Turbidity as a Tool for Cumulative Watershed Effects Assessment

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Background

A fundamental element of the current version of TRA #2 is evaluating the potential for on- and off-site cumulative impacts on the beneficial uses of water. In California, the protection of beneficial uses is achieved through the attainment of water quality objectives (CWC § 13050 (h)). Beneficial uses of water and water quality objectives are listed in the water quality control plans (Basin Plans) for the nine Regional Water Quality Control Boards in California. A water quality objective common to all the Basin Plans for the nine Regional Boards is turbidity.[1]

Turbidity is an expression of the optical property of water that scatters light (Dunne and Leopold, 1978), and is considered by many as the most sensitive indicator of the effects of land use on watercourses (MacDonald et al., 1991). High turbidity can limit the efficacy of drinking water treatment procedures, impact the recreational and aesthetic use of water, limit primary productivity, and affect the feeding and growth of fish species (MacDonald et al., 1991). Turbidity can be assessed visually by gaging the relative cloudiness of water (CVRWQCB, 2010) or can be measured quantitatively through the use of turbidity meters. The latter method has gained considerable favor in the watershed science community, as turbidity has been shown to be a better predictor of suspended sediment concentration than discharge (Lewis, 1996) and is commonly used to estimate suspended sediment loads.

Suspended sediment is usually the primary source of turbidity in forested watersheds, although suspended organic material can account for a large proportion of the suspended load in some watersheds (Madej, 2005). However, as the magnitude of suspended sediment yield for a watershed goes up, the fraction of suspended organic material generally goes down (Figure 1). This indicates the relative importance of organic material as a driver of turbidity is relatively small when overall suspended sediment load is high. In general, cumulative watershed effects become a priority issue when overall sediment load is high and becomes a limiting factor on the recovery of beneficial uses.

Turbidity is highly variable over time and space, and is strongly dependent on factors such as flow generation and flow magnitude, as well as geologic factors (e.g., lithology, landslide potential) (Gomi et al., 2005). Turbidity has also been used in several published studies relating land use activities to favorable (Sullivan, 1985; Reiter et al.,

[1] All of the Regional Boards with the exception of the Colorado River Regional Water Quality use numeric water quality objectives for turbidity.

2009) and unfavorable (Lewis et al., 2001; Klein et al., 2012) changes in sedimentary cumulative watershed effects (CWEs). The widespread use of turbidity monitoring in California was summarized by Harris et al. (2007).

Benefits of Using Turbidity as a Visual Indicator of CWEs

Robust datasets of continuously collected quantitative turbidity data are extremely useful for inferring watershed sedimentary processes and estimating suspended sediment loads. Despite this, the rise of rigorous turbidity sampling should not diminish the fact that the visual assessment of turbidity is arguably the best qualitative diagnostic tool for assessing sedimentary impacts from land use activities. Turbidity is a powerful tool and has been found to be capable of documenting the immediate effects of timber harvest. Qualitative field observations of turbidity can be used to identify specific sediment sources by employing the source-search methodology (MacDonald et al., 1991; Harris et al., 2007). This methodology uses systematic observations of water clarity in the upstream direction in order to identify sediment sources (e.g., landslides, roads) or zones of high sediment yield (i.e., tributaries) (MacDonald et al., 2001; Harris et al., 2007). In turn, this can help practitioners determine if past land use activities are adversely impacting the assessment area (14 CCR § 912.9 [932.9, 952.9] (2)), or if a high proportion of the sediment load is coming from natural sources. By observing the water quality response of BMPs in the field during storm events, it also provides the practitioner with information regarding the effectiveness of certain BMPs in preventing adverse cumulative impacts (14 CCR § 912.9 [932.9, 952.9] (3)).

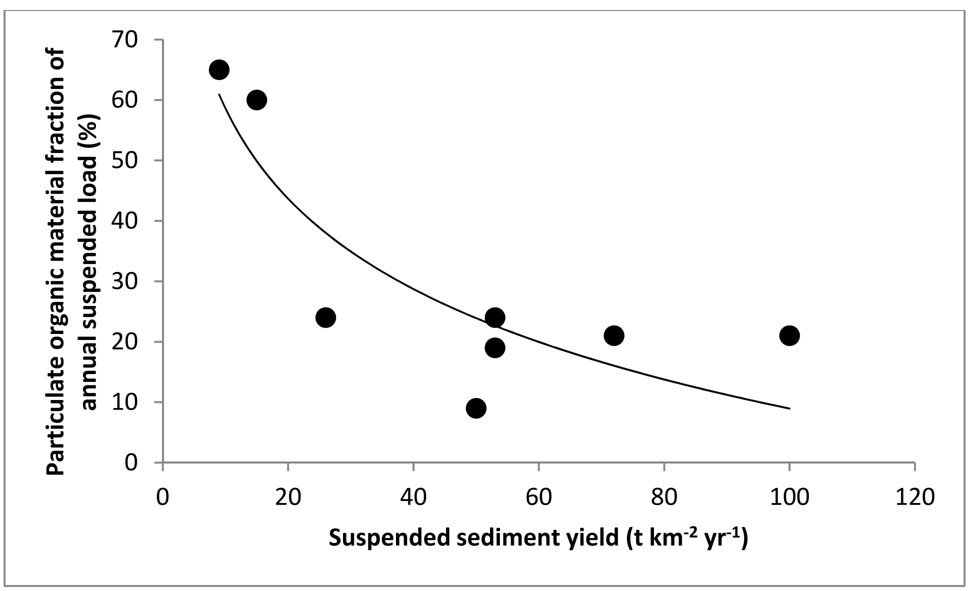

Figure 1. The percent fraction of particulate organic in suspended load versus the suspended sediment yield for four watersheds located in the North Coast of California (data taken from Madej, 2005).

Methods such as visual turbidity observations are relatively practical and inexpensive tools for assessing sedimentary impacts (MacDonald and Smart, 1993). The concept of visual turbidity observations is also built into the Road Rules, 2013 rule package. The definition of significant sediment discharge is the following:

> Significant sediment discharge means soils erosion that is currently, or as determined based upon visible physical conditions, may be in the future, discharged to watercourses or lakes in quantities that violate Water Quality Requirements or result in significant individual or cumulative adverse impacts to the beneficial uses of the water. **One indicator of a Significant Sediment Discharge is a visible increase in turbidity to receiving Class I, II, III, or IV waters** (emphasis added).

Longer term or chronic turbidity is considered to constitute a violation of Water Quality Requirements using standards found in Regional Water Board Basin Plans, and can be considered a significant sediment discharge using the new Road Rules, 2013 rule package definition. Land management activities that elevate turbidities for extended periods, both during and between winter storms, generate chronic turbidity.

The significant sediment discharge definition relates turbidity observations to sediment and to the potential for cumulative adverse impacts. By not considering turbidity in a revision of TRA #2, we ignore the fact that turbidity observations will be used to assess cumulative effects in other portions of the California Forest Practice Rules.

Concerns Regarding the Use of Turbidity

There are unwarranted concerns that landowners will be forced to employ quantitative turbidity sampling with the inclusion of turbidity in TRA #2. There are many elements of the current TRA #2 where quantitative measurement methodologies can be employed. Examples of this include depth-integrated sampling and pump sampling for suspended sediment, and bedload traps or Helley-Smith bedload samplers for measuring bedload. Despite the fact these methodologies exist, there has been no requirement to use them to characterize sedimentary cumulative effects. A reasonable expectation is that past qualitative observations will be used, if available[2], as a line of evidence to help make a determination regarding the potential for CWEs. If sound quantitative turbidity data are readily available for the assessment area, the project proponent should be expected to evaluate its use in making a determination for the potential of CWEs. It is generally acknowledged that robust datasets are needed to evaluate anything more than relative magnitude or general trend of turbidity. As such, most available data will not be conclusive regarding the presence or potential for CWEs, but could be used as an additional line of evidence for the determination.

Another concern is that turbidity should not be included because there is a general lack of issues regarding turbidity and beneficial use impairment (i.e., no 303(d) listings for turbidity). It should be noted that turbidity is a recognized surrogate for suspended

[2] Turbidity observations can only be performed during or immediately after storm events.

sediment (Lewis, 1996), and that many forested watersheds in California are 303(d) listed for sediment. As such, visual and quantitative turbidity measurements should be seen as important tools to assess sedimentary cumulative watershed effects.

Summary

Turbidity standards exists for nine Basin Plans in the State of California and turbidity has a strong linkage to the beneficial uses of water. Although rigorous turbidity monitoring has gained favor in research and monitoring communities (Harris et al., 2007; Lewis and Eads, 2009), the use of visual turbidity observations is a practical and relatively inexpensive way to gage sediment-related impacts. Visual turbidity observations are codified in the new Road Rules as a way to evaluate individual and cumulative watershed impacts. While both quantitative and qualitative turbidity sampling should be used in the appropriate context, they can provide an important line of evidence for practitioners for evaluating the potential for cumulative watershed effects.

Inclusion of turbidity in a revised version of TRA #2 would not require turbidity measurement to be undertaken or new observations to be made by plan proponents. Turbidity data and field observations of turbidity levels would only be used where they are already available. There is no expectation that it would have to be assessed prior to plan development.

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