USGS Chesapeake Bay Activities

Sediment Sources and Transport

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Statement of Problem: Excess sediment is having an adverse affect on the living resources and habitat of the Chesapeake Bay and its watershed. Submerged aquatic vegetation (SAV) has declined drastically in over the past 30 years due to degraded water clarity associated with suspended sediment and eutrophication. Excessive sedimentation can bury or affect the vitality of filter feeders in the Bay. Due to some of these concerns, the Chesapeake Bay was listed as an impaired water body under the Clean Water Act. While nutrient sources and transport to the bay have been addressed over the past 15 years, little is known about sediment sources, sediment transport, sites of deposition, and relation of sediment to water clarity and living resources in the shallow habitats of the Bay. There is a need to determine these sediment processes to formulate a rational sediment-reduction strategy. This study addresses work performed in watersheds draining to the Chesapeake Bay to identify sediment sources in the watershed (i.e. land erosion, stream corridor erosion) and transport processes to the Bay.

Objectives: The principal objective of this study is to determine the watershed sources of sediment in selected non-tidal tributaries of the Chesapeake Bay. This study will coincide with other USGS efforts to understand sediment processes of shoreline erosion, sediment transport in the Bay and sediment resuspension in the Bay. Information from all these sediment processes will be used to understand the relation of sediment delivery to sediment deposition, effects on water clarity, and effects on submerged aquatic vegetation and other biota in the receiving tidal tributaries.

Approach: The approach to identifying sources of sediment will proceed from a large, major watershed scale to a smaller subbasin scale. At each scale various approaches will be used to identify sources of sediment.

The following tasks will be used in the approach to meet the study objectives:

1. Use existing data and modeling results to characterize sediment concentrations, loads, and yields in the major watersheds.

Major watersheds draining into the Chesapeake Bay will be selected for analysis of sediment. The major watershed will be defined based on existing GIS coverages of watersheds already delineated by various Agencies (USEPA, USGS). The scale selected for the major watersheds will depend on already existing political definitions. The major watersheds will be subdivided into portions of the basin that are above the ‘fall line’ and portions that are below the fall line or in the coastal plain.

After major watersheds have been delineated available sediment data will be obtained for each watershed. Sediment data for each major watershed will be characterized as suspended-sediment concentration (mg/L), total suspended-sediment load (metric tons), and sediment yield (tons/km^2). Available data on sediment will consist of both existing data and modeling results (Chesapeake Bay Watershed model; ESTIMATOR model). The sediment data being analyzed suspended sediment collected at streamflow stations by the USGS and other agencies. Other existing data on sediment may be reservoir sedimentation surveys which are typically performed periodically throughout the United States. Reservoir sedimentation surveys performed in the Chesapeake Bay watershed will be located to quantify sediment yield.

2. Use of Cosmogenic Isotopes to estimate sediment yields

Many of the major watersheds will not contain any significant sediment data. Cosmogenic isotopes analysis will be used to estimate sediment yield in these watersheds. Cosmogenic radionuclide abundances in near surface (<1 m) quartz provide a relationship between the rate at which sediment is derived and transported with a drainage basin and the abundance of a cosmogenic radionuclide (Brown and others, 1995; Bierman and Steig, 1996; Clapp and others, 1997). In low erosion areas, sediment at the earth’s surface accumulates a high abundance of radionuclides. Conversely, in high erosion areas the abundance of radionuclides in the sediment is low. Clapp et. al (2001) used the drainage network of the basin as an integrator of sediment from throughout the basin (fluvial integration), and thus interpreted the ^{10}Be concentrations in the stream channel sediments to represent basin-wide average concentrations.

The hypothesis that ^{10}Be concentrations are correlated with sediment yield will be tested at streamflow stations with sediment yield data. Bed material samples of sediment will be collected and analyzed for ^{10}Be. The USGS-Geologic Division, Earth Surface Dynamics Program (team leader Milan Pavich) in collaboration with Paul Bierman at the University of Vermont, will assist in the collection and interpretation of this data. If a relation exists between ^{10}Be concentrations and suspended-sediment yield, samples will be collected at the major watersheds lacking sediment data. If ^{10}Be concentrations from these major watershed plots on or near the correlation line, then these basins may be considered to be in a dynamic equilibrium where sediment eroded from the land surface equals the sediment transport out of the watershed. If ^{10}Be concentrations plot below the line, they represent basins with high rates of erosion. If ^{10}Be concentrations plot above the line, they represent basins with high low rates of erosion or basins that are storing sediment. A combination of existing sediment data, model runs, and ^{10}Be analysis will produce a major watershed ranking of sediment.

3. Sediment Fingerprinting Study

Attempting to relate sediment to its sources is a difficult task. However, there have been advances in the past decade using multiple anthropogenic and natural radio nuclides, and stable isotopes to "fingerprint" sediment sources. The approach necessitates the identification and establishment of a specific physical and/or chemical property to sediment that is specific to that part of the watershed. Fallout radionuclides, in particular, appear to be valuable tracers, as they rapidly adsorb to soil surfaces. Consequently, they are expected to label surface sediments consistently over large areas within a drainage basin and independently of lithology. Fingerprints that are being tested include mineralogy, ^{7}Be, ^{137}Cs, ^{210}Pb, total carbon, nitrogen, and phosphorous, and stable isotopes (N and C). The watershed sampling strategy is focusing on upland sediment sources (land use) and the stream corridor (stream bed and banks and floodplain). Additionally, suspended sediment will be collected in selected watersheds to determine sediment sources during storm events.

The sediment source study began in the Pocomoke River above Willards, MD in 2001 through 2003. The Little Conestoga River Basin, a tributary to the Conestoga River, was studied from 2003 through 2004, and the Mattawoman Creek in Southern Maryland, was studied in 2004.

References Cited

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Selected Reports and Other Products:

Report, Approved: Gellis, A.C., Banks, W.S.L, Langland, M.J., and Martucci, S.K., Summary of Suspended-Sediment Data for Streams Draining the Chesapeake Bay Watershed, Water Years 1952-2002: U.S. Geological Survey Scientific Investigations Report 2004-5056.

Relevance and Benefits: This study provides Chesapeake Bay resource managers and scientists with information that can be used to identify the major sources of suspended sediment to the Bay. Results of this study can be used in conjunction with sediment transport models being developed by the USEPA and USGS for verification purposes.