ATTACHMENT C

LIMITING FACTORS

Attachment C - Evaluation of Potential Factors Affecting Fish Populations in Project Bypass Stream Reaches

Introduction

Fish populations may be affected by a number of different factors including physical, chemical or biotic characteristics of their environment. These characteristics may operate in a number of different ways to regulate the population size or affect individuals within the population. These characteristics are known as “limiting factors” (Bovee 1982, McMahon, et al. 1997). Important factors affecting fish populations are site-specific since they draw from the specific circumstances of the population, its life history and its habitat requirements. Limiting factors can vary by stream reach, by species and lifestage (Bovee 1982). For example, sports harvest may limit the number of adult rainbow trout present in a stream reach, but would have little effect on the number of Sacramento suckers. In another example, recruitment to trout populations can be adversely affected in years with large storms occurring at key times. The flows resulting from these storms can scour embryos and cause high mortality for young fry. The reduced year class can reduce the adult population below stream carrying capacity in subsequent years. In the case investigated by Garcia De Jalon, et al. (1998), populations were limited by torrential flows and by extreme summer droughts. These events occurred with such frequency that the salmonid populations were always in a state of recovery.

In California, low summer flows and high summer water temperature can be important factors affecting the distribution of trout populations (Moyle 2002). Although water temperatures during the rest of the year may fall within the preferred range for trout, the effect of the hot, dry summer with its warm water temperatures may result in additional effects in other seasons. Young trout subjected to stressful water temperatures may grow more slowly (Myrick and Cech 2001), if food supplies are not abundant. Smaller trout have lower survival through the winter than do more robust trout (Biro, et al. 2004). Smaller females also have a lower reproductive capacity than larger females (Hines 1976). Thus, the hot summer temperatures, while operative for only a few months a year, may affect the size or condition of the population.

Limiting factors are best understood when the complete life history of the target organism is considered, because a limitation at one lifestage may affect the population levels at subsequent lifestages or may be negated by limitation from another variable acting on a subsequent lifestage (Bovee, et al. 1998). For example, if adult habitat is limiting the population, then there may be excess production of juveniles. Increasing the number of juveniles would not result in increased number of adults, unless adult habitat was increased as well. Limiting factors can also vary over time. A single large storm event, such as described above, would affect recruitment of fry in that year (year class N). Subsequent year classes (N+1, N+2) would not be affected by this event, unless the first year class was reduced to such a level that its reproductive output did not produce enough fry to fully seed its subsequent year class (N+2). When events like these occur, density-dependent compensatory mechanisms (faster growth of the individuals of that lifestage because of reduced competition of food, and/or higher survival of the offspring from other year classes as a result of reduced competition for spawning habitat) often allow populations to recover quickly (McFadden 1969).

Important factors that may affect or limit fish populations include (Meehan 1991):

- Macrohabitat (reach scale – gradient, confinement, hydrology)
- Mesohabitat (frequency, size and sequencing of individual habitat units)
- Microhabitat (habitat characteristics at a specific location within a unit)
- Water temperature
- Water chemistry (dissolved oxygen, pH, contaminants)
- Passage barriers (natural, man-made, flow and non-flow related)
- Food availability (abundance and availability of aquatic and terrestrial insects)
- Competition (intra and inter-specific)
- Sport harvest and predation
- Entrainment
- Scouring flows

Distinguishing limiting factors is important in attempting to predict the response of a population to a change in one or more of the multiple variables influencing the population (Quist and Hubert 2005, Capra, et al. 2003, Gouraud, et al. 2001). Limiting factors can be related to project operations, such as entrainment, related to non-project activities like sport harvest, or part of the natural environment, such as low summer flows. Understanding which elements have the most influence on fish populations is important in understanding project impacts and in identifying effective protection, enhancement and mitigation measures (PM&Es). PM&Es that do not specifically address a limiting factor for a population may not improve the abundance or health (condition factor, growth, population structure) of the population.

In a recent evaluation, the quantity of a specific mesohabitat type (side channels) was assumed to be limiting salmonid populations (Guetreuter 2004). Further investigation of fish population abundance and distribution, and enumeration of side channels demonstrated that this mesohabitat was not limiting. The implementation of habitat enhancement measures (construction of artificial side channels) designed to address this assumed habitat limitation would not have provided the expected benefits to the fish population. In another instance where the limiting factor was correctly identified, fish populations did respond in the expected manner. In a Michigan stream with rainbow and brown trout populations, sand accumulation was adversely affecting spawning and rearing habitat (Alexander and Hansen 1983). A sediment basin was excavated to reduce sand bedload, and was successful in eliminating 86 percent of this bedload. Over the next six years, the number of young trout increased by about 40 percent and overall trout production was increased by 28 percent.

CAWG Studies

The Combined Aquatic Working Group (CAWG) of the ALP developed a number of studies to characterize the existing conditions in the affected environment and to evaluate the potential effects of project operations on the aquatic resources in the project area (Final Technical Study Plan Package (FTSPP) (SCE 2001; Volume 4, SD-B (Books 6 and 21))). These studies evaluated specific aspects of aquatic communities including abundance (e.g. fish density and biomass, macroinvertebrate densities), species diversity, population characterization (e.g. fish age class structure) and general health (fish condition factor). Fish and macroinvertebrate sampling was conducted upstream and downstream of diversions and/or in reference areas to provide a meaningful basis of comparison. Reference streams for trout populations were selected by the CAWG from data collected by the California Department of Fish and Game (CDFG) Wild Trout Program that reflect streams or streams reaches from upstream of, adjacent to, or near the ALP Project Area of the San Joaquin basin and at comparable elevations not under the influence of hydroelectric or water storage projects. CAWG studies also evaluated habitat conditions and the physical processes that may influence both the populations and their habitat under existing conditions. Both Project-related and naturally occurring habitats and processes were characterized. This information was used to evaluate the importance of factors that may substantially affect or limit fish population. The CAWG study plans[1] that were used to evaluate factors affecting fish communities included:

- CAWG 1 Characterize stream and reservoir habitats
- CAWG 2 Geomorphology
- CAWG 3 Determine flow-related physical habitat in bypass reaches
- CAWG 4 Chemical water quality
- CAWG 5 Water temperature
- CAWG 6 Hydrology
- CAWG 7 Characterize fish populations
- CAWG 9 Entrainment
- CAWG 10 Macroinvertebrates
- CAWG 11 Riparian
- CAWG 14 Fish Passage

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[1] The reader is referred to the CAWG study plans (Final Technical Study Plan Package (FTSPP) (SCE 2001; Volume 4, SD-B (Books 6 and 21))) for a description of the objectives, methods, and results to be prepared for each study. Each of these study plans resulted in one or more reports describing the results of these studies for the attributes being addressed.

Assessment Approach

The results of the CAWG study reports were screened to eliminate factors that were clearly not affecting populations in any project stream. For the remaining factors, criteria were developed to determine whether or not these factors were likely to affect fish populations in any given stream. The rationale leading to the elimination of some factors from further consideration is provided in the next section of this report. This is followed by a description and rationale for criteria used to determine which of the remaining factors are most likely to be important in limiting the fish community for each study reach.

Factors Eliminated from Consideration

No limitations were identified relative to water chemistry (CAWG 4, Water Chemistry, TSRPs (SCE 2004, Volume 4, SD-C (Books 8 and 21) and SD-D (Books 12 and 23))), food availability (CAWG 10, Macroinvertebrates, 2003 TSRPs (SCE 2004a; Volume 4, SD-D (Books 14 and 23))), or entrainment (CAWG 9, Entrainment, TSRPs (SCE 2004b; Volume 4, SD-E (Books 18, 24 and 26))). Water chemistry was generally good throughout the affected waters of the project. In those few cases where a parameter exceeded water quality standards, the values of that parameter were not at a level that would be expected to affect fish populations (CAWG 4, Water Chemistry, TSRPs (SCE 2004, Volume 4, SD-C (Books 8 and 21) and SD-D (Books 12 and 23))). Predation and sports harvest could not be directly assessed. They do not appear to be potentially important factors, but this could not be confirmed with existing information. Descriptions of these parameters are provided at the end of this section.

Food availability was evaluated by reviewing macroinvertebrate population indices, fish condition factor, and size at age in comparison to other streams in the region of the Big Creek Project (CAWG 7, Characterize Fish Populations, TSRPs (SCE 2003; Volume 4, SD-C (Books 8 and 21))). Although the productivity of the waters of this basin are not high, that is a common characteristic for basins of similar elevation and geology on the west slope of the Sierra Nevada range. Within the bypass reaches, the observed values parameters generally were similar to those in reference reaches. This strongly suggested that food was not limiting.

Entrainment was eliminated as a likely limiting factor in project reservoirs. While a few individual fish may be entrained in project diversions, the likelihood of significant entrainment is very low due to the location of the intakes (CAWG 9, Entrainment, TSRPs (SCE 2004b; Volume 4, SD-E (Books 18, 24 and 26))). Entrainment would have little effect on fish populations in Project bypass reaches.

Predation by brown trout was found to be low due to the small number of adult brown trout found at piscivorous size (greater than 250 mm; Leipzig and Deinstadt 1997).

Much sport fishing is focussed on the Project reservoirs, and would not adversely affect fish populations in the bypass reaches. Most sport harvest in the bypass reaches is concentrated in areas with good access, where hatchery trout are planted by CDFG.

Many of the Project streams experience little angling pressure due to their inaccessibility. This inaccessibility results both from restricted access to Project facilities (such as along Big Creek) and to difficult terrain (such as many portions of the South Fork San Joaquin River [SFSJR] and the San Joaquin River Mammoth Reach). Sports harvest has not been specifically identified as a likely limiting factor for entire bypass reaches, but there is circumstantial evidence that it does affect populations in localized areas. In the SFSJR, there were multiple fish population sampling locations located in areas with easy access and more difficult access. Fish populations were observed to be lower in sections of the river with good access (i.e., Jackass Meadow, Mono Hot Springs) than where access is more difficult (CAWG 7, Characterize Fish Populations, TSRPs (SCE 2003; Volume 4, SD-C (Books 8 and 21))). Similar comparisons could not be made in most other streams, because there were fewer sampling sites, or because the entire reach had difficult access conditions.

Factors under Consideration

Potential limitations were identified in one or more project streams relating to the following factors:

- Macrohabitat
- Mesohabitat
- Microhabitat (including competition)
- Passage barriers
- Water temperatures

Macrohabitat

Macrohabitat (channel type) was assessed using the techniques of Rosgen (1996) and Montgomery and Buffington (1977), which describes reach-scale habitat characteristics based on entrenchment ratios, width to depth ratio, sinuousity, slope, substrate, and bed form (CAWG 2, Geomorphology, 2002 FTSR (SCE 2003; Volume 4, SD-C (Books 7 and 21))). These characteristics, in conjunction with the stream hydrology, provide the underlying structure for the mesohabitat, the specific habitat types important to aquatic organisms (Stoneman and Jones 2000, Binns and Eiserman 1979). Geomorphic processes (CAWG 2, Geomorphology, 2002 FTSR (SCE 2003; Volume 4, SD-C (Books 7 and 21))) (erosion, deposition, sediment transport, channel stability, flood plain inundation) govern the formation and maintenance of both macro and mesohabitats. These different structural habitat components influence the distribution and abundance of specific habitat needs, such as the availability of gravels suitable for spawning and the frequency and distribution structural passage barriers (cascades, falls, sheet flow, etc.) (Flosi, et al. 1998)

Rates of formation and change in bedrock and transitional bedrock-alluvial channels typical of much of the Big Creek Project streams are not well-known, but probably occur over decades to millenia (Tinkler and Wohl 1998, Baker and Kale 1998). Thus, macrohabitat is unlikely to be affected within the time scale of the project.

Certain aspects of sediment transport and retention were evaluated as part of the assessment of this project (CAWG 2, Geomorphology, 2002 FTSR (SCE 2003; Volume 4, SD-C (Books 7 and 21))). These aspects include: 1) the likelihood that the project is retaining spawning gravels behind diversions and thus reducing the available supply of such gravels to downstream reaches, and 2) the potential for the project, through flow diversion, to increase the retention of fine sediments in the bypass reaches, which might reduce both the quality of spawning gravels, quality of pools, and the production of macroinvertebrates in the reach. The results of these studies are presented in CAWG 2, Geomorphology, 2002 FTSR (SCE 2003; Volume 4, SD-C (Books 7 and 21)), and summarized below.

Spawning Gravel Retention

The geomorphology study concluded that gravel transport past diversions was likely to be interrupted in the stream reaches in the San Joaquin River from Mammoth Pool Dam through the downstream reaches (including the reach downstream from Dam 6). This reach is characterized by having a large reservoir with upstream sources of spawning-sized material that could be trapped and permanently stored in the reservoir (CAWG 2, Geomorphology, 2002 FTSR (SCE 2003; Volume 4, SD-C (Books 7 and 21))). Huntington Lake was also identified as potentially storing gravel. However, this impact is not considered as substantial because: 1) the lake bed is low gradient and probably stored gravel prior to the construction of the reservoir, 2) some gravel sources upstream of the lake are not directly connected to the lake's tributary streams (and thus gravel sources are less available), and 3) because most of Big Creek downstream of the lake is high gradient with bedrock controls that is unlikely to store gravel. Operations at Mono Diversion may also reduce gravel supply, and is listed as a resource issue. This is a less significant issue than Mammoth Pool because gravel is more abundant in Mono Creek downstream of Mono Diversion than it is in most other stream reaches, and its availability is not considered to limit fish populations (see *Flow-related Habitat*, below).

It was concluded that Florence Lake was not trapping significant amounts of gravel because Blaney Meadow is a significant sediment trap upstream of the lake. Source areas for gravel were not present above Shaver Lake, so it was not identified as trapping significant amounts of gravel.

Assessment of the effects of spawning gravel retention by upstream reservoirs on fish populations in the affected reaches was evaluated as part of the flow-related habitat evaluation described below. In addition to the presence of suitably-sized gravel, an area must have appropriate water depths and velocities over the spawning gravels to be suitable spawning habitat. The flow-related habitat evaluation looks at the availability of suitable spawning habitat at the scale of the fish and evaluates this availability with respect the fish populations in the reach.

Sedimentation Criteria

Fine sediment can have a variety of adverse effects on multiple fish species and lifestages. Trout are particularly sensitive to the effect of excess sediment. Cordonne and Kelly (1961) summarized these effects on stream habitats. Deposition of fine sediment can adversely affect rearing habitat. When fine sediments fill the interstitial spaces in gravel and cobble substrates, it eliminates refuge habitat important to younger lifestages. Excessive fine sediment accumulations along shallow margins of the stream may fill in important fry habitat. Rearing habitat can be affected for adults if sediment accumulates in pools, reducing the pool depth. Increased fine sediment can also affect macroinvertebrate populations, reducing the occurrence of EPT taxa and shifting to a burrowing chironomid community. As part of the Geomorphology studies, all project streams were visually evaluated for fine sediment accumulations (CAWG 2, Geomorphology, 2002 FTSR (SCE 2003; Volume 4, SD-C (Books 7 and 21))). Based on this evaluation, quantitative evaluation of fine sediment accumulations in pools (V*) were conducted on specific streams selected by the CAWG. Fine sediment was determined to be a potential project effect on rearing habitat if V* values exceeded 0.3 and were higher than in the reference reach for a stream. Based on this evaluation, rearing habitat was determined to be potentially affected in Bolsillo, Hooper, and Mono Creeks.

In addition to rearing habitat, spawning and incubation habitat can be adversely affected by fine sediments. Sedimentation can reduce the survival of embryos as the sediment prevents free passage of water through the redds, causing an accumulation of metabolic waste and low dissolved oxygen. Since spawning and incubation are among the most sediment sensitive lifestages, the sediment criteria were based on substrate characteristics suitable for spawning.

Although excessive levels of fine sediment are commonly acknowledged by fisheries biologists to limit spawning success, there is no single particle-size statistic that adequately relates fine sediment composition to survival. Based on a review of laboratory and field studies, Kondolf (2000), suggests that sediments finer than 1 mm can reduce gravel permeability, affecting dissolved oxygen content and removal of metabolic wastes from the redd. Larger sediments in the 1 to 10 mm size range are generally considered to be responsible for inhibiting fry emergence through interstitial gravel spaces. The following criteria for spawning and incubation success, based on a review of the literature (Kondolf 1988, Kondolf, et al. unpublished, Reiser and Bjornn 1991), were adopted for this study:

(a) percentage of sediments finer than 0.84 mm should be less than 14 percent; and

(b) percentage of sediments finer than 6.4 mm should be less than 30 percent.

Sedimentation Results

The presence of reservoirs and diversions can also affect the frequency of occurrence of flushing flows. If the frequency, magnitude and duration of flushing flows are insufficient, fine sediment retention may become an issue. The following reaches were found to have excessive fine sediments in their channels related to diversion of flows necessary for flushing these sediments (CAWG 2, Geomorphology, 2002 FTSR (SCE 2003; Volume 4, SD-C (Books 7 and 21))).

- Mono Creek below Mono Diversion Dam
- Bolsillo Creek below diversion
- Hooper Creek below diversion

Under existing conditions, trout abundance in Mono Creek is low. Sedimentation of habitat, including loss of pool depth and embeddedness of gravels, likely have had adverse effects on trout habitat and recruitment, and are the most likely limiting factor in this stream.

Overwinter Habitat

Sedimentation of pool habitat can decrease the amount of space available for adult and juvenile trout rearing. To address stakeholder concern about over-winter conditions in upper basin streams, water temperatures were recorded in pools in Bear and Mono creeks below the diversions. Water temperature never reached 0ºC, and therefore these locations did not freeze, indicating pools in each creek provided potential habitat for aquatic life over the winter. However, excess sedimentation of pools in upper basin streams, such as Mono, Bolsillo and Hooper creeks, may reduce the amount of overwinter habitat available for juvenile and adult trout.

In two other stream segments, sedimentation of pools, combined with low winter flows, may result in reduced rearing and overwinter habitat. In Big Creek between Dam 5 and Powerhouse 8, there is a large preponderance of shallow pools with little cover. Periodically (once every seven years) the impoundment is drained for tunnel inspections, which results in sedimentation of available habitat. This, combined with low winter flows in dry years, may reduce overwinter habitat for rainbow and brown trout. Similarly, in Big Creek between Dam 4 and Powerhouse 2/2A, periodic de-watering of Dam 4 for tunnel inspections may cause the release of sediments of sufficient volume to temporarily cause sedimentation of pools and aggradation of the channel bed. Combined with low winter flow, this also may result in insufficient overwinter habitat for juvenile and adult trout.

<u>Mesohabitat</u>

Mesohabitat composition is important to fish populations. The presence of different mesohabitat types provides diverse microhabitats, which allows the various species and lifestages to select for locations that best fit their specific needs. Some lifestages are associated with particular mesohabitat types. For example, young rainbow trout occupy riffle habitat and adult brown trout are usually found in deep pools. Some mesohabitats do not provide living space for fish. These can include bedrock chutes, steep cascades, and waterfalls.

Mesohabitat was classified according to the systems described by McCain, et al. (1990) (pool, riffle, run) and Hawkins, et al. 1993) (turbulent, non-turbulent). The results are presented in CAWG 1, Characterize Stream and Reservoir Habitats, TSRPs (SCE 2003; Volume 4, SD-C (Books 7 and 21) and SD-D (Books 11 and 23)). Comparison of mesohabitat composition based on ALP studies in 2001 with similar studies performed in the 1980s (BioSystems 1987) found little change in habitat composition or sequence has occurred in the intervening period, in spite of several massive flow events. This indicates that mesohabitat structure is stable over periods of decades on those streams which have historic information. This also implies that the channel geomorphology is quite stable (neither aggrading or degrading under present-day operational conditions) (ENTRIX 2002, BiCEP PHABSIM Model Review). Because most of the project streams have similar geomorphic conditions, these findings are likely applicable for most of the bypass reaches.

The mesohabitat typing was reviewed to determine where mesohabitat structure might be substantially affecting fish populations. This evaluation looked at the proportion of non-livable mesohabitat types in a reach. Non-livable habitats are those that do not provide substantial habitat for fish, such as waterfalls, steep cascades, chutes, or bedrock sheet. Streams where more than 50 percent of the mesohabitat was comprised of non-livable habitats were classified as having the potential to affect fish populations.

Mesohabitat Results

In several project streams, mesohabitat appeared to be limiting. Channels are steep, and substrate is generally bedrock dominated with predominantly plunge pools, bedrock chutes and falls. Pitman Creek is comprised of 50 percent non-livable mesohabitats. The plunge pools support populations of rainbow and brown trout. Rock Creek, lower Balsam Creek (below Balsam Diversion), and North and South Slide creeks are characterized by mesohabitat compositions that limit fish habitat. In Rock Creek, the stream is comprised of nearly 70 percent non-livable habitat and supports rainbow and brown trout.

In these streams, fish of all species and lifestages, where they occur, are generally forced to occupy habitats such as plunge pools, since they provide almost all of the livable habitat. This situation reduces the opportunity for the different species and lifestages to partition the habitat, leading to increased competition for resources. Stress associated with competitive interactions and jockeying for feeding lanes at the head of the pools may reduce growth rates and lead to dispersion of less fit individuals to areas downstream. These displaced individuals are lost to the population because structural passage barriers prevent any substantial upstream migration. The lack of habitat diversity may also lead to increased predation. Large brown trout may prey on small fry of all species. Competition for limited spawning habitat may also be great and may lead to redd superimposition, thus reducing the reproductive success of the population.

In other stream segments, mesohabitat may not afford appropriate habitat during the winter months. In Big Creek between Dam 5 and Powerhouse 8, there is a large preponderance of shallow pools with little cover. In winter trout seek shelter during the day and come out at night to feed in the shallow water (Campbell and Neuner 1985). Big Creek between Dam 4 and Powerhouse 2/2A, which does not have a minimum instream flow (MIF) may not contain favorable overwinter characteristics under existing conditions.

Flow-related habitat (Microhabitat)

Because the Project alters flow in the bypass reaches, the CAWG was interested in how flow-related habitat might be modified by the project, and how this could affect fish populations. Structural habitat and hydrology combine to form the flow-related physical habitat (microhabitat). Flow-related habitat was assessed using either the Physical Habitat Simulation models (PHABSIM; Milhaus, et al. 1989) or the wetted perimeter methodology (Lohr 1993) depending on the size of the stream, as described in the CAWG 3 Study Plan (Final Technical Study Plan Package (FTSPP) (SCE 2001; Volume 4, SD-B (Books 6 and 21))). The results of these studies are presented in several technical study reports (CAWG 3, Flow-Related Habitat - Upper Basin Wetted Perimeter, TSRPs (SCE 2003; Volume 4, SD-C (Books 7 and 21)); CAWG 3, Flow-Related Habitat - Lower Basin Wetted Perimeter, TSRPs (SCE 2003; Volume 4, SD-D (Books 11 and 23)); and CAWG 3, Instream Flow Studies – PHABSIM, TSRPs (SCE 2003; Volume 4, SD-D (Books 11 and 23)), and Attachment E - Stranding Report (SCE 2007; Volume 4 (Book 5))).

PHABSIM Stream Assessment Criteria

In PHABSIM, microhabitat is described by the distribution of depth, velocity, substrate and cover. These parameters vary with flow and have been identified as key determinants of the suitability of habitat for fish and other aquatic organisms (Bovee 1977, Bovee, et al. 1998). The output of the PHABSIM analysis is a weighted usable area (WUA) vs. flow relationship for each target species and lifestage. WUA is an index of fish habitat; it combines measures for the quantity or quality of the habitat.

When flow-related habitat limits fish populations, WUA may provide an indication of the effect that a given change in streamflow can have on fish habitat and therefore fish populations (Bovee 1982). The current MIF in a bypass reach can be evaluated in terms of the percentage of maximum WUA. When reviewed on a monthly basis by lifestage, habitat limitations can be evaluated for consistency with habitat needs of resident aquatic communities. Further, fish densities that are much lower than reference sites may additionally reflect the presence of habitat limitations (whether related to WUA or other factors). However, when other limiting factors are in effect, there may be little or no relationship between WUA and fish population size. The studies requested by the CAWG were intended to help determine if flow-related habitat was one of the factors limiting fish populations within the various bypass reaches and to quantify the amount of flow needed to support fish populations. The assessment of habitat needs was specifically designed to evaluate summer rearing habitat and spawning habitat, as these were thought to be most likely to limit fish populations. At its' April 14, 2004 meeting, the CAWG elected not to model winter habitat, because winter habitat was presumed not to be limiting. Trout have lower space requirements during the winter because of their reduced metabolic rates (due to cold temperatures) and reduced need to feed (Bjornn and Reiser 1991, Campbell and Neuner 1985, Vondracek, et al. 1992, Bustard and Narver 1975). The habitat suitability criteria developed by the CAWG for use on this project specifically addressed summer habitat requirements and included specific consideration of velocities needed for food transport.

To evaluate whether flow-related physical habitat was likely to be limiting to fish populations, Southern California Edison Company (SCE) compared the amount of habitat provided by the existing MIFs to those needed to support the existing fish population. The amount of habitat (WUA) needed to support an individual fish derived from recommendations from the Instream Flow Group (IFG) and studies conducted in other stream systems (Studley, et al. 1995, PG&E unpublished data, SCE 1995).

This comparison of the amount of habitat needed by an individual fish stems from an analytical technique called the "Effective Habitat Time Series[2] (EHTS)" (Bovee 1982, Milhous, et al. 1989, Bovee, et al. 1998). In this analysis, a cohort (year class) of fish is tracked through time relative to the amount of habitat available to it during critical lifehistory events. The user is required to input a variety of parameters describing the species of interest. These include periodicity, lifespan, age of maturity, fecundity, survivorship from one lifestage to the next, and amount of habitat needed to support an individual fish (WUA to fish ratio) for each lifestage.

An EHTS was conducted as part of the Response of Fish Populations to Altered Flows project (Studley, et al. 1995, PG&E unpublished data). As part of this study, representatives of the IFG suggested that for Sierra trout, WUA to trout ratios of 20 sq. ft per adult, 10 sq. ft per juvenile, and 4 sq. ft. for fry were appropriate (Bovee, pers. comm. 1991, 1993). Based on 13 years of field data, the Response of Fish Populations Study found that these ratios were appropriate when habitat suitability criteria that closely described actual habitat utilization were used and when these habitat suitability criteria encompassed intra- and interspecific habitat overlap. These same IFG ratios were used by an interagency group including CDFG, U.S. Fish and Wildlife Service (USFWS), U.S. Forest Service (USFS) and SCE in the Kern River No. 3 Hydroelectric Relicensing and in development of the Kern River No. 3 Trust Fund Agreement (SCE 1995), demonstrating past agency acceptance of these ratios. To be conservative (more protective of fish), microhabitat was considered to be potentially limiting for a lifestage in a reach only if the WUA to fish ratios where less than double the values used in the Altered Flows Study. The values used for analysis of potential habitat limitations were: 40 WUA units per adult trout, 20 WUA per juvenile trout and 8 WUA units for fry.

Within the project bypass reaches of the Big Creek ALP, WUA to fish ratios were calculated for each lifestage[3]. These ratios were calculated based on the combined

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[2] The CAWG did not request that an EHTS analysis be performed for the Big Creek Project.

[3] Adults are defined as ages 2+ and older, juveniles as Age 1+, and young of year as Age 0+

population of trout species within each age class (to account for habitat overlap and competition between species). The WUA to fish ratios were calculated using rainbow trout WUA, where both species were present, or using brown trout criteria on Bear Creek, where brown trout are allopatric. Rainbow trout WUA was used because for the adult lifestage the amount of WUA provided at a given flow was always less than that for brown trout in the flow range being considered. For juveniles and fry the differences in WUA for the two species were less than 10 percent at this range of flows. The reaches with the lowest WUA to fish ratios (highest density of fish with the lowest amount of habitat) are those where microhabitat is most likely to be limiting to fish.

Spawning habitat may also limit fish populations. The quantity and quality of suitable spawning habitat was assessed in the evaluation of both structural and flow-related habitat. Structural habitat surveys identified the location and quality of substantive patches of spawning gravel in the project bypass reaches. This characterization also included a field evaluation of the quality of the gravel based on embeddedness. The PHABSIM studies characterized the availability and quality of spawning habitat through assessment of the velocities and depths associated with spawning gravels. Thus, spawning habitat was evaluated using depth, velocity, substrate size, and substrate quality.

The assessment of whether spawning habitat is potentially limiting in a reach was based upon the quantity of spawning habitat predicted by the PHABSIM studies, and comparison of this habitat with the existing population and literature derived redd area (2.2 sq. ft per redd for rainbow trout and 5.6 sq. ft per redd for brown trout; Bjornn and Reiser 1991). This analytical approach may under estimate the number of redds that would be supported in a stream. The spawning gravels in nearly all of the bypass reaches (exceptions are Mono Creek and SFSJR near Jackass Meadow) are distributed in small pockets, generally less than 1 to 2 sq. ft in size. These pockets likely are sufficient to accommodate a single redd, but will not support more than this. Thus, each redd may consume less space than the 2.2 and 5.6 sq. ft indicated by the literature for rainbow and brown trout, respectively.

Another conservative assumption in this analysis was a 1:1 ratio of females to males and that each female spawns every year. Generally the number of male spawners exceeds the number of females because males mature earlier than females, and precocious males may also mate (Reiser and Bjornn 1991, Bachman 1991, Moyle 2002). In addition female trout often skip a year between spawning (Moyle 2002, Bachman 1991). Because of these conservative assumptions, the amount of spawning habitat needed by the current population is likely overestimated in this analysis.

PHABSIM Stream Habitat Results

The reach specific WUA to fish ratios are provided in Table Attachment C-1. For rearing habitat, these ratios indicate that adult habitat may be limiting to trout populations in Bear Creek and in Big Creek below Dam 4 (29 and 32 sq. ft per adult, respectively). In all other stream reaches and for juvenile and fry lifestages, the WUA to fish ratios for existing populations are at least twice as high as the WUA to fish ratio criteria. Usually the calculated WUA to fish ratios were many times higher than the criteria values. High WUA to fish ratios show that the existing populations are not fully utilizing the existing habitat and have room to expand under the current MIFs. This indicates that, with the exception of adult habitat in Bear Creek and Big Creek below Dam 4, flow-related physical habitat is very unlikely to be limiting, and would allow substantial expansion of the existing populations if the other factors that limit these populations were removed.

Spawning habitat ratios indicate that spawning habitat may be limiting to rainbow and/or brown trout populations in Bear Creek, Big Creek below Dam 4, and Stevenson Creek (Table Attachment C-1). In all other streams, spawning WUA to fish ratios are substantially greater than the criteria values. This indicates that generally, the existing habitat is not being fully utilized by the existing populations, and that these populations would have room to expand under existing MIFs.

The foregoing analysis indicates that flow-related habitat may be limiting to fish populations in three of the bypass stream reaches. Bear Creek and Big Creek below Dam 4 may have flow-related limitations for adult and spawning lifestages, while Stevenson Creek may have a flow-related habitat limitation on spawning habitat.

In the bypass reach of Big Creek below Dam 4, there was an apparent recruitment failure in 2002 although the presence of all other year classes indicated recruitment was successful in most years. Sedimentation of habitat, low flows, and potentially insufficient overwinter habitat, combined with flow-related limitations for adult and spawning lifestages described above, likely are resource issues for trout populations in this reach. In Stevenson Creek, the flow-related habitat limitation on spawning habitat may be exacerbated by upstream passage barriers (both flow-related and natural, structural barriers). In Bear Creek, brown trout populations have one of the highest densities observed in any project stream, but flow-related adult and spawning habitat are currently at levels that may begin to limit fish populations.

Wetted-Perimeter Stream Assessment Criteria

A wetted-perimeter analysis was conducted on the small, seasonally diverted streams, as described in the CAWG 3 Study Plan (Final Technical Study Plan Package (FTSPP) (SCE 2001; Volume 4, SD-B (Books 6 and 21))). The methods used to conduct the wetted perimeter analysis are described in SD-D CAWG 3 Lower Basin Wetted Perimeter Report, SCE 2004. These streams are generally diverted only during the spring runoff season, March to July and are not in operation during the remainder of the year (Section 3.3.2 Existing Operations). Under unimpaired conditions, flow in these streams becomes quite low, or even absent, in the late summer and fall. The wetted-perimeter analysis indicates the minimum flow needed to be protective of fish and macroinvertebrate habitat (Lohr 1993).

Habitat limitations related to Project operations could result if the Project reduced flows to levels similar to or less than the lowest flows that would naturally occur during the year, or if decreased flows affected a life history need not related to rearing habitat (i.e., food supply). These low natural flows create the most likely habitat bottleneck on these streams. During summer and fall, most of the diversions on these small streams are not in operation.

The wetted-perimeter analysis is not really suited for conducting a limiting factor analysis. While studies have found relationships between invertebrate production and fish populations with wetted perimeter (Leathe and Nelson 1986, Lohr 1993), these relationships do not provide an estimate of expected size of the population for a given wetted perimeter. In evaluating the potential for habitat limitations in the wetted-perimeter streams, a potential habitat limitation was assumed to exist if the existing MIF did not equal or exceed the flow suggested by the wetted perimeter analysis as protective of fish and macroinvertebrate habitat. The unimpaired hydrology was used to evaluate whether a more severe habitat limitation existed in the absence of the project. The existing MIF was assumed to be limiting if a more severe habitat limitation did not exist for a period of one month or longer (based on monthly median flows during July through October). If there is no existing MIF on a stream, then flow-related habitat was assumed to be limiting, unless the stream has been documented to be ephemeral or fishless. This assumption may be overly conservative, recognizing that there is often considerable leakage, tributaries and accretion flows below diversions without MIF requirements. However, these flows are usually not monitored accurately, so the actual flows over time may or may not be limiting.

Wetted Perimeter Stream Habitat Results

The small, seasonally diverted streams are listed in Table Attachment C-2. The limiting factor analysis criteria indicate that current MIFs could limit habitat in five of these streams; Tombstone, Crater, Pitman, Adit 8, and Rock Creeks.

Of these streams, only Pitman Creek has an existing MIF requirement. In Pitman Creek the current MIF is less than the flow suggested as protective of fish by the wetted perimeter analysis. The hydrological model indicates that the unimpaired flow exceeds the protective flow, and thus because SCE could divert some of the flow that is required to maintain fish habitat, this is identified as a potential limiting factor. However, the Pitman Creek bypass reach is a steep, bedrock-dominated stream. About half of this reach is plunge pool and step pool habitat, which provide the vast majority of usable fish habitat. This type of habitat is not responsive to changes in flow. In spite of these constraints, fish populations in this bypass reach were abundant and healthy.

The remaining streams also have perennial flow, based upon the hydrologic models. In the case of Adit 8 Creek, this flow is the result of uncontrolled leakage from Tunnel 2 and SCE cannot control the volume of this flow. Additionally, Adit 8 is fishless, and therefore flows do not place a constraint on fish populations. The Tombstone Creek diversion is not currently in operation, so does not currently limit fish populations in Tombstone Creek. If this diversion were in operation, operations could potentially limit fish habitat. Crater Creek and Rock Creek diversions are both in operation and the streams are perennial. Because there is no existing MIF requirement, these diversions have the potential to limit fish habitat. In Crater Creek, habitat may be limited by the availability of flow upstream of the diversion during the drier portion (late summer and fall) of the year. In Rock Creek, the only habitats suitable for fish are plunge pools, thus the availability of habitat would not responsive to changes in flow. However, decreased flows may affect summer water temperatures, which at times are warmer than suitable for trout (see *Temperature*).

In Hooper Creek the existing MIFs exceed the flow recommended by the wetted perimeter analysis and are therefore not considered to be limiting.

In Balsam Creek below the Forebay, the existing MIF supplements a stream that would otherwise be ephemeral above the diversion, although a tributary enters below the dam that contributes a small (unquantified) amount of flow. Thus while the existing MIFs may restrict habitat, this habitat is already supplemented by flows that would not otherwise exist without the project. During the critical summer months, when flow related habitat is most likely to be limiting, the existing MIF exceeds the flow recommended by the wetted perimeter study (1.0 vs. 0.6 cfs), although the existing MIF is slightly lower than the recommended flow (0.5 vs. 0.6 cfs) in the winter. Because the winter space requirements of fish are lower, the current MIFs are not considered to limit habitat in Balsam Creek below the Forebay.

Balsam Creek below Balsam Diversion does not have a current MIF requirement. Since a small amount of natural flow may have been present in the stream, the Project has the potential to further restrict this habitat and thus may affect fish and macroinvertebrate populations.

The remaining streams (North Slide, South Slide, Chinquapin, Camp 62, Bolsillo, Ely and Ross Creeks), either go dry or have unimpaired flows that are less than the existing MIFs during the summer and fall. These unimpaired flows are considered to cause the most severe habitat limitation. Therefore current MIFs are not considered to be limiting habitat. In the Bolsillo Creek bypass reach, naturally-low summer flows, natural structural barriers to fish passage, and the presence of fine sediments are the factors most likely to constrain fish populations. North Slide and South Slide creeks have not been operational for some time and are fishless. If these two diversions were in operation, they could potentially affect flow-related aquatic habitat.

Passage Barrier Evaluation

Fish passage barriers are the result of both natural and man-made conditions that impede fish migration. Upstream migration barriers can consist of natural structural features within the stream (e.g., waterfalls, bedrock sheets, debris jams, etc.), artificial structural features (e.g., dams, weirs, road crossings, etc.), flow related conditions (e.g., insufficient depth), or combinations of these. These elements were used to evaluate upstream passage issues. The frequency and location of structural upstream passage barriers were evaluated to assess the ability of fish to move within a stream. This assessment was based on the information provided in CAWG 14 Barriers Report (SCE 2004a; Volume 4, SD-D (Books 14 and 23)) and CAWG 1, Characterize Stream and Reservoir Habitats, TSRPs (SCE 2003; Volume 4, SD-C (Books 7 and 21) and SD-D

(Books 11 and 23)). Flow-related passage barriers are evaluated on a seasonal basis consistent with the spring and fall migration periods of salmonids. An impassable barrier at low flows may not be a barrier at higher flows.

Passage Flow Assessment Criteria

For flow-related barriers, the flows needed to allow fish passage[4] were compared to current minimum instream flow levels during appropriate migration periods to identify flow-related passage issues. Passage flow requirements through typical riffles within each reach were determined based on the PHABSIM and wetted riffle transects and Thompson's (1972) criteria for adult trout (Final Technical Study Plan Package (FTSPP) (SCE 2001; Volume 4, SD-B (Books 6 and 21)) and discussed at the February 11, 2005 CAWG Meeting). Streams were evaluated based on *normal* and *dry* year MIFs, where applicable. For wetted-perimeter streams, the lowest median monthly flow was used where appropriate hydrology information was available. Passage flows were evaluated for the spring (May through June – rainbow trout) and fall (October through December – brown and brook trout) spawning migration seasons (Table Attachment C-3).

Structural Passage Barriers

This evaluation also included the frequency of structural barriers (natural or Project-related) to fish passage within a stream. Structural barriers (falls, bedrock sheets, trench chutes) often cannot be eliminated by providing a different amount of flow in the stream. Where structural barriers occurred more frequently than once in every 1,000 feet of stream on average, then these barriers would likely limit fish migration and may affect fish populations. Structural passage barriers were identified based on the information presented in CAWG 14. Additional structural passage barriers were identified through a review of habitat inventory information. High gradient habitats that were dominated by bedrock substrates were assumed to be passage barriers (Table Attachment C-3).

In addition, passage barriers at the lower portion of the streams were also evaluated. Fish move between habitats for spawning, for oversummering, for overwintering and for dispersal (Moyle 2002). A barrier that prevents fish from moving between larger and smaller streams may have a greater effect on populations than a barrier within a stream. If a barrier, either flow-related or structural, was present within 500 ft of the stream mouth or 10 percent of the total reach length from the confluence with a larger stream, whichever was less, then passage was assumed to limit full habitat utilization by the population.

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[4] Fish passage flows were determined in the PHABSIM and wetted perimeter studies (CAWG 3, Flow-Related Habitat - Upper Basin Wetted Perimeter, TSRPs (SCE 2003; Volume 4, SD-C (Books 7 and 21)); CAWG 3, Flow-Related Habitat - Lower Basin Wetted Perimeter, TSRPs (SCE 2003; Volume 4, SD-D (Books 11 and 23)); and CAWG 3, Instream Flow Studies – PHABSIM, TSRPs (SCE 2003; Volume 4, SD-D (Books 11 and 23)), also see the CAWG 3 Study Plan Final Technical Study Plan Package (FTSPP) (SCE 2001; Volume 4, SD-B (Books 6 and 21))).

Stranding

Large flow changes (resulting from changes in MIF requirements) during fall through spring have the potential to strand (dry out) brown trout redds. During the spring through early summer, monthly changes in MIFs have the potential to result in flow changes that may strand rainbow trout redds. Large changes in flows also have the potential to strand fry of trout and native minnows.

Within the Big Creek Dam 1 to Powerhouse 1 bypass reach, there currently is no required MIF from December 15 to April, although SCE releases flow during this period. Lack of flow during that period is undesirable for incubation of brown trout embryos, as well as overwinter survival.

Uncontrolled Spills

High (flood) flows mobilize the streambed and transport sediments. These flows flush fine sediments from the streambed to provide suitable spawning and rearing conditions for trout, but also mobilize larger materials including gravels. By mobilizing gravels, high flows can scour embryos and cause high mortality for young fry.

Downstream of Mammoth Pool Dam, the effect of uncontrolled spills in the spring of Wet and Above Normal Water Years likely result in substantial young-of-the-year mortality in the Mammoth Reach of the San Joaquin River. This adversely affects recruitment to the trout population in some years. Spill events from Dam 6 in the San Joaquin River also may affect recruitment in the same years. Uncontrolled spill events from Dam 4 in Big Creek also may affect recruitment in some years, but also may have a beneficial effect of reducing sedimentation of spawning and rearing habitat.

Periodically, high flows are released to North Fork Stevenson Creek during outages at Eastwood Powerhouse. If flows are sufficiently large, gravels may be mobilized. Fish populations in this stream are recovering from large flow events in the recent past that have adversely affected recruitment.

Temperature

Water temperature criteria applied to this evaluation are described for trout and hardhead. Daily mean temperature criteria were applied to assess whether temperatures would be suitable for fish growth and daily maximum temperature criteria were used to assess conditions that would stress fish. Fish can withstand short-term exposure to water temperatures higher than those needed for longer-term growth or survival without significant negative effects.

Trout

Based upon the best available information in the literature for regional streams, the temperature evaluation criterion applied to assess conditions for suitable trout growth is a mean daily average water temperature at or below 19°C. A daily maximum temperature of 24°C was applied as a criterion for short-term high-temperature exposure, above which temperatures are expected to be stressful for trout. Target temperatures for COLD Freshwater Habitat are met when daily mean water temperatures are 20°C or less and daily maximum temperatures are 22°C or less (J. Canaday, State Water Board). The number of days in which temperatures exceeded a daily mean of 19°C or a daily maximum of 22°C and 24°C was identified for all study streams or stream segments to be managed for trout and for Project reaches to be managed as Central Valley Regional Water Quality Control Board (CVRWQCB) COLD Freshwater Habitat. Tables provided in Appendix H of CAWG 5 (CAWG 5, Water Temperature Monitoring, TSRPs (SCE 2004a; Volume 4, SD-D (Books 12 and 23))) report the number of days during which daily mean water temperatures exceeded each of a range of temperatures from 15°C to 20°C, and the number of days daily maximum water temperatures exceeded a temperatures ranging from 20°C to 26°C during the CAWG 5 temperature monitoring period.

The temperature criteria are based on recent studies focused on California rainbow trout stocks, which are summarized in a review by Myrick and Cech (2001) that focused on California's Central Valley populations. Myrick and Cech (2000) studied growth rates of two strains of resident California rainbow trout at temperatures of 10°C to 25°C. Growth was at a maximum near 19°C, and declined at study temperatures greater and lower than 19°C. Trout grew well at temperatures near 22°C, but growth rates declined rapidly as temperatures approached 25°C. These studies suggest if daily mean summer water temperatures are less than or equal to 20°C in the Project Area, conditions would be suitable for trout growth (Attachment I - Trout Temperature Requirements - Literature Review (SCE 2007; Volume 4 (Book 5))).

For brown trout, Moyle (2002, citing Armour 1994) reports preferred temperatures of 12°C to 20°C and optimal temperatures that appear to be approximately 17°C to 18°C, although high growth rates have been found in temperatures of 12°C to 18°C. Brown trout can survive temperatures up to 28°C to 29°C for short periods of time, depending upon acclimation temperature. Ojanguren, et al. (2001) found juvenile trout growth was above 90 percent of maximum potential between 14 and 20°C and dropped sharply at higher temperatures (experimental temperatures were as high as 24°C) based on constant temperature exposure over 14 days. Fitting their data to the model developed by Elliott, et al. (1995), they predicted an upper limit for positive growth at 24.74°C and a minimum at 1.24°C.

Based on available literature drawn largely from laboratory studies (Cherry, et al. 1977, Raleigh, et al. 1984, Currie, et al. 1998, Coutant 1977) the upper incipient lethal temperature (UILT) for rainbow trout is within the range 25°C to 30°C. Brown trout have been characterized as being tolerant of temperatures of up to 27°C. USEPA (1976) identified maximum weekly temperatures for survival for rainbow and brook trout as 24°C. Eaton, et al. (1995) identified upper temperature criteria for rainbow and brown trout as 24.0°C and 24.1°C, respectively. Myrick and Cech (2001) report critical thermal maximum (CTM) tolerances of 27.7°C to 29.7ºC for juvenile California steelhead, and as high as 32ºC for Eagle Lake rainbow trout acclimated to 25ºC. These studies suggest that a criterion of a daily maximum of 24°C representing a short-term exposure may be considered conservative (extremely protective) for the Project Area. The target temperature of 22°C would be extremely protective of trout.

Hardhead

Moyle (2002) said of hardhead, "Most streams in which they occur have summer temperatures in excess of 20°C, and optimal temperatures for hardhead (as determined by laboratory choice experiments) appear to be 24°C to 28°C." These experiments primarily focused on juvenile hardhead. Preliminary work by Cech suggests that adult hardhead acclimated to water temperatures below 20°C prefer temperatures at or above 20°C (J. Cech, University of California at Davis, pers. comm. 2006). This represented the envelope of suitable summer temperatures for this species and it corresponds well with observed distribution of hardhead in the Horseshoe Bend reach of the San Joaquin River. For the purpose of this analysis, it was compared to daily mean temperatures in the Stevenson Reach of the San Joaquin River, the only location where hardhead were found among the ALP Projects.

Potential Water Temperature Limitations

Water temperatures immediately below project diversions were suitable for trout at all times. Mean daily water temperatures were observed to exceed 20°C in the downstream portions of several streams. These exceedances usually were observed in July and August, and more frequently in dry water years with warm air temperatures, than in normal water years. Maximum daily temperatures rarely exceeded 24°C, and when they did, it was in the stream reaches where mean daily temperature criteria also were exceeded. The stream reaches where temperatures were identified as potentially affecting trout populations are: SFSJR – Bear Creek to Mono Creek and Rattlesnake Creek to San Joaquin River, San Joaquin River – Mammoth and Stevenson Reaches; Big Creek Dam 4 to Dam 5 and Dam 5 to Powerhouse 8, Rock Creek, and Ross Creek (Table Attachment C-4).

Summary of Limiting Factors by Bypass Reach

Table Attachment C-5 summarizes the factors most likely to affect fish populations in the various stream reaches based on the criteria described above. These are described as resource issues in the body of the PDEA. The PM&E measures in the Proposed Action have been developed specifically to address these resource issues. In some cases, a PM&E measure provides some improved abiotic condition (e.g, improved water quality) that although it does not directly address a resource issue, represents a potentially beneficial enhancement of aquatic habitat.

Synthesis of Factors that may Affect Recruitment in Project Bypass Reaches.

Resource issues that were identified for aquatic habitat generally consisted of bypass reaches in which there were no minimum instream flows, portions of bypass reaches where, at time, water temperatures were too warm for favorable trout growth or were stressful for trout, reaches in which trout populations were lower in density than in reference streams, and reaches in which physical habitat may limit trout populations.

Mammoth Pool Project:

Under existing conditions, the bypass reach below Mammoth Pool Dam had low trout abundance and summer water temperatures in the lower portion of the reach that are, at times, warmer than is suitable for good trout growth. Uncontrolled spills during Wet and Above Normal Water Years may scour embryos and result in substantial fry mortality, which may adversely affect recruitment in those years.

There currently are no MIFs in Rock Creek. Flow-related habitat is limited. However, the only habitats suitable for fish are plunge pools, thus the availability of habitat is not responsive to changes in flow. Water temperatures are warmer than suitable for trout growth in the lower portion of the bypass reach in the summer. Ross Creek is dry above and below the diversion during much of the summer and fall due to an upstream non-Project diversion, which limits the value of this stream for fish. However, it is used by reptiles and amphibians.

Big Creek Nos. 1 and 2 Project:

The bypass reach between Dam 1 and Big Creek Powerhouse 1 has numerous natural structural passage barriers. There is no required MIF from December 15 to April 15, although SCE releases flow during this period. Lack of flow during that period is undesirable for incubation of brown trout embryos and overwinter survival. Flows in the first two-mile segment of the channel below the dam are insufficient to maintain sediment transport and therefore spawning gravels have a high fine sediment content. Riparian encroachment and sediment in the stream is extensive in the low gradient portion of the reach. However, densities and biomass of brown trout were at or above reference levels and trout were healthy.

Resource issues for the bypass reach between Dam 4 to Powerhouse 2/2A include (i) summer water temperatures in portions of the reach that are unsuitable for trout growth; (ii) potentially insufficient flow (no MIF required under the current license); (iii) potential flow-related adult rearing and spawning habitat limitations; (iv) apparent recruitment failure in 2002 (although the presence of all other year classes indicates that recruitment is successful in most years); (v) potential insufficient overwinter habitat for trout due to lack of flow and sediment in pools; and (vi) periodic de-watering of Dam 4 for infrequent tunnel inspections may cause the release of sediments of sufficient volume to temporarily cause sedimentation of pools and aggradation of the channel bed. Regardless of these resource issues, trout were abundant and had good condition factors.

The trout population in the bypass reach of Balsam Creek was lower than expected in terms of fish densities and biomass. The extremely steep, bedrock channel provides limited physical habitat for fish and natural, structural barriers to passage are abundant. There is no MIF for this reach under current conditions.

There is no MIF in Ely Creek under current conditions. Ely Creek may go dry upstream of the diversion and habitat in the bypass reach may be restricted to isolated pools or small accretion flows during the drier season, even when the diversion is turned out. Natural passage barriers, including dry streambed, restrict fish movement.

Big Creek Nos. 2A, 8 and Eastwood Project:

Under existing conditions, water temperature was a resource issue that had the potential to adversely affect trout in two portions of the bypass reach of the South Fork San Joaquin River (SFSJR), particularly in dry water years with warm air temperatures; in the 2.5-mile reach upstream of Mono Creek and in the most downstream portion of the reach. Fishing pressure in some areas may reduce populations, as populations were lower in areas with developed recreation facilities (Jackass Meadow Campground, Mono Hot Springs), than in less accessible areas.

The Bear Creek bypass reach does not have identified resource issues. The brown trout population is abundant at or above reference stream densities with successful recruitment. However, due to the abundance of brown trout, physical habitat for adult rearing and spawning habitat may be approaching limiting values.

Under existing conditions, trout populations in Mono Creek are very low. Sedimentation of habitat, including loss of pool depth and embeddedness of gravels, likely has adverse effects on trout habitat, recruitment, and over-winter survival. Current MIFs are sufficient to support many more fish than are currently present. Sediment conditions are the most likely limiting factor in this reach. Although MIFs during the fall of dry years are lower than the identified passage flows for trout, the actual flows in the reach (based on the USGS record) are usually sufficient to provide passage.

Tombstone, North Slide and South Slide creek diversions are currently not in operation and would be decommissioned under the Proposed Action. Therefore, any potential impacts to fish or other aquatic species that would have resulted from the repair and operation of these diversions would be avoided. Of these streams, only Tombstone Creek currently supports trout (below the diversion).

In the Hooper Creek bypass reach, flows for fish passage were identified as a potential limiting factor. Existing conditions, MIFs of 2 cfs are less than the 2.5 cfs needed for passage through a typical riffle on this creek, as identified by the wetted perimeter analysis. Natural structural barriers in this steep, bedrock stream also impede fish passage. Sedimentation was identified as a resource issue.

Crater Creek above and below the diversion had lower than expected trout densities. There are no MIF requirements. The operation of the diversion results in periods where flows below the diversion are less than the flow identified by wetted perimeter analysis as protective of fish and macroinvertebrates in this stream. Natural flows less than this protective flow likely occur in this stream during the summer and fall. Habitat and fish populations in Crater Creek are highly fragmented by numerous falls and areas of bedrock sheet. Extensive upstream fish migration would be impossible at any flow. The Crater Creek Diversion will be removed from service under the Proposed Action.

Chinquapin, Camp 62, and Bolsillo creeks are steep, boulder/bedrock streams containing brook trout. The current MIFs approximate the flow indicated by wetted perimeter analysis to be protective of fish and macroinvertebrate habitat throughout the year. The most severe habitat bottleneck likely occurs in the summer and fall when natural flows upstream of the diversions drop below the protective flow (as identified by the wetted perimeter study and less than the current MIF) for several months or more. During this time, the diversions are turned out (not diverting) and the stream flow is unaffected by the Project. Passage is restricted by frequent structural barriers. Natural summer flows and fish passage are the factors most likely to constrain fish populations in this bypass reach. In Bolsillo Creek, sediment may adversely affect pool habitats.

Resource issues in Pitman Creek are considered minor. In Pitman Creek the current MIF is less than the flow suggested as protective of fish by the wetted perimeter analysis and since the unimpaired flow exceeds the protective flow, this is identified as a potential limiting factor. However, the Pitman Creek bypass reach is a steep, bedrock-dominated stream. About half of this reach is plunge pool and step pool habitat with bedrock controls, which provide the vast majority of usable habitat for fish. This type of habitat is not responsive to changes in flow. Upstream migration through this channel is prohibited by numerous, natural, structural barriers. In spite of these constraints, fish populations in the bypass reach are abundant and healthy under current conditions.

Flows in Balsam Creek below the Balsam Meadow Forebay are augmented by flows from the forebay. Existing MIFs are greater than the flow identified by the wetted perimeter analysis as protective of fish and macroinvertebrate habitat, during the summer months, and slightly less than this flow in the winter months. However, actual releases made to maintain compliance result in flows that exceed the protective flow at all times. The only factor that appears to be a resource issue in this steep, flow-augmented reach is the frequent, natural, structural passage barriers that limit upstream migration at any flow. Nevertheless, this reach supports a self-sustaining population of rainbow trout, trout density and biomass was high, and condition factors were good.

Current flows in North Fork Stevenson Creek, which are augmented by Project releases from Tunnel 7 (North Fork Stevenson Creek RM 3.55), are much higher than that of the original stream. These flows are sufficient to provide fish passage at all times, although natural structural barriers prevent extensive upstream passage in portions of the reach. Resource issues relate to a widening of the channel due to its use as a flow transport reach by SCE prior to the operation of the Eastwood Power Station (EPS). This channel may be used to convey high flows in the spring, if the EPS is offline. Trout populations are lower than expected due to high flow releases in several past years, which adversely affected recruitment. Gravel in this reach is limited in abundance.

In the Big Creek Dam 5 to Powerhouse 8 bypass reach, the principal resource issues under existing conditions are warm summer water temperatures in the lower portion of the reach, upstream migration in the fall of dry years, overwinter flows in dry years, and periodic (once every seven years) sedimentation when the impoundment is drained for tunnel inspections. Despite these issues, trout density is similar to that for reference locations. MIFs in the fall of dry years are lower than the flow necessary for passage through a typical riffle, which may affect brown trout spawning migration (Dry and Critical Water Years collectively occur about half the time). On average, however, flow records indicate that flows exceed the passage flow at all times under actual operations, due to the release of extra water to maintain compliance with the MIF requirement. Frequent, natural, passage barriers occur along the bypass reach preventing extensive upstream migration under any flow conditions. Periodic sedimentation may decrease stream depth and smother spawning gravels and redds until flows of sufficient magnitude and duration occur to move this sediment downstream into the San Joaquin River. Overwinter habitat may also be an issue in dry years due to current lower MIFs and the dominance of shallow habitats.

In Stevenson Creek, the availability of spawning habitat and passage flows were identified as potential resource issues for rainbow trout, particularly in a stream reach in the lower portion of the bypass reach. Recruitment may be affected by these factors. Spawning habitat in Stevenson Creek is likely of reduced availability because suitable spawning gravels are generally uncommon, but current MIFs also contribute to the low availability of spawning habitat. Current MIFs are less than required for passage through a typical riffle, which may reduce access to areas of suitable spawning habitat, but natural structural passage barriers along this stream would prevent migrations longer than 1,000 to 2,000 ft on average at any flow.

Big Creek No. 3:

In the San Joaquin River between Dam 6 and Redinger Lake, resource issues include water temperatures too warm to be suitable for trout present in the lower portion of the bypass reach during the summer, lower than expected trout abundance, and absence of adult hardhead residing in the lower portion of the reach. However, water temperatures in the lower portion of the reach are suitable for hardhead and juveniles utilize the reach. Adult hardhead may spawn in this reach,but reside in Redinger Lake downstream. Uncontrolled spills in wet and above normal water years may scour trout redds and result in fry mortality.

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Table Attachment C-1. WUA to Fish Ratios for PHABSIM Streams Based on ALP Fish Population Sampling.

Stream	South Fork San Joaquin River				Bear Creek	Mono Creek	San Joaquin River		Big Creek		Stevenson Creek	North Fork Stevenson Creek
Reach	**Florence Lake to Bear Creek**	**Bear Creek to Mono Creek**	**Mono Creek to Rattlesnake Creek**	**Rattlesnake Creek to SJR**	**Below Diversion**	**Below Diversion**	**Mammoth Reach**	**Stevenson Reach**	**Dam 4 to PH2[2]**	**Dam 5 to PH8**	**Below Shaver**	**Below Tunnel 7 Outlet**
Adults												
Normal Year	200	157	279	160	29	820	866	15819	32	153	111	109
Dry Year	178	135	246	140	24	657	866	15819	32	141	111	98
Juvenile												
Normal Year	500	296	136	209	42	1131	839	1669	45	46	97	115
Dry Year	505	290	137	212	35	1084	839	1669	45	42	97	108
Fry												
Normal Year	861	1050	227	546	530	4384	1940	10207	656	113	465	366
Dry Year	919	1099	239	583	494	4544	1940	10207	656	110	465	360
Spring Spawning												
Normal Year	343	4	6	4	-	3288	16	415	0	22	2	10
Dry Year	339	4	6	4	-	3288	15	85	0	18	1	10
Fall Spawning												
Normal Year	94	11	17	7	<0.1	490	30	663	0	50	-	30
Dry Year	94	11	17	7	<0.1	490	30	663	0	50	-	28

[1] Based on fish population estimates (CAWG 7), current MIF requirements, and weighted-usable-area functions (CAWG 3).

[2] Used 1 cfs as flow for all lifestages, in absence of existing MIF or measured flow information.

Table Attachment C-2. Assessment of Habitat Limitations Based on Wetted Perimeter and Depth Suitability Analyses in Small, Seasonally Diverted Streams.

	Flow Recommendation[1]	Existing MIF	MIF Potential Limiting Factor[2]	Minimum Unimpaired Flow (Jul-Oct)[3]	MIF greater than Minimum Unimpaired Flow	MIF Potentially Limiting
Upper Basin						
Tombstone	0.9	0	Y	0.5	Y	Y
North Slide	0.4	0.2	Y	0.1	N	N
South Slide	0.7	0.2	Y	0.1	N	N
Hooper	1.3	2	N	2.7	Y	N
Crater	0.8	0	Y	1.4	Y	Y
Chinquapin	0.8	0.5 (Aug-Dec) 1.0 (Jan-Jul)	Y	0	N	N
Camp 62	0.8	0.3	Y	0	N	N
Bolsillo	4	0.4	Y	0	N	N
Lower Basin						
Pitman	0.5	0.3	Y	0.7	Y	Y
Balsam Below Forebay	0.6	0.5 (Oct-May) 1.0 (Jun-Sep)	Y	0	N	N
Balsam Below Diversion	0.6	0	Y	~0.1	Y	Y
Ely[4]	0.5	0	Y	0	N	N
Adit 8[5]	0.4	0	Y	N/A	N/A	Y
Rock	3	0	Y	0.3	Y	Y
Ross[4]	N/A	0	Y	0	N	N

[1] Based on wetted perimeter or depth suitability analysis.

[2] MIF is less than WP Flow Recommendation.

[3] Based on area discharge calculations unless otherwise noted.

[4] Ephemeral above Balsam Meadow forebay, currently augmented by releases from Balsam Meadow forebay.

[5] Minimum unimpaired flow based on field observations by SCE or ENTRIX.

[6] Historically ephemeral, currently perennial due to uncontrolled leakage from Tunnel 2.

Table Attachment C-3. Evaluation of Passage in Project Effected Stream Reaches.

Stream Reach	Structural Barriers		Flow Related Barriers	
	From Mainstem or Impoundments to Tributaries[1]	Frequency of Natural Structural Barriers Within a Reach[2]	Spring Spawners[3] (Rainbow Trout)	Fall Spawners[4] (Brown and Brook Trout)
Mammoth Pool				
San Joaquin River, Mammoth Reach (Mammoth Pool Dam to Mammoth Pool Powerhouse) (RM 18.30 to 26.70)	X	-	-	-
Rock Creek, Diversion to San Joaquin River (RM 0.00 to 0.40)	X	X	-	-
Ross Creek, Diversion to San Joaquin River (RM 0.00 to 0.85)	X	X	-	-
Big Creek 1&2				
Big Creek, Huntington Lake to Dam 4 (RM 6.30 to 9.90)	X	X	-	-
Big Creek, Dam 4 to Dam 5 (RM 1.80 to 6.20)	-	-	-	-
Balsam Creek, Diversion to Big Creek (RM 0.00 to 0.65)	X	X	X	-
Adit 8 Creek to Big Creek (RM 0.00 to 1.00)	-	X	-	-
Ely Creek, Diversion to Big Creek (RM 0.00 to 1.00)	-	-	-	-
Big Creek 2A, 8, and Eastwood				
SFSJR Florence Lake to Bear Creek (RM 22.30 to 27.90)	-	-	-	-
SFSJR Bear Creek to Mono crossing (RM 18.00 to 22.30)	-	-	-	X
SFSJR Mono Crossing to Rattlesnake Creek (RM 14.50 to 18.00)	-	-	-	-
SFSJR Rattlesnake Creek to SJR (RM 0.00 to 14.50)	-	-	-	-
Bear Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.60)	-	-	-	X
Mono Creek, Diversion to SF San Joaquin River (RM 0.00 to 5.80)	-	-	-	X
Tombstone Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.00)	-	-	-	-
North Slide Creek, Diversion to SF San Joaquin River (RM 0.00 to 0.30)	X	X	-	-
South Slide Creek, Diversion to Confluence with North Slide Creek (RM 0.00 to 0.30)	-	-	-	-
Hooper Creek, Diversion to SF San Joaquin River (RM 0.00 to 0.60)	X	X	X	X
Crater Creek, Diversion to SF San Joaquin River (RM 0.00 to 2.85)	-	X	-	-
Chinquapin Creek, Diversion to Camp 62 Creek (RM 0.00 to 0.90)	X	-	-	X
Camp 62 Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.35)	X	-	-	X

Table Attachment C-3. Evaluation of Passage in Project Effected Stream Reaches (continued).

Stream Reach	Structural Barriers		Flow Related Barriers	
	From Mainstem or Impoundments to Tributaries[1]	Frequency of Natural Structural Barriers Within a Reach[2]	Spring Spawners[3] (Rainbow Trout)	Fall Spawners[4] (Brown and Brook Trout)
Bolsillo Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.60)	X	X	-	-
Pitman Creek, Diversion to Big Creek (RM 0.00 to 1.50)	-	X	X	X
Balsam Creek, Forebay to Balsam Creek Diversion (RM 0.65 to 2.70)	-	X	X	-
NF Stevenson Creek, tunnel outlet to Shaver Lake (RM 1.00 to 3.60)	X	X	-	X
Big Creek, Dam 5 to San Joaquin River (RM 0.00 to 1.70)	X	X	-	X
Stevenson Creek, Shaver Lake Dam to San Joaquin River (RM 0.00 to 4.25)	-	X	X	-
Big Creek No. 3				
San Joaquin River, Stevenson Reach (Dam 6 to Redinger) (RM 11.20 to 17.00)	-	-	X	X

[1] An impassable structural barrier exists within 500 ft of stream mouth or 10 percent of bypass reach length from mouth, whichever is less.

[2] The average frequency of natural structural barriers is more than 1 in every 1,000 ft of stream based on consideration of structural barriers identified in CAWG 14 and habitat inventory information in CAWG 1. Passage barriers in CAWG 1 relate to high gradient habitat types that would be impassable, except at very high flows

[3] The lowest MIF during April through June is less than the flow required for passage through a typical riffle.

[4] The lowest MIF during October through December is less than the flow required for passage through a typical riffle.

Table Attachment C-4. Evaluation of Temperature in Project Effected Stream Reaches.

Stream Reach	**Extended Exposure[1]**	**Short term Exposure[2] (> 22**°C)	**Short-term Exposure [2] (24**°C)
Mammoth Pool			
San Joaquin River, Mammoth Reach (Mammoth Pool Dam to Mammoth Pool Powerhouse) (RM 18.30 to 26.70)	**X**	**X**	**X**
Rock Creek, Diversion to San Joaquin River (RM 0.00 to 0.40)	**X**	X	-
Ross Creek, Diversion to San Joaquin River (RM 0.00 to 0.85)	**X**	**X**	**X**
Big Creek 1&2			
Big Creek, Huntington Lake to Dam 4 (RM 6.30 to 9.90)	-	-	-
Big Creek, Dam 4 to Dam 5 (RM 1.80 to 6.20)	**X**	X	X
Balsam Creek, Diversion to Big Creek (RM 0.00 to 0.65)	-	-	-
Adit 8 Creek to Big Creek (RM 0.00 to 1.00)	NM[4]	NM	NM
Ely Creek, Diversion to Big Creek (RM 0.00 to 1.00)	-	X[4]	X[4]
Big Creek 2A, 8, and Eastwood			
SFSJR Florence Lake to Bear Creek (RM 22.30 to 27.90)	-	-	-
SFSJR Bear Creek to Mono crossing (RM 18.00 to 22.30)	**X**	X	-
SFSJR Mono Crossing to Rattlesnake Creek (RM 14.50 to 18.00)		X	-
SFSJR Rattlesnake Creek to SJR (RM 0.00 to 14.50)	**X**	-	-
Bear Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.60)	-	-	-
Mono Creek, Diversion to SF San Joaquin River (RM 0.00 to 5.80)	-	-	-
Tombstone Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.00)	-	-	-
North Slide Creek, Diversion to SF San Joaquin River (RM 0.00 to 0.30)	-	-	-
South Slide Creek, Diversion to Confluence with North Slide Creek (RM 0.00 to 0.30)	-	-	-
Hooper Creek, Diversion to SF San Joaquin River (RM 0.00 to 0.60)	-	-	-
Crater Creek, Diversion to SF San Joaquin River (RM 0.00 to 2.85)	-	-	-
Chinquapin Creek, Diversion to Camp 62 Creek (RM 0.00 to 0.90)	-	-	-
Camp 62 Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.35)	-	-	-
Bolsillo Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.60)	-	-	-
Pitman Creek, Diversion to Big Creek (RM 0.00 to 1.50)	-	-	-
Balsam Creek, Forebay to Balsam Creek Diversion (RM 0.65 to 2.70)	-	-	-
NF Stevenson Creek, tunnel outlet to Shaver Lake (RM 1.00 to 3.60)	-	-	-
Big Creek, Dam 5 to San Joaquin River (RM 0.00 to 1.70)	**X**	X	-
Stevenson Creek, Shaver Lake Dam to San Joaquin River (RM 0.00 to 4.25)	-	-	-
Big Creek No. 3			
San Joaquin River, Stevenson Reach (Dam 6 to Redinger) (RM 11.20 to 17.00)	**X[5]**	**X[5]**	**X[5]**

[1] Mean Daily Temperature exceeds 19°C for more than 10 percent of days in any year. (Note: CRWQCB target temperatures for COLD Freshwater Habitat - daily mean water temperatures are ≤ 20°C)

[2] Maximum Daily Temperature exceeds 22°C (CRWQCB target) or 24°C (stressful to trout) at any time.

[3] NM = Temperature not monitored.

[4] Temperatures were cool when flow was present. Some or all of these exceedance temperatures may have occurred when the temperature recorder was not submerged, reflecting air temperatures rather than water temperatures.

[5] Temperatures in the lower portion of this reach are unsuitable for trout, but are suitable for hardhead.

Table Attachment C- 5. Summary of Potential Limiting Factors by Stream Reach.

	Structural Habitat			Flow Related Habitat						Fish Passage		Temperature
Stream Reach	**Mesohabitat**	**Spawning Gravel**	**Sedimentation**	**Adult Rearing**	**Juvenile Rearing**	**Spawning**	**Wetted Perimeter Protective Flow**	**Low Dry Season Flows**	**High Flow**	**Structural Barriers**	**Passage Flow**	
Mammoth Pool												
San Joaquin River, Mammoth Reach (Mammoth Pool Dam to Mammoth Pool Powerhouse) (RM 18.30 to 26.70)	-	-	-	-	-	-	NA	NA	X	-	-	X
Rock Creek, Diversion to San Joaquin River (RM 0.00 to 0.40)	X	-	-	NA	NA	NA	X	-		X	X	X
Ross Creek, Diversion to San Joaquin River (RM 0.00 to 0.85)	X	-	-	NA	NA	NA	X	-		X	-	X
Big Creek 1&2												
Big Creek, Huntington Lake to Dam 4 (RM 6.30 to 9.90)	-	X	X	NA	NA	NA	NA	NA		X	NA	-
Big Creek, Dam 4 to Dam 5 (RM 1.80 to 6.20)	-	-	X	X	-	X	NA	NA		-	-	X
Balsam Creek, Diversion to Big Creek (RM 0.00 to 0.65)	-	-	-	NA	NA	NA	X	-		X	X	-
Adit 8 Creek to Big Creek (RM 0.00 to 1.00)	-	-	-	NA	NA	NA	X	X		X	X	-
Ely Creek, Diversion to Big Creek (RM 0.00 to 1.00)	-	-	-	v	NA	NA	X	X		X	X	-
Big Creek 2A, 8, and Eastwood												
SFSJR Florence Lake to Bear Creek (RM 22.30 to 27.90)	-	-	-	-	-	-	NA	NA		-	-	-
SFSJR Bear Creek to Mono crossing (RM 18.00 to 22.30)	-	-	-	-	-	-	NA	NA		-	-	X
SFSJR Mono Crossing to Rattlesnake Creek (RM 14.50 to 18.00)	-	-	-	-	-	-	NA	NA		-	-	-
SFSJR Rattlesnake Creek to SJR (RM 0.00 to 14.50)	-	-	-	-	-	-	NA	NA		-	-	X
Bear Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.60)	-	-	-	X	-	X	NA	v		-	-	-
Mono Creek, Diversion to SF San Joaquin River (RM 0.00 to 5.80)	-	-	X	-	-	-	NA	NA		-	X	-
Tombstone Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.00)[1]	-	-	-	NA	NA	NA	X	-		-	X	-

Table Attachment C-5. Summary of Potential Limiting Factors by Stream Reach (continued).

Stream Reach	Structural Habitat			Flow Related Habitat				Low Dry Season Flows	High Flow	Fish Passage		Temperature
	Mesohabitat	Spawning Gravel	Sedimentation	Adult Rearing	Juvenile Rearing	Spawning	Wetted Perimeter Protective Flow			Structural Barriers	Passage Flow	
North Slide Creek, Diversion to SF San Joaquin River (RM 0.00 to 0.30)[1]	-	-	-	NA	NA	NA	X	X		X	X	-
South Slide Creek, Diversion to Confluence with North Slide Creek (RM 0.00 to 0.30)[1]	-	-	-	NA	NA	NA	X	X		-	X	-
Hooper Creek, Diversion to SF San Joaquin River (RM 0.00 to 0.60)	-	-	X	NA	NA	NA	-	-		X	X	-
Crater Creek, Diversion to SF San Joaquin River (RM 0.00 to 2.85)[1]	-	-	-	NA	NA	NA	X	-		X	X	-
Chinquapin Creek, Diversion to Camp 62 Creek (RM 0.00 to 0.90)	-	-	-	NA	NA	NA	X	X		-	X	-
Camp 62 Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.35)	-	-	-	NA	NA	NA	X	X		-	X	-
Bolsillo Creek, Diversion to SF San Joaquin River (RM 0.00 to 1.60)	-	-	X	NA	NA	NA	X	X		X	X	-
Pitman Creek, Diversion to Big Creek (RM 0.00 to 1.50)	X	-	-	NA	NA	NA	X	-		X	X	-
Balsam Creek, Forebay to Balsam Creek Diversion (RM 0.65 to 2.70)	-	-	-	NA	NA	NA	-	-		X	X	-
NF Stevenson Creek, tunnel outlet to Shaver Lake (RM 1.00 to 3.60)	-	-	-	-	-	-			X	-	X	-
Big Creek, Dam 5 to San Joaquin River (RM 0.00 to 1.70)	-	-	X	-	-	-	NA	NA		X	X	X
Stevenson Creek, Shaver Lake Dam to San Joaquin River (RM 0.00 to 4.25)	-	-	-	-	-	X	NA	NA		X	X	-
Big Creek No. 3												
San Joaquin River, Stevenson Reach (Dam 6 to Redinger) (RM 11.20 to 17.00)	-	-	-	-	-	-	NA	NA	X	-	X	X

NA = Analysis not performed for this reach.

[1] Tombstone, North Slide, South Slide and Crater Creek diversions will be removed from service under the Proposed Action.