-3,900) 75% Error
Dead Horse Creek about 3,000 ft upstream of Monogram Rd.	7.9	411 (136-686) 67% Error	636 (216-1,060) 66% Error	825 (272-1,380) 67% Error	1040 (322-1,760) 69% Error	1,760	1710 (440-3,080) 75% Error
Disappointment Creek at confluence with Dolores River	346.0	3390 (1,120-5,660) 67% Error	4890 (1,660-8,120) 66% Error	5950 (1,960-9,940) 67% Error	7330 (2,270-12,400) 69% Error	12,400	11000 (3,100-21,700) 75% Error

Location	Drainage Area (mi²)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
Disappointment Creek 300 ft downstream of Valley Rd.	316.0	3150 (1,040-5,260) 67% Error	4520 (1,540-7,500) 66% Error	5490 (1,810-9,170) 67% Error	6750 (2,090-11,400) 69% Error	11,400	10100 (2,850-20,000) 75% Error
Disappointment Creek 400 ft downstream of confluence with Spring Creek	280.0	2870 (947-4,790) 67% Error	4120 (1,400-6,840) 66% Error	5000 (1,650-8,350) 67% Error	6130 (1,900-10,400) 69% Error	10,400	9120 (2,600-18,200) 75% Error
Disappointment Creek above confluence with Spring Creek	210.0	2350 (776-3,920) 67% Error	3360 (1,140-5,580) 66% Error	4080 (1,350-6,810) 67% Error	4980 (1,540-8,420) 69% Error	8,420	7380 (2,110-14,700) 75% Error
Disappointment Creek 13,000 ft upstream of County Road 19Q	175.0	2100 (693-3,510) 67% Error	3010 (1,020-5,000) 66% Error	3660 (1,210-6,110) 67% Error	4470 (1,390-7,550) 69% Error	7,550	6630 (1,890-13,200) 75% Error
Disappointment Creek Trib 1 above confluence with Disappointment Creek	5.8	670 (221-1,120) 67% Error	1170 (398-1,940) 66% Error	1660 (548-2,770) 67% Error	2300 (713-3,890) 69% Error	3,890	4500 (973-6,810) 75% Error
Disappointment Creek Trib 1 12,000 ft above HW 141	4.9	605 (200-1,010) 67% Error	1060 (360-1,760) 66% Error	1510 (498-2,520) 67% Error	2080 (645-3,520) 69% Error	3,520	4080 (880-6,160) 75% Error
Disappointment Creek Trib 2 at confluence with Disappopintment Creek	3.5	490 (162-818) 67% Error	861 (293-1,430) 66% Error	1230 (406-2,050) 67% Error	1700 (527-2,870) 69% Error	2,870	3340 (718-5,020) 75% Error
Disappointment Creek Trib 2 about 3,600 ft upstream of confluence with Disappointment Creek	3.0	446 (147-745) 67% Error	784 (267-1,300) 66% Error	1120 (370-1,870) 67% Error	1550 (481-2,620) 69% Error	2,620	3060 (655-4,590) 75% Error
Dolores River Trib 1 above confluence with Dolores River	76.9	1590 (477-2,700) 70% Error	2570 (977-4,160) 62% Error	3480 (1,390-5,570) 60% Error	4790 (1,870-7,710) 61% Error	7,710	7680 (2,620-12,800) 66% Error
Dolores River Trib 1 above confluence with McIntyre Canyon	9.6	699 (210-1,190) 70% Error	1210 (460-1,960) 62% Error	1710 (684-2,740) 60% Error	2360 (920-3,800) 61% Error	3,800	4170 (1,290-6,310) 66% Error

Location	Drainage Area (mi²)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
Dolores River Trib 2 (Summit Canyon Creek) above confluence with Dolores River	49.9	1720 (568-2,870) 67% Error	2770 (942-4,600) 66% Error	3670 (1,210-6,130) 67% Error	4830 (1,500-8,160) 69% Error	8,160	8410 (2,040-14,300) 75% Error
Dolores River Trib 2 (Summit Canyon Creek) 3,500 ft downstream of confluence with Stevens Canyon Creek	45.4	1600 (528-2,670) 67% Error	2560 (870-4,250) 66% Error	3390 (1,120-5,660) 67% Error	4450 (1,380-7,520) 69% Error	7,520	7730 (1,880-13,200) 75% Error
Dolores River Trib 2 (Summit Canyon Creek) above confluence with Stevens Canyon Creek	39.1	1430 (472-2,390) 67% Error	2290 (779-3,800) 66% Error	3030 (1,000-5,060) 67% Error	3960 (1,230-6,690) 69% Error	6,690	6860 (1,670-11,700) 75% Error
Dolores River Trib 2 (Summit Canyon Creek) 9,000 ft below confluence with Bishop Canyon Creek	34.5	1300 (429-2,170) 67% Error	2070 (704-3,440) 66% Error	2740 (904-4,580) 67% Error	3580 (1,110-6,050) 69% Error	6,050	6160 (1,510-10,600) 75% Error
Dolores River Trib 2 (Summit Canyon Creek) below confluence with Bishop Canyon Creek	32.6	1250 (413-2,090) 67% Error	1990 (677-3,300) 66% Error	2630 (868-4,390) 67% Error	3440 (1,070-5,810) 69% Error	5,810	5930 (1,450-10,200) 75% Error
Dolores River Trib 2 (Summit Canyon Creek) above confluence with Bishop Canyon Creek	19.9	751 (225-1,280) 70% Error	1260 (479-2,040) 62% Error	1750 (700-2,800) 60% Error	2410 (940-3,880) 61% Error	3,880	4100 (1,320-6,440) 66% Error
Dry Creek at the border of Montrose and San Miguel County	154.0	2040 (673-3,410) 67% Error	2960 (1,010-4,910) 66% Error	3620 (1,190-6,050) 67% Error	4450 (1,380-7,520) 69% Error	7,520	6710 (1,880-13,200) 75% Error
Dry Creek above confluence with The Burn	96.5	1760 (581-2,940) 67% Error	2620 (891-4,350) 66% Error	3280 (1,080-5,480) 67% Error	4110 (1,270-6,950) 69% Error	6,950	6440 (1,740-12,200) 75% Error

Location	Drainage Area (mi^2)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
Dry Creek 7,500 ft downstream of confluence of Dry Creek and Dead Horse Creek	78.7	1480 (488-2,470) 67% Error	2190 (745-3,640) 66% Error	2740 (904-4,580) 67% Error	3400 (1,050-5,750) 69% Error	5,750	5280 (1,440-10,100) 75% Error
Dry Creek above confluence of Dead Horse Creek and Dry Creek	65.5	1300 (429-2,170) 67% Error	1920 (653-3,190) 66% Error	2390 (789-3,990) 67% Error	2970 (921-5,020) 69% Error	5,020	4580 (1,260-8,790) 75% Error
Dry Creek upstream of confluence of Dry Creek and Nelson Creek	33.7	824 (272-1,380) 67% Error	1220 (415-2,030) 66% Error	1520 (502-2,540) 67% Error	1870 (580-3,160) 69% Error	3,160	2880 (790-5,530) 75% Error
Dry Creek 4,000 ft upstream of HW 141	30.1	750 (248-1,250) 67% Error	1100 (374-1,830) 66% Error	1370 (452-2,290) 67% Error	1690 (524-2,860) 69% Error	2,860	2580 (715-5,010) 75% Error
Dry Creek 4,800 ft upstream of HW 141	26.0	668 (220-1,120) 67% Error	980 (333-1,630) 66% Error	1220 (403-2,040) 67% Error	1490 (462-2,520) 69% Error	2,520	2260 (630-4,410) 75% Error
East Fork McKenzie Creek above confluence with McKenzie Creek	6.8	255 (84-426) 67% Error	370 (126-614) 66% Error	457 (151-763) 67% Error	549 (170-928) 69% Error	928	815 (232-1,620) 75% Error
East Fork McKenzie Creek 6,000 ft upstream of confluence with McKenzie Creek	5.0	212 (70-354) 67% Error	309 (105-513) 66% Error	382 (126-638) 67% Error	460 (143-777) 69% Error	777	684 (194-1,360) 75% Error
East Fork McKenzie Creek 2,000 ft upstream of County Road Z60	4.2	190 (63-317) 67% Error	276 (94-458) 66% Error	343 (113-573) 67% Error	412 (128-696) 69% Error	696	615 (174-1,220) 75% Error
East Fork McKenzie Creek 1,400 ft upstream of Frontier Rd.	3.5	171 (56-286) 67% Error	250 (85-415) 66% Error	310 (102-518) 67% Error	373 (116-630) 69% Error	630	557 (158-1,100) 75% Error
Log Coral Creek/ At Mouth of Log Coral Creek	36.4	712 (235-1,190) 67% Error	1020 (347-1,690) 66% Error	1230 (406-2,050) 67% Error	1480 (459-2,500) 69% Error	2,500	2170 (625-4,380) 75% Error
McKenzie Creek above confluence with San Miguel River	47.5	843 (278-1,410) 67% Error	1200 (408-1,990) 66% Error	1460 (482-2,440) 67% Error	1750 (543-2,960) 69% Error	2,960	2560 (740-5,180) 75% Error

Location	Drainage Area (mi²)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
McKenzie Creek below confluence of McKenzie Creek and North Creek	41.4	770 (254-1,290) 67% Error	1100 (374-1,830) 66% Error	1330 (439-2,220) 67% Error	1600 (496-2,700) 69% Error	2,700	2330 (675-4,730) 75% Error
McKenzie Creek above confluence of McKenzie Creek and North Creek	31.9	657 (217-1,100) 67% Error	938 (319-1,560) 66% Error	1140 (376-1,900) 67% Error	1370 (425-2,320) 69% Error	2,320	2010 (580-4,060) 75% Error
McKenzie Creek below confluence of McKenzie Creek and Galloway Draw	27.4	597 (197-997) 67% Error	854 (290-1,420) 66% Error	1040 (343-1,740) 67% Error	1250 (388-2,110) 69% Error	2,110	1830 (528-3,690) 75% Error
McKenzie Creek above confluence of McKenzie Creek and Galloway Draw	19.9	491 (162-820) 67% Error	705 (240-1,170) 66% Error	861 (284-1,440) 67% Error	1035 (321-1,750) 69% Error	1,750	1520 (438-3,060) 75% Error
McKenzie Creek above confluence of McKenzie Creek and Sawdust Gulch	17.3	451 (149-753) 67% Error	648 (220-1,080) 66% Error	793 (262-1,320) 67% Error	953 (295-1,610) 69% Error	1,610	1400 (403-2,820) 75% Error
McKenzie Creek 5,000 ft upstream of confluence of McKezie Creek and Sawdust Gulch	14.3	402 (133-671) 67% Error	578 (197-959) 66% Error	709 (234-1,180) 67% Error	852 (264-1,440) 69% Error	1,440	1250 (360-2,520) 75% Error
McKenzie Creek 2,800 ft below confluence with East Fork McKenzie Creek	12.0	361 (119-603) 67% Error	520 (177-863) 66% Error	639 (211-1,070) 67% Error	768 (238-1,300) 69% Error	1,300	1130 (325-2,280) 75% Error
McKenzie Creek below confluence with East Fork Mckenzie Creek	10.2	327 (108-546) 67% Error	472 (160-784) 66% Error	580 (191-969) 67% Error	698 (216-1,180) 69% Error	1,180	1030 (295-2,070) 75% Error
Naturita Creek/ At Montrose County Line	146.0	1760 (581-2,940) 67% Error	2500 (850-4,150) 66% Error	3020 (997-5,040) 67% Error	3650 (1,130-6,170) 69% Error	6,170	5340 (1,540-10,800) 75% Error
Naturita Creek/ Approx. 4,600' upstream of Montrose County Line	124.0	1560 (515-2,610) 67% Error	2220 (755-3,690) 66% Error	2680 (884-4,480) 67% Error	3240 (1,000-5,480) 69% Error	5,480	4720 (1,370-9,590) 75% Error

Location	Drainage Area (mi^2)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
Naturita Creek/ At Mckee Draw	106.0	1400 (462-2,340) 67% Error	1980 (673-3,290) 66% Error	2380 (785-3,970) 67% Error	2870 (890-4,850) 69% Error	4,850	4170 (1,210-8,490) 75% Error
Naturita Creek/ Approx. 18,300' upstream of Mexican Canyon	91.5	1250 (413-2,090) 67% Error	1770 (602-2,940) 66% Error	2120 (700-3,540) 67% Error	2550 (791-4,310) 69% Error	4,310	3700 (1,080-7,540) 75% Error
Naturita Creek/ Just Downstream of East Naturita Creek Confluence	86.4	1210 (399-2,020) 67% Error	1710 (581-2,840) 66% Error	2050 (677-3,420) 67% Error	2470 (766-4,170) 69% Error	4,170	3570 (1,040-7,300) 75% Error
Naturita Creek/ Just Upstream of East Naturita Creek Confluence	61.4	979 (323-1,630) 67% Error	1390 (473-2,310) 66% Error	1680 (554-2,810) 67% Error	2020 (626-3,410) 69% Error	3,410	2930 (853-5,970) 75% Error
Naturita Creek/ Just Downstream of Log Corral Creek	53.1	896 (296-1,500) 67% Error	1270 (432-2,110) 66% Error	1540 (508-2,570) 67% Error	1853 (574-3,130) 69% Error	3,130	2690 (783-5,480) 75% Error
Naturita Creek/ Just Upstream of Log Corral Creek	16.8	444 (147-741) 67% Error	639 (217-1,060) 66% Error	782 (258-1,310) 67% Error	940 (291-1,590) 69% Error	1,590	1380 (398-2,780) 75% Error
Naturita Creek/ Approx. 1,800' Upstream of CO L40	11.8	358 (118-598) 67% Error	517 (176-858) 66% Error	634 (209-1,060) 67% Error	763 (237-1,290) 69% Error	1,290	1130 (323-2,260) 75% Error
Nelson Creek/ At Confluence with Dry Creek	30.6	851 (281-1,420) 67% Error	1280 (435-2,120) 66% Error	1610 (531-2,690) 67% Error	2010 (623-3,400) 69% Error	3,400	3170 (850-5,950) 75% Error
Nelson Creek/ Approx. 1,500' Upstream of Confluence with Dry Creek	25.5	734 (242-1,230) 67% Error	1100 (374-1,830) 66% Error	1380 (455-2,300) 67% Error	1720 (533-2,910) 69% Error	2,910	2680 (728-5,090) 75% Error
Nelson Creek/ Approx. 4,900' Downstream of U29W RD	23.0	672 (222-1,120) 67% Error	1000 (340-1,660) 66% Error	1260 (416-2,100) 67% Error	1560 (484-2,640) 69% Error	2,640	2420 (660-4,620) 75% Error
Nelson Creek/ At U29 RD	19.7	591 (195-987) 67% Error	877 (298-1,460) 66% Error	1100 (363-1,840) 67% Error	1350 (419-2,280) 69% Error	2,280	2090 (570-3,990) 75% Error
Nelson Creek/ Approx. 6,600' Upstream of US 141	17.9	546 (180-912) 67% Error	809 (275-1,340) 66% Error	1010 (333-1,690) 67% Error	1240 (384-2,100) 69% Error	2,100	1910 (525-3,680) 75% Error
Nelson Creek/ Approx. 8,800' Upstream of US 142	14.8	466 (154-778) 67% Error	686 (233-1,140) 66% Error	854 (282-1,430) 67% Error	1040 (322-1,760) 69% Error	1,760	1590 (440-3,080) 75% Error

Location	Drainage Area (mi²)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
Nelson Creek/ Approx. 2,300' Upstream of 31U RD	13.0	419 (138-700) 67% Error	615 (209-1,020) 66% Error	764 (252-1,280) 67% Error	931 (289-1,570) 69% Error	1,570	1410 (393-2,750) 75% Error
Nelson Creek/ Approx. 4,500' Upstream of CO RD 33U	11.1	371 (122-620) 67% Error	542 (184-900) 66% Error	673 (222-1,120) 67% Error	816 (253-1,380) 69% Error	1,380	1230 (345-2,420) 75% Error
Nelson Creek/ Approx. 9,700' Upstream of CO RD 33U	9.7	334 (110-558) 67% Error	487 (166-808) 66% Error	603 (199-1,010) 67% Error	730 (226-1,230) 69% Error	1,230	1090 (308-2,150) 75% Error
Nelson Creek/ Approx. 9,800' Upstream of CO RD 33U	8.4	301 (99-503) 67% Error	439 (149-729) 66% Error	543 (179-907) 67% Error	656 (203-1,110) 69% Error	1,110	982 (278-1,940) 75% Error
Nelson Creek/ Approx. 3,200' Upstream of 31U RD	7.2	271 (89-453) 67% Error	394 (134-654) 66% Error	488 (161-815) 67% Error	588 (182-994) 69% Error	994	878 (249-1,740) 75% Error
Nelson Creek/ Approx. 8,400' Upstream of 31U RD	5.7	231 (76-386) 67% Error	336 (114-558) 66% Error	416 (137-695) 67% Error	501 (155-847) 69% Error	847	747 (212-1,480) 75% Error
Nicholas Wash/ Mouth of Nicholas Wash	12.1	911 (273-1,550) 70% Error	1570 (597-2,540) 62% Error	2210 (884-3,540) 60% Error	3060 (1,190-4,930) 61% Error	4,930	5380 (1,680-8,180) 66% Error
Nicholas Wash/ 100' upstream of US 141	10.4	837 (251-1,420) 70% Error	1450 (551-2,350) 62% Error	2040 (816-3,260) 60% Error	2830 (1,100-4,560) 61% Error	4,560	5010 (1,550-7,570) 66% Error
Nicholas Wash/ Approx. 1,000' upstream of CO RD 13R	8.5	755 (227-1,280) 70% Error	1310 (498-2,120) 62% Error	1860 (744-2,980) 60% Error	2580 (1,010-4,150) 61% Error	4,150	4610 (1,410-6,890) 66% Error
Nicholas Wash/ Approx. 6,000' upstream of CO RD 13R	7.5	702 (211-1,190) 70% Error	1220 (464-1,980) 62% Error	1740 (696-2,780) 60% Error	2410 (940-3,880) 61% Error	3,880	4330 (1,320-6,440) 66% Error
Nicholas Wash/ Approx. 14,000' upstream of CO RD 13R	6.0	623 (187-1,060) 70% Error	1090 (414-1,770) 62% Error	1560 (624-2,500) 60% Error	2160 (842-3,480) 61% Error	3,480	3930 (1,180-5,780) 66% Error
South Fork San Miguel River/ Mouth of South Fork San Miguel River	58.0	943 (311-1,570) 67% Error	1340 (456-2,220) 66% Error	1620 (535-2,710) 67% Error	1860 (577-3,140) 69% Error	3,140	2830 (785-5,500) 75% Error

Location	Drainage Area (mi^2)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
South Fork San Miguel River/ Approx. 6,200' Upstream of confluence of Turkey Creek	49.2	853 (281-1,420) 67% Error	1210 (411-2,010) 66% Error	1470 (485-2,450) 67% Error	1770 (549-2,990) 69% Error	2,990	2570 (748-5,230) 75% Error
Spring Creek/ Mouth of Spring Creek	52.9	1320 (436-2,200) 67% Error	2000 (680-3,320) 66% Error	2550 (842-4,260) 67% Error	3220 (998-5,440) 69% Error	5,440	5180 (1,360-9,520) 75% Error
Unnamed Stream (Maverick Draw)/ At Montrose Co. Line	37.9	817 (270-1,360) 67% Error	1190 (405-1,980) 66% Error	1460 (482-2,440) 67% Error	1790 (555-3,030) 69% Error	3,030	2690 (758-5,300) 75% Error
Unnamed Stream (Maverick Draw)/ Approx. 2,500' Upstream of Montrose Co. Line	35.1	766 (253-1,280) 67% Error	1110 (377-1,840) 66% Error	1370 (452-2,290) 67% Error	1660 (515-2,810) 69% Error	2,810	2490 (703-4,920) 75% Error
Unnamed Stream (Maverick Draw)/ Approx. 2,600' Upstream of Montrose Co. Line	7.9	405 (134-676) 67% Error	626 (213-1,040) 66% Error	810 (267-1,350) 67% Error	1020 (316-1,720) 69% Error	1,720	1670 (430-3,010) 75% Error
Unnamed Stream (Maverick Draw)/ Approx. 2,400' Upstream of CO RD 43Z N	6.8	357 (118-596) 67% Error	549 (187-911) 66% Error	709 (234-1,180) 67% Error	891 (276-1,510) 69% Error	1,510	1450 (378-2,640) 75% Error
Unnamed Stream (Maverick Draw)/ Approx. 1,800' Downstream of US 145	5.7	310 (102-518) 67% Error	474 (161-787) 66% Error	610 (201-1,020) 67% Error	763 (237-1,290) 69% Error	1,290	1230 (323-2,260) 75% Error
Unnamed Stream (Maverick Draw)/ Approx. 1,500' Downstream of US 145	5.0	277 (91-463) 67% Error	423 (144-702) 66% Error	543 (179-907) 67% Error	676 (210-1,140) 69% Error	1,140	1080 (285-2,000) 75% Error
Unnamed Stream (Maverick Draw)/ 300' Downstream of US 145	4.4	249 (82-416) 67% Error	378 (129-627) 66% Error	484 (160-808) 67% Error	600 (186-1,010) 69% Error	1,010	953 (253-1,770) 75% Error

Location	Drainage Area (mi²)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
West Fork Dry Creek/ At mouth of West Fork Dry Creek	46.0	1180 (354-2,010) 70% Error	1950 (741-3,160) 62% Error	2680 (1,070-4,290) 60% Error	3690 (1,440-5,940) 61% Error	5,940	6100 (2,020-9,860) 66% Error
West Fork Dry Creek/ At CO RD 22W	38.5	997 (299-1,690) 70% Error	1660 (631-2,690) 62% Error	2300 (920-3,680) 60% Error	3170 (1,240-5,100) 61% Error	5,100	5350 (1,730-8,470) 66% Error
West Fork Dry Creek/ 100' Upstream of CO RD 22W	26.2	692 (208-1,180) 70% Error	1180 (448-1,910) 62% Error	1660 (664-2,660) 60% Error	2290 (893-3,690) 61% Error	3,690	4000 (1,250-6,130) 66% Error
West Fork Dry Creek Trib 1/ Mouth of West Fork Dry Creek Trib 1	12.3	759 (228-1,290) 70% Error	1300 (494-2,110) 62% Error	1830 (732-2,930) 60% Error	2520 (983-4,060) 61% Error	4,060	4410 (1,380-6,740) 66% Error

Rainfall-Runoff Method

Three HEC-HMS models were developed for streams within San Miguel county: San Miguel River Reach 4, Fall Creek and Leopard Creek Reaches 1 and 2. By using HEC-GeoHMS Version 10.2 based on 10-meter LiDAR Digital Elevation Model (DEM), 25 sub-basins were delineated within the watershed encompassing San Miguel River Reach 4, 24 sub-basins were delineated within the watershed encompassing Fall Creek, and 29 sub-basins were delineated within the watershed encompassing Leopard Creek Reaches 1 and 2.

National Oceanic and Atmospheric Administration (NOAA) Atlas 14 was used to determine the rainfall depths for the 10-, 25-, 50-, 100- and 500-year return frequencies. The 100-year plus return frequency was determined by converting the upper 90% confidence interval of the NOAA Atlas 14 100-year flow depth to FEMA's standard 84% confidence limit. The SCS Type II Unit Hydrograph method was used to develop the model hydrographs. Rainfall depths used are shown in Table 7 within the model calibration discussion.

The sub-basin boundaries, land use data, and hydrologic soil group data were spatially intersected to generate a runoff curve number (CN) for each sub-basin in accordance with the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Runoff Curve Number methodology. This spatial intersection was performed using an Amec Foster Wheeler ArcGIS proprietary tool. Soil and land use data was downloaded from the NRCS website. Soils within the basin were determined to be a combination of hydrologic soil groups A, B, C, and D. Various land uses exist within the watersheds, including impervious roadway, commercial and residential, woods, cultivated land, rock outcroppings, and brush.

The time of concentration for each sub-basin was calculated following the methodology outlined in Chapter 15 of the National Engineering Handbook and from TR-55 Urban Hydrology for Small Watersheds. The longest flow path, basin topography and the 2-year NOAA Atlas 14 rainfall depth for each sub-basin were inputs into an Amec Foster Wheeler ArcGIS proprietary tool that uses the methodologies outlined in the documents listed above to calculate the time of concentration for each sub-basin. The longest flow path input is a shapefile that segments out sheet, shallow, and channel flow sections and provides roughness characteristics. The tool first uses the basin topography to calculate the slope of each segment from the longest flow path shapefile. The 2-year rainfall depth and roughness characteristics are then used with the calculated slopes to determine the velocity of water for each segment. The tool then calculates the time of concentration using the segment lengths and finally dissolves the segments so that there is one time of concentration for each sub-basin. The resulting time of concentrations for each sub-basin are presented in Table 8 within the model calibration discussion.

The Muskingum-Cunge routing method was used to route the flow from the sub-basins through the watershed. The method is based on the combination of the conservation of mass and the diffusion representation of the conservation of momentum. The routing parameters are recalculated for every time step based on the channel properties and flow depth. Representative channel cross sections taken from the merged LiDAR DEM were utilized in this method.

Rainfall-Runoff Method Calibration

The HEC-HMS discharges at the downstream limits were compared with regression equation results to verify the HEC-HMS results. (See the Regression Equation Methodology section for the regression equation procedure.) One of the parameters in the regression equation is percent area above 7,500 feet, with a suggested range of 0 to 99%. Due to each of the basins being 100% above 7,500-feet, the flow estimates provided by regression were extrapolated with unknown errors. Table 5 shows the regression results for each of the basins evaluated by HEC-HMS.

Table 5 – Regression Calibration Results

Flooding Source	1% Chance Peak Flow Estimate (cfs)
San Miguel River Reach 4	1,770
Fall Creek	1,610
Leopard Creek	2,053

Because the regression analysis is outside of the suggested range of area above 7,500, three nearby gages in similar watersheds were analyzed and projected with the same methodology as described in the gage analysis section above to serve as another calibration indicator. The projected flows from these comparison gages are show in Table 6.

Table 6– Bulletin 17C Comparison Stream Gage Analysis and Projections

Gage/Location		Drainage Area [2] (mi²)	Projection Ratio	Peak Discharge (cfs)					
Number	Name			10%	4%	2%	1%	1% Plus	0.2%
09146020	Uncompahgre River at Ouray	77	At Gage	1,456	1,587	1,677	1,763	1,887	1,949
		64	0.83	1,280	1,390	1,470	1,540	1,650	1,710
		50	0.64	1,070	1,160	1,230	1,290	1,380	1,430
		42	0.55	948	1,030	1,090	1,150	1,230	1,270
09165000	Dolores River below Rico	106	At Gage	1,845	2,138	2,340	2,529	2,840	2,931
		64	0.60	1,290	1,490	1,630	1,760	1,980	2,050
		50	0.47	1,080	1,250	1,360	1,470	1,660	1,710
		42	0.40	956	1,110	1,210	1,310	1,470	1,520
0917200	Fall Creek 2.7 miles upstream from the mouth	64	1.91	926	1,520	2,140	2,960	7,740	5,990
		50	1.49	774	1,270	1,790	2,470	6,470	5,010
		42	1.26	688	1,130	1,590	2,200	5,750	4,450
		33	At Gage	585	958	1,350	1,867	4,887	3,782

Given that both regression and gage variables provided similar results, it was determined that these are the most likely flows for the three flooding sources evaluated in HEC-HMS. However, the flow results produced by HEC-HMS were over three times greater than those produced by gage and regressionfor all three flooding sources. Therefore, several factors were evaluated in order to calibrate the HEC-HMS model to obtain results similar to the gage and regression, including adjustments to rainfall, land use, and initial abstraction.

<u>Rainfall Adjustments</u>

San Miguel County lies within the southwest hydrologic region of Colorado and has a unique climate related to its semi-arid and mountainous environment. To account for region specific climatic effects, an areal reduction factor (ARF) was applied to the three watersheds for all rainfall events. NOAA Technical Memorandum NWS HYDRO-40 (1984) and the 1980 report by Osborn et al. have shown that the depth-area curve developed in NOAA TR-24 (1980) significantly underestimate the reductions from point-to-area in semi-arid regions in the Southwest. For the three watersheds in San Miguel, a conservative depth-area ratio was applied from the NOAA HYDRO-40 report to represent the reductions in the 24-hr rainfall events.

Table **7** shows the rainfall depths and ARF used for each HEC-HMS model.

Table 7 – NOAA Atlas 14 Rainfall Depths and ARF

Model	ARF	Rainfall Depths (in)					
		10%	4%	2%	1%	1% Plus	0.20%
San Miguel River Reach 4	0.75	2.49	2.96	3.36	3.77	4.34	4.85
Fall Creek	0.75	2.25	2.69	3.05	3.44	3.99	4.44
Leopard Creek	0.75	2.10	2.52	2.86	3.22	3.71	4.14

Land Use Adjustments

Through the curve number calibration process, multiple land use types were manually adjusted to represent the hydrologic characteristics of the soils and land cover. A significant portion of the watersheds were defined as barren land or rock outcrop by the USGS National Land Cover. Database (NLCD) which artificially drove up the composite sub-basin curve numbers. To account for this, barren land was manually changed to reflect a curve number equivalent to Pinyon-Juniper cover with fair soils. Similarly, Herbaceous land cover was also changed to Pinyon-Juniper cover with fair soils; a more accurate model of the vegetation seen in the San Miguel watersheds. The final curve numbers applied in the hydrologic models are presented in Table 8.

Table 8 – Sub-basin Parameters

Model	Sub-basin ID	Area (mi2)	CN	Time of Concentration (hrs)	Storage Coefficient (hrs)
San Miguel River Reach 4	S_53	2.88	72	1.01	0.83
San Miguel River Reach 4	S_55	2.25	72	1.33	1.09
San Miguel River Reach 4	S_56	5.45	69	2.27	1.86
San Miguel River Reach 4	S_60	0.70	69	1.83	1.50
San Miguel River Reach 4	S_62	3.55	57	1.9	1.55
San Miguel River Reach 4	S_63	3.73	68	3.37	2.76
San Miguel River Reach 4	S_66	0.19	65	1.17	0.96
San Miguel River Reach 4	S_67	3.83	67	0.83	0.68
San Miguel River Reach 4	S_68	0.40	66	0.63	0.52
San Miguel River Reach 4	S_76	0.64	70	1.55	1.27
San Miguel River Reach 4	S_77	1.52	70	1.76	1.44
San Miguel River Reach 4	S_78	0.61	70	1.35	1.10
San Miguel River Reach 4	S_79	3.72	66	1.01	0.83
San Miguel River Reach 4	S_80	0.80	74	0.5	0.41
San Miguel River Reach 4	S_81	0.84	72	0.47	0.38
San Miguel River Reach 4	S_82	0.58	79	0.42	0.34
San Miguel River Reach 4	S_83	2.56	67	1.19	0.97
San Miguel River Reach 4	S_89	4.29	65	0.93	0.76
San Miguel River Reach 4	S_90	0.33	69	1.1	0.90
San Miguel River Reach 4	S_235	2.11	70	1.46	1.19
San Miguel River Reach 4	S_236	1.69	69	3.84	3.14
San Miguel River Reach 4	S_237	2.62	68	0.94	0.77
San Miguel River Reach 4	S_238	2.09	69	0.87	0.71
San Miguel River Reach 4	S_239	1.34	68	4.13	3.38
San Miguel River Reach 4	S_240	0.88	69	1.15	0.94
Fall Creek	FC10000W	0.38	56	1.46	0.97

Model	Sub-basin ID	Area (mi2)	CN	Time of Concentration (hrs)	Storage Coefficient (hrs)
Fall Creek	FC11000W	0.89	67	2.24	1.49
Fall Creek	FC12000W	0.71	67	2.36	1.58
Fall Creek	FC12100W	2.12	71	2.64	2.16
Fall Creek	FC13000W	1.13	72	3.11	2.55
Fall Creek	FC13100W	1.77	74	2.84	2.32
Fall Creek	FC13200W	2.42	73	3.41	3.41
Fall Creek	FC14000W	1.36	72	2.20	1.80
Fall Creek	FC15000W	2.89	71	2.13	1.74
Fall Creek	FC15100W	1.37	72	2.11	1.72
Fall Creek	FC15200W	1.14	72	1.52	1.24
Fall Creek	FC15300W	1.62	73	2.86	2.34
Fall Creek	FC15400W	1.16	72	2.69	2.20
Fall Creek	FC15500W	2.02	70	1.94	1.29
Fall Creek	FC16000W	2.11	73	3.22	2.64
Fall Creek	FC17000W	2.18	71	2.29	1.87
Fall Creek	FC18000W	0.17	75	3.14	2.57
Fall Creek	FC18100W	2.59	73	2.73	2.23
Fall Creek	FC19000W	1.39	73	3.18	2.61
Fall Creek	FC19100W	2.69	72	3.26	2.67
Fall Creek	FC20000W	2.32	70	1.15	0.94
Fall Creek	FC20100W	1.88	71	1.04	0.85
Fall Creek	FC20200W	2.41	68	1.02	0.83
Fall Creek	FC21000W	3.10	70	1.08	0.72
Leopard Creek Reach 1&2	LCR10100H	0.13	72	1.25	0.84
Leopard Creek Reach 1&2	LCR10110H	0.14	71	1.21	0.81
Leopard Creek Reach 1&2	LCR10200H	0.23	64	1	0.67
Leopard Creek Reach 1&2	LCR10210H	0.31	71	1.37	0.91
Leopard Creek Reach 1&2	LCR10300H	0.39	66	1.41	0.94
Leopard Creek Reach 1&2	LCR10400H	3.44	70	2.03	1.35
Leopard Creek Reach 1&2	LCR10410H	6.55	74	3.34	2.73
Leopard Creek Reach 1&2	LCR10420H	1.07	73	1.88	1.25
Leopard Creek Reach 1&2	LCR10421H	7.73	71	1.91	1.27
Leopard Creek Reach 1&2	LCR10430H	2.49	74	1.72	1.41
Leopard Creek Reach 1&2	LCR10500H	0.35	74	3.77	2.51
Leopard Creek Reach 1&2	LCR10510H	0.33	74	1.9	1.27
Leopard Creek Reach 1&2	LCR10511H	2.14	75	4.16	2.77
Leopard Creek Reach 1&2	LCR10520H	1.12	75	3.48	2.84
Leopard Creek Reach 1&2	LCR10530H	4.48	70	5.62	6.87

Model	Sub-basin ID	Area (mi2)	CN	Time of Concentration (hrs)	Storage Coefficient (hrs)
Leopard Creek Reach 1&2	LCR10600H	0.47	70	1.8	1.2
Leopard Creek Reach 1&2	LCR10610H	3.19	73	3.17	2.59
Leopard Creek Reach 1&2	LCR10700H	0.65	72	1.17	0.78
Leopard Creek Reach 1&2	LCR10710H	3.23	73	3.49	2.86
Leopard Creek Reach 1&2	LCR10720H	5.14	72	1.68	1.37
Leopard Creek Reach 1&2	LCR10800H	0.68	71	2.96	1.97
Leopard Creek Reach 1&2	LCR10810H	1.53	75	4.55	3.72
Leopard Creek Reach 1&2	LCR10900H	1.44	73	2.99	2
Leopard Creek Reach 1&2	LCR10910H	3.75	76	4.58	3.75
Leopard Creek Reach 1&2	LCR11000H	1.59	75	4.73	3.87
Leopard Creek Reach 1&2	LCR11100H	2.50	74	2.26	1.85
Leopard Creek Reach 1&2	LCR11110H	2.05	72	3.16	2.58
Leopard Creek Reach 1&2	LCR11120H	4.08	72	1.45	0.96
Leopard Creek Reach 1&2	LCR11200H	2.66	73	2.26	1.85

Initial Abstraction Adjustments

In addition to calibrating the basin curve numbers for use in the SCS runoff equation calculations, the initial abstraction ratio (λ) was also calibrated for the calculation. It was determined that in the upper slopes, the cracks found in the rocks likely account for a large amount of abstracted water. The default initial abstraction ratio used in the SCS runoff equation is λ = 0.2, the standard value documented in TR-55. However varying values for λ, dependent on geographical locations, have been described by various studies (Ponce, 1999, Yuan, 2012) and a region-specific value has been suggested. From the gage analyses performed on the downstream portion of San Miguel River and the comparison gage projections for the three watersheds, flows were estimated with relatively high confidence. Knowing these flows, the value of λ was altered within a subset of the sub-basins to calibrate the HEC-HMS model to the gage projected flows. The increase in λ was correlated with regions consisting of steep slopes or large percentages of rock outcrop or other high curve number land cover that greatly increased runoff and dominated the overall flow of the watershed. The sub-basins in which λ values differing from 0.2 were applied are shown in Figure 4, Figure ***5***, and Figure ***6***.

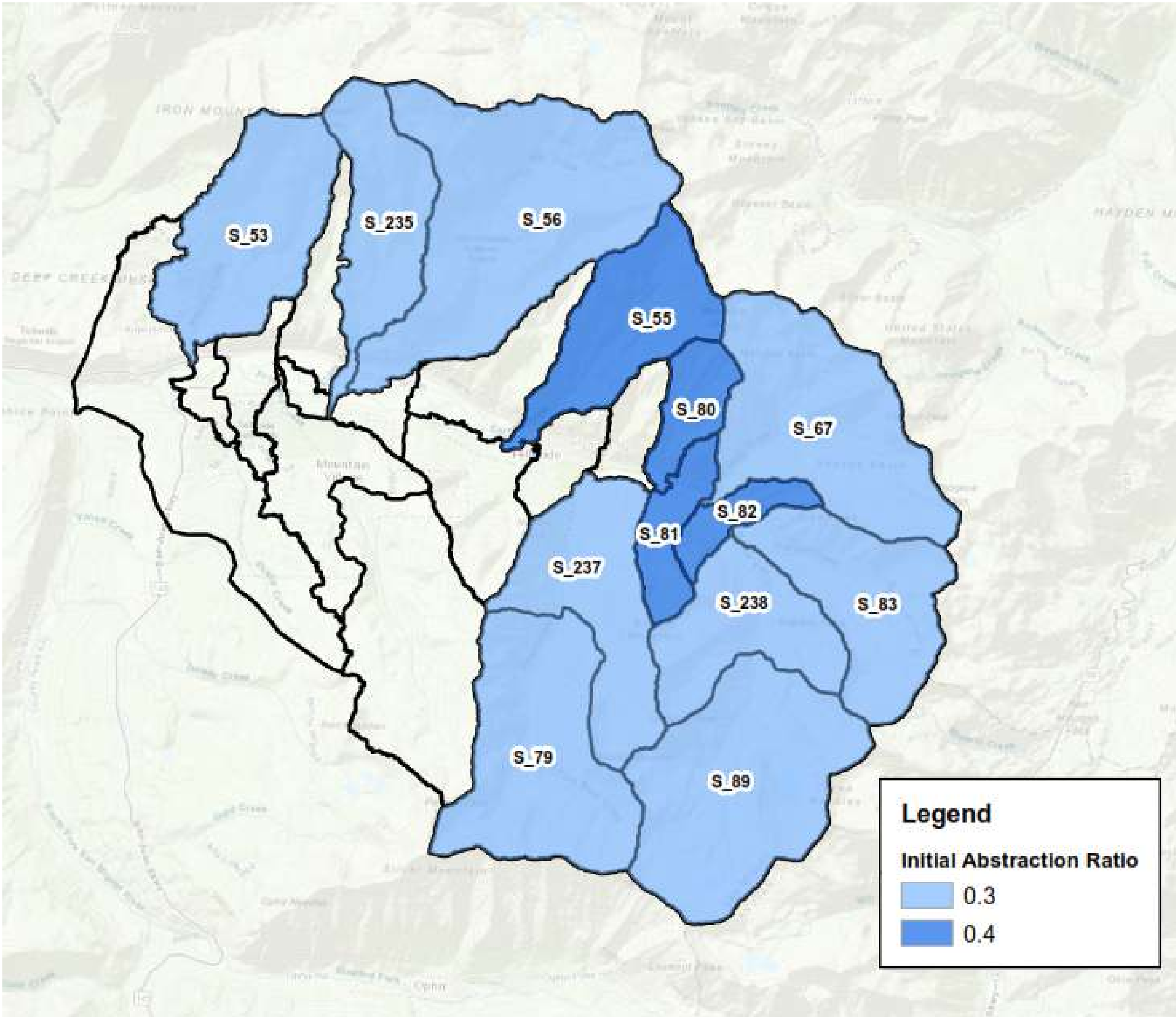

Figure 4 - Values of λ for San Miguel River Reach 4 Sub-Basins

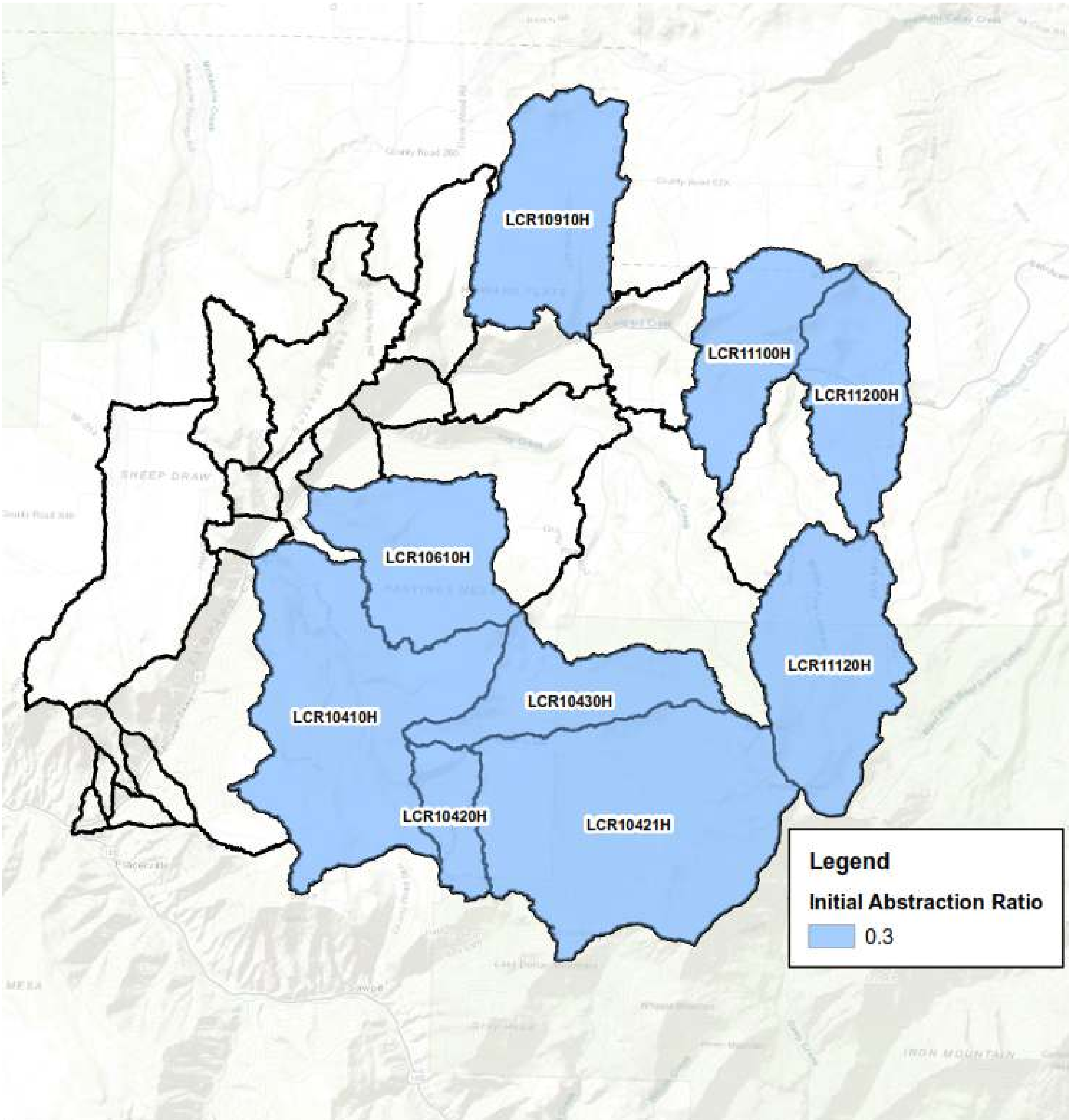

Figure 5 - Values of λ for Leopard Creek Reaches 1 & 2 Sub-Basins

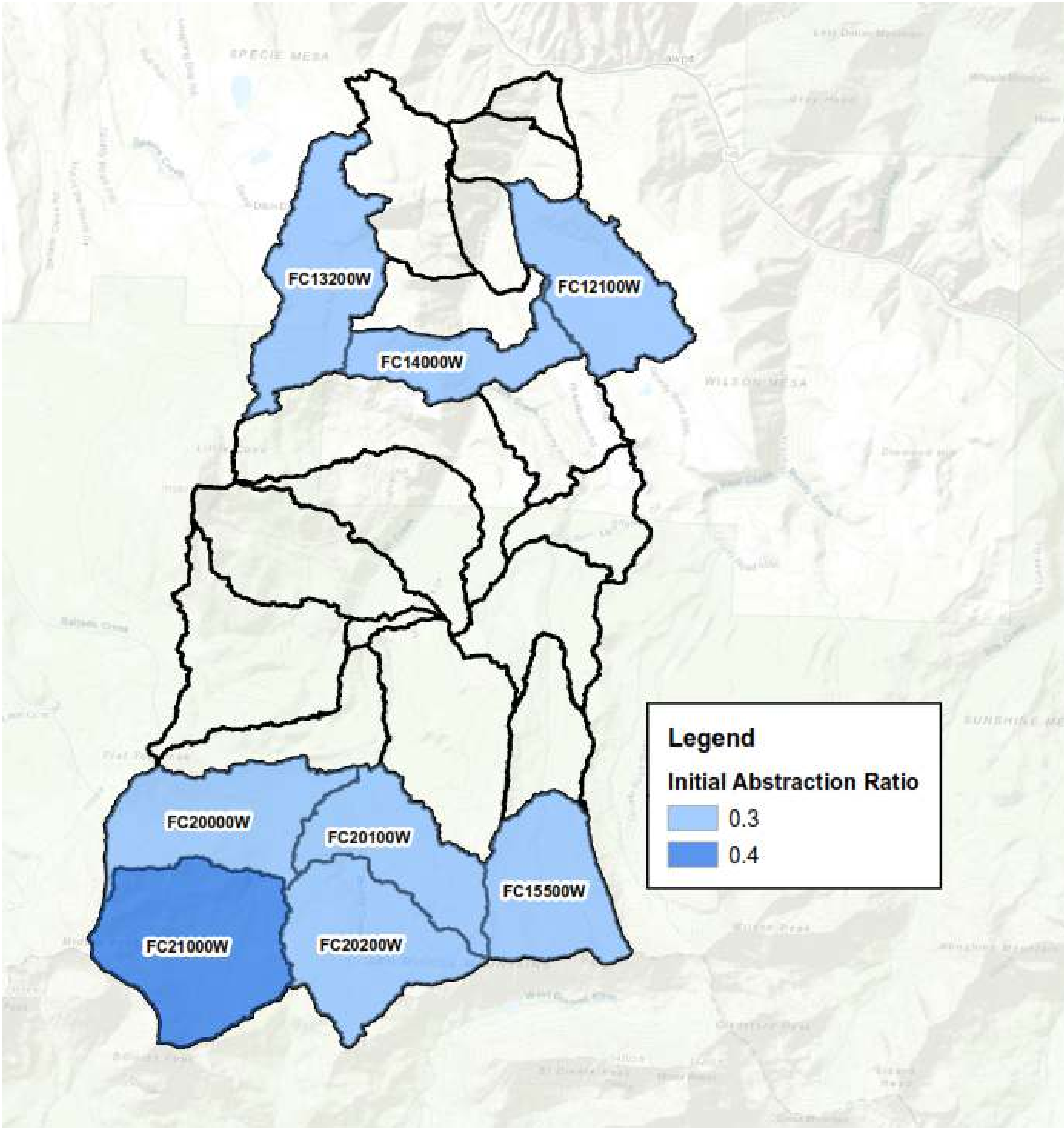

Figure 6 - Values of λ for Fall Creek Sub-Basins

The resulting peak discharges and drainage area at each flow change location are summarized in Table 9. These were determined to be within reasonable flows, within the range of probability given the regression and gage flows they were calibrated against.

Table 9– Rainfall Runoff Analysis Parameters and Results

Location	Drainage Area (mi^2)	Peak Discharges (cfs)					
		10%	4%	2%	1%	1% Plus	0.2%
San Miguel River Reach 4 at confluence of Skunk Creek	49.6	187	508	973	1,650	2,910	4,290
San Miguel River Reach 4 approx. 3,100’ upstream of confluence of Prospect Creek	35.8	104	330	690	1,240	2,280	3,440
San Miguel River Reach 4 just upstream of confluence of Mill Creek	28.1	77.8	256	548	1,010	1,890	2,880
San Miguel River Reach 4 at Mahoney Dr.	22.6	50.3	180	417	803	1,550	2,400
San Miguel River Reach 4 just upstream of confluence of Bear Creek	15.6	34.3	121	288	563	1,100	1,730
Fall Creek at reach mouth	41.8	300	633	1,010	1,520	2,460	3,380
Leopard Creek Reach 1 at reach mouth	63.9	290	652	1,070	1,640	2,570	3,550
Leopard Creek Reach 2 approx. 18,000’ upstream of confluence of Hay Creek	12.9	53.3	143	259	416	684	966

MIP Submittal File Structure

All hydrologic data development TSDN files have been submitted digitally along with this TSDN. The contents have been structure according to the May 2017 Data Capture Standards (DCS) Technical Reference.

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