# Appendix C:  Comment Letter from Dr. Victor R. Baker

**V. R. Baker's Review for North Coast Regional Water Quality Control Board Proposed Actions for the Assessment and Control of Sediment Discharges in the Upper Elk River**

This review addresses the scientific portion of the proposed TMDL rule, specifically whether it is based upon sound scientific knowledge, methods, and practices. The review considers each of the identified assertions, findings, and conclusions from the scientific portions of the "Peer Review Draft Staff Report to Support the Technical Sediment Maximum Daily Load for the Upper Elk River" and for the "Elk River Landslide Hazard Report", the latter also cited as "Stillwater, 2007" in "Appendices for the Upper Elk River Sediment TMDL, Vol. 2."

Because of the reviewer's expertise, the emphasis in this review will be on hydrology and geomorphology. The review is keyed to the July 17, 2012, letter from North Coast Regional Water Quality Control Board requesting the peer review, and specifically Attachment 2 to that letter, titled "Description of Assertions, Findings, and Conclusions to be Addressed by Peer Reviewers." The various topics listed on this attachment are indicated in bold, and each topic is then followed by my applicable review comments.

## Nature of the Water Quality Problem

**1. Anthropogenic sediment loading has resulted in habitat changes, impacts to beneficial uses, and increase in nuisance flooding.**

The supporting science for this finding is found in Chapter 3: Problem Statement of the *Draft Staff Report for the Upper Elk River Sediment TMDL* (not in "Chapter 2" as stated in Appendix 2 for the letter of 7/17/12). The supporting science for assertion/finding number 1 is solid. Considerable evidence is presented in support of this finding.

The comparative study involving two managed subbasins and a reference subbasin (Little South Fork Elk River) clearly documents the role of timber harvest activities on generating vastly increased turbidity levels downstream. Well documented observations also support the impacts of timber harvesting activities on degraded salmonid habitat, instream conditions, water supplies, and other beneficial uses.

There are also informative data sets that document significant reductions in channel cross-sectional areas and reduction in pool depths during 1997-2011 at sites on the upper main-stem Elk River, the lower North Fork, and the Lower South Fork (e.g., Figures 3.9 through 3.13, and 3.15 through 3.18). There is some confusion in that that some location numbers for the South Fork listed on Figure 3.17 (SB2, SB3, SA4, SA3, SA2, and SA1) do not match up in an obvious way with map locations on Figure 3.14, which shows South Fork cross sections numbered 14 through 22.

Though the scientific knowledge, method, and practices presented in the Staff Report provide a sound basis for assertion/finding number 1, there are some details that could receive more attention in regard to future actions. For example, the report notes that excessive sediment deposition occurred on the floodplain for the period 1993-1998, a time when many landslides were triggered in the watershed. I think there should have been more analysis of the actual events during this time period. There is a statement on page 3-10 that the 1964 flooding event that impacted much of northern California did not significantly change channel cross-sectional areas for the Elk River. However, to attach particular importance to this is unwarranted without a regional comparison of specific processes and response in the Elk River basin to those of other basins during various extreme precipitation events.

The fact that the very detailed survey data on channel cross-sectional area change covers the time period from 1998-2011 means that the critical time period of excessive sediment deposition (1993-98, as noted above) was not included in the surveys. This omission is important in regard to a complete understanding of the role of extreme events in the sediment loading issues for the Elk River watershed. Subsequent findings and assertions will emphasize or assume average conditions, and it is my concern, on the scientific basis that I have been charged to review, that there may be inadequate undertanding of the role of extreme events, and that the time period 1993-1998 could well contain important evidence in regard to extreme events that impacted the watershed.

By restricting the presentation of the extensive measurements channel changes to cross-sectional area data, the report fails to document quantitatively the relative importance of other hydraulic geometry factors, specifically the relative importance of channel narrowing versus channel bed aggradation. It would be scientifically more relevant to present the actual cross sections in order to evaluate the evolutionary sequence of complete hydraulic geometry change, not just the cross-sectional area change.

The report makes qualitative statements about (1) bank colonization by invasive species (which might well promoted channel narrowing) and (2) both bed and overbank sedimentation (the former promoting lower channel depth at bankfull stage). These issues cannot be separated and related to the general question of causes for increased overbank flooding solely in terms of cross-sectional area change. Again, it would be scientifically more relevant to present the actual cross sections in order to evaluate the evolutionary sequence of complete hydraulic geometry change, not just the cross-sectional area change.

**<u>Desired Numeric and Narrative Target Conditions</u>**

**2. The instream desired target conditions represent desired conditions supportive of beneficial uses including fisheries uses and domestic and agricultural water supplies.**

**3. Historical measurements by USGS from 1954-1965 on the upper mainstem Elk River provide an appropriate basis for the desired target conditions to prevent nuisance in upper mainstem, lower North Fork and lower South Fork Elk River.**

**4. The hillslope desired target conditions represent conditions in which sediment sources are likely to be controlled by addressing controllable water quality factors.**

**5. The watershed desired target conditions support watershed and stream processes and functions for beneficial use protection.**

The supporting science for these findings is in Chapter 6: Numeric Targets of the *Draft Staff Report for the Upper Elk River Sediment TMDL* (not in "Chapter 4" as stated in Appendix 2 for the letter of 7/17/13).

The main focus on targets relevant to TMDL seems most appropriate in regard to the beneficial uses of fisheries and water supplies. Table 6.2 presents a well-reasoned set of instream habitat indicators as target conditions for sediment. Thus, it seems to me that finding/assertion 2 is based upon sound scientific knowledge, methods, and practices. However, I should note that my expertise does not extend to fisheries, and I am mainly concerned in this review with geomorphology and hydrology.

Inadequate information was provided in the Staff Report itself to evaluate fully topic 3 (nuisance flooding), since the relevant data for the USGS measurements are in a document (Patenaude, 2004) that was available to me. Nevertheless, it does seem scientifically reasonable that the reduced channel capacity that is well-documented by the channel cross section surveys described in Chapter 3 can account for the observed increase in frequency for overbank flooding. Moreover, historic conditions prior to the onset of the increased overbank flooding do serve as scientifically reasonable target conditions. Nevertheless, my in ability to see the actual USGS data and consider it in the light of other information from the Staff Report limits my confidence in regard to assertion/finding number 3.

In contrast to topic 3, the Staff Report documentation in regard to topic 4, "Hillslope Target Conditions," is both extensive and detailed. Appropriate target conditions are outlined for 10 management-related sediment source categories, and sound scientific arguments are provided for each, supported by authoritative reports and peer-reviewed scientific papers. Thus, I conclude that finding/assertion 4 is based upon sound scientific knowledge, methods, and practices.

The watershed target conditions (topic 5) are based on statistical studies relating turbidity levels to timber harvest rates. Given the focus on defining targets in terms of water quality-standards, this provides a scientifically reasonable approach to setting the watershed desired target conditions. Thus, I conclude that finding/assertion 5 is based upon sound scientific knowledge, methods, and practices.

Buried in the report section that provides the numeric hillslope target for cumulative watershed effects (maximum timber harvest rate of 1.5%) derived for the sediment source category "Cumulative Watershed Effects" (pages 6-16 to 6-17) is a statement that embodies far more science (as opposed to engineering methodology and practice) than anything else in Chapter 6 of the Staff Report. This statement is a conclusion of the 2002 Independent Scientific Review Panel (ISRP) regarding effectiveness monitoring and periodic assessment. The ISRP concluded that, "…no analysis could predict with certainty what combination of measures and logging rate restrictions would ensure the protection of water quality and recovery of impaired watersheds. The best that could be done is to **postulate a plan based on the best available information, continually test that plan using a combination of compliance, effectiveness, and trend monitoring; and revise the plan in a timely and appropriate manner based on monitoring results**" (bold emphasis added).

The program outlined in bold from the previous paragraph is a well-stated **scientific methodology**, which is exactly what this reviewer has been charged to assess. From a scientific perspective, the implementation of the program indicated by this statement will be far more important for the achieving protection of water quality and recovery of the impaired watershed than is the justification of some arbitrary numeric target to meet a current regulatory standard.

I emphasize that the scientific program indicated in bold above was "buried" in this chapter because the explanatory statement for topics 3-5 in Appendix 2, i.e., the charge to the reviewers, specifically states, "The numeric indicators and desired target conditions will be compared to monitoring data so as to evaluate watershed health recovery over time." Nowhere in the chapter under review do I find this statement, which would, in part, support a scientific methodology (to be fully scientific one would also have to add "revise the plan" etc., as was done in the IRSP report statement highlighted above in bold). In Table 6-2, which deals with Instream Habitat Indicator and Target Conditions for Sediment there is a column headed "Monitoring/Sampling Notes." This explains how monitoring is to be done, but otherwise there is nothing about revising the TMDL in the light of what is learned from the monitoring.

So my general conclusion has to be that the proposed desired numeric and narrative target conditions can indeed be justified on the basis of current scientific knowledge and engineering practice as a best first approximation to what might be scientifically hypothesized, which is the start of a scientific methodology, but does not of itself constitute a scientific methodology. The the entire program of identifying numeric indicators is not a scientific methodology unless it incorporates the general philosophy outlined in bold above (from the 2002 ISRP report), i.e., that it is a part of a program that incorporates continual evaluation of those numeric indicators in the light of what is continually being learned from appropriate monitoring of exactly the outcomes important to achieving the desired environmental conditions in the Elk Creek watersheds.

**<u>Sediment Source Analysis</u>.**

**6. The sediment source analysis reasonably quantifies the timing and magnitude of natural and management-related sediment source categories.**

**7. Little South Fork Elk River provides a reasonable reference watershed for Upper Elk River.**

The supporting science for these findings is in Chapter 4: Sediment Source Analysis for the Upper Elk River TMDL of the *Draft Staff Report for the Upper Elk River Sediment TMDL* (not in "Chapter 3" as stated in Appendix 2 for the letter of 7/17/13).

This is a data-rich analysis. A great variety and quantity of data collection have been involved in the sediment source analysis. These data are reasonably quantified in terms of timing and magnitude for AVERAGE sediment loading from various sources within a broad set of categories. The aerial photographs used to quantify the source categories do come from time periods from 1955-2011, as noted in the explanatory statement for findings 6 and 7, but there are really many subperiods represented in the 20 or so datasets. There is not a continuous set of observations for the entire 1955-2011 time period that was generated according to a uniform data-collecting protocol, as would be appropriate for a scientific methodology. Nevertheless, the various data sets seem to have been thoroughly and competently analyzed.

The study employs an "Empirical Sediment Budget Approach" for quantifying sediment production. This is a sound scientific methodology, and it is well supported in the peer reviewed literature. On balance I conclude that finding/assertion 6 is based upon sound scientific knowledge, methods, and practices.

As noted above, the use of the control basin of Little South Fork Elk River is a big plus for the study. This basin can reasonably be presented as a reference watershed in regard to estimating the long-term average sediment loading from natural sources. Thus, I conclude that finding/assertion 7 is based upon sound scientific knowledge, methods, and practices.

The sediment source analysis revealed that the largest management-related loading occurred during the 1988-1997 time period. This period also included the 1993-98 period of excessive sediment depostion downstrem from the source areas. Thus, my concerns about understanting the extreme events, noted above, also apply to these topics.

**Sediment TMDL, Load Allocations and Margin of Safety**

**8. 125% of natural sediment loading is a reasonable estimate of the sediment loading capacity for Upper Elk River and is likely to be supportive of beneficial uses of water.**

**9. The load allocation strategy appropriately represents 1) that a portion of the loading capacity is currently taken up by the instream sediment deposits in the middle reach of Elk River and 2) that a change in the volume of instream deposits resulting from recovery of the middle reach may result in a greater portion of loading capacity available for management-related sediment loads.**

**10. The margin of safety will ensure beneficial uses are protected and it reasonably accounts for uncertainty in the estimates of the sediment source analysis, the loading capacity, and seasonal variation.**

The supporting science for these findings is in Chapter 5: Upper Elk TMDL Sediment Loading Capacity and Load Allocations of the *Draft Staff Report for the Upper Elk River Sediment TMDL* (not in Chapters 5 and 7 as stated in Appendix 2 for the letter of 7/17/13). Chapter 5 also included the linkage analysis.

In regard to topic 8, the Staff Report sets the TMDL loading capacity at 120% of natural backgroung sediment loading, not 125%, as stated in assertion/finding number 8. Asside from this relatively minor adjustment, I conclude that the 120% figure is sciencfically reasonable, and that assertion/ /finding number 8 is based upon sound scientific knowledge, methods, and practices.

In considering topic 9 it is clear that the load allocation strategy appropriately represents the 2 factors noted in explanatory notes associated with these two assertions/findings. I conclude that finding/assertion 9 is based upon sound scientific knowledge, methods, and practices.

My reading of the explanatory notes that accompany topics 8-10 in Appendix 2, i.e., the charge to the reviewers, indicates that the Staff Report employs an **engineering methodology** to arrive at a calculation of the sediment loading capacity of the Upper Elk Creek watershed. This methodology has elements of best practice engineering, including a "margin of safety." As such it can be appropriately matched to regulatory standards and prove defensible in legal proceedings as 'best practice." As a preface to my comments on these topics, note that my review task relates to **science** issues, specifically hydrology and geomorphology, so the following comments need to be understood in this light.

In the engineering methodology applied to the TMDL the "margin of safety" (topic 10) is used to quantify the uncertainty in the TMDL calculation. As stated in the Summary section of the Staff Report (page xvi), "A margin of safety ensures that the total maximum allowable load never results in exceedence of amibient water quality objectives, considering seasonal variation and other factors." It is my view that it is not possible to ensure such a result unless there is a program of monitoring, testing of the hypothesized TMDL, and revision of the TMDL in light of what is learned. To claim the ability in advance "to ensure" that the TMDL will never exceed the ambient water quality standards is inherently nonscientific. Scientifically speaking, the proposed TMDL to be generated by the methodology in this program will afford an excellent hypothesis toward something that could likely achieve the desired outcome. But like all scientific hypotheses this must be subject to testing and revision. For this reason I must can say that finding/assertion number 10, while based on sound scientific knowledge and **engineering practice and methodology,** is **not based on sound scientific methodology**.

## Slope Stability Modeling and Resulting Landslide Hazard Maps

**11. The 4-meter Digital Elevation Model (DEM) generated from the bare-earth Light Detection and Ranging (LiDAR) points using kriging is a reasonable technique to model hillslope stability in the project area to maximize representative elevations and definition of actual geomorphic features while reducing topographic artifacts and computation time required for model application and other spatial analyses.**

**12. SHALSTAB and PISA represent reasonable models for predicting potential shallow landslide hazards, in common usage with proven performance in forest mountainous terrain.**

**13. The model testing resulted in determination of appropriate thresholds for breaks in potential instability classes that balance the goals of maximizing correct landslide prediction and minimizing over prediction of unstable area.**

The supporting science for these findings is in Stillwater. 2007. *Landslide Hazard in the Elk River Basin, Humboldt County, California*, which was provided as Appendix 6-D.

The 2005 LIDAR survey campaign that is described in Appendix 2-B looks to have been state-of-the art. The Stillwater 2007 report appropriately justifies the selection of kriging as the method for interpolating from the irregularly spaced bare earth point data from the 2005 LIDAR survey to a regular spaced grid of elevation data, thereby generating the 4-m DEM. The reasonable alternative methods were evaluated and found to be less appropriate for the goals of the landslide hazard study. Thus, I conclude that assertion/finding number 11 is based upon sound scientific knowledge, methods, and practices.

The Stillwell 2007 study modeled shallow landslides using two distributed, physically based models, one deterministic (SHALSTAB) and the other one probabilistic (PISA). Variations of the original versions of these models were employed to allow for spatial variations in soil depth, among other added parameterizations. The SHALSTAB model was originally developed in the late 1990s, subsequently modified and improved over the next decade or so, and applied with considerable success to many study areas in California, Washington, and Oregon—all documented through peer-reviewed papers published in the top scientific journals for this area of research. This model clearly employs sound scientific methodology, derived in a geophysical manner from first principles. Thus, I conclude that assertion/finding number 12 is based upon sound scientific knowledge, methods, and practices.

The PISA model employs a state-of-the-art geotechnical engineering approach. As with many standard geotechnical approaches, it is well documented through technical reports from the engineering firm that developed it (Haneberg Geoscience). This is standard practice in soil mechanical engineering, so the approach looks to be exactly what one should expect for a competent engineering approach to the problem, i.e., that the results will be defensible in legal proceeding as “state-of-the-art”, etc.

It is commendable that the Stillwater 2007 study employed both basic geophysical science and geotechnical engineering approaches to the landslide prediction problem in the Elk River Basin. Moreover, the testing of performance for the various models revealed that the best formulations of each resulted in negligible differences in regard to the prediction of landslide hazard at the scale required for this study.

The rigorous program of model performance was undertaking using statistical p-tests within a hypothesis testing framework to see (1) if the shallow landslide models predict greater potential slope instability at known slide locations than at random positions in the landscape, and (2) if the models are better predictors of instability than predictions based solely on hillslope gradient. Results did show quite positive indicators for both of these performance measures. Thresholds were also established from the sampling approach to determine a threshold for managing the landslide hazard by minimizing the tradeoff costs between (1) that of incorrectly classifying landslides, versus (2) that of over predicting potentially unstable areas. This methodology has also been published in important peer-reviewed scientific literature for study sites in the same regional setting as Elk River. Thus, I conclude that asserion/finding number 13 embodies best scientific knowledge, methodology, and practice.

## **<u>Identification of Additional Beneficial Uses of Water for the Elk River Watershed</u>**

**14.The Wetland Habitat (WET), Flood Peak Attenuation/Flood Water Storage (FLD), and Water Quality Enhancement (WQE) beneficial uses exist in Elk River.**

The supporting science for these findings could not be found in the *Draft Staff Report for the Upper Elk River Sediment TMDL*). There is no chapter entitled “Proposed Beneficial Uses of Water of the *Draft Staff Report for the Upper Elk River Sediment TMDL*”. There was some limited material on this topic in Appendix 1-B “Proposed Revision to the Identification of Beneficial Uses for the Elk River Watershed.” This appendix cites relevant scientific literature on the ecological function of wetlands, specifically in regard to FLD and WQE enhancement. Moreover, it documents the presence of wetlands in the Elk River watershed.

Appendix 1-B was incomplete, and concludes with a staff recommendation to identify additional beneficial uses for WET in the Lower Elk River subwatershed as well as the identification of existing beneficial uses for WQE and FDL. I conclude that this finding is based upon sound scientific knowledge, methods, and practices.

**Other Topics: "Big Picture" questions**

**(a) In reading the technical reports and proposed implementation language, are there any additional scientific issues that should be part of the scientific portion of the proposed rule that are not described above? If so, comment with respect to the *TMDL Summary and Implementation Framework* and *Beneficial Use Amendment* given above.**

**(b) Taken as a whole, is the scientific portion of the proposed actions based upon sound scientific knowledge, methods, and practices?**

The report does not directly discuss the issue that a major source of the sediment problems of the Elk River system derives from a combination of management practices and what probably were extreme storm events in the early 1990s. This suggests that a major pulse of sediment was imposed in this time period and that temporary storage and remobilization of this sediment could likely be an important factor.

Another important "Big Picture" issue is that the regulatory framework in which the Elk River issues are being assessed derives from the use of TMDLs, which are defined by USEPA as containing Elk River targets for water quality standards. Many of the Elk River issues (increased flooding, aspects of recrreation uses) are not strictly water quality issues. Another way to make this point, perhaps a bit bluntly, is to say that forced adherence to this framework (water quality standards) for a larger, and only peripherally related set of issues (flooding, remediation) is not to pursue the matter in a scientific manner. Specifically it does not employ an scientific methodology.

In regard to topic (b), as a scientist, I have been charged to be particularly concerned in this review with the, "…responsibility to determine whether the scientific portion of the proposed rule is based upon sound **scientific** knowledge, **methods**, and practices" (emphasis added in bold). As has been noted in some of my detailed review of individual topics, much of the document is framed, not as a scientific methodology, but as an engineering methodology utilizing scientific knowledge and engineering practice to achieve a regulatory standard. This is obviously a very "Big Picture" issue, and there will be disagreement on it by professionals.

According to Chapter 1 of the Staff Report, a "complete TMDL" includes an "*Implementation Plan*" and a "*Monitoring/Re-evaluation*". Elements of these are included in the Staff Report as Chapter 7. However, everything I read in regard to monitoring is addressed to see if there is compliance with standards. This is engineering, not science. In science standards must always be questioned. A standard must always be rearded as a hypothesis, and a better standard (hypothesis) should be the goal of the scientific methodology. Monitoring for compliance with the standard is engineering methodology, not scientific methodology. To be scientific the monitoring would have to lead to testing for relevance of the existing standard.

I can see two ways to address this issue. One is to embrace a scientific methodology, as I have outlined it, though I think that the response may pose severe problems, given the regulatory framework within which the TMDL is being defined.

The other way to address this issue is to make it very clear to all that the proposed TMDL for the Upper Elk River is the product of an engineering exercise, not a scientific one, Moreover that this exercise works to achieve the best possible estimate of a TMDL for the prevailing circumstances in the watershed, in compliance with current regulatory standards, utilizing best engineering practice, employing the most appropriate existing scientific knowledge, subject to limitations of time and money to perform the analysis, etc. In taking this approach, it should also be made clearto all that circumstances in the watershed are subject to continuous change such that it is impossible to make an absolute prediction in advance of the best possible TMDL that will incorporate unknow changes is the future, and that, as in all engineering solutions, one must accept these limitations.

Submitted by

Victor R. Baker, Regents' Professor of Hydrology and Water Resources,
The University of Arizona, Tucson, Arizona 85721-0011