ATTACHMENT J

REGIONAL FISH DENSITIES MEMO

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Trout Reference Densities

The Combined Aquatic Working Group (CAWG) wanted to assess trout densities in Project bypass reaches with appropriate reference sites. In some locations it was possible to compare trout densities in the Big Creek bypass reaches with the density of fish upstream of project facilities. Comparing populations above and below project facilities provides the best reference for how project operations might be influencing fish populations. The reaches upstream of project diversions are subject to the same factors as the reaches below project diversions (geology, meteorology, runoff, productivity, etc.), and thus would generally be expected to provide similar conditions for fish. In addition, these comparisons used fish densities collected at about the same time using the same techniques and the same personnel. The principal difference between the two reaches are generally the diversion of flow and its effects on geomorphology, flow-related habitat, and temperature. These upstream/downstream comparisons were made for all of the seasonally diverted streams (where fish were present), Bear Creek, and for the South Fork San Joaquin River.

Suitable upstream reference reaches were not available for all project streams, however, including Mono Creek, Big Creek, NF Stevenson Creek, Stevenson Creek, and the San Joaquin River. For these streams, the CAWG decided to use the average of undiverted regional streams that were sampled by CDFG during the past 20 years. Because of differences in technique including the use of salt blocks by CDFG field crews to improve collection efficiency of small fish, comparisons including fry and juvenile fish were not appropriate. For these comparisons, adult trout density was used for comparison. Adult fish sampling is less likely to be biased by the use of salt blocks, but may still represent a higher collection efficiency and produce larger apparent reference populations.

Average regional fish densities were determined based on available information collected by CDFG's Wild Trout crews from 1984 to 2004. Based on discussions with the CAWG, the average density of catchable trout was calculated based on sampling conducted in unimpaired sections of selected streams and rivers in the southern Sierra region. Because stream elevation can affect productivity and trout populations, average densities were calculated based on three elevation ranges, also selected in conjunction with the CAWG. The elevational strata and streams used in calculating the regional density estimates were:

- **Low Elevation Reaches** – 1,500 to 2,400 ft MSL
  Clavey River, Marble Fork Kaweah River, and MF Kaweah River.
- **Middle Elevation Reaches** – 3,300 to 5,000 ft MSL
  Clavey River, Merced River (Yosemite Valley), NF Tule River, SF Kings River, and SF of MF Tule River.

- **High Elevation Reaches** –5,000 to 9,000 ft MSL
  Clark Fork Stanislaus, Clavey River, EF Kaweah River, Kern River near Johnsondale Bridge, Marble Fork Kaweah River, MF San Joaquin River, SF Kern River, SF of MF Tule River, and Trout Creek.

Some of these reaches were sampled only once, while others were sampled repeatedly, either over time, at multiple sites, or both. This could bias the regional average towards the streams that were sampled more frequently. To eliminate this potential bias, the repeat density estimates from a reach with multiple sampling events were averaged to obtain a single density estimate for that reach. This average density was then used in conjunction with the average densities from other streams to obtain the regional average.

The average regional densities were calculated based on adult trout per kilometer or mile and adult trout per hectare or acre basis (Table Attachment J-1). Area-based estimates are considered to be an important metric, since streams may vary in size (width and area) for a standard sampling length.

Interannual Variability of Trout Populations

The regional averages above represent a group of unrelated samples taken in different streams and different years, under different conditions with different methods and different crews. As such, these estimates have a high degree of variability associated with them. The amount and the specific cause of the variability in density estimates (including real differences in estimates) is unknown. Even without these unknown sources of variability, trout populations can vary substantially from year to year, even in unregulated systems. Events (severe drought, scouring of redds, sudden sediment loads) in the current or preceding years can dramatically affect trout populations.

Trout density estimates are dependent on multiple factors, including environmental conditions, sampling method, and the experience level of the crews conducting the sampling. Even in studies by the same crew using the same methods in the same sites from one year to the next, variability in fish population density is expected to occur, and can be quite high.

For the regional averages to be useful for making comparisons with ALP streams, some estimate of the variability of populations around these averages needs to be made.

Data sets are available in the same region that allow us to estimate interannual variability in the same site, where sources of sampling variability are minimized. We evaluated the variation in populations observed during long term studies at the same sites using the same techniques. This variability would be expected to be less than that derived from the group of regional stream and therefore, a conservative estimate of the expected variability.

One such study, the Response of Fish Populations to Altered Flows Project was conducted on the North Fork Middle Fork Tule River (NFMFTR) by PG&E and ENTRIX. As part of a long-term study, eight sites in the NFMFTR were sampled twice annually over a twelve-year span. The same sites were sampled, using the same techniques, by crews that had a large amount of overlap from one year to the next. Table Attachment J-2 shows that the variability relative to the mean of the sample (the coefficient of variation or CV) ranged from about 35 to 70 percent (the 95 percent confidence intervals relative to the mean are also shown in this table and can be seen in Figure Attachment J-1). The CV expresses sample variability relative to the mean of the sample, expressed as the percentage variation from the mean. The 95 percent confidence interval defines the range within which the mean lies with 95 percent confidence. The CV, 95 percent confidence intervals, and other descriptive statistics for the fall sampling events for the Tule River stream sections annually sampled are presented in Table Attachment J-2 and shown in Figure Attachment J-1. The expression of the confidence limit as a percentage of the mean in this table is based on the lower 95% confidence limit.

Long term interannual variability can also be observed in CDFG Wild Trout studies. Eight of the west slope Sierra stream reach sections were sampled by the CDFG during four or more different years. The interannual variability of the CDFG west slope Sierra stream sections is presented in Table Attachment J-3 and shown in Figures Attachment J-2 and -3. The adult trout population (adults per km) CV for these streams ranged from 35 to 95 percent (95 percent confidence intervals relative to the mean are presented in Figure Attachment J-2). The CV was similar on a fish per area basis (Table Attachment J-3, Figure Attachment J-3).

These studies provide substantial insight into the amount of variability (uncertainty) inherent in measurements of fish populations in space and time. None of the sites that were sampled four or more times had a CV of less than 25 percent, and most were characterized by CVs closer to 50 percent. Additionally, none of these sites displayed a 95 percent confidence interval (expressed as a percentage of the mean) that was 25 percent of the mean or less, and most sites were closer to 50 or 60 percent of the mean. Thus a population estimate within 50 percent of the long-term average would be within normal range of population size expected for a stream in this region.

Because fish sampling in the Big Creek ALP streams was conducted in the second of two consecutive dry years, their populations would be expected to be lower than the long-term average for Big Creek streams. A comparison of the ALP bypass reach fish densities with reference sites within the Big Creek system is shown in Table Attachment J-4. The sites without appropriate reference sites within the Big Creek system are compared to regional averages in Table Attachment J-5.

Table Attachment J-1. Average Density of Catchable Trout in Unimpaired Regional Stream by Elevation Group.

Elevation Group	Number of Adult Trout Per Linear Distance	Number of Adult Trout Per Unit Area	Units
High elevation	530	701	Metric (fish/kilometer and fish/hectare)
5,000-9,000 ft	853	284	English (fish/mile and fish/acre)
Middle elevation	519	346	Metric (fish/kilometer and fish/hectare)
3,300 to 5,000 ft	835	140	English (fish/mile and fish/acre)
Low Elevation	275	307	Metric (fish/kilometer and fish/hectare)
1,500 to 2,400 ft	443	124	English (fish/mile and fish/acre)

Table Attachment J-2. Interannual Variability in Adult Trout Density at North Fork of the Middle Fork Tule River Sampling Sites, Fall Sampling Events.

Stream Reach and Section	Number of Years Sampled	Density (adult trout/km)						
		Mean	Min	Max	Upper 95% C. I.	Lower 95% C. I.	95% C. I. as % Mean[1]	C.V. (%)
Above Tule Diversion Site 10	12	413	210	830	520	306	25.9%	40.9
Above Tule Diversion Site 19	4	322	213	463	510	135	58.1%	36.6
Below Tule Diversion Site 11	11	213	120	390	276	149	30.0%	44.4
Below Tule Diversion Site 12	11	172	80	320	226	117	32.0%	47.3
Below Doyle Springs Site 13	12	243	60	630	355	131	46.1%	72.5
Below Doyle Springs Site 14	11	362	114	786	499	225	37.8%	56.2
Below Meadow Creek Site 15	12	122	35	304	173	71	41.8%	65.3
Below Meadow Creek Site 16	11	99	0	189	141	57	42.4%	63.4
Average for All Sites							39.3%	53.3

[1.] Difference between the sample mean and the lower 95 percent confidence limit expressed as a percent of the mean.

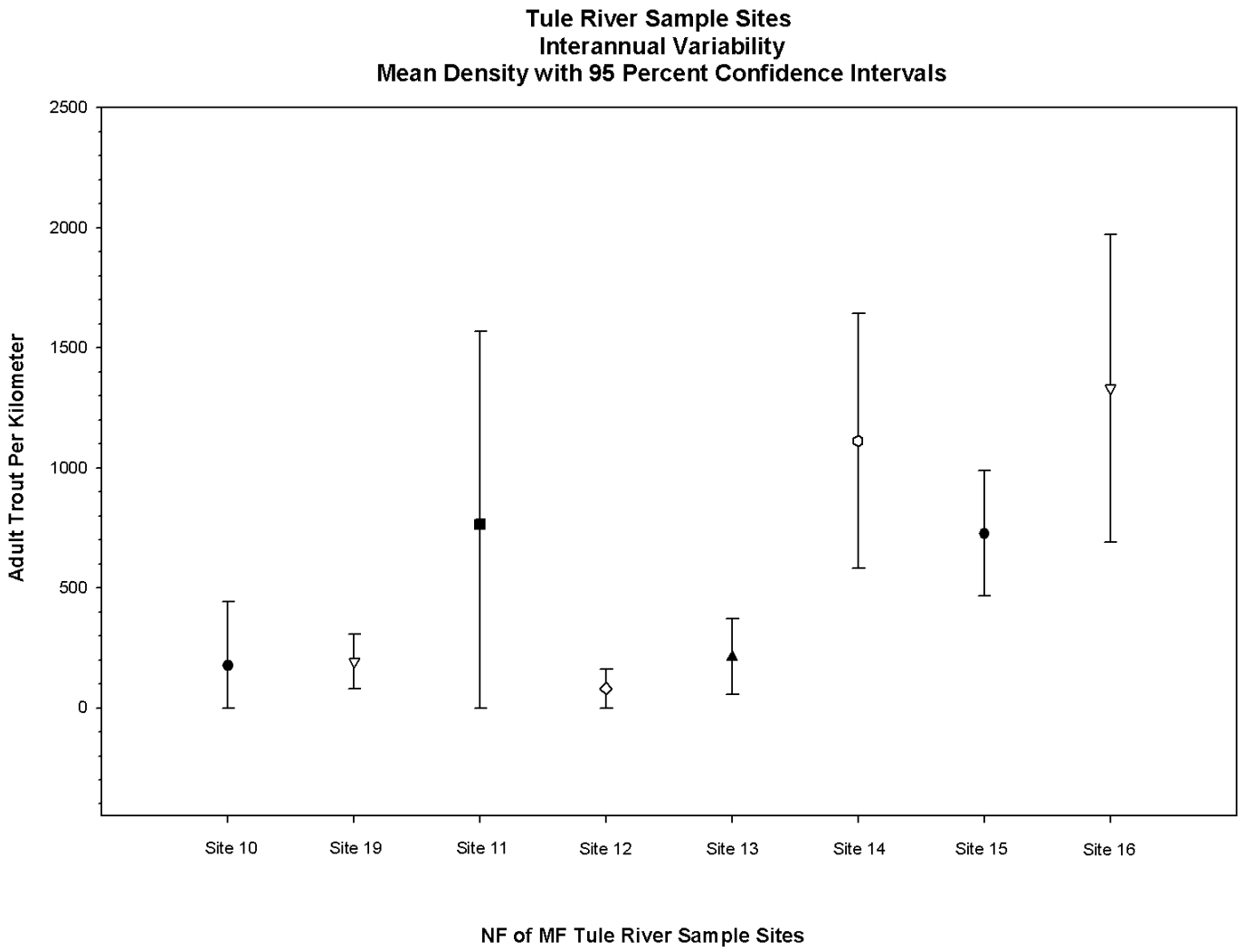

Figure Attachment J-1. Average Density (Adult Trout/Kilometer) with 95 Percent Confidence Intervals at North Fork of the Middle Fork Tule River Sampling Sites, Fall Sampling Events, Years Sampled 4-12.

Table Attachment J-3. Interannual Variability in Adult Trout Density at CDFG Wild Trout Sampling Sites (Sites Sampled Four or More Times Only).

Stream Reach and Section	Number of Years Sampled	Density (adult trout/km)							Density (adult trout/ha)						
		Mean	Min	Max	Upper 95% C. I.	Lower 95% C. I.	95% C. I. as % Mean[1]	C.V. (%)	Mean	Min	Max	Upper 95% C. I.	Lower 95% C. I.	95% C. I. as % Mean[1]	C.V. (%)
Clavey River, Section 2	4	177	31	383	443	0	100.0%	94.6	177	31	371	444	0	100.0%	94.6
Clavey River, Section 7	4	202	120	318	338	66	67.3%	42.4	193	115	287	307	79	59.1%	37.0
Clavey River, Section 6	5	385	102	687	704	66	82.9%	66.8	765	208	1722	1569	0	100.0%	84.7
Merced River at the South Fork, Section 1	5	180	32	398	360	0	100.0%	80.5	81	14	176	162	0	100.0%	81.4
Merced River at El Portal, Section 2	5	361	157	678	632	90	75.1%	60.4	212	104	404	370	55	74.1%	59.8
Upper MF SJR, Section 1	6	1134	756	1725	1551	718	36.7%	35.0	1112	649	1826	1642	582	47.7%	45.4
Upper MF SJR, Section 5	8	837	319	1386	1130	544	35.0%	41.9	726	227	1184	987	466	35.8%	42.9
Upper MF SJR, Section 6	8	1597	249	2954	2294	899	43.7%	52.3	1331	186	2330	1973	689	48.2%	57.7
Average for All Sites	6	609	221	1066			67.6%	52.7	575	192	1038			70.6%	62.9

1. Difference between the sample mean and the lower 95 percent confidence limit expressed as a percent of the mean.

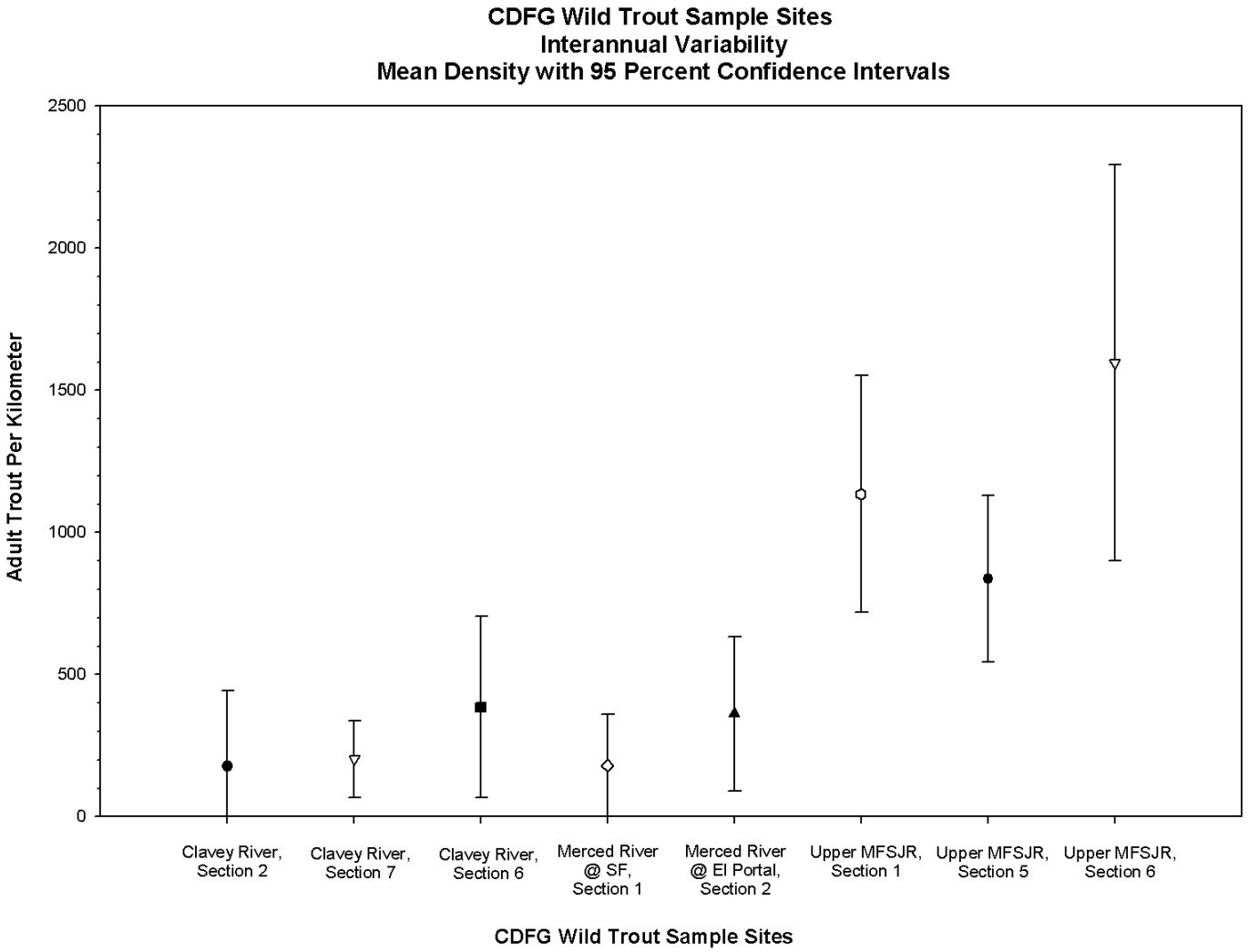

Figure Attachment J-2. Average Density (Adult Trout/Kilometer) with 95 Percent Confidence Intervals at CDFG Wild Trout Sample Sites (Sites Sampled Four or More Times Only).

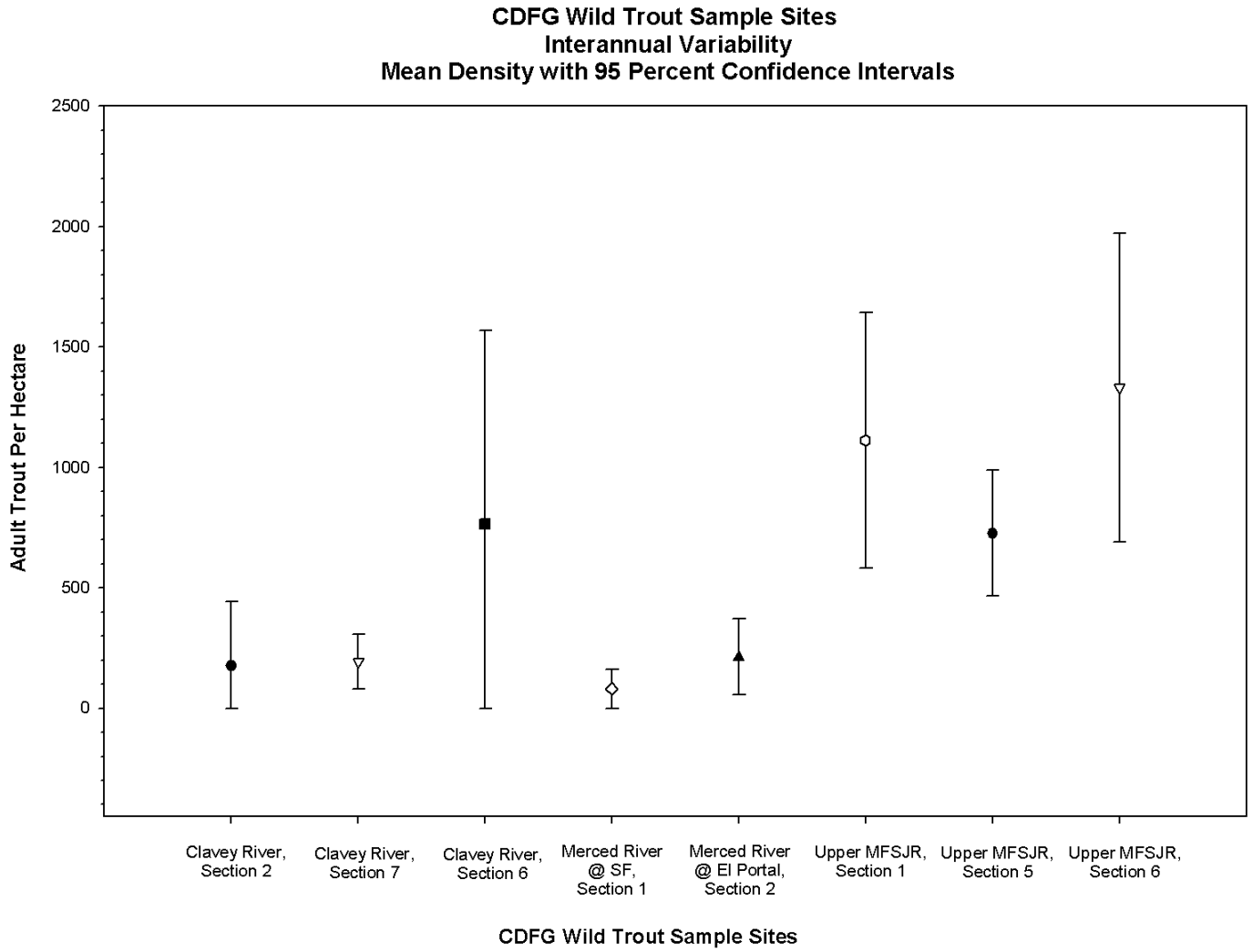

Figure Attachment J-3. Average Density (Adult Trout/Hectare) with 95 Percent Confidence Intervals at CDFG Wild Trout Sample Sites (Sites Sampled Four or More Times Only).

Table Attachment J-4. Comparison of Adult Trout Densities in Big Creek ALP Bypass Reaches with Local Reference Sites.

	Rosgen Channel Type of Reach	Number of Total Trout Per KM	Percent of Reference Site	Number of Adult Trout Per KM	Percent of Reference Site
Chinquapin Creek, Above Diversion	Aa+	665		236	
Chinquapin Creek, Below Diversion	Aa+	2,034	306	173	73
Camp 62 Creek, Above Diversion	Aa+	945		315	
Camp 62 Creek, Below Diversion	Aa+	1,162	123	215	68
Bolsillo Creek, Above Diversion	B	2,187		538	
Bolsillo Creek, Below Diversion	Aa+	143	7	29	5
Bolsillo Creek, Below Diversion	B	1,509	69	257	48
Crater Creek, Above Diversion	Aa+	547		105	
Crater Creek, Below Diversion	Aa+	276	50	39	37
Crater Creek, Diversion Channel	Aa+	1,193	218	253	241
Balsam Creek, Above Diversion	Aa+	1,335		248	
Balsam Creek, Below Diversion	Aa+	12	1	12	5
Ely Creek, Above Diversion	Aa+	190		190	
Ely Creek, Below Diversion	Aa+	368	194	204	108
Hooper Creek, Above Diversion	Aa+	663		306	
Hooper Creek, Below Diversion	Aa+	962	145	368	120
SFSJR, Upstream of Florence Lake	B	206		158	
SFSJR, Florence to Bear Confl	B	696	338	480	304
SFSJR, Florence to Bear Confl	C	324	157	108	68
SFSJR, Bear to Mono Xing	G	338	164	111	70
SFSJR, Bear to Mono Xing	C	858	417	387	245
SFSJR, Bear to Mono Xing	B	920	447	647	410
SFSJR, Mono Xing to Rattlesnake	B	1,334	648	301	191
SFSJR, Rattlesnake to SJR Confl	G	1,222	593	616	390
Pitman Creek, Above Diversion	B	1,486		539	
Pitman Creek, Below Diversion	B	1,152	78	225	42
Rock Creek, Above Diversion	Aa+	1,171		441	
Rock Creek, Below Diversion	Aa+	913	78	296	67
Bear Creek, Above Diversion	B	470		208	
Bear Creek, Below Diversion	A	1,406	299	600	289

Table Attachment J-5. Comparison Between Adult Trout Densities in Big Creek ALP Fish Sampling Reaches and Regional Average Densities.

Comparison	Rosgen Channel Type of Bypass Reach	Site Elevation[1]	Mean Number of Adult Trout Per KM	Percent of Reference Site	Mean Number of Adult Trout Per Hectare	Percent of Reference Site	Average Reach Width (ft)
Upper Elevation Regional Average Density			**530**		**701**		
Mono Creek, Below Diversion	B	7,325	32	6	57	8	22.9
Big Creek, Dam 1 to PH 1	Aa+, B, G, A	6,315	373	70	1,031	147	13.0
North Fork Stevenson Creek	Aa+, G, C	6,103	166	31	425	61	22.3
Middle Elevation Regional Average Density			**519**		**346**		
Big Creek, Dam 4 to PH 2	A	4,450	274	53	611	177	14.7
Stevenson Creek	Aa+, A, B	3,933	169	33	553	160	11.1
Lower Elevation Regional Average Density			**275**		**307**		
Big Creek, Dam 5 to PH 8	Aa+, A	2,488	173	63	328	107	14.2
SJR, Mammoth Reach	B	2,453	137	50	110	36	48.2
SJR, Stevenson Reach	G	1,650	5	2	4	1	40.2