Sediment Tool

A Simple Method for Erosion and Sediment Delivery Estimation

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United States Environmental Protection Agency

Region4 serving the southeast

Sediment Tool

A Simple Method for Erosion and Sediment Delivery Estimation

- Introduction and background
- Sediment tool: Interface, equations and results
- Quick demonstration
- Georgia TMDL example: Stekoa Creek watershed

EPA Region 4 Sediment TMDL:
What Questions Need to be Answered?

- What is the allowable sediment delivery to a stream or how much sediment is too much?
- Where is the sediment coming from?
- What are the major sources?

To Answer These Questions

- A Joint Southeastern Regional Sediment Project
  - U. S. Forest Service — Region 8 and Coweeta Research Lab
  - Natural Resource Conservation Service
  - EPA Region 4
  - Georgia Forestry and Agriculture Agencies
- Recommended a Sediment Tool based on the USLE

EPA Region 4 Sediment TMDL Objectives

- Develop Sediment Procedures for Sampling, Lab Analysis and Data Analysis
- **<u>Develop a Sediment Modeling Tool</u>**
- Integrate Sediment Protocol with Aquatic Ecology
- Test Protocol across Ecoregions
- Develop TMDLs Protective of Stream Functions and Beneficial Uses

Sediment Model Goals

- Calculate potential source erosion from landuses and roads using GIS spatial data sets.
- Calculate potential sediment delivery to streams.
- Evaluate effects of land use change, BMP implementation, and road network on erosion and sediment delivery.
- Intuitive and easy to use.

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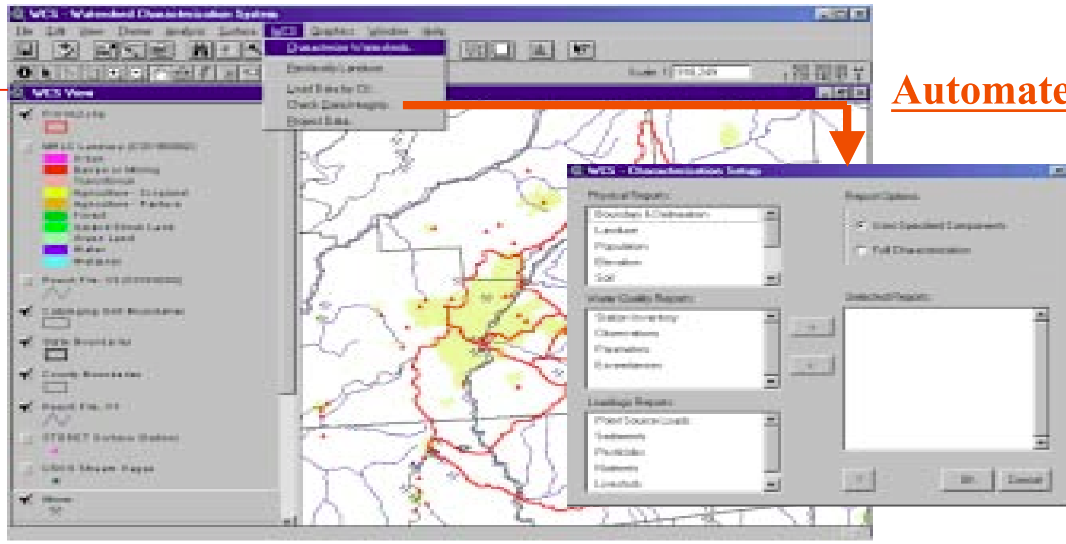
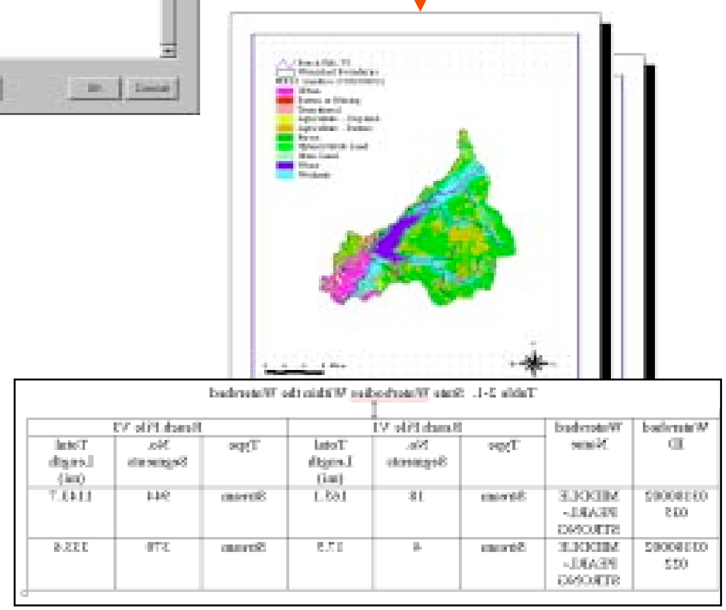
Sediment Tool: An ArcView GIS Extension of The Watershed Characterization System (WCS)

WCS



Automated reports

Maps and Tables



Extensions

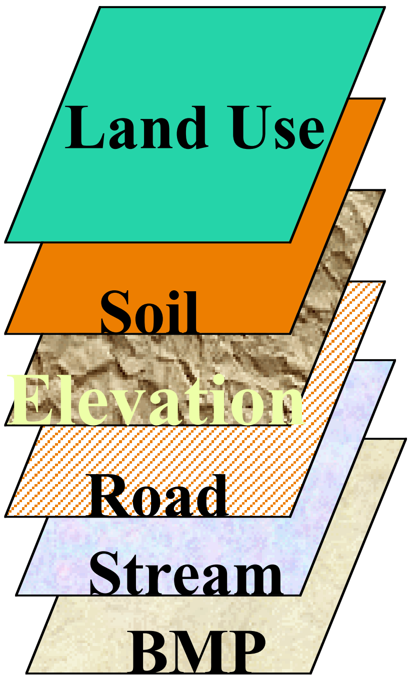
- Additional Menu functions
- Additional Data
- Additional System files
- Supported Models

Watershed Characterization System (WCS)

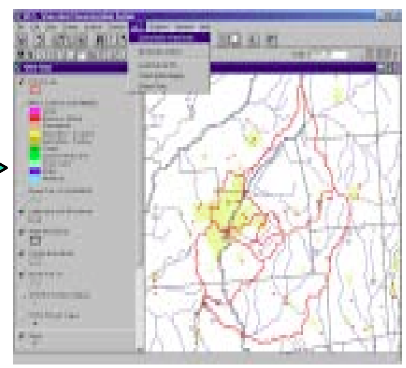
- Characterization of the physical and hydrological properties
- Evaluation of ambient water quality conditions
- Assessment of potential sources of impairment

Sediment Tool: Data Input and Output

- **Input**



- **WCS Core + Sediment Tool**



- **Output**

-Erosion Map

-Sediment Delivery Map

-Sediment Delivery to Assessment Points

-Automated Reports (Maps and Tables)

Soil Erosion

Soil erosion is calculated by the USLE equation:

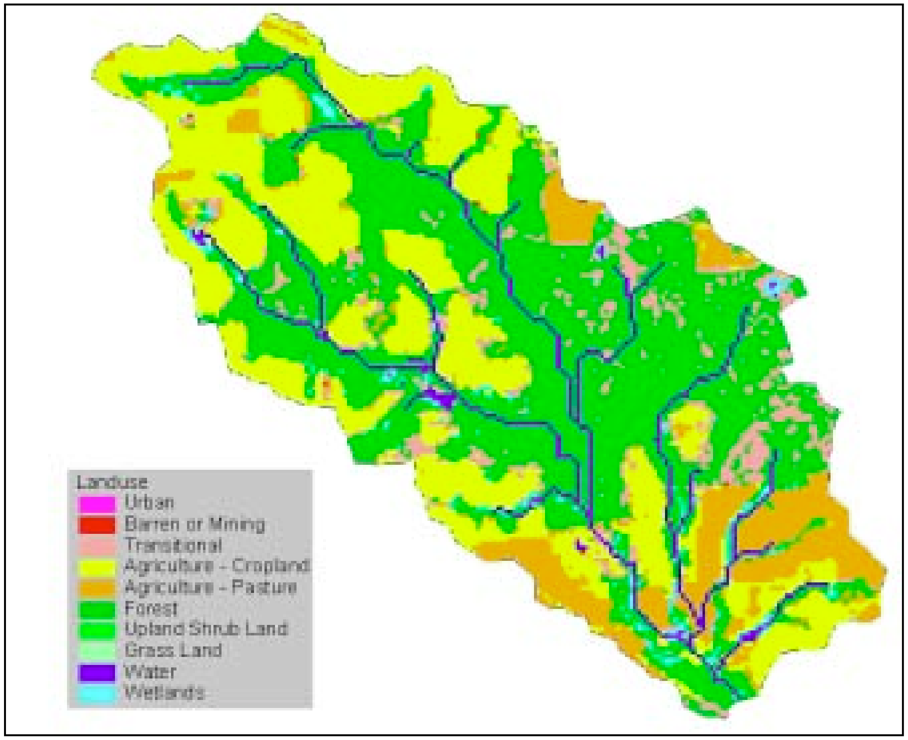
$$A = RKLSCP$$

- ***A*** = average annual soil loss in t/a (tons per acre) → Erosion Map
- ***R*** = rainfall erosivity factor ← County and NRI database
- ***K*** = soil erodibility factor ← STATSGO or SSURGO
- ***LS*** = topographic factor ← DEM and user s input
- ***C*** = cover and management factor← Land use (MRLC)
- ***P*** = conservation practice factor ←BMP table and user s input

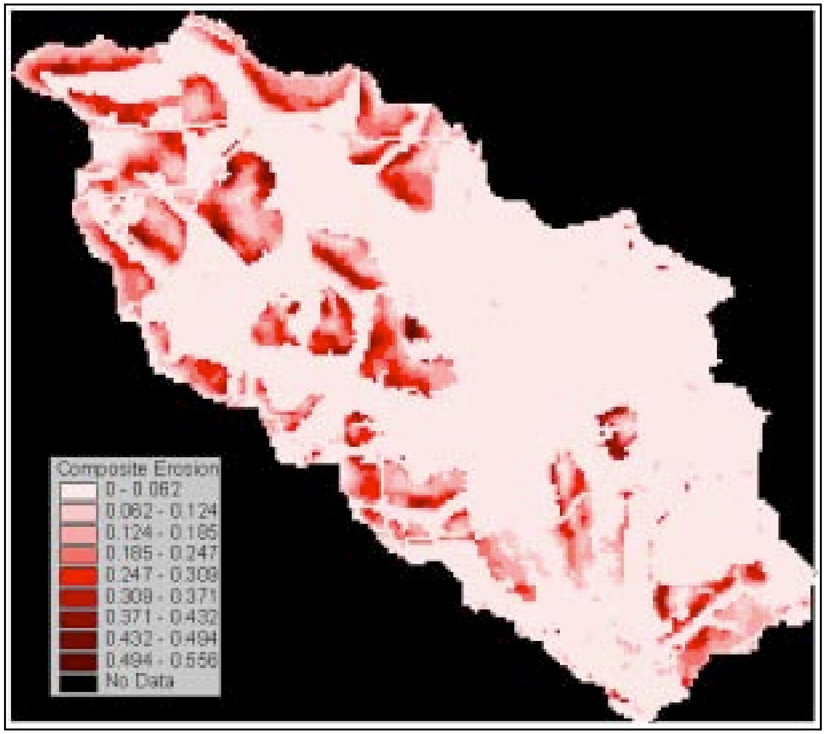
Land Use & Erosion - Little River Watershed K, GA

(Land Erosion = 1032 US tons, Road Erosion =30 US tons)

Land Uses and Covers



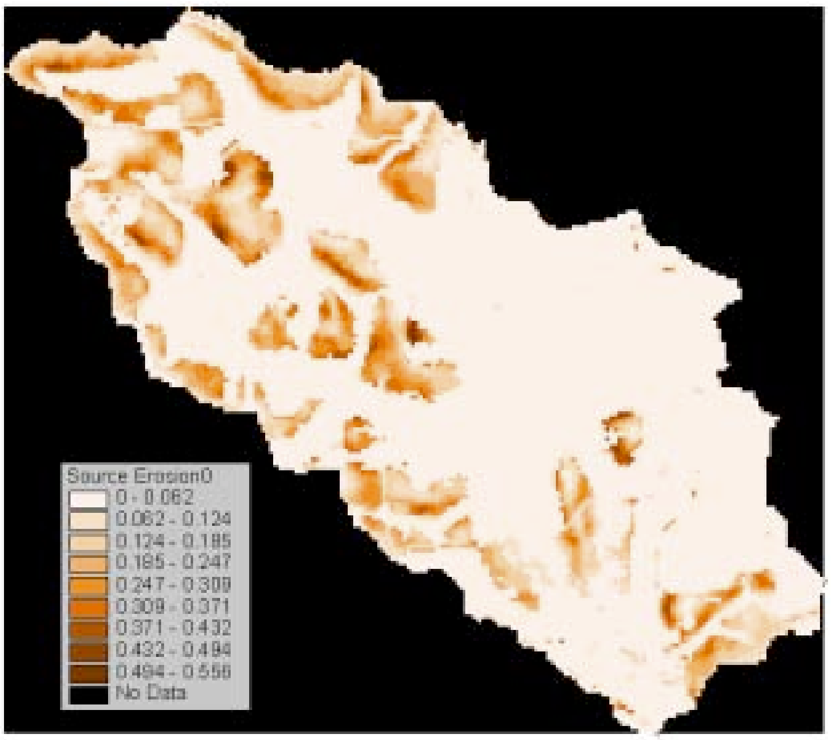
Erosion Distribution

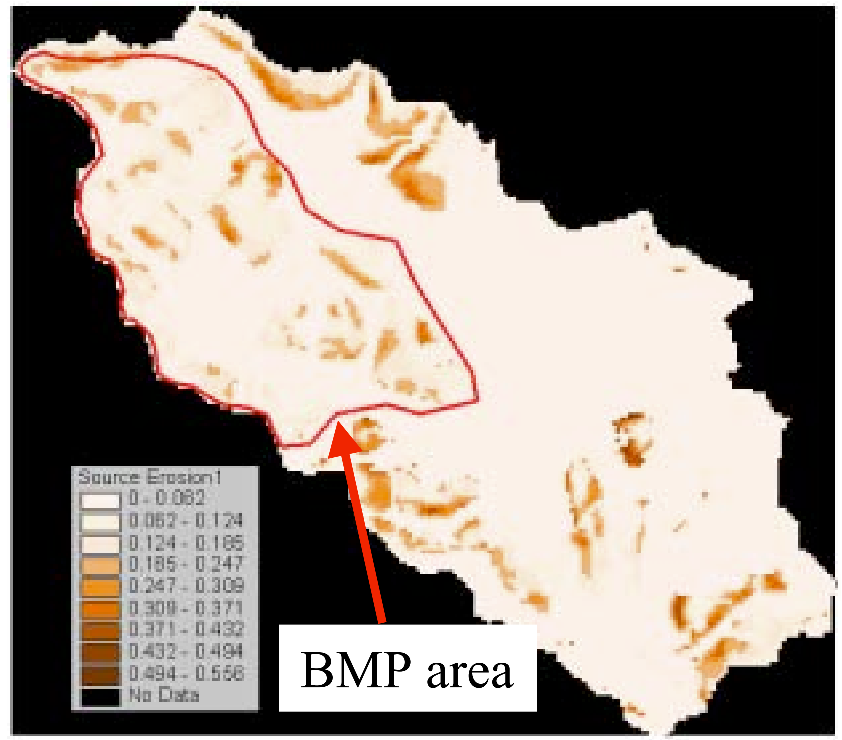


BMP & Erosion - Little River Watershed K, GA

Before, no BMP, erosion = 1032 US tons. Dark orange color indicates high Erosion.

After, applying a BMP to row crop areas, P = 0.65, erosion = 851 US tons, an 18% reduction.





Sediment Delivery Process

- **Method 1**, distance-based, developed for a forested landscape (Sun and McNulty 1998).

- $$\mathbf{Md = M\,(1 - 0.97 * D / L), \text{ and}}$$
  $$\mathbf{L = 5.1 + 1.79 * M.}$$

- *Md* is the mass moved from each cell to the closest stream network (tons/acre/yr.);

  D is the least cost distance from a cell to the nearest stream network; and
  L is the maximum distance that sediment with mass M may travel (meters).

Sun, G. and S. G. McNulty. 1998. Modeling soil erosion and transport on forest landscape. Proceedings of Conference 29. International Erosion Control Association. pp. 187-198.

Sediment Delivery Process

- **Method 2**, a distance- and relief- based method, developed for agriculture lands in Virginia (Yagow et al. 1988).

- For each map grid:

$$\mathbf{Sf = e^{(-16.1*(r/L + 0.057))} - 0.6, \text{ and}}$$

$$\mathbf{DR = e^{(-0.4233*L*Sf)}.}$$

- Where *DR* is the sediment delivery ratio; *L* is the distance to stream in meters; and *r* is the relief to stream in meters.

Yagow, E. R., V. O. Shanholtz, B. A. Julian and J. M. Flagg. 1988. A Water quality module for CAMPS. American Society of Agricultural Engineers Meeting Presentation Paper No. 88-2653.

Sediment Delivery Process

- **Method 3**, a watershed area-based method,
- The equation (converted from a curve from National Engineering Handbook by Soil Conservation Service 1983) can be written as:

$$\mathbf{DR = 0.417762 * A^{-0.134958} - 0.127097.}$$

- Where *DR* is the sediment delivery ratio and *DR* <= 1.0; *A* is the watershed area in square miles.

U.S. Department of Agriculture Soil Conservation Service. 1983. Sedimentation. Section 3, Chapter 6. National Engineering Handbook.

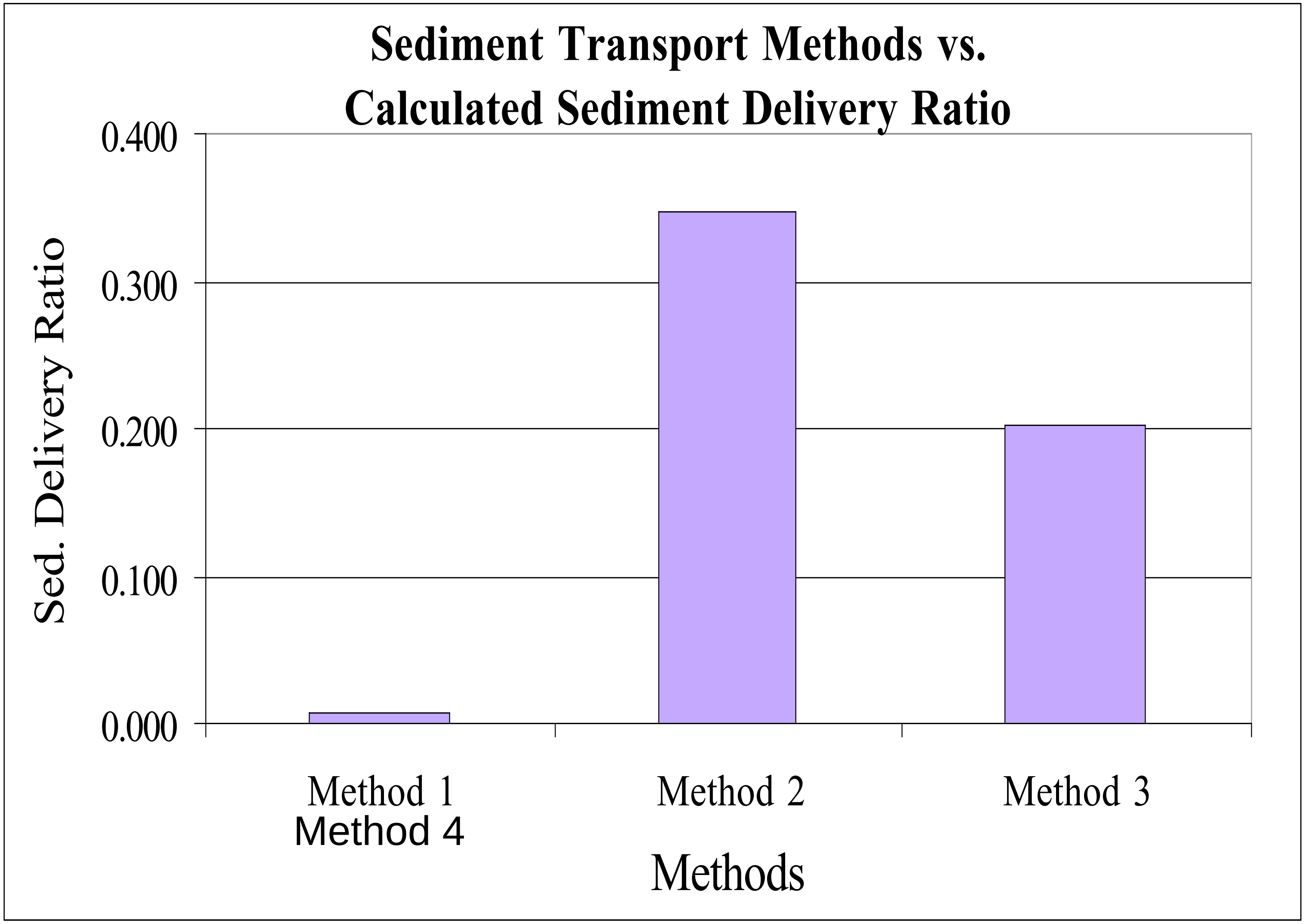
Sediment Delivery Process

- **Method 4**, WEPP-based regression model ,
- The equation was derived for North Carolina and Georgia forested landscape

$$\mathbf{Z = .9004 - .1341\,(\ln X) - .0465\,(\ln X)^2 + .00749\,(\ln X)^3 - .0399\,(\ln Y) + .0144\,(\ln Y)^2 + .00308(\ln Y)^3}$$

- Where *Z* is the sediment passing efficiency (%), *X* is the distance to stream, and *Y* is the slope in percent. $X > 0$ and $Y > 0$.

Lloyd W. Swift. 2000. Equation to dissipate sediment from a grid cell downslope. U. S. Forest Service



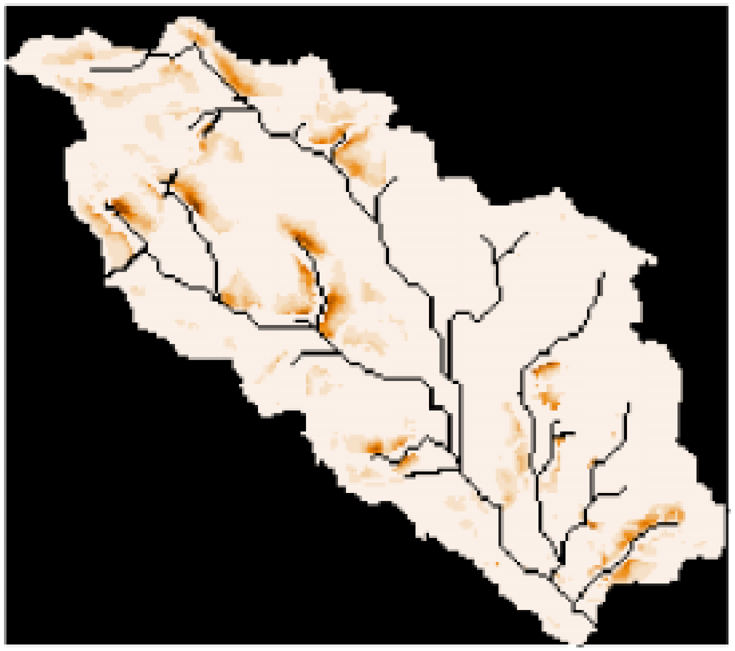
Sediment Transport Methods vs.
Calculated Sediment Delivery Ratio
Sed. Delivery Ratio
0.400
0.300
0.200
0.100
0.000
Method 1
Method 4
Method 2
Method 3
Methods

Sediment Delivery and the Sediment Trapping Structure (Method 2)

Before, no retention pond, sediment = 349.3 US tons.

Dark orange color indicates high sediment source.

After, retention efficiency = 0.6, sediment = 331.3 US tons



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WCS Sediment Tool Menu

- **Sediment Tool**
  - **Sediment Model**
    - Project Setup
    - Create Stream Grid
    - Source Erosion & Sediment
    - Create Assessment Point(s)
    - Sediment Delivery on Stream
    - Automated Reports
  - **Sediment Utility**
    - Change C & P Lookup Tables
    - Create Land Use Change Layer
    - Create BMP Layer
    - Create New C & P Layers
    - Create LS Layer
    - Add/Delete/Edit Roads
    - Add Road Control Structures
    - Create Sediment Mgt. Structure Layer
    - Create Trapping Efficiency Layer
    - Display Drainage Area
    - Tracking Scenarios

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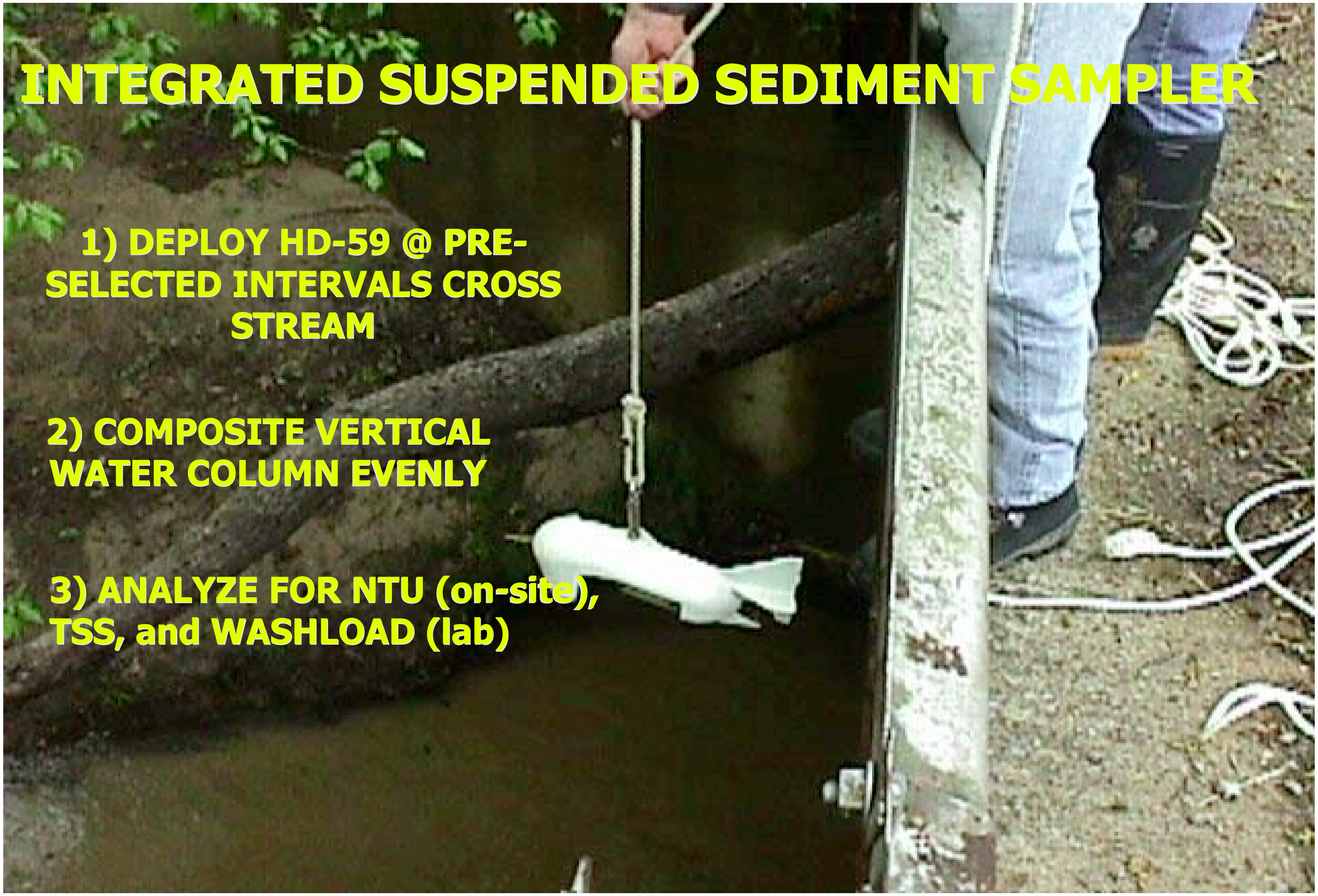
Sediment TMDL
Stekoa Creek Watershed, GA

- The five streams in the Stekoa Creek Watershed were included on the State of Georgia s 1998-303(d) List because of biological and habitat impairment.
- Sediment was determined to be the pollutant of concern

Stream Impairment

Stream	Use Support Status	Pollutant of Concern
Stekoa Creek	Partial Support	Excessive Sedimentation
Scott Creek	Partial Support	Excessive Sedimentation
Pool Creek	Partial Support	Excessive Sedimentation
Chechero Creek	Not Supporting	Excessive Sedimentation
Saddle Gap Creek	Partial Support	Excessive Sedimentation

Chattooga Watershed Evaluation



Chattooga Watershed Evaluation

SEDIMENT TMDL PROTOCOL DEVELOPMENT
SINGLE-STAGE SAMPLIER/MULTIPARAMETER PROBE

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Field and Lab Results

- A positive relationship was observed between TSS and turbidity;
- Good correspondence was observed between TSS and aquatic macroinvertebrate results;
- Total sediment loading is critical to an overall assessment of bedform/habitat condition; and
- Roads and the connection between their ditches are major sources of sediment to streams

Target Identification

- Unimpacted streams in the West Fork Watershed of the Chattooga River Basin.

- A percent reduction TMDL can be developed by comparing the sediment loading rates of impacted watersheds to that of the unimpacted watershed.

Sediment Tool was used to calculate sediment loading for impacted and unimpacted watersheds

Stream Reduction	Area (Mile^2)	Existing Watershed Load (Tons/Year)	Percent Reduction Needed to Meet Target
Stekoa Creek	17	470	55
Scott Creek	6	83	35
Pool Creek	5	45	10
Chechero Creek	4.4	82	55
Saddle Gap Creek	3	82	70

Conclusions

- WCS Sediment Tool is an easy-to-use program for the estimation of watershed erosion and sediment delivery using widely available GIS spatial data.

- WCS Sediment Tool is an intuitive system for assisting users in developing sediment-related TMDLs.

- WCS Sediment Tool provides a flexible framework for adding new models and spatial data layers.

Contact Information

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