APPLICATIONS OF GEOGRAPHICAL INFORMATION SYSTEMS TO TERRAIN ANALYSIS

J. David Rogers
Karl F. Hasselmann Chair in Geological Engineering

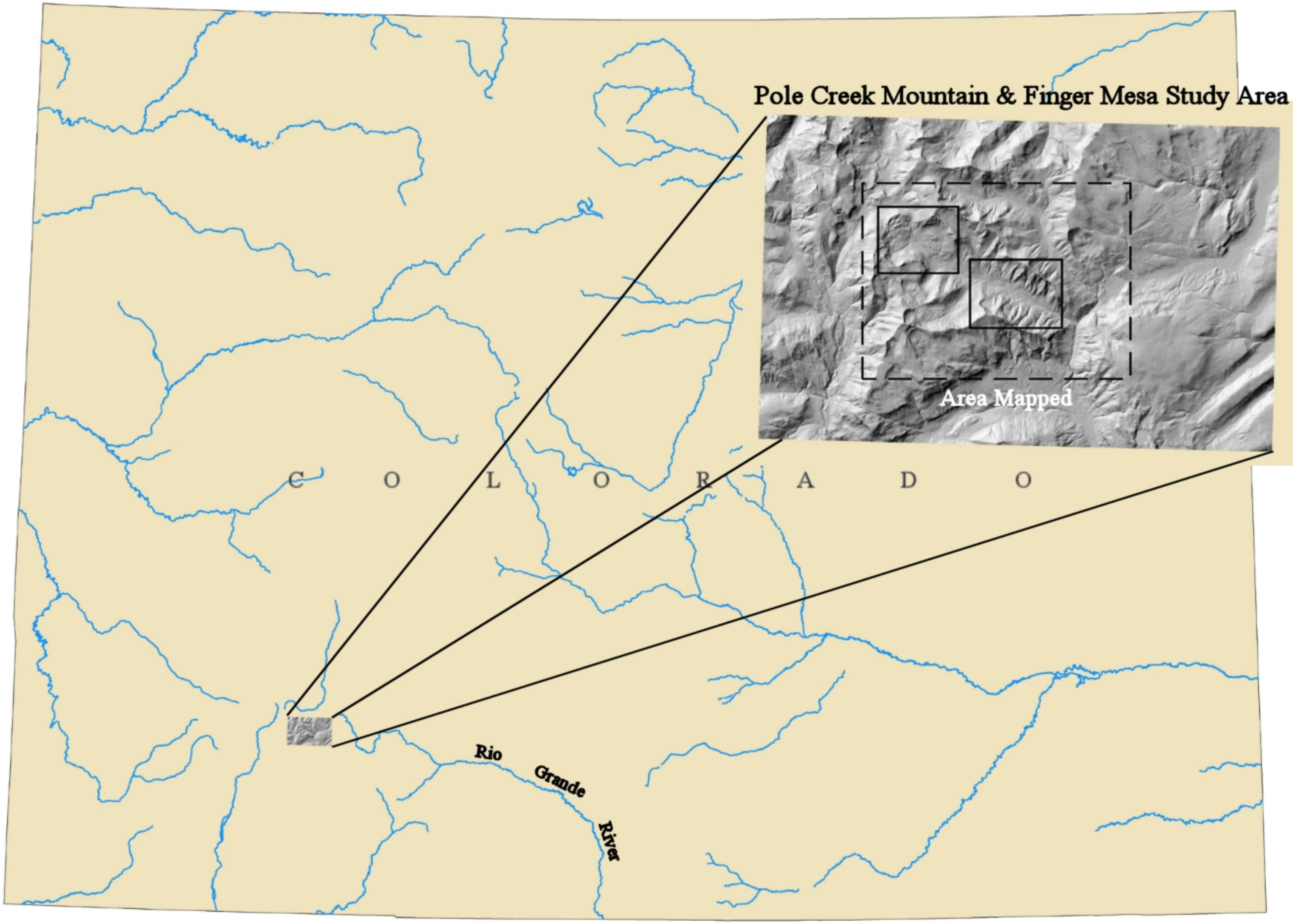
University of Missouri-Rolla

UMR

Mapping Mass Movements: Past, Present and Future

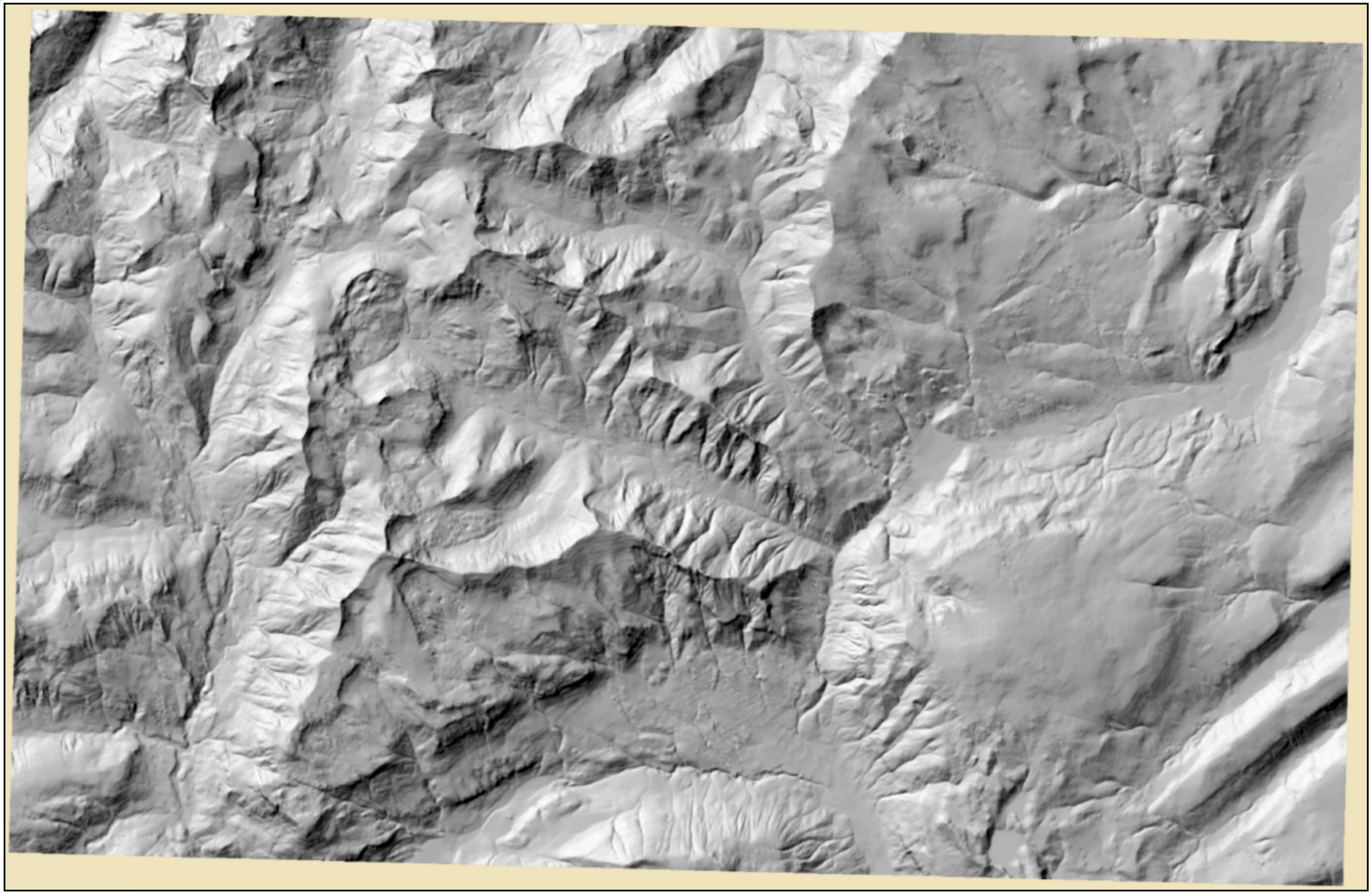
The 1991 West Lost Trail Creek Sturzstrom
Rio Grande National Forest
San Juan Mountains, Colorado

UMR

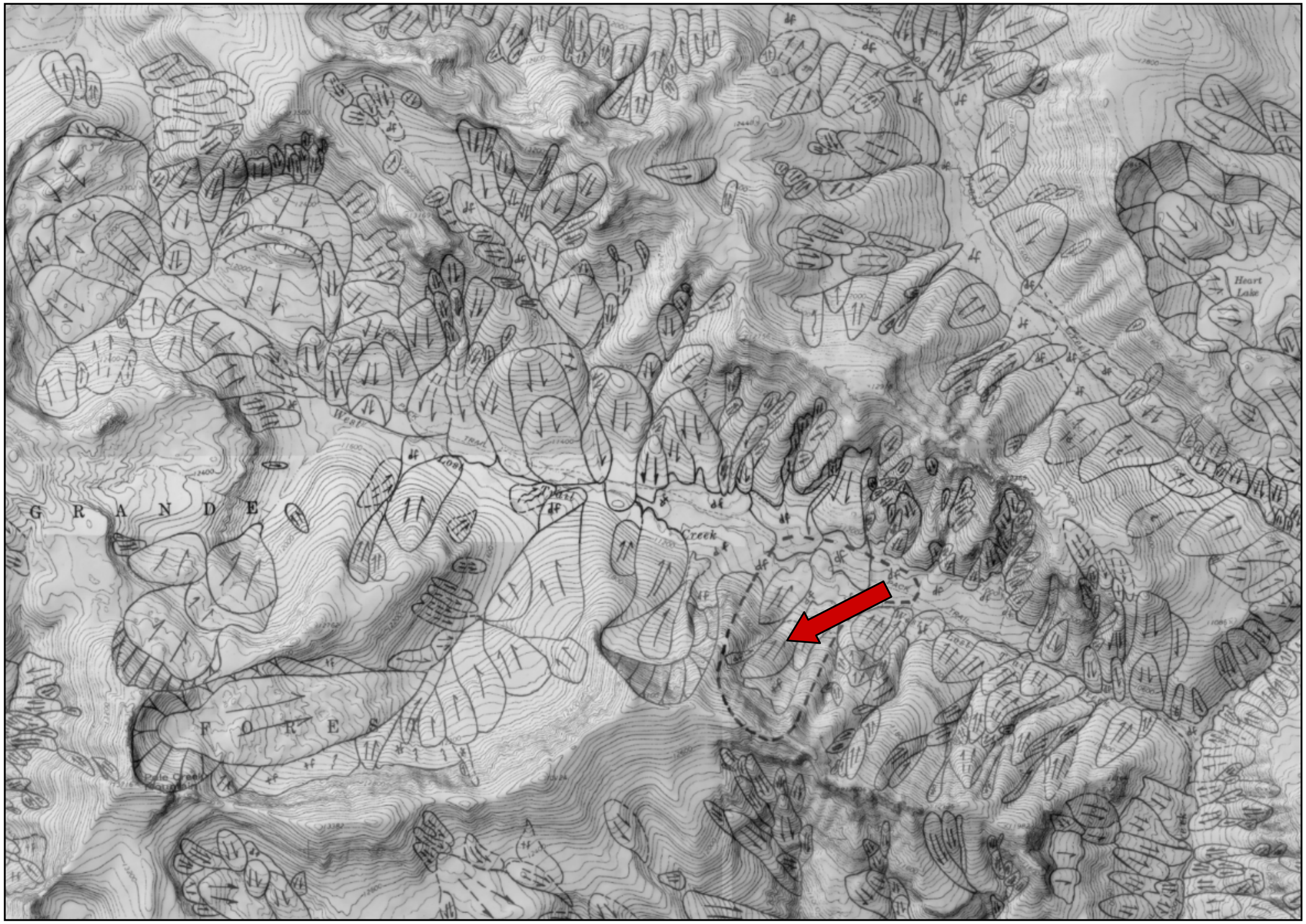


- The 1991 West Lost Trail Creek Landslide occurred on the boundary of the Pole Creek Mountain and Finger Mesa 7.5-min quadrangles in the upper Rio Grande watershed.

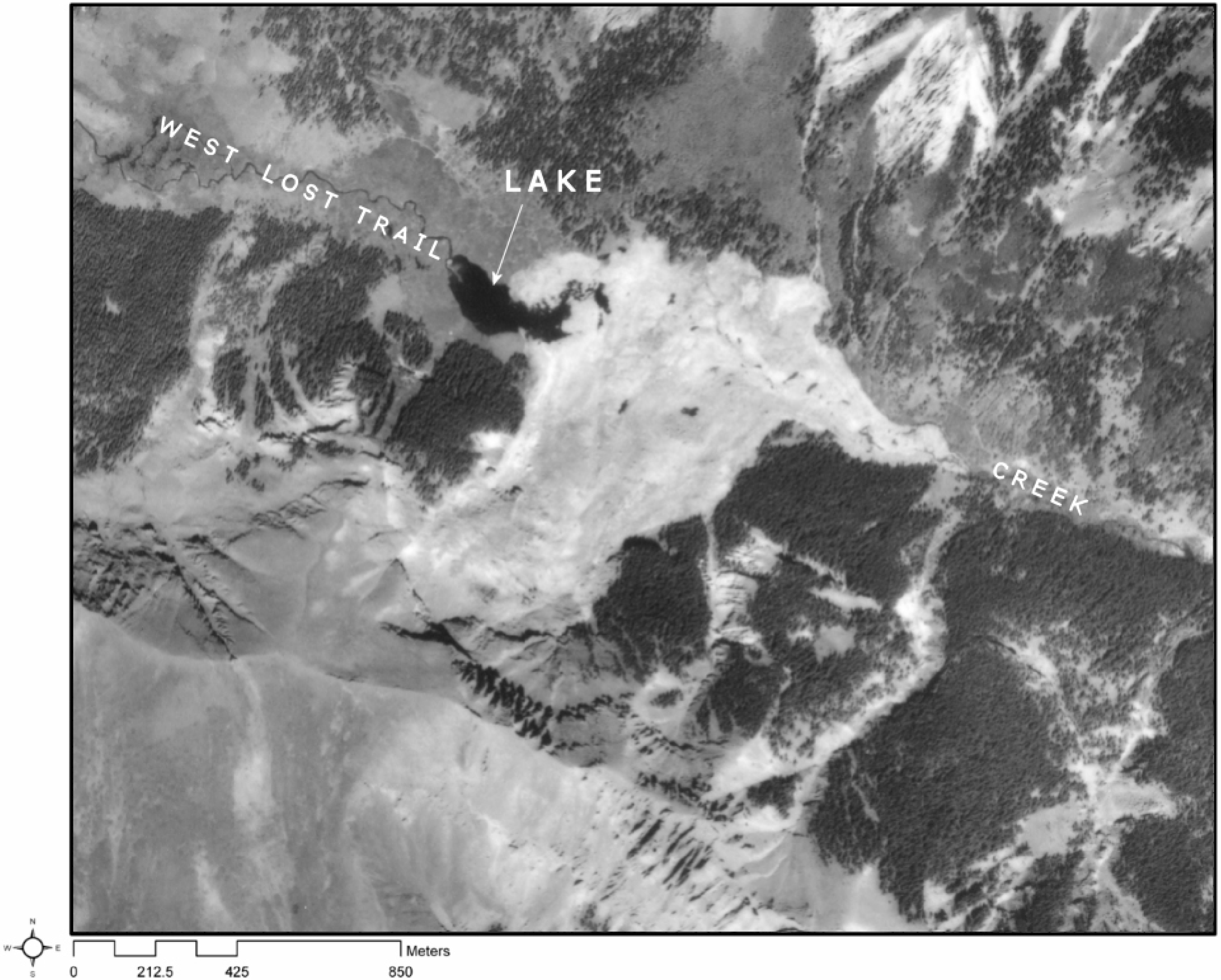
UMR



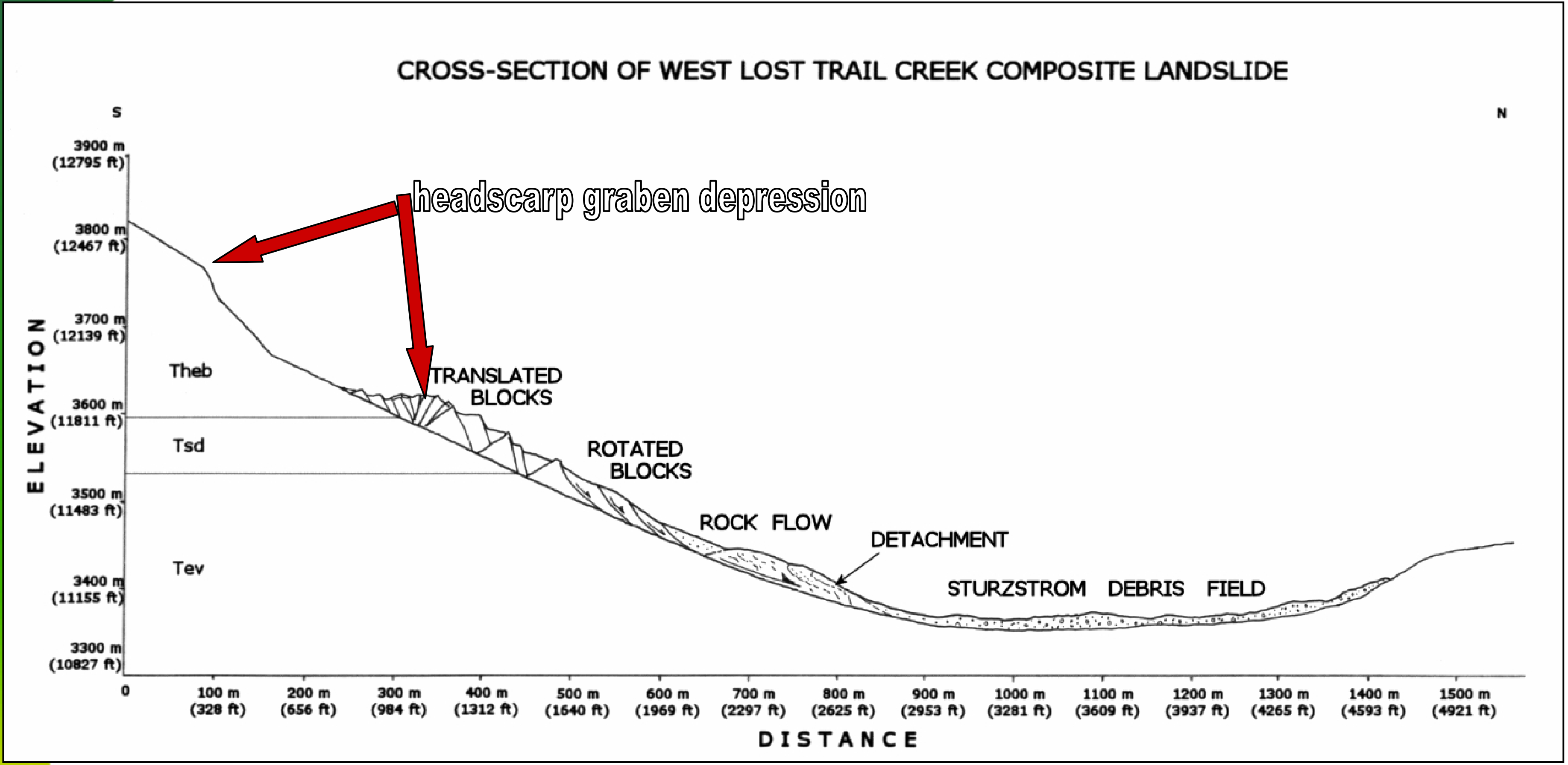
- **10 m Digital Elevation Models for the Pole Creek Mountain and Finger Mesa quadrangles, based on September 1998 photos**



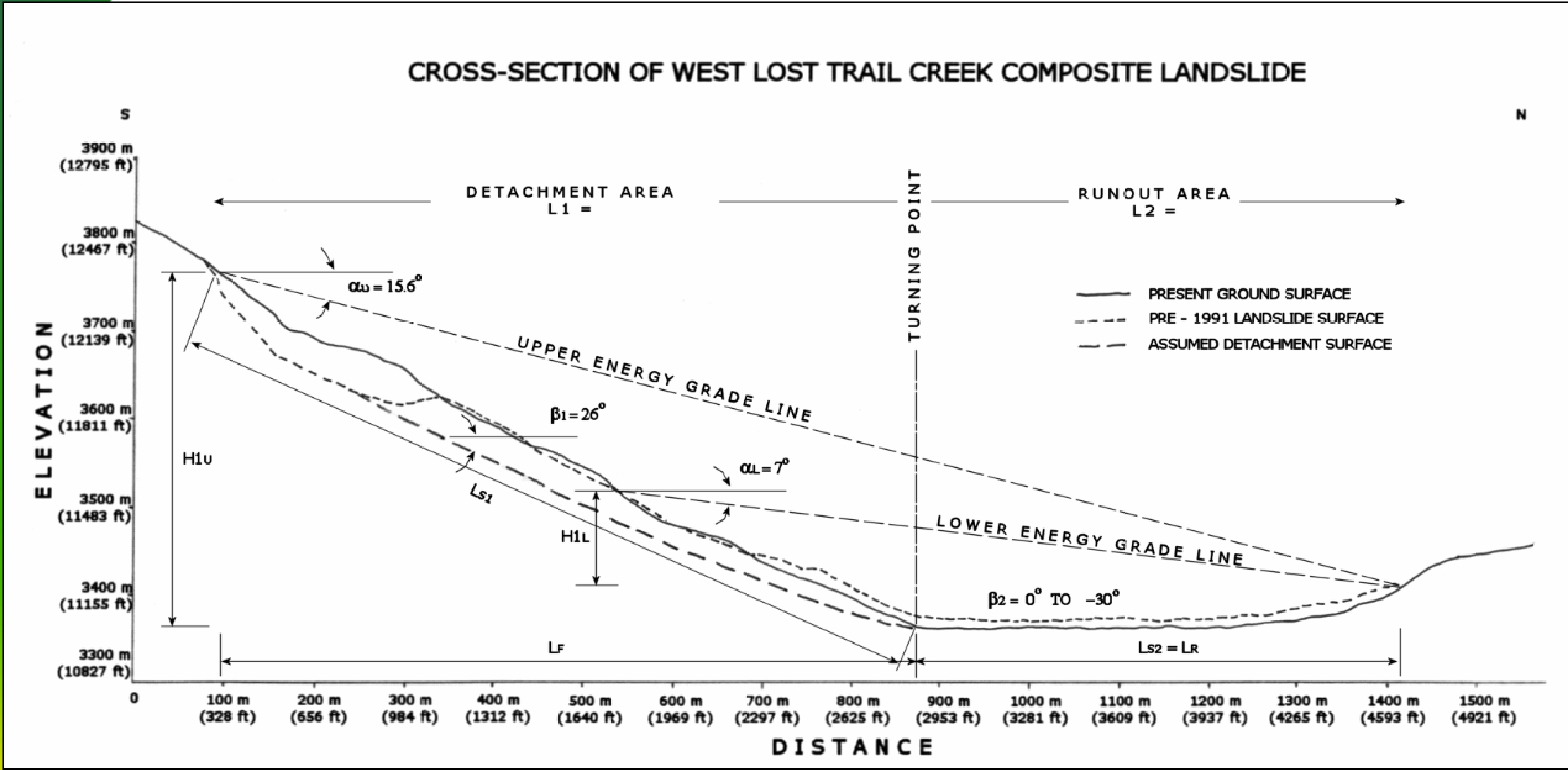
- **Landslide inventory map created on a shaded relief DEM covering 65 km^2 area surrounding the subject landslide (arrow)**



- **Aerial photo imaged in September 1998 showing the lake formed along West Lost Trail Creek and the isolated ponds throughout the debris field**

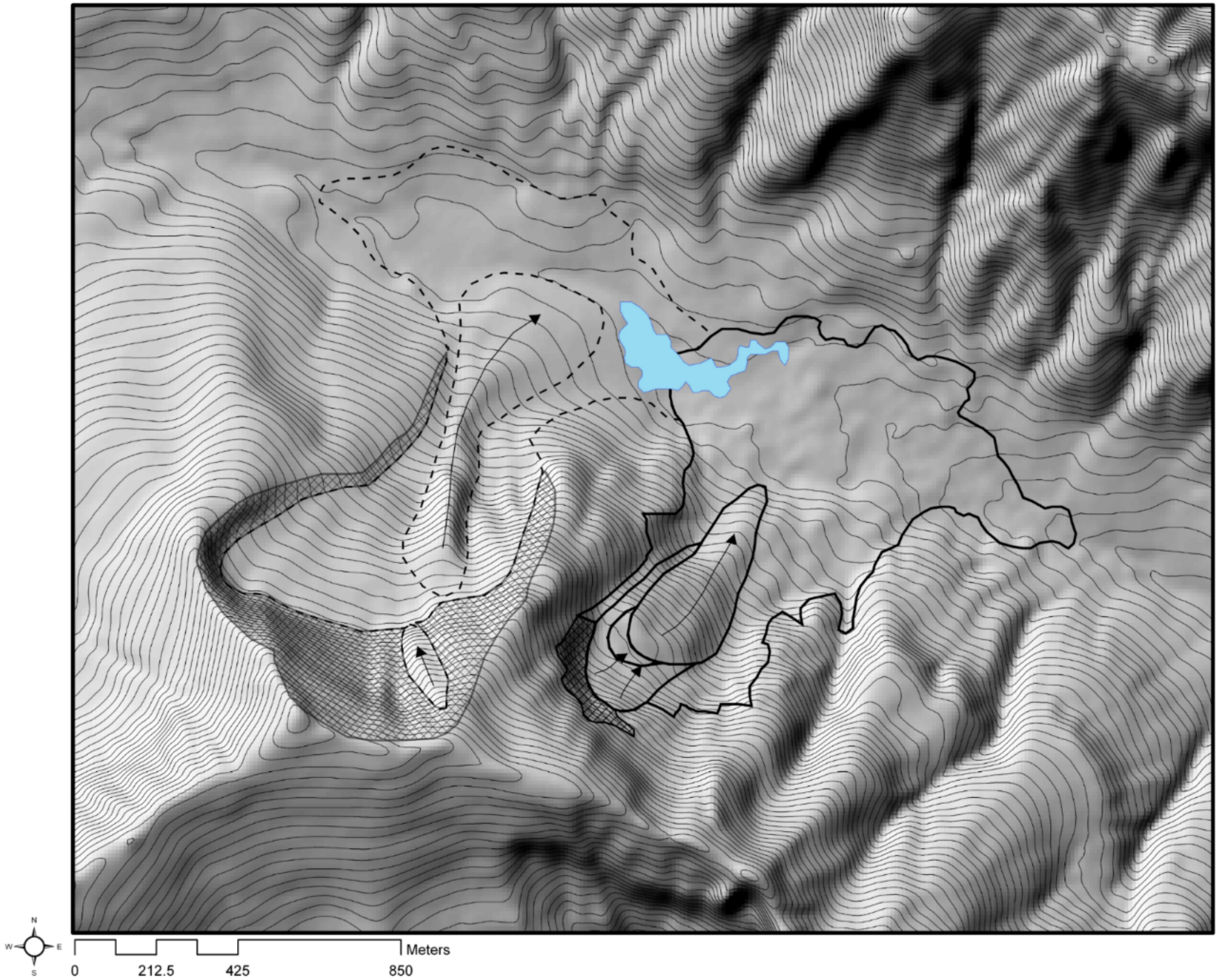


- **Cross section through 1991 sturzstrom after movement ceased, showing the various components of the slide mass**

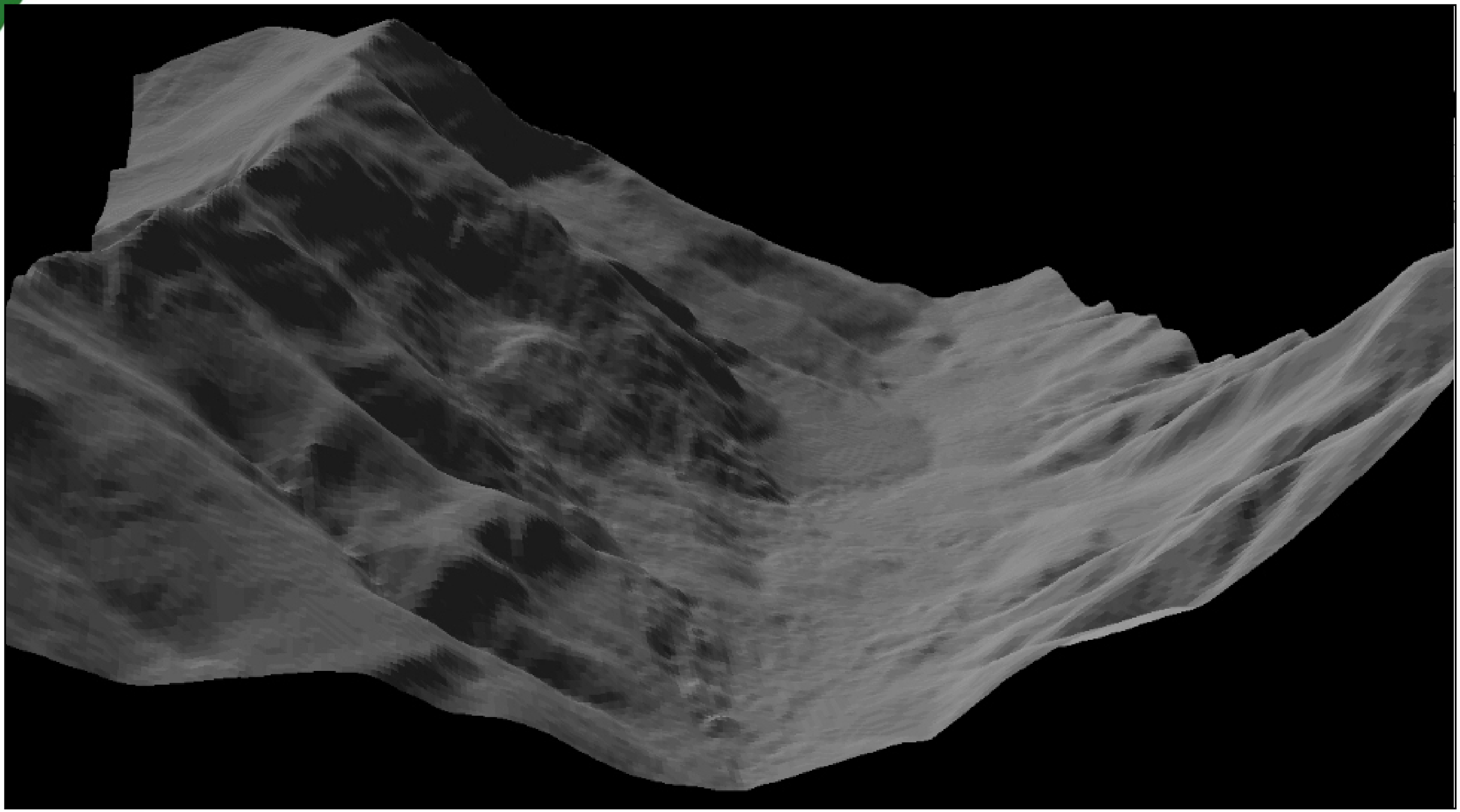


- **Energy Line Models used for evaluating sturzstroms. Complete detachment only occurred below el. 11,480'**
- **The lower ELM predicted runout (1926 ft) within 10% of that observed (1739 ft) and should have taken 32 seconds to decelerate (25 to 30 estimated by observer)**

UMR



- **10 m contour map of the slide area showing 1991 slide and larger prehistoric event immediately upstream**



- Oblique view of the 1991 West Lost Trail Creek landslide on the10 m DEM prepared from 1998 photos using MicroDEM/Terrabase II

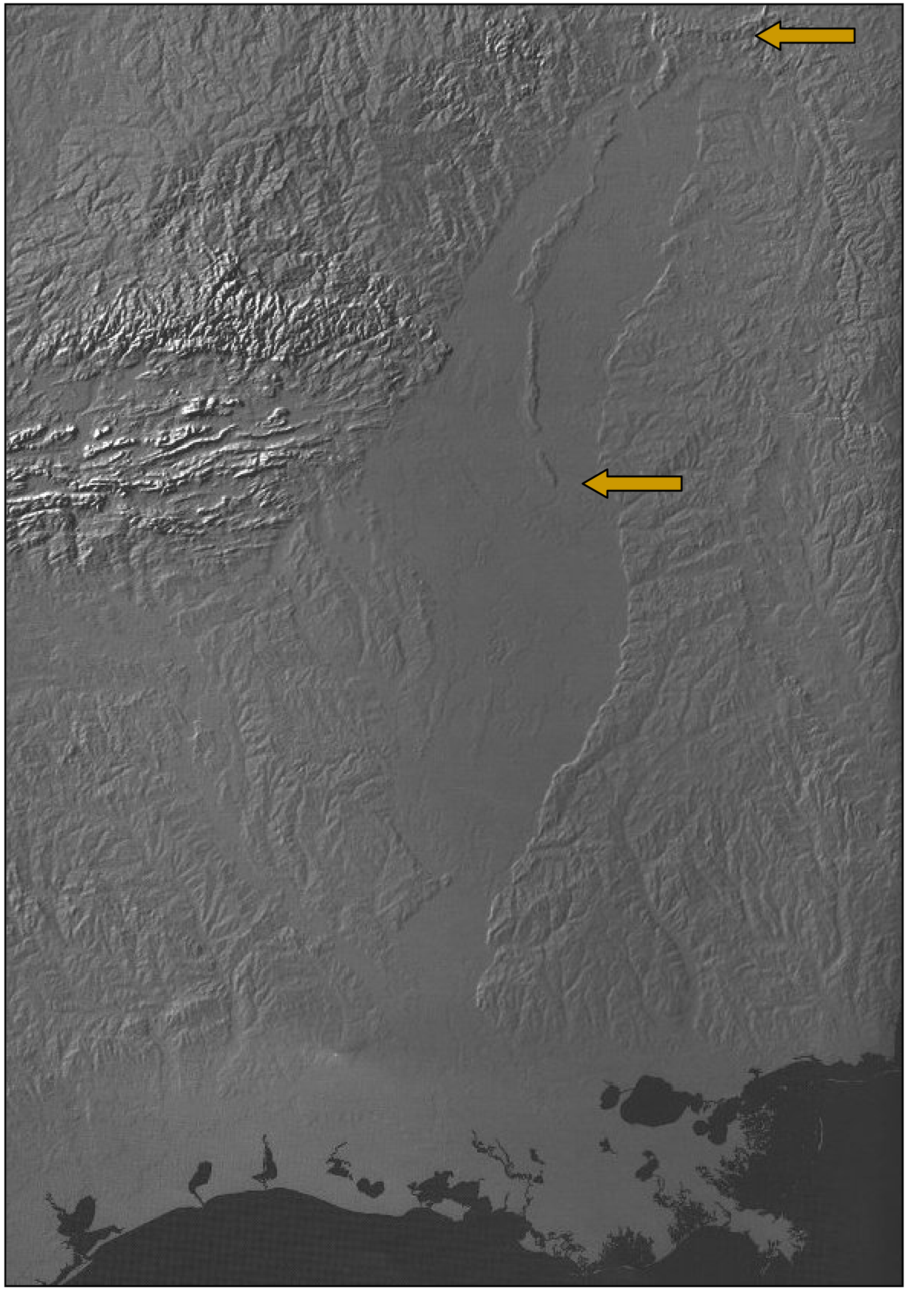
MAPPING LANDSLIDES USING TOPOGRAPHIC ALGORITMS

Crowley's Ridge in Missouri and Arkansas

UMR

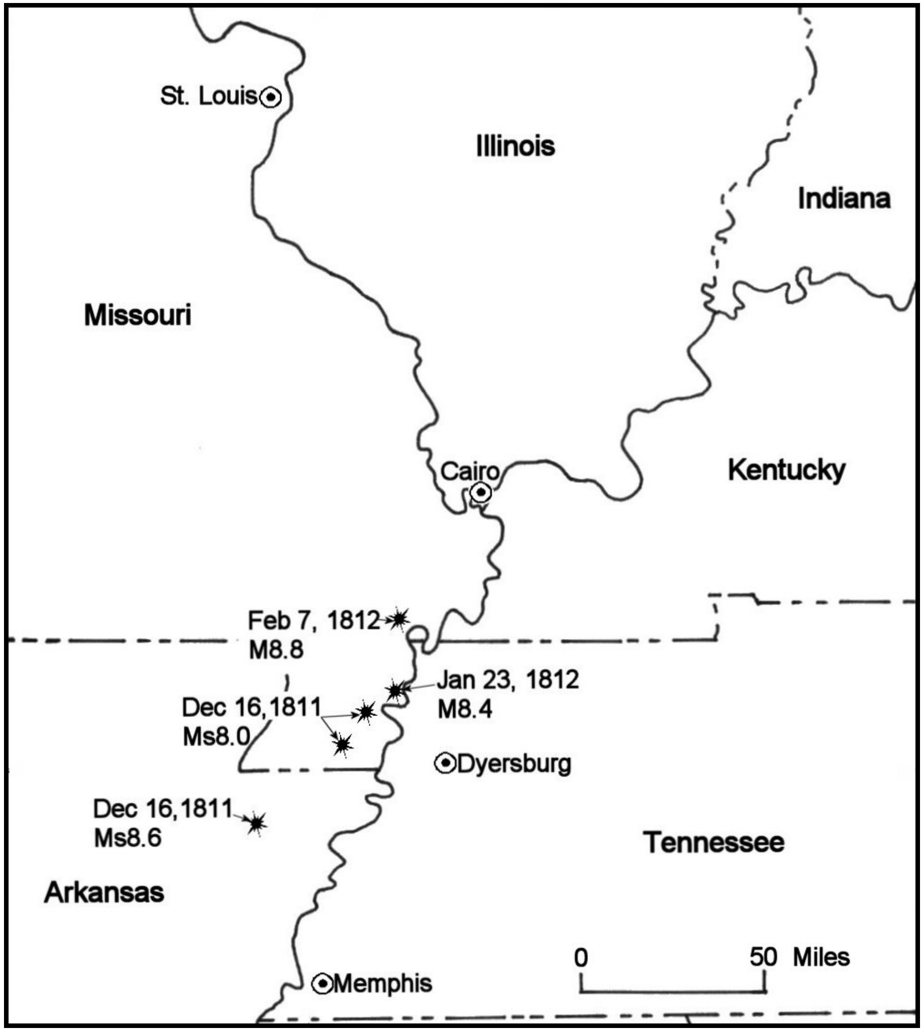
Crowley's Ridge

- Elevated upland within the Mississippi River Embayment and near the NMSZ
- Over 380 km long
- 32 km wide at widest point
- Over 90 m of relief in areas



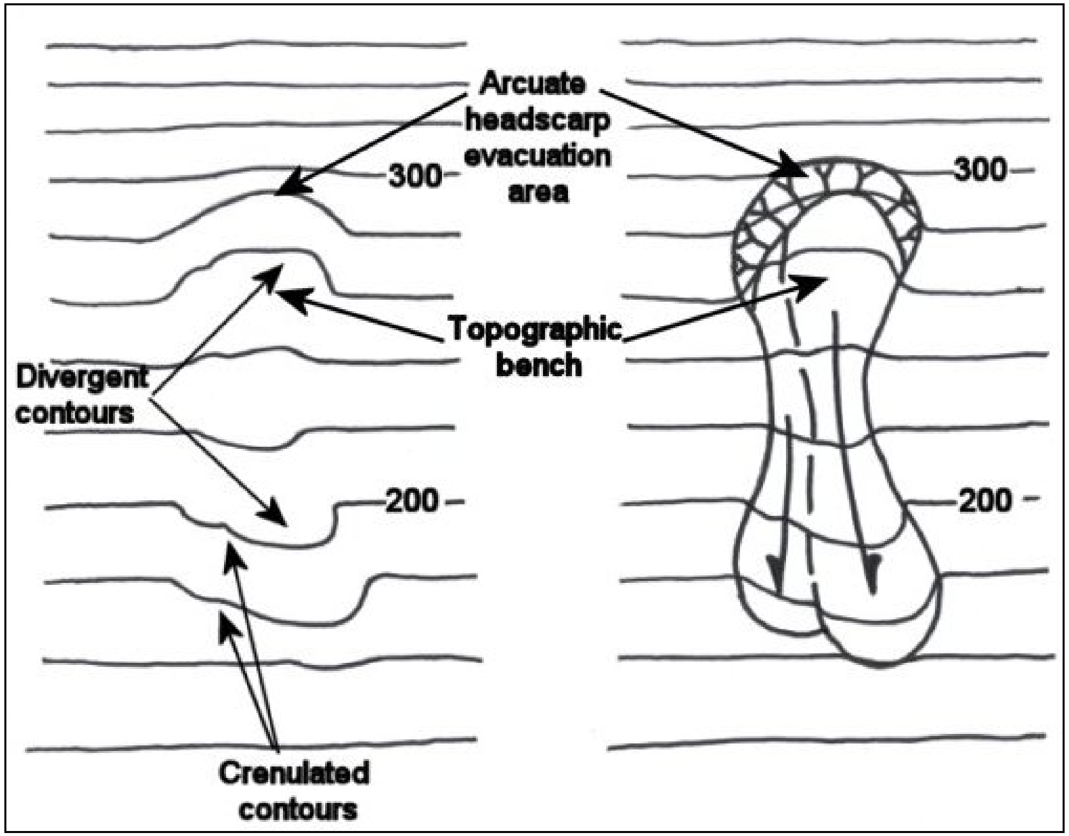
1811-1812 New Madrid earthquakes

- Over 2000 felt earthquakes in 4 month period
  - 5 quakes with $M_s \geq 8.0$
  - Felt over an area of 5 million km^2
- Damage estimates for similar quakes
  - $10 -$20 billion in Central U.S. (1994)



Diagnostic Topographic Patterns

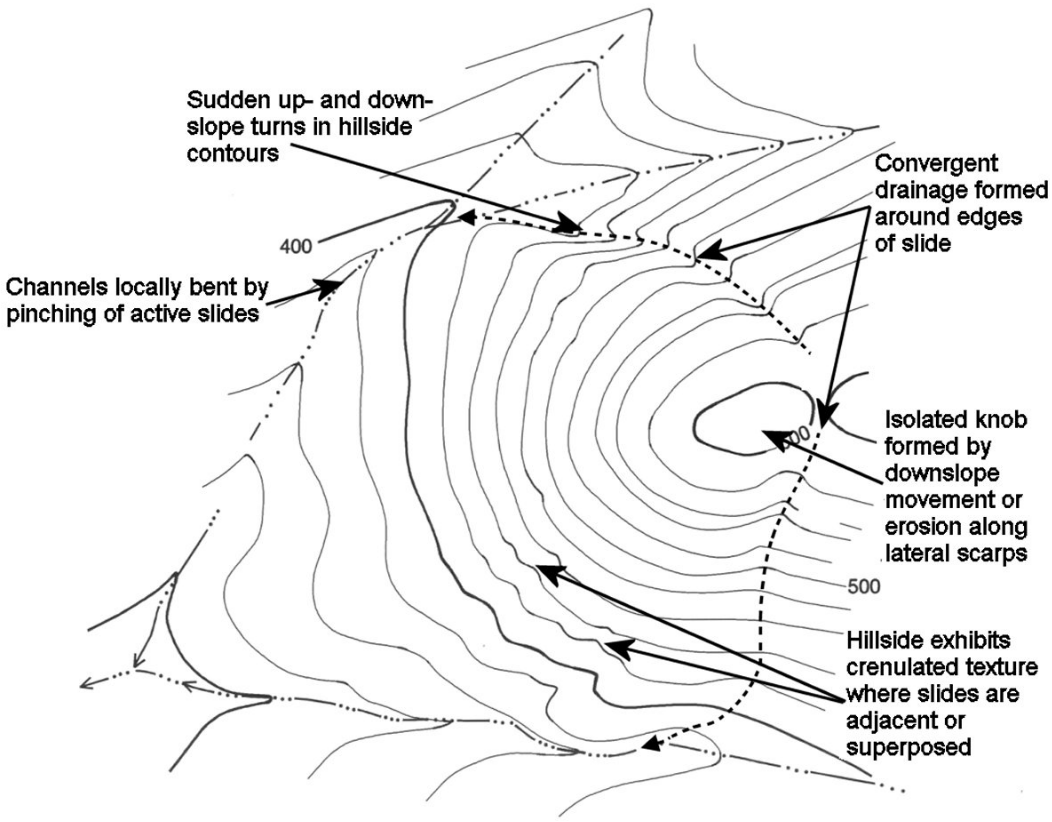
- **Use drainage and topographic keys to recognize anomalous site characteristics typical of landslides**
  - Divergent contours
  - Crenulated contours
  - Arcuate headscarp evacuation areas
  - Isolated topographic benches



UMR

Topographic Patterns on Composite Landslides

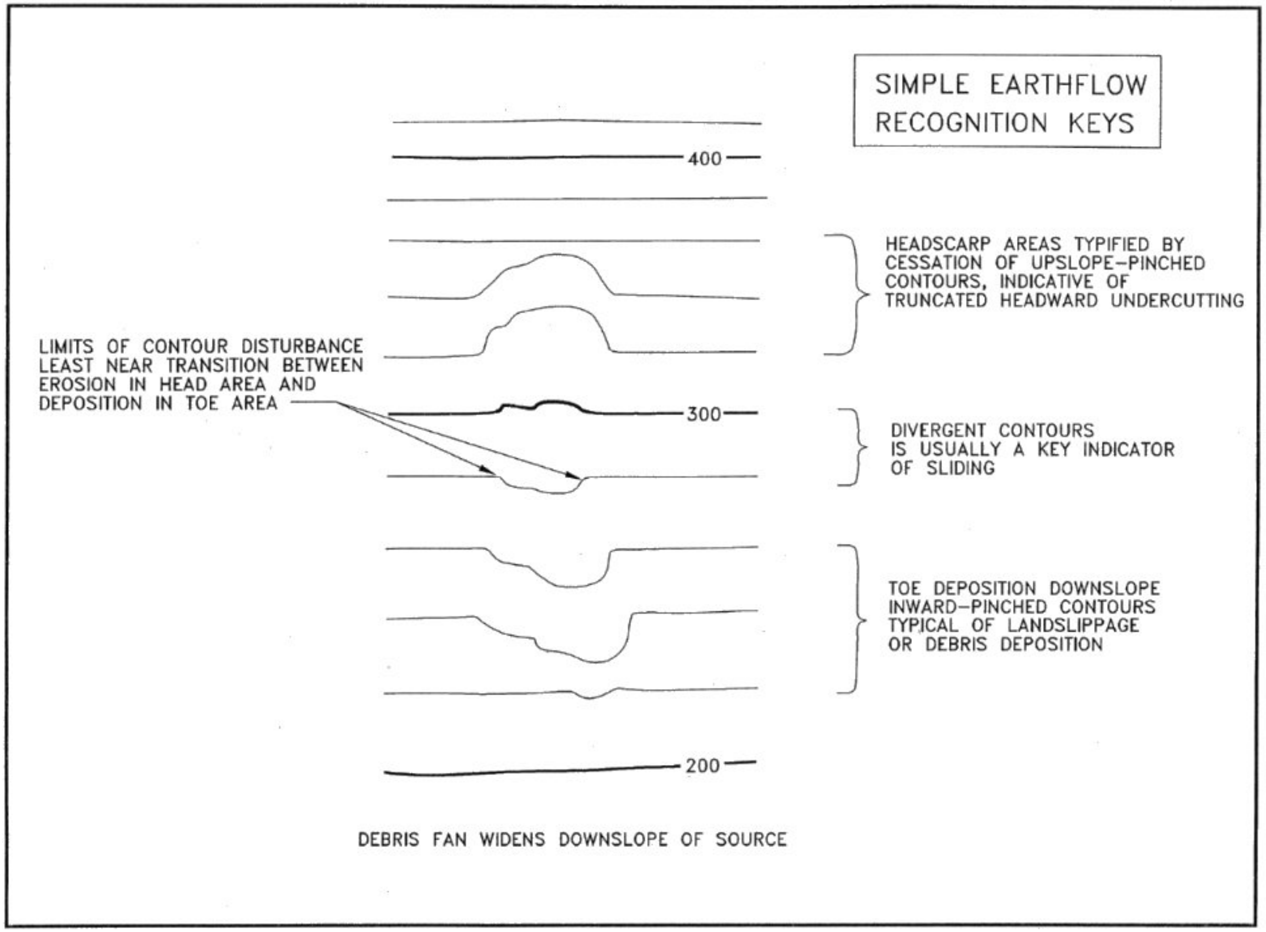
- **Use drainage and topographic keys to recognize anomalous site characteristics typical of landslides**
  - **Extended ridges or isolated knobs**
  - **Sudden turns in hillside contours**
  - **Convergent drainage**



Topographic Expression of Earthflows

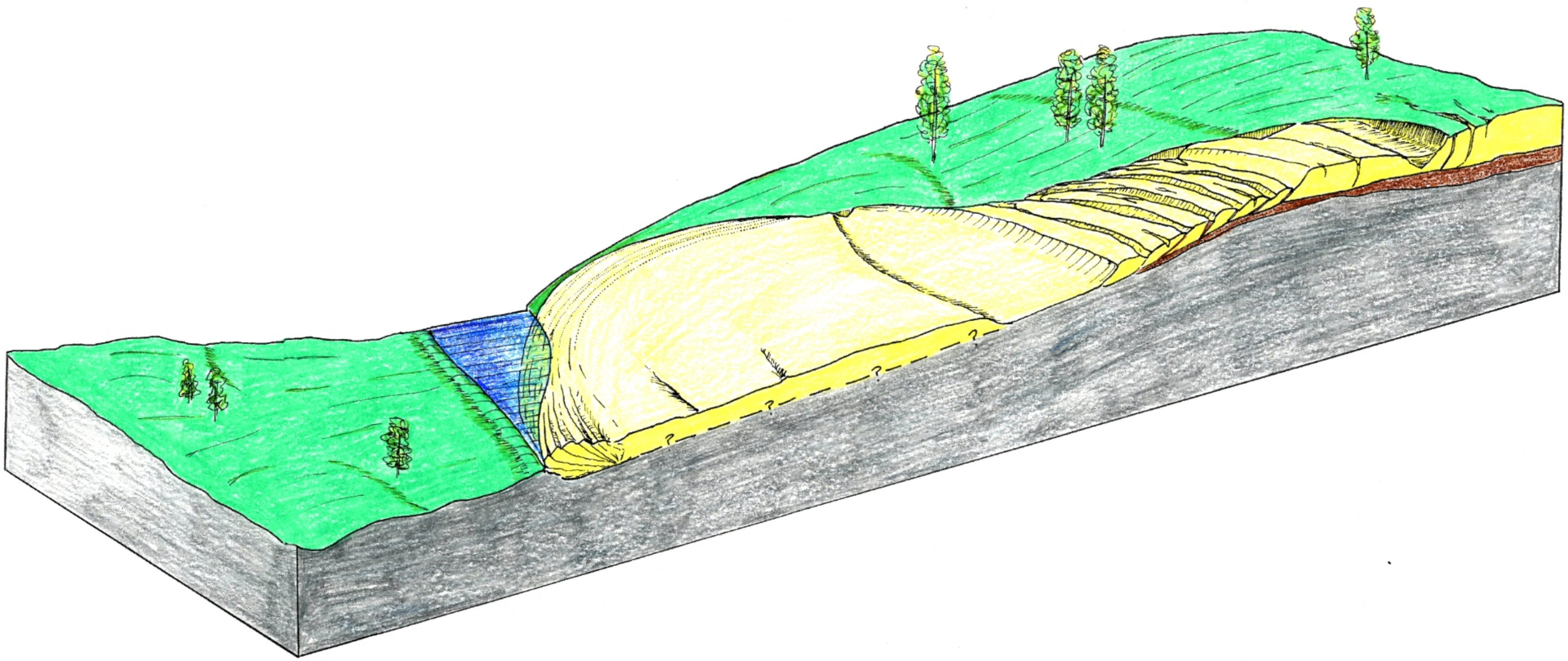
Topographic Keys to Identify Earthflows

- Opposing contours
- Headscarp evacuation areas
- Necking down at transition between deflation/ inflation zones



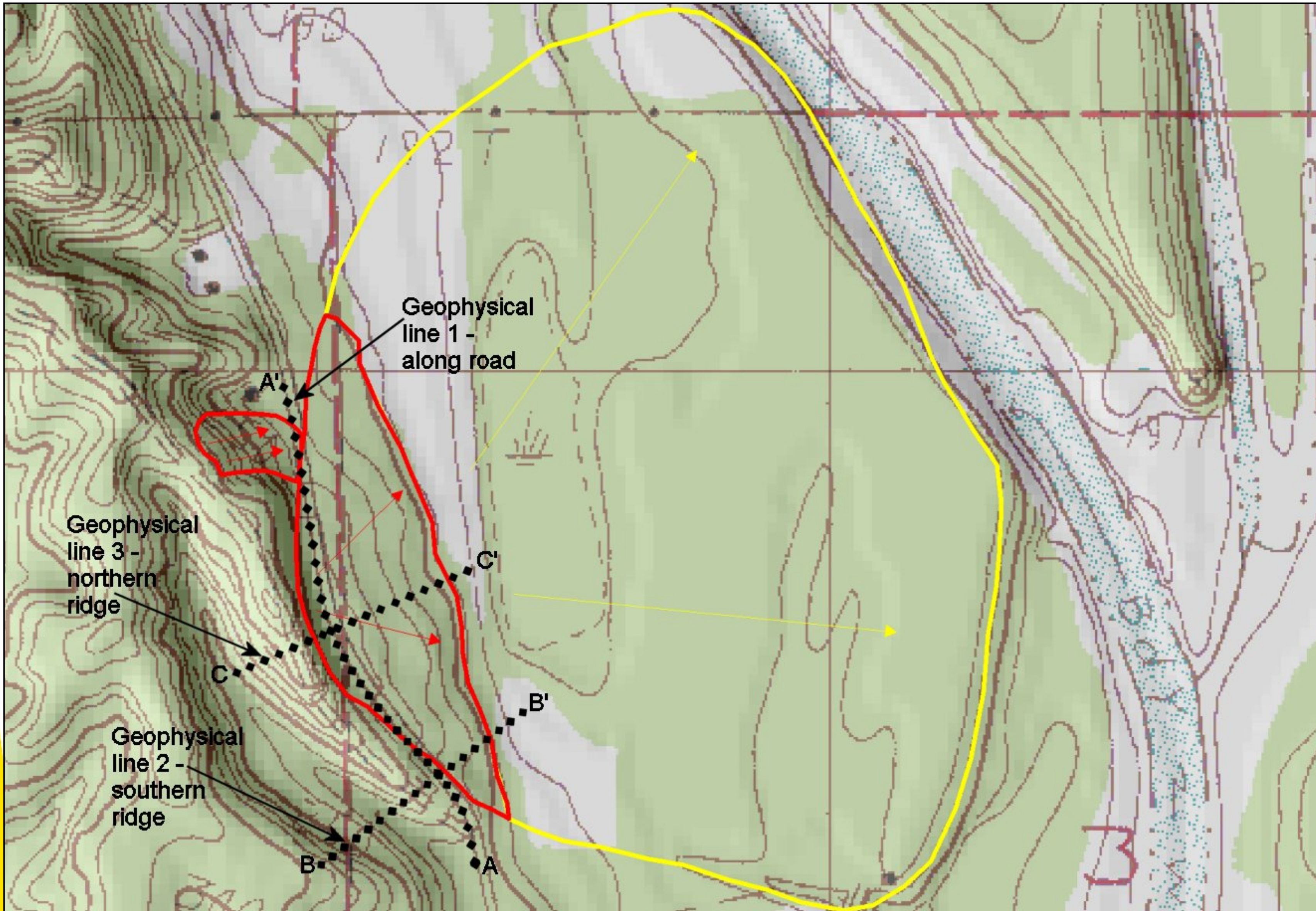
UMR

LATERAL SPREADS



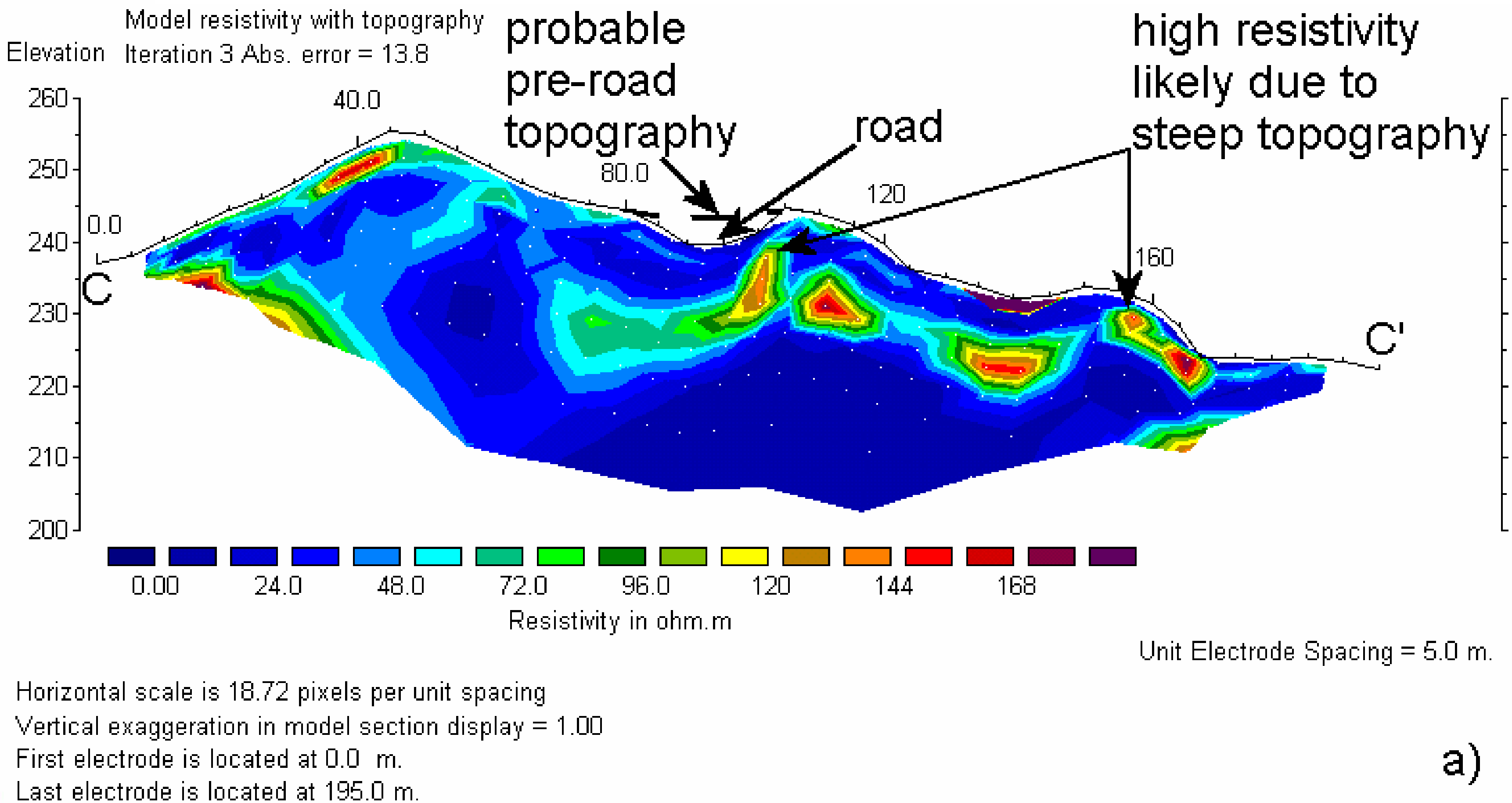
Lateral spreads are caused by liquefaction of discrete buried horizons, which allow overlying materials to "raft" towards an adjacent topographic depression

Seismically-Induced Lateral Spreads

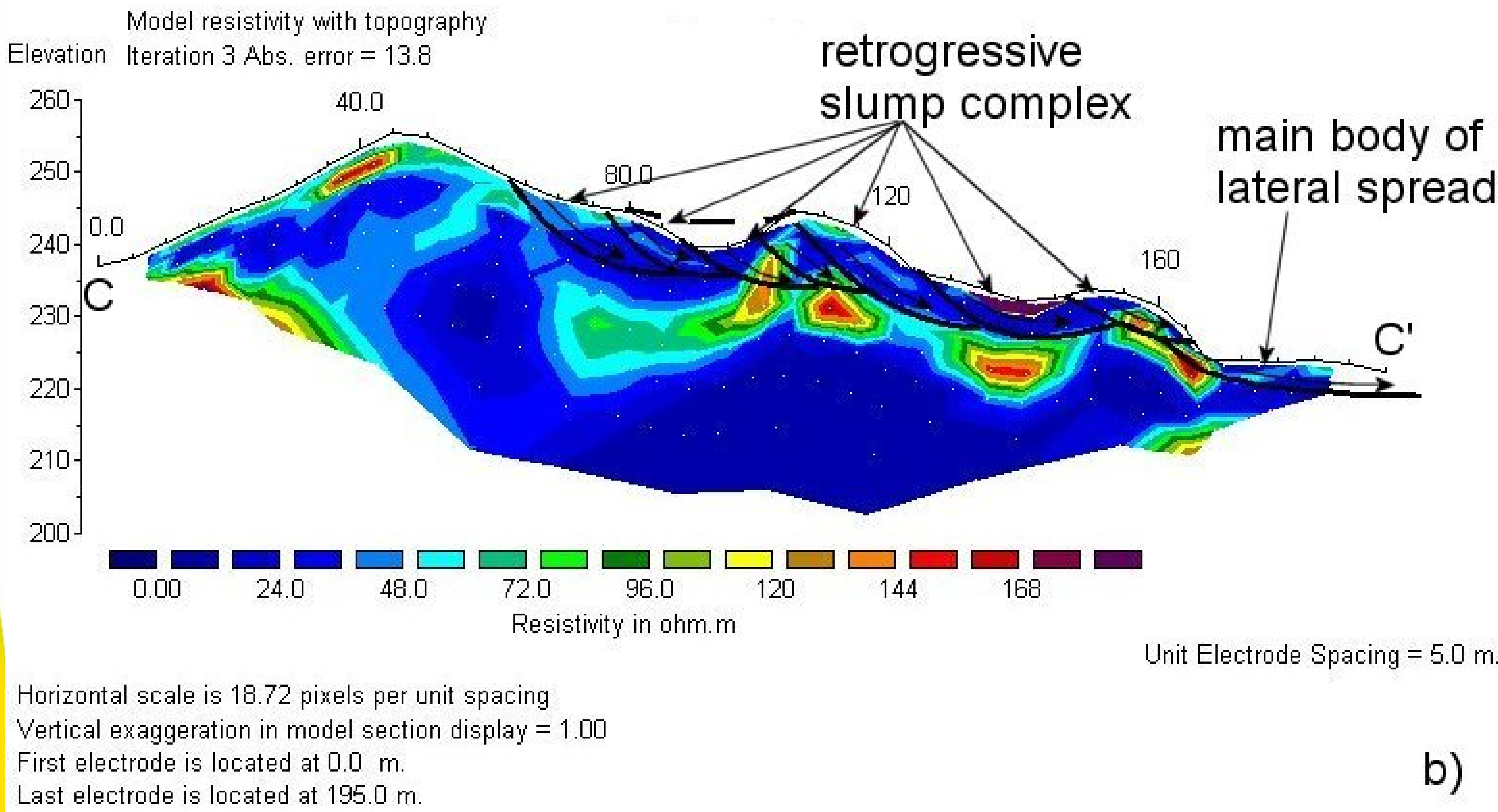


UMR

Soil Resistivity Profiling



Geologic Interpretation

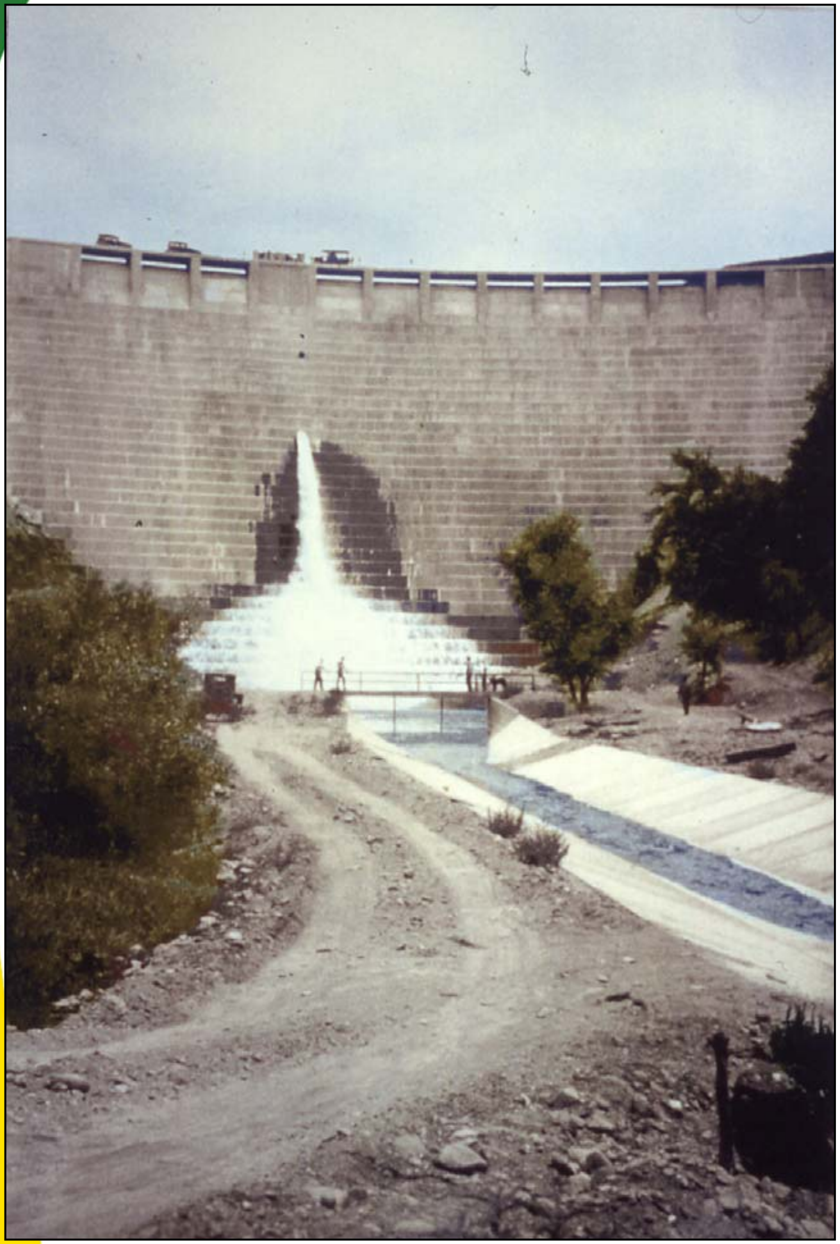


APPLICATION OF GIS METHODS TO GEOFORENSICS

St. Francis Dam Outbreak Flood

March 1928

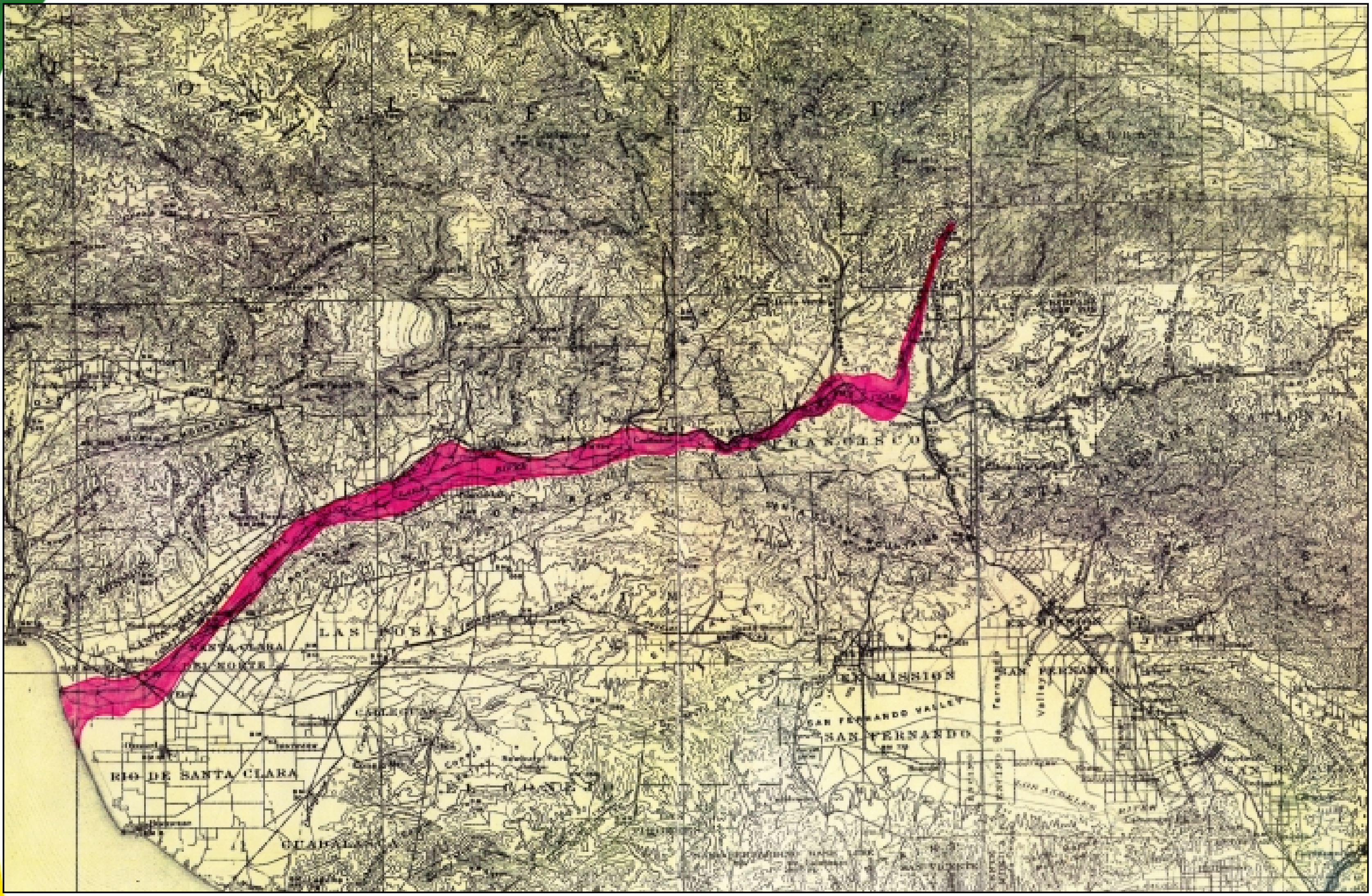
UMR



- St. Francis Dam was a 200-ft high concrete gravity-arch dam constructed by the City of Los Angeles between 1924-26
- It failed near midnight on March 12-13, 1928, killing at least 420 people, making it the worst American civil engineering failure of the 20th Century

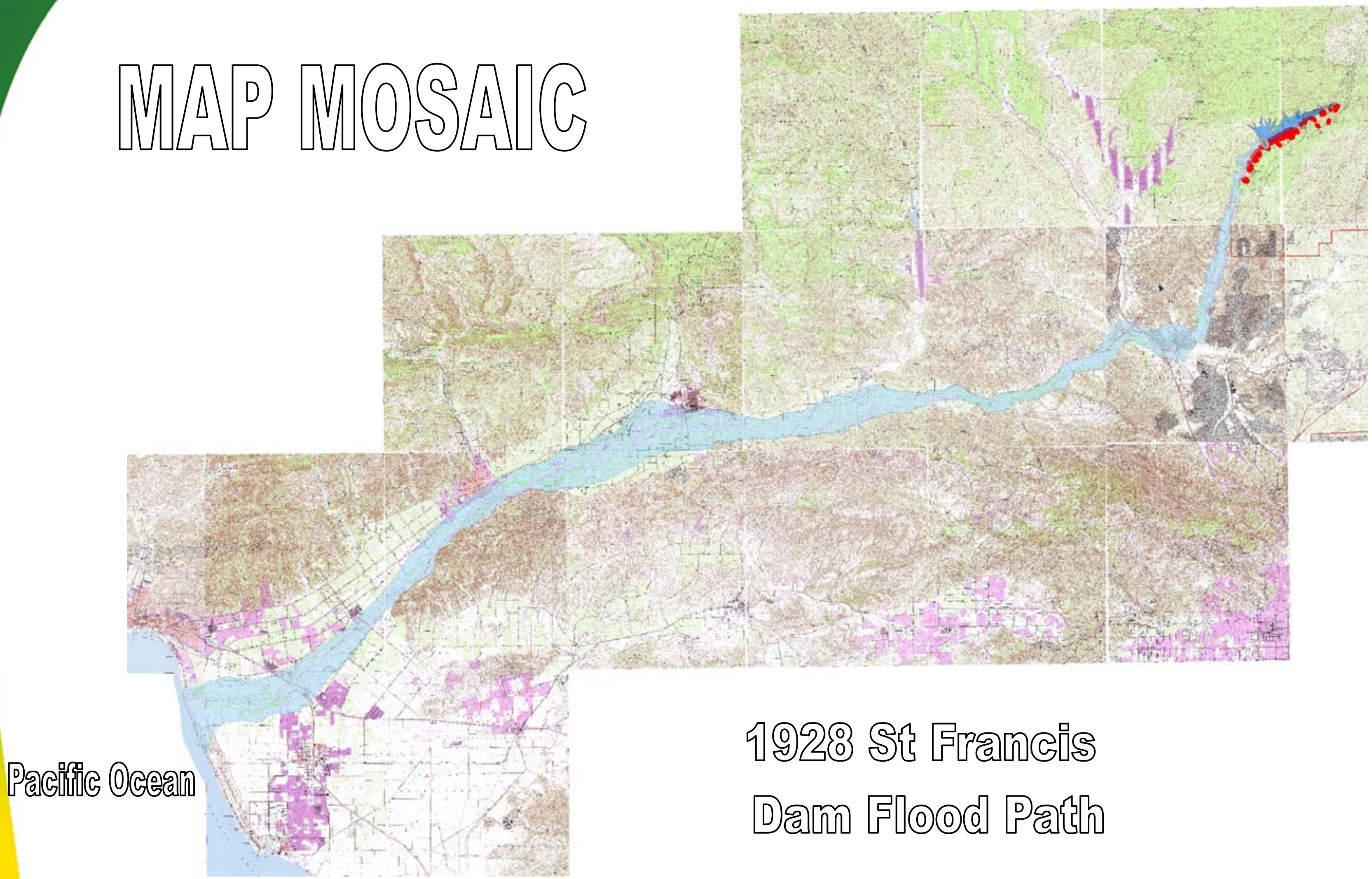
- As the flood moved downstream, the depth of flow diminished. This view shows a saddle 120 feet above the creek bed about ¾ mile downstream, which was overtopped by the outpouring waters.

- The flood swept 6 miles down San Francisquito Canyon to it's junction with the much larger Santa Clara River, where it made a right-hand reverse turn through Castaic Junction.



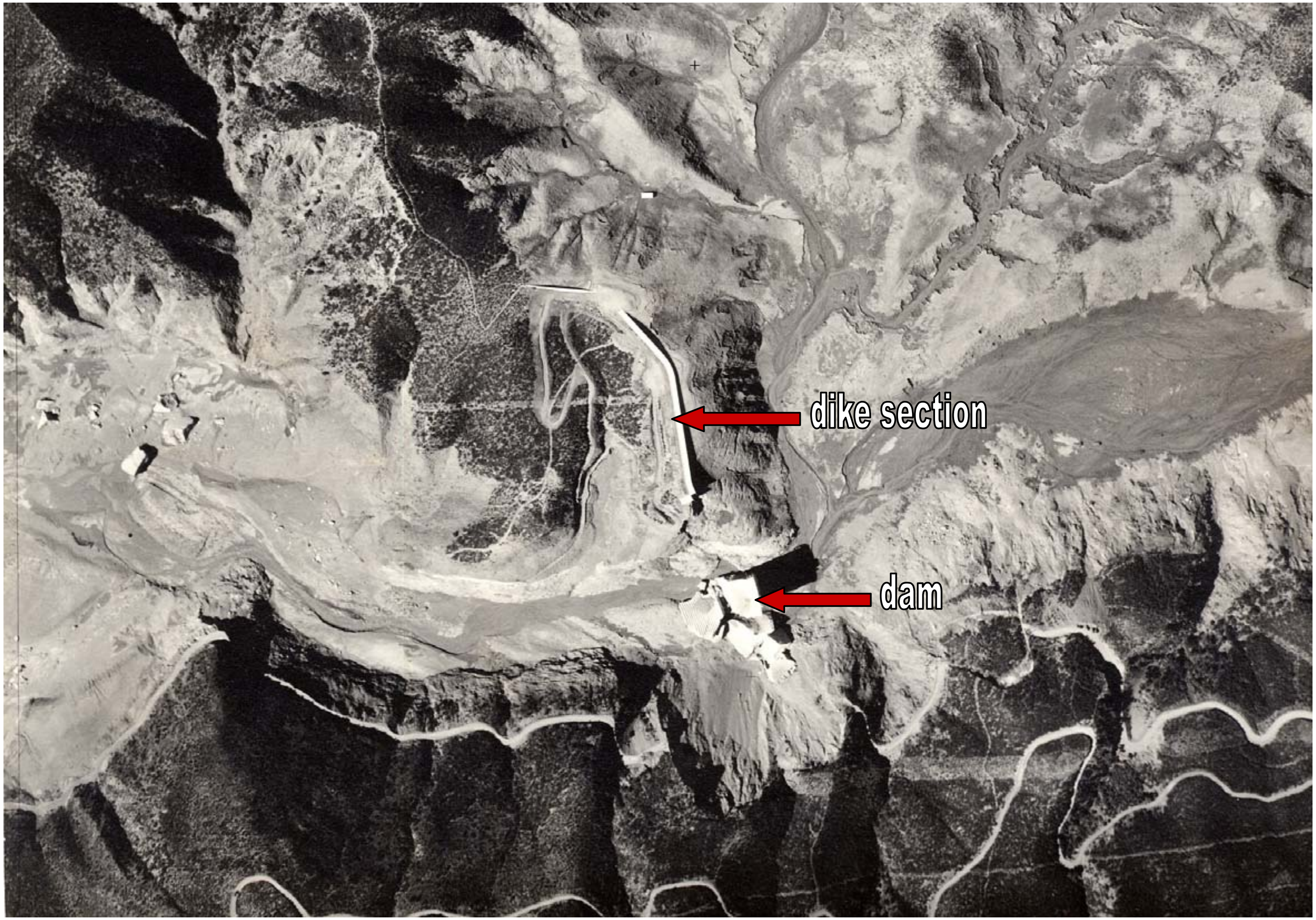
- Charles Lee's map of the flooded area, extending 54 miles from the St. Francis Dam site, through Castaic, Camulos, Filmore, Santa Paula, Saticoy and Montalvo. The smoothed flow distance was 52 miles.

MAP MOSAIC

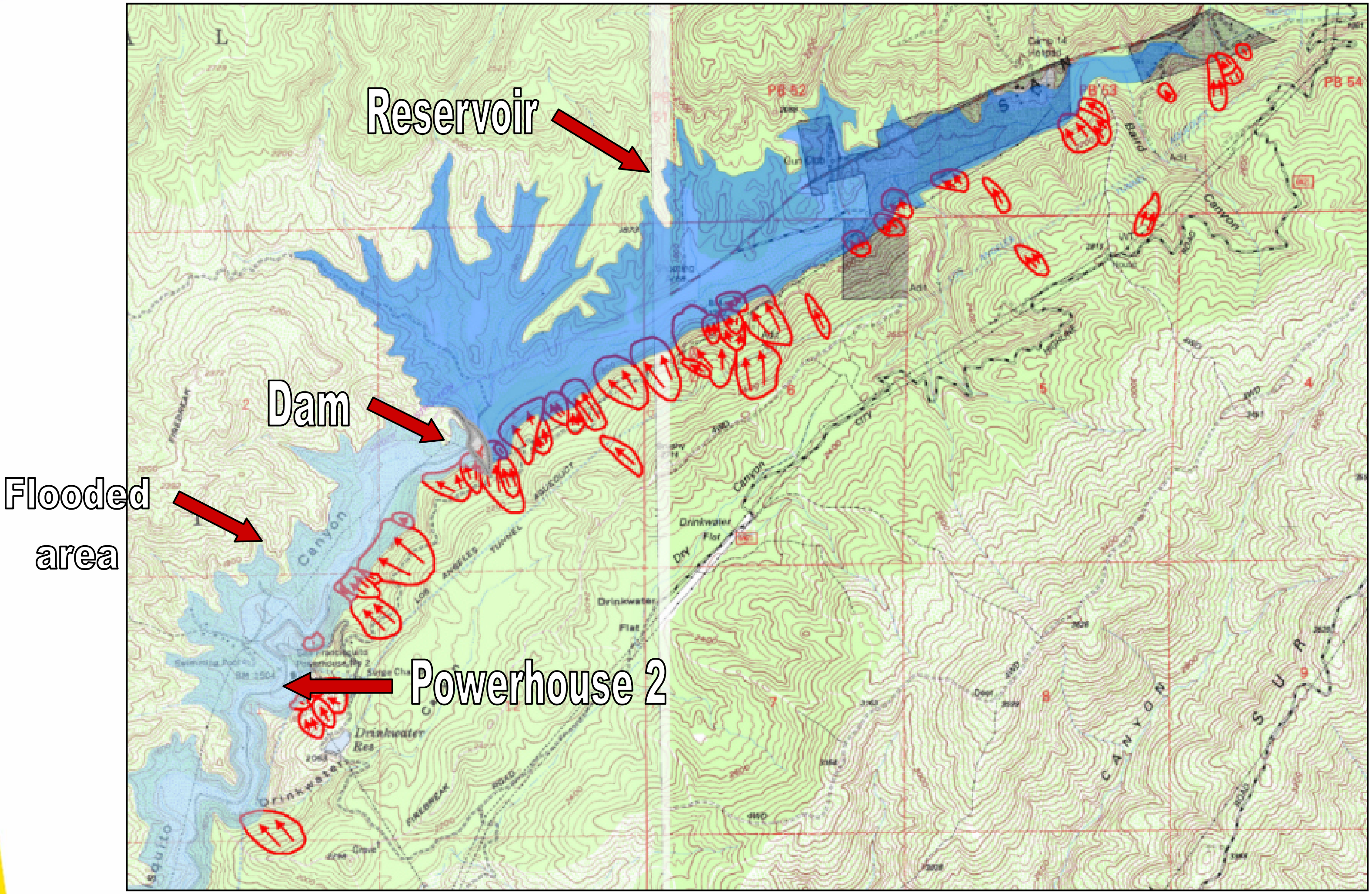


- **19 USGS 1:24,000 scale Digital Raster Graphic (DRGs) quadrangles were stitched to create a flood base map.**

UMR

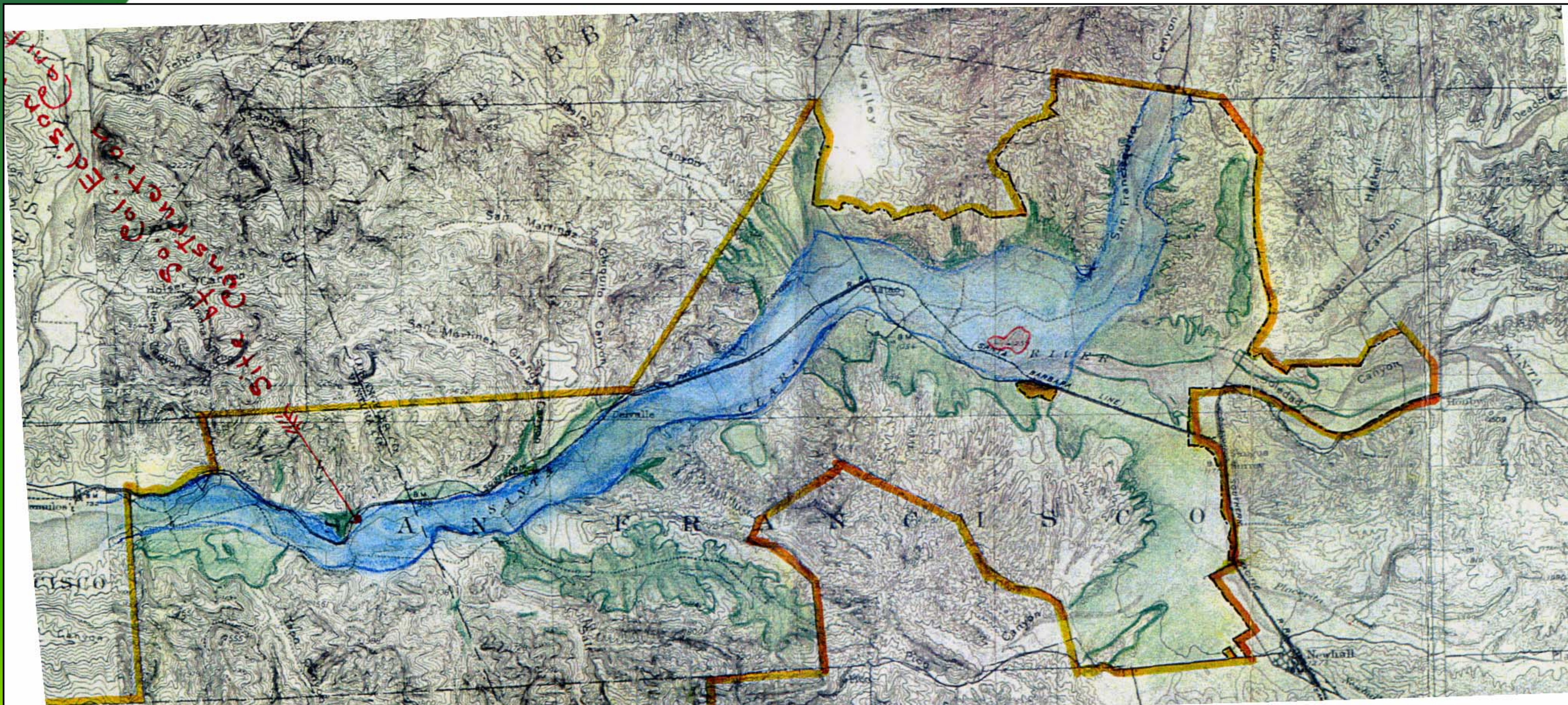


- **Stereopair aerial photos were orthorectified on present-day DRGs to obtain aerial limits of flood waters. This view shows the dam site and immediately downstream.**

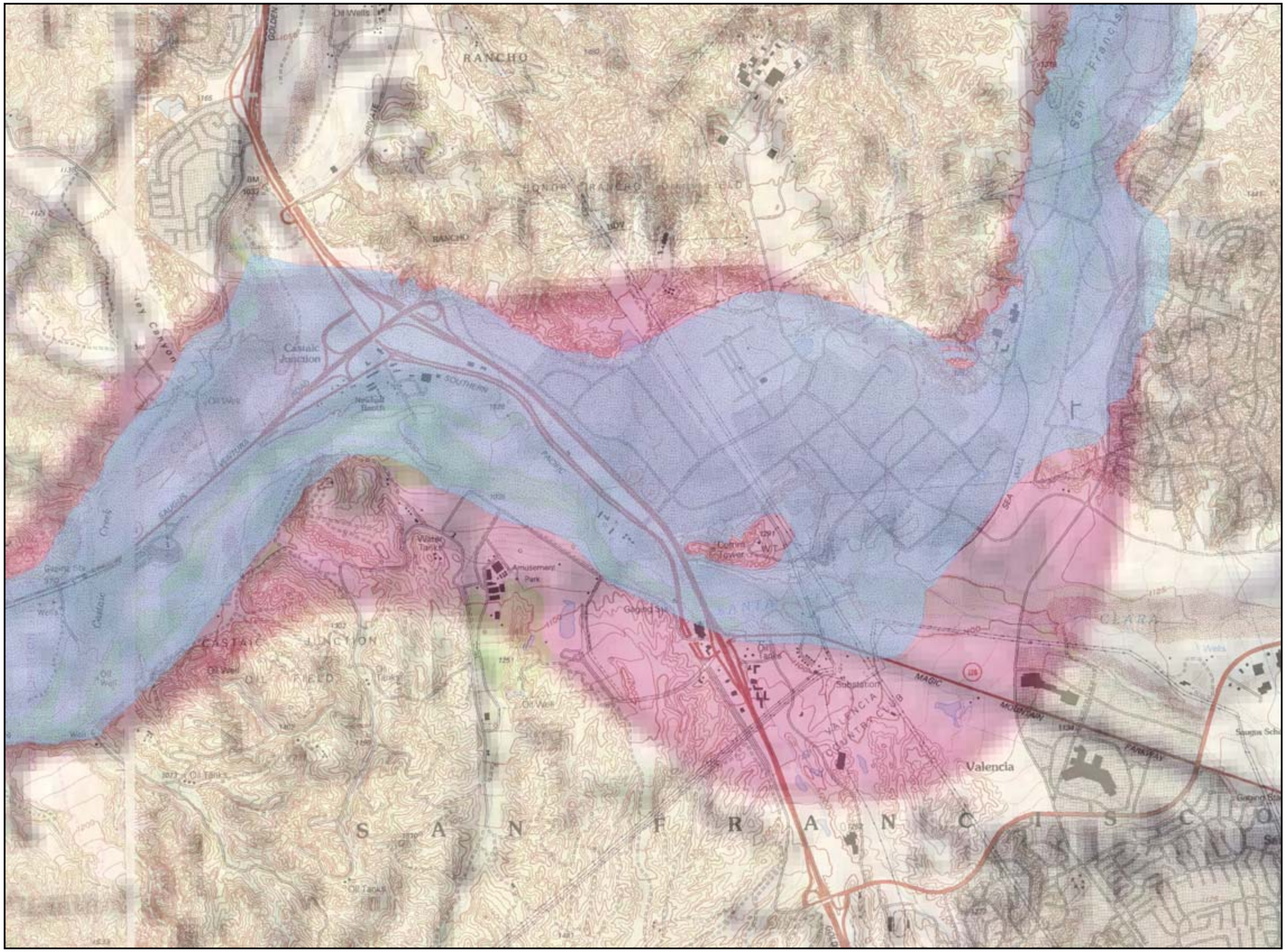


- This flood map was created in ArcGIS on USGS 7.5-minute DRGs. It shows the 1928 reservoir in dark blue and the flood limits in light blue. Landslides are shown in red.

UMR

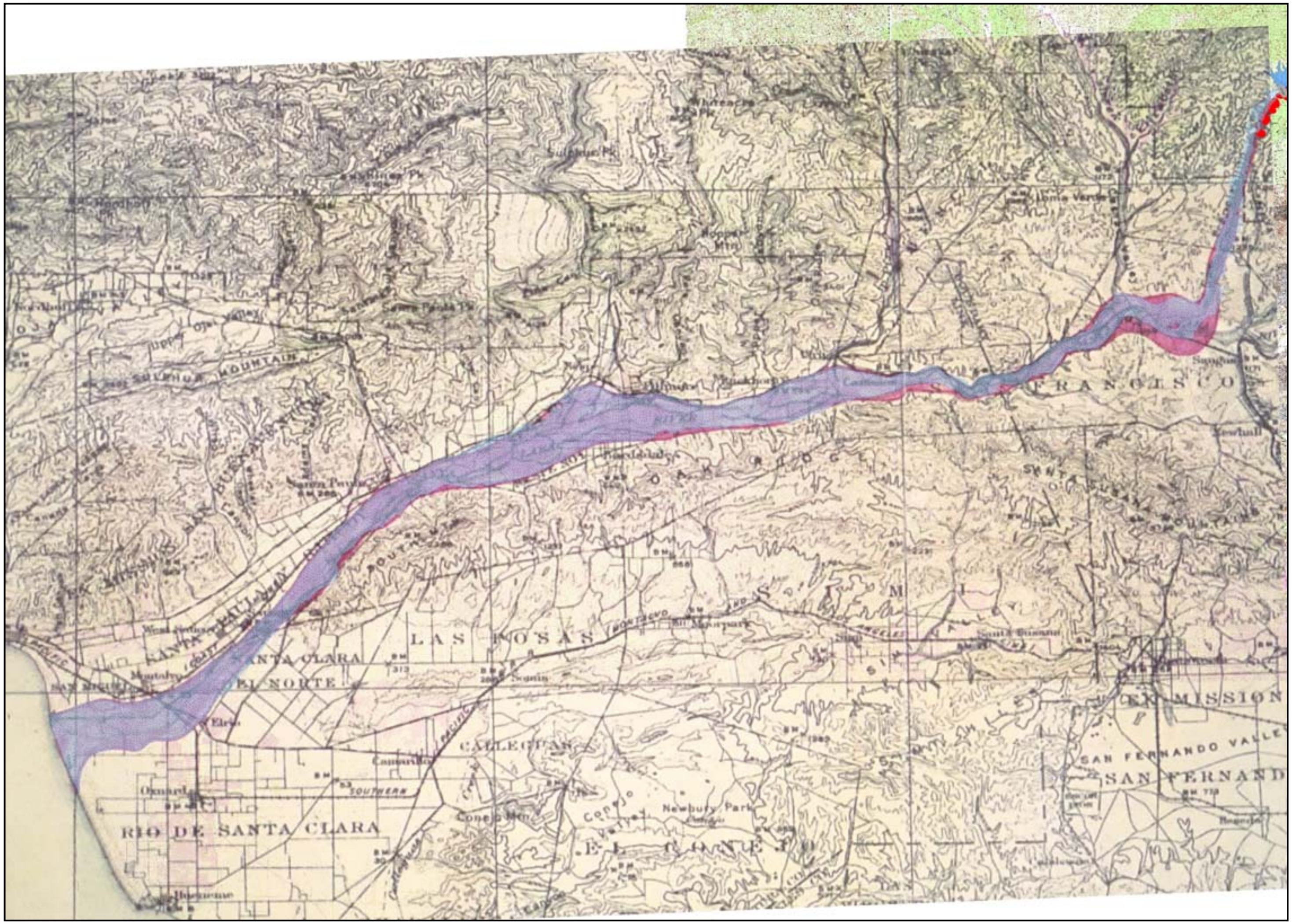


- **Orthorectifed local flood map. By applying Universal Transverse Mercator (UTM) Grid North American Datum (NAD) 1983 (83) geospatial controls, the 1928 planar map is skewed slightly when orthorectified to present-day map projection standards that account for the Earth's actual curvature.**

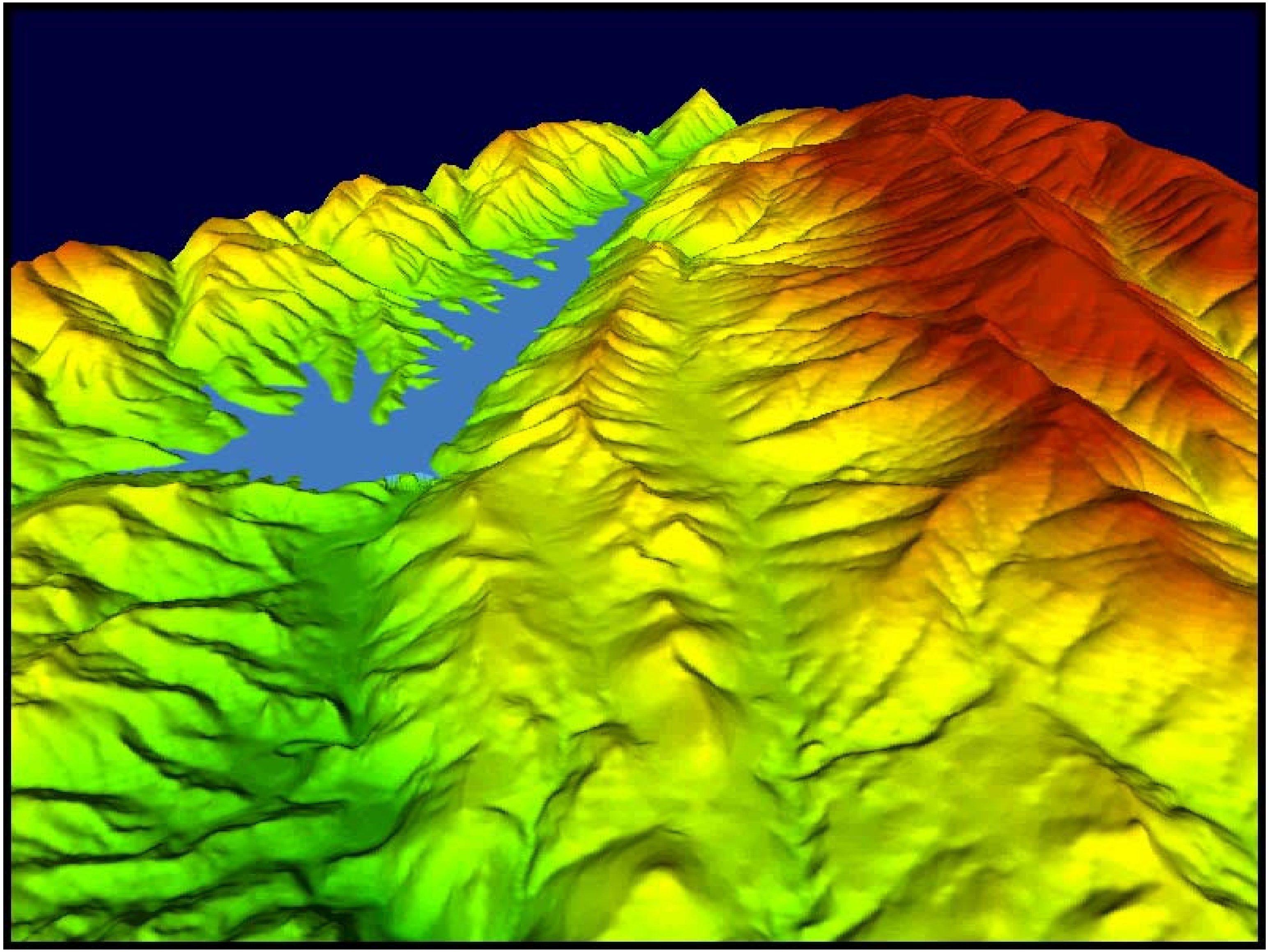


- **When our GIS map (blue) was overlain on Charles Lee's flood map (red); it appeared that he greatly overestimated the spatial limits of flooding in the Castaic Junction area.**

- The flood limits shown on our new map are very similar to those shown on the damage map prepared for the Newhall Land Company in the Castaic Junction area.

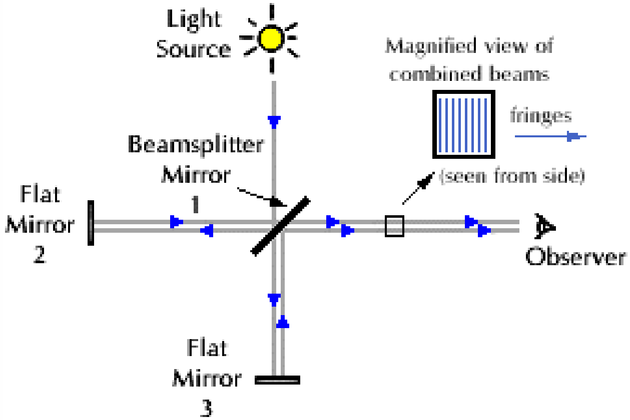


- **Comparison between orthorectifeid version of Lee's flood map (red) and our new flood map (blue). Lee's map was prepared on a 1:250,000 scale base map (1 inch = 4 miles).**

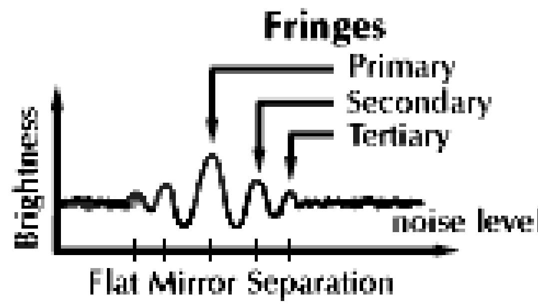


UMR

Interferrometric Synthetic Aperture Radar (INSAR)



Michelson Interferometer



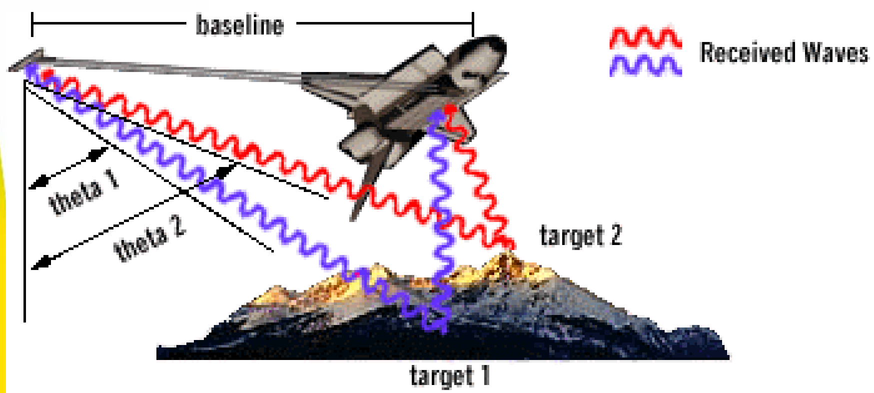
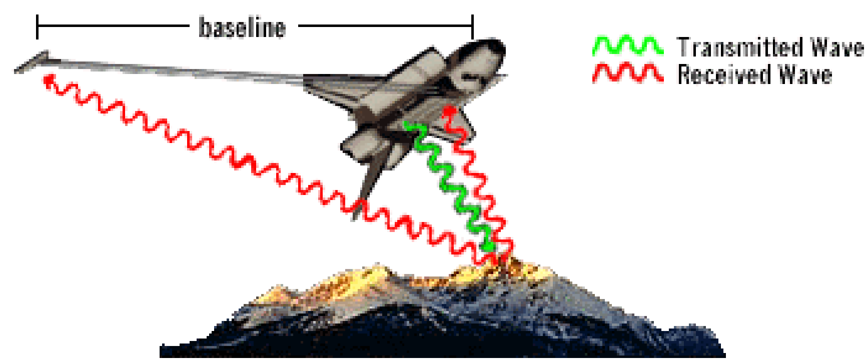
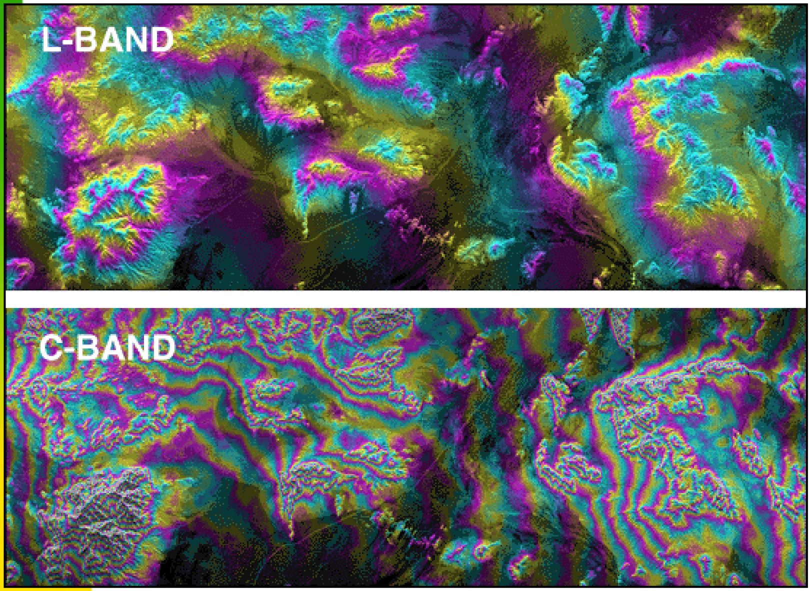


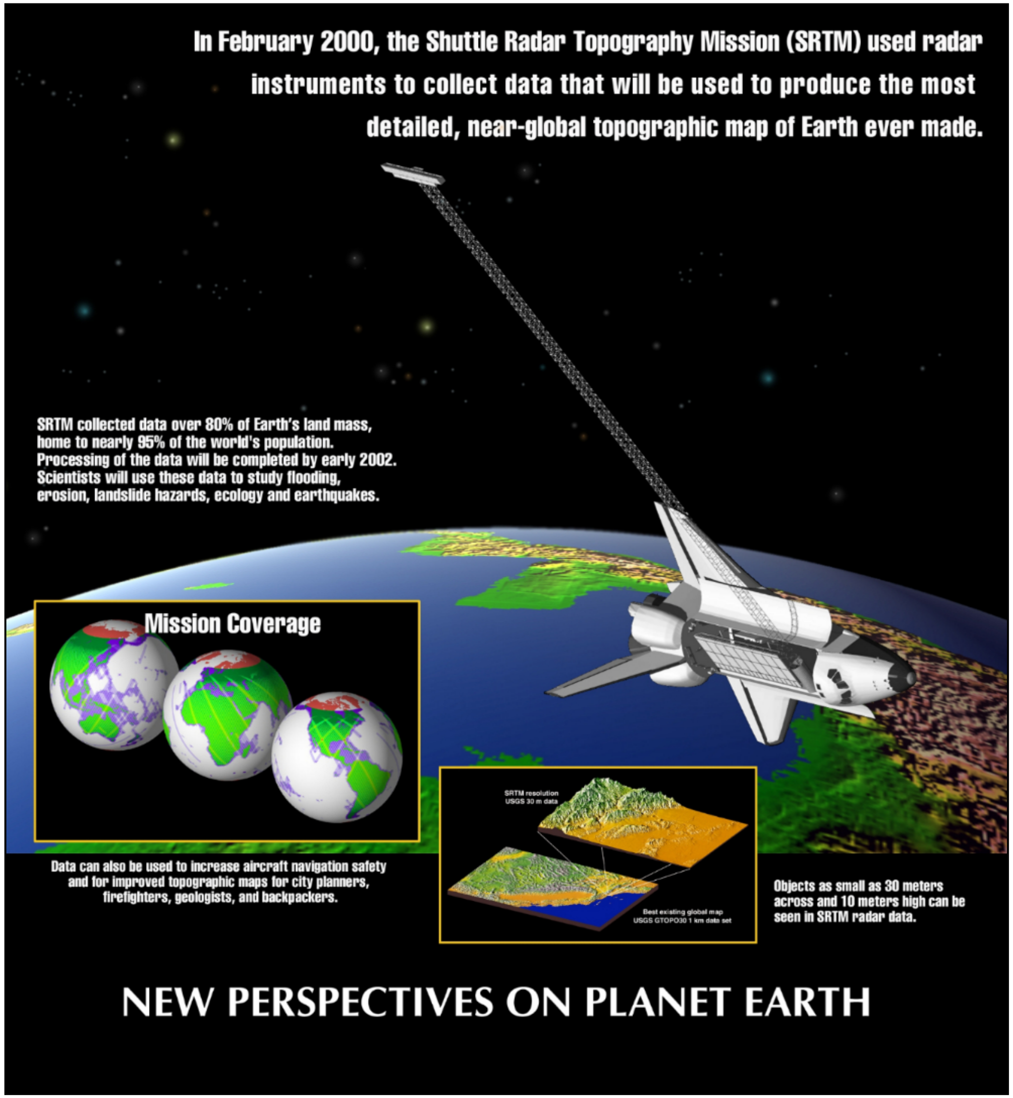
Figure 4: Differential Distance Gives Topography



Radar signals being transmitted and recieved in the SRTM mission (image not to scale).

Shuttle Radar Topography Mission (SRTM) Data

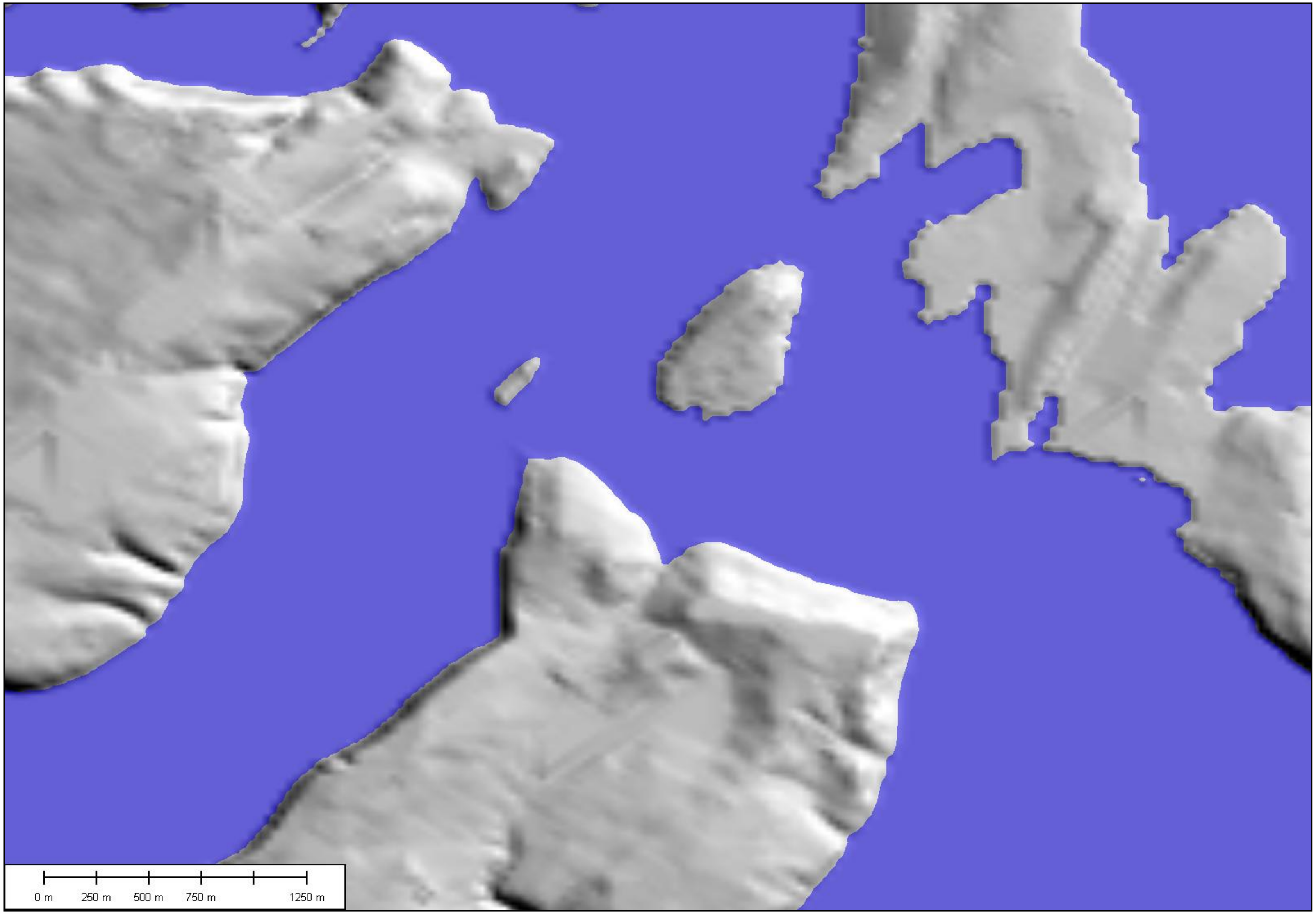




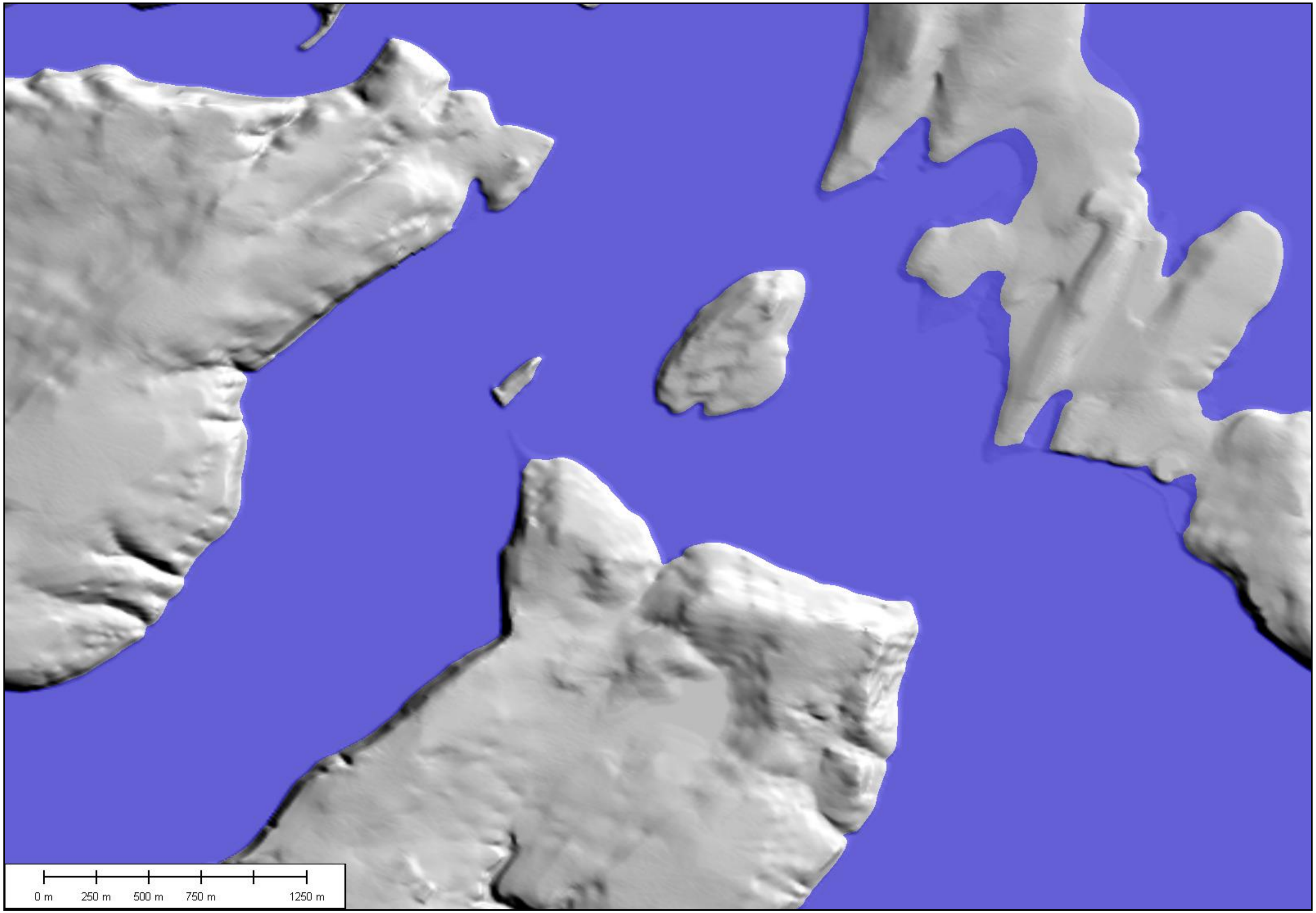
UMR

Topographic Surface Imaging Using Light Detection and Ranging (LiDAR)

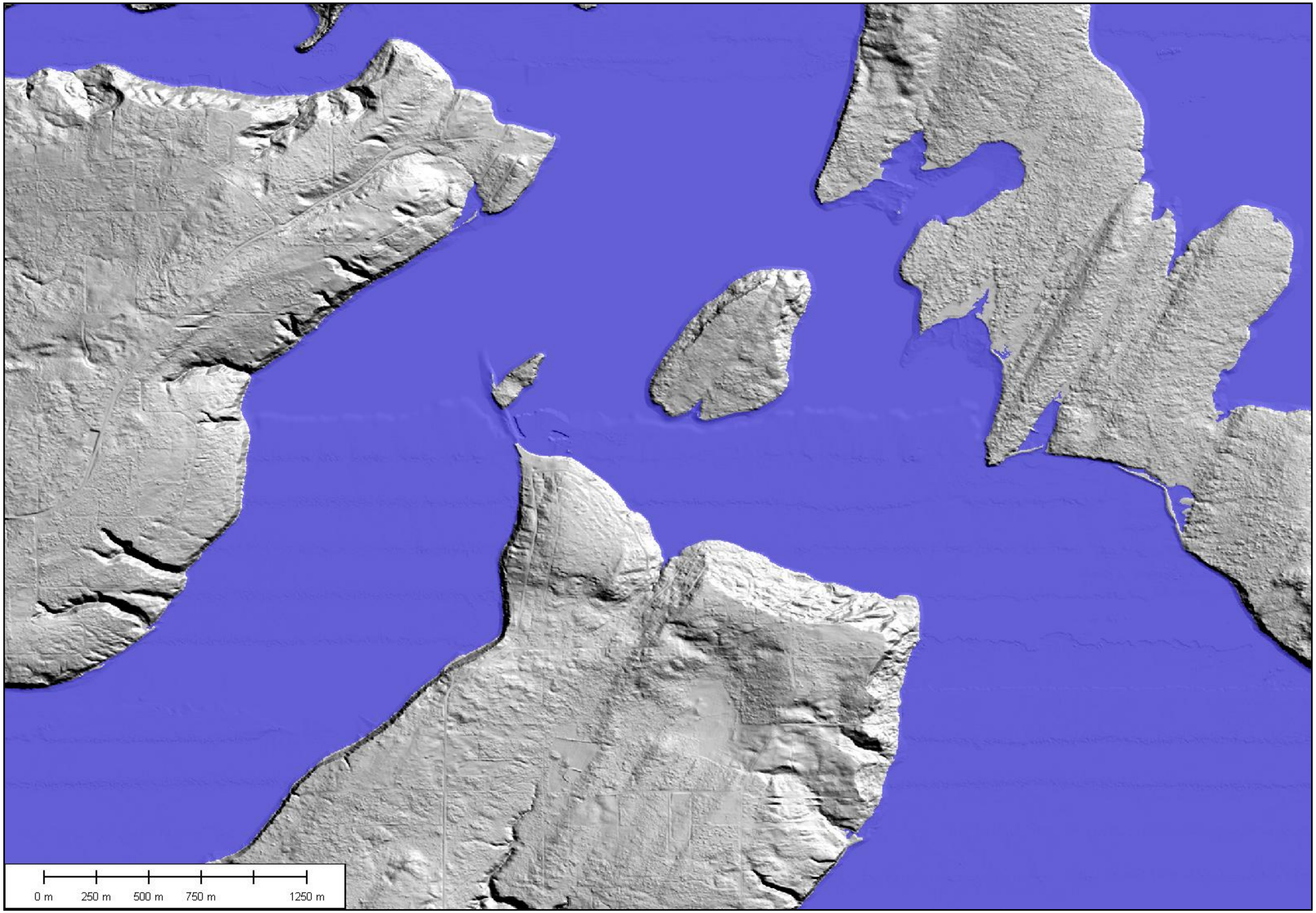
2m LiDAR DEMs
Squaxin Island
Thurston County, Washington



USGS 30m DEM



USGS 10m DEM



LiDAR 2m DEM

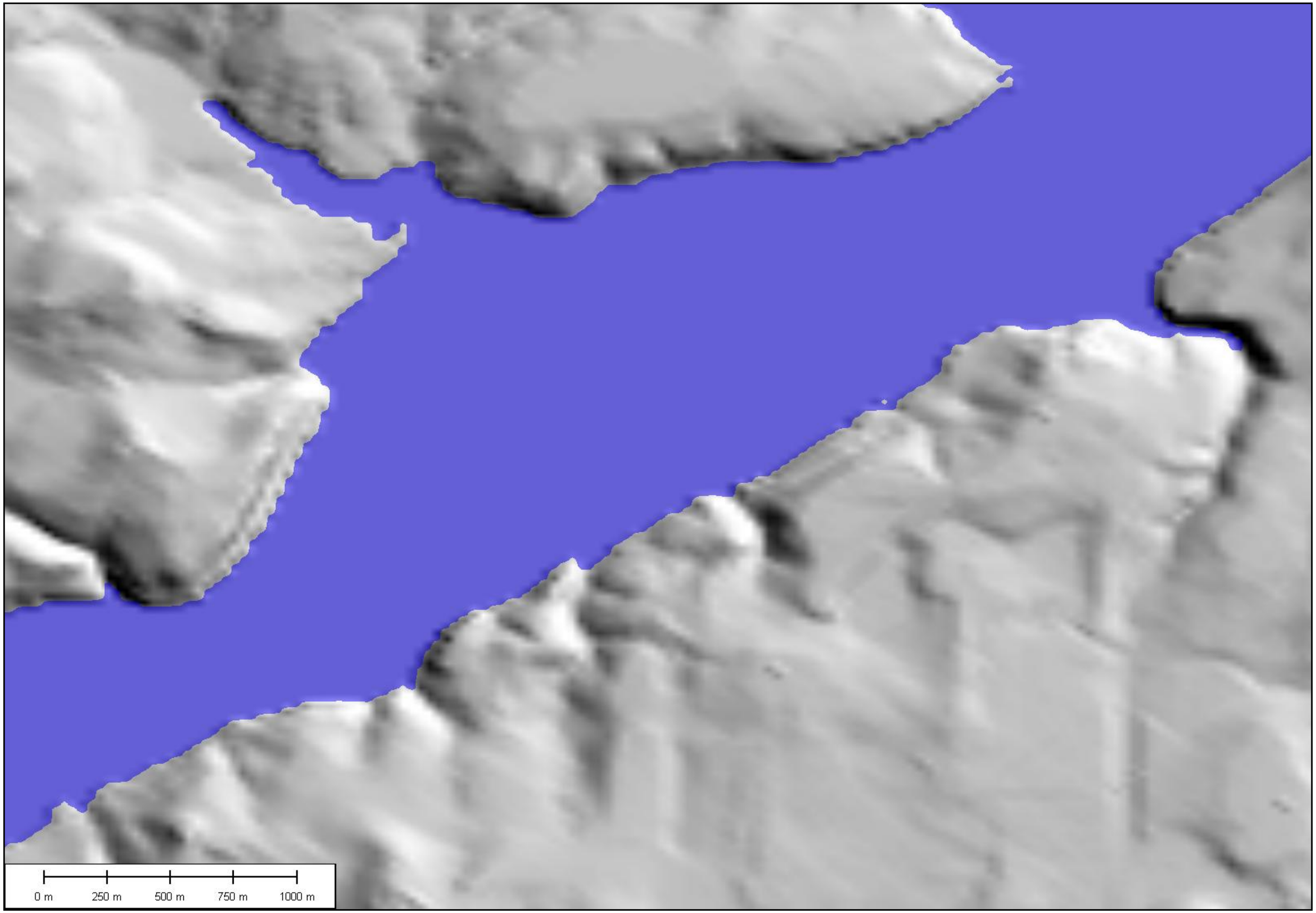
Topographic Surface Imaging Using Light Detection and Ranging (LiDAR)

2m LiDAR DEMs

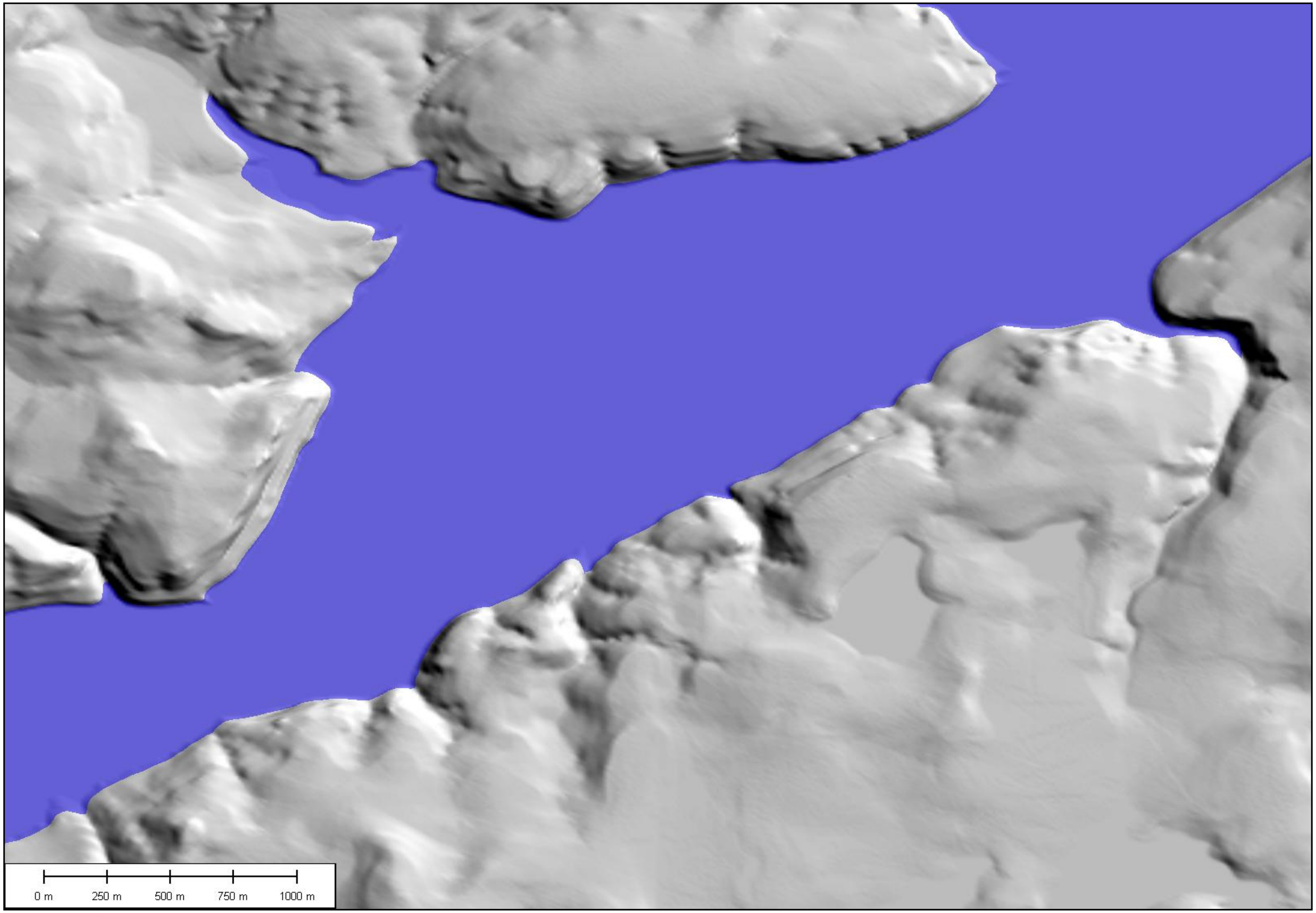
Sunrise and Sunset Beach

Thurston County, Washington

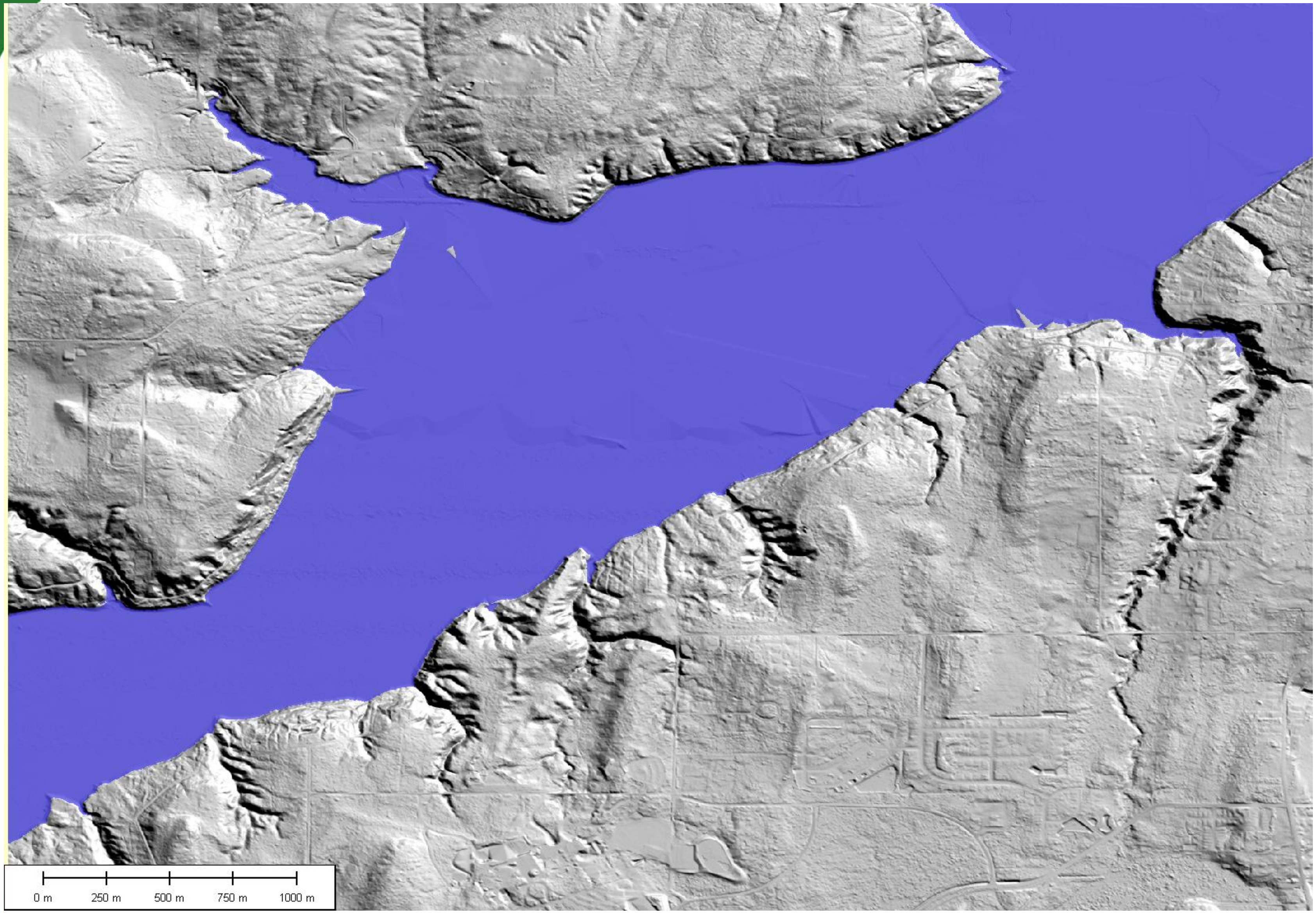
UMR



Standard USGS 30m DEM



USGS 10m DEM - 9X resolution of 30 m DEM



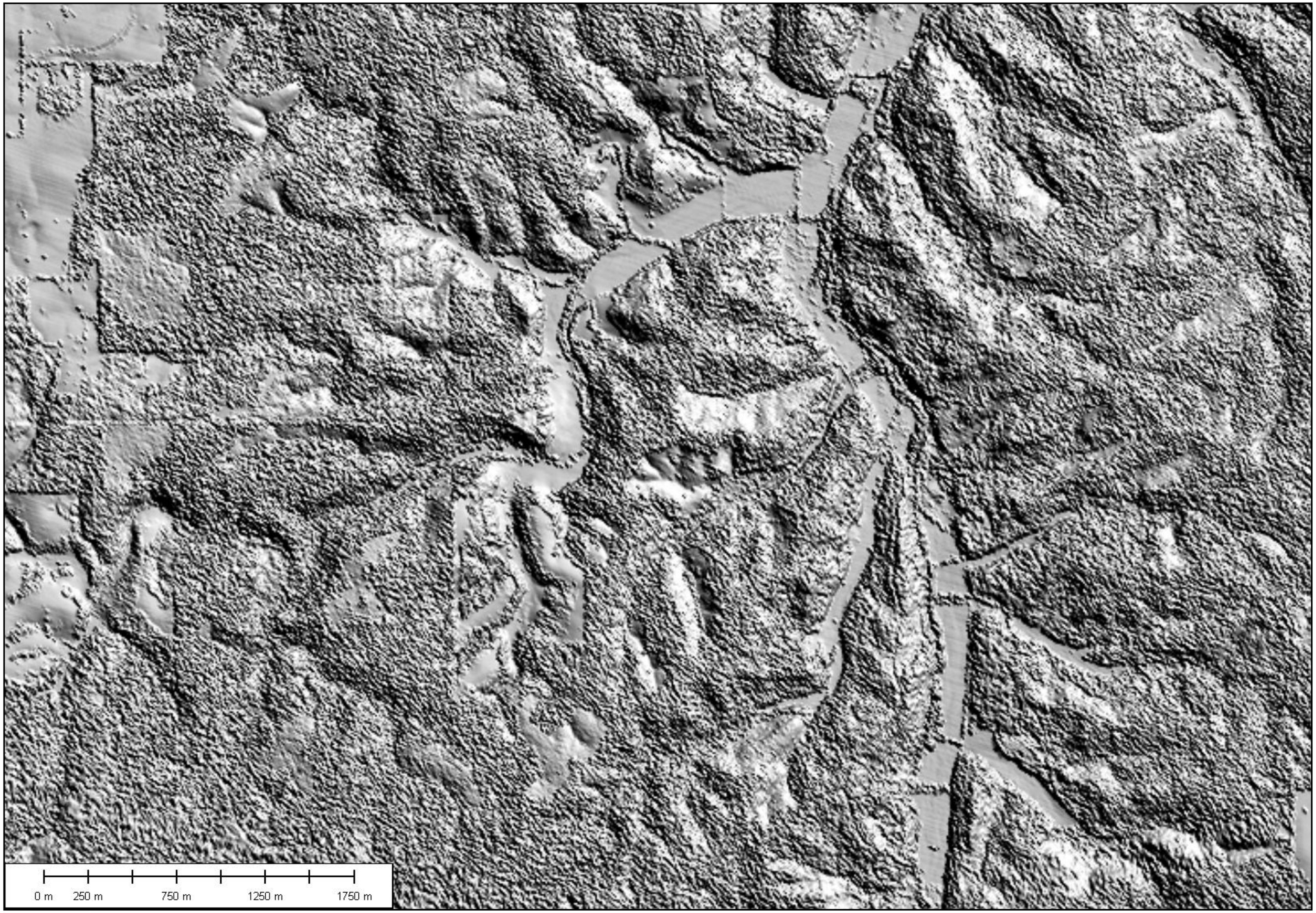
LiDAR 2m DEM – 25X resolution of 10 m DEM

Kaintuck Hollow High-Altitude LiDAR

Southwest of Newburg, MO

UMR

USGS 10m DEM



LiDAR 10m Leaf On DEM (Raw)

UMR

LiDAR 10m Leaf On DEM (Clean)

LiDAR 10m from 5m Leaf-Off DEM

UMR

USGS 10m DEM

UMR

UNIVERSITY OF MISSOURI-ROLLA
The Name. The Degree. The Difference.

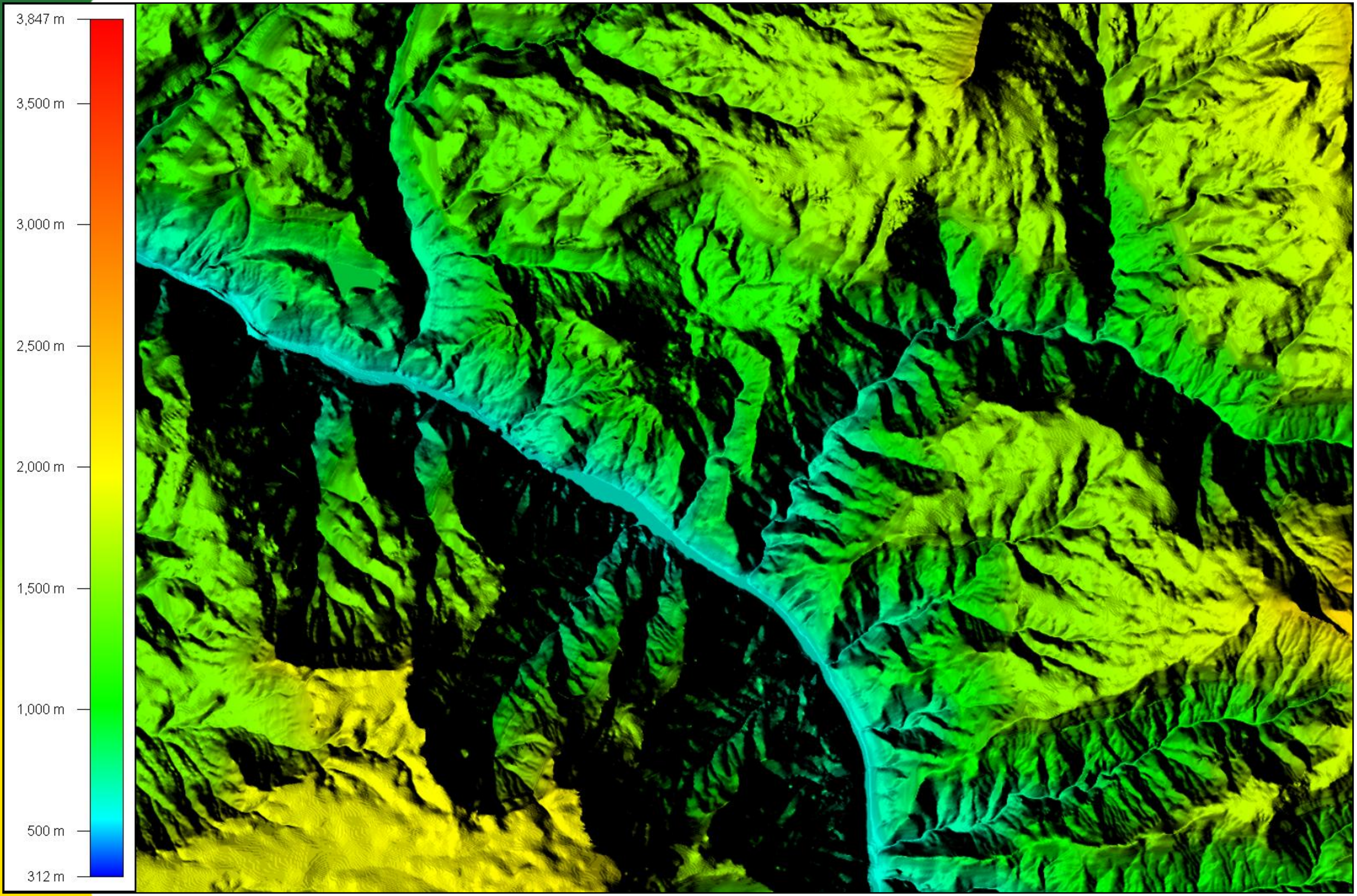
LiDAR 5m Leaf-Off DEM

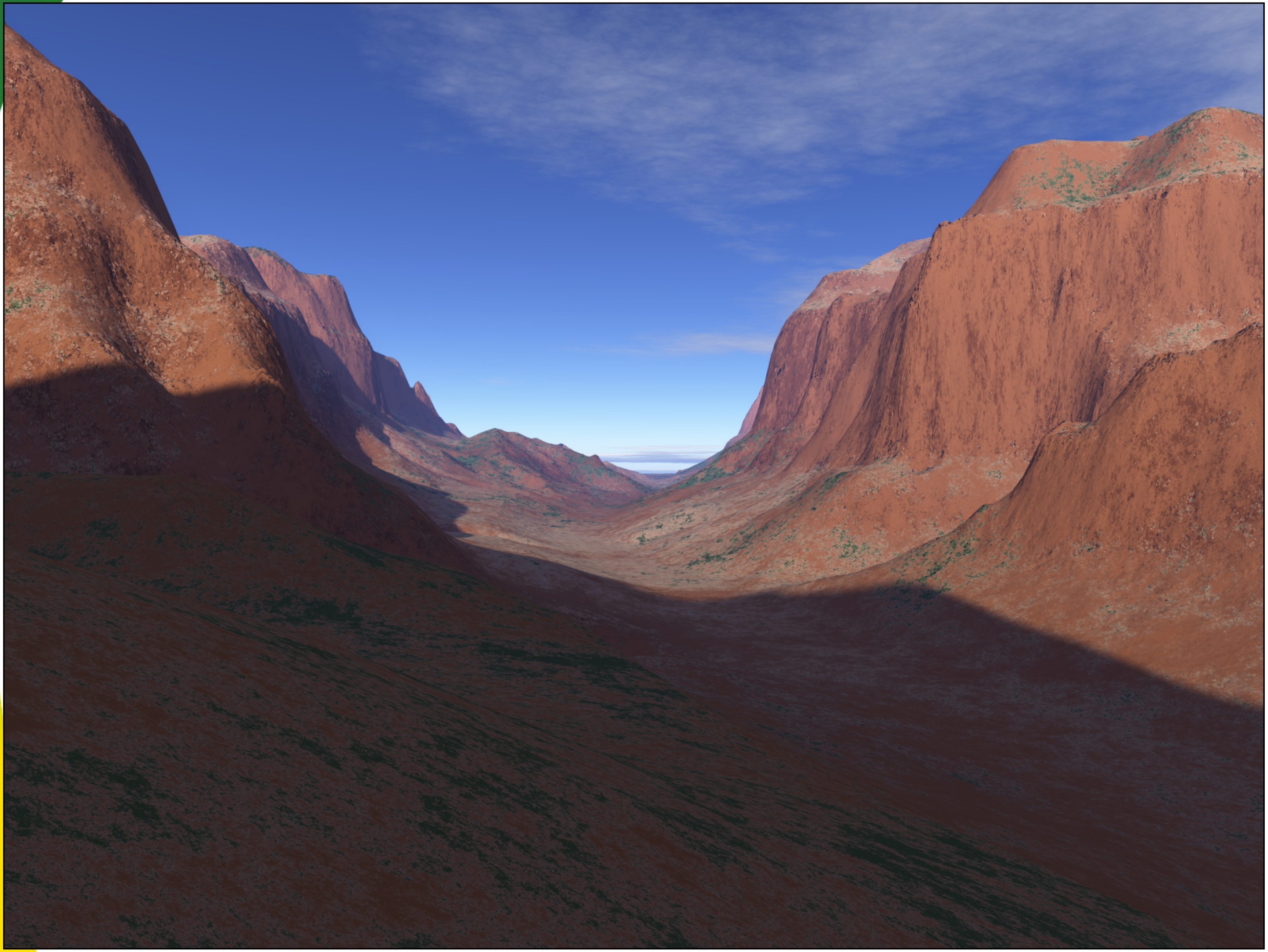
3D Modeling of Terrain Using Terragen Software

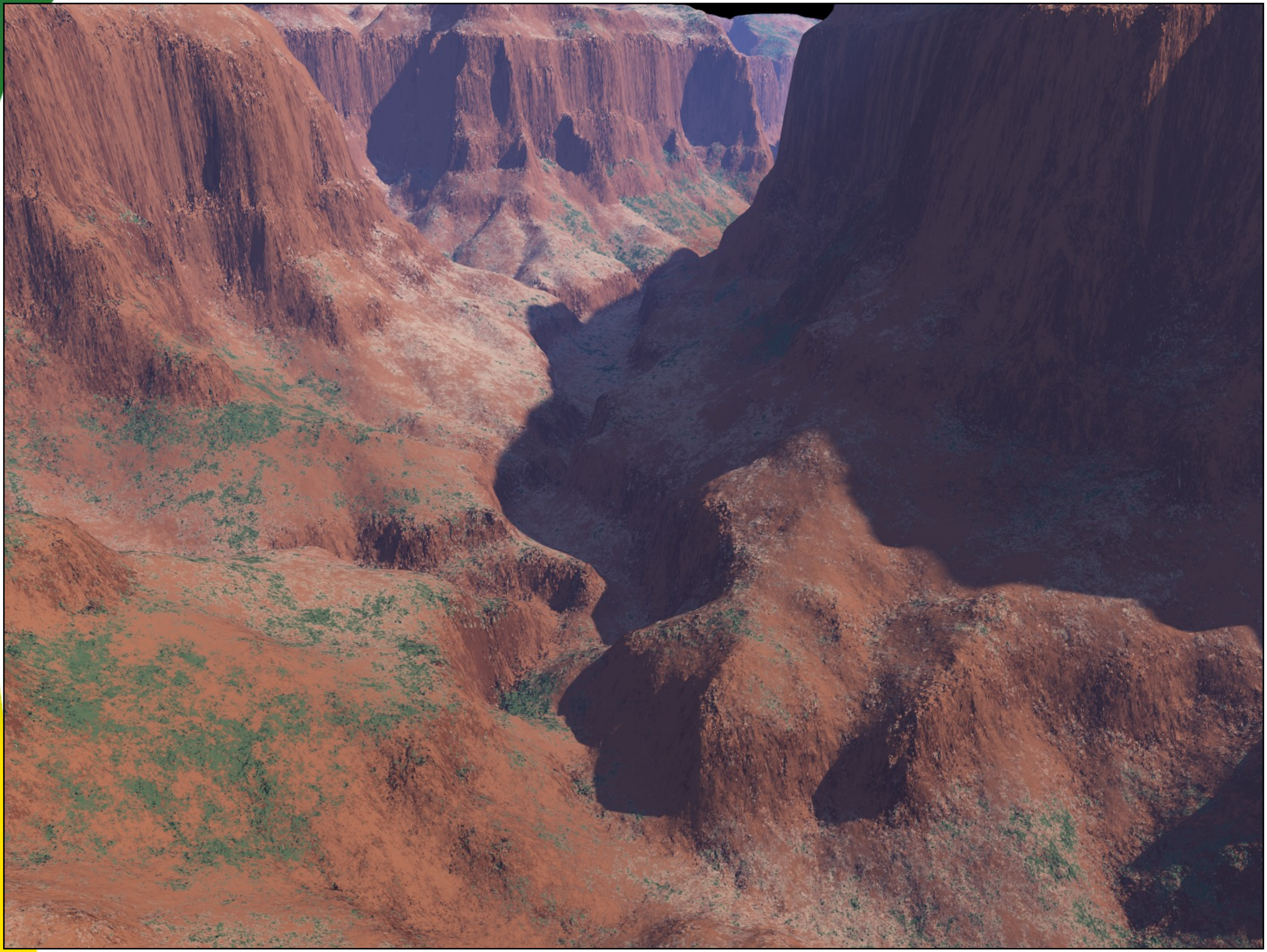
Grand Canyon, AZ

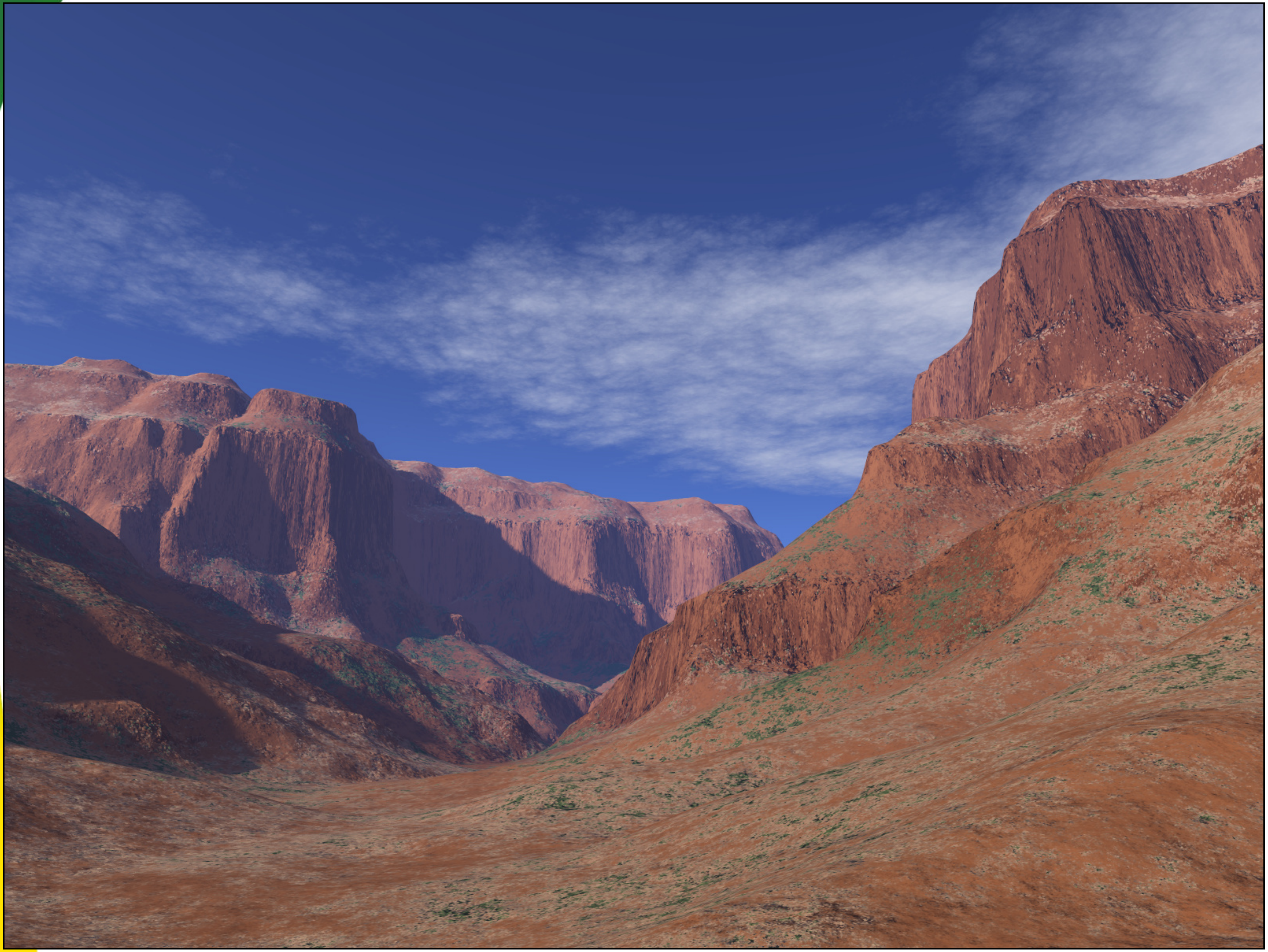
UMR

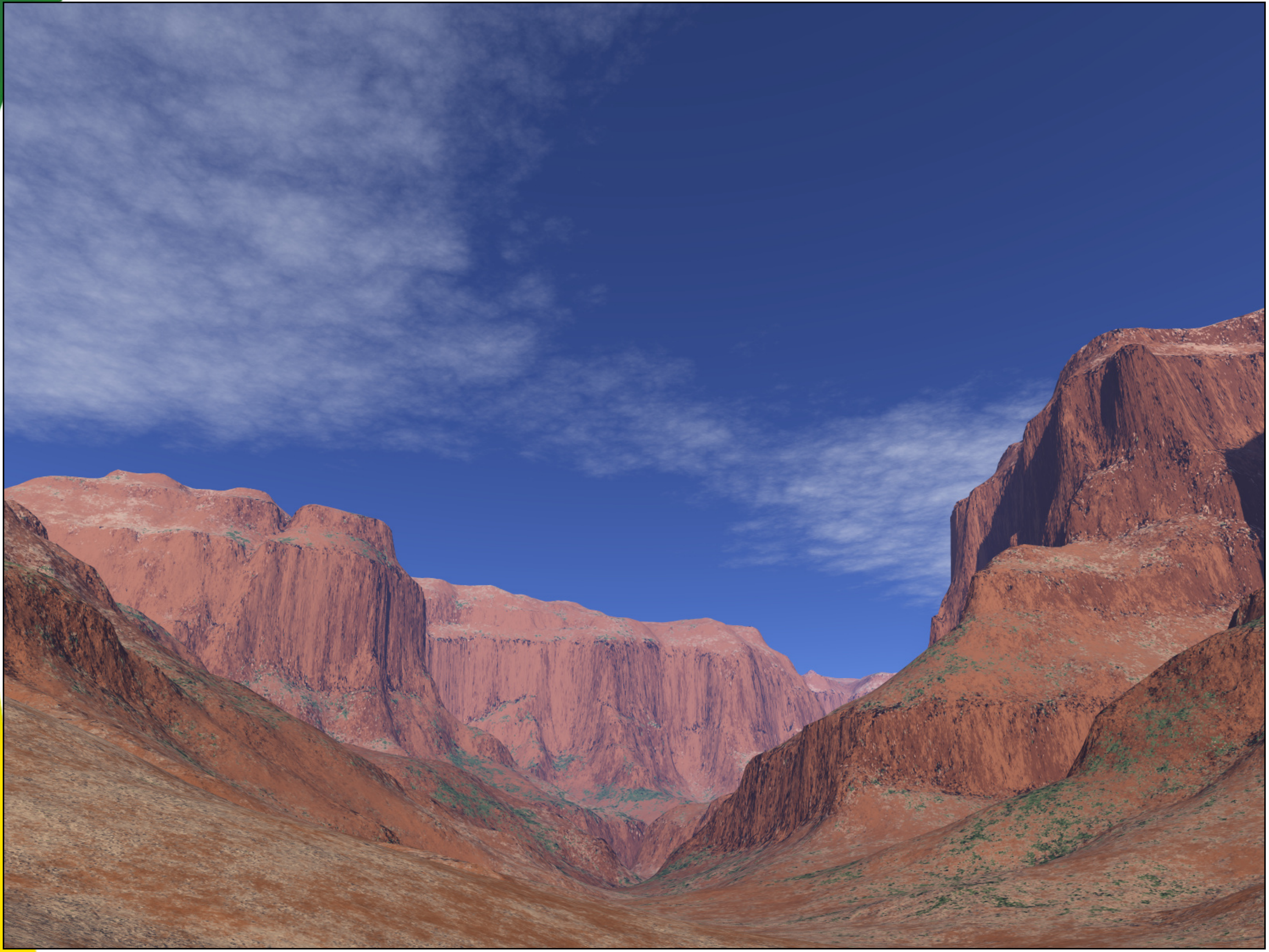
Inner Gorge of the Canyon near Deer Creek


3,847 m
3,500 m
3,000 m
2,500 m
2,000 m
1,500 m
1,000 m
500 m
312 m







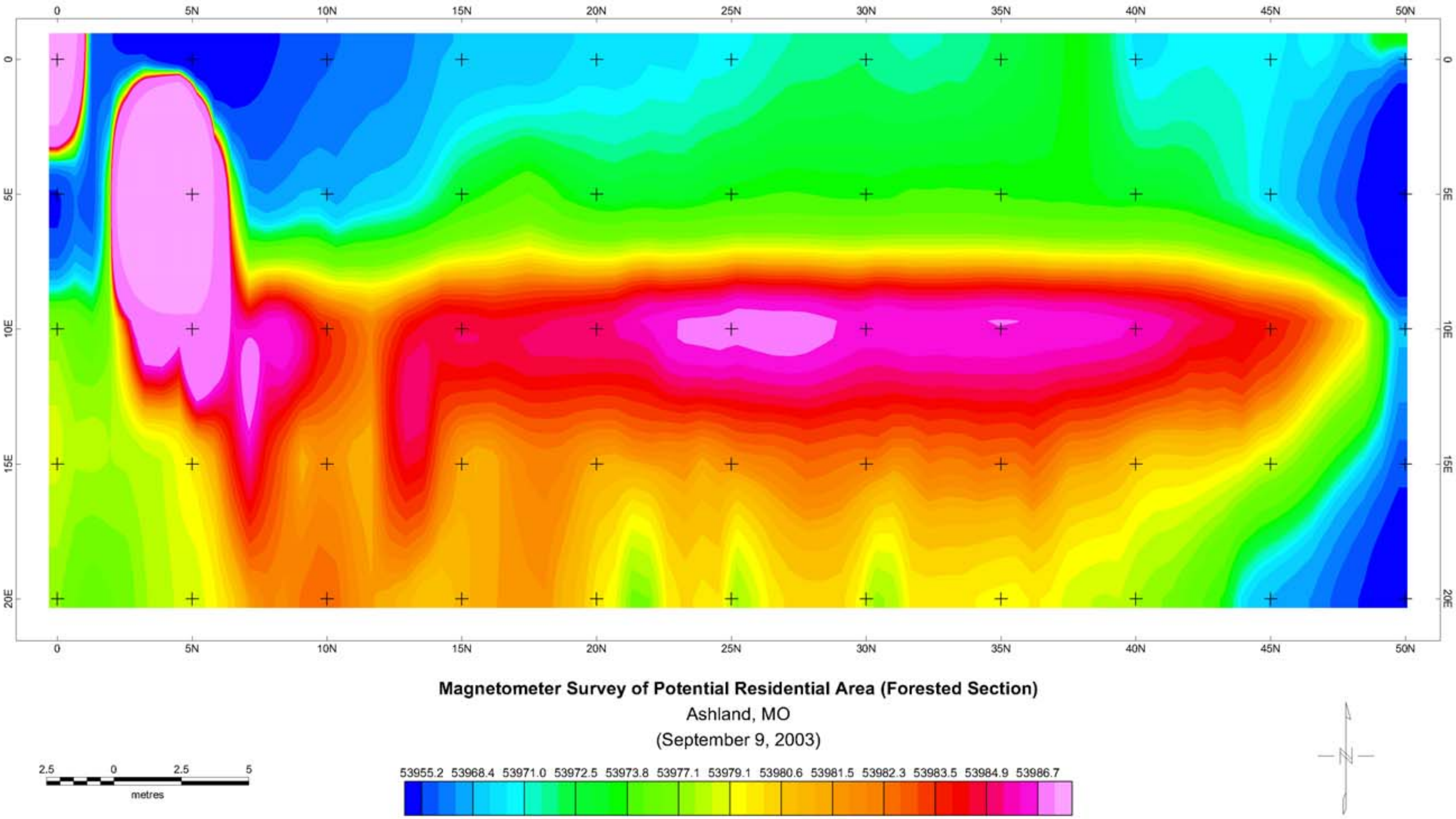


Geophysical Mapping With Magnetic Surveying Methods

Building Site near Ashland, MO

(South of Columbia, MO)

UMR



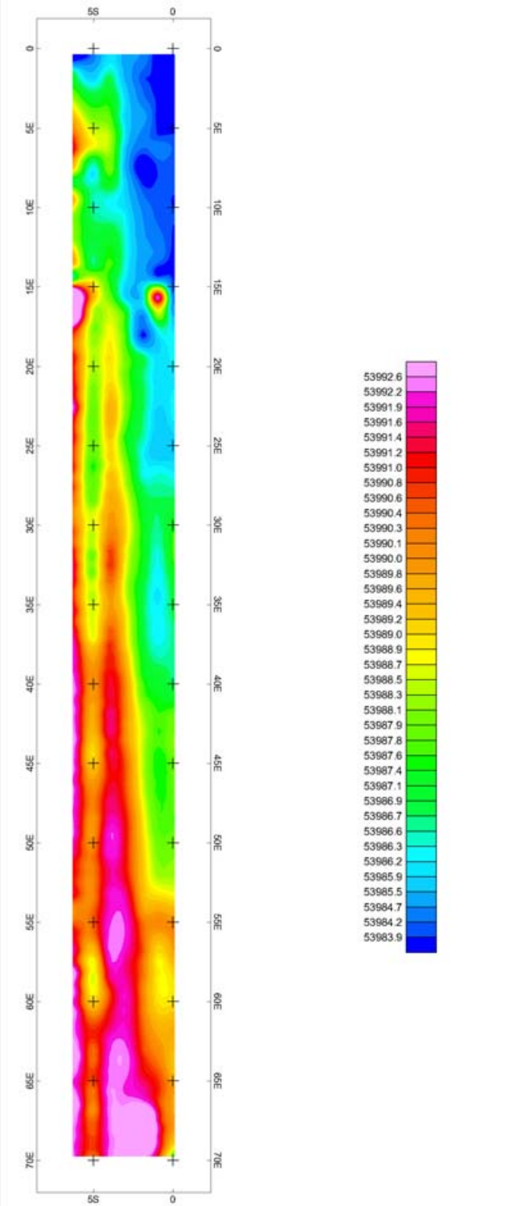
Magnetometer Survey of Potential Residential Area (Forested Section)
Ashland, MO
(September 9, 2003)

UMR

Magnetic Surveying gives the ability to see the metallic resonance in the subsurface.

Identifiable Features:

- Karst
- Buried Drums
- Deposit of Shallow Ores
- Utilities Identification



Magnetometer Survey of Potential Residential Area (Clear Section)
Ashland, MO
(September 9, 2003)

UMR