Estimating influx of mercury-contaminated sediments from eroding banks of a gravel-bedded bedrock river using a bank migration model: Utility for prioritizing bank stabilization projects

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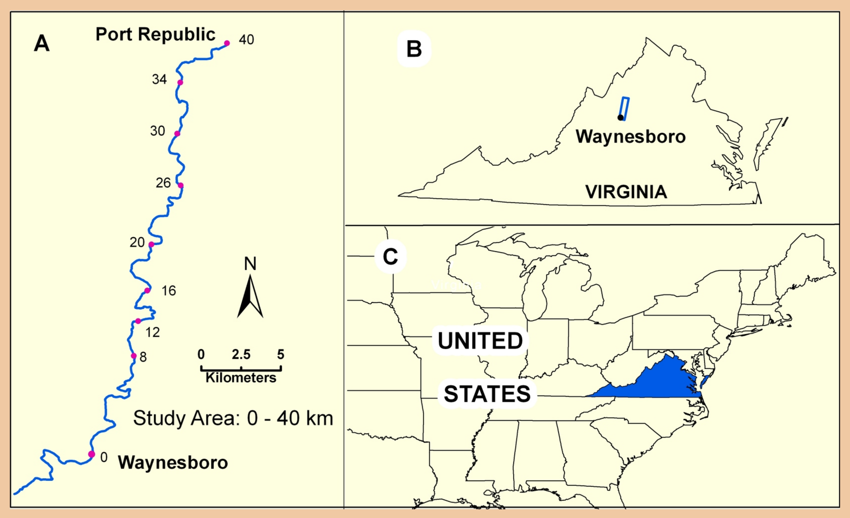
1 RESEARCH OBJECTIVES

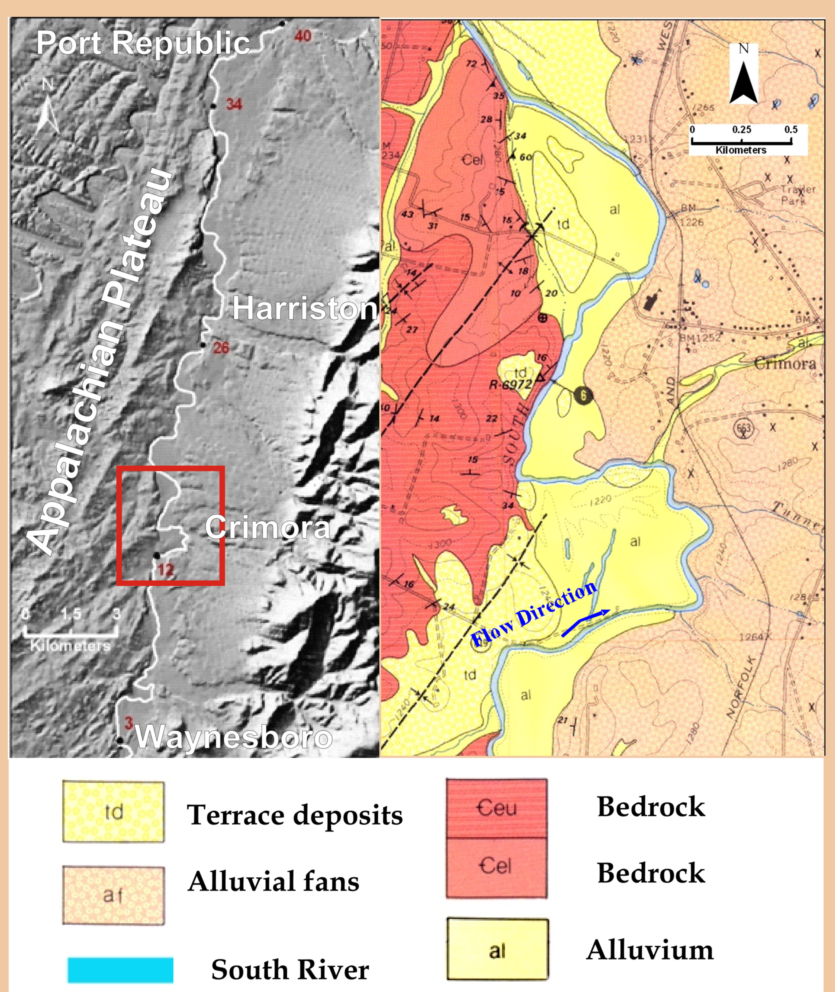
1. To use an erosion model developed for freely meandering rivers to estimate areal erosion on the South River, despite frequent bedrock exposures.
2. To quantify mercury loading from eroding banks using a bank erosion model and other data.
3. To prioritize sites for bank stabilization projects.

2 SOUTH RIVER SETTING

2.1 Location Map/Study Area

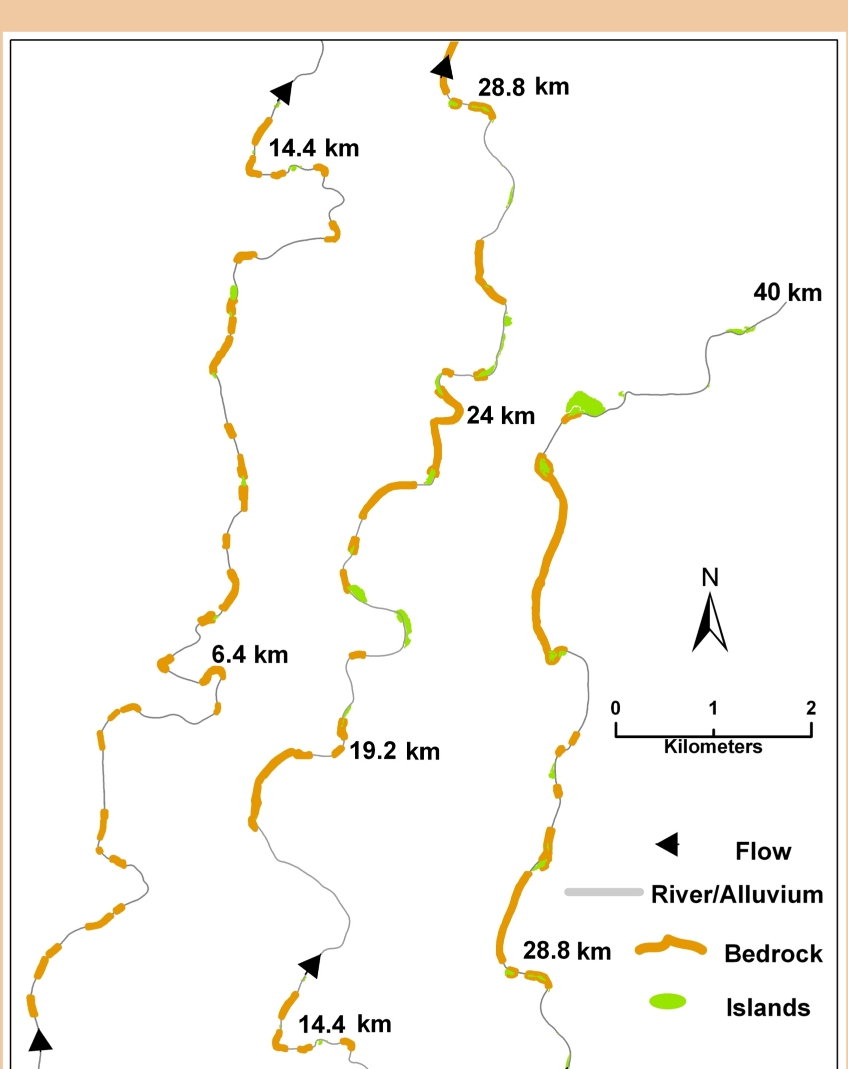


2.2 GEOLOGIC SETTING



DEM and Surficial Geological maps from USGS

2.3 BEDROCK EXPOSURES



Intermittent and extensive bedrock exposures between alluvial sections.

3 BANK EROSION MODEL

3.1 Predictions of areal bank erosion, 1937-2005

$$TM' \quad E_C U T \quad (1)$$

T = Time [s] (Period of 68 yrs. From 1937 to 2005)
M′ = Migration rate [m/s]
Ec = Erodibility coefficient calibrated value
U = Near bank excess velocity [m/s]

Model Steps:
i) Determine near bank excess velocity - using an existing model (JP*).
ii) Calibrate model with subset of mapped migration rates (Rhoades et al., 2009).
Iii) Compare cumulative areal erosion - modeled and mapped.

*Johannesson & Parker (1989) curvature based near bank excess velocity.

3.2 Schematization & Calibration

Schematization
a) Single thread river: Digitize the centerline of the river following the main flow including around islands.
b) Reach length: Subdivide into six reaches considering (i) major tributary inputs and increases in discharge ~ 10%; and (ii) significant changes in slope.
c) Flow depth: Bank full height based on eroding recent alluvial floodplains.

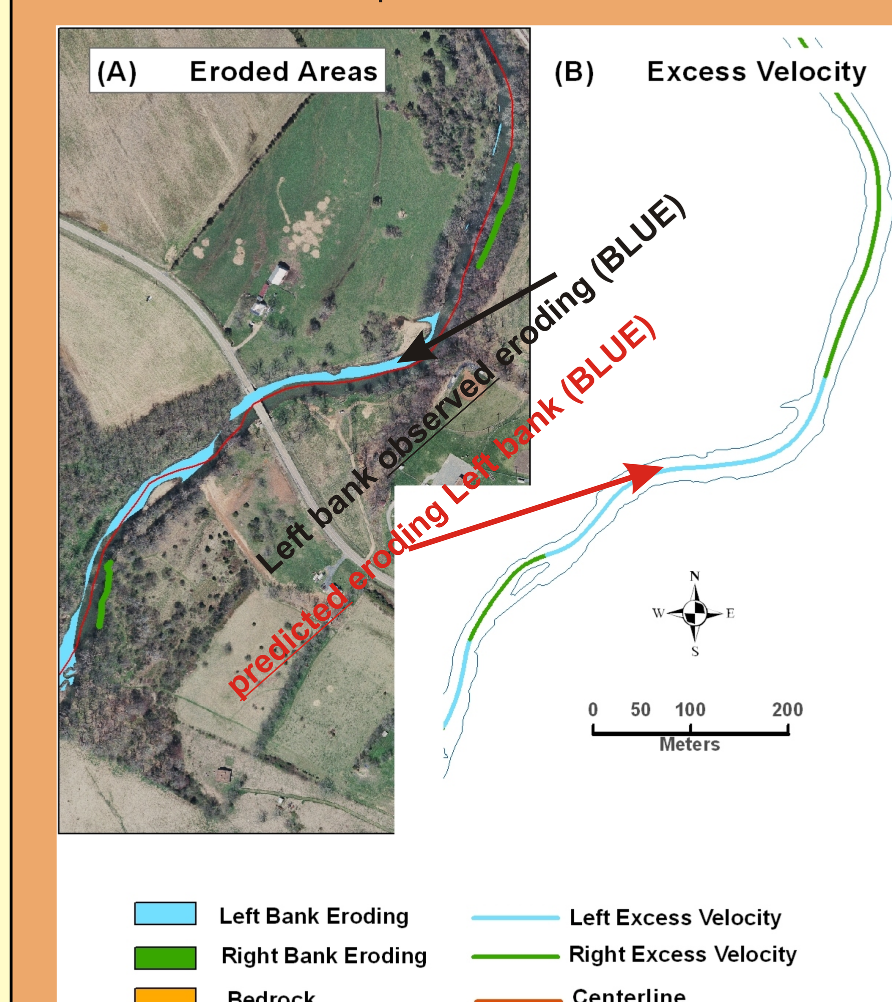


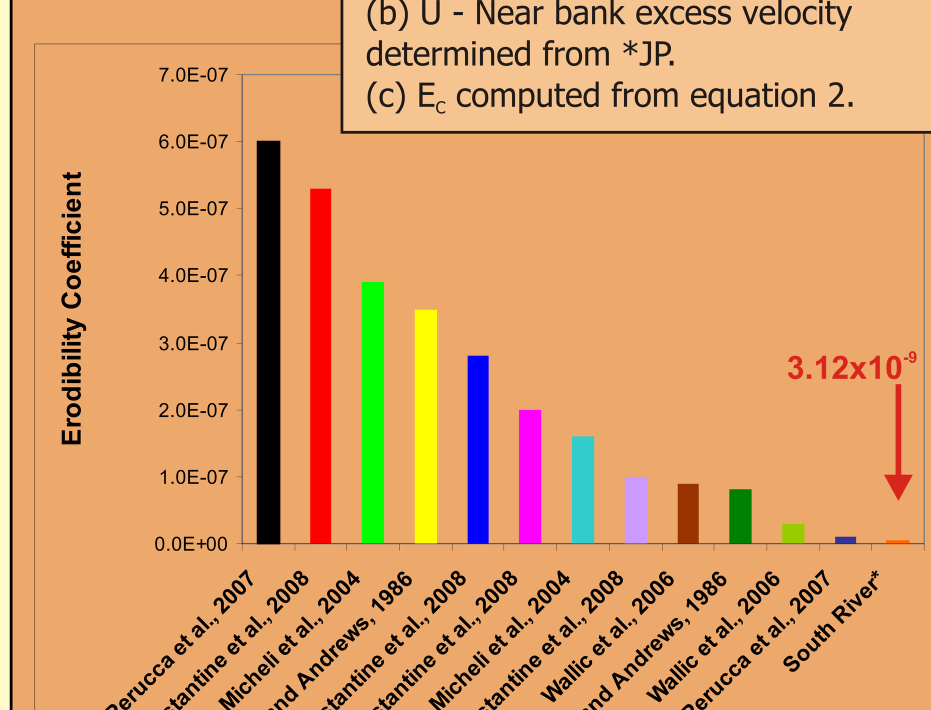
Figure A: Areas of eroding banks (1937-2005) from aerial photographs, colored (BLUE = Left & GREEN = Right).

Figure B: Near-bank excess velocity showing location of predicted erosion (BLUE = Left & GREEN = Right banks). (Narinesingh, P., 2009)

3.3 Calibration: Erodibility coefficient - (E_c)

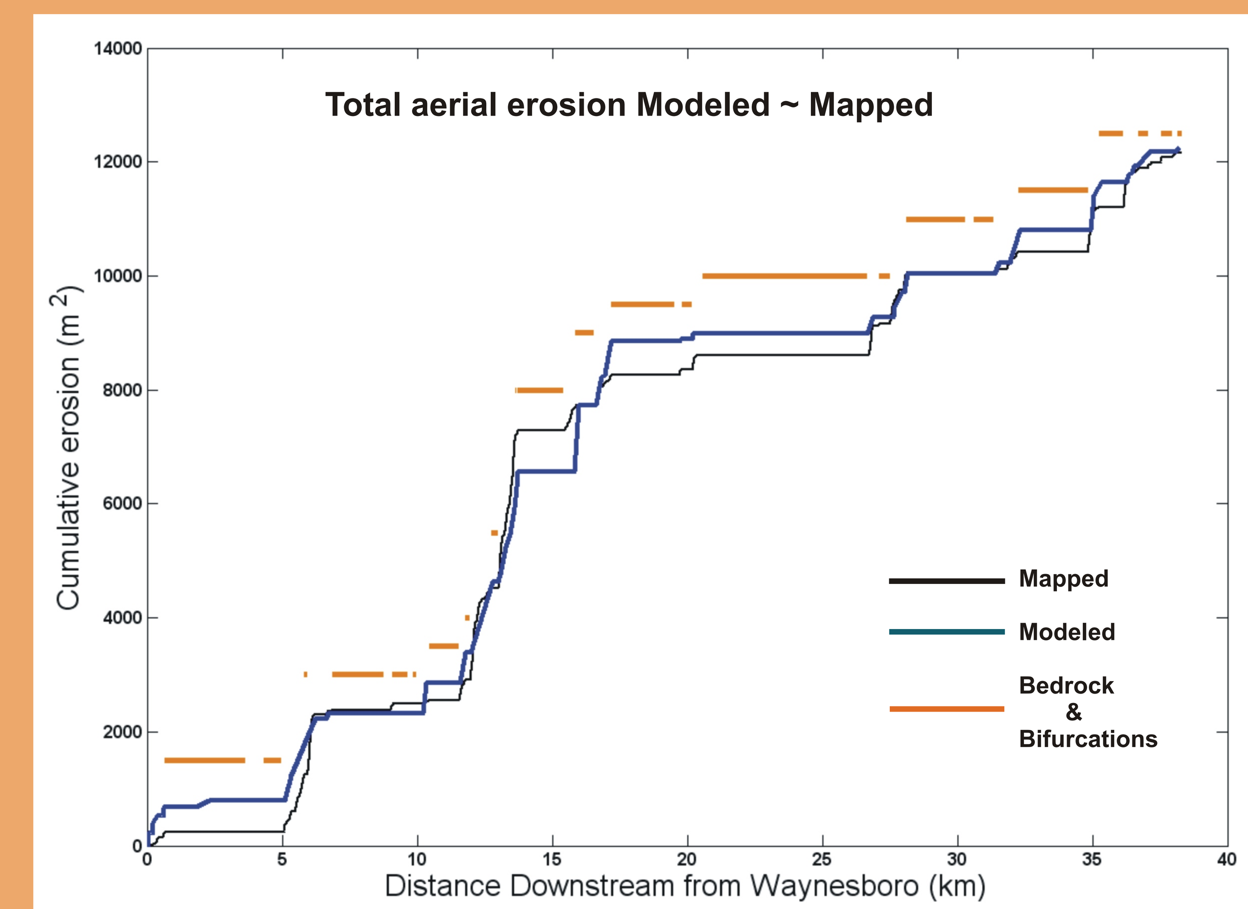
$$\frac{M'}{U} \quad E_C \quad (2)$$

(a) M′ - Rhoades et al., 2009 mapped areal erosion using GIS and aerial photos (1937 - 2005).
(b) U - Near bank excess velocity determined from *JP.
(c) E_c computed from equation 2.



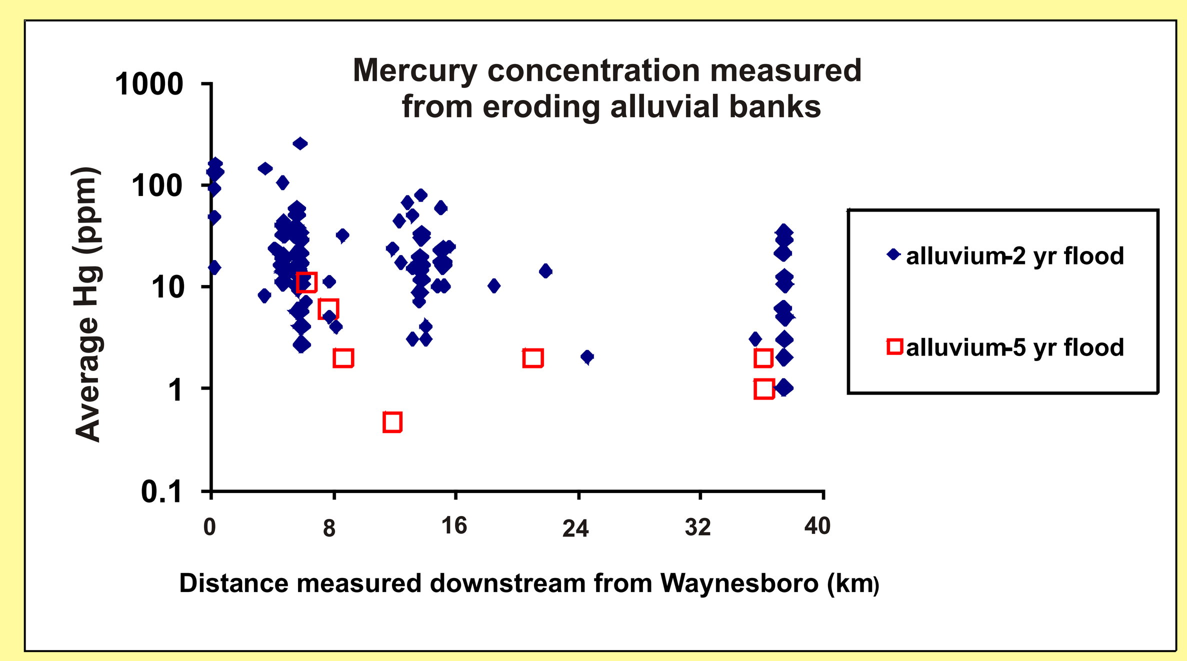
South River has the lowest erodibility coefficient of the alluvial banks reported.

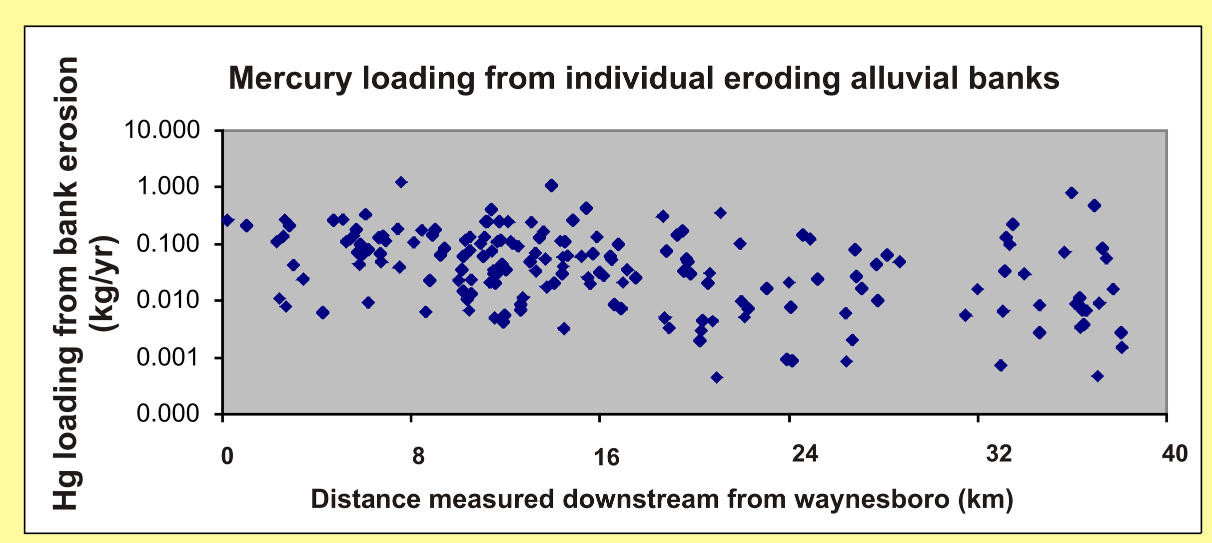
3.4 Comparison of Areal erosion of alluvium: Estimated through Modeling and Aerial Photos



1) Trends in eroded areas determined using the model and aerial photos are simillar.
2) Erosion of bedrock is practically zero relative to the alluvial areas with erodibility coefficient 1000 times bedrock exposures for the period 1937 - 2005.
3) The entire planform is used to estimate the eroding potential of the discharge.
4) Erosion around islands are excluded from these computations as islands represent significant changes in channel properties.

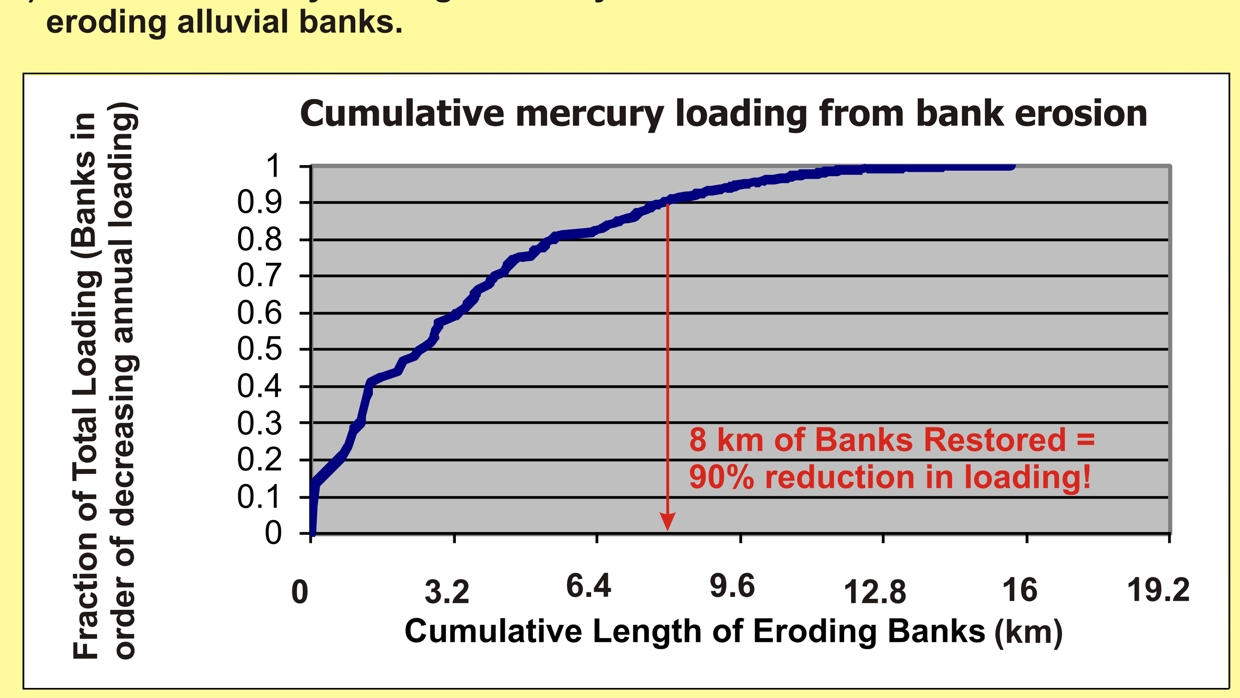
4 Assessment of mercury loading from eroding banks





Computational Steps

1) Estimate areal erosion - Calibrated hydrodynamic model & data from aerial photo analysis from the period 1937 - 2005.
2) Quantify volume of erosion - Bank height estimated from: LIDAR analysis (Rhoades et al. 2009); 2 foot contours derived from aerial LIDAR; field surveys.
3) Estimate mercury loading - Mercury concentration measured from eroding alluvial banks.



Eroding banks that have the largest contribution of Hg loading identified. Reduction in Hg loading may be accomplished through various means of bank protection works.

5. BANK STABILIZATION PILOT PROJECT

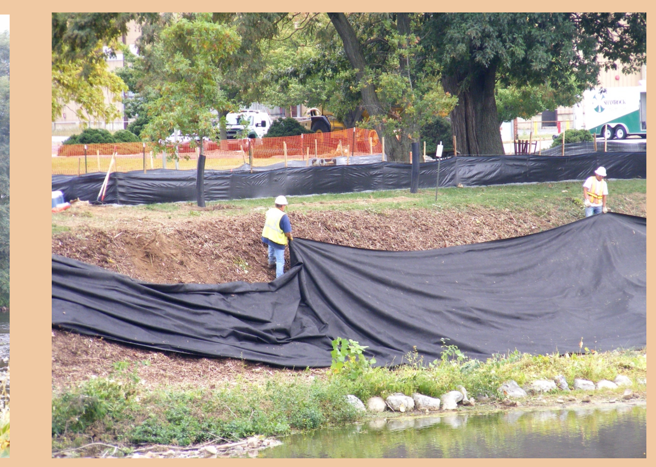
Studies indicate that sediments near eroding alluvial banks are strongly linked to Methyl-Mercury in fish tissue.

Primary Objectives
- Reduce river bank erosion and influx of mercury contaminated sediments.
- Enhance riparian vegetation.

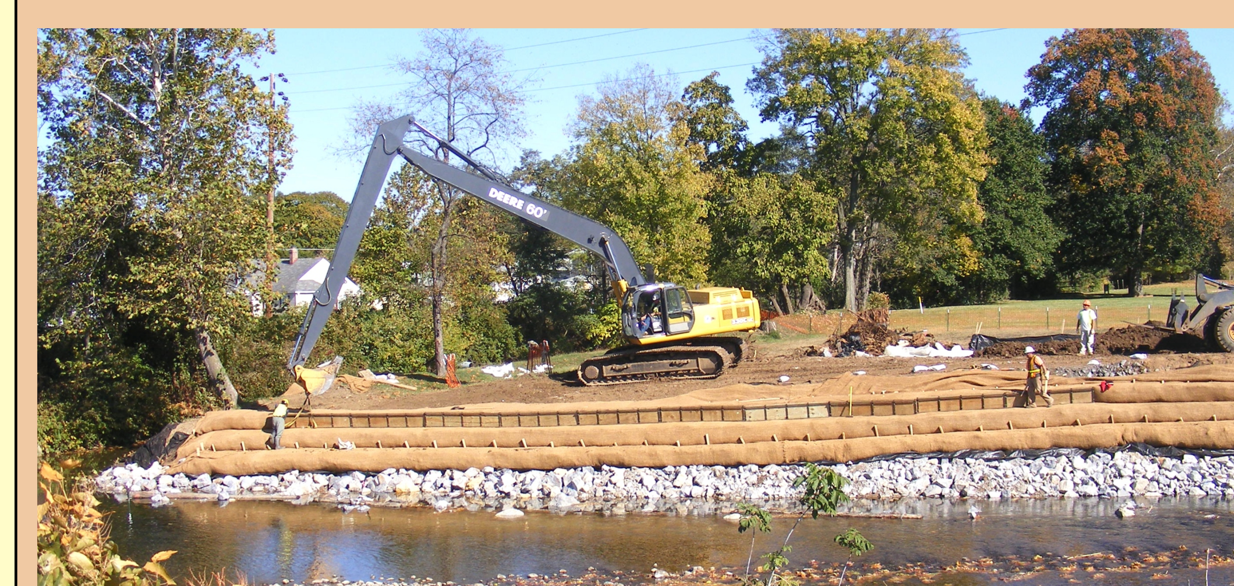
Secondary Objectives
- Evaluate stability of design and installation of bank protection works.
- Evaluate effect on mercury methylation near the bank.
- Evaluate upstream and downstream impacts over time and in relation to vegetation growth.

Location and extent of pilot project.

Riparian vegetation prior to start of works (Left end of site).



Vegetation cleared and filter fabric being placed to contain soil.



Rip rap at toe and three lifts of soil in place stabilized by coir fiber rolls.

Stabilized bank with plant cuttings in place. (Plant types include silky willow, silky dogwood, red osier dogwood, and common elderberry.

(South River ScienceTeam, Meeting 2009)

6 TAKE HOME POINTS

1) The median erodibility value for the South River alluvium is among the smallest value published.
2) The curvature based erosion model predicted the total areal erosion of alluvial reaches within 20% of that mapped using aerial photographs.
3) Mercury concentration in bank sediments varies greatly.
4) Mercury loading from eroded banks also varies greatly.
5) Stabilizing 20% of the banks of the study reach could eliminate 90% of the total mercury loading to the river, if banks with the highest erosion rates are restored.

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STREAM RESTORATION FEB. 2010