Sediment Pollution from Mass Wasting Along River Banks

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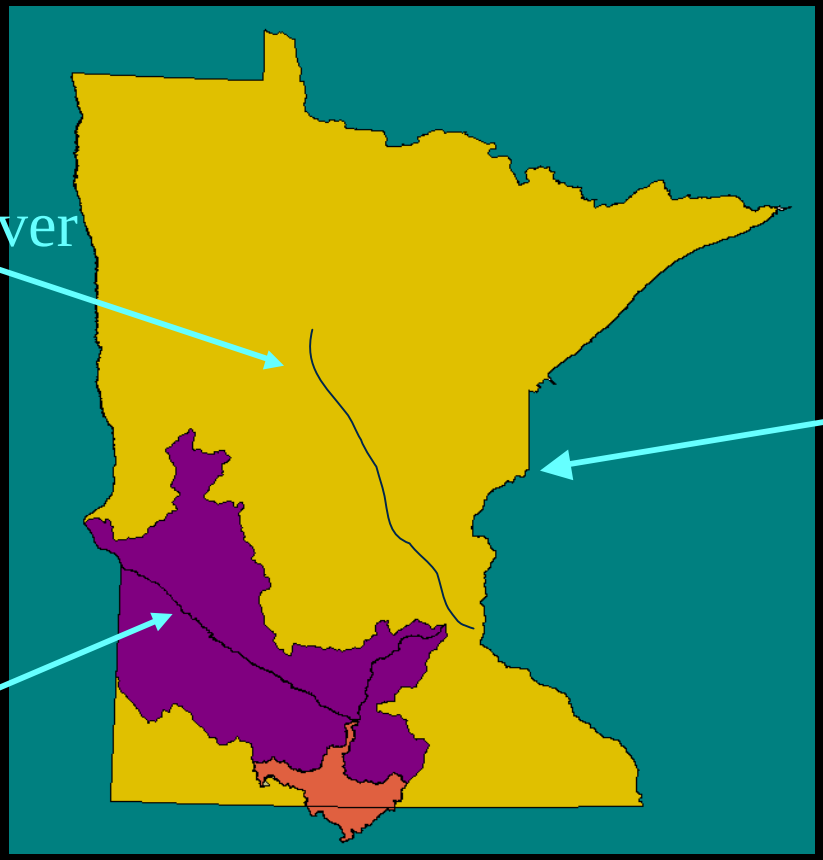
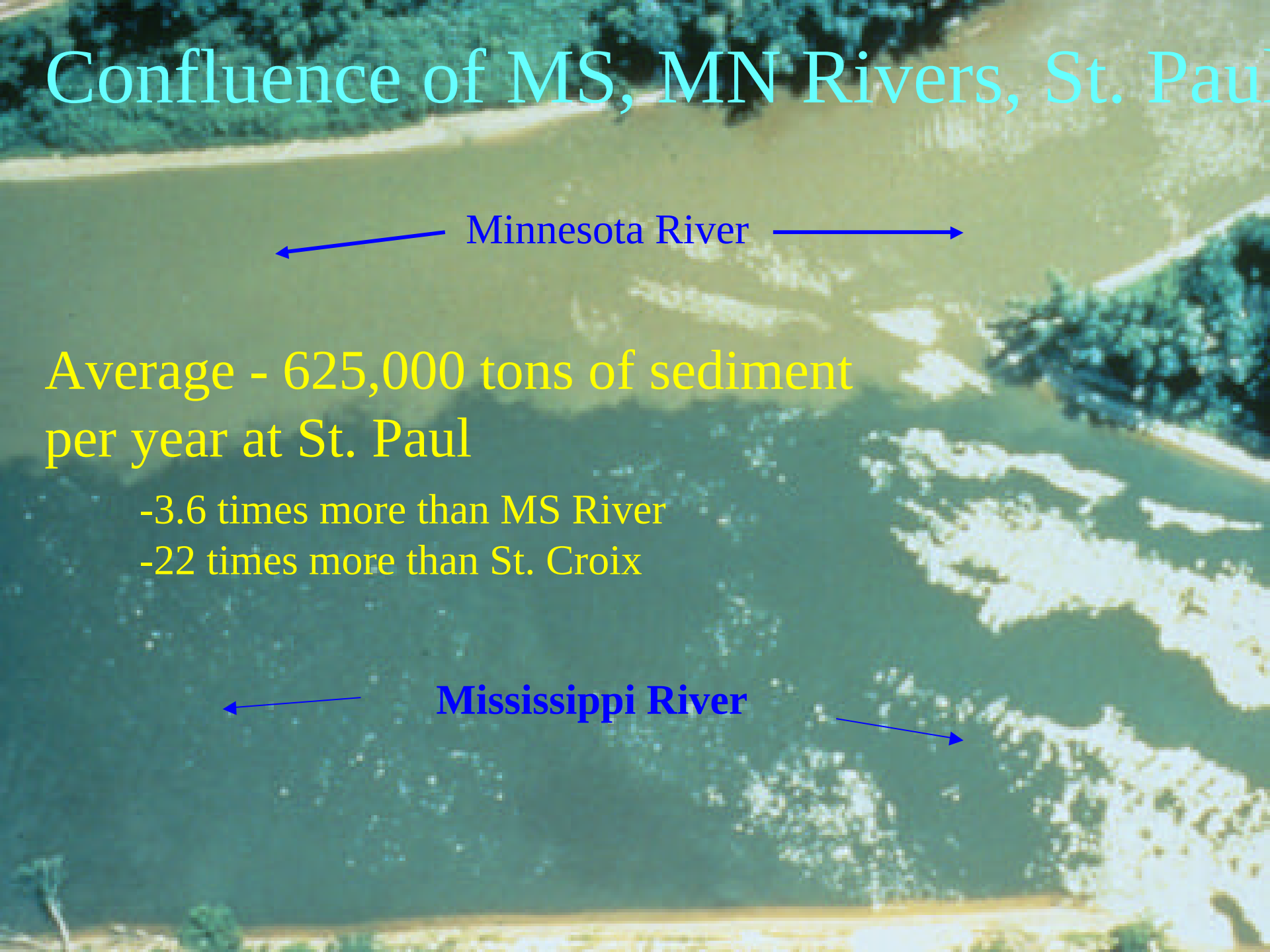
Major Rivers in Minnesota



Confluence of MS, MN Rivers, St. Paul

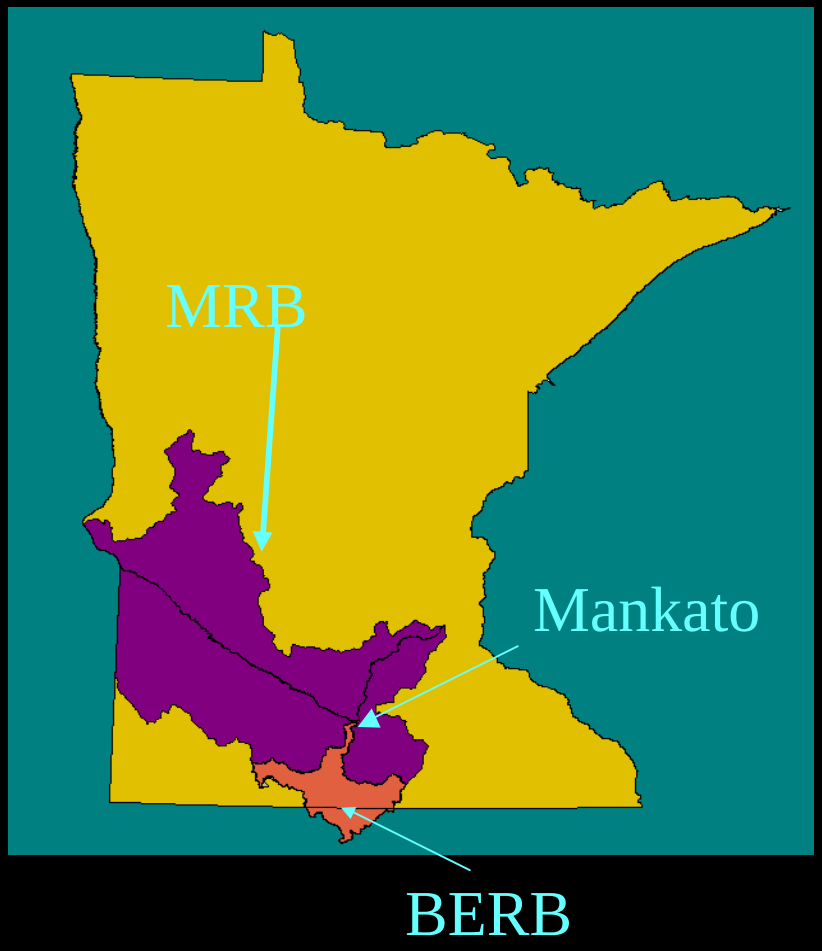


Average - 625,000 tons of sediment per year at St. Paul

- -3.6 times more than MS River
- -22 times more than St. Croix

Confluence of Mississippi and St. Croix at Prescott, 2004

Some Statistics



Minnesota River Basin (MRB)

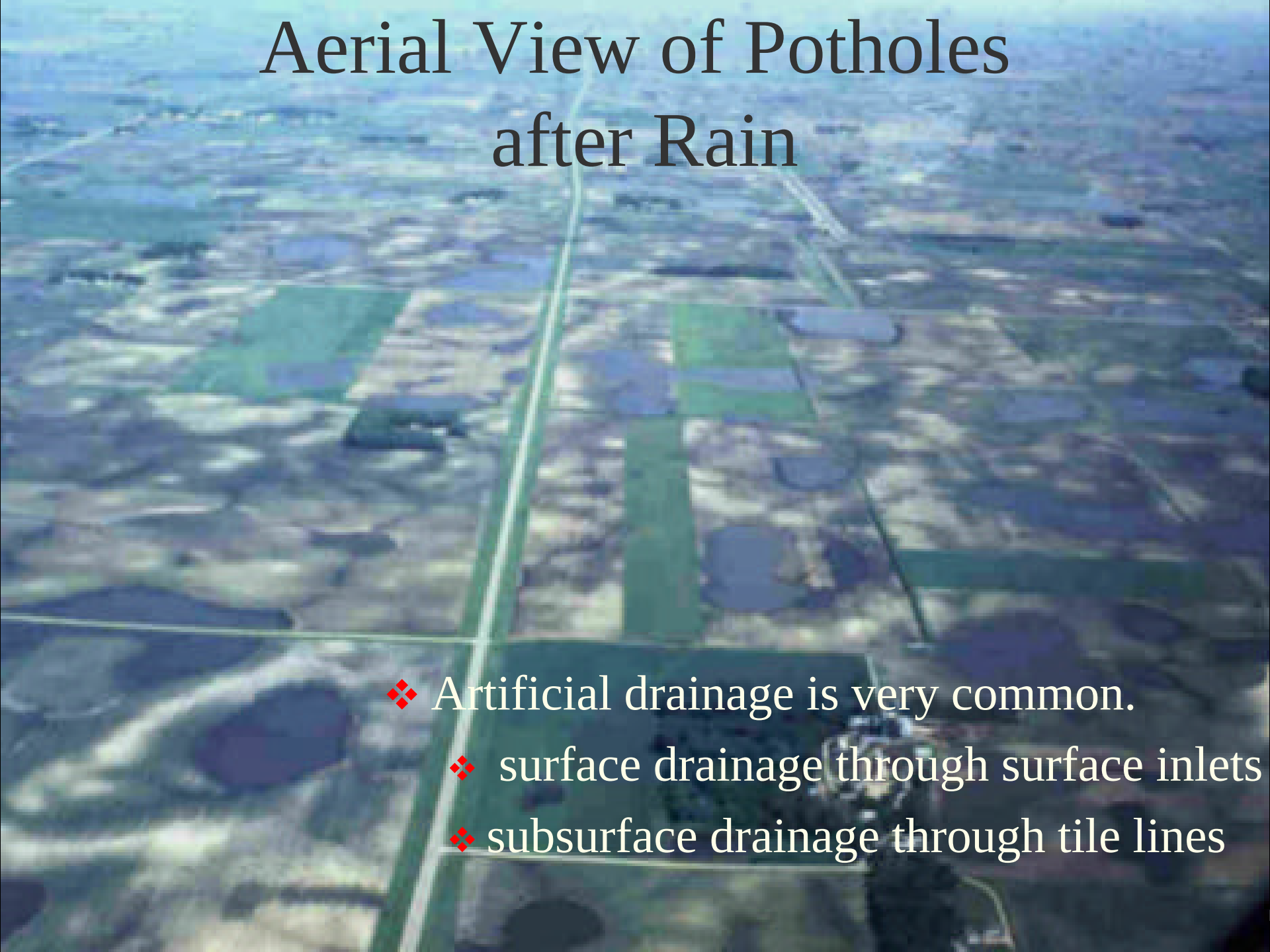
- 33% of the land in MRB is <2% slope
- 74% of the land in MRB is <6% slope

Blue Earth River Basin (BERB)

- 54% of the land in the BERB is <2% slope
- 93% of the land in the BERB is <6%

However, the Blue Earth River delivers 55% of all sediment to the Minnesota River at Mankato.

Aerial View of Potholes after Rain



- Artificial drainage is very common.
  - surface drainage through surface inlets
  - subsurface drainage through tile lines

Removing Excess Water

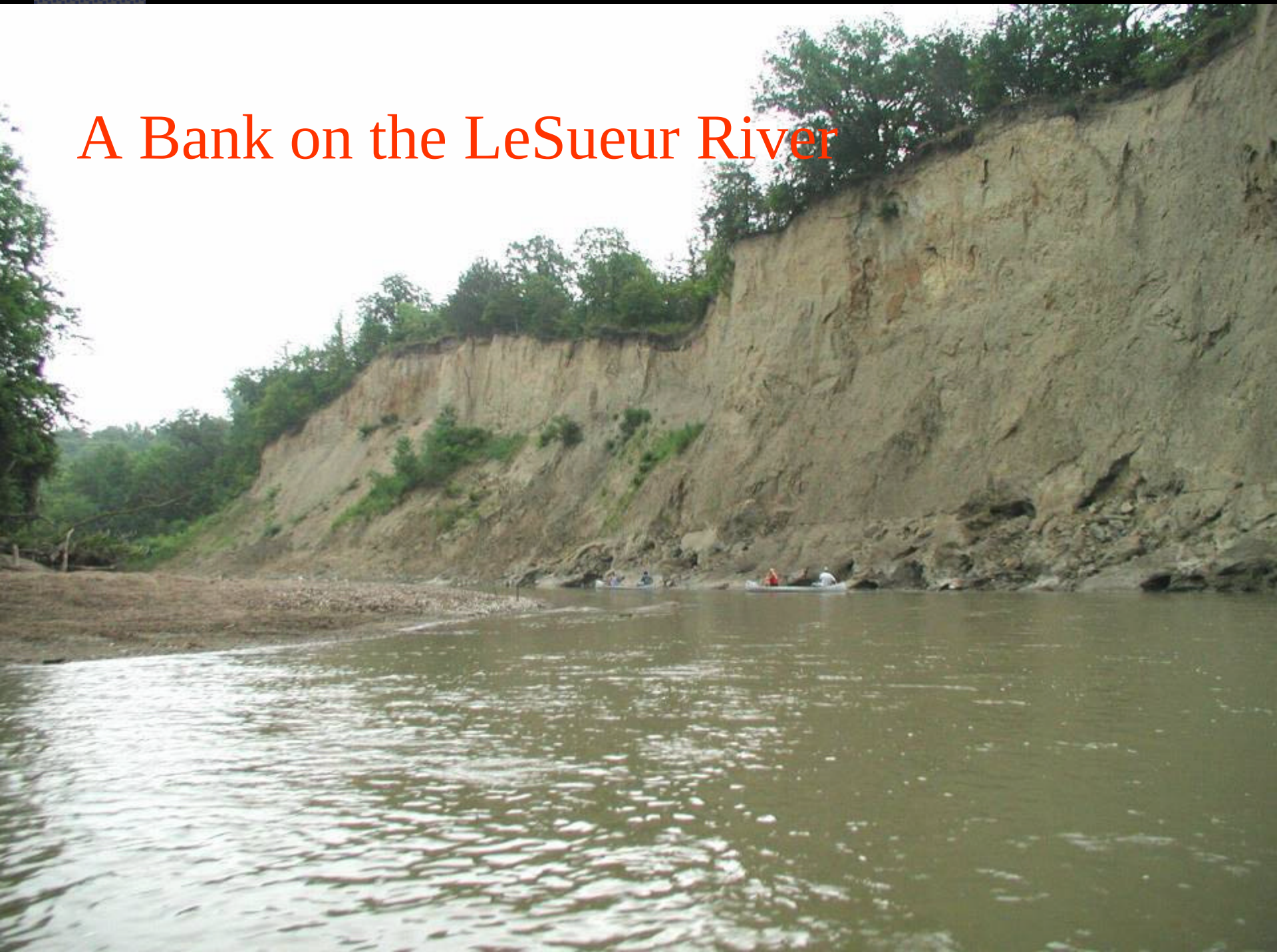
Surface Inlet

Potential Sources of Sediment

Flat upland landscape

Eroding river banks

A Bank on the LeSueur River



Flat Fields

Questions?

- What is the main source of sediment in the Minnesota River Basin: river banks vs. flat fields?
- What is their distribution?
- What mechanisms might be causing bank sloughing?

Sloughing Banks
Jeff Thiesen's Bank

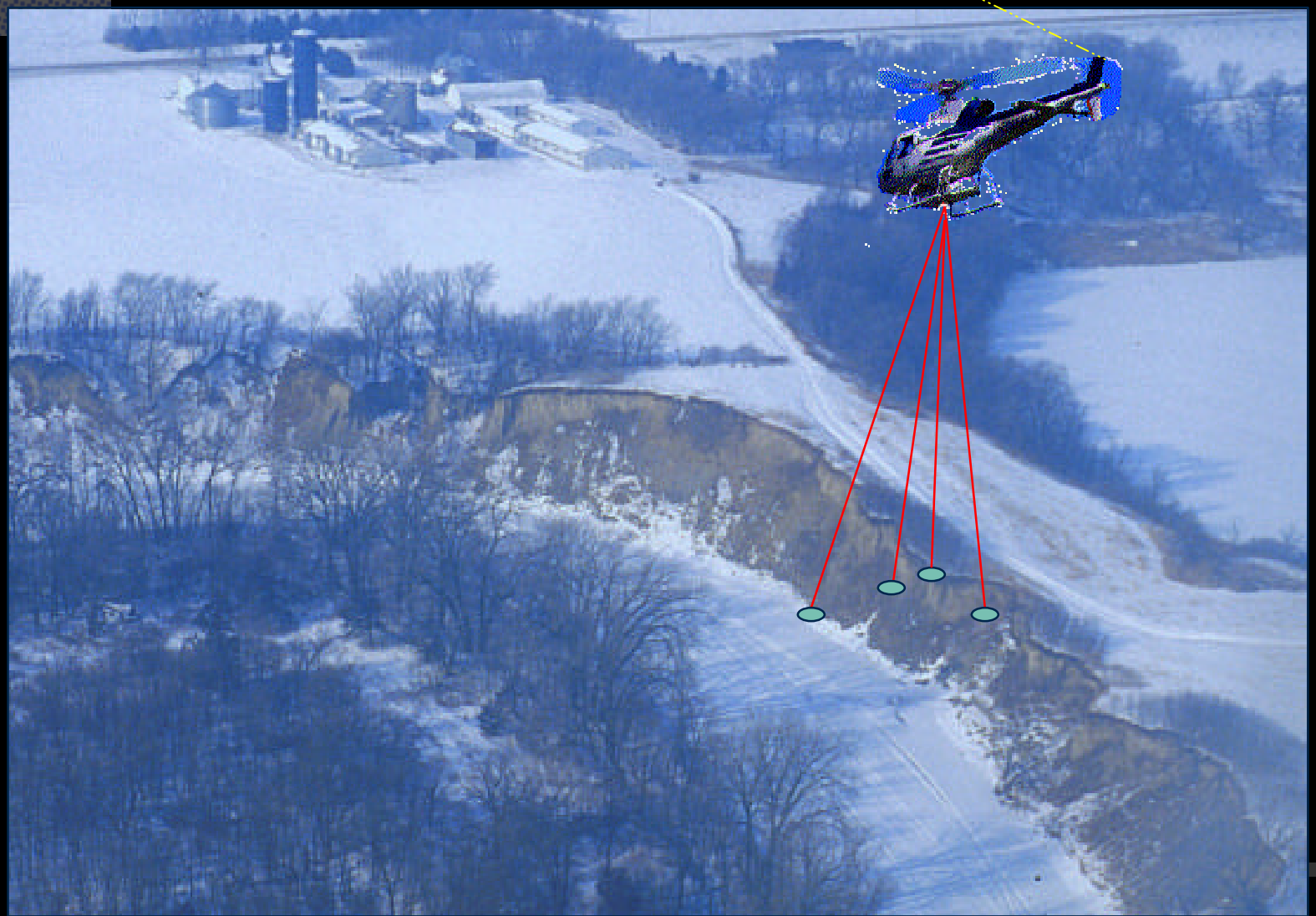
Lost a barn and a corn crib.
In 30 years, he has lost 70 ft of bank
300 long, 200 ft height

Long Term Erosion

River

Floating Logs

Laser Scanning



Laser Altimetry Components

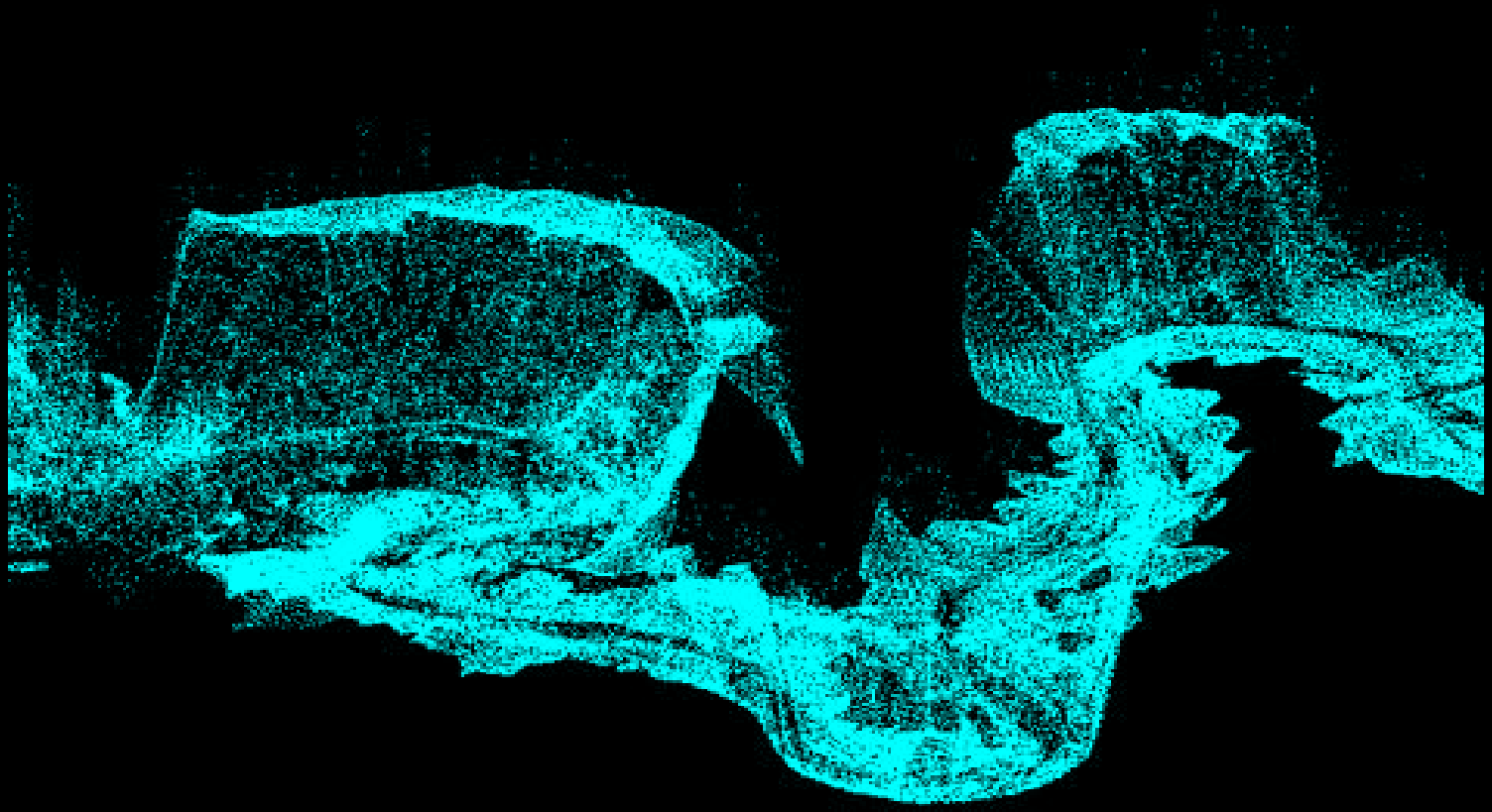
GPS survey equip.

Scanning laser

Data recorder

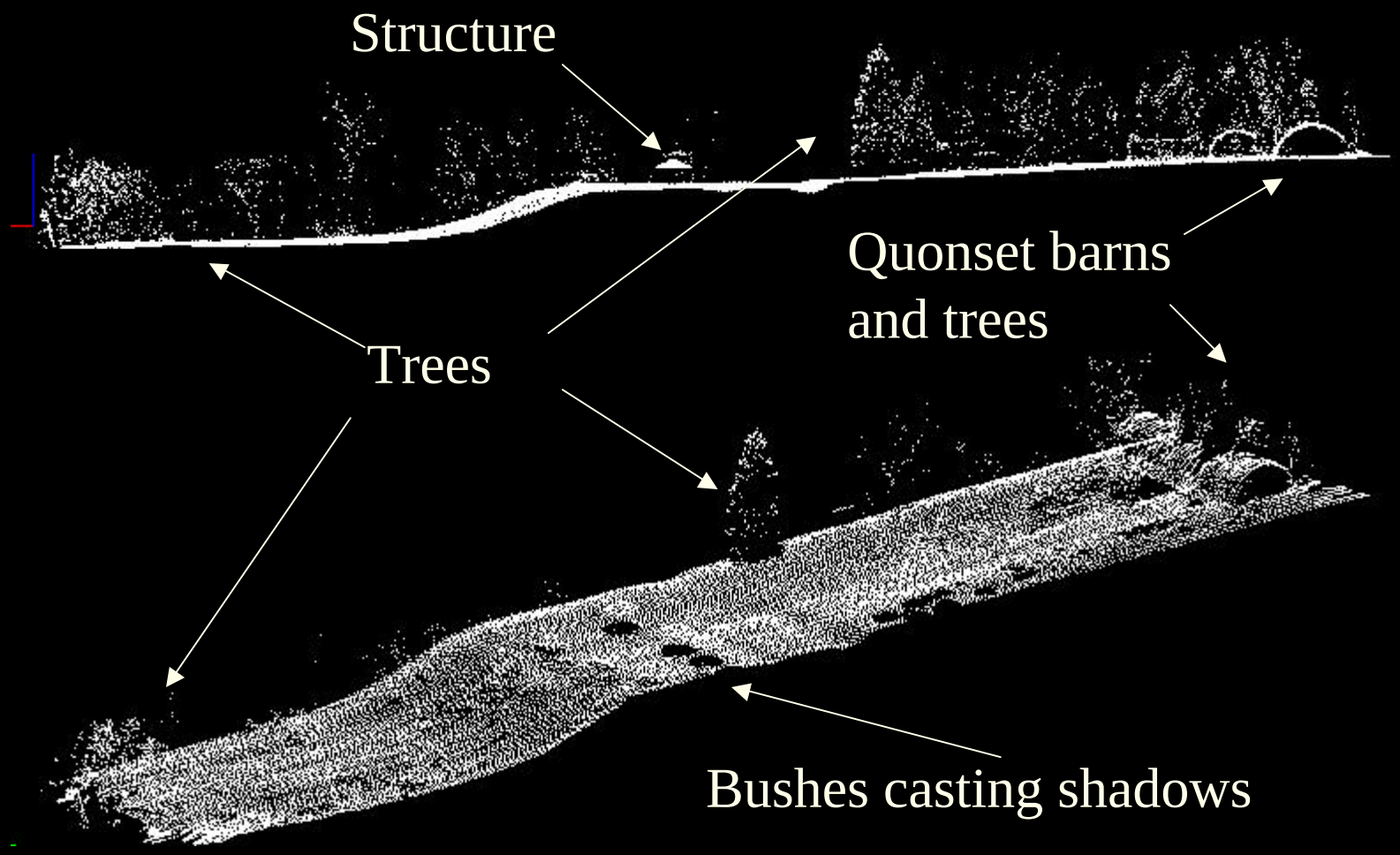
USGS benchmark

Laser scan – raw data

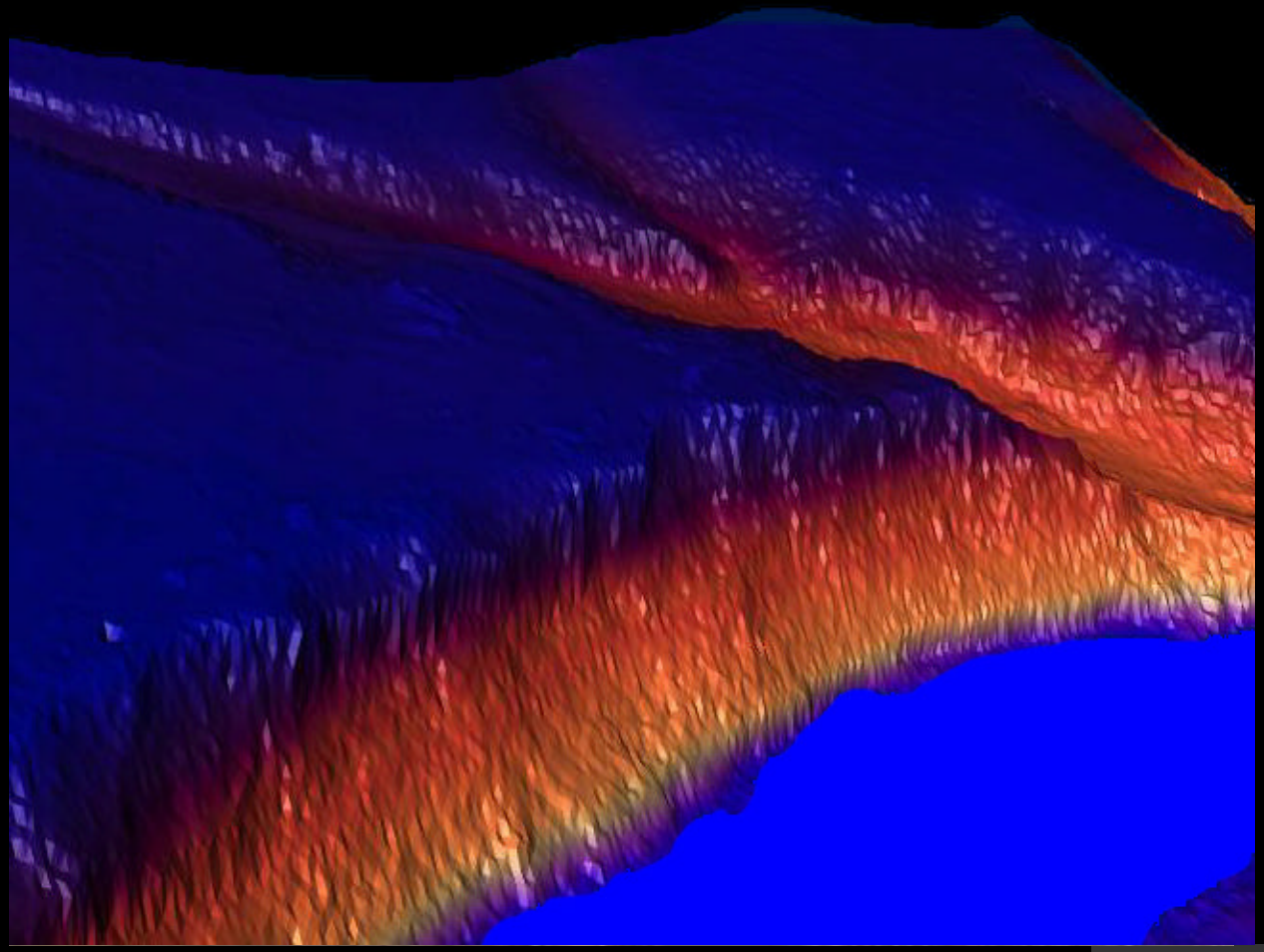


Approx. ¼ mile of 35 river miles scanned

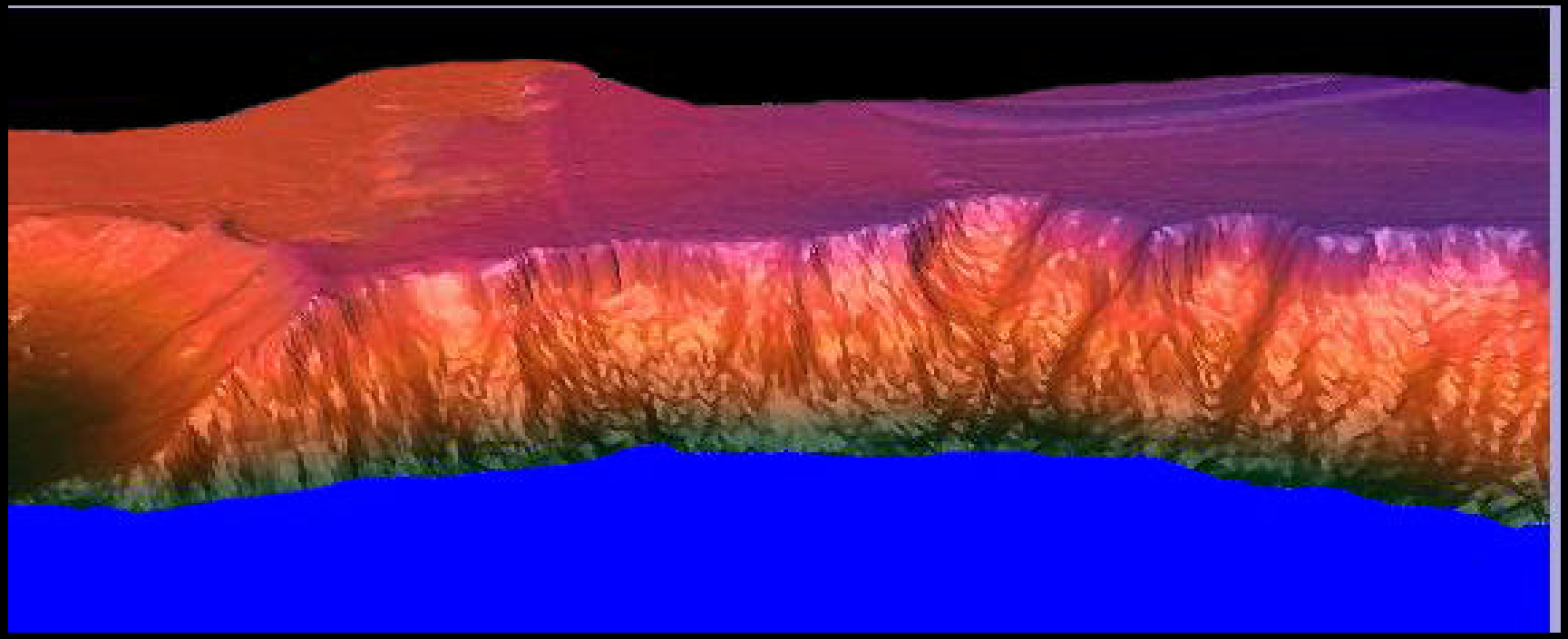
Laser Data ‘Image’of Familiar Objects

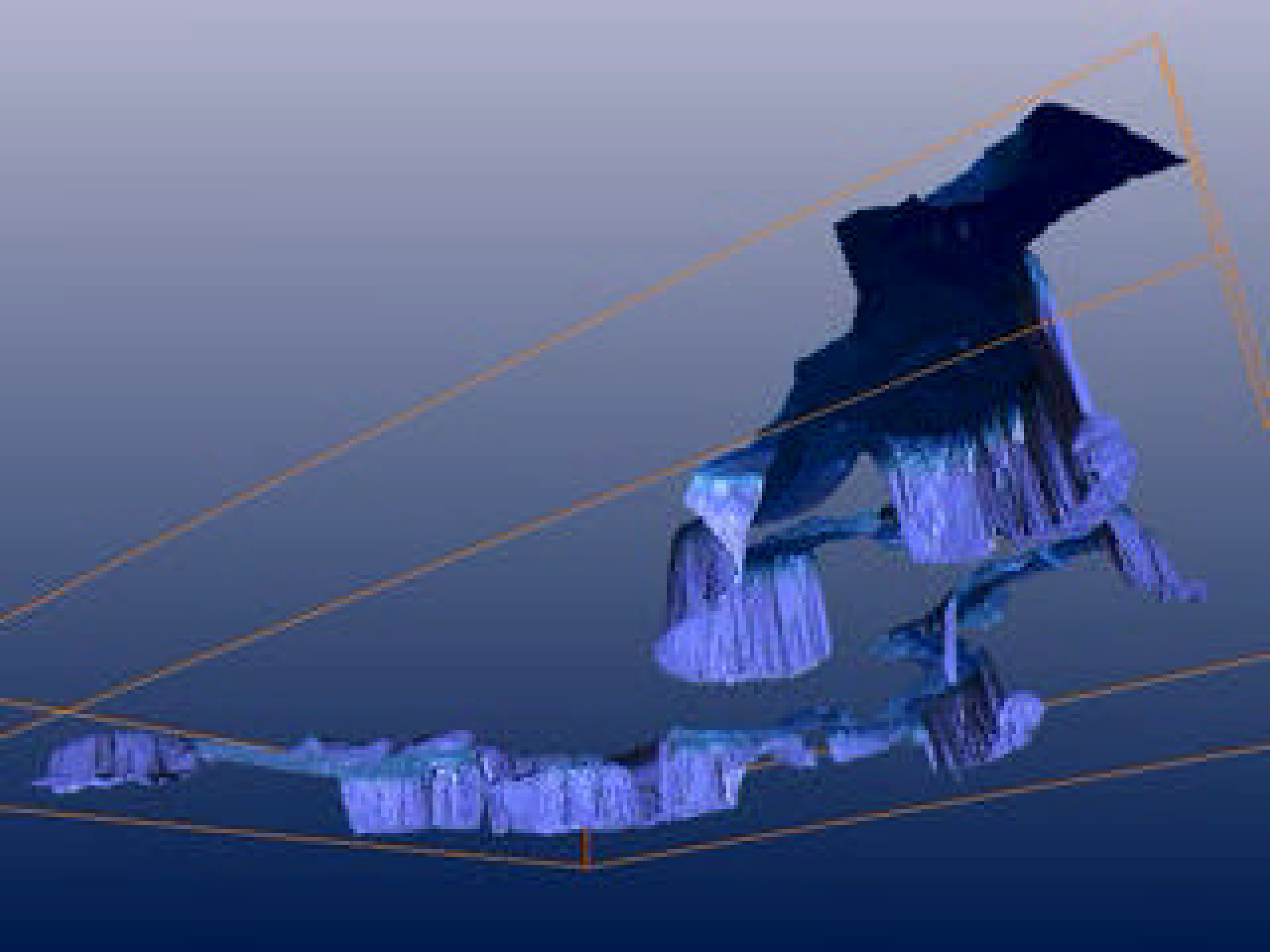


Property in Peril

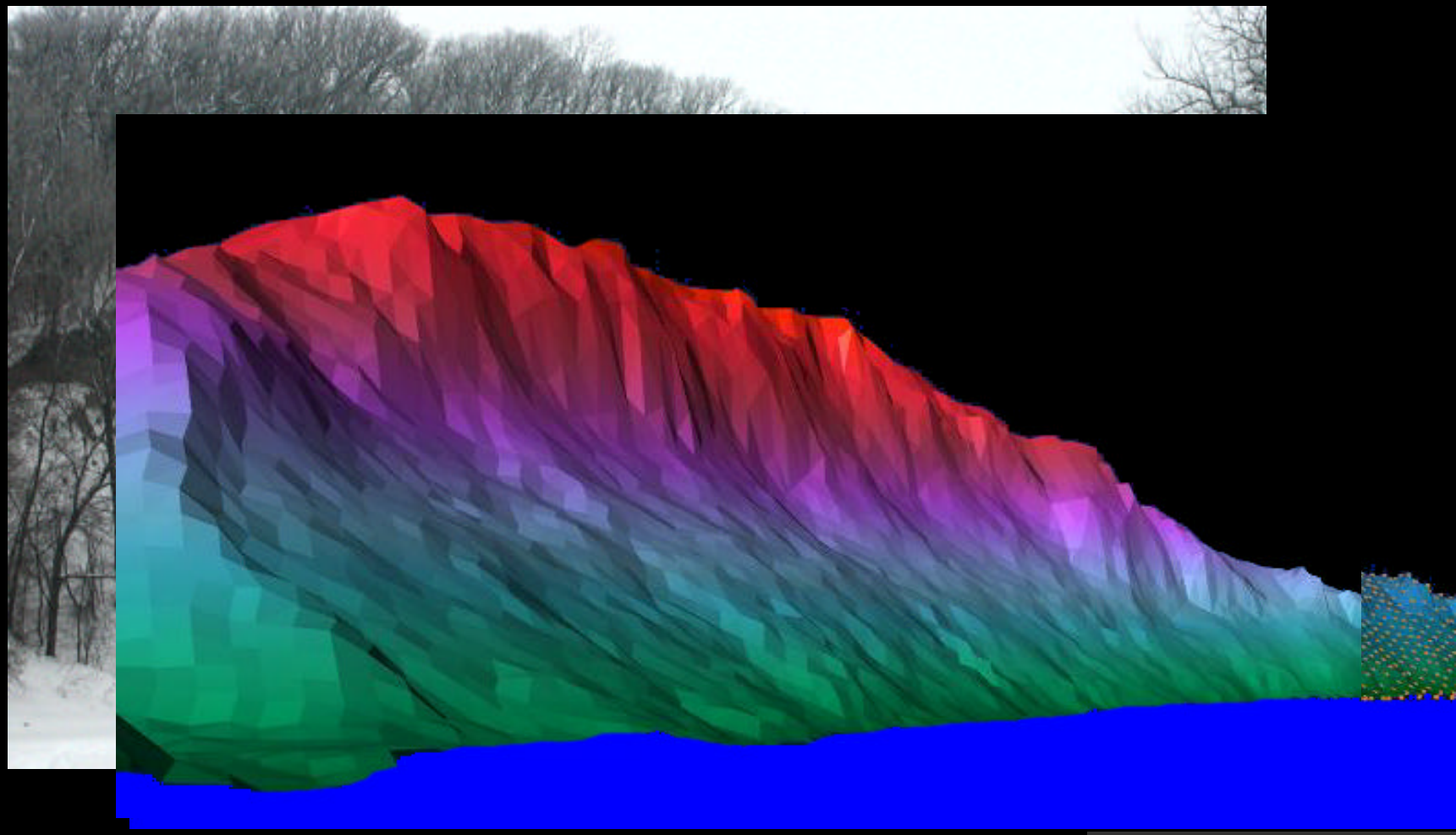


Virtual Reality





Time Series Scans



Results

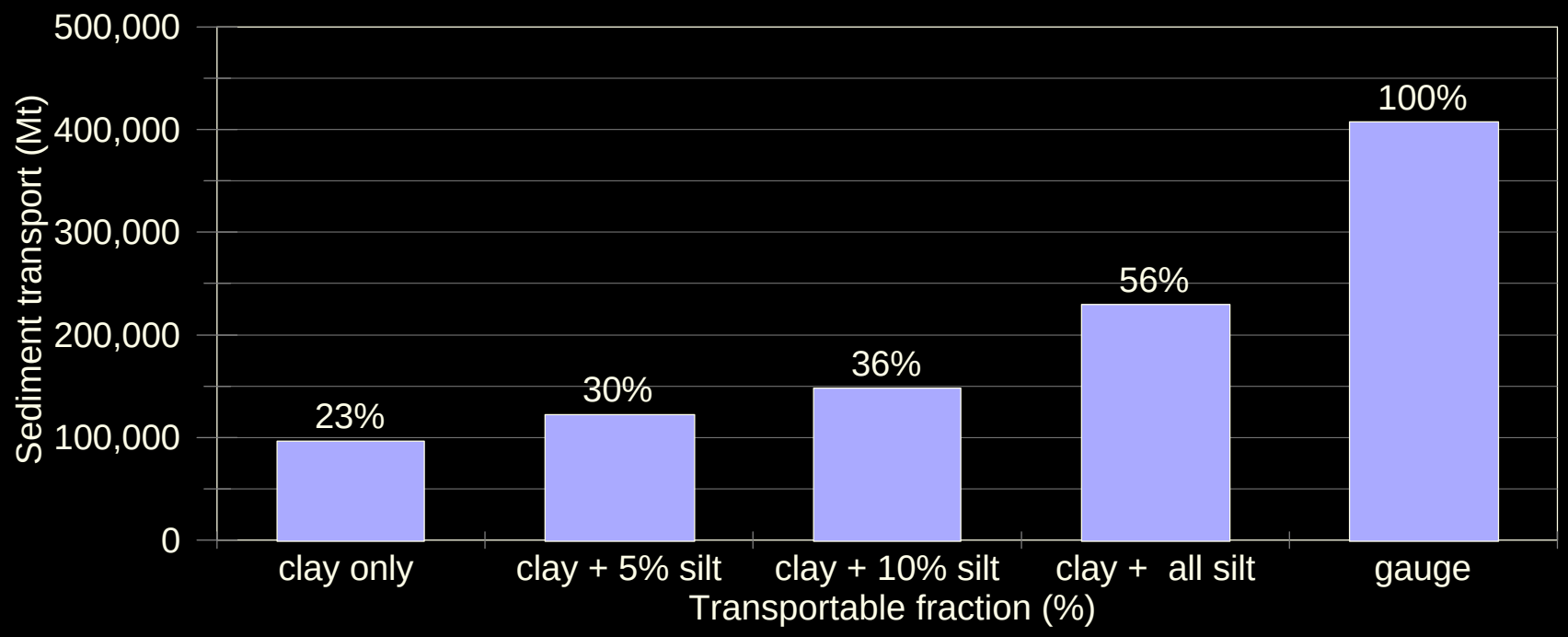
- 281,454 m^3 of bank sloughing
- 0.51 million T added to river
  - (avg bulk density = 1.82 Mg/m^3)
  - 97,000 to 230,000 T of transportable material
- 201 T total P and 40 kg soluble P added to river

Measured from laser scan

- 407,000 T suspended sediment moved downriver

Measured from gauging station

Mass Wasting as Percentage of Transported Sediment



Assumptions:

1) transportable fraction is material finer than sand
2) bulk density is 1.82 Mg/m^3

Mechanisms of Bank Sloughing

- Seepage
- Capillary action and slide
- Under cutting
- Freezing and thawing
- Wetting and drying
- Others

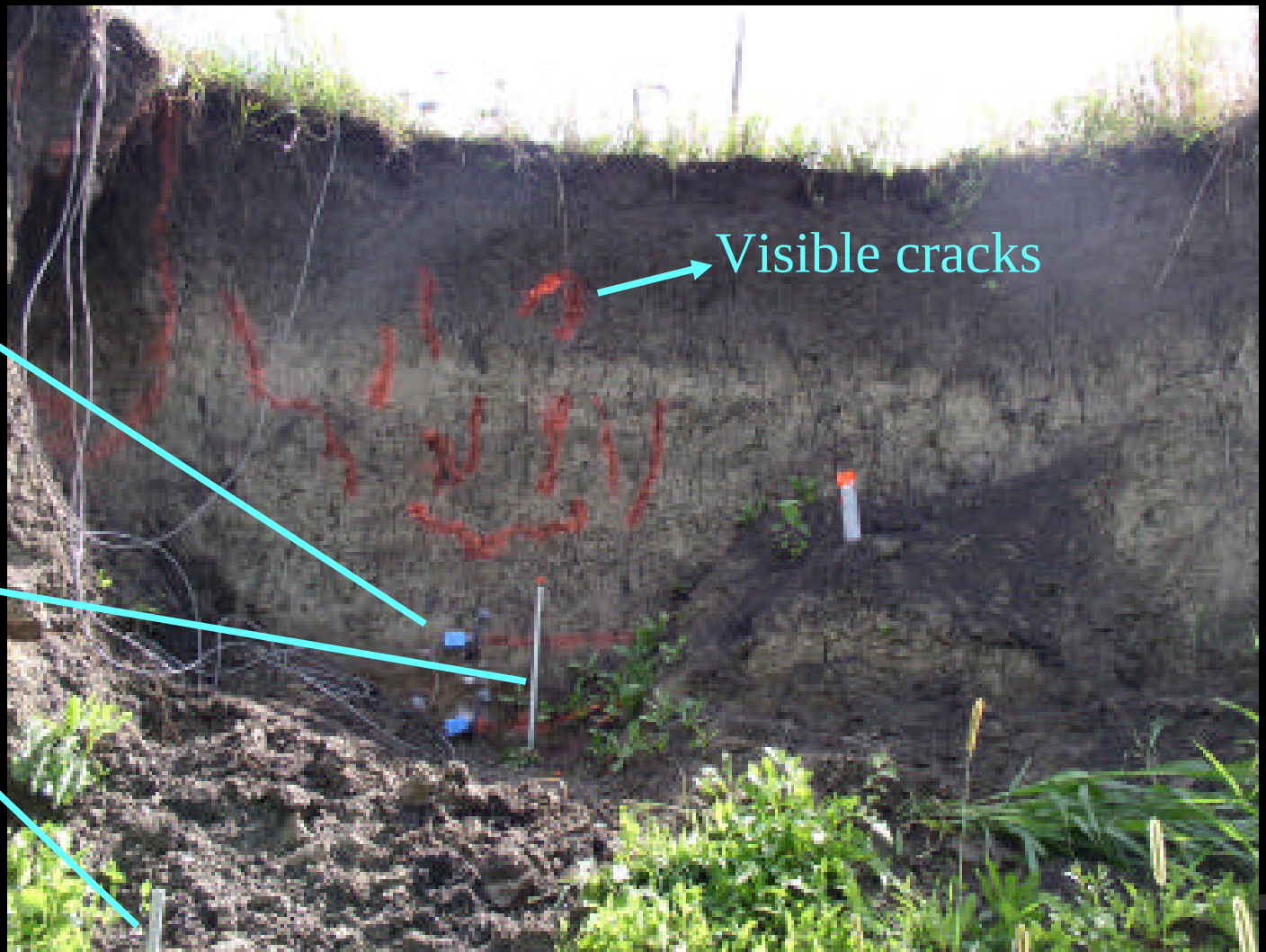
Seeps and mud slide

Wildwood Park Bank, Eagle Lake Glacial Bank

Instrumentation

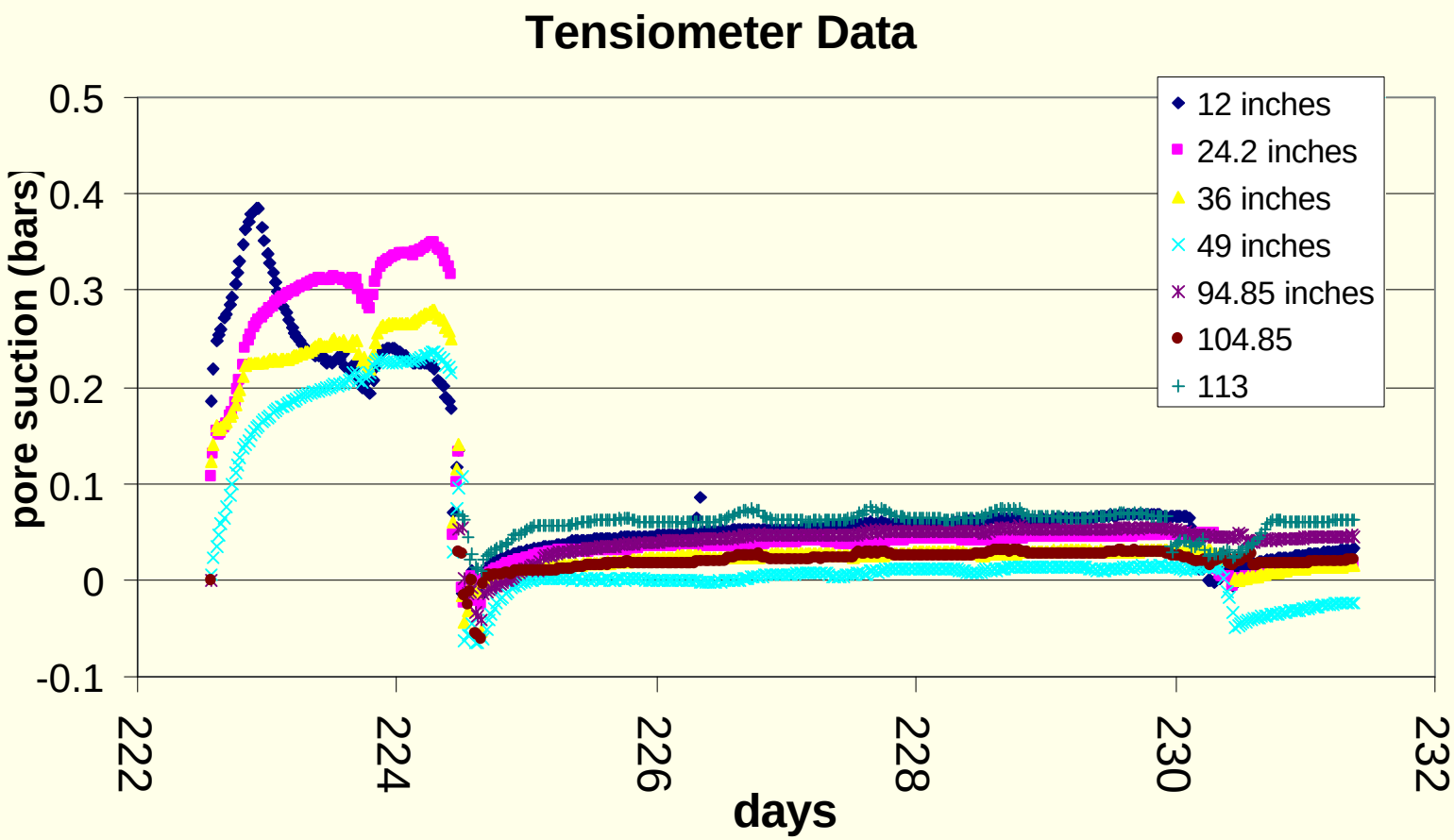
Rapid and Deeper Penetration of Dye

Instrumented Bank



Mass Wasting due to Pore Water Buildup

Tensiometer Data at Wildwood Park, Glacial Till Bank



Shear Strength

$$t = c - u_w + s_n \tan f$$

τ=Shear Strength
c=Cohesion
U_w=Pore water pressure
σ_n=Normal stress
ϕ=Friction angle

Saturated Soils-No Applied Load

$$t = c - u_w$$

There is less cohesion but lot more weight of soil due to saturation and thus sloughing and slide

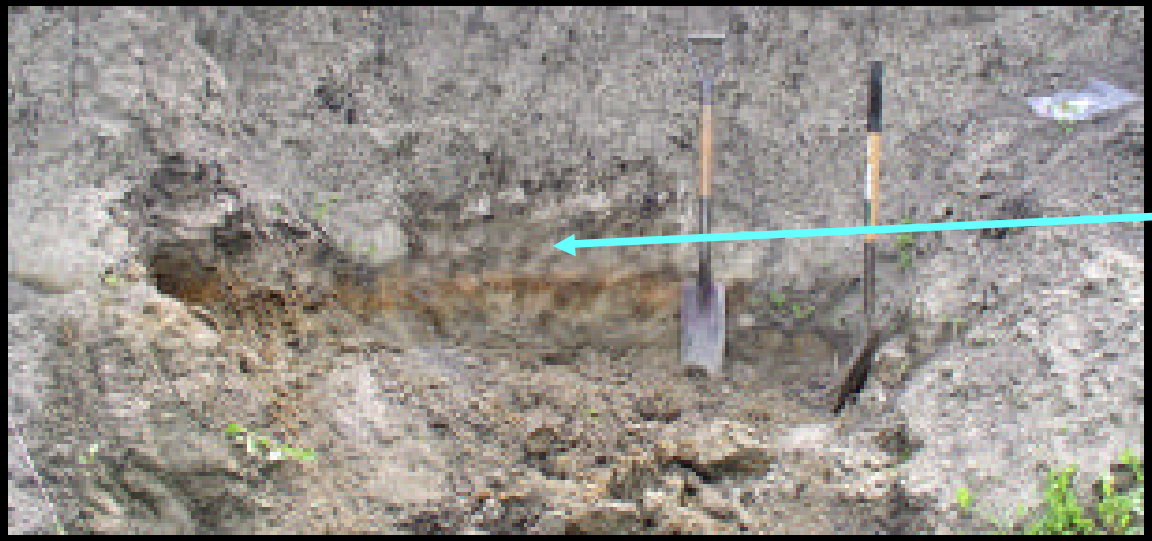
Where is the water coming from for pore water build up

How do we get water for bank slide-SEEPAGE?

Jeff Thiesen's Bank June 2005

Causes of Gullies on River Banks

Sand Layer, Wildwood Park



Base of the Glacial Till Bank at Wildwood Park-Sand Lenses

Water is Seeping at the Sand Layer

Water Is Flowing at the Sand Layer

Piping Effect

Conclusions I

- Laser altimetry has promise
  - but closer inspection of accuracy required
- Conservative estimate that 56% of sediment comes from banks on B.E. river

Conclusions II

- Several mechanisms are responsible for bank sloughing
- Glacial till and Lake Sediment banks are more prone to sloughing and slide
- Recent alluvial banks are more prone to erosion due to moving water

Acknowledgements

- Minnesota Corn and Soybean Research Councils
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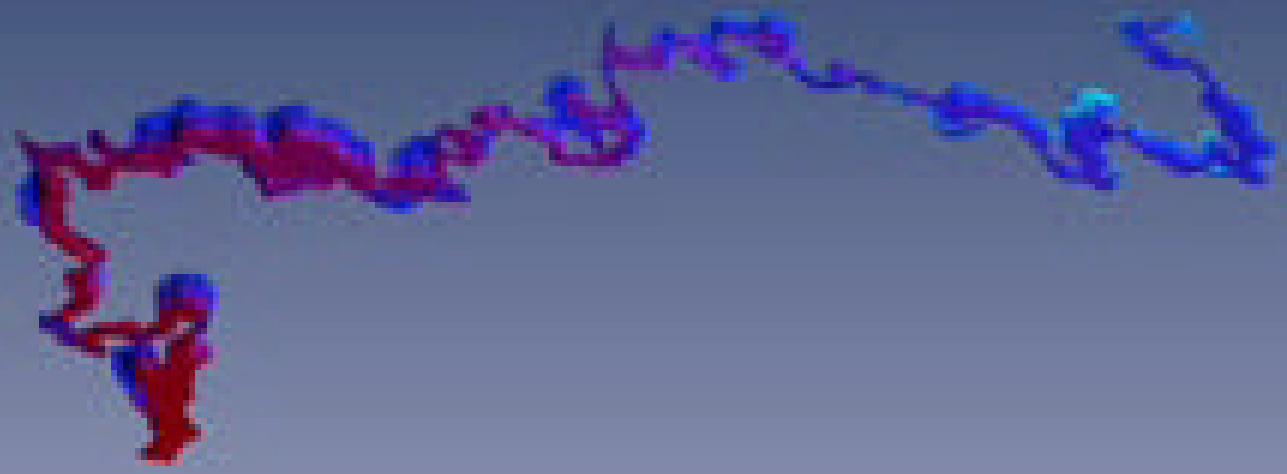
- University of Minnesota Water Resources Center

Thank you