Middle Truckee River Watershed TMDL for Sediment

Scientific Peer Review Comments
and
Water Board Staff Responses

Peer Reviewers:

Dr. N.L. Poff
Department of Biology
Colorado State University

Dr. James Fox
Department of Civil Engineering
University of Kentucky

Scientific Peer Reviewer:

Dr. N.L. Poff, Professor
Department of Biology
Colorado State University

Note: Dr. Poff did not suggest any changes to the TMDL document; therefore, his review did not require responses from Water Board staff. His comments are attached.

TO: Lahontan RWQCB
2501 Lake Tahoe Blvd
South Lake Tahoe, CA 96150
Attn: Anne Holden

FROM: N. LeRoy Poff, Professor
Colorado State University

DATE: November 26, 2007

SUBJECT: N.L. Poff's Scientific Peer Review of Truckee River Watershed TMDL for Sediment

Statement: This review focuses primarily on the issues related to the effects of sediment on the biota of the middle Truckee River, as described in the TMDL document and the report by Herbst and Kane (2006). However, comments are provided on other components of the TMDL document as well.

1. **Determination of sediment impairment based on interpretation of scientific studies, available data and literature on the effects of sediment on aquatic life.**

According to the linkage analysis (p. 6-3), "the link to impairment of beneficial uses due to sedimentation was established based on the relationships between measured sediment volumes and biologic community structure and diversity from Herbst and Kane (2006), literature reviews and best professional judgment."

I read the Herbst and Kane report ("Fine Sediment Deposition and Invertebrate Communities in the Middle Truckee River, California: Development of Criteria for Establishing TMDLs") to better understand the source and quality of the data used to establish the "link to impairment." The Herbst and Kane (2006) report provides an adequate review of the sediment literature. In its findings, it acknowledges that relationships between biological condition and deposited sediment in pump-core samples are weak and that there is no clear evidence of a threshold effect (Table 3, p. 21). The noisy relationships are, however, generally consistently in the direction one would expect *a priori* based on best available scientific understanding of biological responses to deposited sediment, e.g., sensitive taxa decline along a gradient of increasing fine sediment. Table 4 (p. 23) shows that sediment-tolerant taxa have high positive scores on Axis 1 of an NMDS, further indicating an expected association with sediment volume. In general, these results support the inference of a link between sediment volumes and sensitive benthic invertebrate metrics.

The logic chain of the linkage analysis in support of the TMDL appears to be: addition of more SSC to the Middle Truckee River (MTR) for a given discharge will lead to increased fine sediment storage in the river bed, which will induce biological impairment through loss of sensitive benthic invertebrates (and fish). I find this to be a scientifically sound rationale, assuming that suspended sediment (SSC) introduced into the MTR is not all transported downstream and assuming that the samples collected by Herbst and Kane (2006) were representative of near-shore habitats in the MTR. Thus, despite the limitations of the Herbst and Kane (2006) study (which include: lack of replication above tributary junctions, apparent lack of control for depth of sediment sampling in the core samples, and unspecified control for differences in near-bed water velocities), these data provide a reasonable basis for concern about sediment impairment of benthic biota in the MTR.

The failure to find statistically higher sediment volumes in pump-core samples below versus above tributary junctions is perhaps surprising (and perhaps largely reflects the sparse sampling design); however, in my view it but it does not diminish the validity of the observed relationships between biological condition and bed sediment volume. Many other factors aside from sampling location relative to tributary inflow can influence sediment volumes in pump-core samples, including large scale geomorphic features (e.g., bed slope, channel width, reach-scale channel morphology), fine-scale heterogeneity in bed particle size, temporal lags between tributary sediment export and time of benthic sampling, and legacy effects of sediment deposition or transport at sampled locations. Likewise, the finding in the Herbst and Kane (2006) study that there was no association between *modeled* SSC from tributaries and IBI scores in targeted riffles is not particularly surprising, since SSC is generally low during late summer baseflow conditions and the relatively mobile benthic species sampled in these locations would not necessarily reflect SSC conditions prevailing during high flows many weeks before. (I note that no bed sediment data were reported for the targeted riffle samples, so it is unclear that these sites represent storage zones for SSC and whether there is any trend for downstream increases in sediment storage in riffles of the MTR).

In summary, although there is broad scientific agreement that sediment can impair biological communities, there is no general scientific consensus as to what methods are best used to establish direct causal links between increments of sediment addition and biological degradation, especially in natural field settings characterized by complex hydraulics and streambed heterogeneity. I view the data from Herbst and Kane's (2006) study as providing support for the inference of biological impairment of benthic invertebrate communities under existing sediment loading conditions in the MTR.

2. **Identification of the main factors and conditions that contribute to the sediment impairment.**

The identification of sources and magnitudes of sediment contribution to the MTR and its tributaries is reasonable, although the details of such modeling are beyond my particular expertise (and I did not examine the DRI report with an eye toward sediment runoff model development or calibration). The methods certainly seem straightforward and allow for a rough estimation of how land cover and land use (including dams) in different tributaries contribute to overall SSC levels at the Farad gauge. That dirt roads would be significant sources of of sediment production, and that those roads closest to streams would contribute relatively more sediment, is logical. So is the modeled observation that sediment loading is event-driven and greater in high runoff years.

3. **Identification of an appropriate level of suspended sediment to protect aquatic life beneficial uses.**

The method used to identification of a 25 mg/L numeric target for suspended sediment is reasonable given the existing scientific literature and the correspondence of known/inferred SSC on comparable sensitive aquatic species (salmonids) in the MTR. If the goal is to provide guidelines for high levels of protection (as outlined on pp. 4-2 and 4-3), the 25 mg/L target is reasonable.

4. **Determination of load capacity based on existing and desired suspended sediment data.**

The field data and modeling data appear adequate to support the calculation of the loading capacity to attain the annual and high flow target of 90% of daily SSC values not exceeding 25 mg/L at Farad.

5. **Allocation of sediment loads based on the source assessment and estimates of Best Management Practices (BMPs) efficiency, and reductions in sediment yield after application of BMPs.**

This modeling exercise appears straightforward and reasonable, although the modeling per se is outside my particular area of expertise. It is clearly a deterministic model based on many assumptions, but the model affords a comparison of the relative contributions and load reductions by land use category across many tributaries. The explicit margin of safety and conservative estimates about BMP efficiencies seem reasonable.

<u>Summary Statement:</u>

Overall, I find that the process described in the development of the proposed TMDL for the MTR is straightforward and scientifically sound. The by-watershed and by-land-use modeling of sediment production is sensible and model values are compared with field measurements where possible. The distinction between dry year and wet year flows is sensible as sediment runoff from the landscape and sediment transport in streams and rivers is generally event-driven and nonlinear. The biological data collected provide evidence to justify concern over increased biological impairment with additional sediment loading to the MTR. The proposed load reductions are likely to have biological benefits.

Water Board Staff Responses to
Peer Review Comments on the Truckee River TMDL for Sediment

Peer Reviewer: James F. Fox, Assistant Professor, Department of Civil Engineering, University of Kentucky

The full text of the peer reviewer's comments was retained to preserve context. Comments and responses were broken out by staff into a numerical format for ease of reference. Water Board staff's responses are in **bold font** following each comment.

Comment 1: The data used in the report are appropriate given the uncertainty in obtaining information about sediment transport.

Response 1: No response is required.

Comment 2: The treatment of the data is not fully defensible, which is explained below in reference to source assessment estimation. The source assessment section should be corrected, and these corrections should be carried through the remainder of the report (e.g., in the load allocation section).

Response 2: Concerns regarding the source assessment are addressed in responses 7 through 13, below.

Comment 3: Further, analysis of the targets show that Squaw Creek, Donner Creek and Gray Creek watersheds do not meet their targets, however these sub-watersheds are not focused upon in the implementation. The TMDL should be revised to put further emphasis upon these problem areas.

Response 3: The peer reviewer is referring to the proposed suspended sediment target of an annual 90th percentile value no greater than 25 milligrams per liter (mg/L), set for the Truckee River at Farad. This target was selected to protect early life stage aquatic organisms in Truckee River.

We agree that the Squaw Creek, Donner/Cold Creeks, and Gray Creek subwatersheds are significant contributors of sediment loading to the Truckee River. Regarding emphasis of these areas in the TMDL implementation plan:

Squaw Creek was the focus of TMDL for sediment (approved by the USEPA in 2007), and has its own site-specific targets for aquatic life protection, as well as load reductions and an implementation plan to meet those reductions in the watershed. The requirements of the approved Squaw Creek TMDL will not be revised by the Truckee River TMDL, and it is anticipated that the approved load reductions will be sufficient to protect beneficial uses in Squaw Creek, and reduce sediment loading to the

Truckee River. Additional details on the Squaw Creek TMDL will be added to emphasize sediment control actions in that watershed.

Gray Creek is a naturally erosive watershed, and a comprehensive watershed assessment conducted in 2006 indicates that the majority of sediment loading to Gray Creek comes from naturally occurring sources. Dirt roads are the most important anthropogenic source of sediment to Gray Creek. The authors of the watershed assessment suggested that while controlling sediment from dirt roads would have benefit to aquatic habitat in localized areas, significant reductions in the overall sediment load that Gray Creek discharges to the Truckee River is not be feasible. However, control of certain anthropogenic sediment sources is feasible, and would have a positive effect on both Gray Creek and the Truckee River. Recommendations from the watershed assessment to address dirt road erosion will be emphasized in the TMDL implementation plan.

Donner/Cold Creek also exceeds the suspended sediment target, although not as frequently as Squaw or Gray creeks. Like Gray Creek, an extensive watershed assessment was conducted to determine controllable sediment sources and the feasibility of restoration. Recommendations to control sediment sources in the Donner/Cold Creek watershed will be emphasized in the TMDL implementation plan.

Comment 4: The determination of sediment impairment in the watershed appears correct.

Response 4: No response is required.

Comment 5: The determination of the main factors that contribute to sediment impairment in the watershed appears correct.

Response 5: No response is required.

Comment 6: Section 4, Targets: Targets appear well studied based on beneficial uses in the watershed and literature research. The calculation method appears correct. The general conclusion is that the targets are currently being exceeded and improvements are needed in the watershed.

Response 6: No response is required.

Comment 7: Section 5, Source Assessment: The source assessment appears to need some correction and improvement. Further details follow:

Intervening and unmeasured input:

More attention should be given to discussion of the intervening and unmeasured input locations. These locations provide a significant contribution to the sediment loading (~30%). I will suggest a section is needed about these inputs. Were they dominated by urbanized areas, dirt roads, diminished canopy cover, or a mixture? Can the same mitigation procedures be expected in these locations as the measured tribs? Are there some assumptions that are being made for these zones? Were these inputs dominated by legacy sediments or another process?

Response 7: The TMDL source assessment was revised to identify controllable and non-controllable source categories for each of the subwatersheds, intervening zones and unmeasured inputs, and event-based loading. Controllable land uses were defined as urban areas, dirt roads, graded ski runs and legacy sites. Based on the revised Source Assessment, the TMDL and Allocations sections were also revised to describe the assumptions used for the load reductions/allocations and the mitigation expectations for the controllable land uses in the intervening zones and tributary subwatersheds (see Response 17).

Comment 8: Subwatershed loading estimates versus event-based loading estimates and assessment calculations:

Figure 3.2 in DRI (2004) shows visually the order of magnitude increase the suspended sediment concentration (SSC) can undergo during short durations during storm events. In Figure 3.2, SSC measurements at the Farad site vary by an order of magnitude (~3000 mg/L to 300 mg/L) over a time span of 2 hrs. The drastic change in SSC and the corresponding sediment loading highlights the event-based loading that can occur in-stream and the sediment that was not captured from the measurements taken during the DRI (2001) study. The best sediment loading model developed was one in which SSC was predicted from four explanatory variables including turbidity, flow, water temperature and specific conductivity (DRI 2004).

Response 8: We agree that event-based loading is an important element of loading in the system and that the DRI 2004 study highlights these processes. We consider the study as another tool to be used in conjunction with the DRI 2001 study for assessing loading to the Truckee River. However, we don't agree that the DRI 2004 modeling is necessarily the best approach compared with the DRI 2001 study. The correlation value (R^2) for the flow/SSC regression in DRI 2001 was 0.78; whereas, the multiple regression R^2 for flow, turbidity, specific conductivity, and temperature was 0.73 in DRI 2004. The flow-only R^2 in DRI 2004 was 0.39.

Comment 9: Calculations were performed in DRI 2004 which showed that estimates of sediment load using turbidity, flow, water temperature and specific conductivity were 2 to 6 orders of magnitude higher during event months of the year, including March, June, July and December, as compared to sediment loading based only on flow as was done in DRI (2001). The comparison highlights the improved prediction when including turbidity and accounting for the storm variability of sediment loading.

Response 9: We don't agree that comparing the results of DRI 2004 to those of DRI 2001 necessarily highlights improved predictions of DRI 2004, which includes turbidity. The DRI 2004 report notes that model was "based on relatively few high turbidity observations compared to those with moderate turbidity" and that "more frequent maintenance of the turbidity sensors would improve the temporal data record, and allow the calculation of annual sediment loads." In this regard, it appears that the model predictions may not be representative under higher turbidity conditions. As an example, it is estimated in Table 3.2 that there was over 61 million tons of sediment loading at Farad in June 2002. Based on the total flow for the month, this value suggests that the average monthly SSC was over 2 pounds per liter, a value that is obviously not reasonable.

It appears that both models have certain advantages and limitations. The DRI 2001 regressions cover a full range of flow conditions over a 30-year time period, but the sampling method had the potential to miss important short-term loading events. The DRI 2004 model was able to discern short-term loading events, but only covers a 14-month period, may over predict loading at high turbidity, and had problems with instrumentation maintenance/failure. Considering these factors, we concluded that the results from DRI 2004 need to be fully considered in conjunction with the DRI 2001 to appropriately represent sediment loading in the watershed.

Comment 10: The reviewer agrees with the need to use sediment loading estimates from DRI (2004) due to the fact that the data has high temporal variability and includes sediments mobilized over short duration. However the means by which those events were included in the Peer Review Draft TMDL Report does not appear to be correct. The data used in DRI (2001) to produce the sediment versus flow regression relationship at Farad shows flow rate values as high as about 9,000 cfs with sediment concentration measurements of 1000 tons/day—in my opinion this will constitute an event. By including both the regression-based estimates (i.e., based on DRI 2001) and the event-based estimates (i.e., based on DRI 2004) it seems sediment loading is being accounted twice.

Response 10: We understand that sediment loading may be overestimated by combining event-based loading from DRI 2004 with the regression estimates from DRI 2001. The amount of overlap between the datasets cannot be estimated. The source assessment conservatively assumes no overlap to ensure all sediment sources are accounted for. The conservative assumption of no overlap is appropriate given that the event-based study occurred during a below-average water year, when sediment

transport is less than under higher flow conditions. Considering the attributes and limitations of each modeling approach, this conservative use of the available data is appropriate for purposes of the TMDL. This conservative approach is encouraged in EPA TMDL guidance (EPA 1999) and is included as part of an implicit margin of safety in the TMDL. We will revise the TMDL to acknowledge this issue.

Comment 11: While this provides a conservative estimate, it appears incorrect and will make future monitoring comparisons erroneous. Based on comparison of the two reports and discussion with the scientist at California Regional Water Quality Control Board, the overlap that occurs between the datasets will be very problematic to quantify.

Response 11: The sediment loading estimates are quite broad and can easily vary one or more orders of magnitude depending on the type of modeling approaches used and the natural variation in environmental conditions. This fact is emphasized in the TMDL. The loading estimates reflect a one-time snap shot of the watershed and are intended to help identify significant source areas and focus mitigation efforts. The modeling results are not intended for tracking load reductions over time. We do not plan on conducting further modeling for purposes of comparing future loading estimates with those provided in the TMDL. Instead, load reductions and improvement in water quality conditions will be assessed through the targets proposed in the TMDL.

Comment 12: To circumvent the problem, I will suggest the following:
Results from DRI (2001) and DRI (2004) can be used to approximate the source loading assessment for the watershed. The Subwatershed loading estimates (section 5.1) can be used to provide a percentage of sediment derived from each tributary and from the intervening zones and unmeasured inputs. In addition, the Effects of land characteristics estimates (section 5.3) can be used to provide percentages of sediment originated from urbanized, dirt roads, and diminished canopy cover in the subwatersheds and possibly in the intervening zones and unmeasured inputs if this information is available.

With percentage sediment estimates from each source, the improved sediment loading estimates at Farad from DRI (2004) can be used to predict sediment loading per event and annual sediment loading for the watershed.

Response 12: We don't agree that the DRI 2004 sediment loading estimates are necessarily "improved." Please see responses to comments 7, 8 and 13.

Comment 13: Annual loading at Farad can be predicted with the monthly loading data from DRI (2004). Monthly loadings are provided for four sites in DRI (2004). By using all four sites, estimates for the missing months at Farad can be estimated statistically. The monthly estimates can by used to provide an annual sediment load at Farad, which can then be accounted back to the tributaries and land uses using the percentage estimates.

<u>Response 13</u>: The DRI 2004 report explicitly states that annual loading could not be estimated due to the "extensive missing turbidity data at various times during the year at all stations." Additionally, the results presented in Table 3.2 do not show relationships between months and between the four stations that would allow us to statistically estimate loading at Farad for the missing months. A review of the results indicates that relative loading between the other three stations and Farad is quite irregular and ranges widely. Considering the missing turbidity data and the problems with predictions under high turbidity levels, we don't consider it appropriate to use the monthly load estimates provided in DRI 2004 to extrapolate an annual load.

In conclusion, we believe the approach used to estimate current sediment loading is appropriate considering the attributes and limitations of the two modeling approaches.

<u>Comment 14</u>: It is recommended that the DRI (2004) method, that includes turbidity measurements, be used for future monitoring.

<u>Response 14</u>: We do not plan the use DRI 2004 method for future monitoring because the method did not produce an appropriate baseline to compare future results. Additionally, there is no funding mechanism identified for future monitoring of this type. However, DRI currently conducts monthly SSC monitoring at Farad under an agreement with the Nevada Department of Environmental Protection. These data can be compared to an over 30-year record of SSC data and is more appropriate to assess improvement in the watershed.

Section 6. Loading Capacity and Linkage Analysis

<u>Comment 15</u>: Why was 20% instead of 22% percent used in Equation 6.2? I will suggest 22% be used as a conservative percentage to account for TMDL analysis and ensure protection of the beneficial uses.

<u>Response 15</u>: Twenty-two percent was rounded down to twenty percent to be consistent with the order-of-magnitude accuracy of the sediment loading estimates. Other conservative assumptions have been incorporated into the analysis (e.g., event-based loading - see Response 10, lower range of BMP efficiencies, etc.) to address the need for conservatism and ensure protection of beneficial uses.

Section 7. TMDL and Load Allocations

Comment 16: It appears load allocations for the sediment TMDL (see Table 7-1) were applied in an average sense across the tributary watersheds. I will suggest that Squaw Creek, Donner Creek and Gray Creek watersheds present the tributaries with the highest sediment input and should be more heavily weighted for allocations and more focused upon for mitigation.

Response 16: The Source Assessment and TMDL and Load Allocations sections were revised as previously discussed in Response 7. However, the allocations were developed based on the extent of controllable sources estimated in each tributary subwatershed and the BMP efficiencies expected to be attained for each source category. Only the BMP efficiencies (ranging from 50 to 55 percent) were applied in an average sense to the controllable source categories. The overall load allocations (and associated reductions) are weighted according to extent of controllable sources found in each subwatershed. This approach is appropriate because it is consistent with the actual load reduction opportunities anticipated in the subwatersheds.

Comment 17: In addition, intervening zones and unmeasured inputs present a significant percentage of the sediment input and perhaps need to be reduced more than 10%; further information and/or arguments regarding these inputs will benefit this reduction.

Response 17: The TMDL and Load Allocations sections were revised to account for loading from urban and non-urban areas and set allocations for the intervening zones and unmeasured inputs, as well as subwatersheds and event-based loading. All urban loading was considered controllable and a load reduction of 50 percent was set. For non-urban areas, loading associated with dirt roads and legacy sites was estimated at 40 percent of the total non-urban load and a BMP efficiency of 55 percent was estimated for these sources. This resulted in an overall load reduction of 22 percent for non-urban areas associated with intervening zones and unmeasured inputs.

Comment 18: Event-based loading is expected to come from all sources and reducing event-based loading by 35% does not appear to be correct nor does it target mitigation strategies.

Response 18: The section was revised as discussed in Responses 7 and 17. Event-based loading from urban areas was estimated and assigned a load reduction of 50 percent. Event-based controllable loading from non-urban areas was estimated at 40 percent of the total non-urban load and a BMP efficiency of 55 percent was estimated for the controllable load

sources. This resulted in an overall load reduction of 22 percent for non-urban areas associated with event-based loading.

Comment 19: Section 10, Implementation and monitoring: It is suggested that Squaw Creek, Donner Creek and Gray Creek watersheds and possibly the intervening and unmeasured sediment inputs be focused upon in the implementation plan.

Response 19: Please see response to comment 2.

Comment 20: Monitoring should include the turbidity measurements, if funding allows, for comparison with the sediment loading in DRI (2004).

Response 20: Please see response to comment 13.