The following are some thoughts on the Kuhnle and Simon review document titled:

"Evaluation of Sediment Transport Data for Clean Sediment TMDL's. NSL Report No.17 November 2000

Submitted by
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First, it is a shame that neither Troendle nor Rosgen were given the opportunity to participate in the effort or review the results prior to publication and dissemination of the above referenced report. As the following review will document, there are a lot of misconceptions or misunderstandings reported by Kuhnle and Simon that if rectified might have resulted in a stronger report by them and reduced their contribution to scientific confusion.

I am making the assumption that the Kuhnle and Simon citation to Troendle 2000 is reference to the draft progress report that I gave them during their visit to Fort Collins, and which described work to date (ca spring 2000) in developing a "Reference Sediment Transport Curve". Attached to this review is a copy of the Camera Ready draft of that work, submitted for Publication in the Proceedings of the Federal Interagency Sedimentation Conference, March 2001 in Reno, NV. There are significant differences in the Published (Troendle et al 2001) versus Draft (Troendle 2000) documents but the conclusions have not changed.

On page 4 of Report No. 17, the authors cite the objectives we proposed to the EPA for our work to develop the Reference Curve. Initially, the hypothesis proposed developing sediment transport Reference Curves partitioned by Rosgen Stream Type, Pfankuch Stability Rating, and watershed size. The inferences drawn from the subsequent analysis of the historical data sets made available for evaluation, (as reported in the Troendle 2000 draft report and apparently ignored by Kuhnle and Simon) resulted in the rejection of the Hypothesis that Dimensionless Reference Sediment Transport is correlated to Stream Type. We also found that, for the most part, streams with either a Good or Fair Pfankuch Stability Rating could be combined and that streams rated with a Poor Pfankuch Stability Rating generally showed departure (were significantly different) from Good and Fair streams. Although the Dimensionless sediment Transport curve has been strengthened (Troendle et al 2001) by the addition of more data, the draft document given to Kuhnle and Simon presented a new Hypothesis that a single Dimensionless Sediment Transport Curve, one for Suspended Sediment and one for Bedload Transport, represented all Stream Types in the Rocky Mountain region. We have proposed the hypothesis that these models represent "Reference" Dimensionless Transport rates for undisturbed systems, or systems in equilibrium with their sediment supply and discharge, in the Rocky Mountain Region. Stream systems with altered sediment supplies or flow regimes, such as Pfankuch Poor streams, display departure from the "Reference". My understanding of the charge to Kuhnle and Simon was to determine if the "Reference Curve" hypothesis, documented to work in the Central and Northern Rocky Mountains was a viable hypothesis elsewhere. If not they were free to investigate alternate solutions. This understanding of charge is consistent with the objectives Kuhnle and Simon identify for their work. My comments primarily addresses their Assessment of the Reference Curve concept and to a lesser degree critiques their understanding of the Rosgen's Stream Classification. I will primarily focus on the result of their objectives 2 and 3 as presented on P 4 of their report.

The following are some specific comments on the Kuhnle and Simon effort:

1) As noted above, Kuhnle and Simon (p 4) ignored the findings presented in the Troendle 2000 report as they proceeded in their venture. Troendle 2000 (and Troendle et al 2001) rejected, up-front, the hypotheses that each Rosgen Stream Type had its own separate sediment transport Reference Curve. The Dimensionless Sediment Transport Curves for stable streams of all stream types collapsed into a single dimensionless model for bedload and for suspended sediment. As an Observation, current work by Dr. Sandra Ryan (Ryan, in review) of the Rocky Mountain Research Station also implies that Sediment transport may be independent of other river classification schemes as well. Streams exhibiting a Poor Pfankuch stability rating, or those known to be impaired, were found to be significantly different than streams with a Good or Fair rating. Departure of impaired streams from Reference Conditions was documented to be detectable (see Troendle et al 2001). It was this alternate hypothesis that Kuhnle and Simon were to evaluate.
2) My comments will not address the misconceptions presented by Kuhnle and Simon on the Rosgen Stream Classification System, except in those cases where they directly relate to the Reference Curve concept. For the most part, evaluation of the Reference Curve concept can be separated from a river classification scheme, or Stream Type at this point. However, Kuhnle and Simon (p 5) assume that there is no stable or equilibrium phase for all stream types and therefore a single sediment transport model will not fit all stream types. This is not true, a D channel, for example, does occur naturally and it can occur in, or evolve to, an equilibrium state. At the same time, not all D channels are stable and as such may exhibit unstable characteristics or departure. We used data from "stable" systems to develop the Reference Curve and we tested that Reference Curve against other stable as well as unstable systems (Troendle et al 2001). What we concluded, in developing the Reference Curve, is that stable river systems project a consistent and comparable sediment transport signature when presented in a dimensionless format, which compensates for differences in flow regime and sediment supply. The resulting channel morphology (dimension, pattern, and profile), or stream Type, reflects that balance. Stable river systems are composed of a continuum of Stream Types that could not exist with out this balance or continuity. Although we refer to these channel types as "stable" or in equilibrium, adjustments occur continuously within the bounds of dynamic equilibrium. When drastic change occurs, in either sediment supply or flow regime, streams demonstrate "departure" in terms of sediment transport. This departure can be detected relative to the Reference Curve. However, if the disturbance is large enough or occurs long enough, channel type may evolve to a different type, the stream may "stabilize" at

that new channel type or it may continue to evolve to yet another type. These are points about the Reference Curve concept, and Rosgen's Stream Classification system that appear to have escaped Kuhnle and Simon in their review of the proposed methodology. Rosgen discusses the evolutionary stages of rivers in his book as well as in one of his March 2001 FISC papers. He addresses the factors, which cause rivers to evolve from one stream type to another as well as their ability to stabilize at a new type. This is a critical aspect of implementing the Reference Curve concept in the TMDL process. There are times when sediment transport in a stream, if adequately monitored, can be documented to depart from the Reference Conditions. We were able to demonstrate this (Troendle et al 2001). However, if the impact is severe enough or has occurred long enough to cause channel evolution and re-stabilization, departure in sediment transport may not be detectable and a Watershed Assessment Procedure, such as that proposed by Rosgen, must be implemented to assess impacts and define cause and effect. The fact that we could not demonstrate a correlation between stream type and Dimensionless sediment transport, which may at first glance seem inconsistent, is really the fiber that ties the Rosgen classification system together and allows us to once again think about, and treat, rivers as a continuum, an integrated system, rather than a sequence of individual reaches.

3) For all practical purposes, the effort that Kuhnle and Simon expended in evaluating the Reference Curve concept is summarized on page 12 in their report. Much of the text is devoted to explaining why they cannot present the data (points) used in developing the transport models for the 4 sites they used to evaluate the technique. (Weren't the models fit using data points and if so why can't they be plotted?) An equal portion of the page was devoted to expressing concern that in the transformation process, all models pass through the 1:1 on the X:Y axis. No space was devoted to documenting the basis for that concern. As Troendle 2000 and Troendle et al (2001) note, all dimensionless sediment transport curves pass through 1:1 on the X: Y axis. Biometrics review of the work did not surface statistical concerns. However, as Troendle (2000) and Troendle et al (2001) noted, the constraint that all models pass through 1:1 can be a problem if an adequate data set is not available to fit the transport model over a range of values that well exceed the 1:1 intersect. This does not appear to be a critical restriction when adequate data sets are used, because the slope and the intercept of the fitted model are not controlled in the process of transforming the models to a dimensionless format. Since it is, after all, the model that is tested for departure and not whether or not the line passes through 1:1, we recognized but dismissed the concern. As in our analysis, Kuhnle and Simon also observed that the slope of the relationship is not significantly modified in the process of transformation, supporting our observation that the 1:1 intersect problem may be more perception than real. In the absence of any data suggesting that this creates a fatal bias, we proceeded with model development. Troendle et al (2001) noted that every stream has it's own unique sediment transport signature when expressed in absolute values for discharge and sediment transport and every stream is different, as Kuhnle and Simon also conclude. The purpose for attempting to develop the Reference Curve was to determine if those sediment transport signatures unique

to every stream could be presented in a way that accentuates their similarity and "masks" their differences; thus making detection of departure in impaired streams easier. The example presented by Kuhnle and Simon for Toutle River at Kid Valley, in contrast to their interpretation, proves our point. They present sediment transport data for the 1987 and 1988 water years (Fig 15b). Basically the data represent two sample distributions taken from a common population of values. The authors do not indicate that anything happened in 1987 that would cause the sediment to be drastically reduced in 1988 on the same river so one can only assume the data represent two separate samples from the same population. The models describing transport for the two years have virtually the same slope but, as Kuhnle and Simon point out, they do not predict the same sediment transport. (Kuhnle and Simon did not document that the models were in fact significantly different in absolute values, however). Presenting them in a dimensionless format causes them to overlap as shown in Fig. 16a. This is exactly what we would have expected them to do. There is no reason to believe that the same stream sampled two years in a row should exhibit departure if it were not impacted between sampling years. We are not concluding that the absolute sediment transport between the two sample years is not different or that it should or should not be. However, we are concluding that the transport signature for that stream for 1988, as evidenced by its dimensionless form, has not departed from the transport signature observed in 1987 in a similar dimensionless format. The Kuhnle and Simon analysis highlights the inherent uniformity of response that is projected when the transport/discharge data are normalized. Unfortunately Kuhnle and Simon did not appreciate this subtlety nor did they either develop a generic "Reference" curve to test the Kid Valley streams against or compare the Kid Valley data against the Rocky Mountain Reference Curve. They did document that, although the absolute values appeared different, the same stream expressed the same dimensionless sediment transport relationship when sampled in two successive years. This is basically what we found to be true not only for the same stream sampled in successive years but for an extensive array of stable streams sampled over a range of stream types.

4) On page 12 of Report No. 17, Kuhnle and Simon proceed to state, "the presence of departure for sediment rating curves that have significant differences in their slopes (Fig 17a-d) was found not to be obscured in the dimensionless plots". I believe this is the point we were trying to make. Streams that depart from the norm in their dimensionless sediment transport characteristics (are not in equilibrium) will have different slopes, will demonstrate departure, and will be significantly different than reference conditions (those in equilibrium). We suggest the tool that makes detection possible is presenting them in dimensionless format in order to provide a base for comparison.
5) Kuhnle and Simon did not attempt to determine whether a reference sediment transport curve could be developed from existing data for stable streams in their region and thus they provided no valid test of the hypothesis we proposed for the Rocky Mountain region. They did present dimensionless sediment transport models for the four streams they used in the assessment. However, as noted they did not present the data distributions used to fit the models nor did they provide

any insight into the statistical similarity or differences that may or may not exist between the models they did present. On p 12 they also state "no comprehensive set of total sediment load samples exists for the sites on Goodwin Creek and the Toutle River". Again, what did they use for data? From a technical standpoint, there is no documentation in the report as to 1) whether X:Y pairs for sediment transport and discharge as defined by Troendle 2000 were used, 2) the specific procedures used to fit the basic sediment rating curve if X: Y pairs existed, 3) how they estimated the 1.5 year discharge and sediment concentration, and 4) how they normalizing the individual X:Y pairs, and actually derived the dimensionless transport models presented. The procedure outlined by Troendle 2000 is very specific and simple to follow. Given that the X:Y pairs could not be presented for some of the 4 watersheds (as stated on p 12), I don't understand how the recommended procedure could have been followed. If, in fact, the models were not developed using the recommended least squares techniques that might explain why no statistical comparisons were presented. Even with respect to the data that were presented for the Toutle River at Kid Valley for 1987 and 1988 in Fig. 15b, the analytical procedure is not clearly presented. They present two models and imply that the transport in 1987 was higher than in 1988 but they do not present a statistical summary documenting that the two models significantly differ. Levels of statistical probability should always be presented when discussing similarity or difference in analytical models.

In summary, I think that some of the concerns expressed by Kuhnle and Simon regarding the Reference Sediment curve and its application are those that we ourselves raised, and addressed, in our reports (Troendle 2000, Troendle et al 2001). Forcing all models through 1:1 gives the inherent perception of being problematic. The data set used for our analysis was information derived from nearly 160 watersheds throughout much of the West and consisted of both bedload and suspended sediment data that yielded almost 320 separate models. We could not detect any unexplained trend or bias in those models as a result of the dimensionless transformation. We did observe that watersheds expressing a constant sediment concentration, or rate, could not be used in the analysis and were deleted. Most would agree that a watershed exhibiting a constant sediment concentration, or rate, regardless of discharge is either departed or not well defined. In application of the procedure, streams exhibiting a constant sedimentation concentration get flagged as being departed and are treated as such. We also observed that in order to be useful in the model fitting process, sediment/discharge pairs had to extend well beyond the 1.5-year event in order to obtain a properly defined model and not be influenced by the 1:1 intersect. We did observe that some of the historical data sets available for our use did not meet these criteria and they may or may not have contributed to our inability to detect a Stream Type effect. However what we did produce was a "First Generation" Dimensionless Sediment Transport curve for the Rocky Mountain Region extending out to the 20 or 25-year event. We have since tested that model against other data sets not used in its generation and not reported on (perhaps as many as 8 or 10 additional sites that are not reported in any of our documents) and it still appears to be valid. What we have presented to date is presented as a Hypothesis on how things might work. A hypothesis to be tested further. The qualitative comparison done by Kuhnle and Simon, using data of questionable applicability, from 4 streams does not constitute a valid test of that hypothesis.

What needs to be done is:

1) Identify viable, high quality, sediment transport/discharge pairs, for a variety of streams, from other regions and determine if they demonstrate a similar, different, or no response pattern when presented in a dimensionless format and compared with the Rocky Mountain Model.
2) Develop a User Guide to insure the consistent and rigorous application of the procedure both in evaluation and application efforts. It was apparent in the Kuhnle and Simon report that they either did not read the Troendle 2000 draft report they cited or if they did read it, they did not understand the methodology. A User guide would help resolve the latter situation.
3) If the development of Regional Reference Curves proves viable elsewhere, determine if departure can be reliably determined in those Regions and determine the degree of model similarity between regions.
4) If the development of Regional Reference Curves does not prove viable, explore alternative uses of the existing databases to provide base line reference condition, and variability, for reliably detecting departure in other systems. This option can be done in conjunction with the others.