Review of Documents Related to Alternatives for Dam Removal

This is a summary review of two documents that evaluated alternatives for dam removal on Battle Creek, California. We have provided an overall summary response to four questions provided to reviewers by staff of the California Bay-Delta Authority for guidance. Following the summary response are specific comments on each of the two documents. The two documents were prepared by: 1) the California Hydropower Reform Coalition and titled "Analysis of dam removal alternative B Battle Creek Salmon and Steelhead Restoration Project" and 2) the Agencies titled "Draft-Further biological analyses for information presented on March 15, regarding the differences between the 5 dam removal alternative and the 8 dam removal scenario."

Overall Reviewer Responses to Both Documents and the Dam Removal Alternatives

1) Have the biologically relevant issues (hydrology and temperature, for example) been identified?

The two documents evaluated the likely consequences of different dam removal alternatives for relevant ecological characteristics of the Battle Creek basin–sediment transport, hydrology, temperature regime, species response to temperature, species response to habitat, passage at natural obstacles and dams. Both documents presented credible analyses and differed primarily in flow assumptions and emphasis on outcomes. Both documents focused on target species (spring and winter-run Chinook salmon and steelhead) and relied on the large body of information contained in the EIS/EIR for the Battle Creek Restoration Project, the Battle Creek Working Group Biological Technical Team, and adaptive management documents (e.g., Kier 1998, Kier 1999)

The documents differed in their overall criteria for evaluating the outcomes. The agency report focuses more narrowly on the target species. This obviously is a relevant issue. The criteria used for determination of differences are interpreted as if all the information is accurate and complete. This perspective overlooks or chose to avoid the broader framework of ecosystem restoration rather than just the expected performance of the target species. Many scientists in conservation biology would argue that single-species restoration approaches have not been as successful as restoration based on ecosystem function. The 8-dam-removal alternative is more consistent with restoration of the aquatic ecosystems and the natural hydrologic regime of the Battle Creek basin.

The evaluation by the California Hydropower Reform Coalition (CHRC) extends the earlier hydrologic analysis by the agencies and the Battle Creek Working Group. We felt that the CHRC draft strengthened the agency analysis by stating that unimpaired flow is the best "reference point for investigating the impacts of altered flows". We agree that the long-term success of the project will be more likely if it is identifies and incorporates attributes of the hydrograph most likely to mimic the patterns of the natural hydrograph.

2) Have the appropriate data been considered in the analyses of the biological issues?

Overall, the data used in the analyses were appropriate. Four major areas for improvement or resolution are 1) behavioral, life history, and physiological differences between the fish species, 2) hydrological assumptions and reference hydrographs, 3) identification of critical time frames, and 4) geomorphic processes in high gradient, constrained channels.

The agency draft disregarded the increased habitat area in the lower basin under the 8-dam removal because the temperatures were higher (though not lethal). This assumption disregards life history adaptations and behavioral adaptations that are possible in these species to move within the basin and to locate coldwater refuges. The agency draft either disregards the occurrence of coldwater refuges or assumes the models are totally accurate and concludes that coldwater habitats would be eliminated by the 8-dam-removal alternative. Stream temperature models have become much more sophisticated in recent years, but no temperature model has been demonstrated to accurately predict hyporheic dynamics and occurrence of coldwater refuges. This lack of certainty (as acknowledged for IFIM analyses) should be noted and incorporated in the assessment. The agency draft tended to regard uncertainty as a basis for concluding that there would be no difference between alternatives on which to base restoration choices. Another direction would be to use additional lines of evidence or information on other ecosystem functions in areas of uncertainty.

The hydrologic analysis was similar but the years of record differed. It would strengthen the assessment if a common hydrologic record could be used for assessment. The white paper uses the hydrograph for a “normal year in Battle Creek” while the white paper prepared by the CHRC developed a synthetic range in flows. This will be critical for two important time periods–peak flood flows for sediment transport and summer low flow for juvenile salmonid rearing and survival.

The geomorphic analysis in the two reports largely relies on relationships developed for unconfined alluvial channels. The steeper, canyon-confined channels of Battle Creek may not exhibit bed movement at the Q1.5 assumed in the reports. The overall assessment approach is sound, but sediment transport is a process that will require careful monitoring in these steep, confined stream channels.

3) Have the appropriate methods been used to analyze the data?

The methods of analysis were appropriate in both reports. The major differences and questions about the assessments are based more on the reference conditions, criteria for evaluation, and the emphasis on species or ecosystems as the focus of restoration.

4) Are the biological conclusions reasonably supported by the data and analyses?

Overall, the conclusions of both documents are reasonable. We three reviewers differed slightly in our final conclusions, but agreed that the ecosystem benefits of the 8-dam-removal alternative have more merit than acknowledged in the agency draft. Also, differences that were projected for the lower portion of the mainstem during summer should be acknowledged more clearly. Both the agency draft and the CRHC draft

concluded that flows would be greater and summer temperature would be cooler ("However the lowest elevation section of the mainstem is generally cooler under the 8 Dam Scenario" Agency draft). This means that total available habitat during summer low flows would be greater (though not directly proportional to discharge) and cool water habitats would be available.

Questions about gravel dynamics are centered on the scientific uncertainty of flows and sediment dynamics in steep, confined channels. This means that a scientifically sound monitoring program and an active adaptive management plan are critical.

Overall, the 8-dam-removal alternative appears to offer more potential ecosystem benefits and is likely to create more habitat in the lower mainstem of Battle Creek. Questions about temperature and habitat use in the lower mainstem are important and should be addressed either through further discussion and analyses or through monitoring and adaptive management. The 5-dam-removal alternative provides important ecological benefits above the current hydropower license.

Specific Independent Reviews

DRAFT-Further biological analyses for information presented on March 15, regarding the differences between the 5 dam removal alternative and the 8 dam removal scenario.

1) Have the biologically relevant issues (hydrology and temperature, for example) been identified?

The white paper considered sediment transport, hydrology, temperature regime, species response to temperature, species response to habitat, and passage at natural obstacles and dams. The issues identified were relevant and the authors explained the relevancy. The priority target species were identified. The issues addressed are similar to issues addressed in the California Hydropower Reform Coalition white paper on the same topic. The issues are not new to the agencies inasmuch as they had substantial participation in development and design of the Battle Creek Restoration Project. Much of the supporting species specific criteria for habitat and temperature have been presented in the EIS/EIR, the Battle Creek Working Group Biological Technical Team, and presented in Kier (1998 and 1999)

The agency draft does not identify the relation between the two alternatives and ecosystem restoration. This is not necessarily a shortcoming, inasmuch as the white paper clearly states the priority target species for the Restoration Project is spring and winter-run Chinook salmon and steelhead. The 8 Dam Alternative is more likely to result in restoration of the Battle Creek ecosystem. Restoration of the ecosystem will almost certainly enable managers to restore the target species. On the other hand, will attempts to restore salmon ever restore the ecosystem to a point where salmon can be delisted or become self sustaining? The agencies could have considered the advantages of restoration of ecosystems as it seems especially relevant for the 8 Dam Alternative.

2) Have the appropriate data been considered in the analyses of the biological issues?

The appropriate data have been considered in the analyses. Use of more citations or specifics for the habitat and temperature data would have been desirable.

When the authors considered the spring-run Chinook juvenile and steelhead responses to temperature they could have considered some behavioral, life history, and phygiological differences between the two species (p. 5). Steelhead are well known for their reversion from smolt if migration is delayed in migration and exposed to high temperatures as described in the paper. Spring-run Chinook salmon smolts are not know to do the same to the extent observed in steelhead. Steelhead that cease migration are not necessarily lost to the population as this may be a survival strategy. Furthermore, any differences between the 8 Dam Alternative and the 5 Dam Alternative in the lower reaches of the Forks or below the confluence of the Forks would seem minor unless conditions were lethal. The lower reaches are free-flowing and the time required for steelhead smolts to migrate through the reaches is probably a day or two for active migrants. Therefore, concern that steelhead with a disposition to migrate will suddenly loose that migratory behavior is not likely over such a short reach unless conditions are highly stressful.

The authors assure the reader, " the flow setting method (IFIM) incorporated the flow needs to provide passage at natural obstacles during the migration period". They provide no specifics and this was an issue that CHRC (2004) also noted in their white paper.

3) Have the appropriate methods been used to analyze the data?

The methods were appropriate. The approach used flow estimates that would protect about 90 to 95% of the habitat. The Agencies used a categorical habitat classification presented in Kier (1999) (i.e., optimum, low stress, moderate stress, and chronic for temperature). For comparison, the CHRC white paper placed much more emphasis on degrees difference in temperature. The authors were conservative inasmuch as they indicated no response between preferred and lethal temperatures for winter-run Chinook salmon juveniles because of considerable variation depending on other factors.

The authors recognized "The amount of usable habitat predicted under the 8 dam scenario for the priority species and life satges is not significantly different than that for the 5 Dam Alternative, particularly given the inherent uncertainty of IFIM." Acknowledging the uncertainty of IFIM is appropriate even though that uncertainty was not quantified in any way such as a sensitivity analysis.

The white paper uses the hydrograph for a "normal year in Battle Creek" while the white paper prepared by the CHRC developed a synthetic range in flows. The approach using a normal year to consider habitat during summer months seems not very robust. If Battle Creek will be a thermal refugia, then it would seem more appropriate to consider conditions for a hot and dry year. In dry years, the authors acknowledge (P7, Para 3) that "Because the 8 Dam Scenario has much higher flows it has the potential to disrupt cold water refugia that would otherwise form." This reviewer does recognize that under the 5 Dam Alternative flows of about 35 cfs would be the minimum flows.

4) Are the biological conclusions reasonably supported by the data and analyses?

The agency white paper provides some assessment of their conclusions and how they relate to the big picture of the Restoration Project. For example, "Within the remaining half of the project are, the mainstem constitutes approximately half (i.e., one quarter of the project area). Furthermore, the authors state "under either the 8 dam scenario or the 5 Dam Alternative in the warm months there is not a significant improvement that would make this reach suitable for temperature sensitive life stages (embryos , prespawning adults and smolts). This assessment is useful, but significance is not defined.

The authors of the agency white paper rely heavily on the findings of Roberts (2004) for their conclusions about sediment transport and the relation to hydrology. Roberts (2004) was invaluable in placing the concerns about frequency, magnitude, and duration of flood events and their role in sediment transport in perspective. Roberts (2004) observed that Kondolf and Katzel found gravel supply to be in relatively good condition and that sediment is no longer thought to be limited. Furthermore, better management of sediments through sluicing and less removal will likely be the norm in the future. The information on magnitude, duration, and magnitude to initiate bedload sediment transport were very persuasive in support for the conclusions on sediment transport. In Figure 3, Roberts supports the conclusions by showing the relatively small difference in

discharge at the Coleman gauge with and without diversions in place. Roberts (2004) in the last paragraph astutely mentions the scientific uncertainty of dam removal and the sediment transport and the robust evaluations now in the AMP. This reviewer believes much can be learned about sediment transport by studies in the AMP, but differences between the 8 and 5 Dam Alternatives are not likely to result in a biological difference. The primary reason is that at high flows, the alternatives have very similar effects on the Battle Creek hydrograph.

The authors observe "the last of the steelhead smolt out migrants that are present in June are not expected to find normal year conditions better than marginal and there is no significant difference in the type of exposure between the two cases."(p 8) This seems counter to the observation (Page 8, Para 1) where they observe "However the lowest elevation section of the mainstem is generally cooler under the 8 Dam Scenario".

The following comments are on statements in the white paper that came from the "Results and Discussion" or "Conclusions" section and the comments are specific to the statements.

Page 6, Para 2: "In summary, the 8 Dam Removal Scenario offers little sediment transport benefit over that provided by the 5 Dam Removal Alternative." This statement is supported by the information presented in this white paper and additional information available in Roberts (2004).

Page 6, Para 3: "The 8 Dam Scenario does not substantially change the pattern and variability of the hydrograph for a normal year in Battle Creek over that provided by the 5 Dam Alternative". This statement is accurate only if the broad seasonal patterns in the hydrograph are considered. This statement seems to ignore the issues of summer flows for incubation, adult holding, and smolt migration during parts of the summer. This is the most important difference between this white paper and the paper prepared by the CHRP.

Page 7, Para 3: "Removal of the dam under the 8 Dam Scenario adds more of the warmer surface water that dilutes out the cooling affect the springs and diminishes the amount of habitat available at the minimum possible temperature" This relation is fairly compelling and does not support the 8 Dam Alternative for development of summer thermal refugia. This reviewer speculates that the upper watershed is yielding water during the summer that is slightly higher in temperature than it did historically. If so, then the extra thermal energy may swamp the cool water springs and they may not play the refugia role that they are thought to have played historically.

Page 9, Para 4: "The three new fish ladders are not expected to cause a significant impact to the migration of salmon and steelhead" This statement can not be supported with empirical data from Battle Creek at this time because the proposed facilities have not been built. The proposed facilities are likely to be effective, but they are costly and that is part of the reason the 8 Dam Alternative is receiving additional consideration.

Page 12, Para 2: "There are adverse biological consequences of missed opportunities to provide listed species with recovery opportunities sooner than later, due to the need for drought resistant refugia in areas like Battle Creek." This statement is not supported by specifics in the white paper. However, native steelhead in Battle Creek and the

genetic role of hatchery steelhead may be one of those missed opportunities if the Restoration Project returns to prolonged negotiations.

White paper by the California Hydropower Reform Coalition (CHRC) titled "Analysis of dam removal alternative B Battle Creek Salmon and Steelhead Restoration Project."

1) Have the biologically relevant issues (hydrology and temperature, for example) been identified?

Not only do the authors identify the relevant issues, but they also provide the appropriate background to address why those issues should be considered. The authors restate the Biological Principles that the USFWS, NMFS, CDFG, and USBR consider essential for salmonid restoration. They then succinctly state that Alternative B, the 8 Dam Alternative, "better meets these principles than does the MOU" or 5 Dam Alternative.

A biologically relevant issue identified by the CHRC is the paradigm that unimpaired flow is the best "reference point for investigating the impacts of altered flows". Furthermore, the authors follow the recommendations of the Instream Flow Council (2002) in identifying the attributes of the hydrograph most likely to mimic the patterns of the natural hydrograph. The white paper provides detailed graphics showing the differences between the magnitude, frequency, duration, timing, and rate of change in the predicted hydrographs for the 8 Dam Alternative and 5 Dam Alternative.

2) Have the appropriate data been considered in the analyses of the biological issues?

The CHRC provided additional analysis of flow and temperature data from the 40-year record. The CHRC used the 1962-2002 flow record and identified the 10%, 30%, median, 70%m and 90% percentile flows for each day. Presentation of this data in Figures S are fairly simple graphics, deceptively simple. For any given day the data is very useful. However, as longer time period are considered, the probability that they represent a flow record that would occur decreases because daily flows might change percentiles due to a single storm event. The greatest value of these representations is to illustrate that the issue is summer flows. How much is enough? The similarity in graphs of percentiles of winter flow also serve to illustrate why the difference between the 8 Dam Alternative (Alt B) and the 5 Dam Alternative (MOU) will not be an important determinant of whether a storm event is sufficient to initiate bedload sediment transport.

3) Have the appropriate methods been used to analyze the data?

Page 10, Para 3: The authors are critical of the PHABSIM/, IFIM/WUA. They correctly observe that "The Battle Creek PHABSIM study does not include transects in two dimensions." That is true, the approach uses multiple one dimensional transects. Perhaps the greatest shortcoming is the observation that "it has not been validated, despite the fact that interim flows based upon it began in 1995." This does indicate the interim flows are being paid for, but no measure of their effectiveness has been made using the tools that were used to justify those interim flows. On the other hand, two-

dimensional computational fluid dynamic models are very data intensive and probably not practical for large reaches of Battle Creek given the abundance of large complex structure in the bed in many reaches. The categorical approach to habitat suitability also lessens the need for the level of detail the authors identify as lacking in the approach used. Although not ideal, the tools used were appropriate given the information available at the time of project development.

4) Are the biological conclusions reasonably supported by the data and analyses?

Page 6, Rate of Change: "possibly causing fish stranding" this statement is speculative and the authors do not provide an adequate explanation. Stranding in the Battle Creek drainage is likely to be minimal because of the relatively steep lateral slope, lack of meandering bed, and lack of braided channels.

Page 9, Table 1 and 2: The authors conclude "Alternative B provides equal or greater optimal habitat for each life stage." For the 8 Dam Alternative the increase in optimal habitat for selected life stages is relatively small in absolute values in miles. The difference between the two alternatives generally favors the 8 Dam Alternative, but the percentage difference is also small in most cases. The numbers lend support to the 8 Dam Alternative, but are not sufficiently large to support a compelling argument for the Alternative.

Page 10, Para 1: In Table 3 the authors estimate the days of mixing of North and South Fork waters due to planned and unplanned powerhouse maintenance. They estimate 12 days of planned plus any additional unplanned for the 5 Dam Alternative (MOU) and only the unplanned for the 8 Dam Alternative (Alt B). They indicate "Concerns have been raised about the possibility of resident juveniles imprinting on the North Fork water during these periods." This is an unlikely event for resident juvenile salmon. Imprinting in juvenile salmon has been shown to occur during seaward migration and is thought to be the primary mechanism facilitating their return to natal streams as adults. Inasmuch as it occurs during a relatively small time window just prior to and during the seaward migration exposure to mixed water could cause imprinting to North Fork water at that time. If planned maintenance is timed to avoid periods of active smolt migration, then risk should be minimized. For non-anadromous, or true resident salmonids, it is not likely that they will undergo imprinting.

Page 12, Table 4: The authors conclude that "These results show Alternative B mobilizes sediment more frequently than the MOU alternative and for more total days using the simulated historic hydrology." This statement may be true, however Roberts 2004 should be read carefully to put the results on CHRC geomorphology section in an appropriate perspective. Based on Table 4, in a 40 year flow record in the mainstem of Battle Creek Alternative B will have one additional year at the >2 days/0.6 geomorphic threshold and two additional years when the >2 days/ 0.8 geomorphic threshold will occur, compared to the MOU, 5 Dam Alternative. In other word, if the reader considers the number of years with two or more days at or above the threshold flows over a period of 40 years, then the
difference is one or two years.

Page 12, Table 4: Discharge for 0.6-0.8 of 1.5 return flow for Inskip is 354-472 cfs. Discharges for initiation of sediment transport, 0.6-0.8 I assume. Discharges at Inskip for the 1.5 year return interval flow in the agency white paper Figure 2 range from about 2,225 to 2,750 cfs. Is this for March 1989 flow event only or for 1.5 year Q?

Page 12, Para 3: Connectivity can be restored to a high level with either of the Alternatives. Although the maintenance of juvenile fish screens is significant, screens and ladders are not an insurmountable problem. Automated monitoring equipment and telecommunications equipment can make operation at remote sites more effective and less costly.

THE CRITICAL BIOLOGICAL QUESTION:
The important biological questions related to the two alternatives are probably not related to geomorphology and sediment transport events. In winter, spring, or fall, when the high flows associated with bed sediment transport will most likely occur, the incremental difference in flows between the alternatives is relatively small. Connectivity can likely be restored under either alternative.

The following statement comes close to summing up the critical biological question: Page 11, Para 2: "it is assumed that the best that can be achieved through Alt B over the MOU is an additional 5% habitat. The hydrological and temperature benefits of Alt B alone show this not to be the case (80-130% more water in summer, and a conservative 3-7 miles 8-18 % more optimal thermal habitat in critical months)." The white paper by CHRC does identify the summer as a critical time period for the priority species. The CHRC does not adequately quantify the advantages of more water in summer. The CHRC does quantify improved habitat related to temperature, but the miles of additional habitat are relatively small. Desirable thermal habitat will be extended downstream. However, mainstem habitat and habitat downstream from the Coleman Dam on the South Fork has generally ranked low for winter-run Chinook (E), Spring-run Chinook (D,E), and steelhead (D) (Kier 1999). In short, based on the CHRC analyses, summer flows and temperatures will improve conditions for selected life stages of the target salmonid species. However, the incremental improvements to salmonid habitats derived from the 8 Dam Alternative over conditions expected from the 5 Dam Alternative will be relatively small and in reaches that have habitat ranked low.

Review based on 1) the TNC analysis of potential geomorphic effects of removing 8 vs 5 dams on Battle Creek, i.e., Alternative B vs MOU alternative (Roberts 2004), 2) the analysis by the California Hydropower Reform Coalition (CHRC 2004), and 3) relevant of the Technical Review Panel Report of Sept 2003

The TNC analysis took the reasonable approach of asking whether the frequency of sediment transporting flows would differ under the two scenarios, for sediment transport and presumably also as an indication of channel dynamics more generally. Based on the literature and expert opinion, TNC concluded that bedload transport tends to begin in rivers at flows of 0.6 to 0.8 times the Q1.5, and determined the values of Q1.5 for the mainstem gauge determined from a Log Pearson type III probability distribution and then used the discharge per unit area breakdown of Greimann (2001) to estimate the values at three upstream points (Table 1).

Table 1. Values of Q1.5 Estimated by TNC and CHRC

	TNC	CHRC
North Battle Feeder	1900	
Eagle Canyon	2250	1246
Inskip	3250	590
Mainstem	5900	2390

CHRC posed the same question but differed in its estimate of Q1.5, ranking unimpaired peak daily flows for the period 1962-2002 and pulling the 27th ranked flow from this series. For a 40-year series, the 27th ranked flow should correspond to a "plotting position" of a return period (RI) of 1.5 years. The actual Q-RI relation should be read from the line, rather than directly from the plotting positions, but the difference between these would normally be small. Curiously, the CHRC results are very different from the TNC results (Talbe 1), showing much lower values for Q1.5 at the upstream stations and on the mainstem, the latter presumably equivalent to the gauge at Coleman. Without access to the Navigant model, it is difficult to explain the extremely low values for Q1.5 assigned for the unimpaired conditions in this analysis.

The TNC figure 2 did not print out properly in my copy of the report, but it is clear from the narrative text that this analysis did not show big differences in number of days in which flow would exceed 0.6 or 0.8 of Q1.5 depending on whether the amounts diverted by the remaining dams were subtracted from the flow or not. TNC also showed the effect of adding the amounts diverted by the three remaining dams to the hydrograph of the March 1989 flood, the only event for which any empirical data on bed mobility have been collected (Kondolf and Katzel 1989). This analysis (Figure 3 of Roberts 2004) showed little effect of having the additonal flow.

The CHRC analysis showed significant differences in number of days above the 0.6Q1.5 and 0.8Q1.5 thresholds because its estimated Q1.5 was much lower, and the amounts

diverted by the remaining three dams would have more effect on the likelihood of exceeding these lower flow thresholds.

Of the two analyses, the Q1.5 values of TNC appear more reasonable based on the gauge record downstream. However, one could question the approach used by both analyses in that the research indicating bed mobility at 0.6 to 0.8 times Q1.5 was conducted on lower gradient channels, commonly with pool-riffle sequences and floodplains, and would be of questionable applicability to a bedrock and boulder-contolled step-pool system such as the channels of Battle Creek. The empirical observations of Kondolf and Katzel (1989) that some but not all marked spawning gravels moved in the 1989 flow, with a RI of appx 2.4 years, is in line with later (but still unpublished) research on the mobility of pocket gravels in step-pool streams of California by Alan Barta. The 0.6-0.8 times Q1.5 is going well beyond the empirical data.

Nonetheless, the basic approach of trying to estimate the effect of the marginal increase in flow is a reasonable one. The question of most concern is how accurately can we calculate such differences in such a steep system? Probably not very well.

Stepping back to the question of what geomorphic and sediment transport benefits might be derived from removing eight dams instead of five, however, the most straightforward approach is to recognize that it is not only potential changes in the magnitude and frequency of flows capable of transporting sediment, but the fact that the dams seasonally trap sediment, and at least in the past this sediment has NOT been returned to the stream channel but stockpiled or used on roads. Thus there has been a net loss of gravel to the system, and certainly a change in the seasonal supply. The natural variability in bed material size, channel hydraulics, and the temporal variability in flows, and the steep gradient and high channel roughness mean that any estimate is subject to significant error, such that the changes we seek to quantify may fall well within the error margin. The most conservative approach ecologically is to assume that the most natural system, ie removing the eight dams, is most likely to benefit the habitat.

Also given the dynamic nature of the channel geomorphology here, artificial structures will always be vulnerable to damage during floods, partial burial in sediment, or in some sites, damage from rockfalls. Having less vulnerable infrastructure in place would seem a more geomorphically sustainable approach.