

TECHNICAL MEMORANDUM

DATE: August 16, 2022
TO: Wesley Walker and Angela Bezzone (MBK Engineers)
PREPARED BY: Carissa Abraham, EIT (MBK Engineers)
SUBJECT: Development of Funks Creek and Stone Corral Creek Streamflow Estimate

MBK Engineers was tasked with developing a streamflow estimate for Funks Creek and Stone Corral Creek to assist with determining the water available for appropriation from these creeks for Sites Reservoir. Sites Reservoir is a reservoir proposed near Maxwell, California, which would store water diverted off the Sacramento River to increase water supply in dry years. Sites Reservoir would include two dams that would impound the creeks flow: Sites Dam on Stone Corral Creek and Golden Gate Dam on Funks Creek.

Background

Stone Corral Creek and Funks Creek are both located in Colusa County and flow east towards the Sacramento River. The total drainage area of the historical gauge on Stone Corral Creek is approximately 38.3 square miles, with approximately 35.4 square miles located upstream of the proposed Sites Dam location. The total drainage area of Funks Creek upstream of the proposed Golden Gate Dam location is approximately 50.3 square miles as shown in Figure 1. Streamflow data for Stone Corral Creek is available from United States Geological Survey (USGS) Gage No. 11390672, which includes recorded discharge for the period April 1, 1958, through September 29, 1985. There is some missing and erroneous data in 1964-1965. There is no historical streamflow data available for Funks Creek.

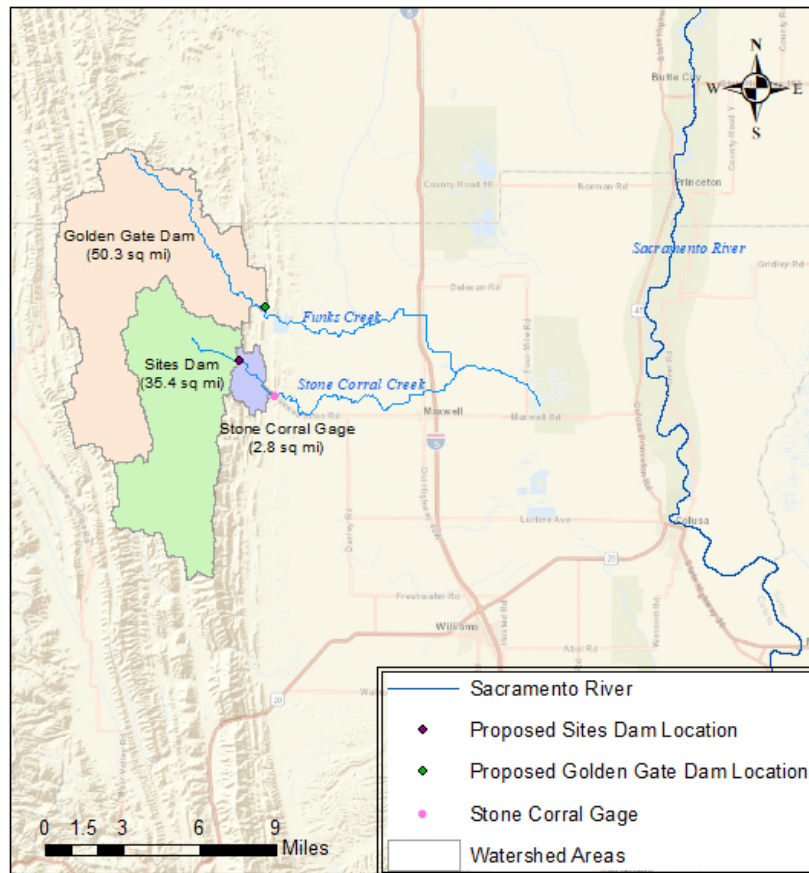


Figure 1 - Stone Corral Creek and Funks Creek Watersheds Upstream of Proposed Sites Dam and Golden Gate Dam Locations and Stone Corral Gauge

Analytical Approach

Because the historical gauge record for Stone Corral Creek is limited and Funks Creek is ungauged, historical stream gauge data from Elder Creek was used to produce an estimate of streamflow on Stone Corral and Funks creeks. The Elder Creek gauge was chosen because it was the nearest gauge on the valley floor with a long record of data available. It was assumed that Elder Creek has relatively similar precipitation and runoff patterns to Stone Corral and Funks creeks. The streamflow of Elder Creek, located in Tehama County, has been measured since 1948 (USGS Gage No. 11379500). The Elder Creek gauge is approximately 49 miles northwest of the proposed Sites Reservoir location as shown in Figure 2. The drainage area above the Elder Creek gauge is approximately 92.4 square miles.



Figure 2 - Elder Creek Proximity to Proposed Sites Reservoir Location

The overlapping period of gauge records for Stone Corral Creek and Elder Creek (1958-1985) was used to determine a logarithmic correlation between the two gauges for each month of the year. A monthly correlation was chosen as the daily variability in flow between Elder Creek and Stone Corral Creek limited the utility of developing a reasonable and acceptable daily correlation. The monthly correlation was then used to estimate the monthly Stone Corral Creek flow for the period of September 1985 (end of gauge record) through September 2021. An example of the logarithmic correlation for the monthly flow at each gauge for January is shown in Figure 3 below. Based on a review of the available data, Stone Corral Creek can be described as a stream with an intermittent flow regime. Available data suggested that essentially no measured surface flow occurred at the gauge location during the months of August-October and only three years with marginal flow in July. Based on this data and for the purposes of the water availability analysis, it was assumed that no measurable surface flow would occur at the gauge location on Stone Corral Creek during July-October or at any time there was no flow measured at the Elder Creek gauge.

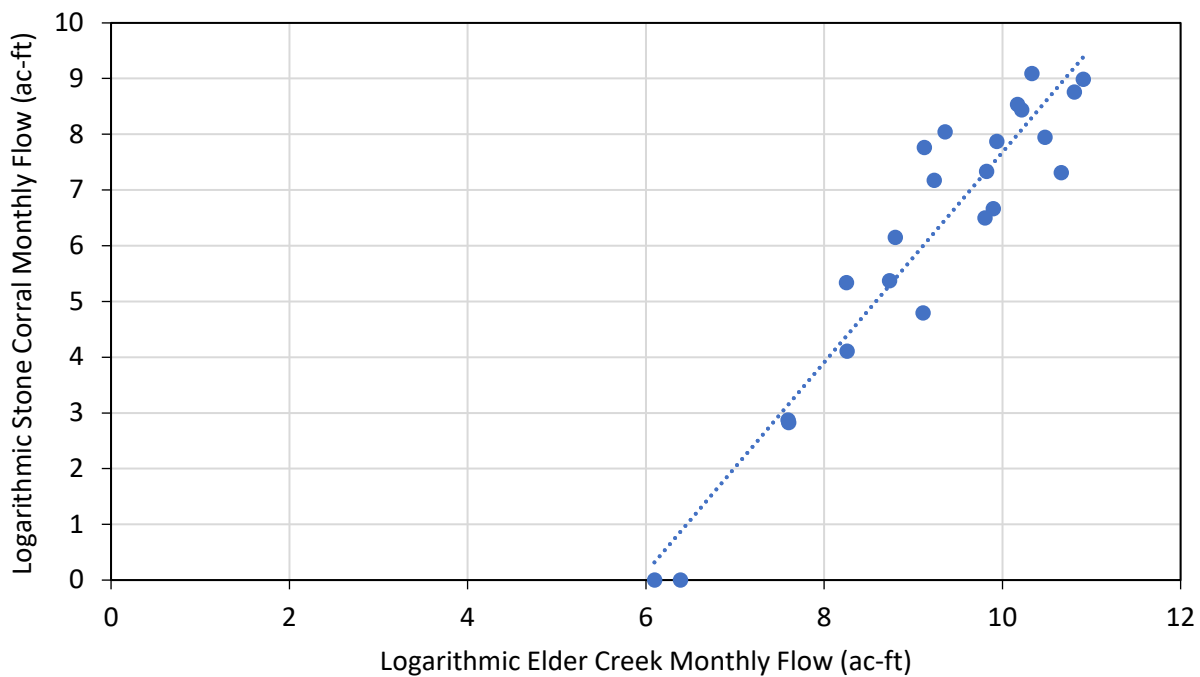


Figure 3 - Logarithmic Correlation between Elder Creek and Stone Corral Creek for January (1958-1985)

The monthly flow at the Stone Corral gauge was estimated using the following equation for each month in Table 1. The R^2 correlation between Stone Corral Creek and Elder Creek for each month over the period of available data is also included for reference.

Table 1 - Monthly Logarithmic Correlation Equations for Flow at Stone Corral Gauge

Month	Stone Corral Gage Flow Equation	R^2 Correlation
Nov	$\exp(1.216 * \ln(\text{Elder Creek Flow}) - 7.595)$	0.837
Dec	$\exp(1.523 * \ln(\text{Elder Creek Flow}) - 9.314)$	0.694
Jan	$\exp(1.886 * \ln(\text{Elder Creek Flow}) - 11.184)$	0.946
Feb	$\exp(2.178 * \ln(\text{Elder Creek Flow}) - 14.056)$	0.912
Mar	$\exp(2.188 * \ln(\text{Elder Creek Flow}) - 14.678)$	0.858
Apr	$\exp(2.041 * \ln(\text{Elder Creek Flow}) - 13.465)$	0.826
May	$\exp(1.560 * \ln(\text{Elder Creek Flow}) - 9.770)$	0.761
Jun	$\exp(1.125 * \ln(\text{Elder Creek Flow}) - 6.950)$	0.666

The calculated Stone Corral Creek flow at the proposed Sites Dam location was then determined by prorating the estimated flow at the Stone Corral gauge by the ratio of the watershed areas

upstream of the gauge and the proposed dam location. The monthly streamflow in Stone Corral Creek at the proposed Sites Dam location is estimated using the following equation (Equation 1):

$$\text{Stone Corral Flow @ Sites Dam} = \frac{35.4 \text{ sq mi}}{38.3 \text{ sq mi}} * (\text{Stone Corral Gage Flow})$$

Since there is no streamflow data available for Funks Creek, the same correlation approach cannot be followed to estimate Funks Creek streamflow. Given that the Funks Creek and Stone Corral Creek watersheds have similar watershed areas, soils, vegetation, and elevation, the hydrologic characteristics of the two creeks were assumed to be similar. As such, the flow in Funks Creek was estimated by prorating the monthly Stone Corral Creek streamflow data by the ratio of Funks and Stone Corral Creek's watershed areas upstream of the proposed dam locations. The monthly streamflow in Funks Creek at Golden Gate Dam is estimated using the following equation (Equation 2):

$$\text{Funks Creek Flow @ Golden Gate Dam} = \frac{50.3 \text{ sq mi}}{35.4 \text{ sq mi}} * (\text{Stone Corral Flow @ Sites Dam})$$

Results of Analysis

The average monthly flow volume in Stone Corral Creek at the proposed Sites Dam location by Sacramento Valley Water Year Types is shown in Figure 4 and Table 2. The average monthly flow volumes are calculated using the gauge record for October 1958 through September 1985 and using the logarithmic monthly correlations for October 1985 through September 2021. Results are summarized by Sacramento Valley Water Year Type: wet (W), above normal (AN), below normal (BN), dry (D), and critical (C).

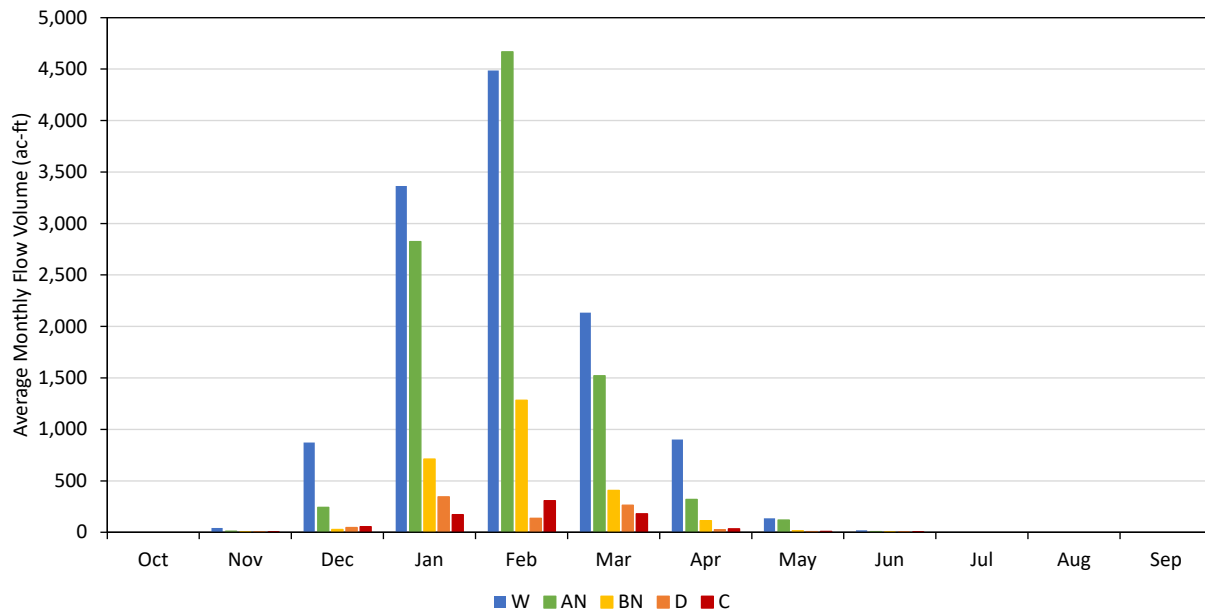


Figure 4 – Estimated Average Monthly Flow Volume Based on WY Type for Stone Corral Creek at Proposed Sites Dam (1958-2021)

Table 2 - Stone Corral Creek at Proposed Sites Dam Average Monthly Flow Volume (ac-ft) by Water Year Type (1958-2021)

Month	Water Year Type					Average of All Years
	Wet	Above Normal	Below Normal	Dry	Critical	
Oct	0	0	0	0	0	0
Nov	42	11	2	5	0	17
Dec	872	242	29	47	54	342
Jan	3,365	2,825	711	345	171	1,663
Feb	4,487	4,667	1,283	135	307	2,317
Mar	2,135	1,522	407	264	179	1,039
Apr	901	319	114	25	35	375
May	136	119	15	7	9	65
Jun	20	8	2	1	1	8
Jul	1	0	0	0	0	0
Aug	0	0	0	0	0	0
Sep	0	0	0	0	0	0
WY Total	11,959	9,713	2,562	828	757	5,827

Table 3 shows a comparison of the flow estimated using monthly logarithmic regressions and the gauged record for Stone Corral Creek. Overall, the regression produces estimated streamflow volumes that are comparable in most months of all water year types, with some larger differences in the winter months of Wet and Above Normal¹ years. The error in Wet, Above Normal, and Below Normal years is a negative value indicating the estimated flow was less than the observed gauge flow. This indicates the estimated flow may be conservative and underestimating the flow in these year types.

Table 3 - Average Difference between Estimated Stone Corral Monthly Flow at the Gage from Logarithmic Regression and the Monthly Flow from Gauge Period of Record, 1958-1985 (ac-ft)

Month	Water Year Type					Average of All Years
	Wet	Above Normal	Below Normal	Dry	Critical	
Nov	-82	-23	-2	-7	1	-37
Dec	-1,548	-208	16	4	1	-640
Jan	-1,670	-4,286	-645	-276	2	-1,366
Feb	1,974	-2,125	-1,073	164	1	353
Mar	-1,129	188	41	156	2	-390
Apr	1,216	551	143	73	5	596
May	20	56	30	14	8	24
Jun	-3	10	5	4	2	1
Jul	-1	2	2	1	1	1
WY Avg	-1,109	-5,837	-1,486	133	22	-1,463

The average monthly calculated flow volume in Funks Creek by Sacramento Valley Water Year Type using the monthly flow volumes calculated using Equation 2 is shown in Figure 5 and Table 4.

¹ As only three Above Normal years occur over the 1958-1985 period, the average is overly biased by the limited data points available. As noted above, the large negative value indicates the correlation provides a conservative estimate of potential water available by underestimating flow in these wetter years.

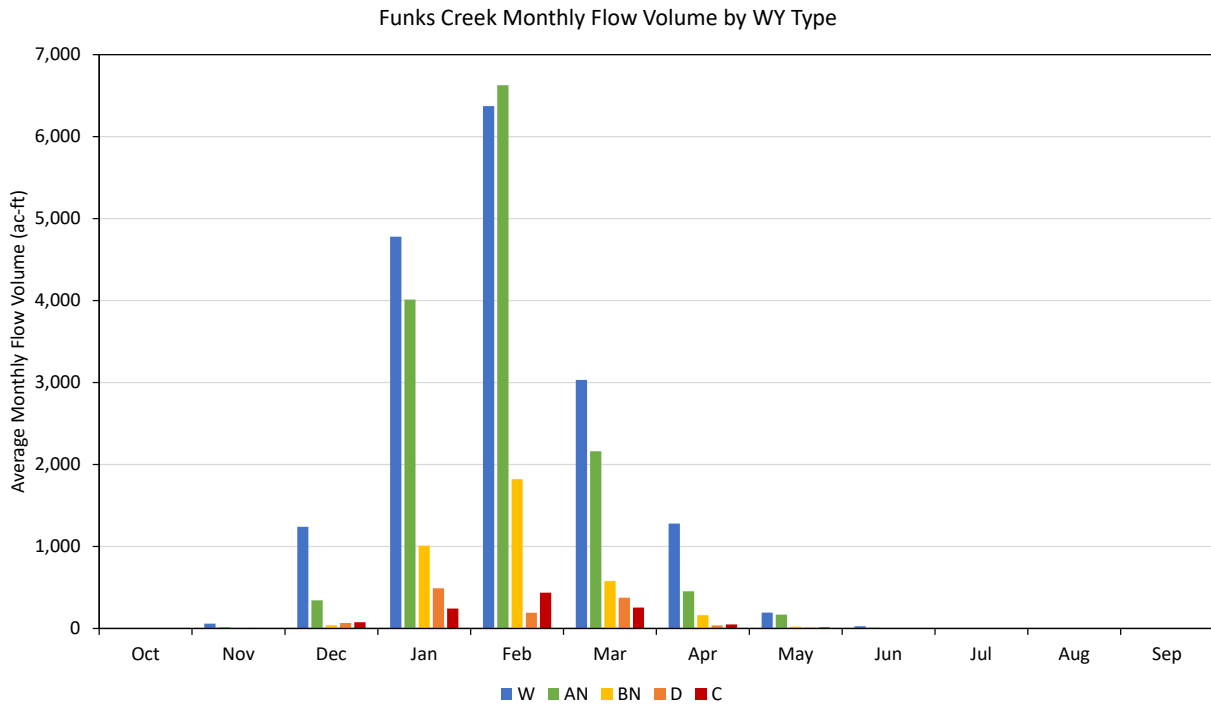


Figure 5 - Estimated Average Monthly Flow Volume Based on WY Type for Funks Creek (1958-2021)

Table 4 - Funks Creek Average Monthly Flow Volume (ac-ft) by Water Year Type (1958-2021)

Month	Water Year Type					Average of All Years
	Wet	Above Normal	Below Normal	Dry	Critical	
Oct	0	0	0	0	0	0
Nov	60	16	3	7	1	24
Dec	1,239	343	41	66	77	485
Jan	4,778	4,011	1,010	489	243	2,362
Feb	6,372	6,628	1,822	192	436	3,290
Mar	3,031	2,161	578	375	255	1,475
Apr	1,280	453	162	36	49	533
May	193	169	21	9	13	93
Jun	28	11	2	1	2	12
Jul	2	0	0	0	0	1
Aug	0	0	0	0	0	0
Sep	0	0	0	0	0	0
WY Total	16,984	13,793	3,638	1,176	1,075	8,275