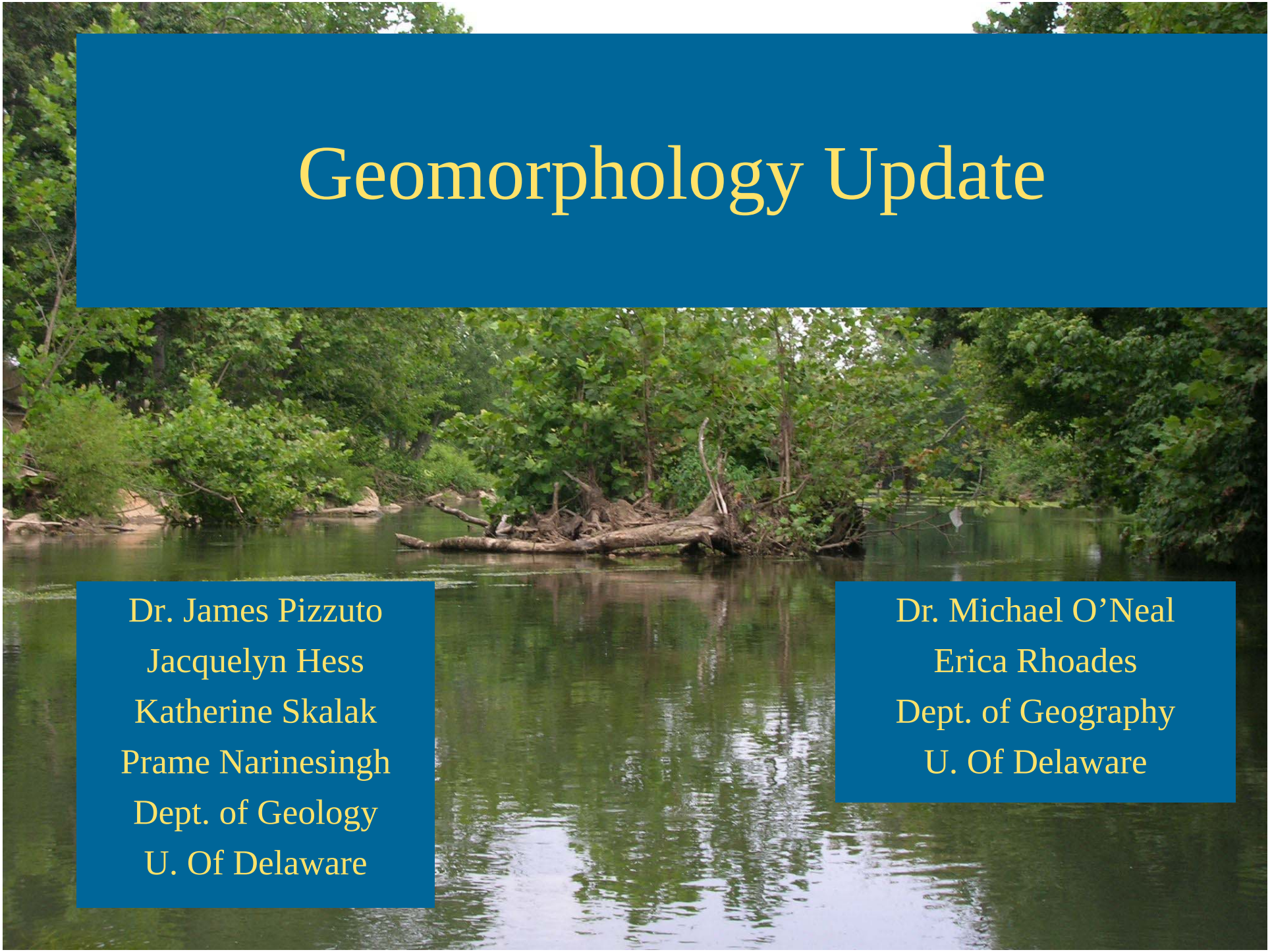
Geomorphology Update



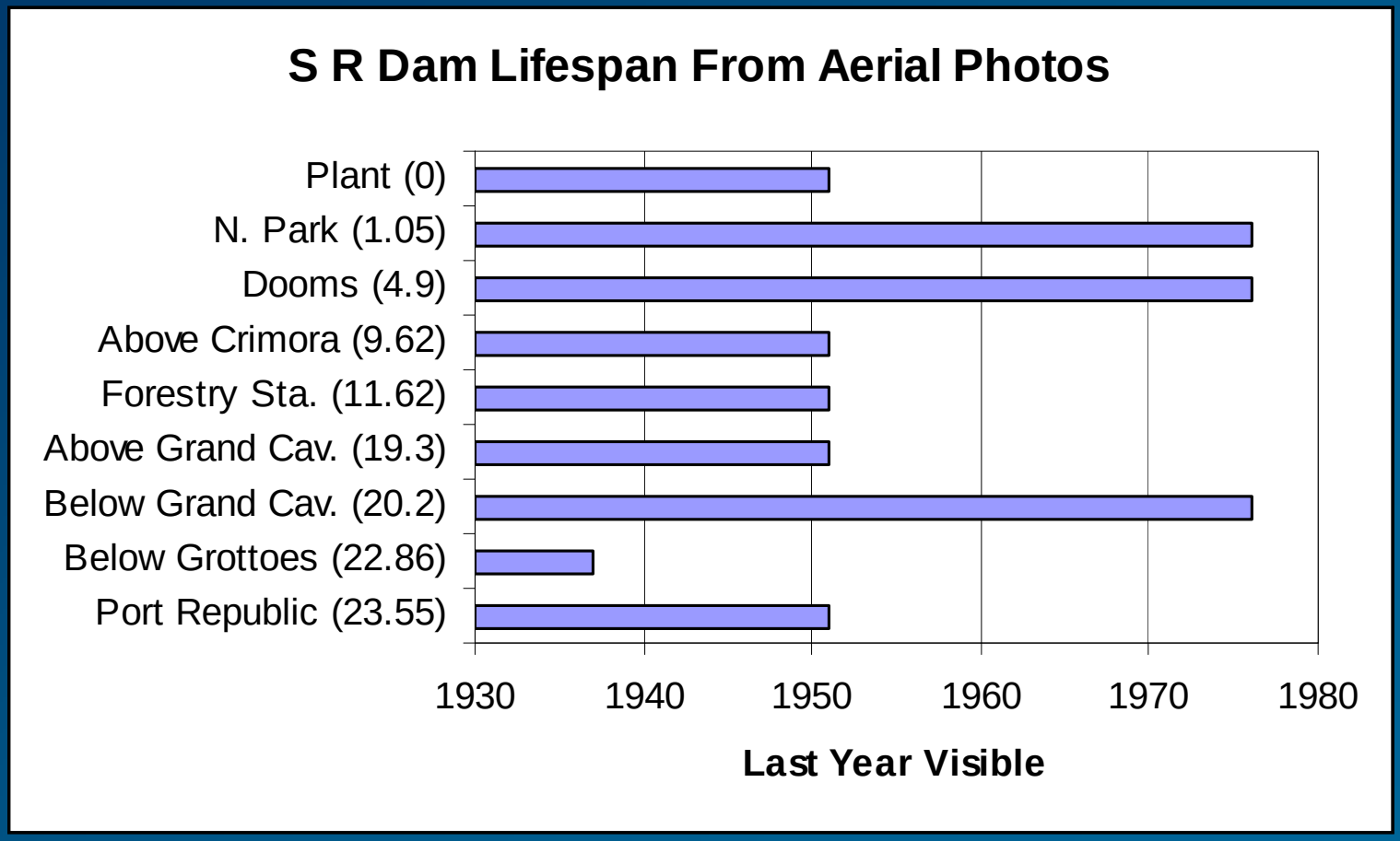
Dr. James Pizzuto
Jacquelyn Hess
Katherine Skalak
Prame Narinesingh
Dept. of Geology
U. Of Delaware

Dr. Michael O'Neal
Erica Rhoades
Dept. of Geography
U. Of Delaware

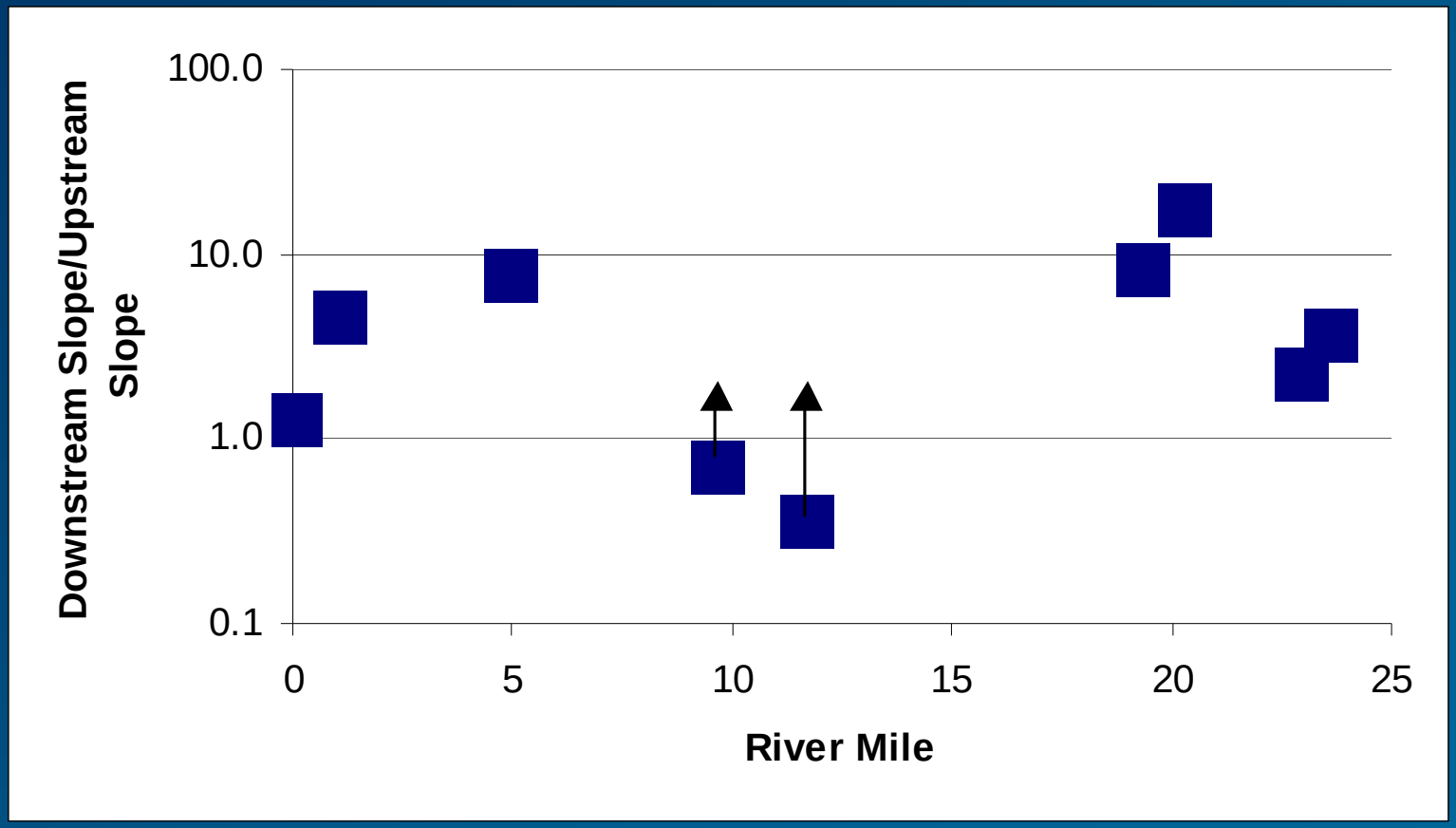
Recent Results

1. Database of historic Dams
2. Upstream vs downstream river reaches
3. Mapping eroding banks, Forestry Station-Pt. Republic
4. Mapping fine-grained channel margin deposits, Forestry Station-Pt. Republic
5. Patterns and rates of bank erosion and channel migration, 1937-2005.
6. New floodplain terminology and landforms
7. “Valley Flat” sedimentation
8. “Bank Attached Active Floodplain” sedimentation
9. Sediment storage within the pores of the streambed gravel.
10. C14 dating fine-grained channel margin deposits
11. Updating the budget of fine-grained sediment in the study reach.

Database of Historic Dams



At Dam Sites, Slope is Steeper Downstream (the right place to build dams…)



Plant Site, Waynesboro

1937

1949

1951

North Park

1937

Dooms Dam

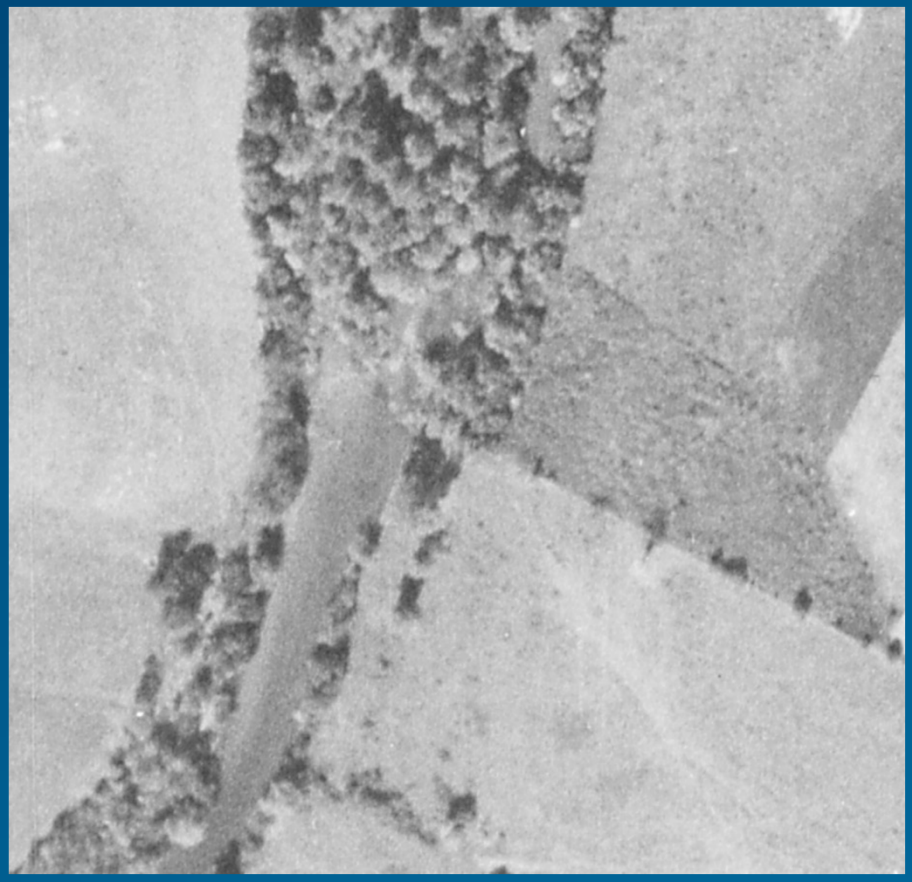
1937

1951

Above Crimora

1937

1951



Forestry Station

1937

1951

Above Grand Caverns

1937

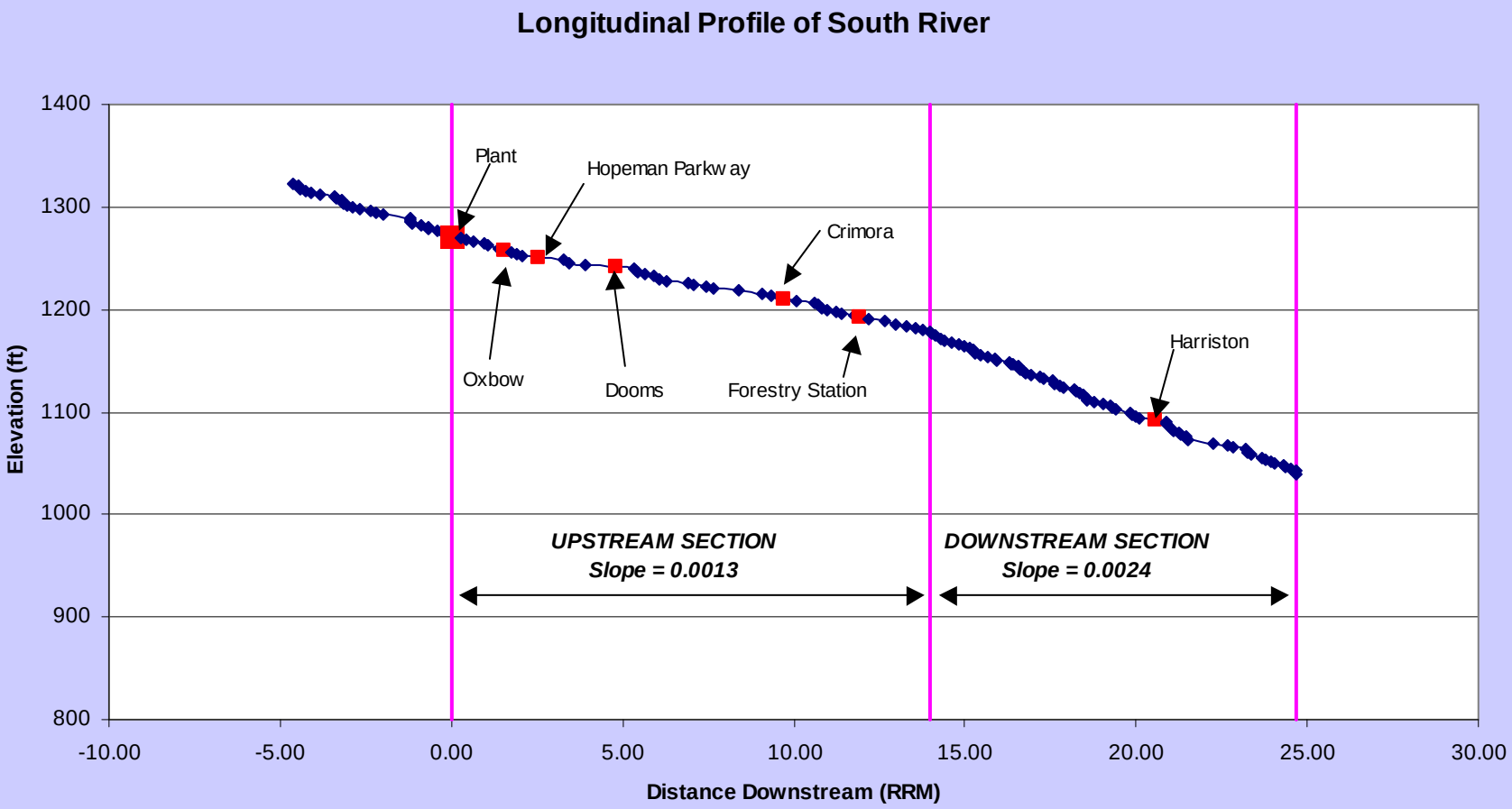
1951

Below Grand Caverns, 1937

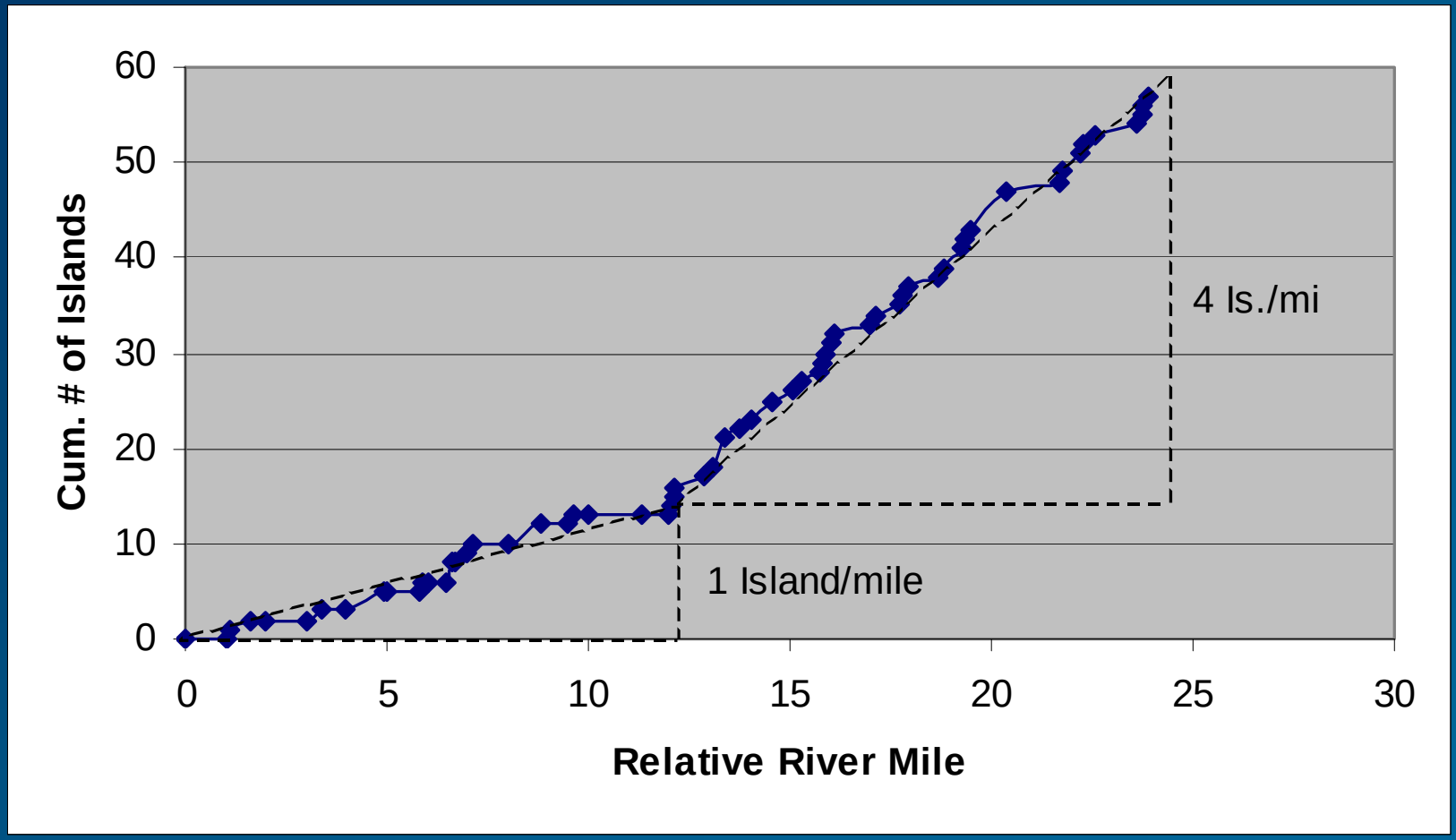
Below Grottoes, 1937

Port Republic, 1937

Upstream vs Downstream River Reaches



Islands – Upstream and Downstream



Downstream Section Should not be termed “anastomosing”

Downstream – Abundant Islands

Mapping Eroding Banks, Forestry Station – Port Republic

- Mapped 3 km of eroding banks in this reach
- Categorized by material (mud, cobble, etc) and origin (alluvial, terrace/alluvial fan)
- Fewer eroding banks downstream than upstream as hypothesized
  - Many eroding banks downstream supply very old terrace/alluvial fan sediments likely w/o Hg
  - Others consist primarily of sand/cobbles with low Hg
  - Some look like upstream banks – steep, muddy, significant potential as Hg sources

Mapping Eroding Banks

(Upstream banks are greater potential sources of Hg)

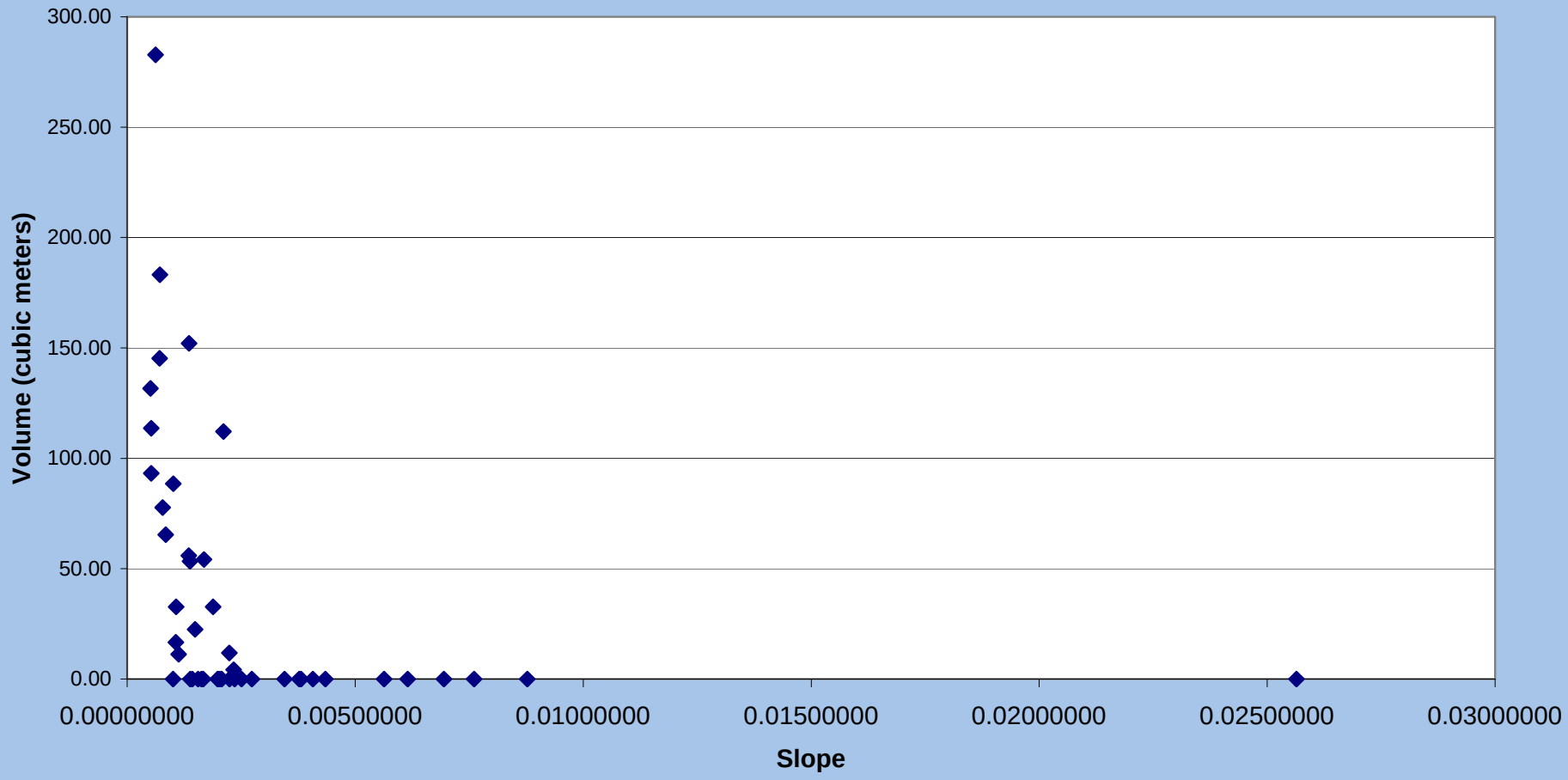
Region	Total Length of Eroding Banks (miles)	% of Banks Eroding
Upstream	3.1	***22***
Downstream	1.9	***8***

Note – draft Results!

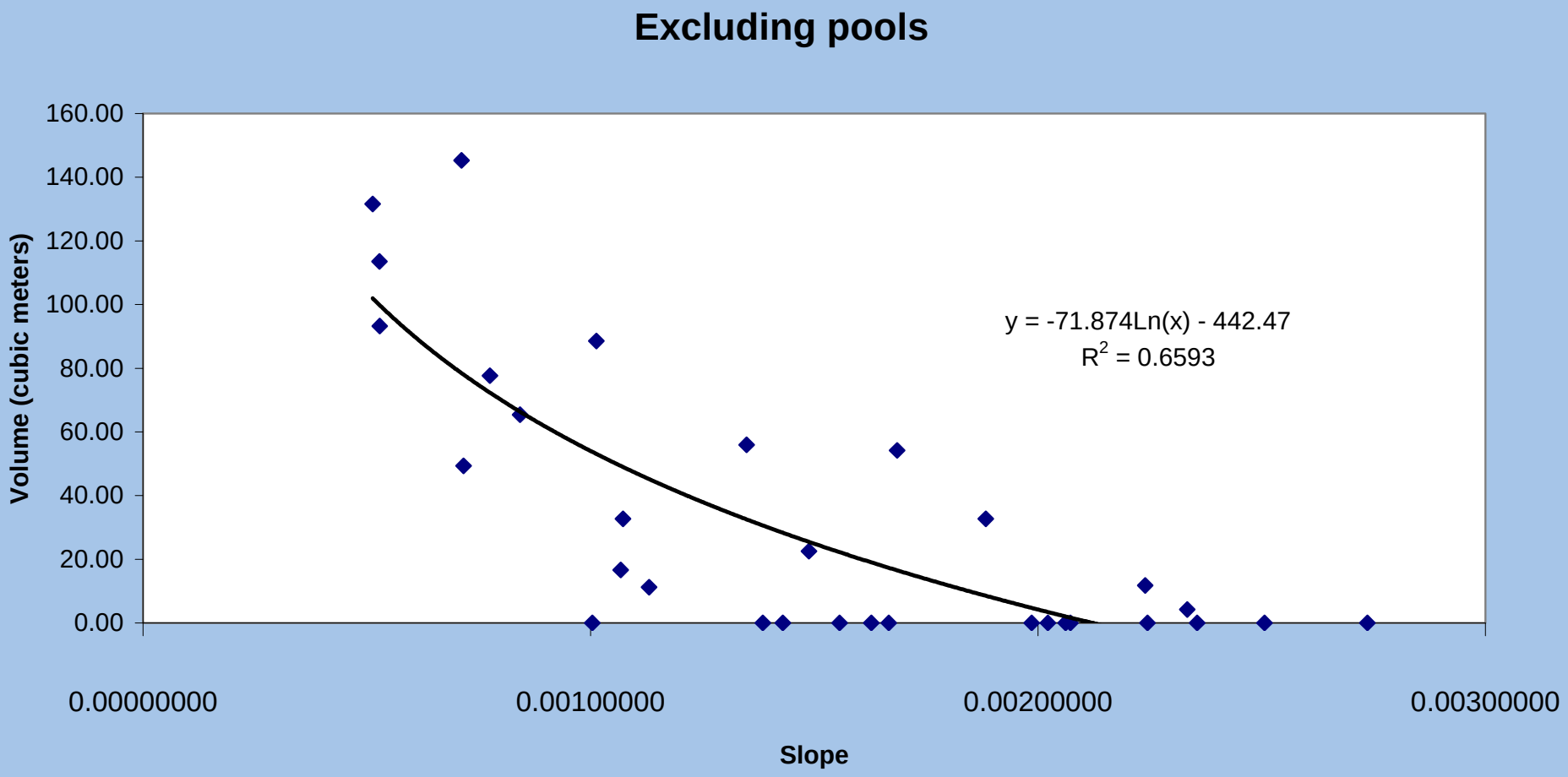
Mapping Fine-Grained Channel Margin Mud Deposits, Forestry Station-Pt Republic

- Mapped 3 1000 ft reaches above Harriston
- Found 2 long pools with abundant mud deposits
- Other areas are quite steep and have no mud deposits
- We are working on a correlation between deposit volume and slope to forecast mud accumulations in unmapped areas
- All mud deposit locations and attributes available as GIS coverage

Accumulation of Mud is Related To River Slope!!



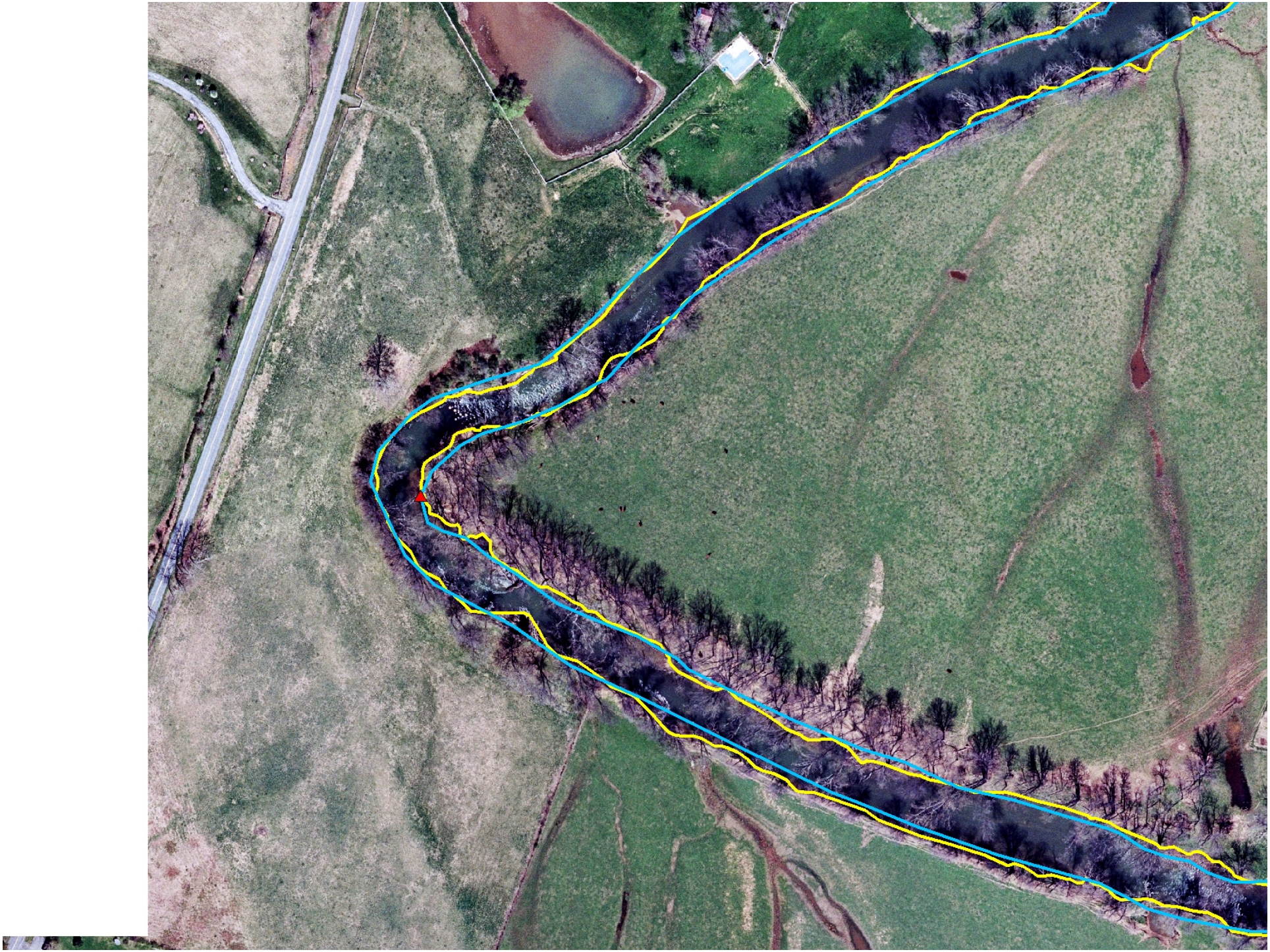
Below a threshold, the volume of mud can be predicted as a function of slope

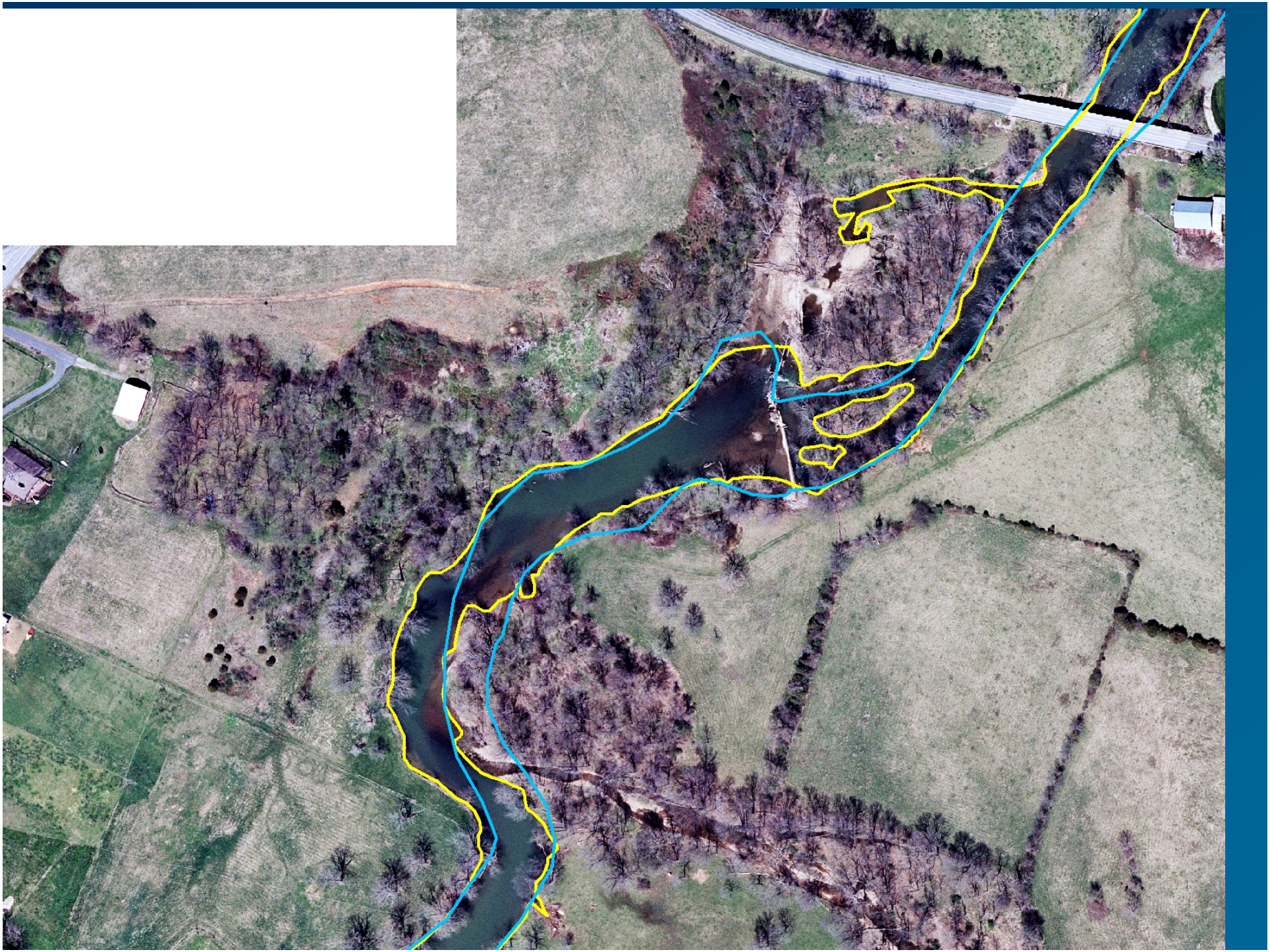


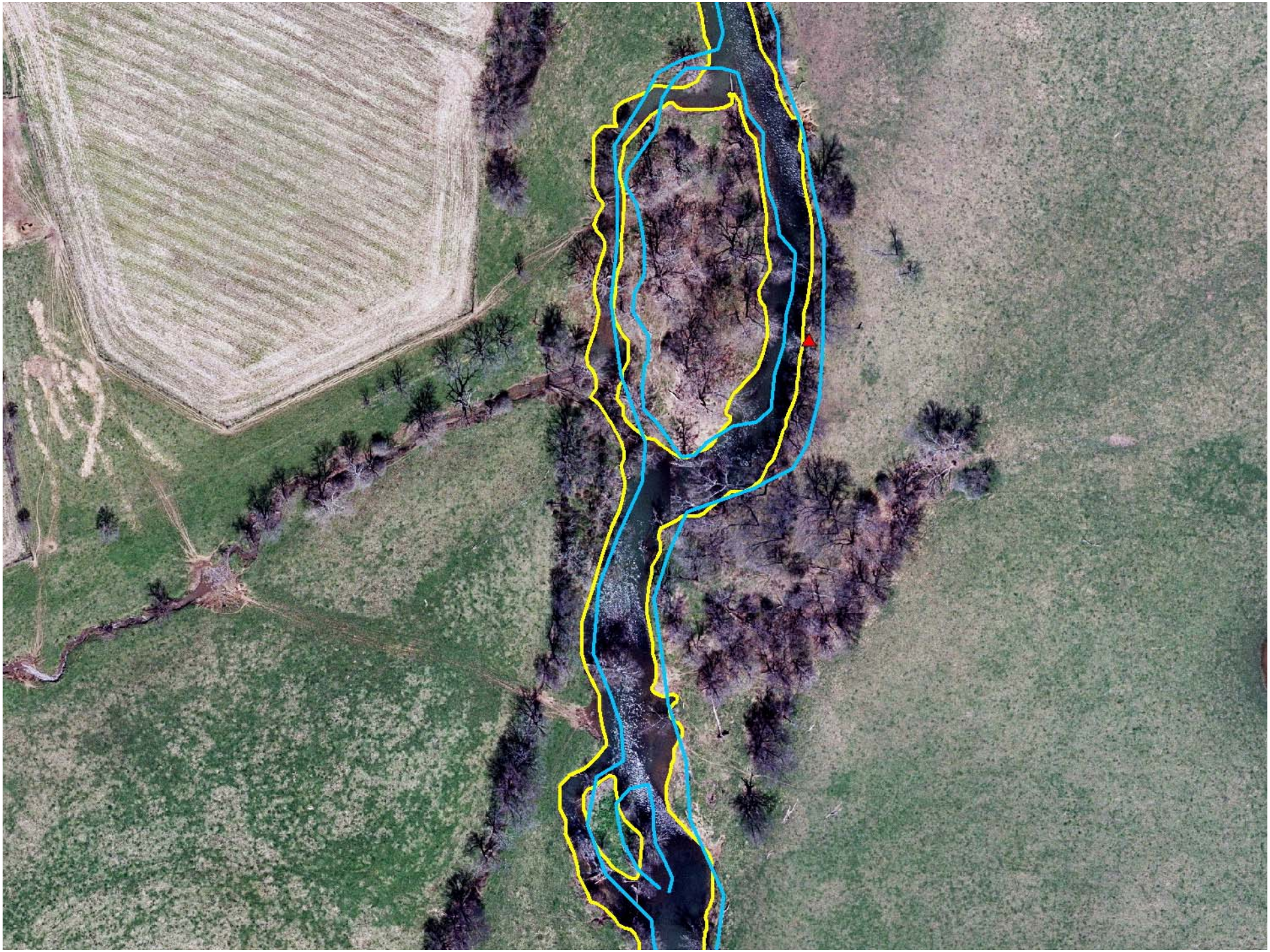
Rates of Bank Erosion 1937-2005

- Use aerial photographs to document spatial patterns of long term bank erosion

Blue – 1937, Yellow, 2005 – not much change!



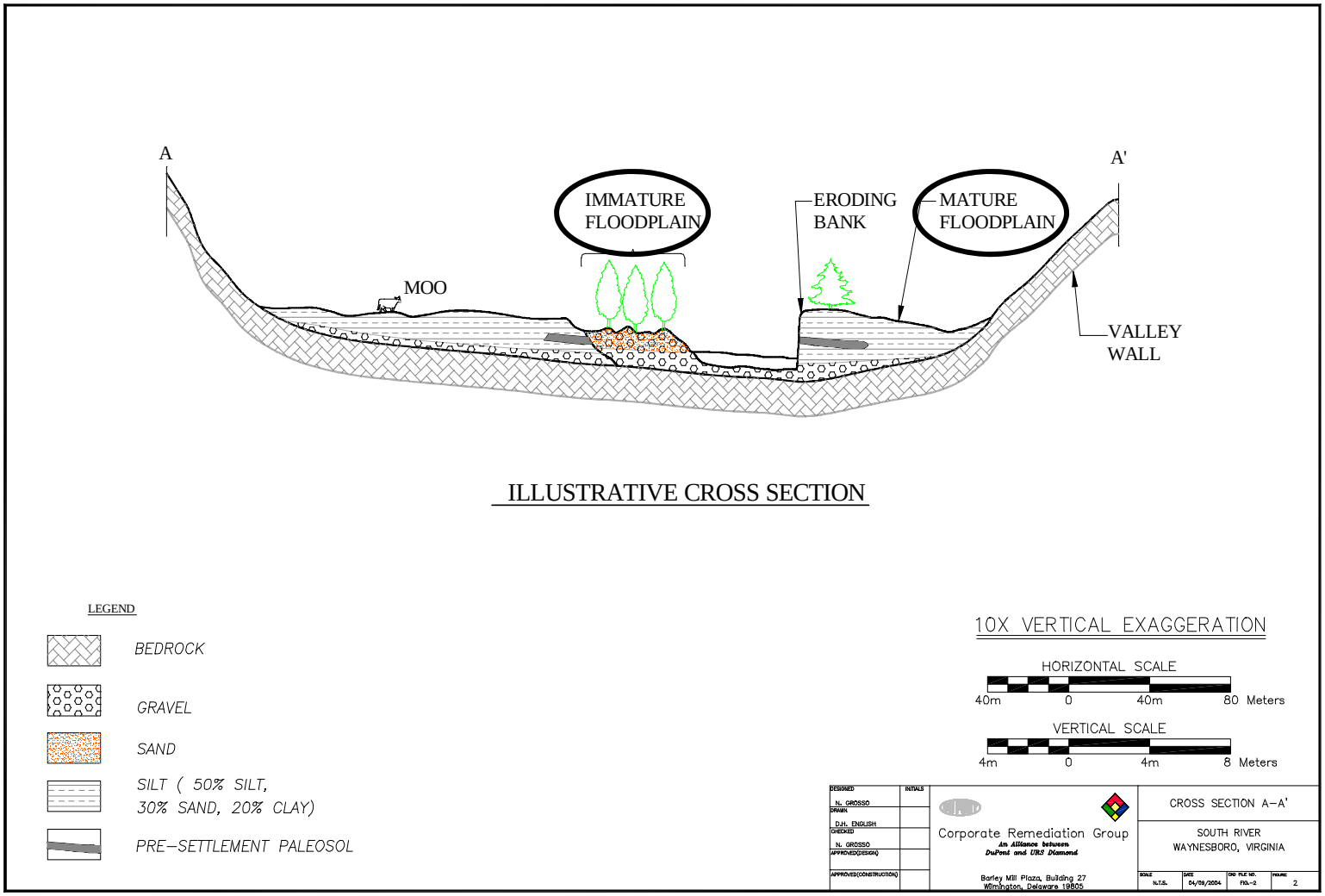




Aerial Photos and Bank Erosion

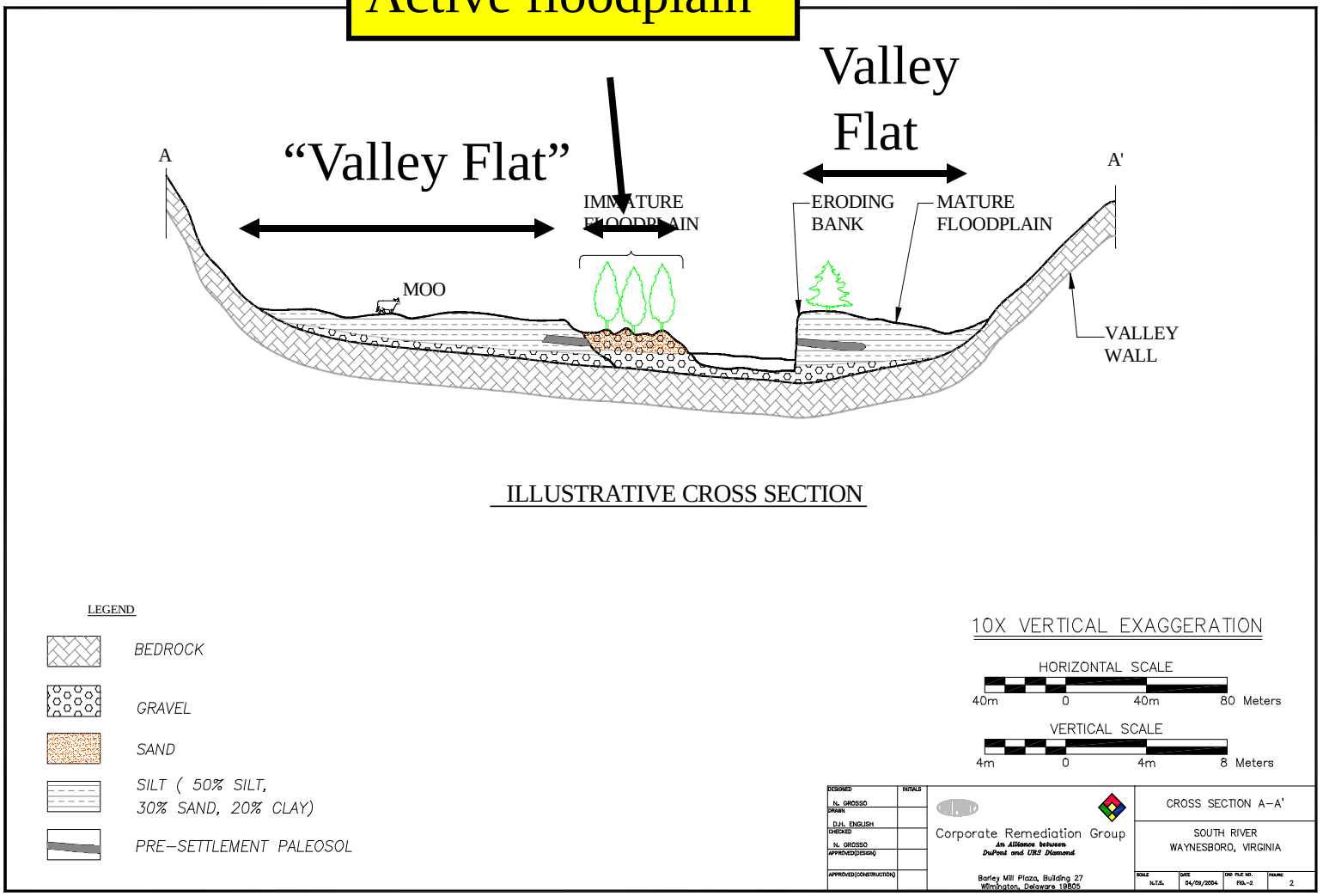
- These define long term average rates of bank erosion
  - Accurate, high quality data
  - Rms errors about 1 ft in rectification
- Rates are very slow in most places
  - Many places have bank erosion rates below threshold of resolution
    - According to mapping of eroding banks, erosion is nonetheless occurring
  - Threshold of resolution is about 10 ft/(68 yrs), less than 2 inches per year
- Preliminary “look” indicates a few hotspots of rapid erosion
  - Areas without bedrock control or trees, and presence of other factors

Re-Evaluation of Terminalogy for Floodplains – “Mature vs Immature” no longer appropriate.



Avoid genetic terms that imply a specific history

"Bank-attached Active floodplain"



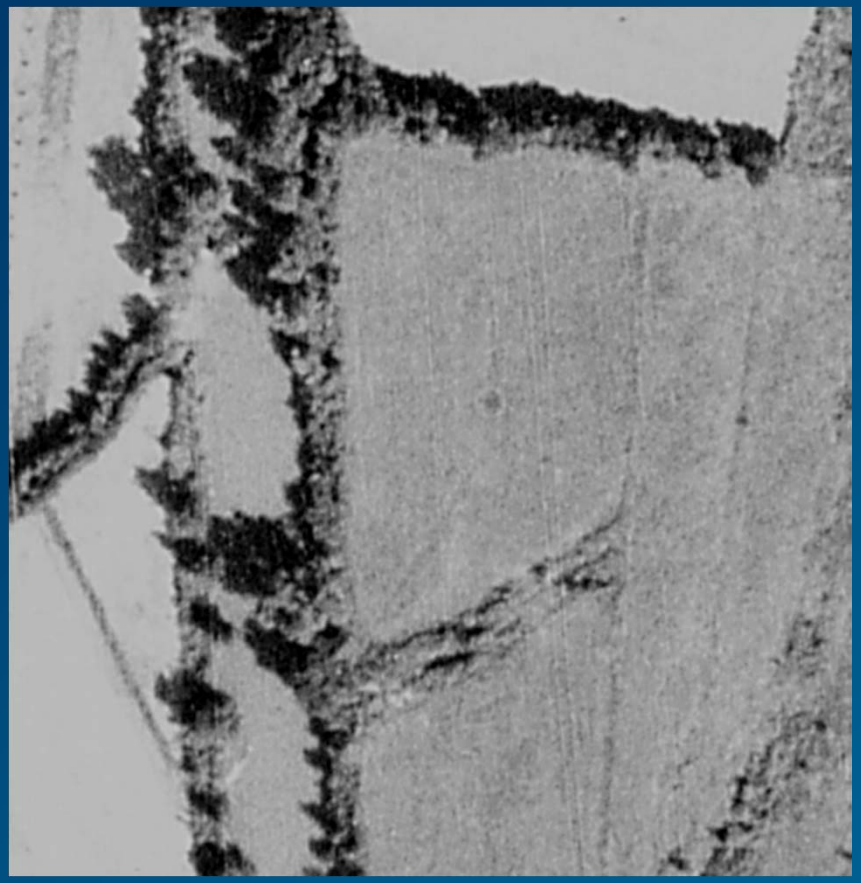
Valley Flat Deposition/Storage

- Evaluated by quantifying deposition over basal tree roots
- Coring the trees provides the age of the tree, and an average rate of accumulation
- Our hypothesis is that valley flat deposition has been negligible in recent decades

Valley Flat Study Area

Hopeman Floodplain Photos

1937

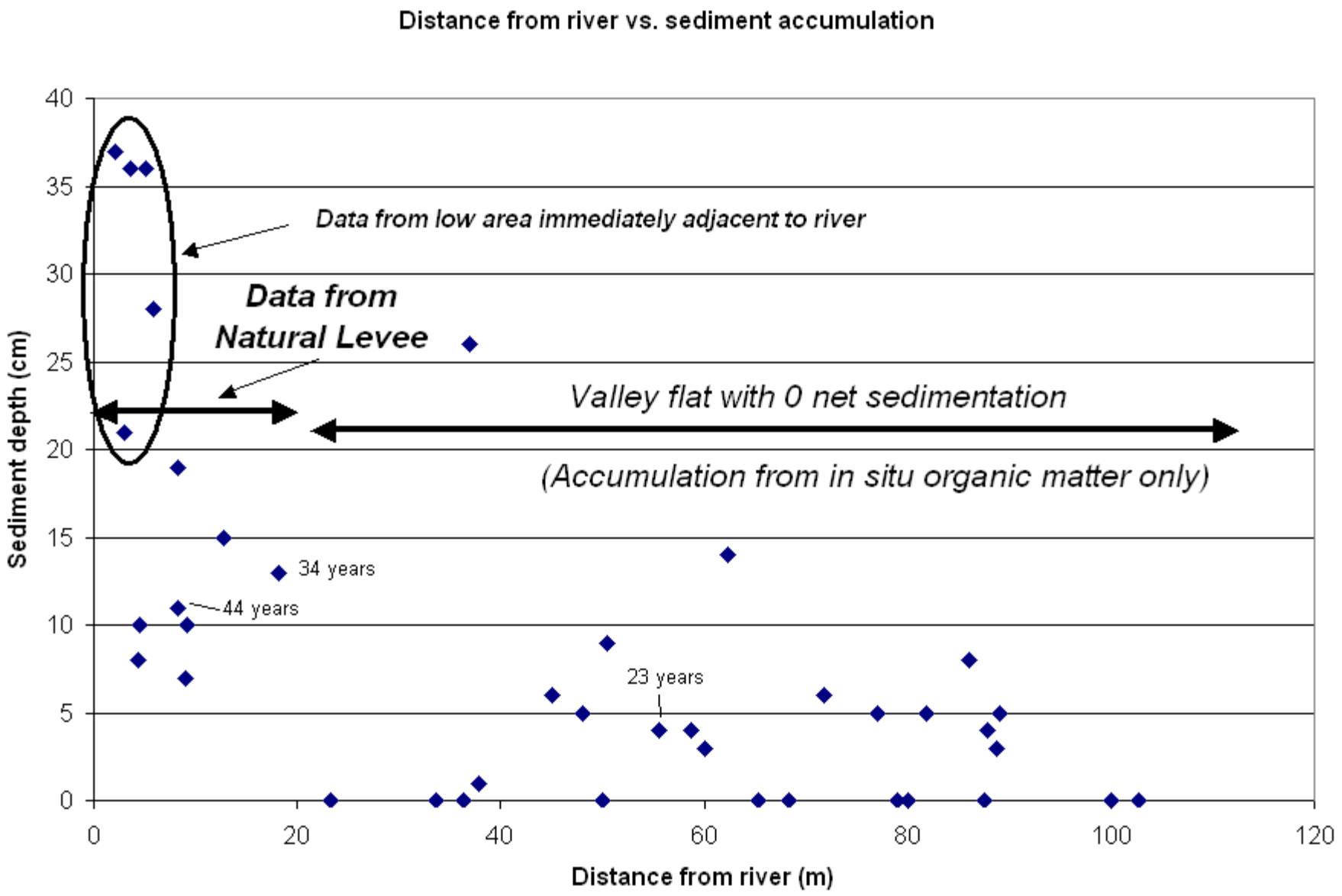


1949

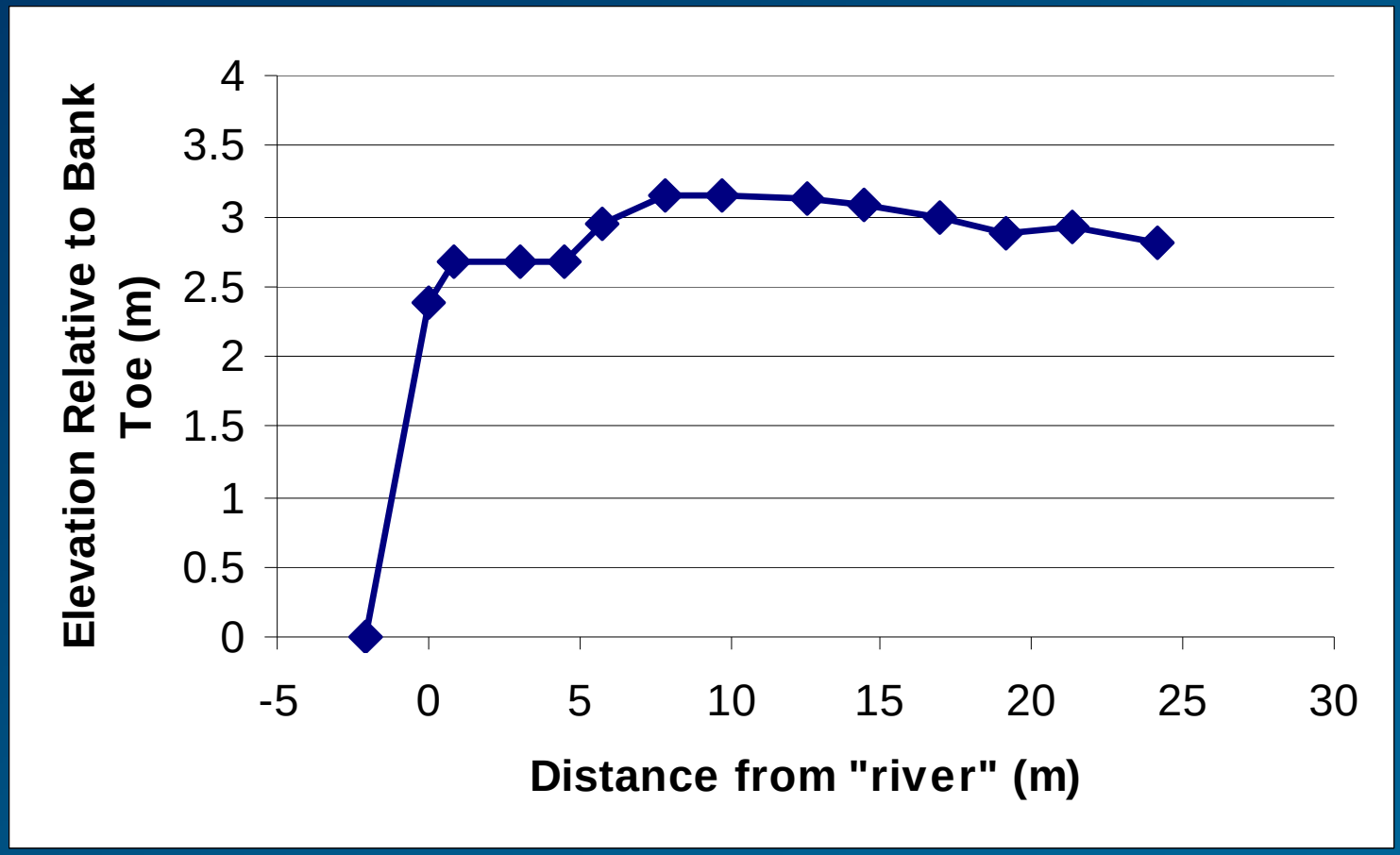
1951

1974

Valley Flat Accumulation



Natural Levee Topography



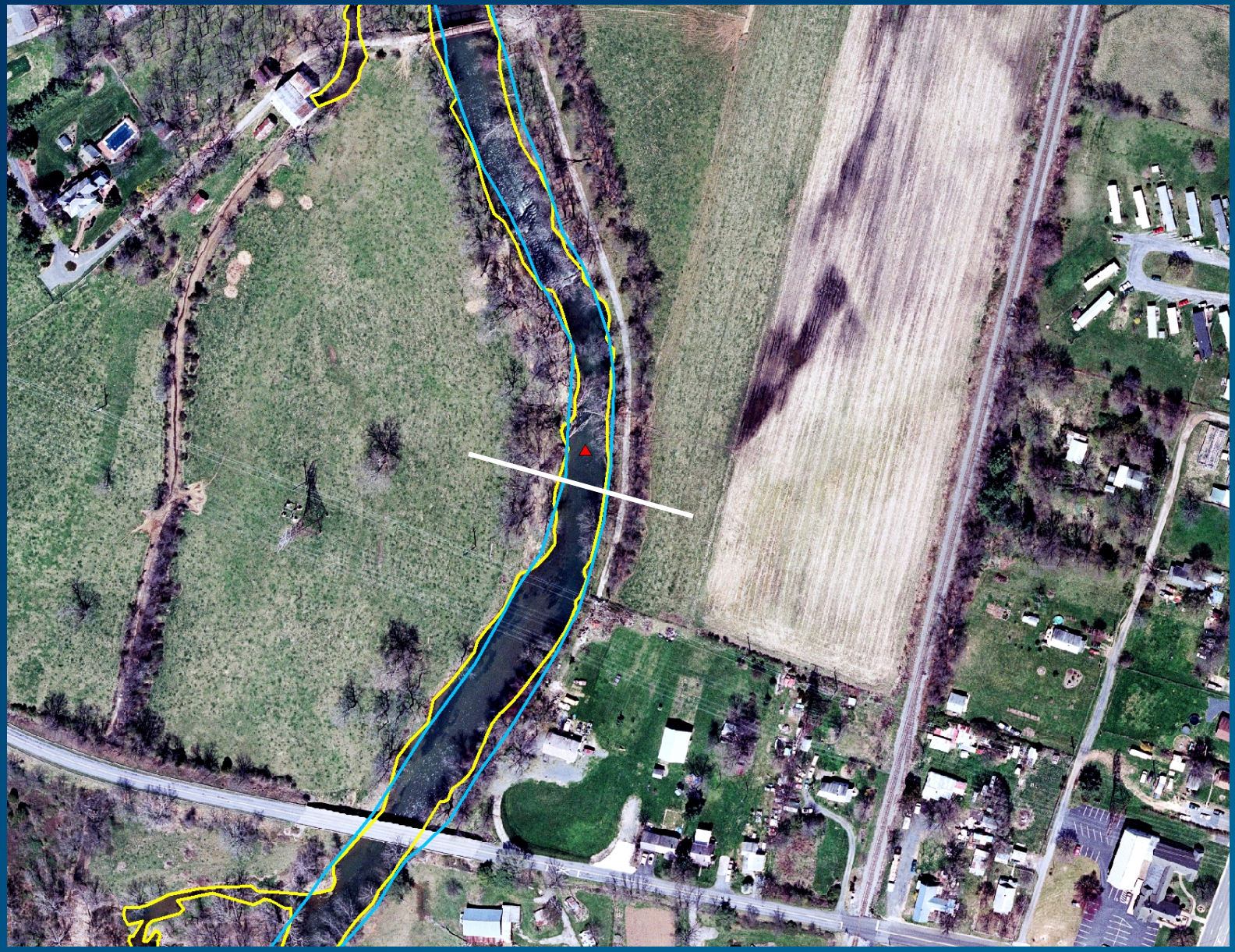
Valley Flat Accumulation - Summary

- To “first order”, accumulation on the valley flat has been negligible in recent decades
- Significant accumulation occurs on “levee areas” within a few 10s of meters of the stream channel
- We are working on dating more trees
- Grain size analysis of sediment in progress

Accumulation on "Bank Attached Active Floodplains"

Initial hypothesis: Deposits should show evidence of lateral migration and consist of mostly sand and gravel

Banks have eroded here from 1937-2005 !



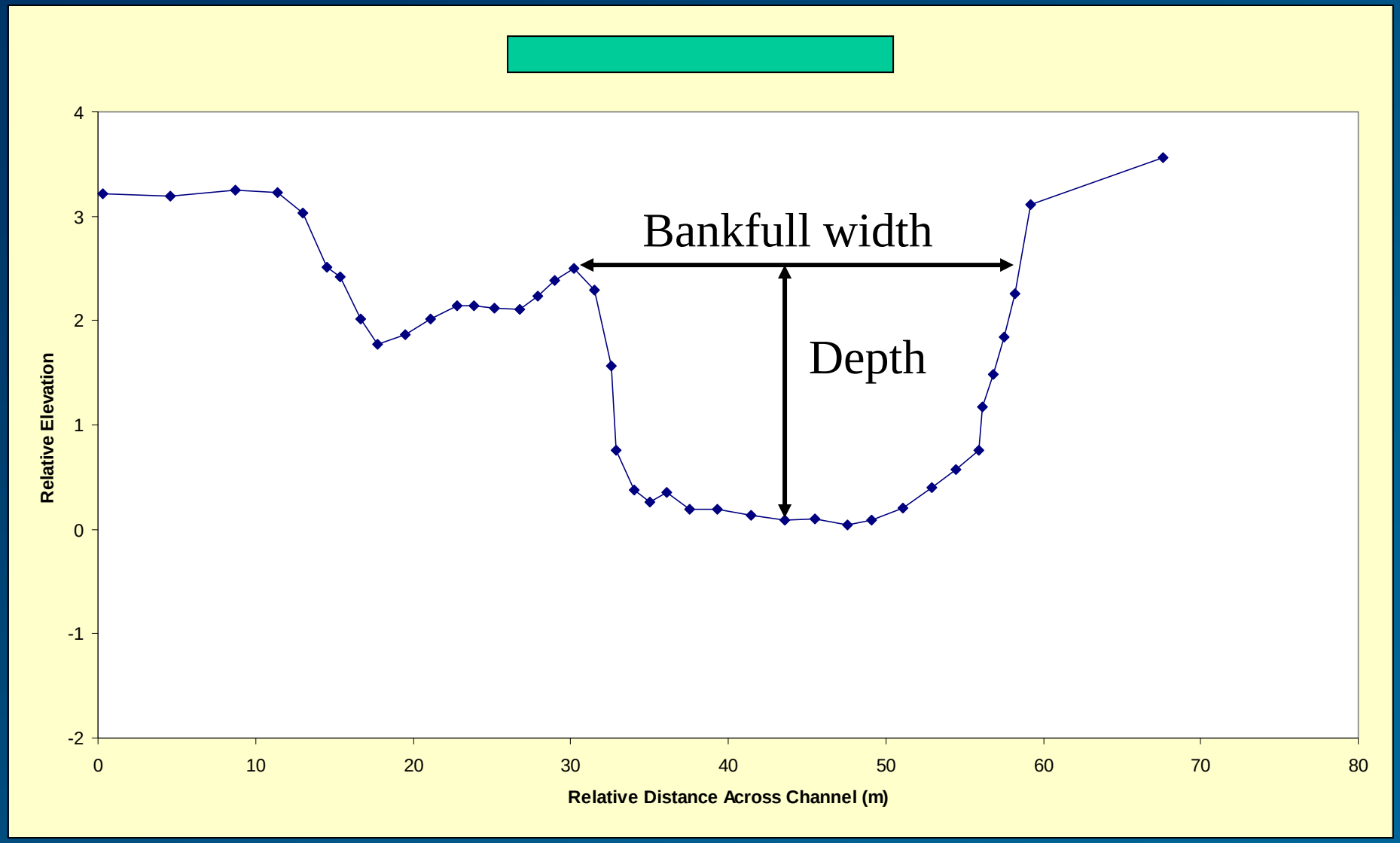
Evidence of “Recent Erosion”

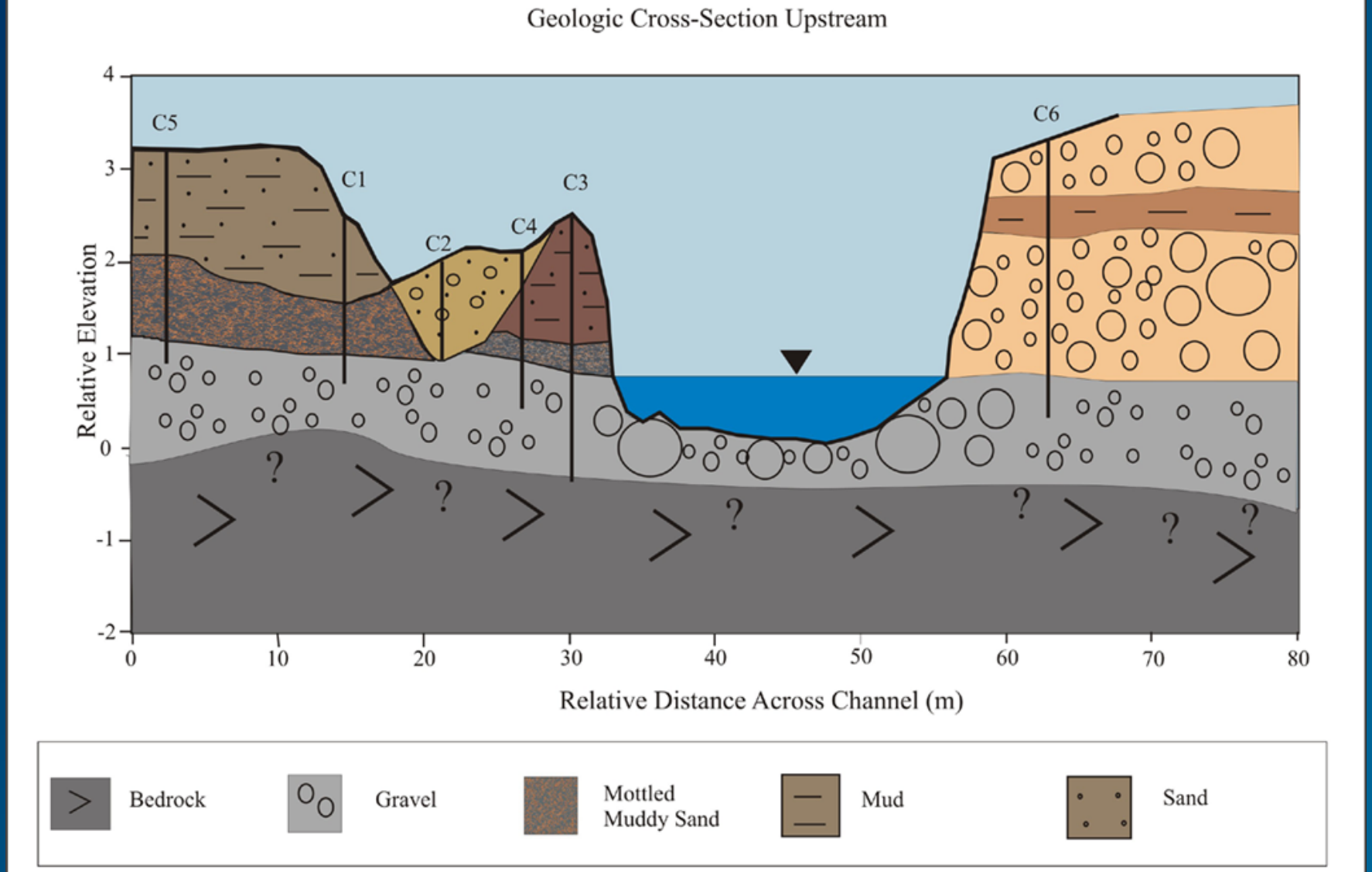
Evidence of “Recent Erosion”

Episodic Deposition of Sand and Gravel

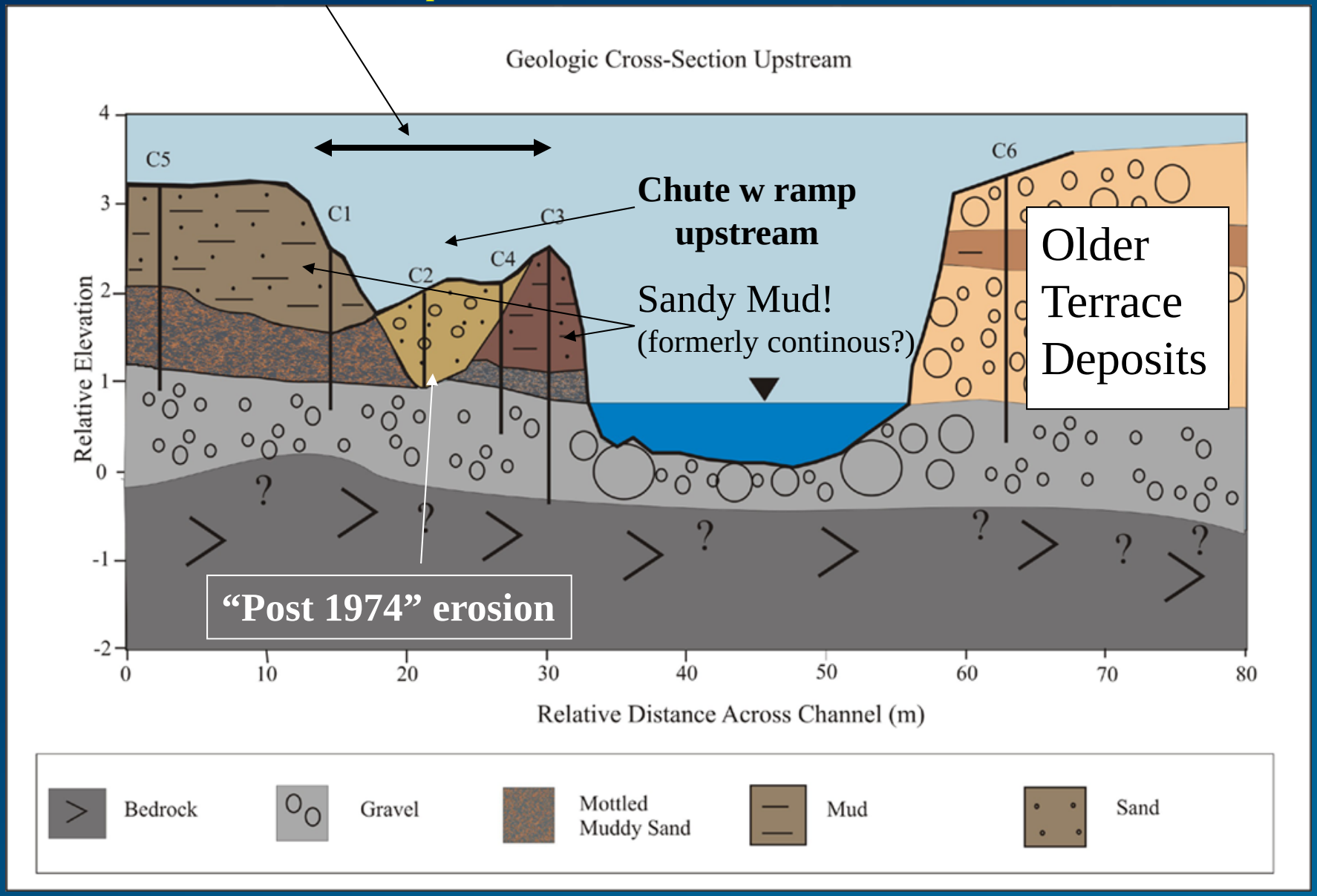
Coring Studies…

Topographic Profile (Cross-section) Below Dooms




Geologic Cross-Section Upstream
C5
C1
C2
C3
C4
C6
Relative Elevation
4
3
2
1
0
-1
-2
0
10
20
30
40
50
60
70
80
Relative Distance Across Channel (m)
Bedrock
Gravel
Mottled
Muddy Sand
Mud
Sand

"Bank attached active floodplain"



Geologic Cross-section – Observations, Questions

- "Bank attached active floodplains" contain significant mud deposits
  - How old? Aerial photos suggest that they formed before 1937.
    - Should not be involved in the Hg story. Proof required?
  - These apparently form very slowly as a result of very slow lateral migration and bank erosion
- No evidence of any fine-grained deposits currently forming
  - *Abundant evidence of "recent" erosion*
  - Is erosion a long-term trend, or a result of recent storms?
    - Looks like a long term trend, but detailed proof is lacking
- Working hypothesis:
  1. These are areas of recent erosion and episodic accumulation of sand and gravel
  2. Accumulation of silt and clay may be neglected in the sediment budget

Mud Storage in the Pores of the Gravel/Cobble Bed

- Measured monthly at 12 sites by pumping pore water and fine-grained sediment out of the river bed.
- Storage in pores is 3 orders of magnitude less than the annual suspended sediment load
  - Negligible volumetrically

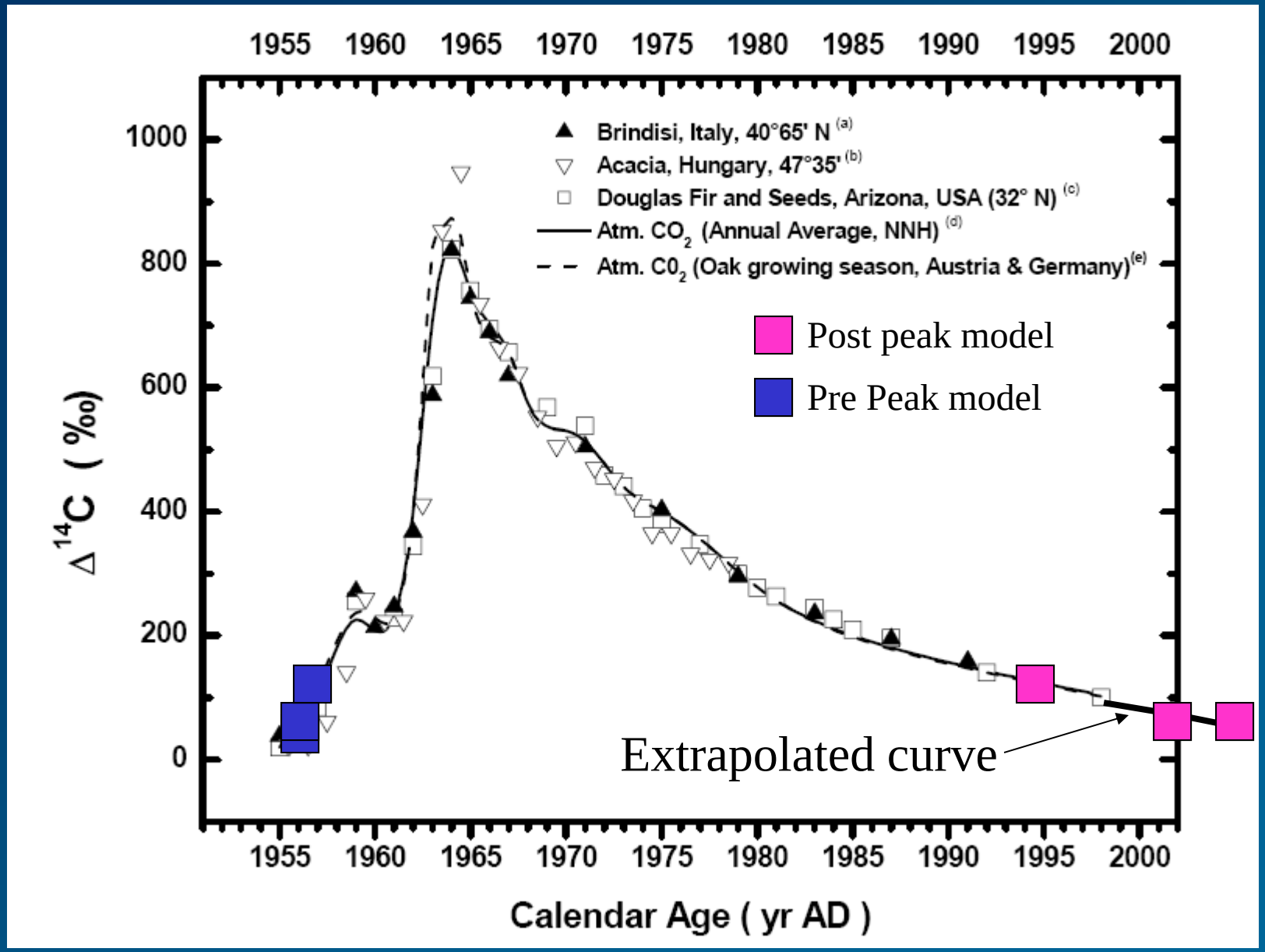
Radiocarbon Dating Mud Deposits

Based on post-1950 record of C14 released into the atmosphere during testing of nuclear weapons

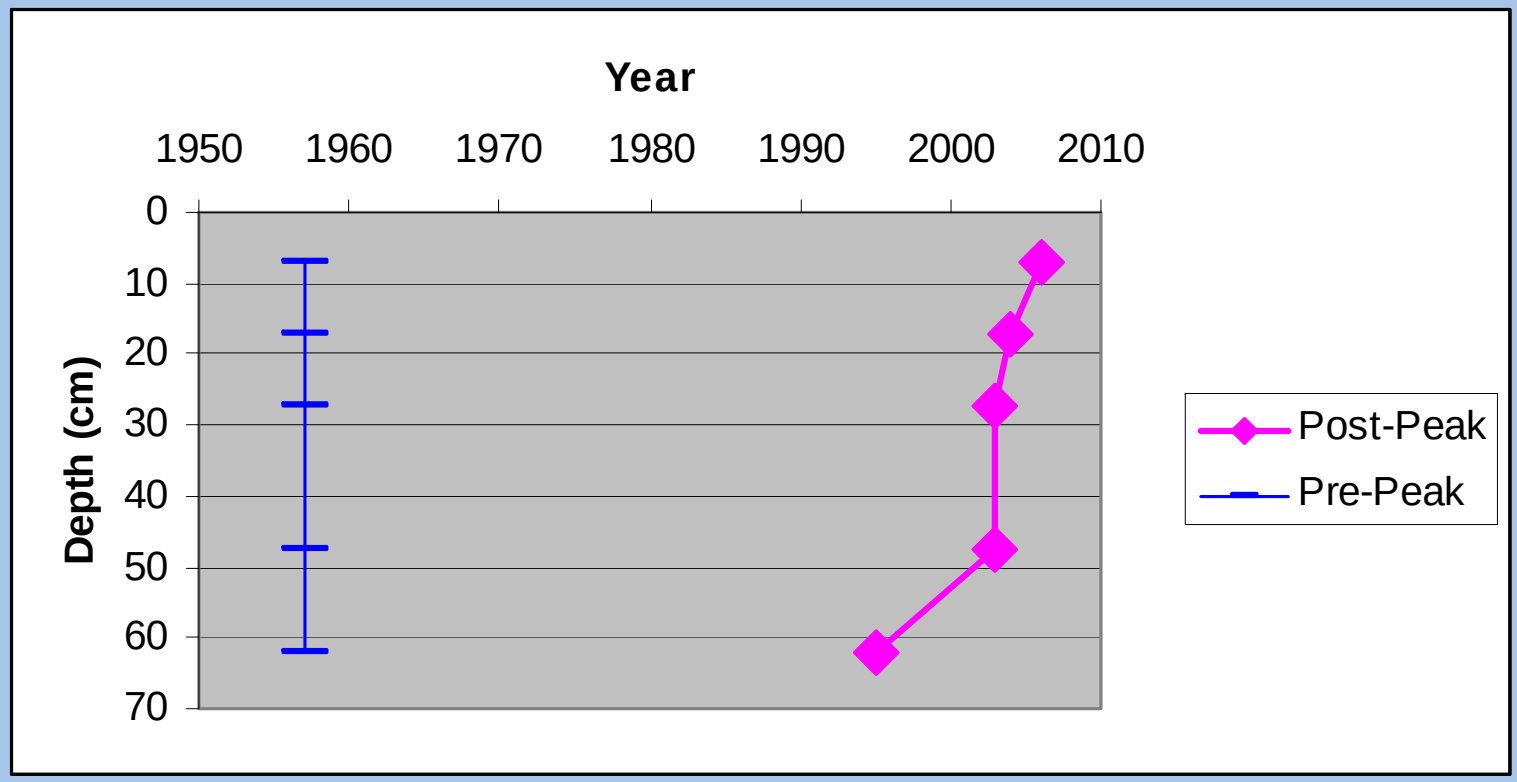
Results for 5 samples from Core H2C (River mile 3.25):

1. ***The entire deposit is younger than 1950***
2. Two possible age models (next slides)

Bomb Radiocarbon Curve with H2C Analyses



Two Age/Depth Models for Core H2C



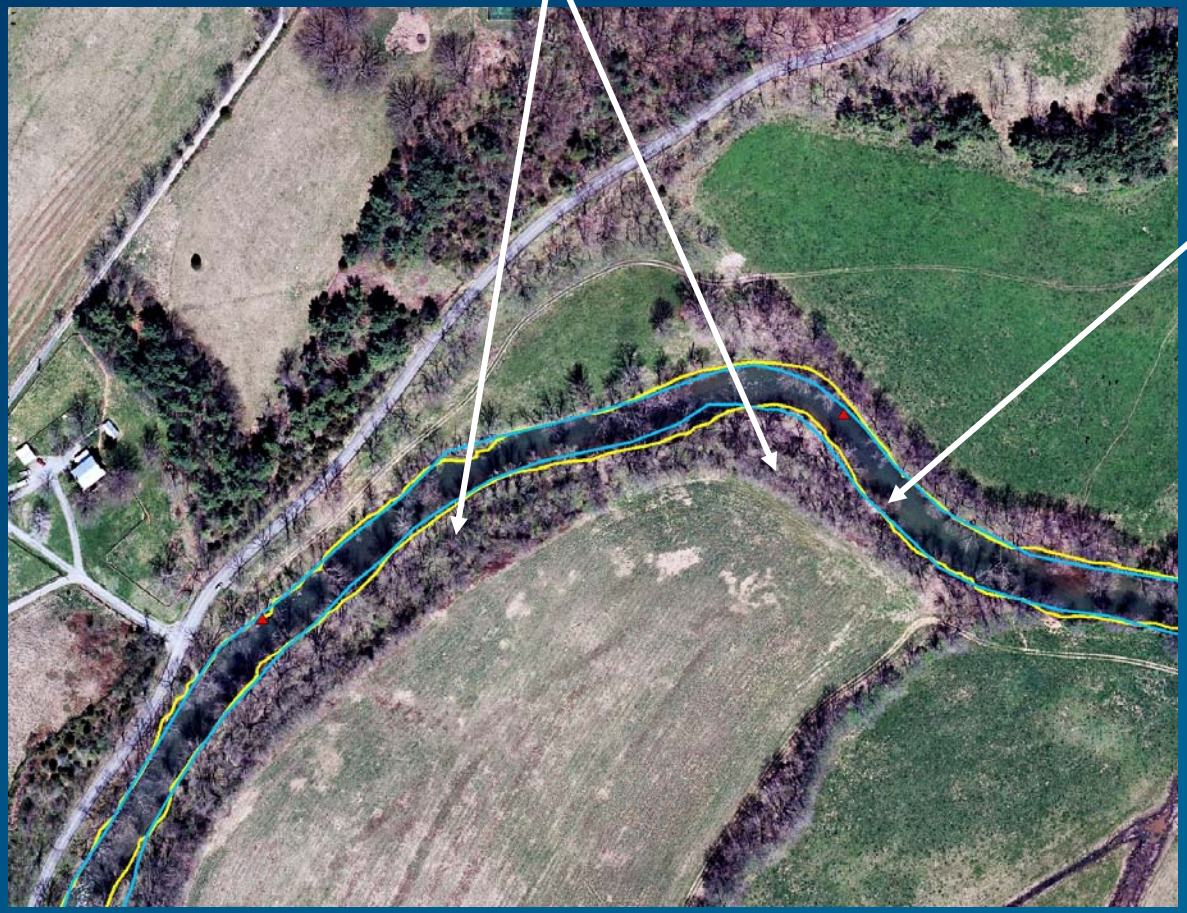
Which Model is Best?

- Use dendrochronology to determine when the trees died
  - Which should be related to when they arrived here
  - Which should predate the mud deposit …..

Core H2C

Which Age Model is Best?

The construction of this artificial levee likely predates mud accumulation at H2C (look on historical aerial photos, use other sources)

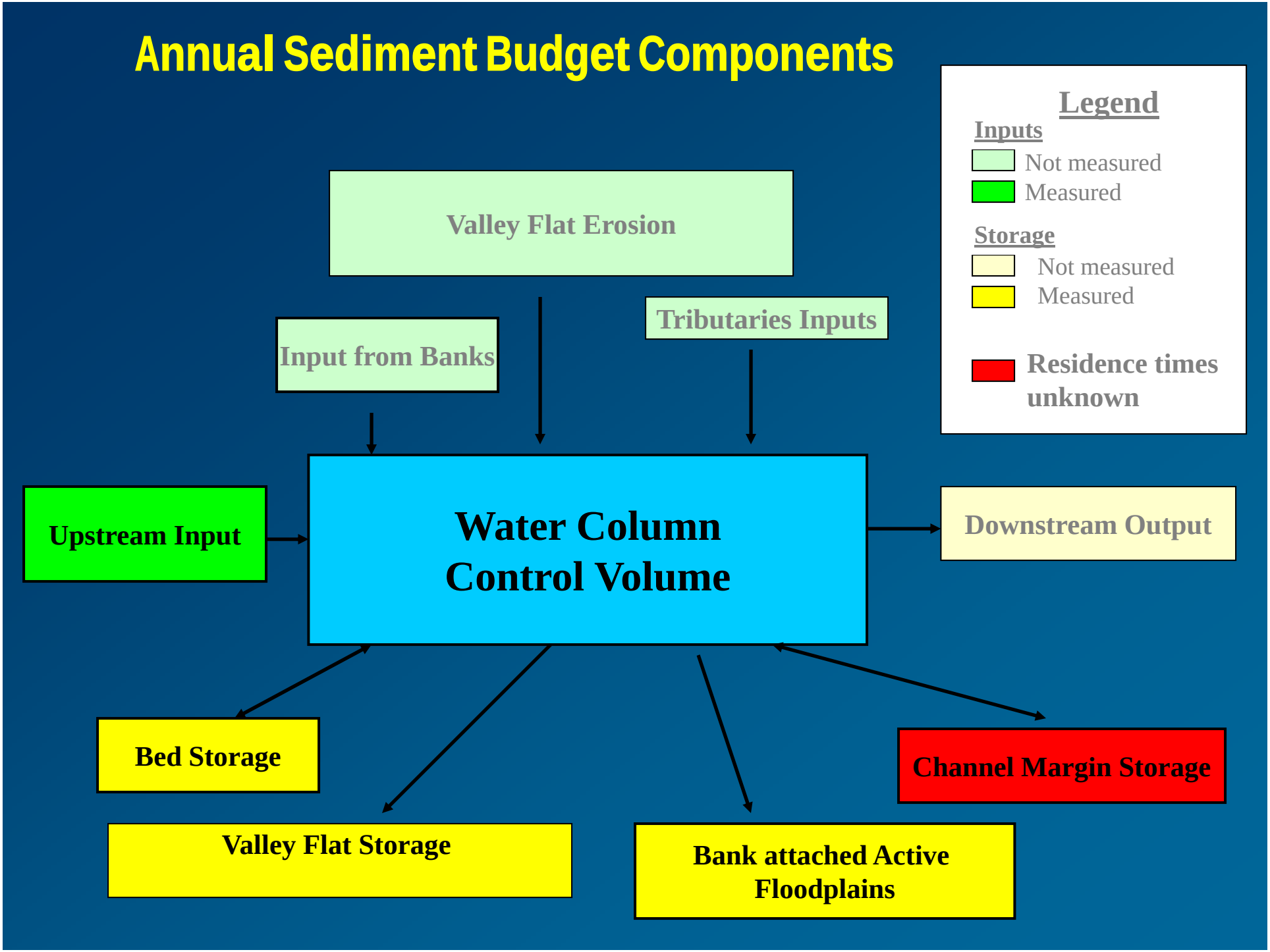


Core H2C

Which Age Model is Best?

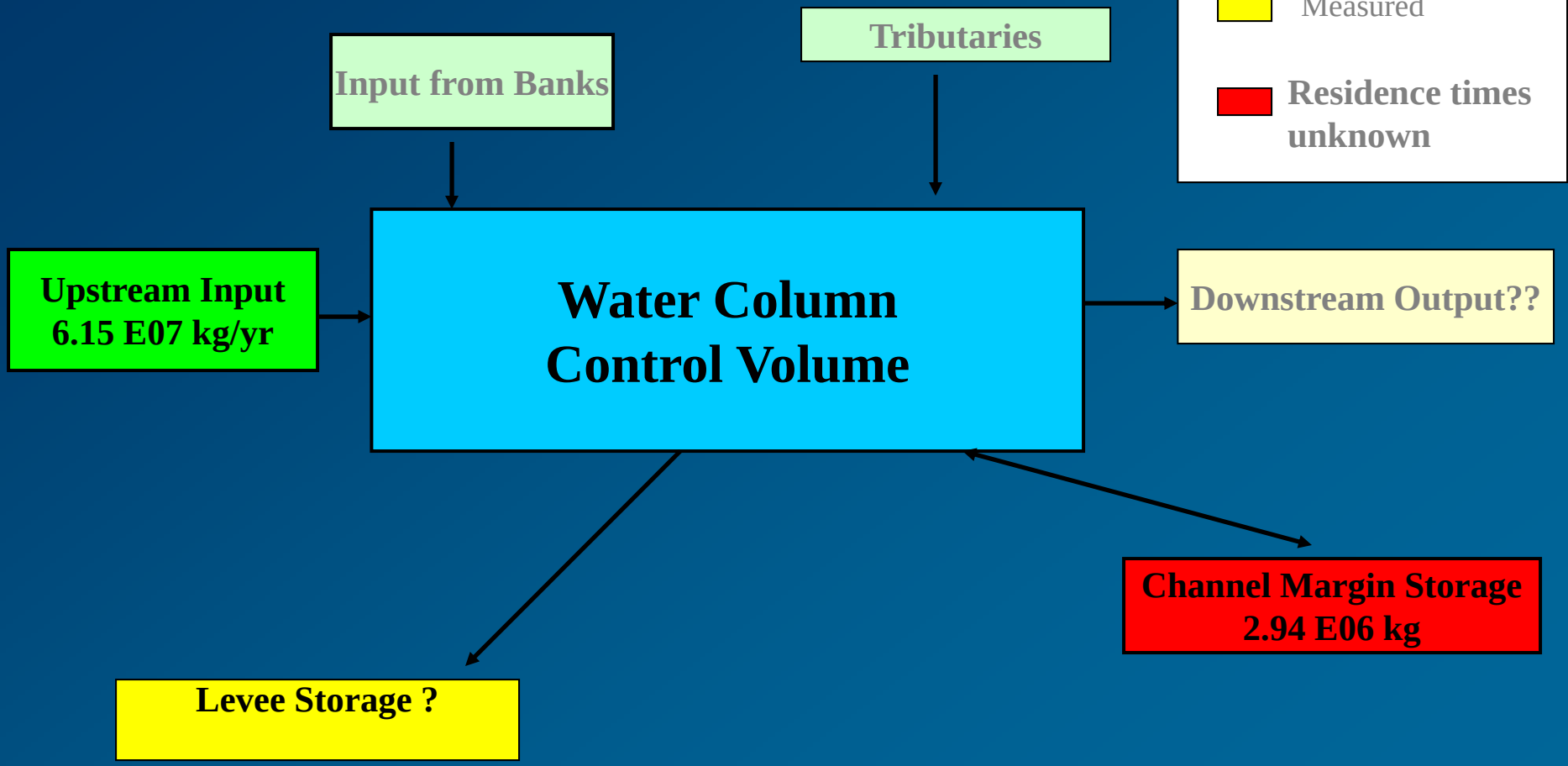
- Additional sleuthing is underway….

Annual Sediment Budget Components



Updated Provisional Annual Sediment Budget (Waynesboro – Crimora) – It's Simple!

Numbers available for all except levees by 6/30 for entire study area to Port Republic



Conclusions from Recent Work

- Bank erosion is a likely significant source of silt, clay, and Hg to the channel of South River
- Silt, clay, and Hg are stored in the channel for decades in “fine-grained channel margin deposits” created in part by large woody debris
- Floodplain deposits do not appear to be currently active sites of sediment accumulation
  - Levee areas remain poorly studied

Future Work Under Discussion

- Aerial Photo Analysis
  - Maps showing position of river banks in 1950s and 1970s to supplement data from 1937 and 2005
  - Where lateral migration is rapid, look at channel position at decadal intervals
    - Is migration continuous, or episodic (driven by hurricanes, land use changes, etc.)
- Lidar monitoring of contemporary bank erosion rates and processes
  - 35 sites for baseline data
  - Resurvey within 1 year where migration is likely to be detected
- Develop predictive bank erosion models from data obtained

Conclusions – South River Geomorphology

- The floodplain shows evidence of historical accumulation during past centuries, likely as a result of land use changes related to European settlement and possibly construction of mill dams (at least 8) along the river
- Currently, floodplain deposits are being slowly eroded by bank erosion.
- Bank erosion along South River is very slow, and are strongly influenced by bedrock and by erosion resistant trees
- “Bank attached active floodplains” are sites of erosion and episodic accumulation (and reworking) of sand and gravel.
- Geomorphic principles from alluvial rivers DO NOT APPLY
- Fine-grained channel margin deposits persist for decades
- The sediment budget for South River is currently very simple:
  - Inputs – bank erosion, upstream areas, and tributaries
  - Temporary storage – channel margin and levee deposits