SYNOPSIS OF OUTCOMES FROM THE FEDERAL INTERAGENCY WORKSHOP ON TURBIDITY AND OTHER SEDIMENT SURROGATES

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ABSTRACT

The goals of the April 30-May 2, 2002, Federal Interagency Subcommittee on Sedimentation Workshop on "Turbidity and Other Sediment Surrogates," were to (1) propose a technically supportable, unambiguous definition of turbidity, and (2) describe the proper use, capabilities, and limitations of turbidimeters and other instruments for providing reliable surrogate data to characterize selected properties of suspended sediment, and for sediment-flux computations.

There is considerable ambiguity in the definition, meter calibration, and measurement of turbidity. Turbidity measurements can be unreliable and relatively inaccurate. A new standard method for measurement of the optical properties of natural water and wastewater is recommended. Standard and reliable procedures are needed for measuring and storing data on water clarity and suspended sediment, and for computing sediment fluxes.

INTRODUCTION

Methodologies for quantifying the clarity or solid-phase content of surface waters that require routine collection and subsequent analysis of water samples are well established (Wilde and Gibs 1998, Edwards and Glysson 1999). However, these traditional methods are increasingly being forsaken in favor of less expensive, potentially safer continuously recording in-situ methods for monitoring water clarity and (or) for obtaining surrogate[1] data for quantification, including analysis of uncertainty of selected sedimentary characteristics of surface waters. Monitoring turbidity is the most common means for obtaining water-clarity data, and for inferring suspended-sediment concentrations. Other sediment-surrogate measurement techniques, including those based on laser-optical, digital-optical, acoustical, and pressure-differential technologies, are increasingly being used (Gray et al. 2003).

The proliferation of instruments for measuring water clarity and the sedimentary properties of water has occurred despite a lack of nationally accepted standards for collection or use of data derived from these techniques. For example, there are currently many designs of "turbidity" meters (turbidimeters) that use different approaches and light sources to determine "turbidity" in situ or in a sample. Some are based on the International Standards Organization standard 7027

[1] As used in this report, a surrogate is an environmental measurement than can be reliably correlated with an in-stream characteristic, such as concentration or particle-size distribution of fluvial sediment. Surrogate data are typically easier, less expensive, and (or) safer to collect than the target variable, and may enable reliable estimates of uncertainty associated with the measurement.

(ISO 1999); some are based on the U.S. Environmental Protection Agency Method 180.1 (U.S. Environmental Protection Agency 1999); and some are based on neither of these standards, yet, all derivative data from these methods are reported as "turbidity." A need for better understanding and standardization of data produced by turbidity meters and other sediment-surrogate technologies was the impetus for holding the Workshop on "Turbidity and Other Sediment Surrogates."

The goals of the Workshop were to:

- Propose a technically supportable, unambiguous definition of turbidity,
- Describe the proper use and limitations of instruments to measure turbidity of a stream and to infer suspended-sediment concentrations from turbidity, and
- Identify capabilities and limitations of other instruments and (or) techniques that might be used to measure concentrations and other selected characteristics of suspended sediment and compute sediment fluxes.

Outcomes from the Workshop, summarized by Gray and Glysson (2003), were derived through results of a pre-Workshop questionnaire completed by representatives from most of the States and some Tribes; through measurements of the turbidity of blind quality-control samples made during the Workshop; and through the deliberations of the following four breakout sessions:

- Definition of Optical Methods for Turbidity and Data Reporting.
- Use of Optical Properties to Monitor Turbidity and Suspended-Sediment Concentration.
- Computing Suspended-Sediment Records Using Surrogate Measurements.
- Other Fluvial-Sediment Surrogates.

The major findings and recommendations from the Workshop are described in the following sections.

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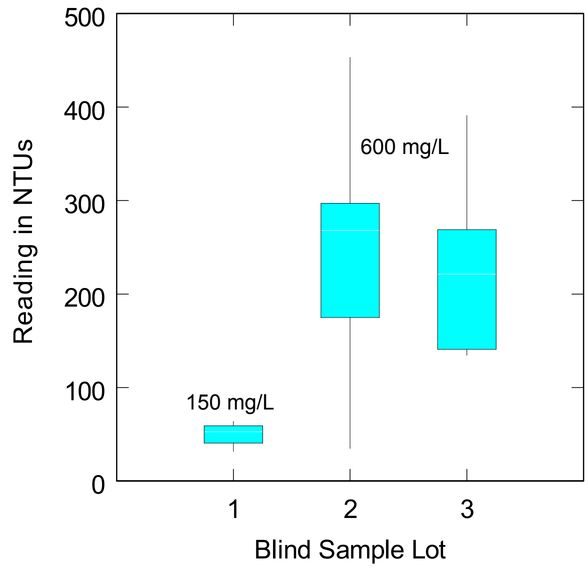
MAJOR FINDINGS FROM THE WORKSHOP

The order in which the major findings are provided does not imply ranking of the findings.

1. <u>Nature of Turbidity</u>: Turbidity is a crucial property in water-quality regulation, but it is not a well-defined quantity. Different sensors and standards will produce different results from the same sample. This ambiguity complicates the development of turbidity monitoring programs, regulations based on measured turbidity, and the application of estimates of water clarity and sediment concentrations based on those data.

2. Variance in Turbidity Measurements: A review of standard calibration protocols from different manufacturers had noted differences of less than 5 percent among the standards. However, the range and standard deviations associated with measurements of quality-control samples under the relatively controlled conditions of the workshop blind-sampling session for samples containing sediment concentrations of about 150 (blind sample lot 1) and 600 (blind sample lots 2 and 3) milligrams per liter were comparatively large (Gray and Glysson 2003; see figure at right).



These results infer a lack of rigor in the turbidity-measurement process, and indicate that the variability in recorded nephelometric turbidity unit (NTU) values with calibration standards is small compared to other sources of variance, including those associated with the operator, the measurement technology, subsampling, and uncontrolled environmental factors. They also provide one means for estimating minimum variances associated with field-derived turbidity values.

3. Turbidity Metrics: All but 5 of the 40 agencies that responded to the questionnaire indicated that narrative or numeric standards (metrics) for turbidity have been established in their jurisdictions. In addition to these water-quality standards, several agencies are using either turbidity or total suspended solids (TSS) data to identify sediment-impaired streams or stream reaches to develop Total Maximum Daily Loads for sediment (U.S. Environmental Protection Agency 2003).

4. Turbidity as a Surrogate Measurement: Agencies responding to the questionnaire identified water clarity as the parameter of primary interest when measuring turbidity. Several agencies have correlated either turbidity or TSS with habitat or aquatic life. Reported ranges in turbidity vary widely among reporting agencies, ranging from below detection limits to over 10,000NTUs. The majority of agencies are using instruments operating on the bulk optical properties of the water-sediment mixture, including turbidimeters, optical backscatter meters (OBS), and optical transmissometers to infer turbidity, and analyses of grab samples to provide the comparative suspended-sediment concentration or TSS data.

5. Turbidity Calibration Standard and Method: The majority of States and Tribes who responded to the questionnaire and that measure turbidity use formazin as a calibration standard and U.S. Environmental Protection Agency Method 180.1 for analysis.

6. Turbidity Data Storage: The majority of the agencies responding to the questionnaire use Oracle, STORET, or a local database or spreadsheet for data storage and analysis. Data currently are stored under a parameter code designated as "turbidity" and no distinction is made between data collected using different equipment technologies or collection procedures. As illustrated by the blind sample test, considerable variance among measurements of the same sample can exist. Because of this, the existing data will probably not be comparable with data in other data sets and possibly not compatible within a given data set.

7. Proliferation of Other Sediment-Surrogate Technologies: A number of surrogate technologies other than turbidity are being used to infer suspended-sediment concentrations and other characteristics of fluvial sediment. These data suffer from many of the same drawbacks as those associated with turbidity, including the lack of reliable standards for in-situ calibration.

PRINCIPAL WORKSHOP RECOMMENDATIONS TO THE FEDERAL INTERAGENCY SUBCOMMITTEE ON SEDIMENTATION

The order in which the principal recommendations are provide does not imply ranking.

1. Turbidity Definition: Adopt the current definition of turbidity for natural water and wastewater, contained in ASTM Standard Test Method for Turbidity in Water, D 1889-00 (ASTM International, 2002), as follows: *Turbidity—an expression of the optical properties of a sample that causes light rays to be scattered and absorbed rather than transmitted in straight lines through a sample. (Turbidity of water is caused by the presence of suspended and dissolved matter such as clay, silt, finely divided organic matter, plankton, other microscopic organisms, organic acids, and dyes.)*

2. New Turbidity Standard Method: Adopt a new standard method for measurement of the optical properties of natural water and wastewater. The method should include a hierarchical decision tree for selection of an instrument for a specific application. The method should specify that the different instrument types and models will yield different turbidity results and generally should not be expected to be equivalent. Existing water-quality monitoring guidelines, with consideration for instrument manufacturer protocols, should be updated to reflect the new standard method.

3. Storage of Turbidity Data: Until a uniform industry standard is developed for the measurement and storage of the optical properties of water, consider storing the derivative data on the basis of instrument manufacturer, an instrument identifier, and sensor mode, or use another method that captures most or all of the specific information that may enable eventual adjustment of these data. Data descriptors for internal and external use with a detailed description of the turbidity methodology should be included in the database. A set of proposed turbidity reporting units to differentiate between various instruments and methodologies should be developed (data reporting should consider and include incident light wavelength, orientation and number of detectors, instrument manufacturer, model number, calibration measurement documentation, reporting of variability, and other relevant factors.)

4. Retrospective Turbidity Comparisons: Quantify instrument differences to enable valid comparisons that may be required for retrospective data mining for comparison of data collected by new and historical techniques. Document the percentage difference in data derived by historical and newer methods, and include references for published reports that compare turbidity data collected with different instruments and (or) methods.

5. Technology Transfer and Communication: Increase technology transfer between groups and individuals with interests in turbidity and other sediment-surrogate technologies. A steering committee should be formed that includes a coordinator and topical expert advisers on turbidity and on other sediment-surrogate technologies. Resources associated with the steering committee may include publication of a newsletter, creating and maintaining a web-based compilation of information, supporting user groups and on-line help, documenting methods, transferring industrial technology to the environmental field, and otherwise providing guidance to the Subcommittee on Sedimentation.

6. Stakeholder and Peer Review: Keep the public and users of turbidity and other sediment-surrogate data informed of the issues involved in producing these data, including assumptions, limitations, methods, and applicability.

7. Testing and Development Program for Instruments and Methods: Develop a program to foster research, testing, and evaluation of instruments and methods for measuring, monitoring, and analyzing water clarity and selected characteristics of fluvial sediment by cost-effective, safe, and quantifiably accurate means. Technically supportable and widely available standard guidelines for sensor deployment, calibration, and data processing (including real-time data), are needed. Acceptance criteria for data from given parameters, such as suspended-sediment concentration, should be developed, endorsed by the Subcommittee on Sedimentation, and widely advertised to encourage methods and instrumentation development.

8. Collection and Computation of Sediment-Surrogate Records: Develop standardized procedures for the collection of sediment-surrogate data. This should include protocols for instrument calibration and criteria for acceptance of the derivative sediment data. A standard procedure for computation of sediment-discharge records should be developed for all sediment-surrogate records utilizing the fullest set of data.

9. Technical Needs for Turbidity Measurements: The agencies responding to the questionnaire identified several technical needs related to turbidity including:
   a. Improve the understanding of the relation between turbidity, total suspended solids, suspended-sediment concentration, channel stability, and biological impairment.
   b. Establish reference conditions for fluvial sediment, and a means of measuring significant departure from reference conditions.
   c. Develop a consistent data-collection protocol and less expensive probes that can be rapidly deployed and are stable in the field.
   d. Obtain more long-term stream discharge, suspended-sediment, bedload, and bed-material data.

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