

## Memorandum

**DATE:** August 30, 2018

**TO:** Vicky Peacey, Resolution Copper

**FROM:** Ted Lehman, PE, Hydrologist, JE Fuller

**RE:** USGS Regression Equation Computation Updates for Queen Creek, Devil's Canyon, Dripping Springs Wash (Skunk Camp), and Donnelly Wash area (Peg Leg)

Dear Ms. Peacey,

At your request, JE Fuller has updated its previous analysis of flood flow frequency and volume-duration-frequency values for points of interest on Queen Creek and Devil's Canyon. The updates for Queen Creek include the addition of the Silver King tailings storage facility (TSF) location alternative. The update also added computations for Dripping Springs Wash for the Skunk Camp TSF and an area of Donnelly Wash for the Peg Leg TSF. The intent is to quantify surface water hydrology in these watersheds to assist Resolution Copper with assessment of potential impacts to surface water flows associated with the proposed mining and tailings storage activities near Superior, Arizona.

To accomplish these goals, flood flow frequency and volume-duration-frequency were computed using two sets of regression equations recently published by the United States Geological Survey (USGS) – Scientific Investigations Reports (SIR) 2014-5211 (peak flow frequency) and 2014-5109 (volume-duration-frequency). These reports provide regression equations to estimate the magnitude and frequency of surface water hydrology for unregulated watersheds in Arizona. The statistical analyses presented in these reports were performed for streamflow data collected through 2010 for dozens of stream gaging stations with hundreds of years of cumulative streamflow records to develop regression equations to compute peak flow and volume frequency estimates. As such, they represent an excellent method to quantify surface water hydrology in central Arizona including the watersheds of Queen Creek, Devil's Canyon, Dripping Springs Wash, and Donnelly Wash.

Significant variables used in the USGS regression equations include watershed drainage area, mean annual precipitation, and mean elevation. Equations are presented to compute annual exceedance probability (AEP) for the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2-percent levels for un-gaged basins in Arizona. These reports also present standard error of prediction percentages for each set of equations for each AEP. Copies of these two USGS reports are provided with this memo for convenience.

### **Peak Discharge Flow Frequency (SIR 2014-5211)**

Regression equations for unregulated watersheds in Arizona were developed by the USGS to estimate magnitude and frequency of floods using peak-flow data through Water Year 2010. Figure 1 shows a map from SIR 2014-5211 of the regions and stream gage locations used in the development of the peak-flow regression equations. The subject watersheds

lie within Region 5 – Southeastern Basin and Range. Table 1 shows the regression equations developed for flood region 5. For each annual exceedance probability (AEP), the predicted peak discharge is computed solely as a function of drainage area (DRNAREA).

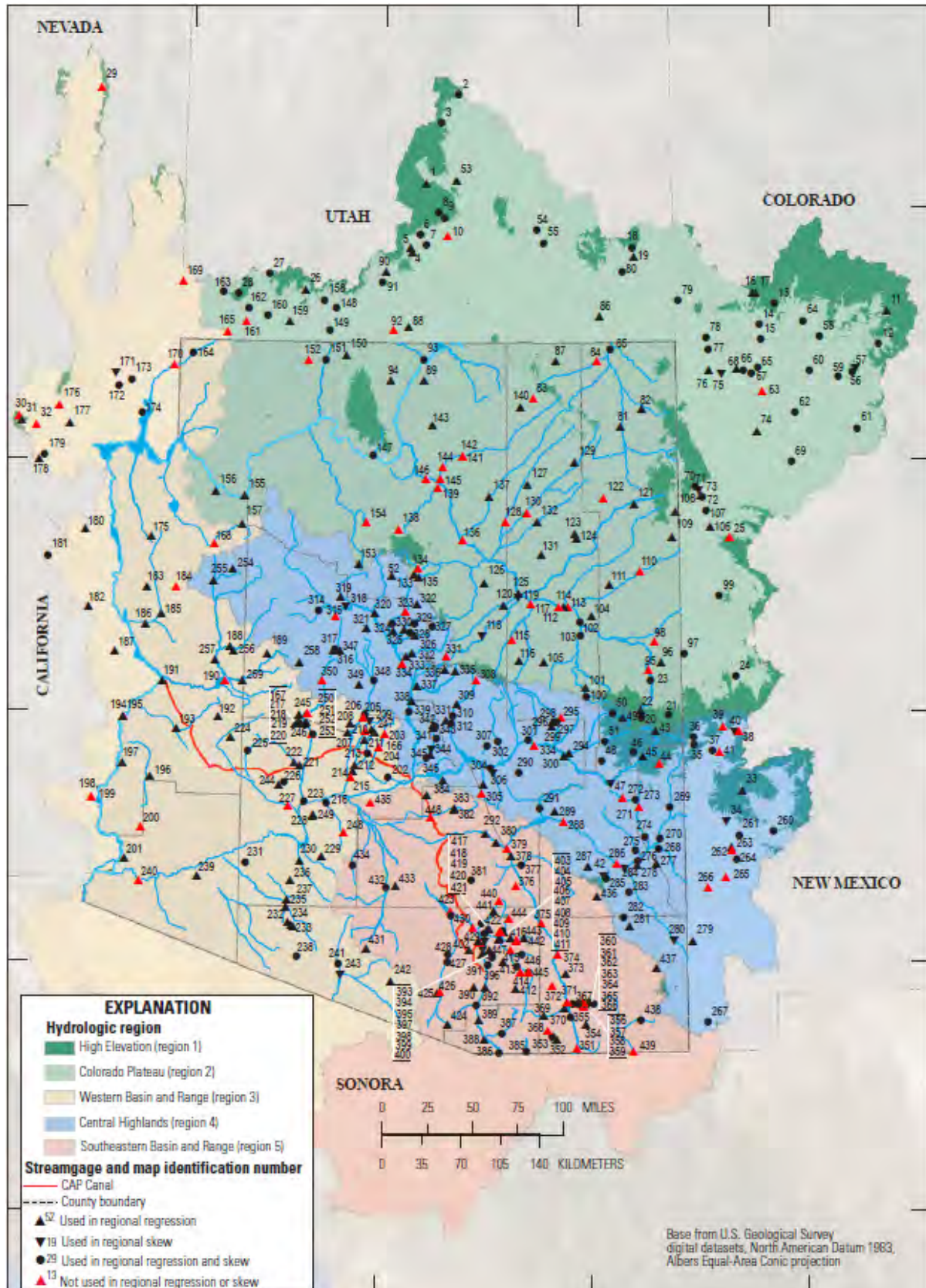


Figure 1. Map of regions and stream gages used in SIR 2014-5211 regression equations (Figure 4 in SIR 2014-5211)

*Table 1. Flood region 5 regression equations from SIR 2014-5211, DRNAREA in square miles*

<b>AEP (percent)</b>	<b>Regression Equation (peak discharge, cubic feet per second)</b>	<b>Standard Error of Prediction (SEP) in percent</b>
50	$10^{(6.363-4.386*DRNAREA^{-0.06})}$	86.6
20	$10^{(5.868-3.506*DRNAREA^{-0.08})}$	61.5
10	$10^{(5.778-3.218*DRNAREA^{-0.09})}$	52.4
4	$10^{(5.757-2.988*DRNAREA^{-0.10})}$	45.8
2	$10^{(5.696-2.795*DRNAREA^{-0.11})}$	43.5
1	$10^{(5.651-2.634*DRNAREA^{-0.12})}$	42.6
0.5	$10^{(5.761-2.638*DRNAREA^{-0.12})}$	42.4
0.2	$10^{(5.750-2.502*DRNAREA^{-0.13})}$	43.2

Watersheds to seven (7) key locations on Queen Creek and Devil's Canyon were identified upstream and downstream of the proposed mining impact areas. An additional five (5) key locations were added as part of this update on Dripping Springs and Donnelly Wash. Drainage basins were delineated to each from USGS 7.5-minute topographic quadrangles. The drainage area for each location was then computed using GIS.

Impacts from the proposed mining operations were assessed by subtracting the impacted areas from the drainage areas for each watershed. This approach reflects the assumption that surface water drainage will not be allowed to exit the proposed mining impact areas or will be diverted around any impacted areas as shown in the alternatives reports provided to JE Fuller by Resolution Copper. The impacted areas for Queen Creek were updated to remove the roadway areas since drainage off these narrow corridors will continue to contribute to downstream drainages. The twelve key locations, watershed boundaries, and proposed mining impact areas area shown in Figure 2.

The results of the peak-flow magnitude and frequency calculations from the SIR 2014-5211 regression equations are shown in Table 2. In general, the results show that the peak discharge for each frequency (AEP) is reduced by about half the percentage difference in the reduction in drainage area. The reduction in peak discharges is less than the reduction in drainage area because smaller drainage areas tend to have higher unit peak discharges (cfs/sq.mi.) for a given AEP than watersheds with more drainage area (FCDMC, 2013). One cause for this pattern is that storm intensities tend to be less over larger areas. In other words, spatially large intense storms are less likely (probable) than smaller storms. Or, intense smaller storms occur more frequently than spatially larger, similarly intense storms.



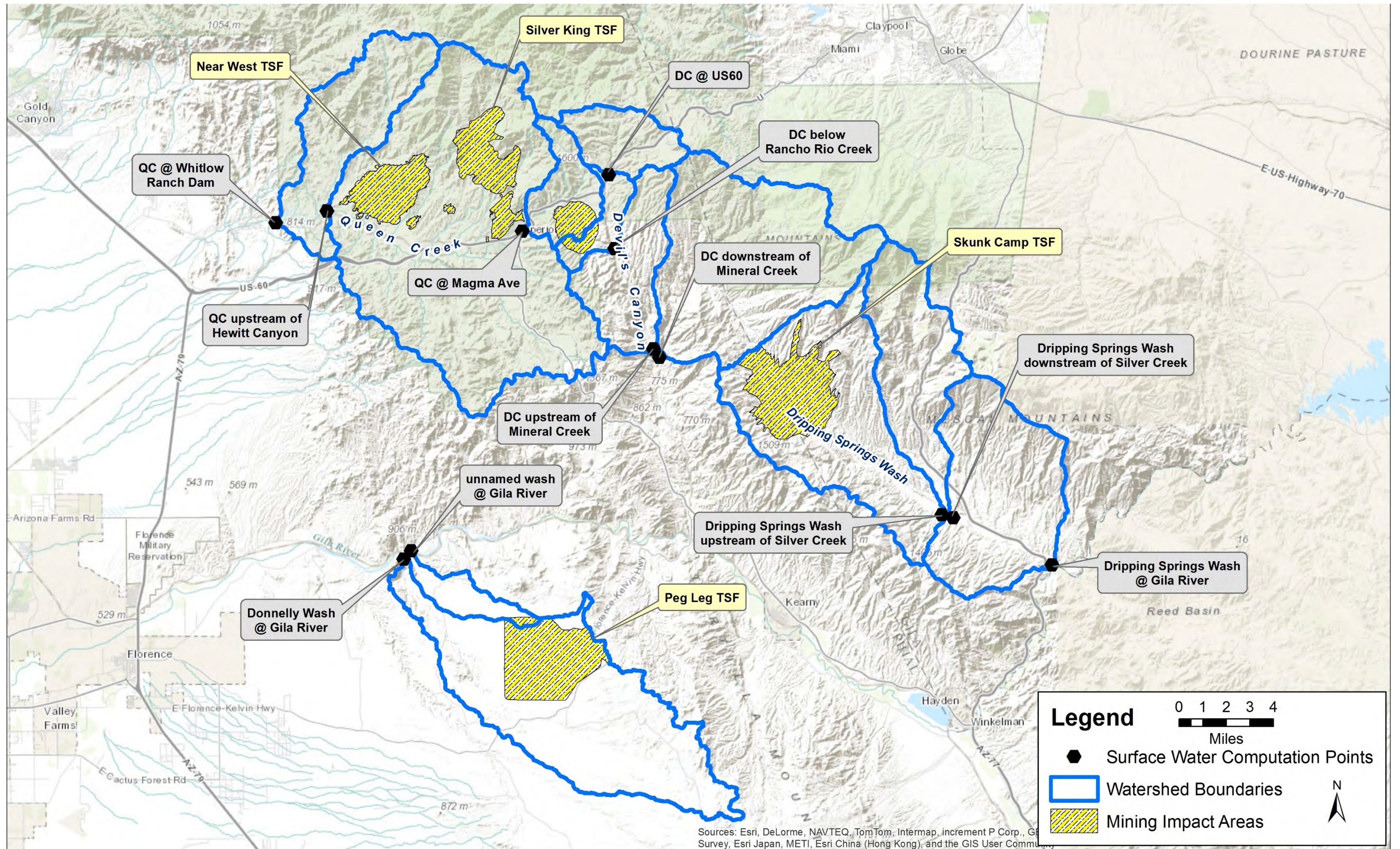


Figure 2. Watershed boundaries and regression equation computation locations



Table 2. Peak-flow frequency computations for selected key locations

**Existing Condition**

Location	D.A. (sq.mi.)	Flood Peak Flows, in cfs for Annual Exceedance Probability (%)							
		50	20	10	4	2	1	0.5	0.2
QC at WRD	143.401	1,280	3,246	5,245	8,679	11,949	15,829	20,289	27,415
QC u/s Hewitt Canyon	117.49	1,169	2,975	4,814	7,977	11,001	14,599	18,710	25,326
QC at Magma Ave	10.4	356	914	1,484	2,471	3,433	4,595	5,879	8,029
DC @ US60	10.95	366	940	1,526	2,541	3,531	4,727	6,047	8,260
DC blw Rancho Rio	16.55	454	1,167	1,898	3,163	4,399	5,890	7,538	10,300
DC u/s Mineral Creek	35.63	666	1,713	2,786	4,642	6,447	8,619	11,037	15,054
DC d/s Mineral Creek	90.4	1,037	2,647	4,290	7,122	9,841	13,086	16,768	22,745
DSW u/s Silver Creek	51.16	793	2,036	3,309	5,508	7,638	10,194	13,057	17,778
DSW d/s Silver Creek	78.21	969	2,479	4,021	6,680	9,240	12,301	15,760	21,400
DSW at Gila River	117.3	1,168	2,973	4,811	7,972	10,994	14,589	18,697	25,309
Gila River at DSW	15,473	Not estimated due to influences of San Carlos Reservoir upstream. See Note 5.							
Donnelly Wash at Gila	61.54	866	2,220	3,605	5,997	8,307	11,076	14,188	19,296
unnamed wash at Gila	6.08	267	681	1,103	1,830	2,537	3,388	4,333	5,906
Gila River at Donnelly	22,152	Not estimated due to influences of San Carlos Reservoir upstream. See Note 5.							

**Proposed Condition**

Near West TSF Alternative									
QC at WRD	133.243	1,238	3,144	5,083	8,415	11,593	15,368	19,696	26,632
QC u/s Hewitt Canyon	107.33	1,122	2,858	4,628	7,673	10,590	14,064	18,023	24,414
QC at Magma Ave	8.27	316	808	1,310	2,178	3,024	4,044	5,173	7,061
DC @ US60	10.95	366	940	1,526	2,541	3,531	4,727	6,047	8,260
DC blw Rancho Rio	15.59	440	1,131	1,840	3,066	4,264	5,709	7,307	9,983
DC u/s Mineral Creek	34.67	657	1,690	2,749	4,582	6,364	8,508	10,895	14,861
DC d/s Mineral Creek	89.45	1,032	2,635	4,270	7,089	9,796	13,028	16,693	22,645
Silver King TSF Alternative									
QC at WRD	133.602	1,239	3,148	5,089	8,424	11,606	15,384	19,718	26,660
QC u/s Hewitt Canyon	107.69	1,124	2,863	4,635	7,684	10,605	14,083	18,048	24,447
QC at Magma Ave	8.27	316	808	1,310	2,178	3,024	4,044	5,173	7,061
DC @ US60	10.95	366	940	1,526	2,541	3,531	4,727	6,047	8,260
DC blw Rancho Rio	15.59	440	1,131	1,840	3,066	4,264	5,709	7,307	9,983
DC u/s Mineral Creek	34.67	657	1,690	2,749	4,582	6,364	8,508	10,895	14,861
DC d/s Mineral Creek	89.45	1,032	2,635	4,270	7,089	9,796	13,028	16,693	22,645
Skunk Camp TSF Alternative									
DSW u/s Silver Creek	39.47	700	1,800	2,927	4,876	6,769	9,045	11,584	15,792
DSW d/s Silver Creek	66.52	898	2,302	3,736	6,212	8,602	11,463	14,685	19,963
DSW at Gila River	105.62	1,114	2,838	4,595	7,620	10,518	13,970	17,903	24,254
Gila River at DSW	15,461	Not estimated due to influences of San Carlos Reservoir upstream. See Note 5.							

Peg Leg TSF Alternative									
Donnelly Wash at Gila	49.914	784	2,013	3,271	5,446	7,552	10,081	12,912	17,582
unnamed wash at Gila	5.67	257	655	1,060	1,758	2,436	3,252	4,158	5,666
Gila River at Donnelly	22,140	Not estimated due to influences of San Carlos Reservoir upstream. See Note 5.							

**Difference (Existing – Proposed)/Existing**

Near West TSF Alternative									
QC at WRD	-7.1%	-3.3%	-3.1%	-3.1%	-3.0%	-3.0%	-2.9%	-2.9%	-2.9%
QC u/s Hewitt Canyon	-8.6%	-4.0%	-3.9%	-3.9%	-3.8%	-3.7%	-3.7%	-3.7%	-3.6%
QC at Magma Ave	-20.5%	-11.4%	-11.6%	-11.8%	-11.9%	-11.9%	-12.0%	-12.0%	-12.1%
DC @ US60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DC blw Rancho Rio	-5.8%	-3.0%	-3.0%	-3.1%	-3.1%	-3.1%	-3.1%	-3.1%	-3.1%
DC u/s Mineral Creek	-2.7%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%
DC d/s Mineral Creek	-1.1%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.4%	-0.4%	-0.4%
Silver King TSF Alternative									
QC at WRD	-6.8%	-3.1%	-3.0%	-3.0%	-2.9%	-2.9%	-2.8%	-2.8%	-2.8%
QC u/s Hewitt Canyon	-8.3%	-3.9%	-3.8%	-3.7%	-3.7%	-3.6%	-3.5%	-3.5%	-3.5%
QC at Magma Ave	-20.5%	-11.4%	-11.6%	-11.8%	-11.9%	-11.9%	-12.0%	-12.0%	-12.1%
DC @ US60	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
DC blw Rancho Rio	-5.8%	-3.0%	-3.0%	-3.1%	-3.1%	-3.1%	-3.1%	-3.1%	-3.1%
DC u/s Mineral Creek	-2.7%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%	-1.3%
DC d/s Mineral Creek	-1.1%	-0.5%	-0.5%	-0.5%	-0.5%	-0.5%	-0.4%	-0.4%	-0.4%
Skunk Camp TSF Alternative									
DSW u/s Silver Creek	-22.8%	-11.8%	-11.6%	-11.6%	-11.5%	-11.4%	-11.3%	-11.3%	-11.2%
DSW d/s Silver Creek	-14.9%	-7.3%	-7.2%	-7.1%	-7.0%	-6.9%	-6.8%	-6.8%	-6.7%
DSW at Gila River	-10.0%	-4.7%	-4.5%	-4.5%	-4.4%	-4.3%	-4.2%	-4.3%	-4.2%
Gila River at DSW	-0.075%	Not estimated due to influences of San Carlos Reservoir upstream. See Note 5.							
Peg Leg TSF Alternative									
Donnelly Wash at Gila	-18.9%	-9.5%	-9.3%	-9.3%	-9.2%	-9.1%	-9.0%	-9.0%	-8.9%
unnamed wash at Gila	-6.7%	-3.7%	-3.8%	-3.9%	-3.9%	-4.0%	-4.0%	-4.0%	-4.1%
Gila River at Donnelly	-0.054%	Not estimated due to influences of San Carlos Reservoir upstream. See Note 5.							

**Notes:**

- 1) Impacts to Devil's Canyon (DC) from subsidence area. Same for all alternatives.
- 2) Impacts to Queen Creek (QC) include West Plant area for all alternatives.
- 3) Impacts for Peg Leg alternative to Donnelly Wash at Gila River reflect about 1 square mile of Donnelly Wash watershed which is diverted to the unnamed tributary.
- 4) DSW = Dripping Springs Wash
- 5) Peak flow rates for the Gila River were not computed due to influence of Coolidge Dam/San Carlos Reservoir upstream which regulate flows. However, the total drainage area reductions are very small (< 0.1%) for both the Skunk Camp and Peg Leg alternatives.

**Volume-Duration-Frequency (SIR 2014-5109, v1.1)**

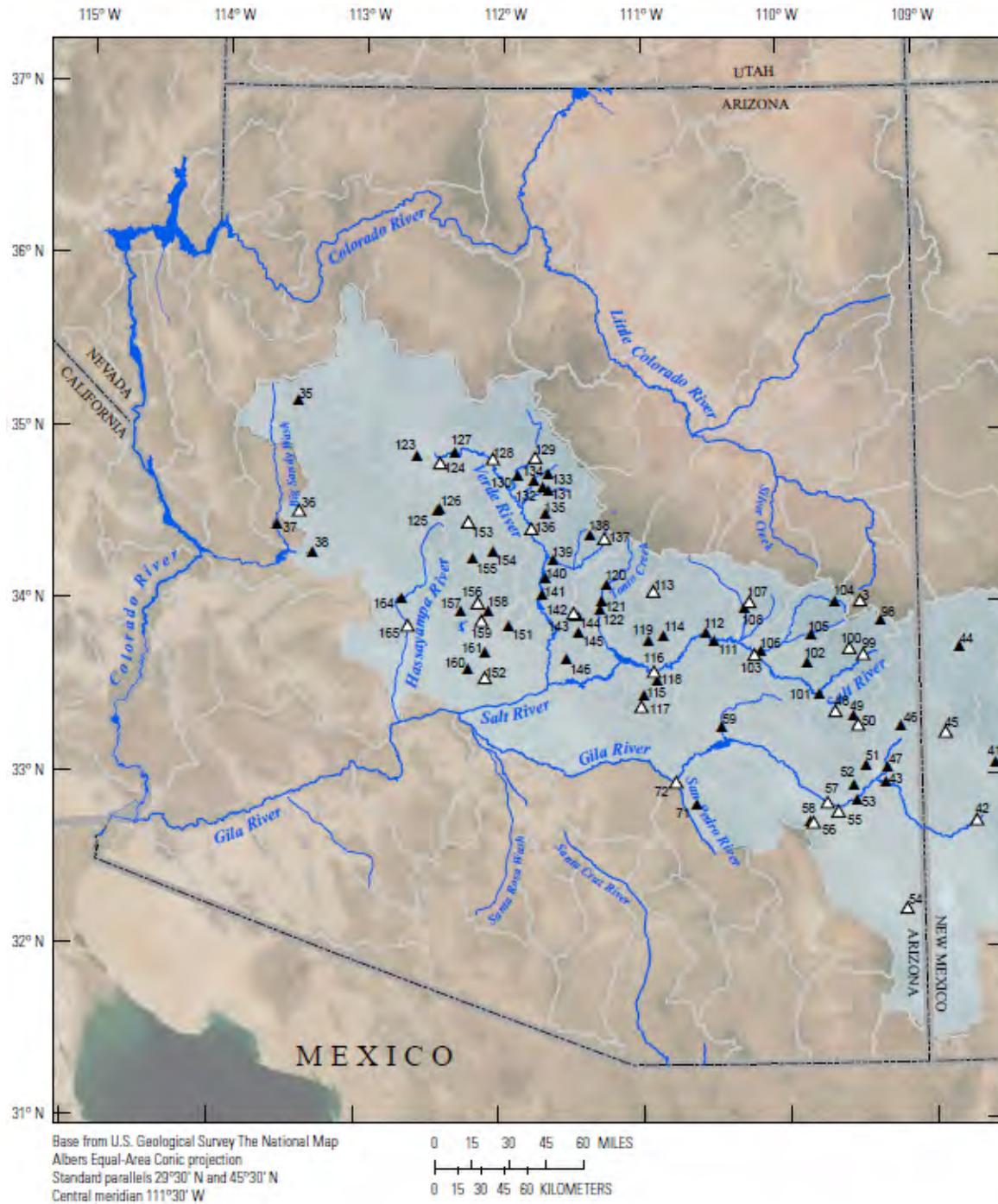
The USGS also developed regression equations from streamflow gaging stations to compute magnitude and frequency of flow volumes for five (5) durations – the 1-, 3-, 7-, 15-, and 30-day durations for the same eight (8) annual exceedance probabilities (AEP) as for the peak-flow frequency equations (50, 20, 10, 4, 2, 1, 0.5, and 0.2 percent) yielding 40 separate regression equations. Only one region of the state was found to have statistically significant relationships for the volume-duration estimates – the Central Highland region, which includes the Queen Creek, Devil’s Canyon, and Dripping Springs watersheds. The Donnelly Wash area watersheds lie immediately south of the Gila River which forms the southern boundary of the Central Highlands region west of the San Pedro River. Figure 3 shows the location of the Central Highland region and the stream gaging station locations used in the development of the volume-duration-frequency regression equations.

Three variables were found to explain the volume-duration-frequency relationships – drainage area (DRNAREA), mean annual precipitation (PRECIP), and mean basin elevation (ELEV). The resulting equations are shown in Figure 3 (Table 9 from SIR 2014-5109, v1.1). The standard error of prediction for these equations ranges from a little more than 50 percent for the 50-percent AEP equations to a little less than 30 percent for the 15- and 30-day 0.2-percent AEP equations. Drainage areas were computed using GIS from watersheds delineated using USGS 7.5-minute topographic quadrangles. Mean annual precipitation was computed for each watershed area in GIS from the NOAA US PRISM climate data for the 1990-2010 period. Mean basin elevation was computed in GIS from the USGS 10-meter digital elevation models (DEM).

Tables 3, 4, and 5 present the volume-duration-frequency results for the existing and proposed conditions and the differences between the two. The results show that the differences are nearly directly proportional to the reduction in drainage area at each location.

Volume-duration-frequency statistics were computed for the USGS Gila River at Kelvin gaging station (0947400) using the US Army Corps of Engineers HEC-SSP software. Gage data for the period of record following completion of Coolidge Dam (Nov. 1928) were analyzed. Those results are presented at the end of Table 3. No direct comparison of the proposed conditions is presented. However, due to very small ratio of drainage area impacts (about 12 square miles) from Skunk Camp (0.075%) or Peg Leg (0.054%) alternatives, changes to the Gila River are considered negligible. The drainage area at the Kelvin gage is 18,011 square miles of which 12,866 square miles lie upstream of Coolidge Dam and 5,125 square miles below Coolidge Dam, most of which flow from the San Pedro River. The Skunk Camp TSF site is upstream of the San Pedro River.





#### EXPLANATION

- ▲ Streamgaging stations used in the regional regression analysis
- △ Streamgaging stations with regression-weighted flood-duration flow estimates
- Region over which volume regression equations apply
- Eight-digit Hydrologic Unit Code (HUC) boundaries

Figure 3. Map showing central highland region and stream gage locations used in SIR 2014-5109

[Pct. AEP, percent annual exceedance probability; DRNAREA, drainage area in square miles; PRECIP, mean annual precipitation in inches. ELEV, mean basin elevation in feet]

Pct. AEP	Regression equation
1 day	
50	$0.00759 (DRNAREA)^{0.882} (PRECIP)^{2.454} 10^{(-0.095 * ELEV / 1,000)}$
20	$0.0692 (DRNAREA)^{0.836} (PRECIP)^{2.310} 10^{(-0.128 * ELEV / 1,000)}$
10	$0.189 (DRNAREA)^{0.808} (PRECIP)^{2.233} 10^{(-0.131 * ELEV / 1,000)}$
4	$0.240 (DRNAREA)^{0.781} (PRECIP)^{2.422} 10^{(-0.136 * ELEV / 1,000)}$
2	$0.619 (DRNAREA)^{0.765} (PRECIP)^{2.278} 10^{(-0.138 * ELEV / 1,000)}$
1	$1.50 (DRNAREA)^{0.751} (PRECIP)^{2.132} 10^{(-0.138 * ELEV / 1,000)}$
0.5	$3.44 (DRNAREA)^{0.739} (PRECIP)^{1.988} 10^{(-0.140 * ELEV / 1,000)}$
0.2	$30.1 (DRNAREA)^{0.700} (PRECIP)^{1.503} 10^{(-0.144 * ELEV / 1,000)}$
3 day	
50	$0.00597 (DRNAREA)^{0.875} (PRECIP)^{1.978}$
20	$0.0127 (DRNAREA)^{0.868} (PRECIP)^{2.516} 10^{(-0.101 * ELEV / 1,000)}$
10	$0.0524 (DRNAREA)^{0.847} (PRECIP)^{2.380} 10^{(-0.121 * ELEV / 1,000)}$
4	$0.173 (DRNAREA)^{0.826} (PRECIP)^{2.285} 10^{(-0.144 * ELEV / 1,000)}$
2	$0.568 (DRNAREA)^{0.812} (PRECIP)^{2.081} 10^{(-0.152 * ELEV / 1,000)}$
1	$1.68 (DRNAREA)^{0.800} (PRECIP)^{1.882} 10^{(-0.158 * ELEV / 1,000)}$
0.5	$4.61 (DRNAREA)^{0.790} (PRECIP)^{1.688} 10^{(-0.163 * ELEV / 1,000)}$
0.2	$23.6 (DRNAREA)^{0.755} (PRECIP)^{1.365} 10^{(-0.165 * ELEV / 1,000)}$
7 day	
50	$0.000538 (DRNAREA)^{0.916} (PRECIP)^{2.527}$
20	$0.00314 (DRNAREA)^{0.877} (PRECIP)^{2.669} 10^{(-0.074 * ELEV / 1,000)}$
10	$0.00820 (DRNAREA)^{0.871} (PRECIP)^{2.719} 10^{(-0.118 * ELEV / 1,000)}$
4	$0.0267 (DRNAREA)^{0.847} (PRECIP)^{2.672} 10^{(-0.147 * ELEV / 1,000)}$
2	$0.180 (DRNAREA)^{0.816} (PRECIP)^{2.288} 10^{(-0.161 * ELEV / 1,000)}$
1	$0.298 (DRNAREA)^{0.816} (PRECIP)^{2.246} 10^{(-0.168 * ELEV / 1,000)}$
0.5	$0.877 (DRNAREA)^{0.803} (PRECIP)^{2.041} 10^{(-0.175 * ELEV / 1,000)}$
0.2	$3.24 (DRNAREA)^{0.788} (PRECIP)^{1.787} 10^{(-0.183 * ELEV / 1,000)}$
15 day	
50	$0.0000440 (DRNAREA)^{0.958} (PRECIP)^{3.121}$
20	$0.000508 (DRNAREA)^{0.908} (PRECIP)^{3.006} 10^{(-0.065 * ELEV / 1,000)}$
10	$0.00209 (DRNAREA)^{0.884} (PRECIP)^{2.880} 10^{(-0.094 * ELEV / 1,000)}$
4	$0.00652 (DRNAREA)^{0.860} (PRECIP)^{2.865} 10^{(-0.129 * ELEV / 1,000)}$
2	$0.0217 (DRNAREA)^{0.844} (PRECIP)^{2.678} 10^{(-0.144 * ELEV / 1,000)}$
1	$0.0668 (DRNAREA)^{0.829} (PRECIP)^{2.490} 10^{(-0.157 * ELEV / 1,000)}$
0.5	$0.192 (DRNAREA)^{0.816} (PRECIP)^{2.305} 10^{(-0.168 * ELEV / 1,000)}$
0.2	$1.20 (DRNAREA)^{0.808} (PRECIP)^{1.857} 10^{(-0.172 * ELEV / 1,000)}$
30 day	
50	$0.00000789 (DRNAREA)^{0.978} (PRECIP)^{3.519}$
20	$0.000512 (DRNAREA)^{0.889} (PRECIP)^{2.637}$
10	$0.000361 (DRNAREA)^{0.903} (PRECIP)^{3.208} 10^{(-0.078 * ELEV / 1,000)}$
4	$0.000897 (DRNAREA)^{0.882} (PRECIP)^{3.255} 10^{(-0.113 * ELEV / 1,000)}$
2	$0.00261 (DRNAREA)^{0.868} (PRECIP)^{3.103} 10^{(-0.129 * ELEV / 1,000)}$
1	$0.00716 (DRNAREA)^{0.855} (PRECIP)^{2.942} 10^{(-0.141 * ELEV / 1,000)}$
0.5	$0.0187 (DRNAREA)^{0.843} (PRECIP)^{2.778} 10^{(-0.152 * ELEV / 1,000)}$
0.2	$0.111 (DRNAREA)^{0.837} (PRECIP)^{2.327} 10^{(-0.154 * ELEV / 1,000)}$

Figure 4. Volume-duration-frequency regression equations for Arizona central highland region (SIR 2014-5109, v1.1)



Table 3. Volume-duration-frequency results for select locations - Existing conditions

Queen Creek at Whitlow Ranch Dam								
	DRNAREA	PRECIP	ELEV					
	143.401	19.44	3435					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	415	1,514	2,797	5,230	8,000	11,633	16,266	26,942
3 day	163	743	1,485	2,947	4,625	6,810	9,612	15,456
7 day	91.8	375	778	1,554	2,573	3,559	5,056	7,660
15 day	53.9	206	412	828	1,297	1,915	2,732	4,207
30 day	34.8	105.9	235	459	699	1,013	1,405	2,090
Queen Creek upstream of Hewitt Canyon								
	DRNAREA	PRECIP	ELEV					
	117.49	19.54	3484					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	349	1,279	2,373	4,464	6,842	9,969	13,960	23,234
3 day	138.3	626	1,252	2,488	3,909	5,759	8,132	13,148
7 day	77.5	316	654	1,309	2,173	3,002	4,269	6,472
15 day	45.2	173.6	347	697	1,094	1,615	2,305	3,546
30 day	29.1	89.9	197.8	386	588	854	1,184	1,759
Queen Creek at Magma Ave								
	DRNAREA	PRECIP	ELEV					
	10.4	23.09	4289					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	52	195	381	782	1,213	1,780	2,501	4,189
3 day	23	96	190	377	583	846	1,174	1,959
7 day	12.8	51	100	200	327	442	619	919
15 day	7.5	28	55	110	169	245	343	496
30 day	4.9	16	33	64	95	135	184	256
Devil's Canyon at US60								
	DRNAREA	PRECIP	ELEV					
	10.95	24.37	4773					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	56	200	387	798	1,223	1,778	2,475	4,011
3 day	27	103	197	379	574	818	1,116	1,824
7 day	15.4	57	106	205	322	432	593	860
15 day	9.3	32	61	116	174	246	336	471
30 day	6.2	19.5	37	70	102	141	188	256

Table 3. Volume-duration-frequency results for select locations - Existing conditions - continued

Devil's Canyon below Rancho Rio Creek								
	DRNAREA	PRECIP	ELEV					
	16.55	24.07	4587					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	81	290	556	1,133	1,730	2,507	3,479	5,592
3 day	38	149	286	551	835	1,190	1,625	2,627
7 day	22	82	155	299	470	632	868	1,260
15 day	13.3	46	88	169	254	359	492	692
30 day	8.9	27	54	101	148	206	275	375
Devil's Canyon upstream of Mineral Creek								
	DRNAREA	PRECIP	ELEV)					
	35.63	22.07	4190					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	141	507	960	1,892	2,896	4,208	5,864	9,577
3 day	62	256	499	971	1,493	2,157	2,985	4,835
7 day	35.3	136	266	520	835	1,134	1,580	2,333
15 day	21.1	76.2	147	287	438	630	877	1,282
30 day	13.9	42.9	87.7	167	247	350	474	670
Devil's Canyon downstream of Mineral Creek								
	DRNAREA	PRECIP	ELEV					
	90.4	22.84	4171					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	350	1,203	2,211	4,280	6,422	9,165	12,569	19,471
3 day	149.7	629	1,197	2,279	3,437	4,879	6,648	10,288
7 day	90.4	339	660	1,261	1,944	2,638	3,606	5,208
15 day	57.3	197.3	372	710	1,060	1,495	2,045	2,920
30 day	39.0	107.4	227.7	426	620	864	1,152	1,592
Dripping Springs Wash upstream of Silver Creek								
	DRNAREA	PRECIP	ELEV					
	51.2	19.84	3731					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	165	615	1,165	2,241	3,469	5,099	7,193	12,246
3 day	68.9	299	600	1,195	1,885	2,787	3,946	6,539
7 day	37.6	152	309	621	1,043	1,434	2,046	3,114
15 day	21.4	82.4	165	331	521	771	1,102	1,691
30 day	13.6	44.7	93.9	183	279	405	563	833



Table 3. Volume-duration-frequency results for select locations - Existing conditions - continued

Dripping Springs Wash downstream of Silver Creek								
	DRNAREA	PRECIP	ELEV					
	78.2	21.93	4062					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	285	1,002	1,856	3,584	5,424	7,805	10,788	17,158
3 day	121.6	514	991	1,911	2,917	4,187	5,766	9,095
7 day	71.4	273	537	1,038	1,638	2,232	3,086	4,524
15 day	43.9	155.6	298	576	872	1,247	1,725	2,515
30 day	29.4	84.8	178.8	338	498	702	946	1,333
Dripping Springs Wash at its confluence with the Gila River								
	DRNAREA	PRECIP	ELEV					
	117.3	20.8	4090					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	356	1,234	2,269	4,290	6,499	9,370	12,986	20,853
3 day	156.2	635	1,224	2,345	3,596	5,189	7,189	11,361
7 day	90.6	336	657	1,258	2,000	2,729	3,794	5,598
15 day	54.9	191.0	364	696	1,056	1,514	2,103	3,129
30 day	36.2	105.8	216.5	404	596	842	1,138	1,639
Donnelly Wash at its confluence with the Gila River								
	DRNAREA	PRECIP	ELEV					
	61.5	17.67	2867					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	176	708	1,353	2,560	4,034	6,027	8,643	15,579
3 day	64.3	320	678	1,421	2,326	3,554	5,187	8,899
7 day	33.2	152	335	713	1,280	1,793	2,651	4,210
15 day	17.8	78.2	168	360	594	919	1,369	2,226
30 day	10.9	38.8	89.2	185	295	446	644	1,008
unnamed wash at its confluence with the Gila River								
	DRNAREA	PRECIP	ELEV					
	6.08	14.5	2115					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	17	81	168	329	556	885	1,345	2,940
3 day	5.7	31	74	172	306	506	792	1,583
7 day	2.4	13	32	76	163	233	374	656
15 day	1.0	5.9	14	35	64	108	176	320
30 day	0.6	2.9	6.7	15	27	44	69	120

Table 3. Volume-duration-frequency results for select locations - Existing conditions - continued

Gila River at Kelvin, USGS Gaging Station 09474000								
	DRNAREA	PRECIP	ELEV					
	18,011*							
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	2,620	6,373	10,730	19,539	29,496	43,445	62,807	99,982
3 day	1,756	3,975	6,539	11,763	17,740	26,235	38,223	61,754
7 day	1,171	2,491	3,990	7,006	10,432	15,281	22,104	35,479
15 day	873	1,766	2,765	4,754	6,997	10,154	14,580	23,228
30 day	757	1,423	2,119	3,422	4,812	6,677	9,175	13,803
Volume-duration-frequency statistics computed using HEC-SSP software for period of record Water Year 1930 to 2017. Coolidge Dam was completed in Nov. 1928. Drainage area includes 12,866 sq.mi. above Coolidge Dam and 5,125 sq.mi. below Coolidge Dam.								



Table 4. Volume-duration-frequency results for select locations - Proposed conditions

Queen Creek at Whitlow Ranch Dam – Near West TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	133.243	19.44	3435					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	389	1,424	2,635	4,939	7,562	11,009	15,406	25,591
3 day	153	697	1,395	2,774	4,357	6,421	9,070	14,624
7 day	85.8	351	729	1,461	2,424	3,352	4,766	7,229
15 day	50.2	193	386	777	1,219	1,802	2,573	3,964
30 day	32.4	99.2	220	430	655	952	1,321	1,965
Queen Creek upstream of Hewitt Canyon – Near West TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	107.33	19.54	3484					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	322	1,185	2,206	4,159	6,384	9,314	13,057	21,809
3 day	128	579	1,160	2,309	3,632	5,357	7,571	12,283
7 day	71.3	292	605	1,213	2,019	2,789	3,970	6,026
15 day	41.5	160	320	645	1,013	1,499	2,141	3,296
30 day	26.7	82.9	182	357	544	790	1,097	1,631
Queen Creek at Whitlow Ranch Dam – Silver King TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	133.602	19.44	3435					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	390	1,427	2,641	4,949	7,578	11,031	15,437	25,639
3 day	153	699	1,398	2,780	4,367	6,435	9,089	14,654
7 day	86.0	352	731	1,464	2,429	3,359	4,777	7,244
15 day	50.4	193	387	779	1,222	1,806	2,578	3,973
30 day	32.4	99.4	220	431	657	954	1,324	1,970
Queen Creek upstream of Hewitt Canyon – Silver King TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	107.69	19.54	3484					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	323	1,189	2,212	4,170	6,401	9,337	13,090	21,860
3 day	128	581	1,163	2,316	3,642	5,372	7,591	12,314
7 day	71.5	293	606	1,216	2,024	2,796	3,980	6,042
15 day	41.6	160	321	647	1,016	1,503	2,147	3,305
30 day	26.7	83.2	183	358	546	793	1,100	1,636

Table 4. Volume-duration-frequency results for select locations - Proposed conditions - continued

Queen Creek at Magma Ave – All Alternatives								
	DRNAREA	PRECIP	ELEV					
	8.27	23.09	4289					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	42	161	317	654	1,018	1,499	2,112	3,568
3 day	19	79	157	312	484	704	979	1,649
7 day	10.4	42	82	165	271	367	515	768
15 day	6.0	23	45	90	139	203	285	412
30 day	3.9	13	27	52	78	111	152	212
Devil's Canyon at US60								
	DRNAREA	PRECIP	ELEV					
	10.95	24.37	4773					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	56	200	387	798	1,223	1,778	2,475	4,011
3 day	27	103	197	379	574	818	1,116	1,824
7 day	15.4	57	106	205	322	432	593	860
15 day	9.3	32	61	116	174	246	336	471
30 day	6.2	19.5	37	70	102	141	188	256
Devil's Canyon below Rancho Rio Creek								
	DRNAREA	PRECIP	ELEV					
	15.59	24.07	4587					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	77	276	530	1,081	1,653	2,397	3,329	5,363
3 day	36	142	272	524	795	1,134	1,550	2,512
7 day	21	78	147	284	448	602	827	1,202
15 day	12.5	44	84	161	241	341	468	660
30 day	8.4	26	51	96	140	196	262	356
Devil's Canyon upstream of Mineral Creek								
	DRNAREA	PRECIP	ELEV					
	34.67	22.07	4190					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	137	496	939	1,853	2,836	4,123	5,747	9,395
3 day	60	250	488	949	1,460	2,110	2,922	4,736
7 day	34.4	133	260	508	816	1,109	1,545	2,284
15 day	20.5	74.3	144	281	428	616	858	1,254
30 day	13.6	41.9	85.5	163	241	342	464	655

Table 4. Volume-duration-frequency results for select locations - Proposed conditions - continued

Devil's Canyon downstream of Mineral Creek								
	DRNAREA	PRECIP	ELEV					
	89.45	22.84	4171					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	346	1,192	2,192	4,245	6,370	9,093	12,472	19,327
3 day	148.3	624	1,186	2,260	3,408	4,838	6,593	10,206
7 day	89.5	336	654	1,250	1,927	2,616	3,575	5,165
15 day	56.7	195.4	368	703	1,051	1,482	2,027	2,896
30 day	38.6	106.4	225.5	422	615	856	1,142	1,578
Dripping Springs Wash upstream of Silver Creek – Skunk Camp TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	39.47	19.84	3731					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	131	495	944	1,829	2,843	4,194	5,934	10,207
3 day	54.9	238	481	964	1,526	2,264	3,213	5,376
7 day	29.6	121	247	498	843	1,159	1,660	2,537
15 day	16.7	65.0	131	265	418	621	891	1,370
30 day	10.6	35.5	74.2	145	222	324	452	670
Dripping Springs Wash downstream of Silver Creek – Skunk Camp TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	66.52	21.93	4062					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	247	875	1,629	3,159	4,793	6,912	9,572	15,321
3 day	106	447	864	1,672	2,558	3,679	5,075	8,052
7 day	61.6	237	466	905	1,436	1,956	2,710	3,982
15 day	37.6	134	258	501	761	1,090	1,512	2,207
30 day	25.1	73.5	154	293	433	611	825	1,165
Dripping Springs Wash at its confluence with the Gila River – Skunk Camp TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	105.62	20.8	4090					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	324	1,130	2,085	3,952	5,998	8,660	12,018	19,377
3 day	143	580	1,120	2,150	3,302	4,772	6,617	10,498
7 day	82.3	307	599	1,151	1,836	2,505	3,487	5,154
15 day	49.6	174	332	636	967	1,388	1,931	2,874
30 day	32.7	96.4	197	368	544	770	1,042	1,501



Table 4. Volume-duration-frequency results for select locations - Proposed conditions - continued

Donnelly Wash at its confluence with the Gila River – Peg Leg TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	49.92	17.67	2867					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	147	594	1,143	2,175	3,439	5,153	7,408	13,462
3 day	53.6	267	568	1,196	1,964	3,008	4,399	7,606
7 day	27.4	127	279	597	1,079	1,512	2,242	3,572
15 day	14.6	64.7	139	301	498	773	1,154	1,881
30 day	8.9	32.2	73.9	154	246	373	540	846
unnamed wash at its confluence with the Gila River – Peg Leg TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	5.67	14.5	2115					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	16	76	159	312	527	840	1,277	2,799
3 day	5.4	29	70	162	289	478	749	1,502
7 day	2.3	13	30	72	154	220	353	620
15 day	1.0	5.5	14	33	60	102	166	303
30 day	0.5	2.8	6.3	14	25	41	65	113
Notes:								
1) Impacts to Devil’s Canyon from subsidence area. Same for all alternatives.								
2) Impacts to Queen Creek include West Plant area for all alternatives.								
3) Impacts for Peg Leg alternative to Donnelly Wash at Gila River reflect about 1 square mile of Donnelly Wash watershed which is diverted to the unnamed tributary.								
4) No proposed condition is presented for Gila River at Kelvin. However, due to very small ratio of drainage area impacts from Skunk Camp (0.075%) or Peg Leg (0.054%) alternatives, changes to the Gila River are considered negligible.								

Table 5. Volume-duration-frequency results for select locations – Difference (Existing – Proposed)/Existing

Queen Creek at Whitlow Ranch Dam – Near West TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-7.1%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-6.3%	-6.0%	-5.8%	-5.6%	-5.5%	-5.4%	-5.3%	-5.0%
3 day	-6.2%	-6.2%	-6.0%	-5.9%	-5.8%	-5.7%	-5.6%	-5.4%
7 day	-6.5%	-6.2%	-6.2%	-6.0%	-5.8%	-5.8%	-5.7%	-5.6%
15 day	-6.8%	-6.5%	-6.3%	-6.1%	-6.0%	-5.9%	-5.8%	-5.8%
30 day	-6.9%	-6.3%	-6.4%	-6.3%	-6.2%	-6.1%	-6.0%	-6.0%
Queen Creek upstream of Hewitt Canyon – Near West TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-8.6%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-7.7%	-7.3%	-7.0%	-6.8%	-6.7%	-6.6%	-6.5%	-6.1%
3 day	-7.6%	-7.6%	-7.4%	-7.2%	-7.1%	-7.0%	-6.9%	-6.6%
7 day	-8.0%	-7.6%	-7.6%	-7.4%	-7.1%	-7.1%	-7.0%	-6.9%
15 day	-8.3%	-7.9%	-7.7%	-7.5%	-7.3%	-7.2%	-7.1%	-7.0%
30 day	-8.5%	-7.7%	-7.8%	-7.7%	-7.6%	-7.4%	-7.3%	-7.3%
Queen Creek at Whitlow Ranch Dam – Silver King TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-6.8%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-6.1%	-5.7%	-5.6%	-5.4%	-5.3%	-5.2%	-5.1%	-4.8%
3 day	-6.0%	-6.0%	-5.8%	-5.7%	-5.6%	-5.5%	-5.4%	-5.2%
7 day	-6.3%	-6.0%	-6.0%	-5.8%	-5.6%	-5.6%	-5.5%	-5.4%
15 day	-6.6%	-6.2%	-6.1%	-5.9%	-5.8%	-5.7%	-5.6%	-5.6%
30 day	-6.7%	-6.1%	-6.2%	-6.1%	-6.0%	-5.9%	-5.8%	-5.8%
Queen Creek upstream of Hewitt Canyon – Silver King TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-8.3%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-7.4%	-7.0%	-6.8%	-6.6%	-6.4%	-6.3%	-6.2%	-5.9%
3 day	-7.3%	-7.3%	-7.1%	-6.9%	-6.8%	-6.7%	-6.6%	-6.3%
7 day	-7.7%	-7.4%	-7.3%	-7.1%	-6.9%	-6.9%	-6.8%	-6.6%
15 day	-8.0%	-7.6%	-7.4%	-7.2%	-7.1%	-7.0%	-6.9%	-6.8%
30 day	-8.2%	-7.5%	-7.6%	-7.4%	-7.3%	-7.2%	-7.1%	-7.0%

Table 5. Volume-duration-frequency results for select locations - Difference - continued

Queen Creek at Magma Ave – All Alternatives								
	DRNAREA	PRECIP	ELEV					
	-20.5%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-18.3%	-17.4%	-16.9%	-16.4%	-16.1%	-15.8%	-15.6%	-14.8%
3 day	-18.2%	-18.0%	-17.6%	-17.2%	-17.0%	-16.8%	-16.6%	-15.8%
7 day	-18.9%	-18.2%	-18.1%	-17.6%	-17.1%	-17.1%	-16.8%	-16.5%
15 day	-19.7%	-18.8%	-18.3%	-17.9%	-17.6%	-17.3%	-17.1%	-16.9%
30 day	-20.1%	-18.4%	-18.7%	-18.3%	-18.0%	-17.8%	-17.6%	-17.5%
Devil's Canyon at US60								
	DRNAREA	PRECIP	ELEV					
	0.0%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3 day	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
7 day	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15 day	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
30 day	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Devil's Canyon below Rancho Rio Creek								
	DRNAREA	PRECIP	ELEV					
	-5.8%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-5.1%	-4.9%	-4.7%	-4.6%	-4.5%	-4.4%	-4.3%	-4.1%
3 day	-5.1%	-5.1%	-4.9%	-4.8%	-4.7%	-4.7%	-4.6%	-4.4%
7 day	-5.3%	-5.1%	-5.1%	-4.9%	-4.8%	-4.8%	-4.7%	-4.6%
15 day	-5.6%	-5.3%	-5.1%	-5.0%	-4.9%	-4.8%	-4.8%	-4.7%
30 day	-5.7%	-5.2%	-5.3%	-5.1%	-5.1%	-5.0%	-4.9%	-4.9%
Devil's Canyon upstream of Mineral Creek								
	DRNAREA	PRECIP	ELEV					
	-2.7%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-2.4%	-2.3%	-2.2%	-2.1%	-2.1%	-2.0%	-2.0%	-1.9%
3 day	-2.4%	-2.3%	-2.3%	-2.2%	-2.2%	-2.2%	-2.1%	-2.0%
7 day	-2.5%	-2.4%	-2.4%	-2.3%	-2.2%	-2.2%	-2.2%	-2.1%
15 day	-2.6%	-2.4%	-2.4%	-2.3%	-2.3%	-2.2%	-2.2%	-2.2%
30 day	-2.6%	-2.4%	-2.4%	-2.4%	-2.3%	-2.3%	-2.3%	-2.3%



Table 5. Volume-duration-frequency results for select locations - Difference - continued

Devil's Canyon downstream of Mineral Creek								
	DRNAREA	PRECIP	ELEV					
	-1.1%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-0.9%	-0.9%	-0.8%	-0.8%	-0.8%	-0.8%	-0.8%	-0.7%
3 day	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.8%	-0.8%	-0.8%
7 day	-1.0%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.8%	-0.8%
15 day	-1.0%	-1.0%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.8%
30 day	-1.0%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%	-0.9%
Dripping Springs Wash upstream of Silver Creek – Skunk Camp TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-22.9%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-20.5%	-19.5%	-19.0%	-18.4%	-18.0%	-17.8%	-17.5%	-16.7%
3 day	-20.4%	-20.2%	-19.8%	-19.3%	-19.0%	-18.8%	-18.6%	-17.8%
7 day	-21.2%	-20.4%	-20.3%	-19.8%	-19.1%	-19.1%	-18.9%	-18.5%
15 day	-22.1%	-21.0%	-20.5%	-20.1%	-19.7%	-19.4%	-19.1%	-19.0%
30 day	-22.5%	-20.7%	-20.9%	-20.5%	-20.2%	-19.9%	-19.7%	-19.6%
Dripping Springs Wash downstream of Silver Creek – Skunk Camp TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-14.9%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-13.3%	-12.6%	-12.3%	-11.9%	-11.6%	-11.4%	-11.3%	-10.7%
3 day	-13.2%	-13.1%	-12.8%	-12.5%	-12.3%	-12.1%	-12.0%	-11.5%
7 day	-13.8%	-13.2%	-13.1%	-12.8%	-12.4%	-12.4%	-12.2%	-12.0%
15 day	-14.4%	-13.7%	-13.3%	-13.0%	-12.8%	-12.6%	-12.4%	-12.3%
30 day	-14.6%	-13.4%	-13.6%	-13.3%	-13.1%	-12.9%	-12.7%	-12.7%
Dripping Springs Wash at its confluence with the Gila River – Skunk Camp TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-10.0%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-8.8%	-8.4%	-8.1%	-7.9%	-7.7%	-7.6%	-7.5%	-7.1%
3 day	-8.8%	-8.7%	-8.5%	-8.3%	-8.2%	-8.0%	-8.0%	-7.6%
7 day	-9.2%	-8.8%	-8.7%	-8.5%	-8.2%	-8.2%	-8.1%	-7.9%
15 day	-9.6%	-9.1%	-8.9%	-8.6%	-8.5%	-8.3%	-8.2%	-8.1%
30 day	-9.7%	-8.9%	-9.0%	-8.8%	-8.7%	-8.6%	-8.5%	-8.4%

Table 5. Volume-duration-frequency results for select locations - Difference - continued

Donnelly Wash at its confluence with the Gila River – Peg Leg TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-18.8%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-16.8%	-16.0%	-15.5%	-15.0%	-14.8%	-14.5%	-14.3%	-13.6%
3 day	-16.7%	-16.6%	-16.2%	-15.8%	-15.6%	-15.4%	-15.2%	-14.5%
7 day	-17.4%	-16.7%	-16.6%	-16.2%	-15.7%	-15.7%	-15.4%	-15.2%
15 day	-18.1%	-17.3%	-16.8%	-16.4%	-16.1%	-15.9%	-15.7%	-15.5%
30 day	-18.5%	-16.9%	-17.2%	-16.8%	-16.6%	-16.3%	-16.1%	-16.0%
unnamed wash at its confluence with the Gila River – Peg Leg TSF Alternative								
	DRNAREA	PRECIP	ELEV					
	-6.7%	0.0%	0.0%					
	Flood Duration Flows, in cfs, for Annual Exceedance Probability (%)							
Duration	50	20	10	4	2	1	0.5	0.2
1 day	-6.0%	-5.7%	-5.5%	-5.3%	-5.2%	-5.1%	-5.0%	-4.8%
3 day	-5.9%	-5.9%	-5.7%	-5.6%	-5.5%	-5.4%	-5.4%	-5.1%
7 day	-6.2%	-5.9%	-5.9%	-5.7%	-5.5%	-5.5%	-5.5%	-5.4%
15 day	-6.5%	-6.1%	-6.0%	-5.8%	-5.7%	-5.6%	-5.5%	-5.5%
30 day	-6.6%	-6.0%	-6.1%	-6.0%	-5.9%	-5.8%	-5.7%	-5.7%
Notes:								
1) Impacts to Devil’s Canyon from subsidence area. Same for all alternatives.								
2) Impacts to Queen Creek include West Plant area for all alternatives.								
3) Impacts for Peg Leg alternative to Donnelly Wash at Gila River reflect about 1 square mile of Donnelly Wash watershed which is diverted to the unnamed tributary.								
4) No volume-duration-frequency difference is presented for Gila River at Kelvin. However, due to very small ratio of drainage area impacts from Skunk Camp (0.075%) or Peg Leg (0.054%) alternatives, changes to the Gila River are considered negligible.								

## References

FCDMC, 2013, Drainage Design Manual for Maricopa County, Arizona, Hydrology, 4<sup>th</sup> Edition, August 15, 2013.

Kennedy, J. R., Paretti, N.V., and Veilleux, A.G., 2015, Methods for Estimating Magnitude and Frequency of 1-, 3-, 7-, 15-, and 30-day flood-duration flows in Arizona, USGS Scientific Investigations Report (SIR) 2014-5109, Version 1.1, 35 pp.

Paretti, N. V., Kennedy, J. R., Turney, L. A., and Veilleux, A. G., 2014, Methods for Estimating Magnitude and Frequency of Floods in Arizona, Developed with Unregulated and Rural Peak-Flow Data through Water Year 2010. USGS Scientific Investigations Report (SIR) 2014-5211, 61 pp.



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September 4, 2018

Ms. Mary Rasmussen  
US Forest Service  
Supervisor's Office  
2324 East McDowell Road  
Phoenix, AZ 85006-2496


**Subject:** Follow-up to July 17, 2018 Request: USGS Regression Analysis for Tailings Alternatives and Water Year 2017 Baseline Streamflow Data and Precipitation/Runoff Analysis.

Dear Ms. Rasmussen,

For your review and consideration and in response to the July 17, 2018 request for USGS regression analysis for all tailings alternatives please see the attached technical memorandum from JE Fuller titled "*USGS Regression Equation Computation Updates for Queen Creek, Devil's Canyon, Dripping Springs Wash (Skunk Camp), and Donnelly Wash area (Peg Leg)*." The report updates the previous analysis of flood flow frequency and volume-duration-frequency with the addition of values for the Tailings Storage Facility (TSF) Alternatives 4, 5 and 6 for Queen Creek, Devil's Canyon, Drilling Springs Wash and Donnelley Wash.

Additionally, a second technical memorandum by JE Fuller titled "*Water Year 2017 Streamflow data and Precipitation vs. Runoff Analyses*" has also been included with this submittal which presents compiled streamflow data for several gaging sites in the Queen Creek, Devil's Canyon and Mineral Creek watersheds for water year 2017 (October 1, 2016 through September 30, 2017). This work extends previously compiled streamflow records performed by JE Fuller for data collected prior to Water Year 2017.

Sincerely,



Vicky Peacey,

Senior Manager, Environment, Permitting and Approvals; Resolution Copper Company, as  
Manager of Resolution Copper Mining, LLC



Cc: Ms. Mary Morissette; Senior Environmental Specialist; Resolution Copper Company

Enclosure(s):

JE Fuller Technical Memorandum, August 2018. USGS Regression Equation Computation Updates for Queen Creek, Devil's Canyon, Dripping Springs Wash (Skunk Camp), and Donnelly Wash area (Peg Leg)

JE Fuller Technical Memorandum, August, 2018. Water Year 2017 Streamflow data and Precipitation vs. Runoff Analyses