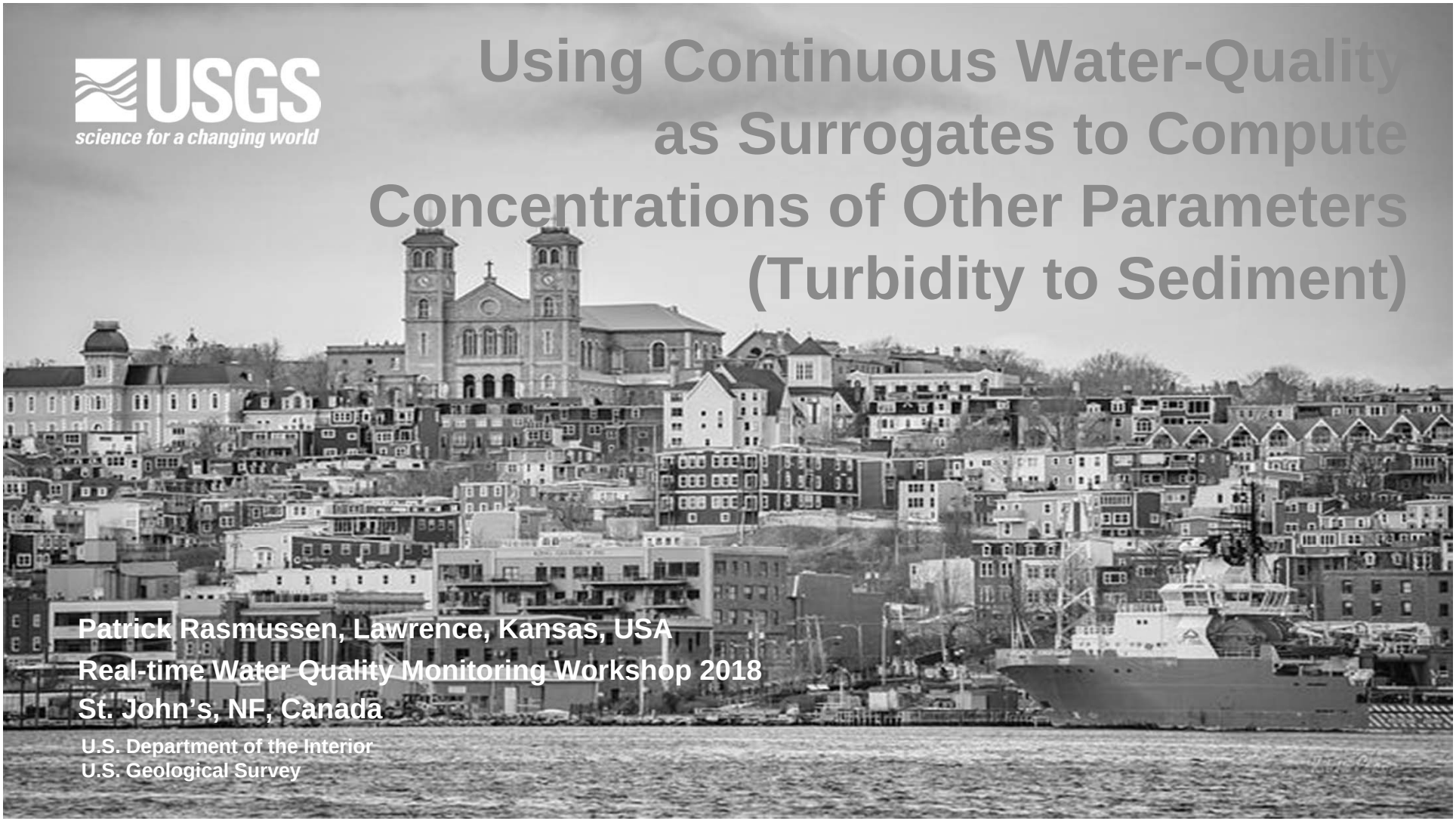


Using Continuous Water-Quality as Surrogates to Compute Concentrations of Other Parameters (Turbidity to Sediment)

Patrick Rasmussen, Lawrence, Kansas, USA

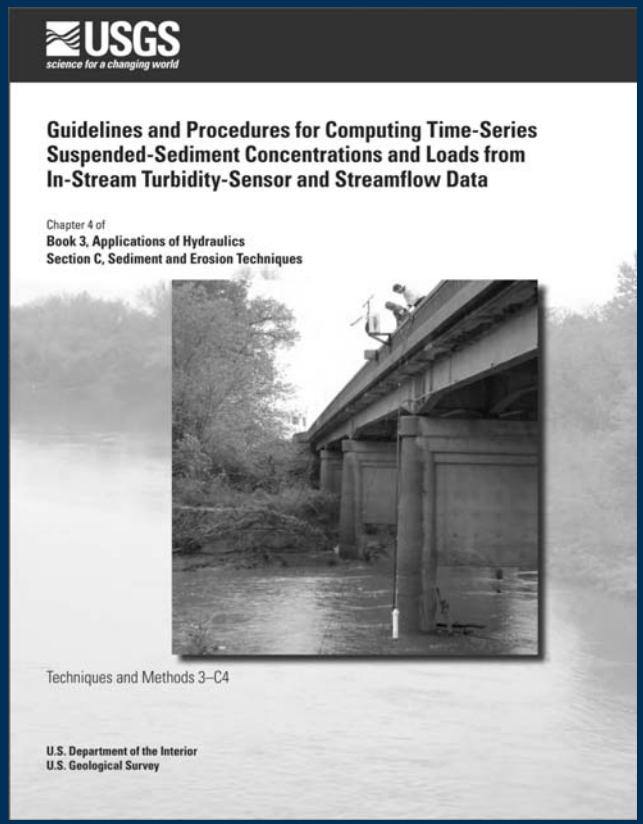
Real-time Water Quality Monitoring Workshop 2018

St. John's, NF, Canada

U.S. Department of the Interior
U.S. Geological Survey

Surrogates for suspended sediment

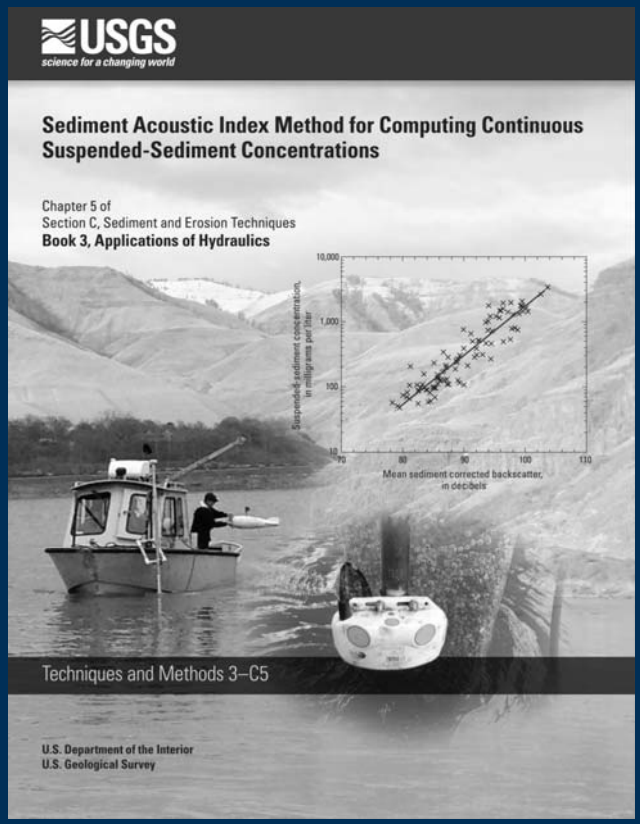
TM3C4 – Rasmussen and others, 2009, Continuous turbidity and streamflow to compute SSC



USGS

Surrogates for suspended sediment

TM3C5 – Landers and others, 2016, Acoustic indices from ADVM backscatter data to compute SSC



USGS

Policy for suspended-sediment surrogates

Tech memo 9/2016 – policy and guidance for SSC surrogates

United States Department of the Interior

U. S. GEOLOGICAL SURVEY
Reston, VA 20192

In Reply Refer to:
Mail Stops 412, 415

September 30, 2016

Office of Surface Water Technical Memorandum 2016.07
Office of Water Quality Technical Memorandum 2016.10

Subject: Policy and guidance for approval of surrogate regression models for computation of time series suspended-sediment concentrations and loads

BACKGROUND

The definition of a surrogate measure is a measurement taken with the intent to gain insight into a variable that is either impractical to measure directly, or not possible to measure at the desired continuous time interval. With a direct and uncomplicated causal relation, surrogate measurements can be nearly as useful as direct measurements although uncertainty associated with individual computed values generally is larger than discrete sample data. Increased temporal data richness could compensate for the larger uncertainty associated with computed data compared to laboratory results from actual samples.

In-situ turbidity, acoustic, and streamflow data, combined with discrete sample data, can be used

General regression model approach

- Install water-quality monitors at streamflow gages and transmit data in real time
- Collect water samples
- Develop regression models using samples and monitor data
- Display computed data on the Web
- Continue sampling to verify models

USGS

Policy for suspended sediment surrogates

(1) Surrogate data and calibration samples are collected using consistent USGS-approved methods

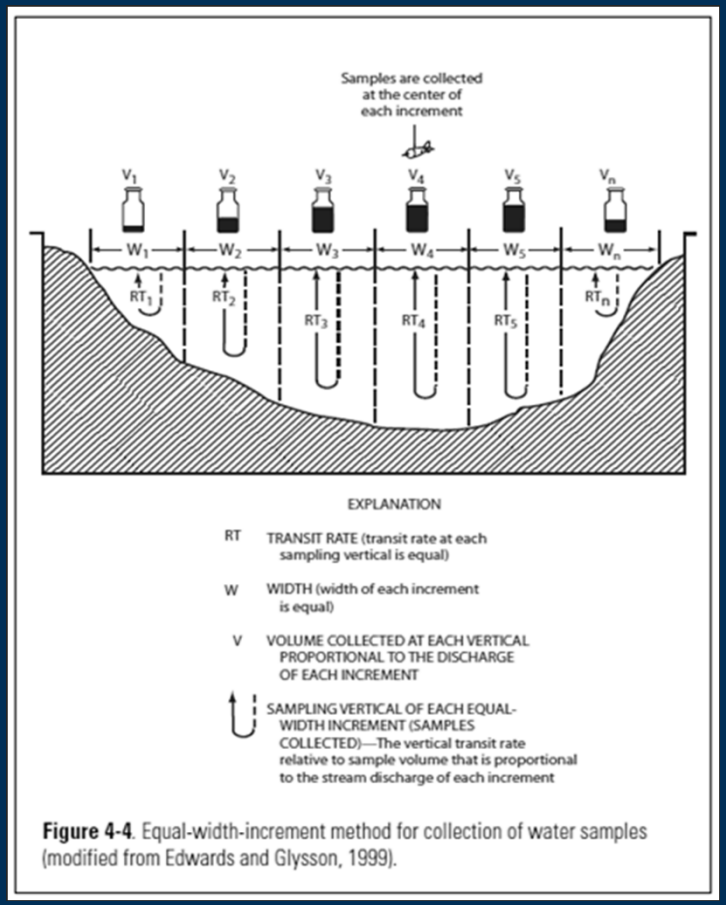
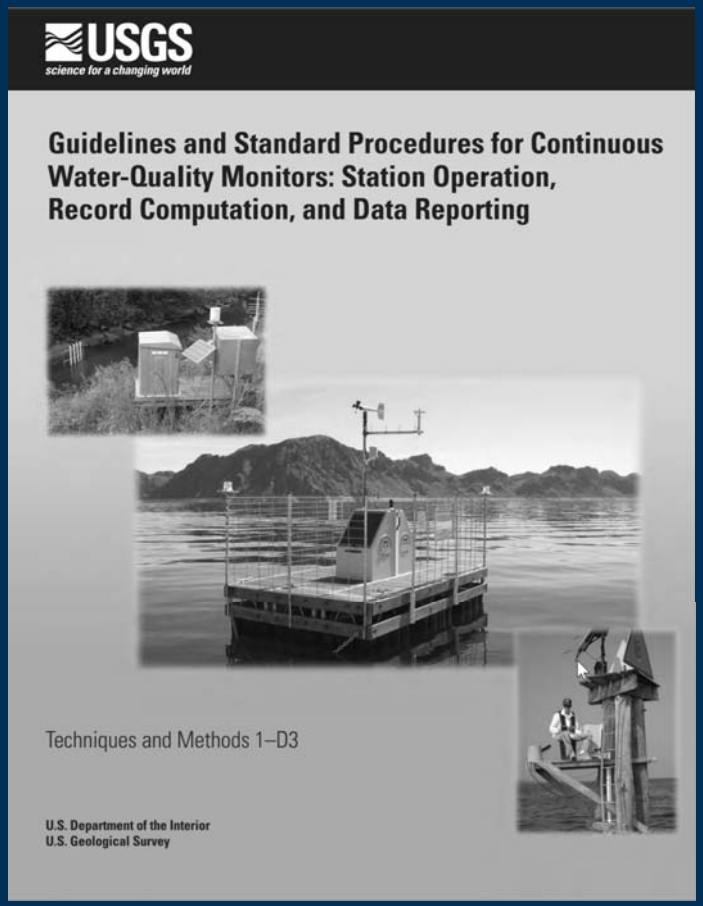


Figure 4-4. Equal-width-increment method for collection of water samples (modified from Edwards and Glysson, 1999).

Sensor data collection

- Don’t “over calibrate” optical sensors
- New wipers are more robust
- Sensor stays clean in velocity



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Policy for suspended-sediment surrogates

(2) Computed data are derived from linear, log-linear, or log-log statistical models developed according to Ordinary Least Squares (OLS) regression methods

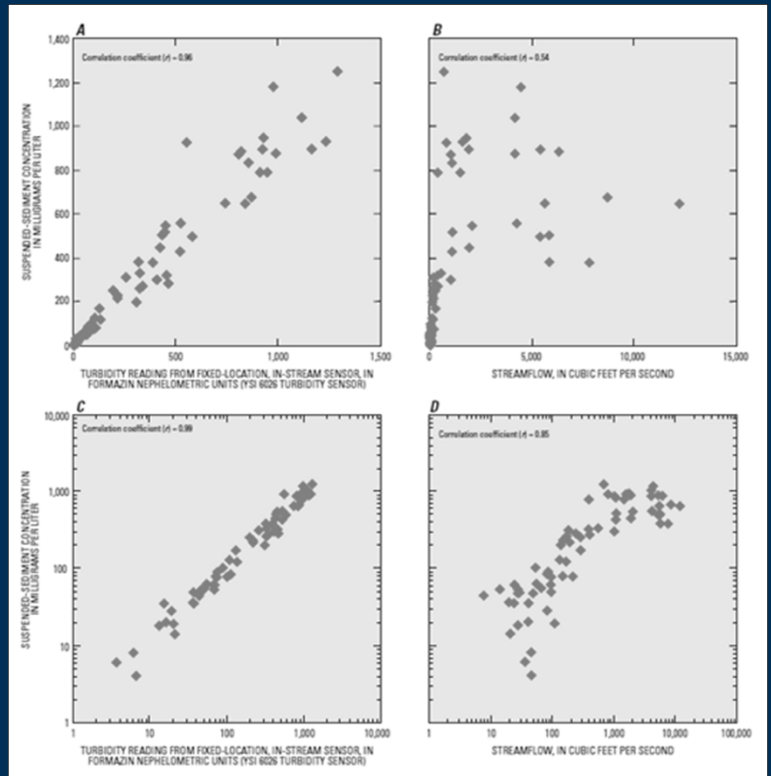
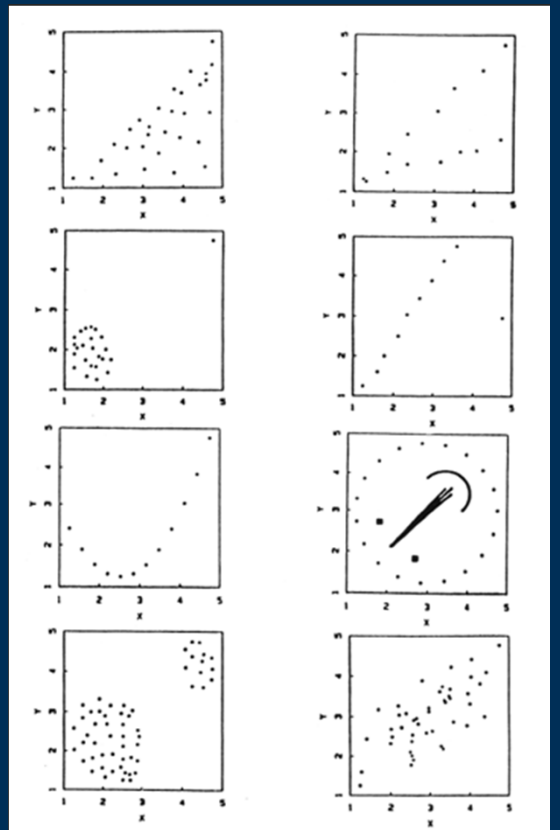


Figure 8. Relations between *A*, turbidity and suspended-sediment concentration, *B*, streamflow and suspended-sediment concentration in linear space, *C*, turbidity and suspended-sediment concentration, and *D*, streamflow and suspended-sediment concentration in $\log_{10}$ space for U.S. Geological Survey streamgage on Little Arkansas River near Sedgwick, Kansas, 1999–2005.

Policy for suspended-sediment surrogates

- Use recommended statistical diagnostics and graphs to evaluate models
  - Residual plots, time series, boxplots, model standard percentage error (MSPE), prediction error sum of squares (PRESS), Mallow's C, others

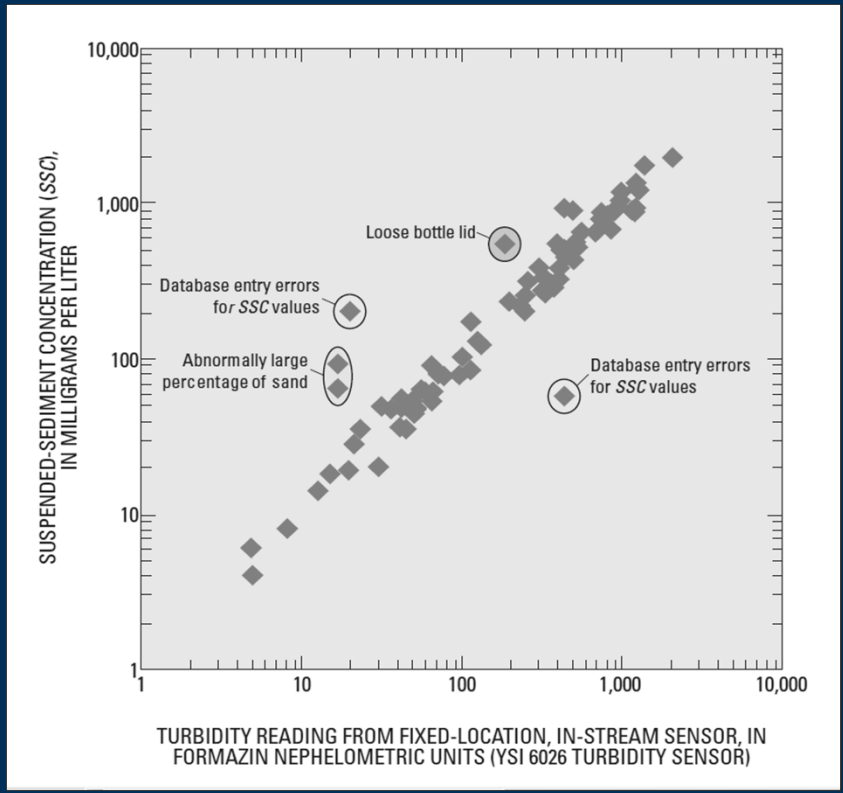


8 scatterplots with $R^2 = 0.70$
(from Helsel and Hirsch, 2002)

USGS

Policy for suspended-sediment surrogates

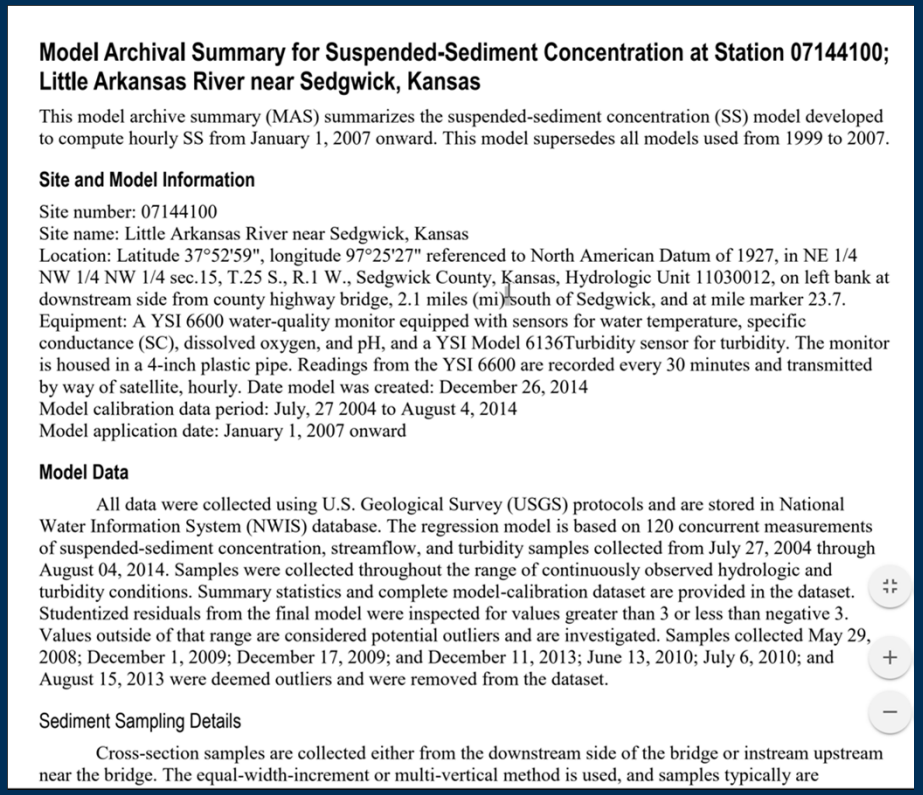
- Exclude outliers only when shown to be errors (or rare circumstance)
- If more than 2-5% of data are non-detects, use different approach (Tobit)
- Include transformation bias correction



USGS

Policy for suspended-sediment surrogates

(3) Each model is documented in an electronic model archive summary (MAS)



Model Archival Summary for Suspended-Sediment Concentration at Station 07144100; Little Arkansas River near Sedgwick, Kansas

This model archive summary (MAS) summarizes the suspended-sediment concentration (SS) model developed to compute hourly SS from January 1, 2007 onward. This model supersedes all models used from 1999 to 2007.

Site and Model Information

Site number: 07144100
Site name: Little Arkansas River near Sedgwick, Kansas
Location: Latitude 37°52'59", longitude 97°25'27" referenced to North American Datum of 1927, in NE 1/4 NW 1/4 NW 1/4 sec.15, T.25 S., R.1 W., Sedgwick County, Kansas, Hydrologic Unit 11030012, on left bank at downstream side from county highway bridge, 2.1 miles (mi) south of Sedgwick, and at mile marker 23.7.
Equipment: A YSI 6600 water-quality monitor equipped with sensors for water temperature, specific conductance (SC), dissolved oxygen, and pH, and a YSI Model 6136Turbidity sensor for turbidity. The monitor is housed in a 4-inch plastic pipe. Readings from the YSI 6600 are recorded every 30 minutes and transmitted by way of satellite, hourly. Date model was created: December 26, 2014
Model calibration data period: July, 27 2004 to August 4, 2014
Model application date: January 1, 2007 onward

Model Data

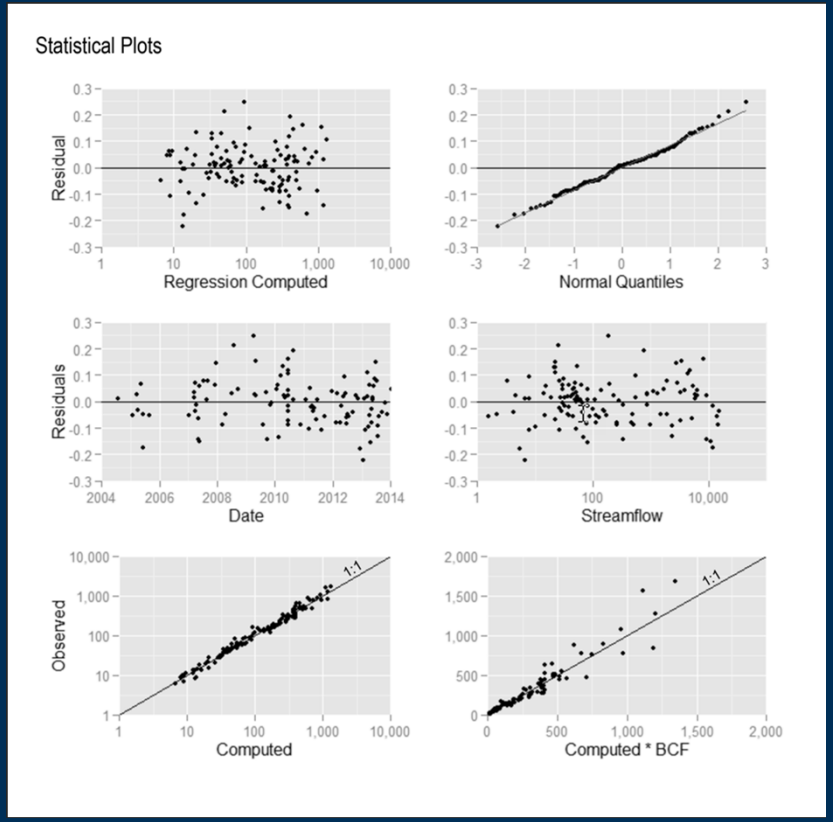
All data were collected using U.S. Geological Survey (USGS) protocols and are stored in National Water Information System (NWIS) database. The regression model is based on 120 concurrent measurements of suspended-sediment concentration, streamflow, and turbidity samples collected from July 27, 2004 through August 04, 2014. Samples were collected throughout the range of continuously observed hydrologic and turbidity conditions. Summary statistics and complete model-calibration dataset are provided in the dataset. Studentized residuals from the final model were inspected for values greater than 3 or less than negative 3. Values outside of that range are considered potential outliers and are investigated. Samples collected May 29, 2008; December 1, 2009; December 17, 2009; and December 11, 2013; June 13, 2010; July 6, 2010; and August 15, 2013 were deemed outliers and were removed from the dataset.

Sediment Sampling Details

Cross-section samples are collected either from the downstream side of the bridge or instream upstream near the bridge. The equal-width-increment or multi-vertical method is used, and samples typically are

Policy for suspended-sediment surrogates

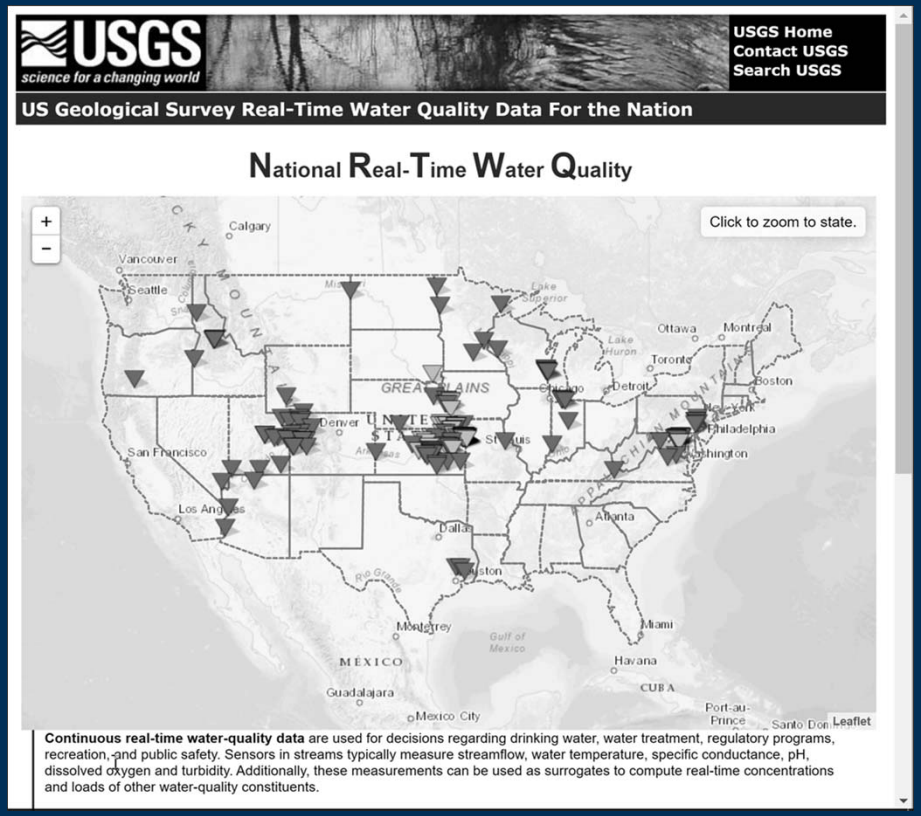
(3) Each model is documented in an electronic model archive summary (MAS)



USGS

Policy for suspended-sediment surrogates

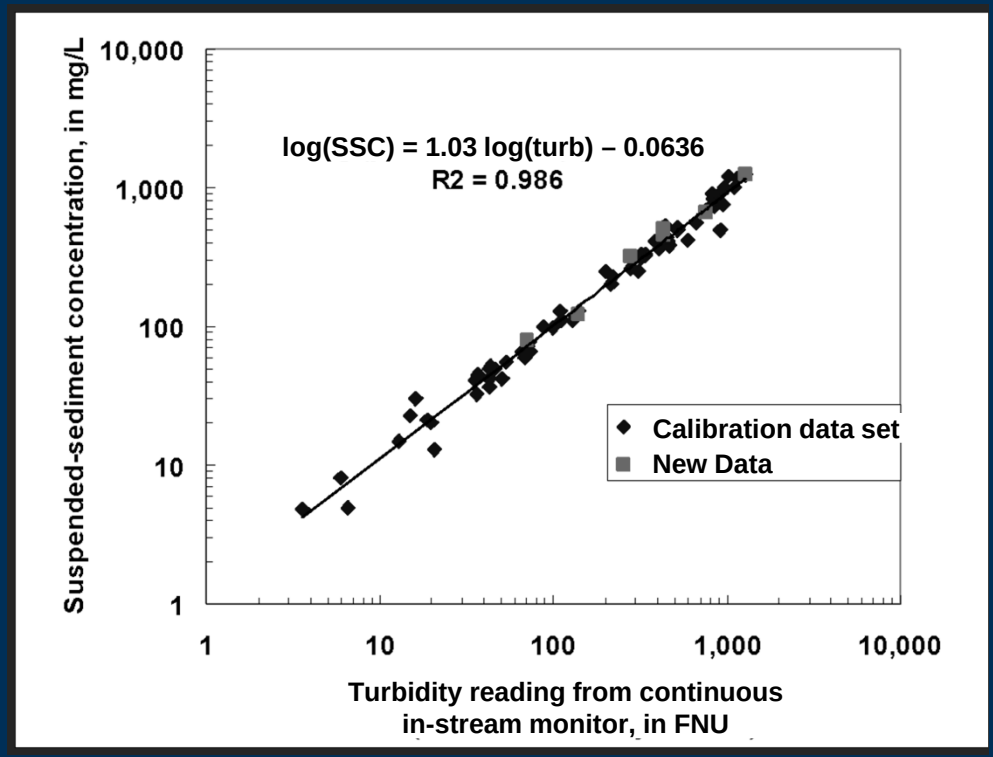
(4) Once the MAS has been approved and publicly released, the computed suspended-sediment data may be disseminated to the public



USGS

Policy for suspended-sediment surrogates

(5) Continued sampling is required after model development to validate model performance if models are used to estimate suspended-sediment concentrations or loads



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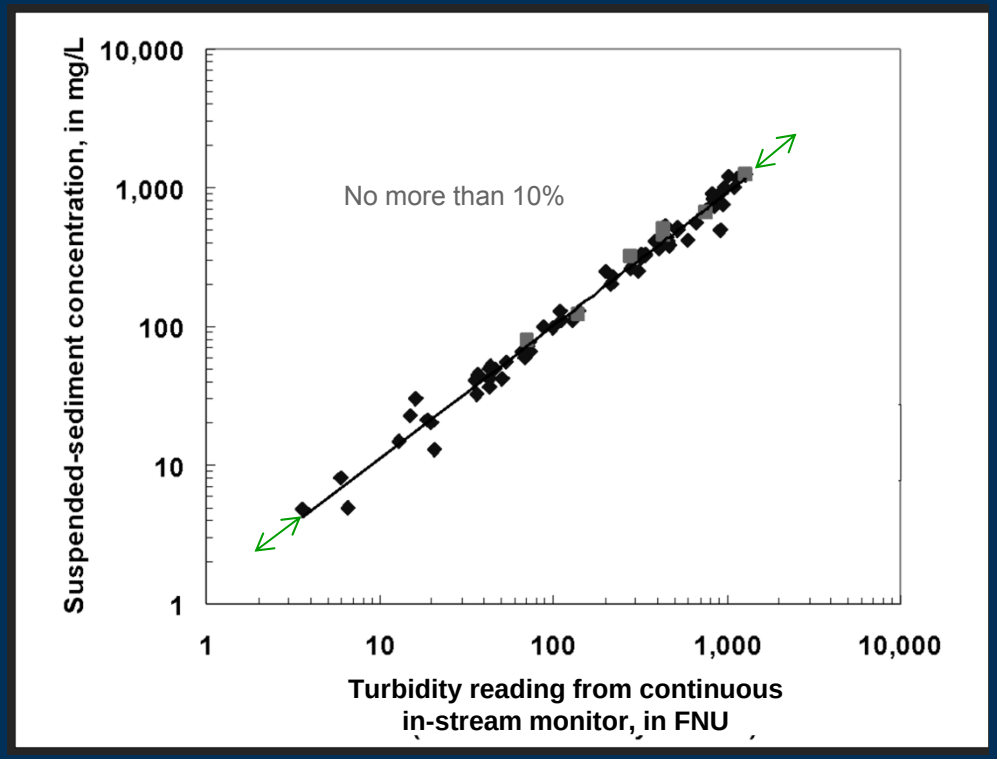
Policy for suspended-sediment surrogates

(6) Data interpolation defined as estimation between measured unit values and extrapolation defined as computation beyond the range of the model calibration dataset are permitted to a limited extent



USGS

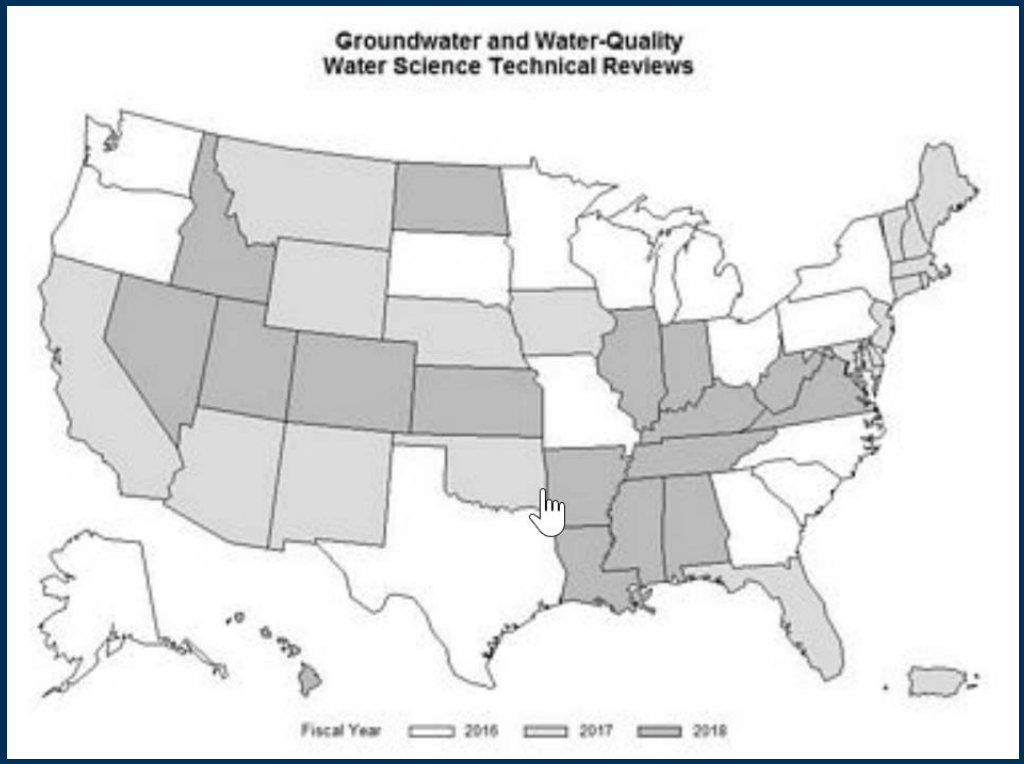
Policy for suspended-sediment surrogates

(7) Surrogate regression models as described in this memorandum are used to compute suspended-sediment concentration or load on the basis of observed explanatory variable(s) and cannot be used alone to predict future suspended-sediment concentration

USGS

Policy for suspended-sediment surrogates

(8) Surrogate models and applications of this policy are reviewed during triennial technical reviews



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Policy for suspended-sediment surrogates

(9) This policy describes the standard approach for surrogate regression models for suspended sediment. Models documented in interpretive reports published previous to this memorandum may continue to be used if validation sampling and ongoing model evaluation are completed as described in this memorandum

USGS

Policy for suspended-sediment surrogates

(10) A Bureau-approved interpretive report is required when conditions described in this memorandum are not met. This includes using alternative methods for collection of continuous and discrete data, sensor technologies, laboratory analyses, statistical model-building, and data computation

USGS

Examples of other published water-quality surrogates

Water-quality constituent	Surrogate
Acetochlor, metolachlor	TBY, Q, sin/cos
Actinomycetes bacteria	TBY, sin/cos
Alkalinity	SC, Q, WT
Arsenic	SC, Q
Atrazine	SC, Q, TBY, sin/cos
Calcium, magnesium, potassium, sodium	SC, Q
Chloride	**SC**, Q, sin/cos
Dissolved organic carbon	fDOM
Dissolved solids	**SC**
Fluoride	SC, Q, sin/cos
Geosmin	TBY, Q, sin/cos
Indicator bacteria	**TBY, Q**, SC, sin/cos
Iron	SC, Q, sin/cos
Microcystin	fCHL, sin/cos
Salinity	SC, Q
Selenium	SC, Q, sin/cos
Suspended sediment	**TBY, Q, acoustic backscatter**
Total mercury, methylmercury	TBY, fDOM
Total nitrogen	**TBY,** Q, fCHL, **NO3+NO2, sin/cos**
Total organic carbon	TBY, Q, SC, sin/cos
Total phosphorus	**TBY,** Q, SC, **sin/cos**
Total suspended solids	**TBY, Q**

USGS

Questions?

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pras@usgs.gov

http://pubs.usgs.gov/tm/tm3c4/

http://water.usgs.gov/osw/suspended_sediment/time_series.html

http://waterwatch.usgs.gov/wqwatch/

http://nrtwq.usgs.gov

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