Breakout Session IV, Sediment Data: Management, Sediment-Flux Computations, and Estimates from New Technologies

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Breakout session IV had *two major* topics assigned to it that *integrate issues* across breakout sessions I, II, and III. The results are presented in the two following sections: Sediment-Data Management, and Sediment-Flux Computations.

Sediment-Data Management

<u>Background ("Big Picture") Considerations:</u>

I. How are sediment data being used in a broad sense? Principal uses of sediment should be served effectively by sediment-data-management designs. Principal uses of data identified in the breakout session were:
    A. Deriving reliable sediment-flux data.
    B. Identifying trends caused by land-use management changes.
    C. Assessing logging rehabilitation efforts.
    D. Assisting in establishing Total Maximum Daily Loads (TMDLs; U.S. Environmental Protection Agency, 2004) for "clean" sediment and contaminants.
    E. Assessing the effects of downstream reservoirs (sediment trapping).
    F. Predicting or quantifying effects of dam removal.
    G. Monitoring fisheries habitat and stream restoration efforts.
    H. Maintaining conveyance of navigation channels.

II. What data-management format(s) are optimal for these sediment-data users?
    A. Nearly all are using relational database management systems (RDBMS).
    B. These RDBMS must be (and almost always can be) accessible using Structured Query Language (SQL), an American National Standards Institute standard computer language. SQL statements are used to retrieve and update data in a database, which makes them adaptable for use by other database software, statistical packages, and advanced web software.
    C. An essential feature for sediment databases is consistent definitions of each specific sediment and ancillary parameter. Valuable data attributes, in addition to site information, dates and times, should include method of sampling, method of analysis, and a quantitative uncertainty associated with the measurement.

III. How do new technologies of sediment measurement and estimations from surrogates challenge sediment-data-management methods?
    A. The advent of automatically and continuously monitored sediment data requires sediment time-series data storage, with time units of 15 minutes becoming typical.
    B. New technologies use one of a number of different operating principles and hence yield data that may be biased from or have a different variance than data produced by traditional methods (Edwards and Glysson, 1999). The uncertainty of different methods is not adequately quantified. Differences in sediment characteristics determined by different methods at a site may represent a bias between two methods; or simply greater measurement variance between methods.
    C. Additional ancillary data that quantify the relation of the surrogate to the target sedimentary property (see below) are essential. For example, ancillary data are needed to define how optical technologies measure water/sediment properties (laser, OBS, turbidity, digital photo-optics; Gray and Gartner, 2004).

<u>Status of sediment-data management and storage:</u>

IV. How are data being managed now?
    A. Discrete and composite samples, and those collected by the Equal-Width-Increment or Equal-Discharge-Increment methods (Edwards and Glysson, 1999) are stored in typical water-quality sample-data format and databases (Turcios and others, 2001; U.S. Geological Survey, 2004a). Raw analyses of sediment concentrations and particle-size distributions determined from physical samples are also in this database and in individual sediment

laboratory databases. Another example targeting sediment-associated parameters is the USEPA "National Sediment Quality Survey Database: 1980-1999" (U.S. Environmental Protection Agency, 2004). Computed daily values of sediment load are stored in time-series databases. Two examples are Automatic Data Processing System (ADAPS) (U.S. Geological Survey, 2003), and the USGS "Suspended-Sediment Database: Daily Values of Suspended and Ancillary Data" (U.S. Geological Survey, 2004b).

B. Databases are commonly developed and utilized for individual projects. These may offer maximum flexibility to the specific project, but often severely limits the availability and overall usefulness of the data, unless the data also are stored in a more distributed RDBMS.

<u>Details of sediment-data management and storage:</u>

V. What data need to be managed in any database, and which data elements are considered primary or secondary?

Recommendations for primary data elements:

A. Quantitative (model) uncertainty of any computed value.

B. Qualitative remark codes for data where uncertainty cannot be quantified.

C. Store all samples with appropriate quality-control flags.

D. Storage of sediment-surrogate unit values at the same time interval on which they are recorded.

E. Archiving original (raw) electronic data sets.

F. All available particle-size distribution data should be stored electronically.

G. Flag sediment data estimated or computed from surrogate data using a flag specific to the type of surrogate used.

H. Store and archive documentation of descriptions of the surrogate technology, the instrumentation, any calibration techniques or equations/models used.

I. Models and computations should be done in units that are consistent or are easily comparable.

J. Store raw analyses of sediment data in sediment lab database or make provisions to more easily move data from lab database to permanent agency database.

Recommendations for secondary data elements:

K. Original (raw) data should be stored in same database (side by side) as computed data.

L. Archive models or equations used to estimate sediment value from a surrogate value.

M. Document and archive overall uncertainty including model and measurement or calibration errors.

N. General Data-Management Observations

O. There are substantial gaps between current sediment-data-management methods and the methods needed to accommodate newly developing technologies. Developments in instrument technology are moving far faster than efforts to test, evaluate and approve their use.

P. Existing databases generally are not sufficient to manage and archive data collected using new, unique or non-standard methods.

Q. General Data-Management Recommendations

R. Expeditiously establish and approve new protocols for use of new technologies so that data generated by these means can be made available to the wide group of interested parties, not just individual project or internal agency personnel.

S. Make non-standard data – not collected or computed by approved methods – tagged with reliable uncertainty estimates available to the public; otherwise non-standard data should be appropriately flagged as "incomplete."

T. The Subcommittee on Sedimentation should form a task group to establish guidance for sediment-database management. This guidance should include required and recommended characteristics of sediment databases. The guidance should address specific parameters and ancillary data requirements, as well as database functionality, availability, and distribution.

U. The Subcommittee on Sedimentation should consider formation of a sediment-data clearinghouse and establish minimum requirements for those data.

Sediment-Flux Computations

<u>Background ("Big Picture") Considerations:</u>

The potential users and applications of sediment-flux information are increasingly diverse as sediment and sediment-associated constituents become water-quality and habitat-limiting factors in an increasing number of streams nationwide.

I. What time scales are being used and are needed? [Ranging from annual or seasonal to real time]

A. All time intervals are being used and are needed as follows:

   1. Real-time data for environmental impact assessment or management, health impacts for recreational users, intake quality for drinking water and other commercial users, and managing for impacts as they occur, including storm events and point source spills.
   2. Sediment-flux information during storm runoff and discharge peaks can now be characterized. Traditionally this information was difficult to obtain through collection of physical samples.
   3. Use of surrogates to estimate sediment concentrations for flux computations can yield fast turn-around times for peak load estimates and assessments (TMDLs).
   4. Daily, seasonal, and annual flux estimates continue to be needed.
   5. Decadal or longer climatological studies are needed.
   6. The appropriate time scale may depend on the sediment sources.
   7. Different time scales for data may be needed to drive models (physical and empirical).

II. What spatial scales are needed and what are the uses?

   A. Scales involving multiple cross sections for evaluation of changes through reaches, or to define variations in transport among riffles and pools.

   B. Multiple sampling and monitoring locations are needed to define incoming tributary loads or reduced sediment loads from management practices.

   C. Adequate spatial resolution is needed to evaluate non-point source affects.

III. How may the sediment characteristics measured or estimated in continuous time series from surrogate measurements change the capabilities and accuracies of sediment-flux computations?

   A. Has potential to greatly increase the accuracy of computations due to increased frequency of surrogate measurements to better characterize natural temporal variability in sediment characteristics. Data will provide validation or calibration for models.

   B. High temporal resolution data may elucidate sediment processes that can in turn be used to improve physically based models.

   C. Some surrogates provide better spatial resolution and are representative of larger sample volumes. For example acoustic backscatterance may ‘measure’ a sample volume of many cubic feet and can do so at a frequency that results in orders of magnitude more streamflow being measured compared to traditional techniques.

   D. Laser diffraction devices may provide capability to obtain time-series particle-size distribution information that can lead to improved models, rating curves, and sediment management.

   E. Time-series data may allow determination of sediment sources and rates of transport for different particles sizes (suspended sediment and bedload).

   F. Surrogates other than water discharge will enable us to observe changes in sediment flux that are not represented by streamflow.

   G. Provisional data may be available in near-real time.

   H. Has ability to identify and incorporate the sedimentary attributes of floods into computations and models that would otherwise be missed or misinterpreted by collecting only routine samples.

   I. Has capability to define sedimentary extremes for runoff periods, particularly maximum values, that could not be determined without collecting numerous physical samples, sometimes in hazardous situations.

   J. Some surrogates that may supply sediment-flux information are being collected to obtain other kinds of information. Thus, they have multiple values and they are available without additional cost. For example acoustic backscatterance data are being collected for water discharge in ADCP measurements and Index Velocity stations. Turbidity data are being collected at many stations as a measure of the bulk optical property of water.

IV. What additional data/information are needed when computing sediment flux from surrogate parameters?

   A. Ancillary data that can influence the relation of surrogates to sediment parameters.
      1. Particle-size distributions
      2. Sediment color
      3. Water and air temperature
      4. Salinity
      5. Organic content
      6. Stream stage and water discharge

   B. Surrogate sensor/instrument calibration information.
      1. Instrument make, model, meter identifier
      2. Records of instrument recalibration or changes in instrumentation

   C. Sensor-to-data calibration: Collect physical samples that represent the immediate vicinity of the sensor and in the cross section and use it to calibrate the sensor output in units of the physical sample.

D. Take independent field measurements of the surrogate being recorded when possible using the same type of instrument.

Details:

V. Models can be grouped by the general methodology on which they are based. These include:
  A. Physically based deterministic models.
    1. Shear-based Transport formulas: Modified Einstein (Stevens, 1985), Meyer-Peter Müller, and others (Stevens and Yang, 1989)
      a. GSTARS (Bureau or Reclamation, 2004)
      b. HEC-6 (U.S. Army Corps of Engineers, 2004)
      c. CONCEPTS (Langendoen, 2000)
  B. Empirical rating-curve models.
    1. Regression (linear, non-parametric, LOESS, etc.)
      a. LOADEST (can use surrogate data) (Runkel and others, 2004)
      b. ADAPS (U.S. Geological Survey, 2003)
      c. Sediment-transport curves (Glysson, 1987)
  C. Empirical time-series interpolation models.
    1. GCLAS (U.S. Geological Survey, 2004c; Mckallip and others, 2001)
  D. Other models.
    1. Statistical time series can use surrogate data
    2. ARIMA estimators
    3. Neural net models

VI. Modeling Needs
  A. Models that can accept multiple parameters of surrogate data as well as physical samples
  B. Ensure that future models/computational software can incorporate multiple parameters of time-series surrogate data
  C. Models and computational software should be able to provide estimates of errors
  D. Models and computations need to be done in units that are consistent or are easily comparable

General Sediment-Flux Observations

A. Flux computations and estimates based on surrogates should be made based on sufficient calibration sample data collected during the time period being computed or estimated. Strongly encourage collection of actual calibration samples during time period and for entire range of the period of interest, whenever possible.

B. Models and computational software should be able to provide estimates of error, preferably expressed in units of the modeled parameter.

C. Models and computations need to be done in units that are consistent or are easily comparable.

D. All models need to have plotting capabilities.

General Sediment-Flux Recommendations

A. Further research and development on existing surrogates are needed to determine if the data being recorded actually represents the sediment parameter of interest. Examples (Gray and Gartner, 2004):
  1. Optical backscatterance
  2. Turbidity
  3. Acoustics (single- and multi-frequency)
  4. Laser diffraction
  5. Pressure difference
  6. Digital-optic imaging

B. Convene a working group to establish minimal standards and criteria for use of surrogates to compute sediment records.

C. Establish a clearinghouse of models, including a description of proper use and limits of the model.

D. Develop and support models that have the ability to incorporate multiple parameters from surrogate data and physical samples.

E. Ensure that future models/computational software can incorporate multiple parameters of time-series surrogate data as well as physical samples

F. Develop protocols for data collection and flux computations that are based on surrogate data.

G. Create the ability to compute transport rates of different particle-size classes; important for contaminant load estimates.

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