The Impact of Surface Mining and Mine Reclamation on Surface Runoff and Flood Risk in Appalachia

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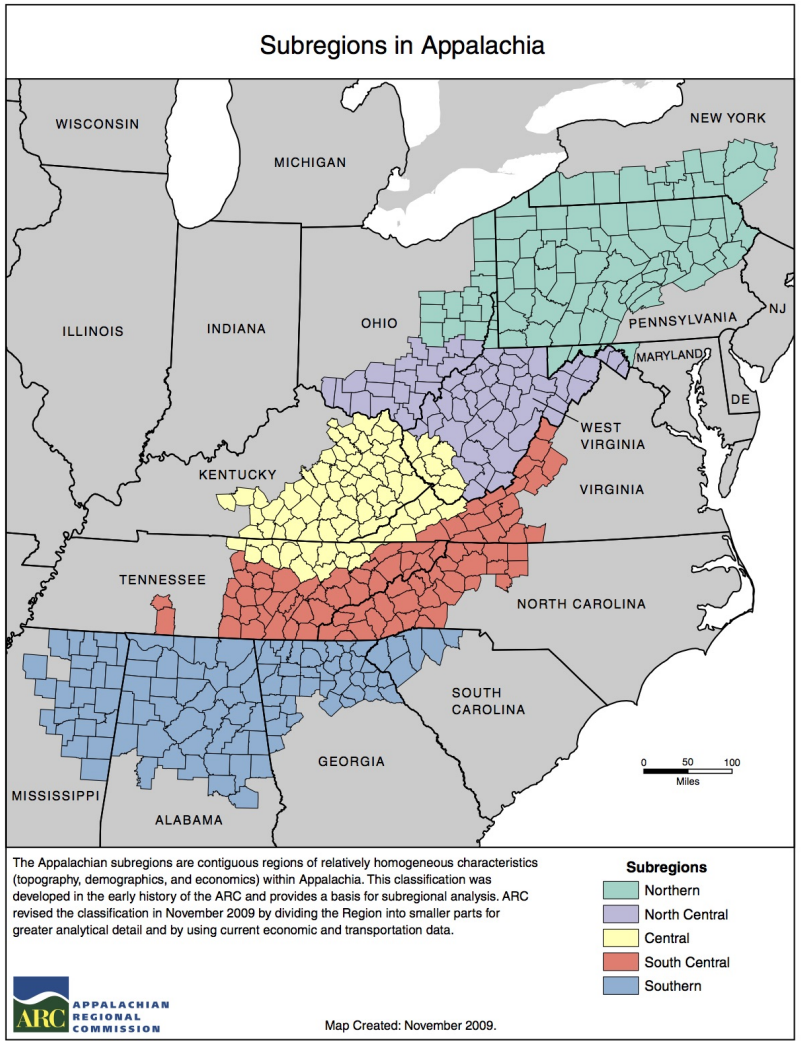
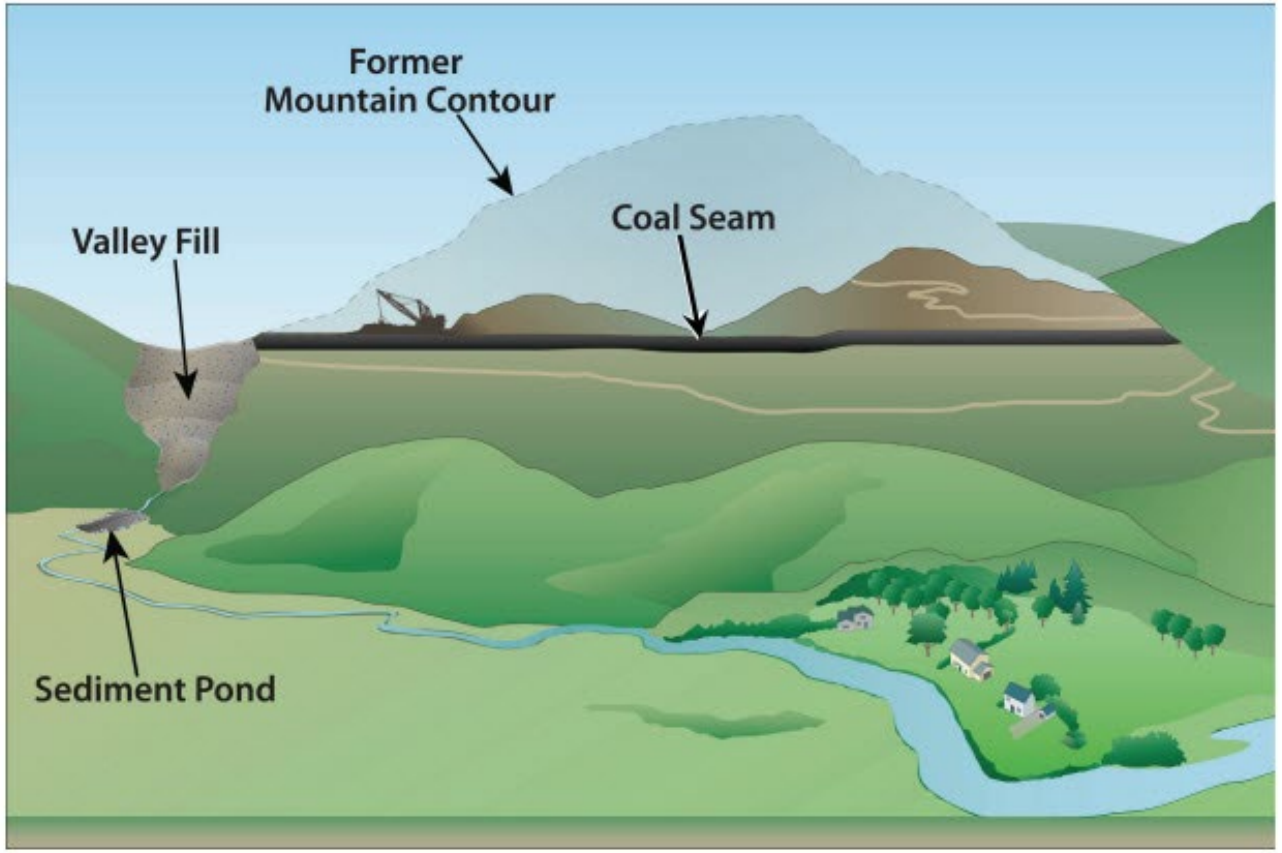
Surface Coal Mining in Applachia

- The Appalachian region is a leading producer of coal in the United States.
- Major areas of operation include eastern Kentucky, southern West Virginia, and western Virginia
- Surface mining involves:
  - removing parts or all of mountaintops to expose buried seams of coal
  - disposing excess overburden and interburden rocks in adjacent valleys



Surface Mining Impacts

- According to a 2011 EPA report, surface mining leads to:
  - Springs and perennial streams being lost permanently
  - Concentrations of major chemical ions downstream
  - Degraded water quality which can become lethal to organisms
- Surface coal mining has contributed to the destruction of over 500 mountain tops in Appalachia



Source: epa.gov

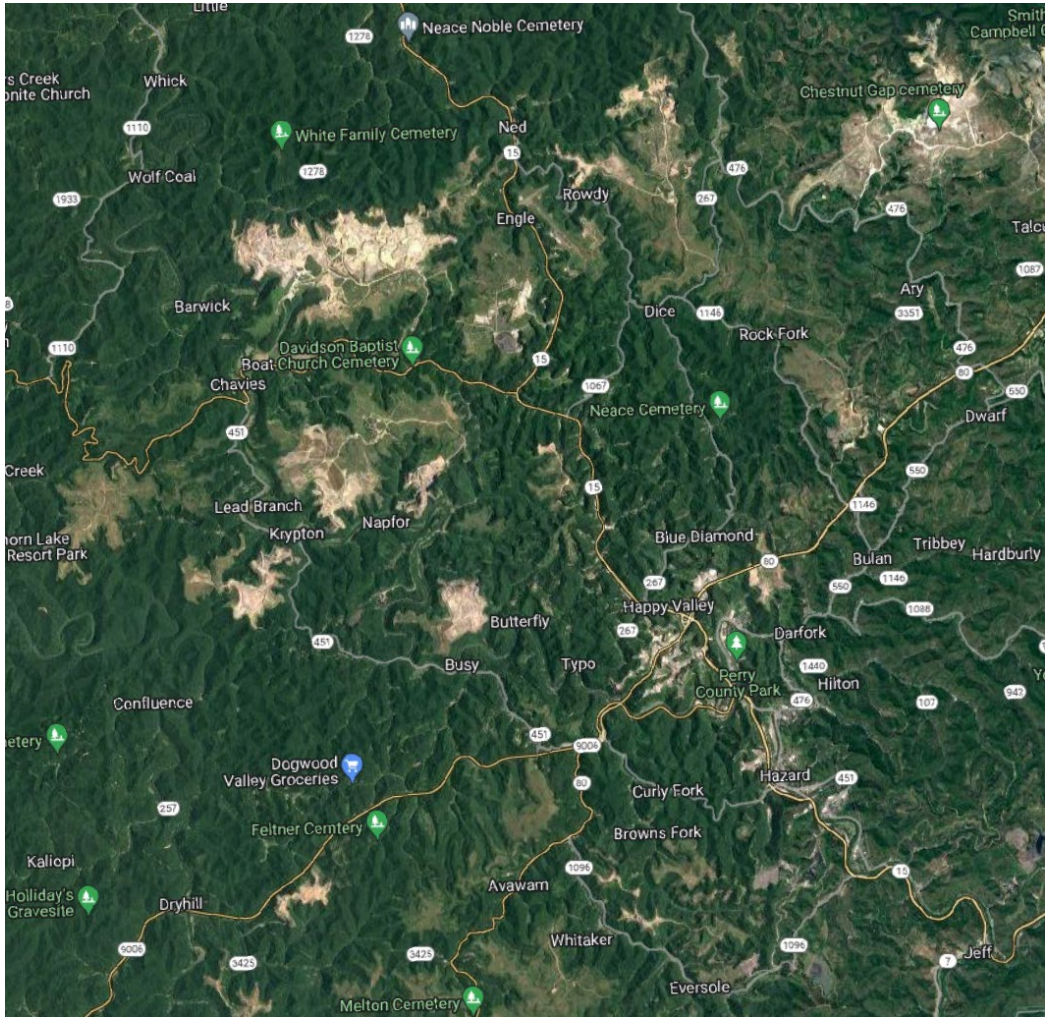
2022 Kentucky Flooding

- In July 2022, a large flood event occurred in eastern Kentucky
- An estimated 14-16 inches (35.6-40.6 cm) of rain fell in a 5-day period
- Almost 9,000 homes in 13 counties were damaged or destroyed
- Over 40 people were killed

Leandro Lozada/AFP via Getty Images
https://www.npr.org/2022/07/30/1114706847/kentucky-flood-deaths

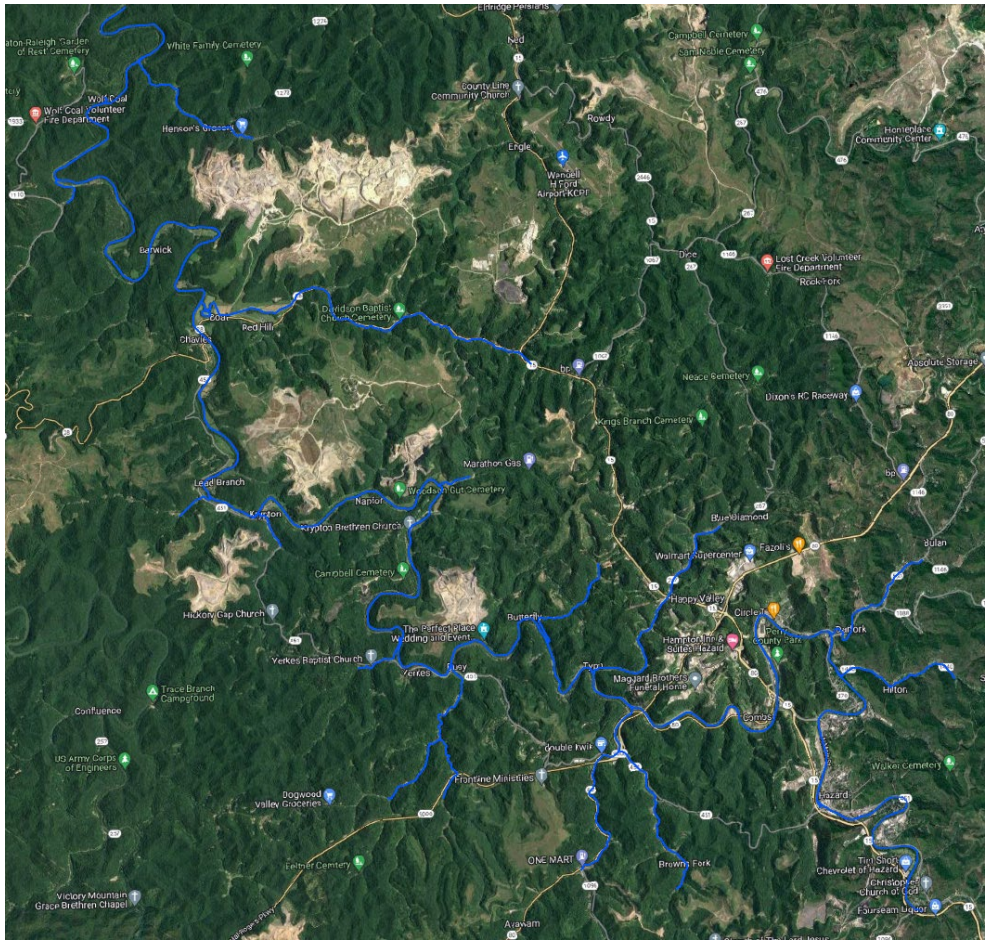
Investigation Area

- The area is approximately 23 km by 24 km
- Large areas of mines are present, which were created by the removal of forests and mountaintops
- The North Fork of the Kentucky River flows through this area



North Fork of the Kentucky River

- The North Fork of the Kentucky River has been highlighted in blue
- Mining has disrupted portions of the mountainous forests around the river
- This river has been known to consistently flood, such as the major one in 2022



Present Terrain DEM

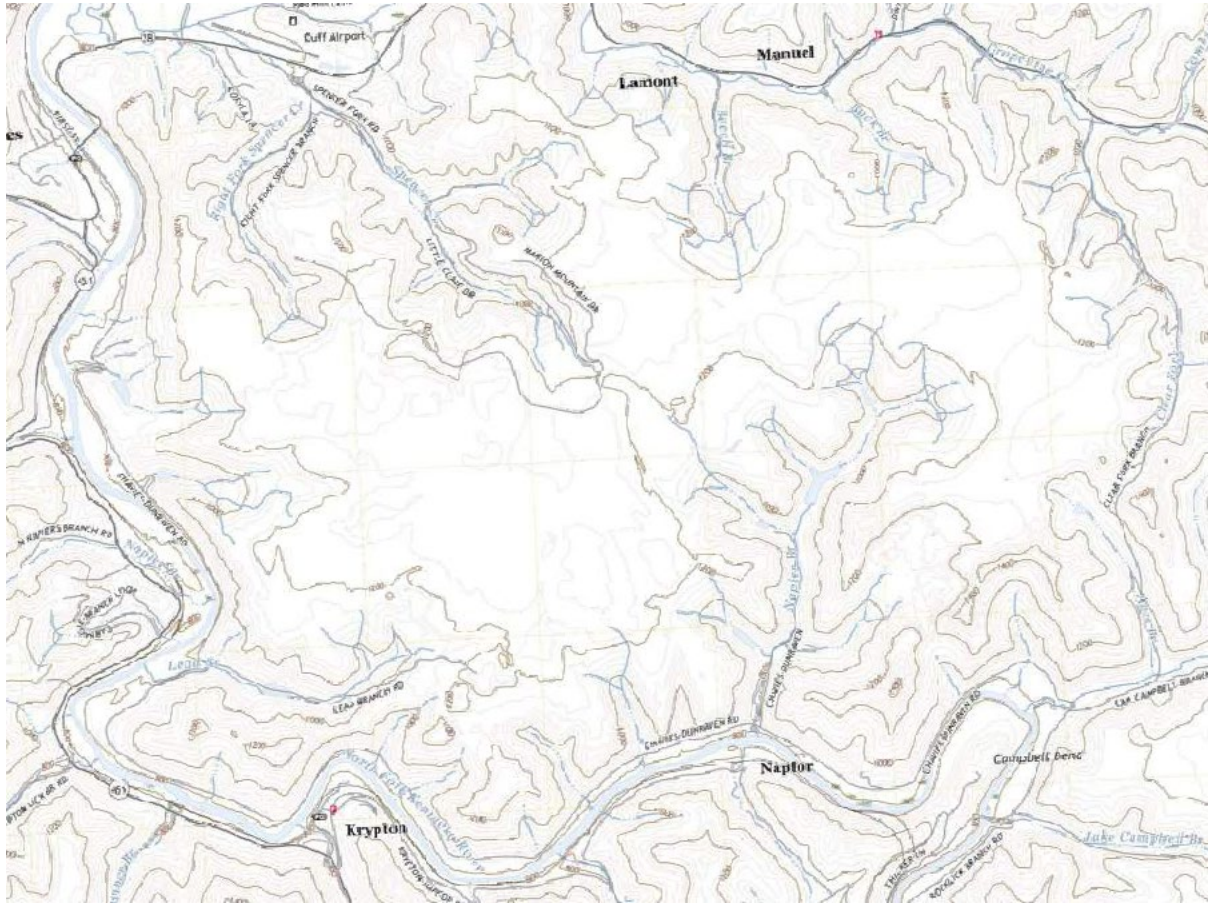
- The state of Kentucky has an Elevation Data and Aerial Photography Program (https://kyfromabove.ky.gov/)
- 5-foot (1.5 m) resolution DEMs are available for the entire state collected between 2010 and 2017
- Updated DEMs from Phase 2 should be available later this year

Historical Topography

- USGS (United States Geological Survey) has historical topographic maps available
- While historical DEMs were not readily available, these maps can be used to adjust the present DEMs
- A portion of a map from 1972 is shown on the right

Historical Topography

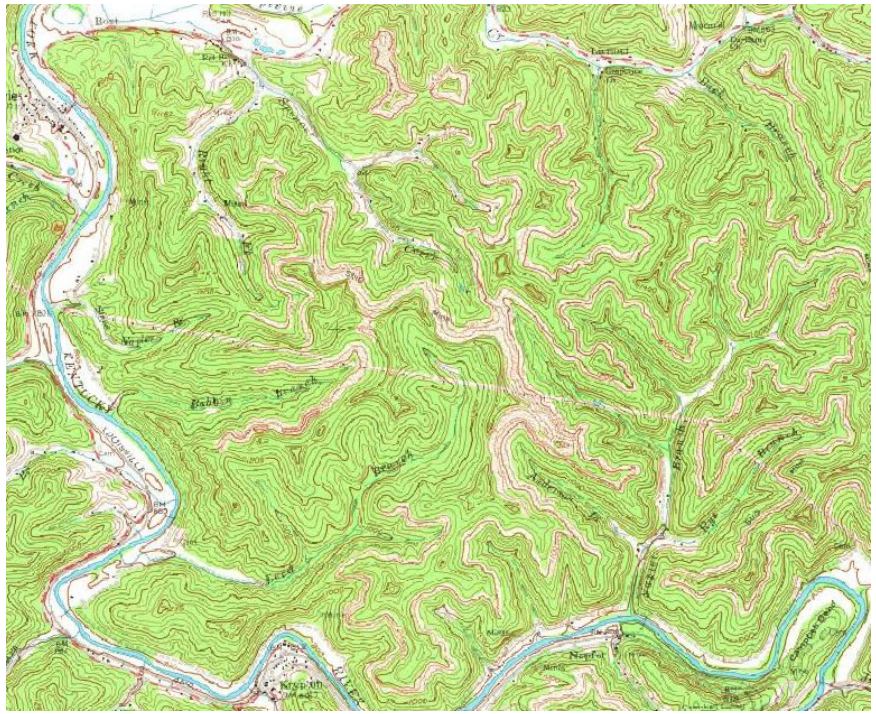
Topographic map from 1972



Topographic map from 2022

Historical Topography Digitization

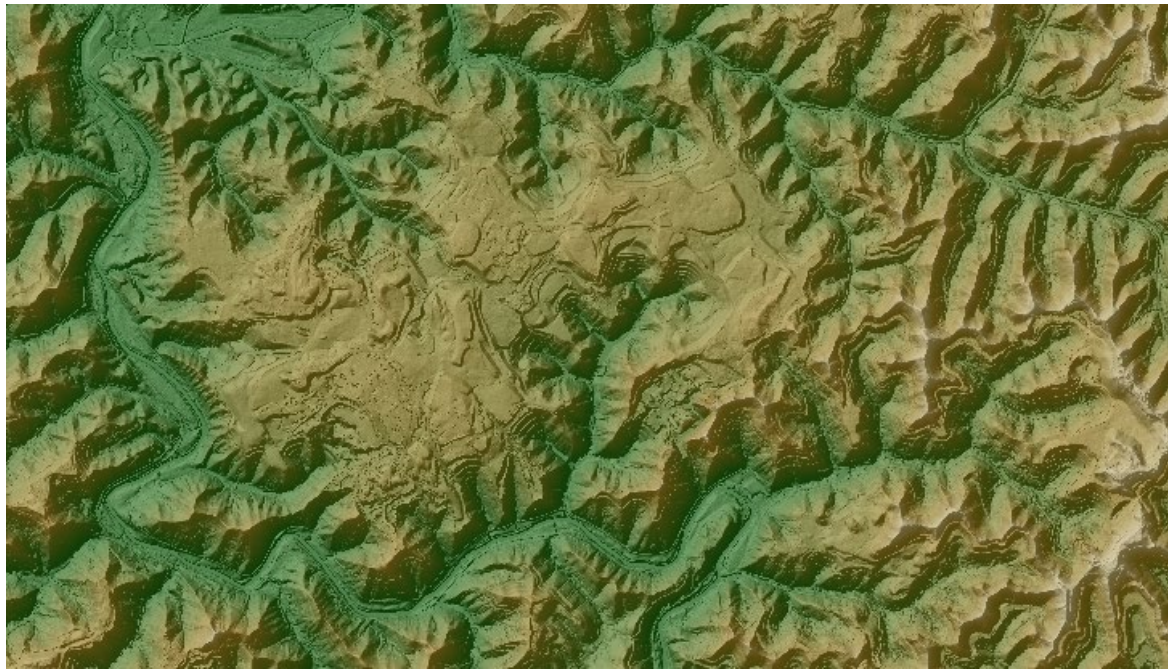
- Using QGIS, the topographic map contours were converted into shapefiles
- From this, DEMs were created to reflect the previous mountaintops



Topographic map

Contour shapefiles created

Mining Terrain

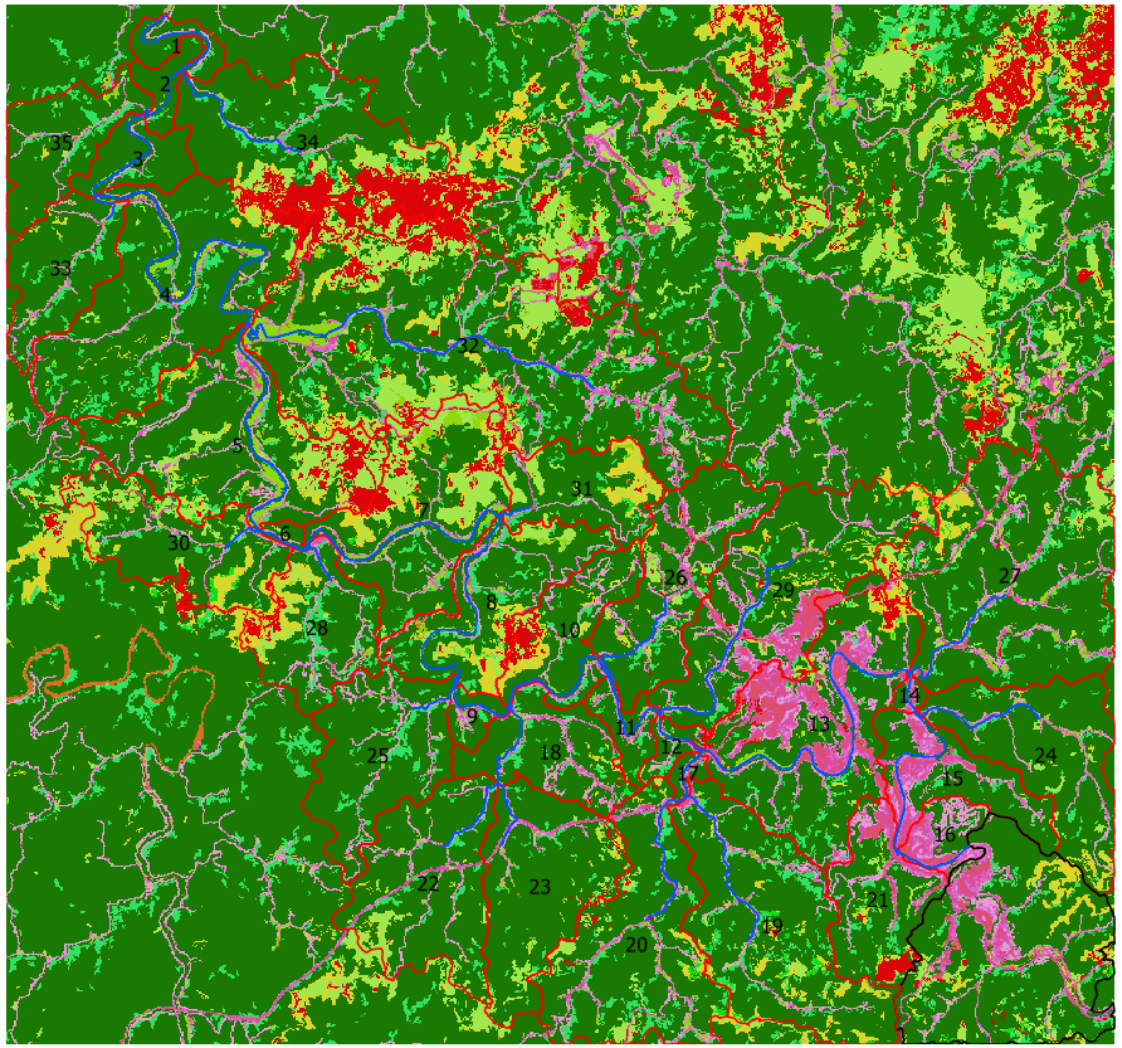


Present day terrain of a mined area from the Kentucky database

Terrain recreated from topographic maps of the area before mountaintop removal and mining

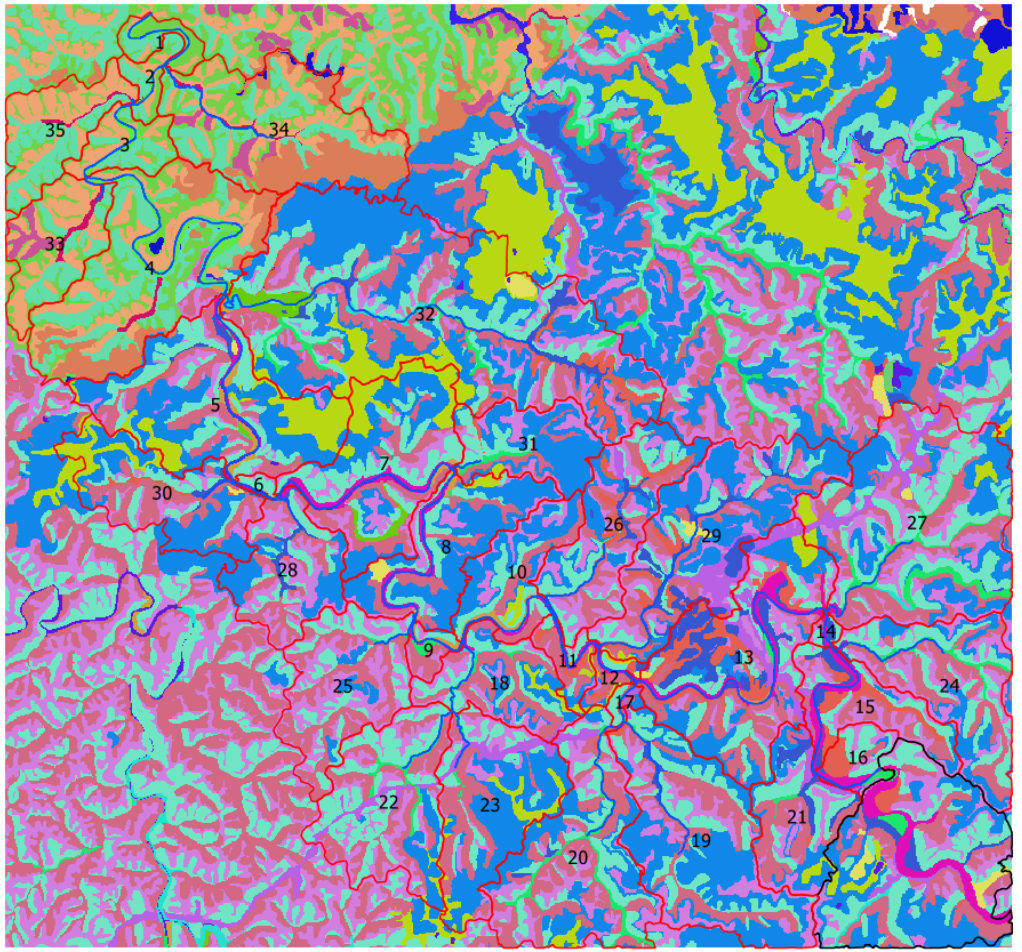
Landuse Data

- The landuse data was taken from the 2021 National Land Cover Database (NLCD)
- The map for the test area is shown. The dark green represents forested areas, which is large portion
- Portions of the mined areas show some reclamation attempts have already begun to restore vegetation



Soil Data

- The soil data was acquired from the Soil Survey Geographic Database (SSURGO)
- Specific soils seem more prevalent in mined areas
  - These soils have increased clay content along with reduced water holding capacity compared to surrounding areas



Streamflow and Weather Data

- Multiple USGS Streamflow monitoring stations exist along the North Fork of the Kentucky river
- A station located at Hazard, Kentucky is located just upstream of the area of interest
- An additional station is located downstream in Jackson, Kentucky

Streamflow monitoring station at Hazard, KY
Source: https://waterdata.usgs.gov/

Simulations Performed

- The SWAT simulations used a 21 year time frame with the first 5 years used for model warmup
- Several simulations were performed using identical weather and streamflow station inputs:

1. Premining terrain with forest land cover returned to the mountains
2. Current terrain, with mountaintops removed due to mining, with bare rock/mine land cover
3. Current terrain with land cover and soil changed to reflect reclamation of the land

Simulation Results

- Pre-mined terrain with unchanged landcover resulted in a negligible difference in surface runoff compared to mines
- Pre-mined terrain with forests returned to the mountains resulted in a 29.6% decrease of runoff compared to mines
- Reclamation by converting mined areas back to forests resulted in an 8.2% decrease of runoff compared to mines
- Reclamation by converting mined areas to grassland showed minimal changes to surface runoff
- Despite some large differences in surface runoff, downstream flow values experienced minimal changes

Conclusions

- If the pre-mined terrain resembled the surface cover of the mined land, minimal change to runoff would be seen. However, this is not the case
- The removal of forested mountaintops for mining has caused a large increase in surface runoff
- Reclaiming the mine land with vegetation, particularly forests, can reduce the surface runoff, but not nearly to the level before mining
- Additional simulations for flood inundation will need to be performed to quantify the impacts during flash flood events

Future Work

- To investigate the impacts for sudden flash flood events, HEC-RAS (Hydrologic Engineering Center's River Analysis System) will be used to simulate flood inundation
- The area of the SWAT simulations can be expanded to include the next USGS flow station in Jackson, KY
- Additional mined areas can be included for more complete coverage