STATE OF CALIFORNIA—NATURAL RESOURCES AGENCY Edmund G. Brown Jr., Governor

DEPARTMENT OF FORESTRY AND FIRE PROTECTION
P.O. Box 944246
SACRAMENTO, CA 94244-2460
(916) 653-7772
Website: www.fire.ca.gov

April 8, 2014

Mr. Matthew St. John, Executive Officer
North Coast Regional Water Quality Control Board
5550 Skylane Boulevard, Suite A
Santa Rosa, California 95403

Subject: Comments on "Peer Review Draft – Staff Report to Support the Technical Sediment Total Maximum Daily Load for the Upper Elk River"

Dear Mr. St. John:

The California Department of Forestry and Fire Protection (CAL FIRE) appreciates the opportunity to comment on the North Coast Regional Water Quality Control Board (NCRWQCB) document titled "Peer Review Draft – Staff Report to Support the Technical Sediment Total Maximum Daily Load for the Upper Elk River" (Elk River TMDL). CAL FIRE recognizes the enormity of effort needed to produce a document of this magnitude. Despite the tremendous work put into the Elk River TMDL, CAL FIRE has significant concerns about the document. For brevity's sake, only the largest issues are presented in the following comments. The information and basis for the comments contained below are derived primarily from RWQCB supported studies in the Elk River watershed and scientific references that are used in the Elk River TMDL document. A brief summary of the concerns are:

- The background loading rate is derived using a "reference study subbasin approach" which disregards systematic variations in watershed processes. This lack of a process-based framework for watershed stratification results in the inappropriate extrapolation of loading rates from one portion of the watershed to another (Montgomery, 1999).
- Regional studies have suggested that deep-seated landsliding can drive sediment budgets in Coast Range watersheds, despite the landforms only comprising a small proportion of watershed area (Bedrossian and Custis, 2003; Mackey and Roering, 2011).Terrain models (DSLED-Rough and DSLED-Drain) suggest that deep-seated landsliding is a dominant geomorphic process operating in the Elk River watershed (Stillwater Sciences, 2007). The same

- terrain models suggest that deep-seated landsliding is not a dominant process in the reference study subbasin (i.e., Upper Little South Fork Elk River). Regardless of this, deep-seated landsliding rates derived from the reference study subbasin are applied to the rest of the watershed.

- Stratification using questionable assumptions has resulted in a background loading rate attributed to deep-seated landsliding that is two orders of magnitude less than those obtained from regional studies (Bedrossian and Custis, 2003; Mackey and Roering, 2011).

- Loading estimated from decadal scale regional reservoir sedimentation studies and from conventional suspended sediment and bedload sampling show large discrepancies with the estimated background rate (Ferrier et al., 2005; Minear and Kondolf, 2009; Andrews and Antweiler, 2012).

- The background loading rate for the Upper Elk River appears to be underestimated by more than an order of magnitude (i.e., up to a factor of 19) when compared to millennial scale estimates of sediment loading using cosmogenic radionuclide methods (CRN).

- Adding regionally-derived watershed-averaged estimates of loading attributed to deep-seated landsliding to the TMDL background loading rate brings the TMDL rate into conformance with the long-term loading rates.

- The large disparity between estimated background rates and the current loading rates are automatically attributed to recent management activities, when they should be attributed to errors in the sediment source analysis. As a result of this, the sediment load increase attributed to management (1400 percent) is not consistent with values in other studies (Kramer et al., 2001; Lewis et al., 2001; Sommerfield et al., 2002; Cafferata et al., 2007).

- The errors in the analysis are large and pervasive and directly carry over to the numeric targets for load reduction. Hence, the feasibility of meeting these targets is extremely low given the hydrogeomorphic processes operating in the watershed and current watershed conditions.

These points are addressed in more detail in the following text. Recommendations are also offered to help improve the implementation of the TMDL over time.

Lack of Process-Based Framework for Analysis

The hydrogeomorphic processes operating in a given watershed are not uniform over time and space. Rather, a watershed should be viewed as a mosaic of process domains – areas where unique and systematic sets of hydrogeomorphic processes govern the response of water quality and habitat characteristics to natural and anthropogenic disturbance (Montgomery, 1999). The Elk River TMDL lacks this process-based framework, and instead uses a reference watershed approach to evaluate the changes in condition for the rest of the watershed. In the case of the Elk River TMDL, the reference watershed approach assumes that background loading rates derived from the pristine Upper Little South Fork Elk River subbasin (3.6 mi^2) are directly applicable to the much larger Upper Elk River subbasin (44.2 mi^2). Although CAL FIRE acknowledges that reference watersheds provide useful information that can aid in analysis, the approach used by the NCRWQCB ignores systematic patterns in processes that drive water quality response. Without considering the hydrogeomorphic context, extrapolating data from a reference watershed to another area can lead to misleading comparisons if the other areas are subject to different suites of watershed processes (Montgomery, 1999).

For the northern part of the Coast Ranges province, noted process domains include earthflow terrain and/or terrain dominated by other deep-seated landsliding processes (Kelsey, 1977; Kelsey, 1980; Swanston et al., 1995; Reid et al., 2003; Mackey and Roering, 2011). Mackey and Roering (2011) found that while earthflows only comprised 6 percent of the area within their study area in the Eel River watershed, the landforms were responsible for approximately half of the total sediment yield for a 87 mi^2 subbasin. Overall, sediment loading[1] attributed to earthflows when averaged across their study area was approximately 3200 $t\ mi^{-2}\ yr^{-1}$. Bedrossian and Custis (2003) estimated that deep-seated landsliding processes and soil creep accounted for approximately 1000 to 3000 $t\ mi^{-2}\ yr^{-1}$ of sediment when averaged across the entire Gualala River watershed (298 mi^2). They also estimated that inputs attributed to deep-seated landsliding were underestimated by a factor of 5 to 15 in the Gualala River TMDL (Bedrossian and Custis, 2003). The background rate of sediment loading due to deep-seated landsliding is estimated in the Elk River TMDL as 4 $t\ mi^{-2}\ yr^{-1}$, or two orders of magnitude lower than the rates suggested by these regional studies.

Geologic reports, geomorphic mapping, and modeling of the Elk River watershed suggest that deep-seated landsliding is a dominant process within the watershed (Marshall, 2002; Marshall and Mendes, 2005; Stillwater Sciences, 2007). CGS notes the presence of deep-seated landforms in the Elk River watershed in a memo and in geologic/geomorphic mapping (Marshall, 2002; Marshall and Mendes, 2005). Figures 3-12 and 3-13 from the Stillwater Sciences report in Appendix 6D of the Elk River TMDL (Stillwater Sciences, 2007) illustrates terrain analysis using the DSLED-Rough and DSLED-drain models. Both DSLED models detect the topographic signature of deep-seated landsliding and have shown success for predicting the presence of deep-seated landsliding (Roering et al., 2006; Booth et al., 2009). Figure 1 shows the study subbasins used in the Elk River TMDL overlaid onto figure 3-12 (DSLED-Rough) from the 2007 Stillwater Sciences report.

---

[1] For the purpose of this report, mass is reported in short (standard) tons.

Figure 1 shows distinct differences in the topographic signatures indicative of deep-seated landsliding for the reference versus managed watersheds. The figure also suggests that topographic signatures related to deep-seated landsliding are widespread throughout the Elk River watershed, despite being absent in much of the Upper Little South Fork Elk River.

Data from a recent report on streamside landsliding and bank erosion in the Elk River watershed performed for the Humboldt Redwood Company (SHN, 2013) also suggests the importance of deep-seated landsliding on local sediment delivery rates. Streamside landsliding often occurs at the toe of deep-seated slides (Marshall, 2002; Mackey and Roering, 2011). The highest rate of streamside landsliding (i.e., approximately 750 cubic yards per mile of stream) was found in the Tom Gulch subbasin, which the DSLED-Rough model predicts to have a high frequency of deep-seated landforms (Figure 1). Humboldt Redwood Company's updated Watershed Analysis for Elk River also notes the importance of deep-seated landsliding and streamside landsliding, and data from the report suggests that these two geomorphic associations account for 87 percent of the total landslide delivery during the period of analysis (HRC, 2013; Figure 2). This is consistent with other studies showing that deep-seated landslides and streambank erosion contribute >80 percent of the sediment yield in northwestern California watersheds (Brown and Ritter, 1971; Kelsey, 1980; Nolan and Janda, 1995).

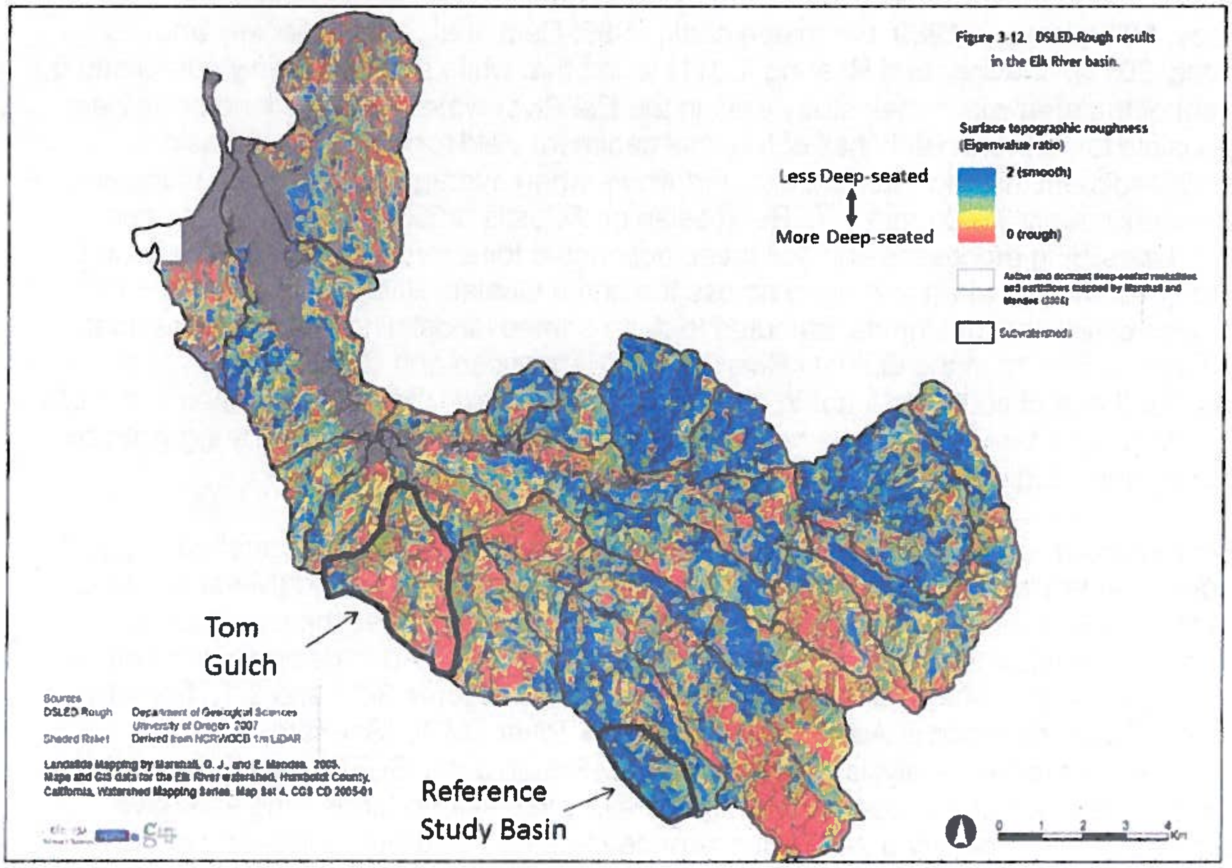

Figure 1. Figure showing the distribution of surface topographic roughness, a topographic signature of deep-seated landsliding derived from the DSLED-Rough model, in the Elk River watershed (from Stillwater Sciences, 2007). Higher surface roughness (red) is related to deep-seated landsliding processes, whereas low surface roughness (blue) is related to other geomorphic processes. Note the lack of surface roughness in the reference study basin relative to the rest of the watershed.

Overall, the available evidence suggests that deep-seated landsliding processes have been largely ignored in the Elk River TMDL. The stratification of the watershed does not consider this unique process domain, despite the evidence that deep-seated landsliding can drive watershed scale sediment budgets (Bedrossian and Custis, 2003; Mackey and Roering, 2011). Estimates of watershed-wide background rates for deep-seated landsliding were performed exclusively in the Upper Little South Fork of Elk River, even though terrain models suggest a low frequency of these landforms occurring in that particular watershed. This sampling bias has resulted in an estimated background loading rate attributed to deep-seated sliding that is two orders of magnitude lower than regional estimates of sediment loading due to deep-seated landsliding. Despite this disparity, the background rate is applied to the Upper Elk River, even though the terrain model suggests a much higher frequency of deep-seated landsliding in Upper Elk River than in the reference study basin.

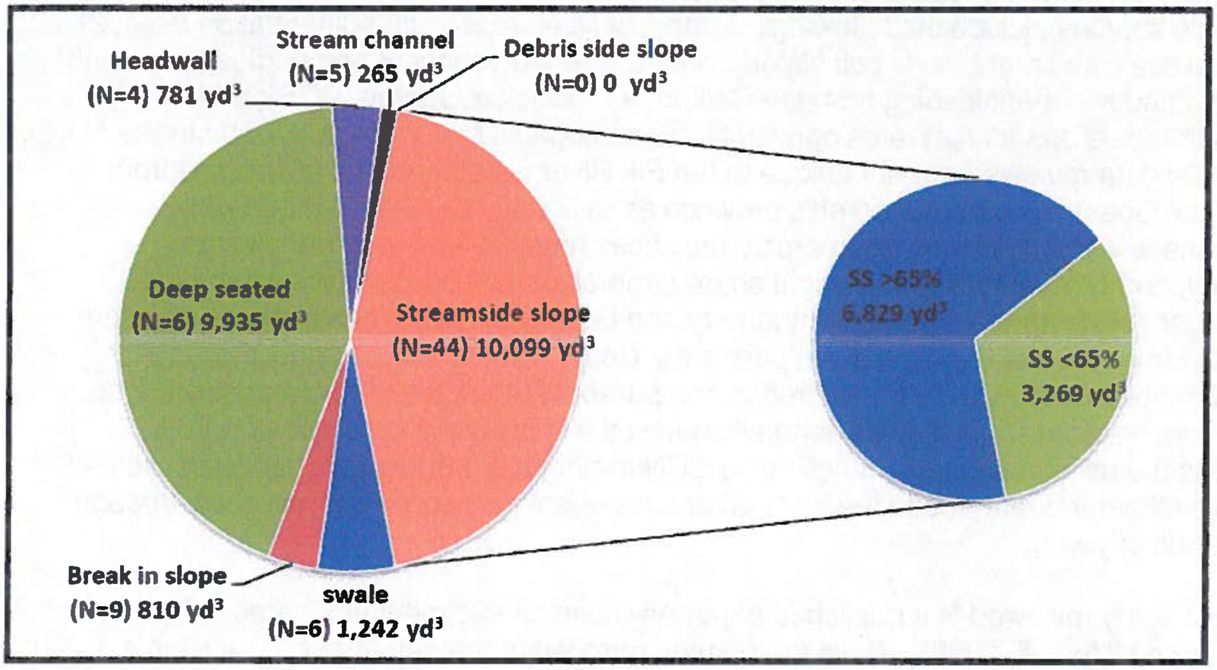

Figure 2. Sediment delivery volume by geomorphic association from the Humboldt Redwood Company's updated watershed analysis (HRC, 2013). The pie chart on the left shows that deep-seated slides and streamside landslides account for 87 percent of the sediment delivery over the period of analysis. The pie chart on the right show the percentage of sediment delivery from streamside landslides by slope percentage.

Natural Background Pollutant Loads

There is substantial evidence that the natural background pollutant load for the Elk River watershed is significantly underestimated by an order of magnitude or more. These lines of evidence suggest a discrepancy between the estimated background loads and published decadal and millennial scale measurements of sediment yield. Reasonably accurate estimates of background load are critical, as the load allocations designated for timber harvest activities are a percentage (i.e., 20 percent) of estimated natural sediment loading. Without a reasonably accurate measurement of the background rate, loading may be inaccurately attributed to current management sources. In turn, these errors affect the numeric targets for load reduction measures, and the feasibility for meeting these targets.

The Elk River TMDL contains an estimated background pollutant load of 68 $yd^3\ mi^{-2}\ yr^{-1}$, or 95 tons $mi^{-2}\ yr^{-1}$. These numbers were estimated through a sediment source analyses of the Upper Little South Fork of Elk River, a 3.6 mi^2 undisturbed headwater basin within the Elk River watershed. The authors of the TMDL used sediment budgeting techniques for estimating background rates of sediment loading. A critical step in preparing sediment budgets is to check the reasonableness of the estimated sediment yields against analogous data from other sources (i.e., reservoir sedimentation rates; sediment yields derived from suspended sediment sampling) (Reid and Dunne, 1996). If the comparison indicates large differences in estimated rates versus rates from other sources (i.e., literature; regional studies), additional work should be done to try and resolve the discrepancies (Reid and Dunne, 1996).

Data from several sources indicate there is a large discrepancy between the estimated background sediment loads and those found in the available literature. Data from the available sources include the following: 1) decadal scale reservoir sedimentation rates; 2) decadal scale sediment loads calculated from suspended sediment and bedload sampling; 3) estimated sediment loading from the California Geological Survey (CGS); and 4) millennial scale denudation rates derived from cosmogenic radionuclide (CRN) studies.[2] While the data reviewed are not unique to the Elk River watershed, the data come from within the Coast Ranges geomorphic province as defined in CGS Note 36 (2002). Watersheds within the same geomorphic provinces have generally similar climate, geology, and physiography, and might share general similarities in hydrogeomorphic processes (Montgomery, 1999; Montgomery and Bolton, 2003). When possible, data are selected from studies in the northern part of the Coast Ranges (i.e., Mendocino County and Humboldt County) to further increase comparability to the Elk River watershed. The rates from decadal scale studies generally reflect the influence of land use activities, whereas the millennial scale studies using CRN methods are thought to represent more of a true background rate due to the fact that anthropogenic erosion is averaged out through thousands of years.

The first study reviewed is a published paper on reservoir sedimentation rates in California (Minear and Kondolf, 2009). While the primary purpose of the paper was to develop a reservoir sedimentation model, the data used for model development was also summarized to provide decadal scale reservoir sedimentation rates by geomorphic province. The sample size of reservoirs studied the Coast Range province was 23. The volumetric mean[3] and median sedimentation rates for all samples (n=23) within the Coast Range province are 1415 $yd^3\ mi^{-2}\ yr^{-1}$ and 889 $yd^3\ mi^{-2}\ yr^{-1}$, respectively. The mean and median sedimentation rates from the paper are larger than the estimated background loading rate for Elk River by a factor of 21 and 13, respectively.

The second series of papers estimated sediment loading using data derived from suspended sediment and bedload sampling techniques, generally over decadal scales (Ferrier et al., 2005; Madej, 2005; Keppeler et al. 2007, Andrews and Antweiler, 2012). Ferrier et al. (2005) summarized sediment loads derived from suspended sediment and bedload sampling from various subwatersheds within the Caspar Creek (n=6) and Redwood Creek (n=4) watersheds. The study watersheds in Caspar Creek were small,

---

[2] For assumptions behind this methodology, see Granger and Riebe (2007).

[3] The standard error of the mean is 482 $yd^3\ mi^{-2}\ yr^{-1}$.

ranging from 0.1 to 1.8 mi^2, while the study watersheds in Redwood Creek ranged from 3.5 to 278 mi^2 in size. The range of data reported for all sites was 34 t mi^{-2} yr^{-1} to 3723 t mi^{-2} yr^{-1}. Results indicate that mean sediment loads were 203 t mi^{-2} yr^{-1} to 2067 t mi^{-2} yr^{-1} for Caspar Creek and Redwood Creek, respectively. In general, the smallest watersheds produced the smallest amount of sediment. Keppeler et al. 2007 reported a decadal average annual sediment yield for the South Fork of Caspar Creek (drainage area = 1.6 mi^2) of 393 t $mi^{-2}yr^{-1}$. The range of values represents a 2 to 22 factor increase in sediment loading when compared to the background loading rate for Elk River.

Andrews and Antweiler (2012) used climatic and physiographic data to estimate sediment yields for various Coast Range rivers in California. Sediment yield was calculated using decadal scale measurements of suspended sediment and bedload from established monitoring stations. Data selected for comparison include sediment yields for the Van Duzen, Mattole, South Fork Eel, Middle Fork Eel, and Navarro watersheds. Sediment loads for these watersheds ranged from 3134 t mi^{-2} yr^{-1} to 10541 t mi^{-2} yr^{-1}. The overall mean was 6895 t mi^{-2} yr^{-1}, or approximately 73 times greater than the estimated rate for Upper Elk River. The Van Duzen and the Mattole watersheds had the highest rates, with sediment yields of 10541 t mi^{-2} yr^{-1} and 8832 t mi^{-2} yr^{-1}, respectively.

Data from cosmogenic radionuclide (CRN)[4] studies provide estimates of sediment yield at a time scale that theoretically averages out the effects of anthropogenic erosion (Kirchner et al., 2005). CRN-derived data exists for multiple sites within multiple watersheds in the northern portion of the Coast Ranges province, including Caspar Creek, the South Fork Eel River, the mainstem Eel River, the Van Duzen River, the Mad River, the Ten Mile River, and Redwood Creek (Kirchner et al., 2005; Andras et al., 2005; Fuller et al., 2009; Balco et al., 2013). The average sediment yield[5] from these studies was approximately 1800 t mi^{-2} yr^{-1}, with a range from 510 t mi^{-2} yr^{-1} to 8400 t mi^{-2} yr^{-1}. Ferrier et al. (2005) reported that long-term CRN data for the Caspar Creek watershed (approximately 695 t mi^{-2} yr^{-1}) imply that this watershed has experienced erosion rates that are approximately two times higher than decadal erosion rates. As a potential explanation, they state that sediment delivery to streams is highly episodic and that over decades of monitoring, relatively few large storm events that dominate long-term average erosion rates will have occurred.[6]

Rates of sediment loading were a power function of watershed area (Figure 3), indicating large increases in sediment loading with increasing spatial scale. The mean sediment load estimate from the available CRN data suggest that the background loading rate for the Elk River watershed is underestimated by a factor of 19. The regression line from Figure 3 suggests that the background loading rate for the Upper Elk River is underestimated by a factor of 19.

---

[4] Bedrock lowering estimates are converted to mass by assuming a bedrock density of 2.23 t yd^{-3}.

[5] The median rate was 900 t mi^{-2} yr^{-1}.

[6] Lewis (2013) reported the average annual suspended sediment yield from Elk River site SFM in the years that have been analyzed to date (2003-2008, 2011, 2013) is 797 t mi^{-2} and from site KRW (2003-2008, 2011) is 491 t mi^{-2}. Station KRW is located on the North Fork Elk River 1.0 miles above the confluence of North and South Fork Elk Rivers; site SFM is located on the South Fork Elk River 0.5 miles above the confluence. Assuming an average of approximately 650 t mi^{-2} is two times lower than a CRN millennial estimate would produce a background rate of approximately 1300 t mi^{-2}, roughly 14 times higher than the TMDL estimate provided.

Data derived from conventional sediment sampling methods exists for two relatively undisturbed (i.e., pristine) watersheds in or near the Redwood Creek drainage. Ferrier et al. (2005) reported a mean sediment load for Little Lost Man Creek of 293 t mi^{-2} yr^{-1}; updated data produce a mean annual yield of 157 t mi^{-2} yr^{-1}.[7] The latter value is approximately two times higher than the rate estimated for Elk River. Two years of suspended sediment sampling in Upper Prairie Creek showed a range between 26 t mi^{-2} yr^{-1} to 43 t mi^{-2} yr^{-1} (Madej, 2005), or roughly one-quarter to one-half of the estimated rate for Elk River. The mean average annual suspended sediment yield at the upper Prairie Creek station is 40 t mi^{-2}, based on data collected from 1990 to 2009 (R. Klein, RNSP (retired), written communication). CRN data also exists for Little Lost Man Creek, and the millennial averaged rate is 6.7 times higher than rates calculated using conventional methods. Millenial scale data from the pristine Little Lost Man Creek (3.5 mi^2) suggests a more than 10-fold difference between long term rates and those estimated in the Elk River TMDL (Figure 3). Published geological mapping (Delattre and Rosinski, 2012; Dell'Osso et al., 2002) shows Prairie Creek to be underlain by Prairie Creek formation and Lost Man Creek to be underlain by Eastern Belt Franciscan Lacks Creek unit rocks. Harden et al. (1995) report that, "The underlying bedrock exerts a strong influence on both the type and rate of mass movement processes operating in the (Redwood Creek) Basin." Dell'Osso et al. (2002) note that the Prairie Creek formation is relatively stable from a mass wasting perspective. The unit descriptions provided in Cashman et al. (1995) and Dell'Osso et al. indicate fine (silt and clay) materials are a minor component of the Prairie Creek formation while mudstone is a major component of the Lacks Creek unit. The cited information seems to indicate that because of a general dearth of fines in the underlying bedrock and a low propensity for mass wasting, Prairie Creek is somewhat anomalous as a North Coast watershed. For its propensity for both deep-seated and shallow landslide processes and a plenteous supply of fine material in the underlying bedrock, Lost Man Creek seems more typical of a North Coast watershed and more readily comparable to Elk River.

---

[7] The mean average annual suspended sediment yield at the Little Lost Man Creek station is 157 t mi^{-2}, based on data collected from 1993 to 2012 (R. Klein, RNSP (retired), written communication).

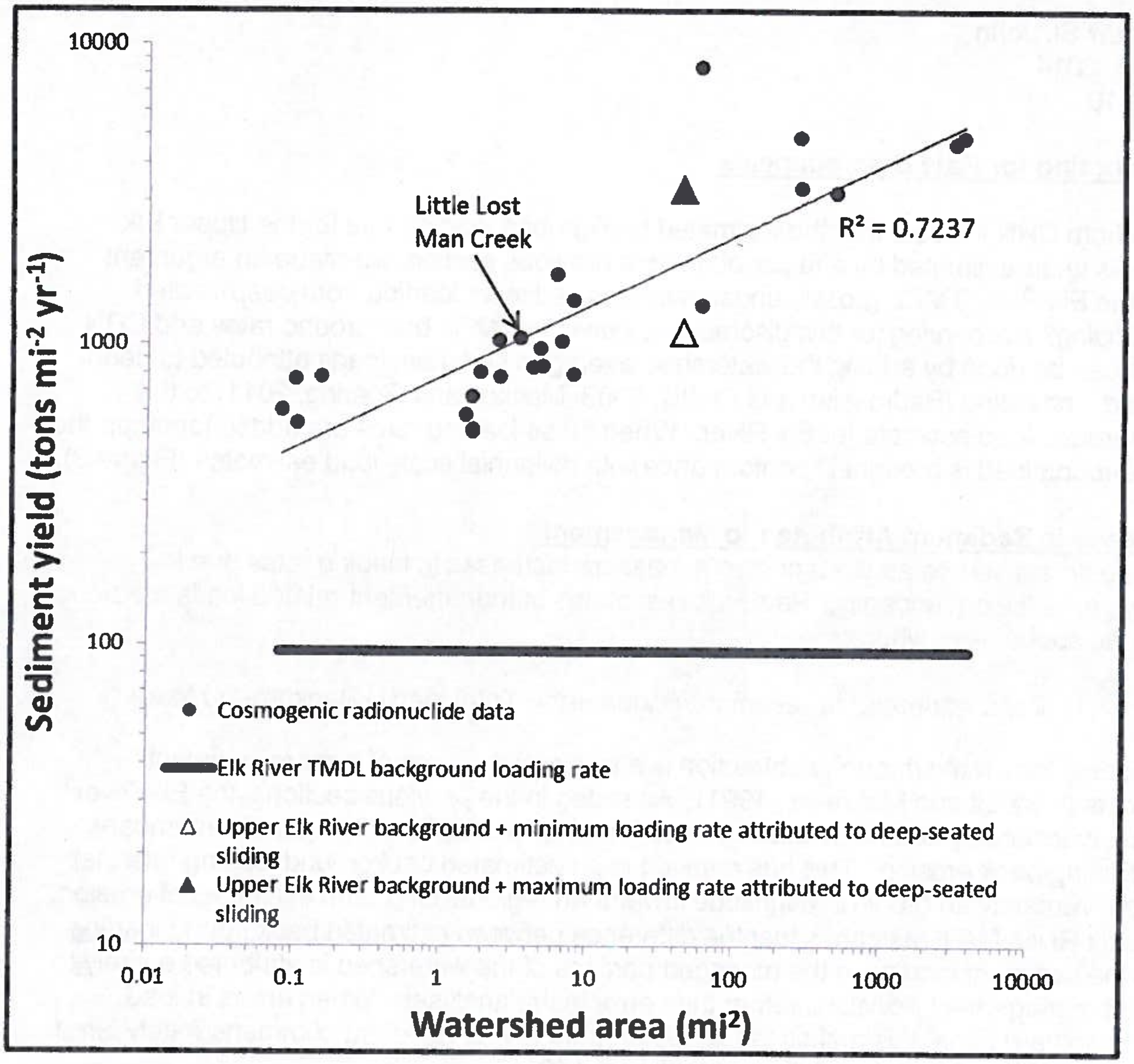

Figure 3. Sediment yield versus watershed area for data derived from cosmogenic radionuclide studies in the northern Coast Range geomorphic province and the background rate estimated (Ferrier et al., 2005; Andras et al., 2005; Fuller et al., 2009; Balco et al., 2013). The Elk River TMDL rate is plotted for comparison. The triangles represents the Upper Elk River TMDL background load estimate plus the minimum and maximum watershed-averaged loading rates estimated for deep-seated landsliding (Bedrossian and Custis, 2003; Mackey and Roering, 2011). Little Lost Man Creek is a relatively pristine, old-growth dominated watershed located in the Redwood Creek basin in Humboldt County.

Altogether, data from reservoir sedimentation studies, conventional sediment measurement studies, and CRN studies strongly suggest that the Elk River TMDL background loading rate is underestimated by an order of magnitude or more. Data obtained through conventional sampling methods from pristine sites suggest less of a disparity with the Elk River TMDL background rate. Data from CRN studies offers advantages over other methodologies because the data represents a sufficiently long record to average out the effects of management and to represent time varying geomorphic processes. For this reason, CRN data is used to account for rate discrepancies.

Accounting for Rate Discrepancies

Data from CRN indicate that the estimated background loading rate for the Upper Elk River is underestimated by a factor of19. In a previous section, we made an argument that the Elk River TMDL grossly underestimates sediment loading from deep-seated landsliding. Accounting for this discrepancy between TMDL background rates and CRN rates can be done by adding the watershed-averaged sediment loads attributed to deep-seated landsliding (Bedrossian and Custis, 2003; Mackey and Roering, 2011) to the background load estimate for Elk River. When these loading rates are added together, the background load is brought in conformance with millennial scale load estimates (Figure 3).

Increase in Sediment Attributed to Management

The sediment source analysis does not measure increases in loading rates due to management independently. Rather, its estimates of management-related loads are done through subtraction, where:

(1) Load attributed to recent management = Total load – Background load

Assigning load rates through subtraction is a well noted source of error in sediment budgets (Kondolf and Matthews, 1991). As stated in the previous sections, the Elk River TMDL inaccurately estimates loading rates for deep-seated landsliding and streambank landsliding/bank erosion. This has resulted in an estimated background loading rate that is approximately an order of magnitude lower than regional long term estimates of erosion. The Elk River TMDL assumes that the difference between estimated background loading and the sediment loading in the managed portions of the watershed is attributed entirely to recent management activities, rather than error in the analyses. When errors in load estimation are large, this makes the load attributed to management commensurately large (i.e., the residual term) (Kondolf and Matthews, 1991).

The Elk River TMDL attributes a 14-fold increase in sediment loading to land use activities (i.e., 68 $yd^3\ mi^{-2}\ yr^{-1}$ vs. 976 $yd^3\ mi^{-2}\ yr^{-1}$) over a period extending from 1955 to 2011. This level of increase attributed to management is much higher than that reported in other sediment budgets for California (CDF 1999; Kramer et al., 2001; Cafferata et al., 2007), regional watershed studies (Lewis et al., 2001), and those derived from longer term sedimentary analysis (Sommerfield et al., 2002).

In 1999, Stillwater Sciences developed a rapid sediment budget for the Jackson Demonstration State Forest Habitat Conservation Plan (HCP)/Sustained Yield Plan (SYP) watershed assessment area (approximately 156 mi^2). The assessment area for the draft JDSF HCP/SYP included the South Fork of the Noyo River, four small coastal watersheds (Hare, Mitchell, Caspar Creeks, and Russian Gulch), Lower Big River, and the North Fork of Big River (CDF 1999). Average sediment yield was estimated at 856 $t\ mi^{-2}\ yr^{-1}$ for the period from 1958 to 1997, which was a 2.5 fold increase over estimated background rates (342 $t\ mi^{-2}\ yr^{-1}$). More broadly, in an analysis of 19 sediment budgets in California, Cafferata et al. (2007) found that management accounted for approximately half of the total sediment load (i.e., 100 percent increase) over the time frame of the sediment budget (Figure 4). Earlier, Kramer et al. (2001) reported similar data for nine North Coast TMDL watersheds.

Data from the North Fork of Caspar Creek suggest that recent management activities increased sediment yield by 89 percent, including landslide inputs (Lewis et al., 2001). Sommerfield et al. (2002) looked at stratigraphic evidence from continental-shelf deposits off the Eel River and estimated that anthropogenic sediment inputs accounted for approximately 33 percent of the total sediment load reaching the ocean. They also concluded that climatically-induced increased frequency of extreme floods was responsible for most of the three-fold increase in sedimentation rates after 1950. This information strongly suggests that the rate increase attributed to management in the Elk River TMDL is overestimated a minimum of several hundred percent.

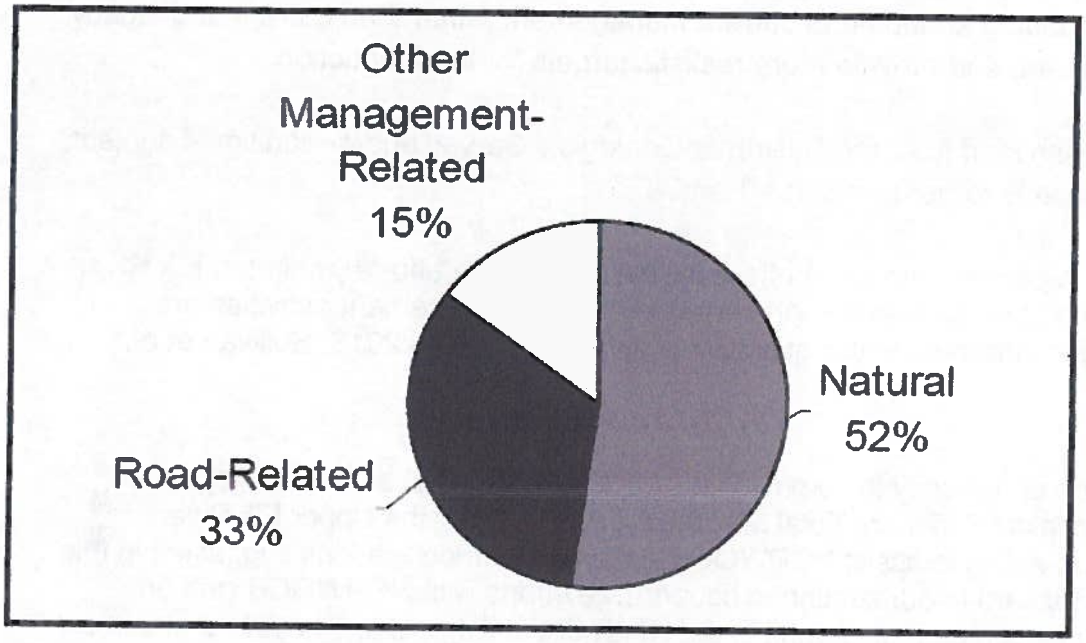

Figure 4. Relative contribution of management activities to total sediment load from 19 sediment budgets in California (from Cafferata et al., 2007). Sixteen of the sediment budgets were conducted in the Coast Range geomorphic province.

The Importance of Geomorphic Context

CAL FIRE encourages the NCRWQCB to consider the long-term geomorphic context of the Elk River watershed when making changes to the Elk River TMDL. The tectonic setting of the North Coast produces rapid uplift. Local uplift from the 1992 Cape Mendocino earthquake exceeded 4.5 feet (Carver et al., 1994). This not only increases hillslope relief (i.e., a driver of erosion), but also causes large scale weakening of hillslope materials (Molnar et al., 2007). The North Coast is also well noted for having some of the largest unit area flood flows on record (Connor and Costa, 2004). The interaction of these factors creates a situation where sediment yields can become extraordinarily high (Brown and Ritter, 1971), even in the absence of management. Without fully considering this context, the assumptions behind sediment source analyses can be flawed. Errors in analyses are directly transferred to the calculation of numeric targets for sediment reduction. If these errors are large, as they appear in the case of the Elk River TMDL, the feasibility for meeting numeric targets may be extremely low given the hydrogeomorphic processes operating in the watershed and current watershed conditions.

Recommendations

Given the previous comments, CAL FIRE's recommends the following:

1. Revisit the sediment source analysis using a process-based framework for watershed stratification.

2. Using a more appropriate stratification, account for relevant watershed processes (i.e., deep-seated landsliding) to more accurately estimate background sediment loading, loading attributed to current management rather than current and legacy management, and provide more realistic targets for load reduction.

3. Consult with staff from the California Geological Survey and/or additional subject matter experts to perform steps 1 and 2.

4. Support implementation and effectiveness monitoring efforts within the Elk River watershed to determine if improvements in land management activities are resulting in improved water quality over time (e.g., Lewis 2013, Sullivan et al. 2012).

Thank you for the opportunity to comment on the "Peer Review Draft – Staff Report to Support the Technical Sediment Total Maximum Daily Load for the Upper Elk River." CAL FIRE staff is willing to assist NCRWQCB staff with the modifications suggested in this letter. We look forward to our continued cooperative efforts with NCRWQCB staff on water quality protection and monitoring in the North Coast Region, and believe that some of the issues related to Elk River can be further explored in the new Effectiveness Monitoring Committee being established by the Board of Forestry and Fire Protection (e.g., mass-wasting prescription effectiveness). If you have any questions or comments regarding this letter, please, contact Drew Coe of my staff at (530) 224-3274, or drew.coe@fire.ca.gov (note that Mr. Coe will be at the CAL FIRE Academy from March 24, 2014 to May 2, 2014).

Sincerely,

Duane Shintaku
Deputy Director
Resource Management

References

Andras, K., L. Benda, and P. Bigelow. 2005. Erosion rates in the Ten Mile River Basin, northern California using cosmogenic isotopes. Final report prepared by Lee Benda and Associates, Inc. Mt. Shasta, CA. 15 p.

Andrews, E.D. and R.C. Antweiler. 2012. Sediment fluxes from California coastal rivers: The influences of climate, geology, and topography. The Journal of Geology. 120: 349-366

Balco, G., N. Finnegan, A. Gendaszek, J.O.H. Stone, and N. Thompson. 2013. Erosional response to northward-propogating crustal thickening in the Coastal Ranges of the U.S. Pacific Northwest. American Journal of Science. 313: 790-806. DOI 10.2475/11.2013.01

Bedrossian, T.L. and K. Custis. 2003, Importance of deep-seated landslides in determining background rates of sedimentation for Total Maximum Daily Loads on California's north coast: AEG News, Program with Abstracts, 2003 Annual Meeting of the Association of Engineering Geologists, Vail, Colorado, v. 46, July, p. 51

Booth, A.M., J.J. Roering, and J.T. Perron. 2009. Automated landslide mapping using spectral analysis and high-resolution topographic data: Puget Sound lowlands, Washington, and Portland Hills Oregon. Geomorphology. 109: 132-147.

Brown, W.M. and J.R. Ritter. 1971. Sediment transport and turbidity in the Eel River basin, California. U.S. Geological Survey Water-Supply Paper 1986. 70 p.

Cafferata, P.H., D.B.R. Coe, and R.R. Harris. 2007. Water resource issues and solutions for forest roads in California. Hydrological Science and Technology. 23: 39-56.

California Department of Forestry and Fire Protection (CDF). 1999. Draft Habitat Conservation Plan/Sustained Yield Plan for Jackson Demonstration State Forest. Administrative Review Draft prepared by Stillwater Sciences, Berkeley, California, dated June 1999. Sacramento, CA.

California Geological Survey (CGS). 2002. California geomorphic provinces, Note 36, California Geolical Survey, Sacramento, CA. 13 p.

Carver, G. A., A.S. Jayko, D.W. Valentine, and W.H. Li. 1994. Coastal uplift associated with the 1992 Cape Mendocino earthquake, northern California. Geology, *22*(3), 195-198.

Cashman, S. M., H.M. Kelsey, and D.B. Harden. 1995. Geology of the Redwood Creek Basin, Humboldt county, California, *in* Nolan, K.M. , Kelsey, H.M., and Marron, D.C., eds, Geomorphic Processes and Aquatic Habitat in the Redwood Creek Basin, Northwestern California: U.S. Geological Survey Professional Paper 1454.

Connor, J.E. and J.E. Costa. 2004. Spatial distribution of the largest rainfall-runoff floods from basins between 2.6 and 26,000 km2 in the United States and Puerto Rico. Water Resources Research. 40, W01107, doi:10.1029/2003WR002247

Delattre, M. and Rosinski, A., 2012, Preliminary Geologic Map of the onshore portions of the Crescent City and Orick 30'X60' Quadrangles, California, scale 1:100,000.

Del'Osso, D., J. Falls, D. McGuire. 2002. Geologic and Geomorphic Features related to landsliding (Plate1), Relative Landlside Potential with Geologic and Geomorphic Features (plate2), Redwood Creek Watersed, Humboldt County, California, California Geological Survey, Watershed Mapping Series, Map Set 6, Scale 1:24,000,

Ferrier, K.L., J.W. Kirchner, and R.C. Finkel. 2005. Erosion rates over millennial and decadal timescales at Caspar Creek and Redwood Creek, Northern California Coast Ranges. Earth Surface Processes and Landforms. 30: 1025-1038.

Granger, D.E. and C.S.Riebe. 2007. Cosmogenic nuclides in weathering and erosion. In *Treatise on Geochemistry*, Vol. 5, ed. KK Turekian, HD Holland, pp. 1–43. Oxford: Elsevier.

Hardin, D.R., S.M. Colman, and K.M. Nolan. 1995. Mass movement in the Redwood Creek Basin, Northwestern California , *in* Nolan, K.M. , Kelsey, H.M., and Marron, D.C., eds, Geomorphic Processes and Aquatic Habitat in the Redwood Creek Basin, Northwestern California: U.S. Geological Survey Professional Paper 1454.

Humboldt Redwood Company. 2013. Elk River/Salmon Creek Watershed Analysis Revisited. Draft Report. Scotia, CA. 109 p.

Kelsey, H.M. 1977. Landsliding, channel changes, sediment yield and land use in the Van Duzen River basin, northern coastal California, 1941-1975. Earth Resources Monograph No. 3. USDA Forest Service, Pacific Southwest Region, San Francisco, CA. 370 p.

Kelsey, H.M. 1980. A sediment budget and an analysis of geomorphic processes in the Van Duzen River basin, north coastal California, 1941-1975. Geological Society of America Bulletin. 91: 1119-1216.

Keppeler, E.T., P.H. Cafferata, and W.T. Baxter. 2007. State Forest Road 600: a riparian road decommissioning case study in Jackson Demonstration State Forest. California Forestry Note No. 120. California Department of Forestry and Fire Protection. Sacramento, California. 22 p.

Kondolf, G.M. and W.V.G. Matthews. 1991. Unmeasured residuals in sediment budgets: a cautionary note. Water Resources Research 27(9): 2483-2486.

Kramer, S.H., M. Trso, and N. Hume. 2001. Timber harvest and sediment loads in nine northern California watersheds based on recent Total Maximum Daily Load (TMDL) Studies. Watershed Management Council Networker. Summer 2001. 10(1): 1, 17-24.

Lewis, J. 2013. Salmon Forever's 2013 annual report on suspended sediment, peak flows, and trends in Elk River and Freshwater Creek, Humboldt County, California. Final report submitted to the Redwood Community Action Agency by Salmon Forever under SWRCB Agreement No. 07-508-551-0. 52 p.

Lewis, J.; S.R. Mori; E.T., Keppeler; and R.R. Ziemer. 2001. Impacts of logging on storm peak flows, flow volumes and suspended sediment loads in Caspar Creek, California. *In:* Mark S. Wigmosta and Steven J. Burges (eds.) Land Use and Watersheds: Human Influence on Hydrology and Geomorphology in Urban and Forest Areas. Water Science and Application Volume 2, American Geophysical Union, Washington, D.C.; 85-125.

Madej, M. A. 2005. The role of organic matter in sediment budgets in forested terrain. In Proceedings of the International Symposium on Sediment Budgets. IAHS Public (pp. 9-15).

Marshall. G. 2002. Memo: Rapid Review of Engineering Geologic Conditions for Specific Timber Harvest Plans in the Elk River Watershed. Department of Conservation Division of Mines and Geology.

Marshall, G. J., and E. Mendes. 2005. Geologic and geomorphic features related to landsliding and landslide potential in the Eel River watershed. State of California, Department of Conservation, California Geological Survey, Sacramento, California.

Minear, J.T. and G.M. Kondolf. 2009. Estimating reservoir sedimentation rates at large spatial and temporal scales: A case study of California. Water Resources Research. 45, doi:10.1029/2007WR006703.

Molnar, P., R.S. Anderson, and S.P. Anderson. 2007. Tectonics, fracturing of rock, and erosion. Journal of Geophysical Research. 112, F03014, doi:10.1029/2005JF000433
Montgomery, D.R. 1999. Process domains and the river continuum. Journal of the American Water Resources Association 35(2): 397-410.

Montgomery, D. R., and S.M. Bolton. 2003. Hydrogeomorphic variability and river restoration. Strategies for Restoring River Systems: Sources of Variability and Uncertainty in Natural and Managed Systems. American Fisheries Society, Bethesda, MD, 39-80.

Nolan, K.M. and R.J. Janda. 1995. Impacts of logging on stream-sediment discharge in the Redwood Creek Basin, northwestern California. *in* Nolan, K.M. et al., (eds). Geomorphic processes and aquatic habitat in the Redwood Creek Basin, northwestern California: U.S. Geological Survey Professional Paper 1454, p. N1-N22.

Reid, M. E., D.L. Brien, D, R.G. LaHusen, J.J. Roering, J. De La Fuente, and S.D. Ellen. 2003. Debris-flow initiation from large, slow-moving landslides. Debris-Flow Hazards Mitigation: Mechanics, Prediction, and Assessement Millpress, Rotterdam, ISBN, 90, 77017.

Reid, L. M. and T. Dunne. 1996. Rapid evaluation of sediment budgets. Catena Verlag.

SHN. 2013. Streamside Landslide and Bank Erosion Survey, Summer 2012. Elk River, Humboldt County, California. Prepared for the Humboldt Redwood Company. 18 p.

Sommerfield, C.K., D.E. Drake, R.A. Wheatcroft. 2002. Shelf record of climatic changes in flood magnitude and frequency, north-coastal California. Geology. 30(5): 395-398.

Stillwater Sciences. 2007. Landslide hazard in the Elk River basin, Humboldt County, California. Report prepared for the North Coast Regional Water Quality Control Board. Arcata, CA. 51 p. plus Figures and Appendices.

Sullivan, K., D. Manthorne, R. Rossen, and A. Griffith. 2012. Trends in sediment-related water quality after a decade of forest management implementing an aquatic habitat conservation plan. Technical Report, Humboldt Redwood Company, Scotia, CA. 187 p.

Swanston, D. N., R.R. Ziemer, and R. Janda. 1995 . Rate and mechanics of progressive hillslope failure in the Redwood Creek basin, northwestern California. USDI Geological Survey Professional Paper, 1454.