Review of "Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams" (2/08/08)

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I. Background

The purpose of this independent review is to evaluate and comment on the use of the best available scientific information that forms the basis of the "Draft Policy for Maintaining Instream Flows in Northern California Coastal Streams." This region supports three federally listed species, Chinook salmon, coho salmon, and steelhead, and the overarching purpose of the Policy is to determine if there is some allowable diversion on regional streams that will fully maintain the habitat needed to support all the different stages of the freshwater life cycle of these at-risk anadromous species. Specifically, the goal of the Policy is to mimic the natural hydrograph as closely as possible, thereby maintaining natural stream processes that support salmon and steelhead in these streams, while also evaluating what levels and rates of diversion would be protective.

The Policy contains three major elements or proposed regulatory actions: 1) implementation of a seasonal limit on diversion; 2) implementation of minimum bypass flow requirement to maintain access for spawning, adequate habitat for incubation of embryos and winter rearing of juveniles, and suitable flows for outmigration; and 3) implementation of limits on the maximum cumulative diversion rates within a stream. Other elements in the Policy included proposed rules for onsite dams, requirements for fish passage and screening at all diversion sites, and development of a detailed hypothesis testing-based monitoring program to reduce uncertainties and data gaps in knowledge and allow for potential adjustments in the proposed flow rules in the future within an adaptive management framework.

Reviewers were asked to address whether the scientific basis of each proposed regulatory action is based upon sound scientific knowledge, methods, and practices (*Draft Policy, Attachment 2*). I focused my review on the assumptions (explicit and implicit), scientific literature, data, and analyses used to develop each of the Policy elements listed below. Materials consulted in my review, in addition to the Draft Policy Report and Appendices provided, included reports by Moyle et al. (2000), McBain and Trush and Trout Unlimited (MTTU) (2000), and various other reports and journal articles located during a literature search.

II. Review of Scientific Issues

1. **Seasonal limits on diversion.** The proposed Policy would restrict the season of new diversions to the winter high flow period, when some 'excess' flow could presumably be diverted with little or no harm to salmon and steelhead; no new diversions would be allowed for the summer, fall, or late spring months. The primary question concerning the protectiveness of this element is to determine which dates bracketing the winter diversion season are the most biologically appropriate for the target species (p. 3-3). Three alternative diversion seasons were evaluated: Dec 15- Mar 31 (DS1); no limitation as to season (DS2);

and Oct 1-Mar 31 (DS3); in terms of level of protection for salmon and steelhead spawning, rearing, and outmigration, and channel and riparian maintenance.

I found the analysis of protectiveness for diversion season relative to upstream passage, spawning and incubation habitat, juvenile winter rearing habitat, outmigration, and riparian and channel maintenance to be based on solid biological information for all three target species. I also found the reasoning for ending the season on March 31 to be well supported based on the argument that there are few freshets beyond this date (i.e., potential for 'excess' flow is low) and that any diversion could jeopardize outmigration by reducing the flow needed to stimulate and facilitate downstream migration (p. 5-4), and by the potential for reduced flows to increase water temperature during this sensitive period.

The year-round alternative (DS2) was not considered a feasible option in the Report because diversion of any flow during this low flow, critical period was considered inappropriate. This seemed a biologically justifiable, risk-averse conclusion, though the question raised by MTTU (2000) of the feasibility of enforcing a diversion season, regardless of length, seemed to have merit (question of compliance also raised by Moyle et al. 2000). Of the main comparison between DS1 and DS3, the preferred alternative was DS3, a diversion season of Oct 1-Mar 31. This recommended diversion season reflects a change from the earlier DFG-NMFS 2002 recommendation of Dec 15-Mar 31. The Report argues that an earlier diversion start date would not be any less protective than a later start date based on the justification that if MBF (minimum bypass flows) and MCD (maximum cumulative diversion) levels are adequate, then the earlier start date should be equally protective. The main argument against an earlier diversion start date is to protect the earliest fall freshets, which are critical for triggering upstream migration and of extent of access to small tributaries for spawning, particularly by steelhead (MTTU 2000). First fall freshets often are critical too for channel restructuring and gravel sorting, and flooding of, and seasonal access to, floodplain wetlands.

The hydrograph analysis for MCD supports the Report's assumption that early freshets would be protected under an adequate MBF and MCD scenario [e.g., Flow Alternative Scenario (FAS) 3 using the recommended MBF3 and MCD2 as shown in Figure 4-3]. However, one possible limitation to this analysis was that there was no direct comparison of impaired and unimpaired hydrographs using the two different diversion seasons with all else equal. For example, Table 4-2 and 4-3 evaluated different FAS's using different diversion seasons but also with different MBF and MCD levels too, and so it is difficult to know for sure how diversion season would influence the hydrograph and other metrics, including potential days for upstream passage and spawning (e.g., Fig I-7) and for total diversion amounts.

One final comment concerns the current flow state of regional streams. MTTU (2000) and Moyle et al. (2000) allude to an existing condition of a large number of authorized and unauthorized diversions already in place. While the proposed diversion season policy restricts any new diversion to the winter high flow season only, it is unclear what the current flow levels are during other seasons. Implementation of a diversion season along with the proposed MBF and MCD standards to maintain the fall-winter hydrograph could offer a false sense of protection to the listed species if flow levels during other seasons are insufficient to support the completion of rest of the freshwater life cycle.

2. **Minimum bypass flow requirements.** The MBF is defined as the minimum instream flow that must be moving past a point of diversion before water may be diverted. The Report provides a very detailed explanation of the data and analyses used to arrive at the recommended alternative, MBF3, which provides a formula for determining minimum instream flows within the diversion season, scaled by basin size. Biological flow needs were derived from a literature review of flow needs for passage, spawning, incubation, winter rearing, and outmigration for salmon and steelhead, and for channel and riparian maintenance. Derivation of the MBF equation was accomplished by combining data on passage and spawning flow relationships from a variety of different datasets, including field data collected at validation sites. The various MBF alternatives were compared by generating impaired and unimpaired hydrographs using various combinations of Flow Alternative Scenarios that incorporated the four different MBF levels at the field validation sites. The absolute number and percentage of days with suitable passage and spawning habitat were then used as primary response variables for assessing differences between the generated hydrographs.

I found that the biological flow needs were based on a thorough review of the literature, explained in detail in Appendix D, and I didn't find any major literature absent from their analysis that would have altered any of the assumptions used to derive passage and spawning flow needs. Passage flow criteria were appropriately derived using steelhead as an 'indicator species' given their propensity to spawn further upstream than Chinook salmon and coho salmon, and it is notable that a more conservative minimum spawning depth was used in the analysis (0.8 ft vs. 0.7 ft in most previous studies). Spawning habitat flow criteria seemed to be based on well-supported information on suitable depths, velocities, and substrates.

For the biological criteria, the only potential limitation I found was with the assertion that juvenile anadromous salmonid winter rearing habitat was assumed to be protected if the flows provided by the MBF protected spawning and incubation habitat (p. 4-15). From my reading of the Report, this assumption was based on two sources of information: 1) data from Swift that showed that flows for rearing juvenile salmonids, derived during summer low flow, were lower that flows required for spawning; and 2) the study by Vadas (2000), conducted partially in northern California coastal streams, that determined that upstream migration and spawning of Pacific Coast steelhead and salmon required more flow than rearing life stages.

However, both studies measured depths and velocities selected by juveniles during the summer, when these smaller-bodied life stages selected much slower and shallower stream locations than do spawning adults. The potential limitation I see with this is that <where> these slower and shallower habitats occur during winter is likely to be much different than summer. In the summer, rearing juvenile salmon and steelhead choose velocity and depth microhabitats largely in the middle of open channels, much like spawners do. However, in winter, the position of these microhabitats becomes much more restrictive in the sense that suitable depths and velocities are not occupied unless located underneath banks or LWD cover (Tschaplinski and Hartman 1983; McMahon and Hartman 1989). So my main question is whether the MBF criteria based on passage and spawning flows, fully ‘wet’ the undercuts and bank habitats used as winter habitat. Additionally, as noted in the MTTU report, sidechannels, alcoves, and seasonally flooded wetlands are also critical winter habitats, but it is unclear if these habitats would be fully wetted by MBF flows as well. This question is raised with the knowledge that the above studies were conducted in more northerly, wetter climates, and as Moyle et al. pointed out, there has been a lack of winter habitat work in the more Mediterranean climate of the Regional streams, where winter temperatures are much more moderate. For example, previous work has shown that in more temperate rainforest climates, that juvenile coho and steelhead migrate into winter cover and offchannel habitat with the first fall freshets and when temperatures drop below about 7ºC (Bustard and Narver 1975). However, the Report shows that winter temperatures are well above this level, suggesting that juveniles in Region streams may well be active and out of cover in these warmer winter conditions. Finally, it may be that spawning and passage flows <are> protective of winter habitat in that the former flows are derived from the steeper, more confined single channel riffle reaches, and where breaks in slope occur, the associated sidechannel and offchannel winter habitats would have adequate flow. In sum, there seems to be sufficient uncertainty to question whether the assumption that passage and spawning flows are protective of winter habitat is truly valid, without some further information and analysis. While the ‘further information’ might have to wait for knowledge gained during future adaptive management and hopefully specific winter habitat research in the study area, it seems that some simple modeling of flow height in relation to the bank could be done provisionally to see to what extent banks are wetted at the designated MBF levels. For example, it might be possible to run a wetted perimeter analysis (Reinfelds et al. 2004), based on the information collected at the field validation transects, to determine if stream banks will have adequate water depth to fully wet undercut banks at MBF levels established for passage and spawning.

Overall, I found the development of the MBF3 regression model quite innovative. The rather complicated analysis that was performed utilizing a rather diverse array of new field data and existing literature values was clearly explained and in my opinion based on sound science. The blending of field and literature passage and spawning flow values was a creative and I think very effective way of generating scientifically valid regional MBF criteria, and the good regression fit across different regional datasets suggests that the relationship is a fairly good generalization of suitable passage and spawning flows for anadromous salmonids. The use of 99% prediction interval was a very creative way to objectively and statistically identify a ‘risk averse’ MBF. The close matching of predicted spawning and passage flows when the MBF regression was compared to independent data sets was a convincing initial ‘test’ that the model is a good predictor of suitable flows. The field validation sites seemed to be a good representation of regional variation in streams across the study area; to be concentrated appropriately in smaller basins where earlier reviews had noted a lack of information; and also were positioned at likely point-of-diversion locations. The Report explicitly recognized the limited time frame of sampling of only a few days and the potential of considerable extrapolation error associated with flow predictions for a stream based on only 1-2 transects at each site. Nevertheless, the limited inference frame does mean that there remains a fair degree of uncertainty about how well predicted MBF's will match with observed MBF's after implementation of the instream flow rules.

The hydrograph comparison analyses provided a clear and convincing demonstration of how the various flow alternatives influenced the percentage and number of days of passage and spawning habitat restriction compared to unimpaired flows on the validation streams. However, I believe it would be helpful, and make a more objective comparison among flow scenarios, if the data were reported in a table listing the average number and percentage of days based on all sites combined, which would also facilitate a statistical comparison (ANOVA) among the MBF alternatives. Additionally, I would suggest some quantification of the term 'substantial reduction.'(e.g., p. 4-12). This term is used to ascertain the level of protectiveness but was not defined.

3. **Maximum cumulative diversion requirements.** The MCD sets limits on the maximum diversion that can be withdrawn when stream flows exceed the MBF. The overall intent of the MCD is to allow for some flow diversion while still preserving the natural flow variability downstream and protecting anadromous salmon habitat. The Report considered four flow MCD alternatives, and as in the MBF analysis, relied on comparisons of impaired and unimpaired hydrographs using various combinations of Flow Alterative Scenarios to assess the level of protectiveness offered by each alternative.

Inclusion of an MCD is a progressive facet of the Policy given that most instream flow rules have been set primarily on minimum flow standards alone. The challenge for developing an appropriate maximum diversion was to derive a metric that is regionally applicable yet capable of assessing to what degree the frequency and magnitude of channel and riparian maintenance high flows are preserved within a region where fall-winter streamflows vary widely across wet, normal, and dry water years.

I found the data, rationale, and analysis used to compare the various alternatives to be well documented and a good faith effort. The analysis included a good range of different water years and streams across the Policy area, and I found the assessment on how MCD might influence all the various biological and physical components influencing salmon and steelhead and the habitats that support them, to be thorough and well supported by best available information from the literature.

The analysis convincingly demonstrated that the MCD volume alternative would significantly dampen early high flow events in most years, and nearly eliminate peak flow events in dry years. The analyses of MCD rates (e.g., Tables F-14,15,19) showed that all three alternatives generally protected peak flows across different streams and flow conditions, and supported the objective of protecting the natural flow variability (e.g., Fig. 4-22). I thought the rationale for scaling the diversion rate to the 1.5-year return peak flow or the 20% winter exceedance flow was an appropriately conservative way to preserve minimum bankfull and channel maintenance flows especially during dry years.

The recommended Policy was the MCD2 rate of 5% of the 1.5-year flood flow. This alternative was favored given that the protectiveness levels of all three MCD rate alternatives were predicted to be fairly similar, ranging from negligible channel change for the MCD1 and MCD4 alternatives, and minor channel narrowing resulting from the MCD2 alternative. The MCD2 alternative was favored as the closest of the alternatives to a protective regional channel maintenance threshold (p. 4-28) while offering the highest rate of cumulative diversion than the other alternatives. The Report noted that there is a high degree of uncertainty in defining a clear threshold between protective and non-protective maximum diversion rates, and, that for all MCD alternatives, effectiveness monitoring is essential.

I didn't find the rationale for selecting the MCD2 alternative as compelling or sufficiently risk averse as some of the other Policy recommendations. Although the Report provides an honest assessment of the uncertainty in defining a suitable maxiumum diversion rate, it appears to rely heavily on monitoring to assess the Policy effectiveness over a 10-20 year time period (Table 7-2). However, as Moyle et al. (2000) noted, appropriated water rights are essentially irrevocable. So while it seems less restrictive MCD rates could be implemented if so indicated by future monitoring, it seems much less likely they could be decreased. Given that the MCD2 alternative allows for 5-7 times the amount of diversion than the MCD1 rate, and the high level of uncertainty surrounding this element, it would seem that the MCD1 rate, roughly equal to 1% of the 1.5 year flood, might be a more appropriately conservative interim standard, following the approach outlined in Appendix p. D-7.

4. **Site specific studies.** Although the Report alludes to the allowance for site specific studies to determine adjustment to the regionally protective MBF and MCD levels (p. 3-5 and 7-5), I did not find specific criteria therein on how these studies were to be conducted or what information could be collected to determine the upper limit of anadromy referred to in the "Attachment 1 to Reviewers," so was unable to address this question.

5. **Cumulative effects of water diversions on instream flows needed for protection of fishery resources.** The Report analyzed two different means to limit the amount of water that can be cumulatively withdrawn from a system (both above and within the range of anadromous salmonids) to avoid or minimize impacts to downstream habitats. Four alternatives were examined, three based on an MCD rate and one on an MCD volume.

The recommended alternative method for evaluating cumulative effects was the MCD2 rate, a diversion rate based on 5% of the 1.5 year flood peak flow. The MCD3 volume alternative, based on a cumulative flow index of a maximum 10% of the estimated unimpaired runoff, a method previously forwarded in an earlier report, was not recommended based on an impaired hydrography analysis demonstrating the difficulty in protecting early fall freshets, particularly during dry and average water years.

As noted in the Report, there remains a fair bit of uncertainty as to which alternative is best in terms of protectiveness. With some qualifications noted above in #3, the MCD2 rate method appears to be protective of the hydrograph, though other rate alternatives may be more so. As noted in previous reports, it seems that the protectiveness of this element may hinge more on implementation than on which level is actually chosen. The 'success' of any alternative would seem to hinge on close monitoring of diversion rates at all points of diversion. Such monitoring would likely require a fair bit of investment in technology and human resources to accurately measure diversion rates and instream flows throughout a large number of watersheds; perhaps requiring a 'water manager' for each watershed to insure that flow rules for diversion season and rates are being followed.

6. **Effects of on-stream dams on fishery resources.** This element of the policy evaluates under what conditions on-stream dams could be allowed without impacting downstream resources. The proposed Policy would prohibit construction of new on-stream dams on Class I and Class II streams (DP1.1 and DP2.2). Dams may be considered for Class III streams (DP3.2) provided there is a passive bypass system for provision of minimum flows; an exotic species eradication plan is implemented; and a gravel and wood augmentation plan or bypass system is implemented. Permits for existing dams on Class II waters may be considered if the above criteria for new dams on Class III streams are implemented.

I found the biological analysis of protectiveness of on-stream dams on class III streams mostly thorough and inclusive of the main elements that could influence salmon and steelhead habitat downstream, namely, gravel and wood transport, maintenance of flows in downstream reaches, and the reservoirs as a source for nonnative species dispersal. The MTTU (2000) report also raised a pertinent question about the role of seasonal flows in these streams for creating off- channel wetlands. The primary question surrounding the allowance for on-stream dams for class III streams seems to revolve around the maintenance of early peak flows to downstream reaches to allow for full spawning and rearing access in streams, particularly those reaches located near the upper limit of anadromy. As noted in the Report and in MTTU (2000), 'fill and spill' dams on ephemeral streams have the potential to greatly dampen the early fall/winter freshets important for access to the upper reaches of small spawning tributaries by their capture of the entire flow within the stream until the reservoir is filled, potentially resulting in significant dewatering downstream.

To maintain flows downstream, the recommended DP3.2 alternative for Class III streams requires a passive bypass system to bypass the minimum instream flow requirements. (question: are the "minimum instream flows" the same as the MBF criteria?) However, it was unclear how this alternative will maintain the peak flow hydrograph downstream. Perhaps maintenance of peak flows will be protected by inclusion of the MCD requirement, but this was not clear to me in reading the report. The DFG-NMFS (2002) policy recommendation (DP3.1) seemed to more directly address the peak flow issue by the rule a Class III dam "will cause less than 10% cumulative instantaneous flow impairment at locations where fish are seasonally present."

7. **Provision of passage for fish migration and screening of diversion intakes.** No comment here, as there were no direct technical issues involved in the Policy requiring bypasses and screens at all points of diversion on all Class I waters. The Policy seems very biologically appropriate given the listed status of salmon and steelhead in the region. Given the variety of fish screening devices and recent questions raised as to their relative

effectiveness (Moyle and Israel 2005), incorporating screening evaluation as part of the overall Effectiveness Monitoring Program would be desirable.

8. **Application of criteria based on anadromous salmon for protection of other fishery resources in the policy area.** This question is a bit difficult for me to answer as I don't have an intimate understanding of the other fish fauna in the area, though I assume that sculpin, coastal cutthroat trout, and rainbow trout, among other species, occur in reaches above the limit of anadromy. One aspect of this question that I believe needs some clarification in the Report is to the apparent distinction between the upper limit of anadromy and upper limits of Class I waters, defined based on the presence of fish (p. 1-8). Some aspects of the Report treat them as one and the same; for example, the restrictions placed on on-site dams are for all Class I streams, not just anadromous reaches as I read the Report. However, the drainage area metric included in the calculation of MBF is calculated at the upper limit of anadromy, and not the upper limit of Class I streams, suggesting there is indeed a distinction, at least in some applications of the Policy. Description of how these limits are defined would be helpful.

In theory, it would seem that if adequate MBF flows and MCD rates are applied at the upper limits of anadromy, that minimum flows and natural hydrograph shape would have to be retained through nonanadromous Class I waters upstream, thus offering flow protection to non- salmon and steelhead species. The rationale for this conclusion, explained on page E-20 of the Report, is that the inverse relationship (Fig. E-8) between drainage area and spawning flow would offer protection to spawning areas downstream. However, without further clarification on the distinction between the two boundaries, and some actual field testing of the modeled relationship, the assumption might not hold, particularly if the stream distance separating the two boundaries is large. Following the tenor of the Policy to be 'conservatively protective' in the face of uncertainty, my recommendation would be to apply the MBF and MCD rates to all Class I waters.

III. Conclusions and Recommendations. **(9. Big Picture: a) additional scientific issues not addressed above; and (b) overall scientific and technical basis for the proposed policy)**

The Policy is based on a very comprehensive and well written report. I found the overall scientific and technical basis for the proposed policy to be based on reasonable assumptions and detailed analyses within the constraints posed by incomplete hydrological information, incomplete knowledge about specific habitat needs of salmon and steelhead in the Policy area, limited data collection opportunities, and of the need for broad based regional instream flow rules. The Report makes a good faith effort to address the many previous issues raised in reviews of earlier drafts of the policy, such as questions surrounding basin size, the need for field validation, and incorporating adaptive management and monitoring to reduce uncertainty. The Report provides a very detailed description of assumptions made throughout, and in nearly all cases, of incorporating a 'risk averse' strategy where uncertainty is high.

In my view, the Policy represents a unique and substantive effort to retain a natural flow regime and maintain natural stream processes that support salmon and steelhead, while also evaluating whether there is some proportion of the flow available for diversion with minimal negative effects. Despite the recognized importance of retaining natural flow regimes when allocating instream flows (Poff et al. 1997; Moyle et al. 2000), providing such environmental flow rules to achieve this is difficult due to scientific uncertainty and regulatory constraints (Arthington et al. 2004), therefore there aren't many examples of successful models to draw upon (Foster 2003). The detailed monitoring plan is one of the best examples I've seen on how to plan and implement adaptive management. If fully implemented, I believe it has the potential to become a showcase example of how to manage instream flows within an adaptive management framework.

My recommendations are to:

1) include more direct comparison of MBF's under different diversion seasons;
2) further evaluate and analyze the assumption that winter habitat is protected by suitable spawning and passage MBF's;
3) chose a more 'risk averse' MCD1 maximum diversion rate than the recommended MCD2 alternative;
4) include discussion of the current state of flows in Policy streams during non-diversion season time periods and how this might influence the implementation and effectiveness of the proposed winter flow diversion Policy;
5) add some additional, more quantitative, comparisons of impaired and unimpaired hydrographs; and
6) include further discussion of the distinction between upper limits of anadromy and upper limits of Class I streams and the implications thereof for maintaining minimum and peak flows in both 'types' of streams.

I offer two suggestions for monitoring. First, with regards to the need for more detailed flow data over the entire region, we have had good luck using TruTrack dataloggers (www.trutrack.com) that measure stream height and temperature at low cost ($200)(see figure) such that flow measurements can be obtained inexpensively at a large number of sites. The steel-rod loggers are rugged and easily attached or positioned near a flow constriction like a culvert with a fixed cross section that makes it amenable for school students or nonprofit group members to measure velocities and provide information for calculating stage height-flow curves. The loggers are easily deployed and moved and could be used to validate the basin area-flow equations, especially for small drainages.

The second suggestion is to include a critical reach concept into the monitoring plan. Biologists have increasingly documented that salmonid spawning and rearing tends to be largely concentrated in a proportionally small area of an entire watershed (e.g., Benda et al. 1992; Magee et al. 1995; Reeves et al. 1995). These 'biological hotspots' tend to be geomorphically complex areas comprised of multiple channels and extensive groundwater influence, typically located at tributary junctions and other depositional areas. In my view, these areas tend to be overlooked in instream flow studies. This is probably a result of a lack of basin-wide evaluations necessary to identify them, but also I think a byproduct of an historical focus to make flow recommendations based on fish positions from a few transects across a uniform section like a pool tailout or riffle, where flows and suitable habitat estimations can be easily modeled. However, if flows are to be truly protective of the listed species, I believe that maintenance of both surface and subsurface flows in these 'critical reaches' will be vital to maintain long-term salmon and steelhead productivity. So directed sampling for identifying these hot spots, and population and flow monitoring directed specifically at these areas, would be desirable.

IV. References

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Figure A-1. Culvert 1 outlet. Note the stage recorder installed in the stilling basin on the right-hand side of the photo. The PIT tag antenna was not installed at the time the photo was taken.