The following was presented at DMT'11
(May 22-25, 2011).

The contents are provisional and will be
superseded by a paper in the
DMT'11 Proceedings.

See also earlier Proceedings (1997-2010)
http://ngmdb.usgs.gov/info/dmt/

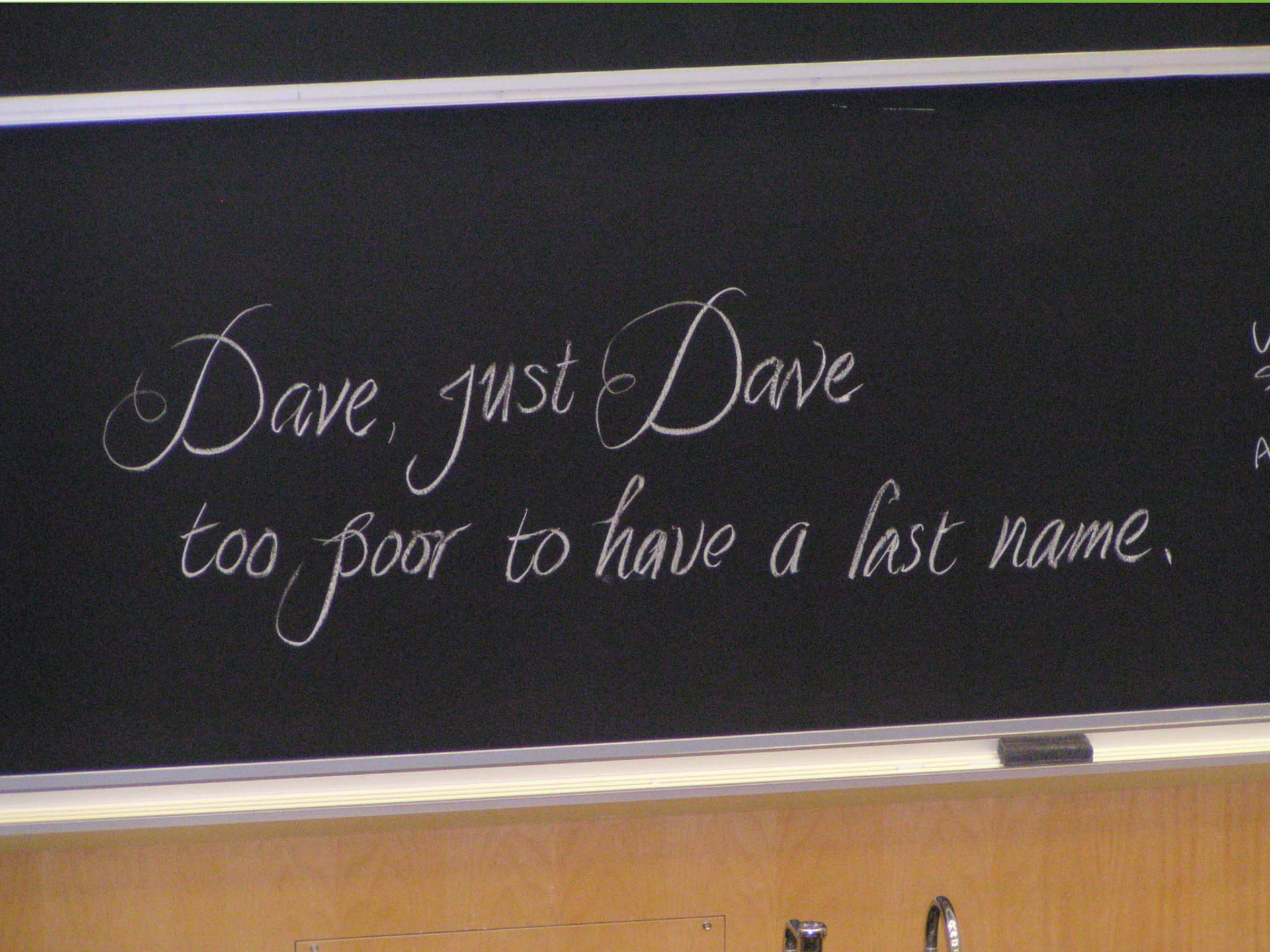
Mapping with Lidar Based DEMs – a Geologist's New Tool

Thomas G. Whitfield, P.G.

Pennsylvania Geological Survey

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

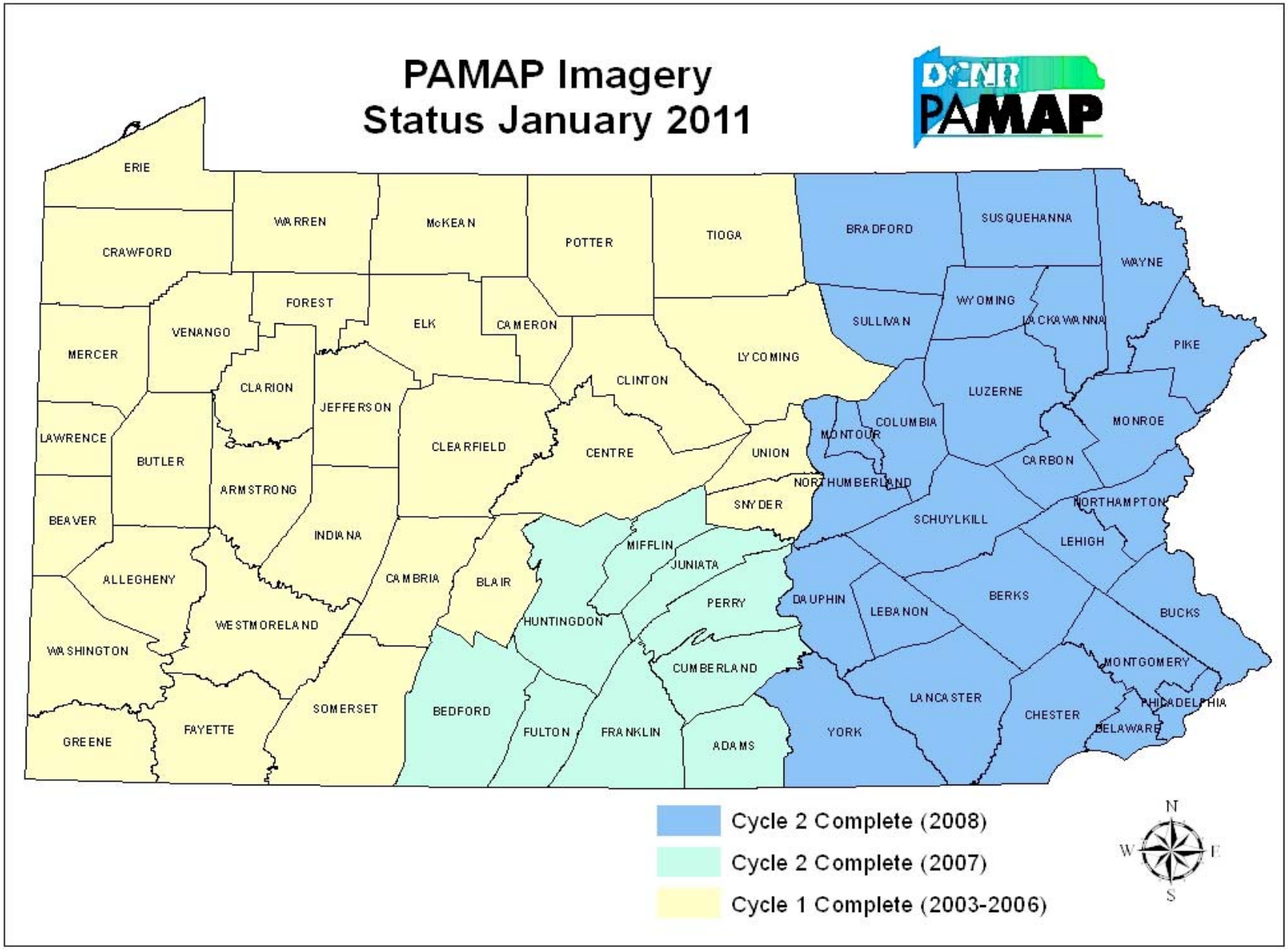

Dave, just Dave
too poor to have a last name.

PAMAP lidar program review

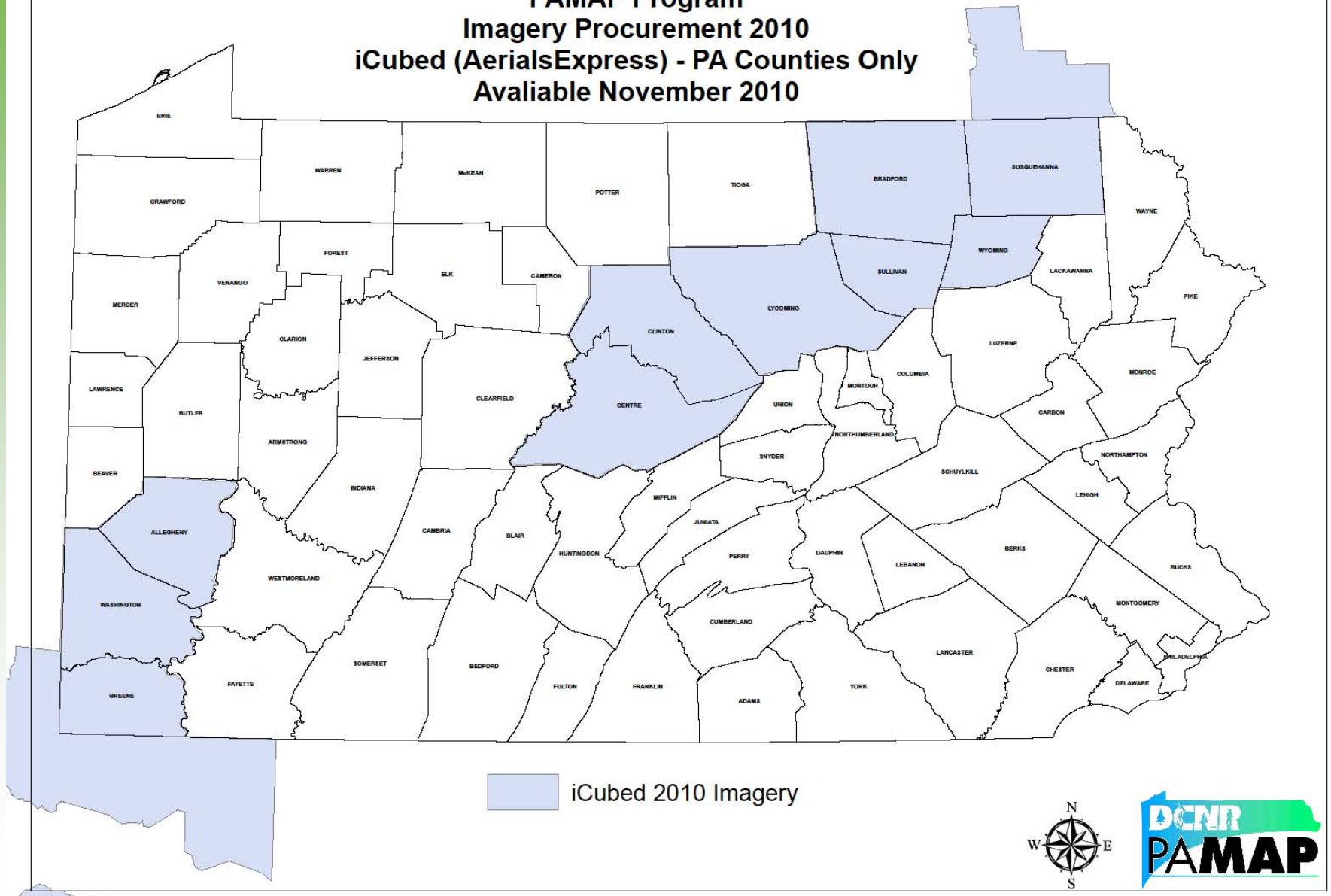
- Statewide program
- Generates a very detailed DEM (digital elevation model)
- 10,000-foot grid tile for whole state
- Flown in conjunction with high-resolution full color aerial imagery (1-foot pixels)

www.dcnr.state.pa.us/topogeo

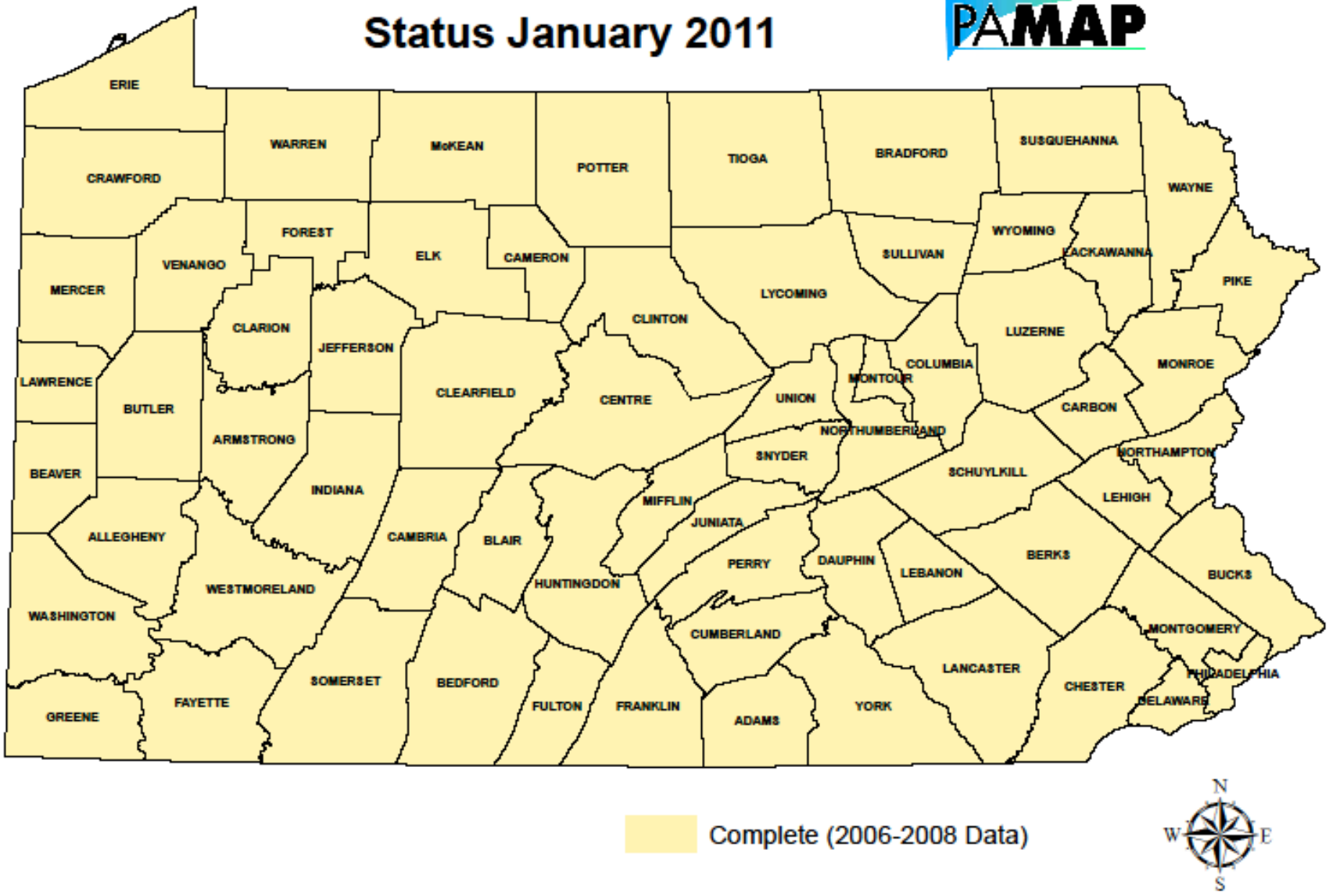
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES


PAMAP Imagery
Status January 2011
DCNR
PAMAP
ERIE
WARREN
McKEAN
POTTER
TIOGA
BRADFORD
SUSQUEHANNA
WAYNE
CRAWFORD
FOREST
ELK
CAMERON
VENANGO
MERCER
CLARION
JEFFERSON
CLINTON
LYCOMING
SULLIVAN
WYOMING
LACKAWANNA
PIKE
LUZERNE
MONROE
COLUMBIA
MONTOUR
LAWRENCE
BUTLER
ARMSTRONG
CLEARFIELD
CENTRE
UNION
CARBON
NORTHUMBERLAND
SNYDER
NORTHAMPTON
SCHUYLKILL
BEAVER
INDIANA
MIFFLIN
LEHIGH
JUNIATA
ALLEGHENY
CAMBRIA
BLAIR
PERRY
DAUPHIN
LEBANON
BERKS
BUCKS
WESTMORELAND
HUNTINGDON
WASHINGTON
CUMBERLAND
MONTGOMERY
LANCASTER
SOMERSET
BEDFORD
CHESTER
PHILADELPHIA
FAYETTE
FULTON
FRANKLIN
YORK
DELAWARE
GREENE
ADAMS
Cycle 2 Complete (2008)
Cycle 2 Complete (2007)
Cycle 1 Complete (2003-2006)
N
W
E
S

PAMAP Program
Imagery Procurement 2010
iCubed (AerialsExpress) - PA Counties Only
Avaliable November 2010



PAMAP Lidar
Status January 2011



PAMAP lidar program review

- Aerial imagery and lidar flown between 2004 – 2008 covers the entire state
- Freely downloadable form Pennsylvania Spatial Data Access (PASDA) website

  http://www.pasda.psu.edu

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Lidar review

- One year of processing and filtering
- Multiple derivative products
- Lots of uses
- “Bare earth” or “last returns” model
- Our lidar derived DEM is a 32-bit, floating point GRID with 3.2-foot pixel resolution
- Pretty sophisticated stuff

Put our Pinto...

under your tree.

A happy gift your whole family will enjoy all year long. Our new '73 Ford Pinto Wagon packs lots of luxury and comfort. It's perfect for those extra holiday trips... or just cruising the country.

Fold down the rear seat and you have over 60 cubic feet of space (wouldn't Santa like to have that much room in his sleigh?).

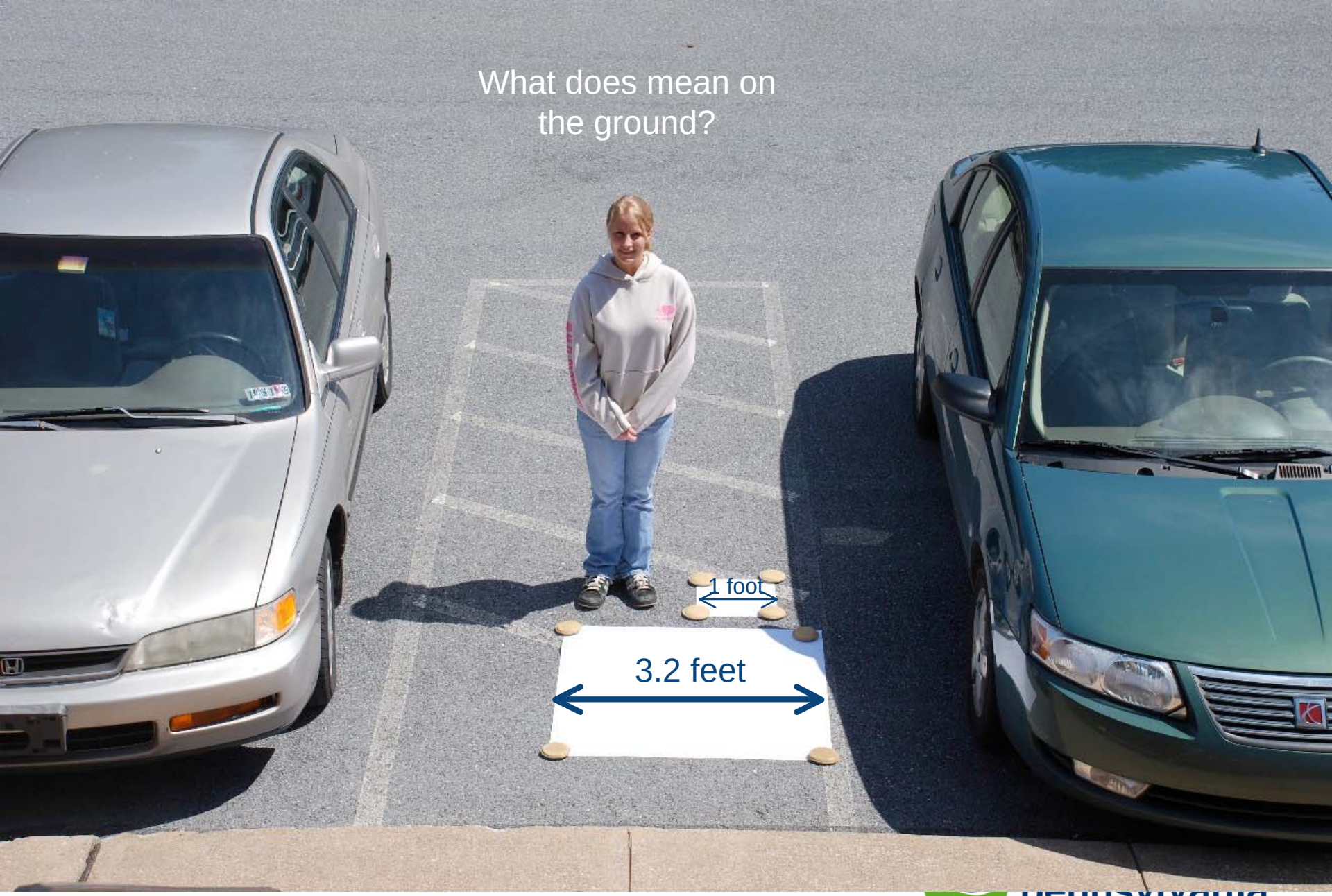
Pinto Wagon, shown above, has the deluxe Squire option that includes: rich woodgrain paneling on body-sides and lift gate, super-soft vinyl seats, deluxe wheel covers, cut pile carpeting. Spunky 2,000-cc engine and manual front disc brakes are standard.

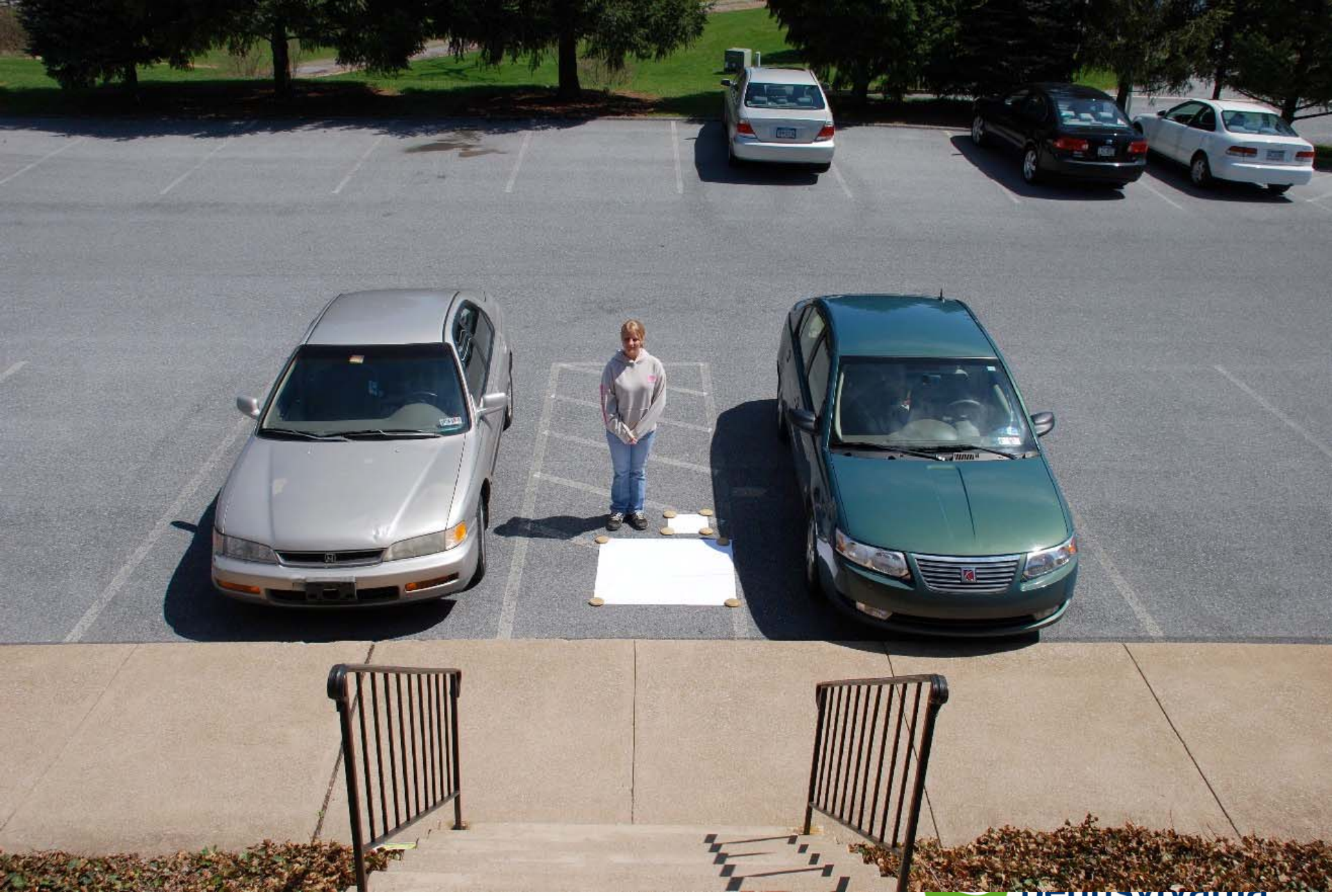
This Christmas wrap a red ribbon around our Pinto ... and have a happy.

Your FORD Team

"WE WANT TO MAKE YOU HAPPY"

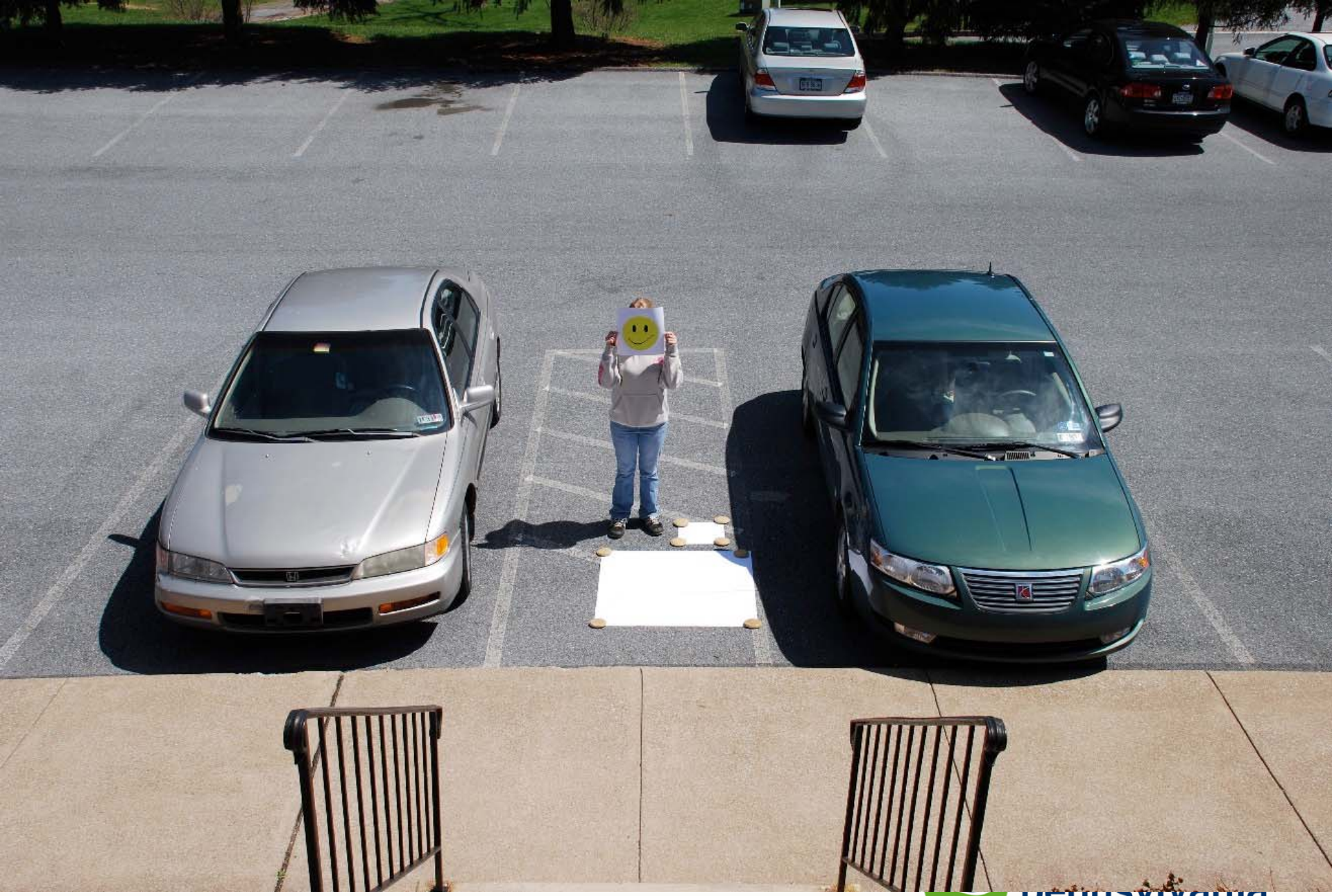
69


What does mean on
the ground?
1 foot
3.2 feet



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES


Those of you in a witness
protection program are safe.
1 foot

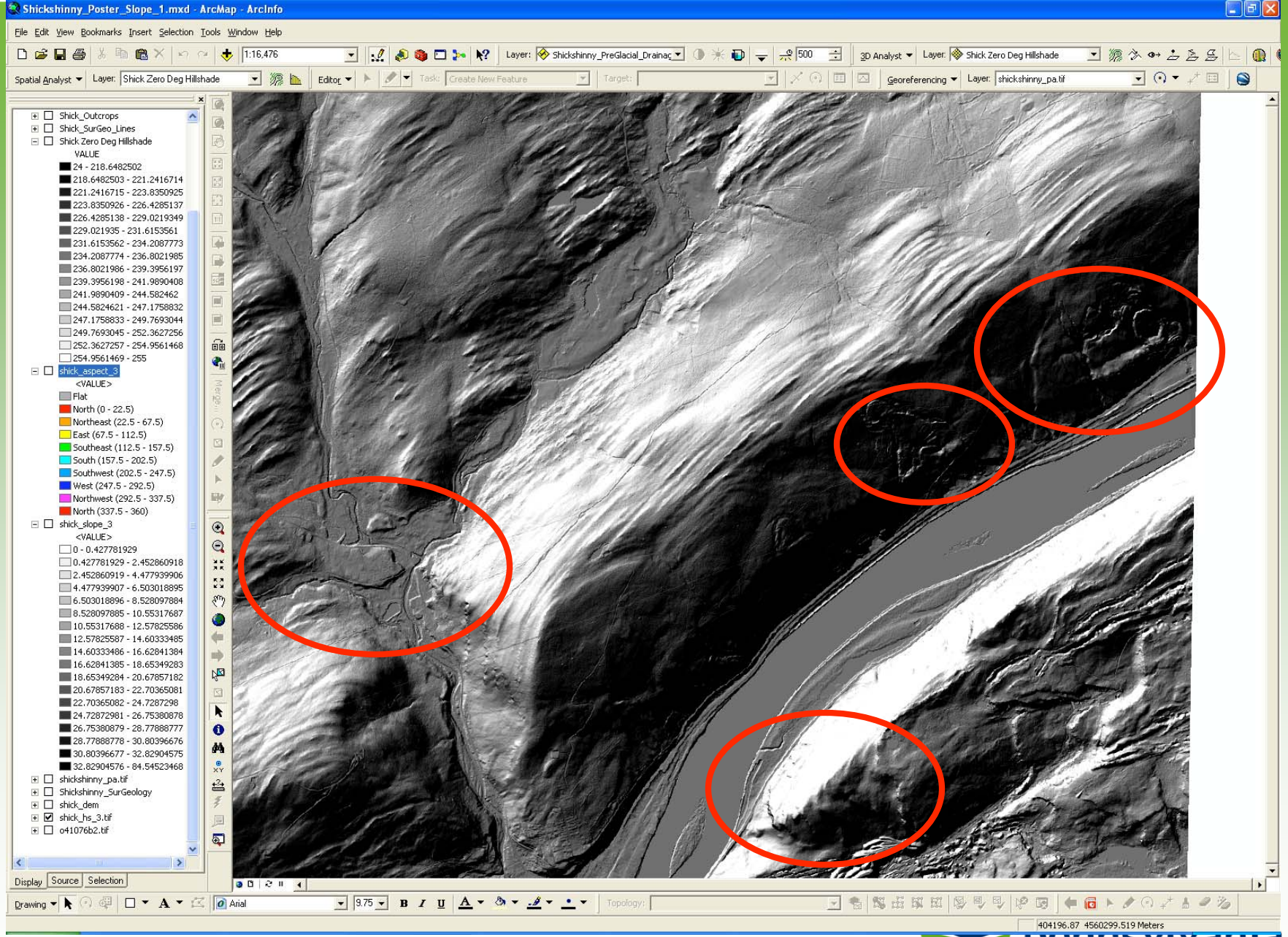
Two most used derivatives

- Hillshade model – pseudo solar illumination based on based on sun angle of 45° and never occurring sun azimuth of 315° (NW)
- Slope – the rate of maximum change in z-value from cell to cell.
- Slope-shape is a display schema of a slope raster

Technical page

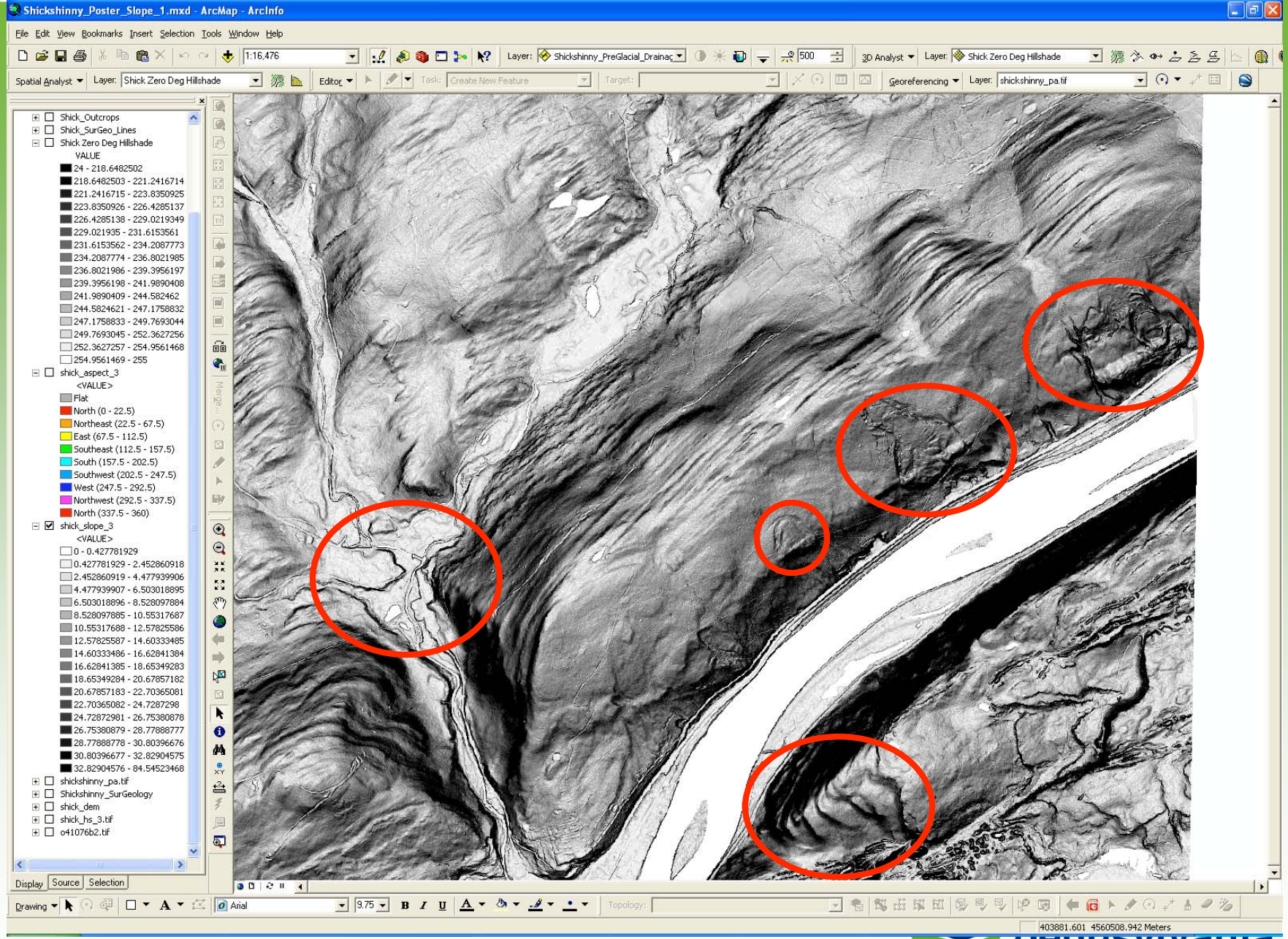
- Hillshade = 255.0 * ((cos(Zenith_rad) * cos(Slope_rad)) + (sin(Zenith_rad) * sin(Slope_rad) * cos(Azimuth_rad - Aspect_rad)))

- slope_degrees = ATAN (√ ([dz/dx]2 + [dz/dy]2)) * 57.29578



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

The slope caveat page…..

- We do not have “sun and shadow” effects
- We lose the sense of “up and down”
- Without visual clues – sometimes cannot tell high points from low points

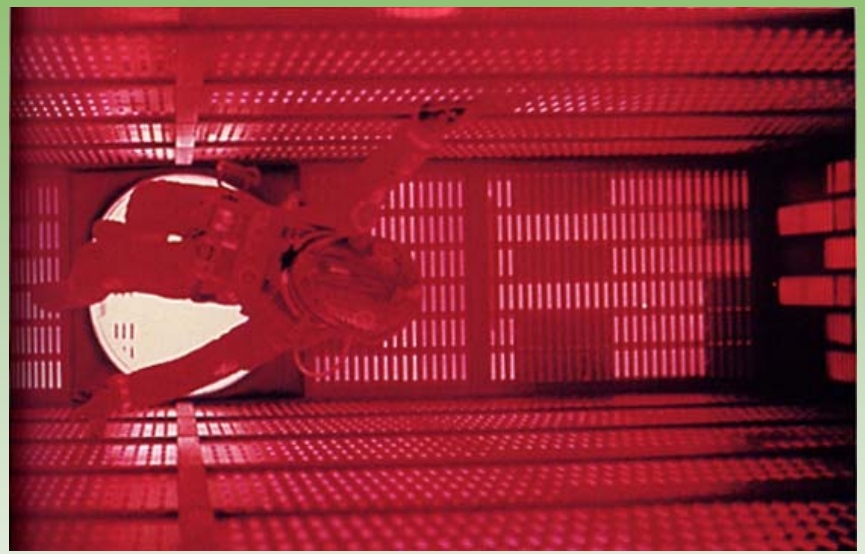
- We are looking strictly at slope angle

www.dcnr.state

nnsylvania
RTMENT OF CONSERVATION
NATURAL RESOURCES

Slope-shape – “How to’s”

- Ain’t rocket science
- Easy to create
- Easy to display – most important part
- Easy to interpret
- One grid to track
- No right way, no wrong way, but there is always the…..



www.dcnr.state.pa.us/topogeo

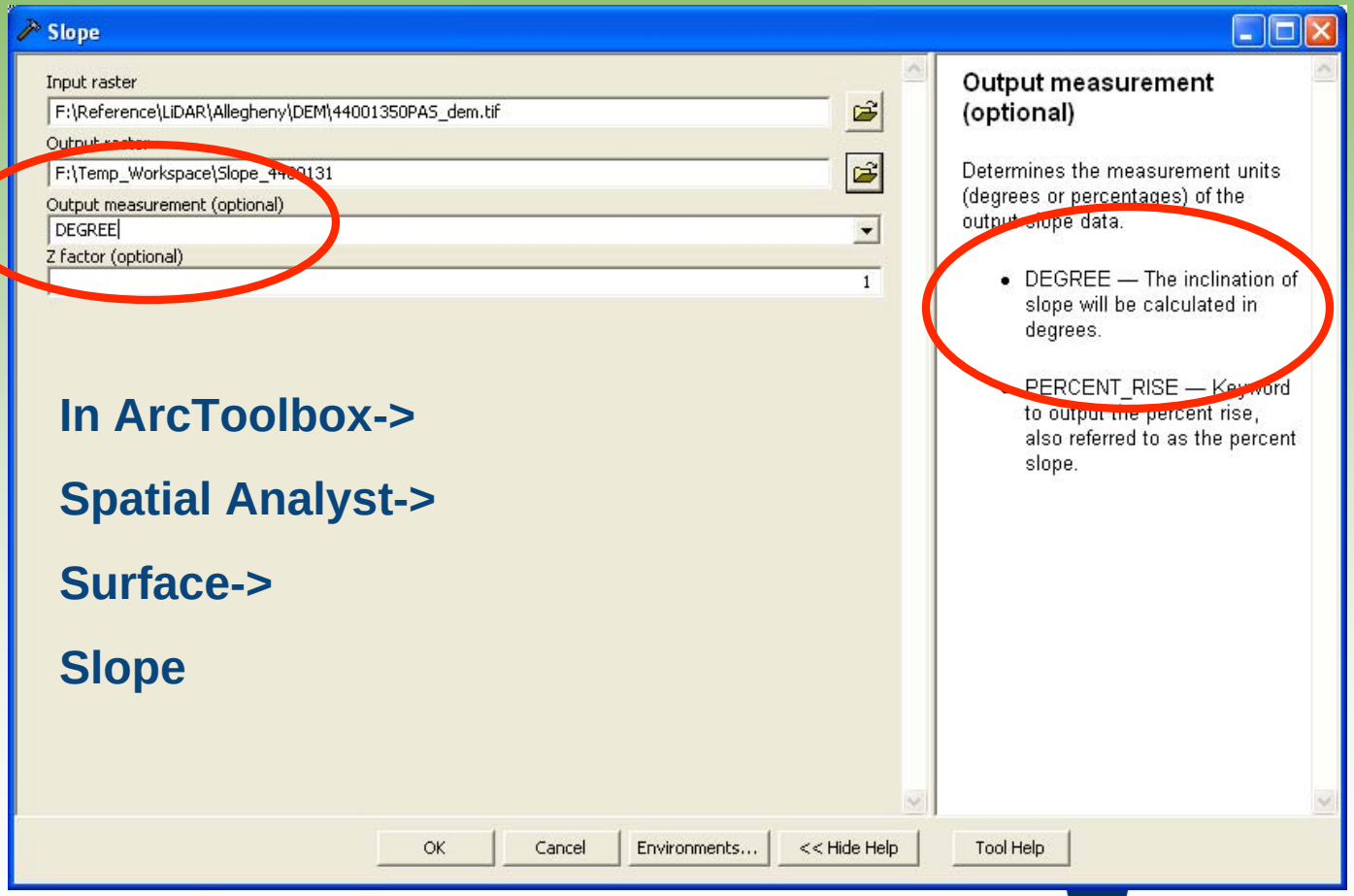
pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES


GOV'T WAY

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Create a slope grid



In ArcToolbox->

Spatial Analyst->

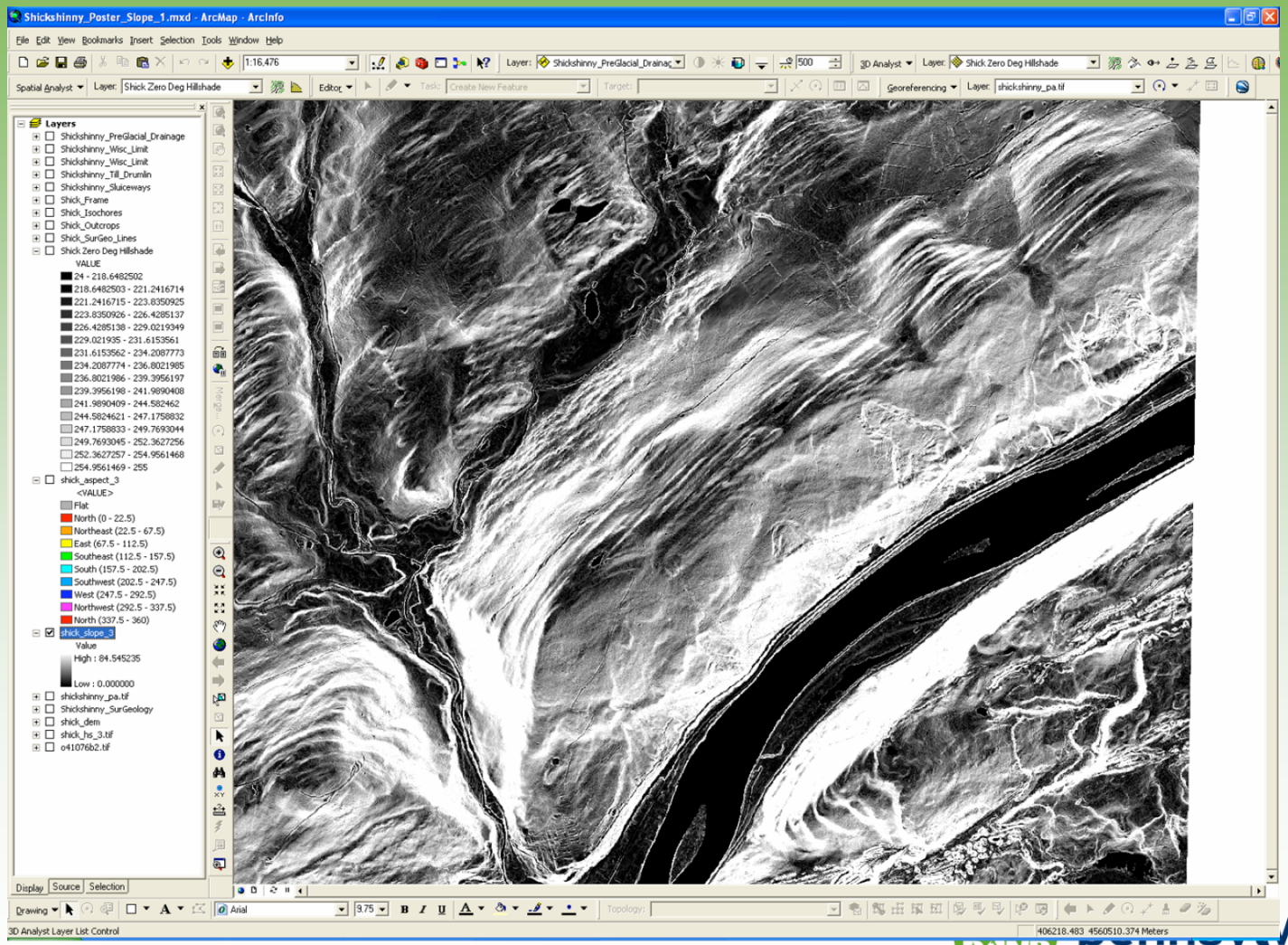
Surface->

Slope

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

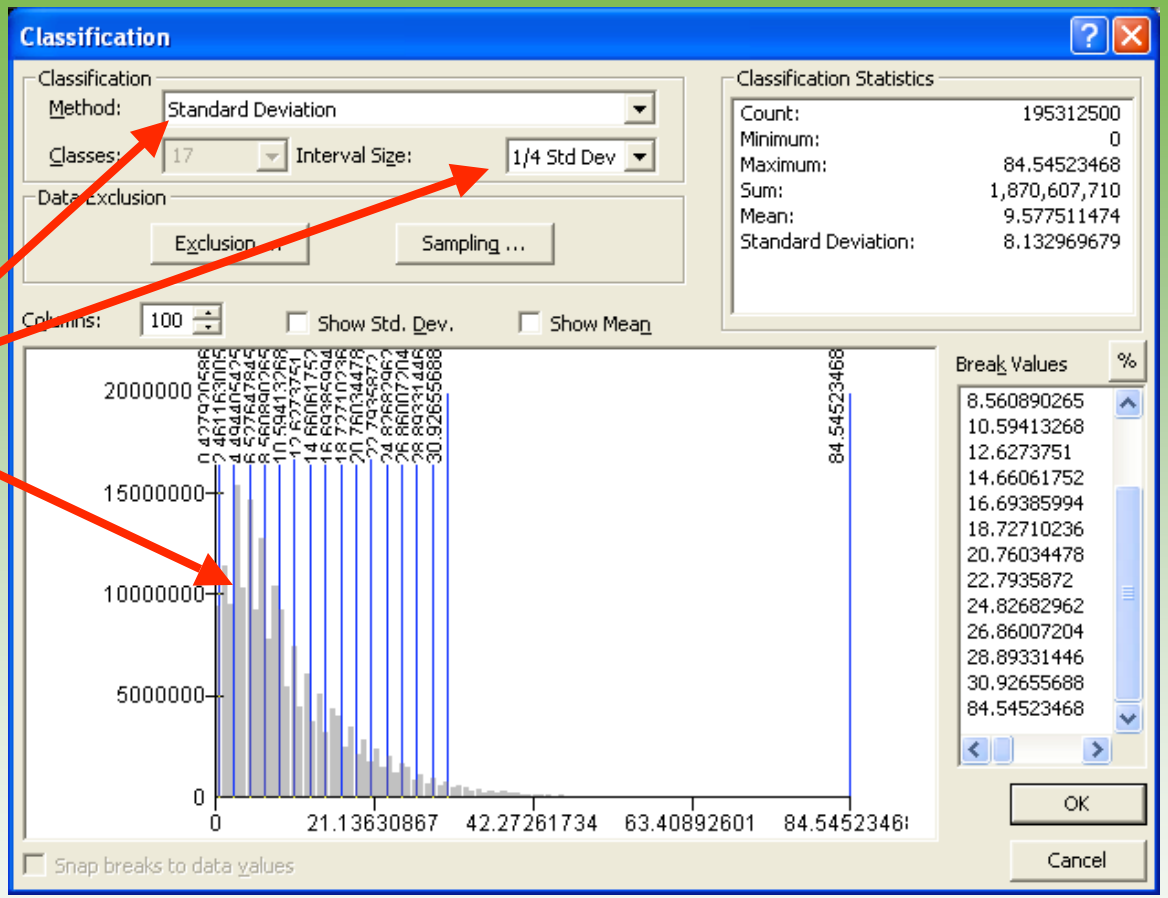
Not a pretty result – but that's okay



www.dcnr.state.pa.us/topogeo

DCNR Pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

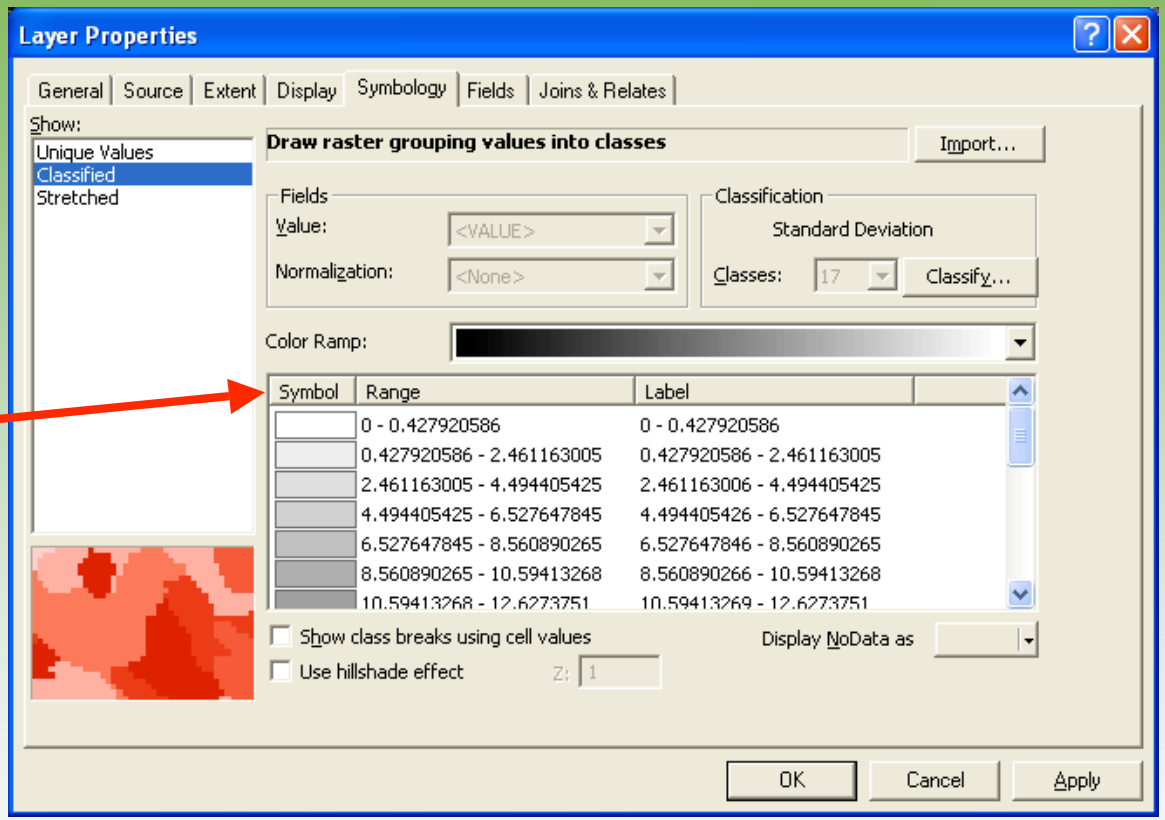
A standard deviation and 1/4 interval size gives a nice spread over the bell curve



www.dcnr.state.pa.us/topogeo

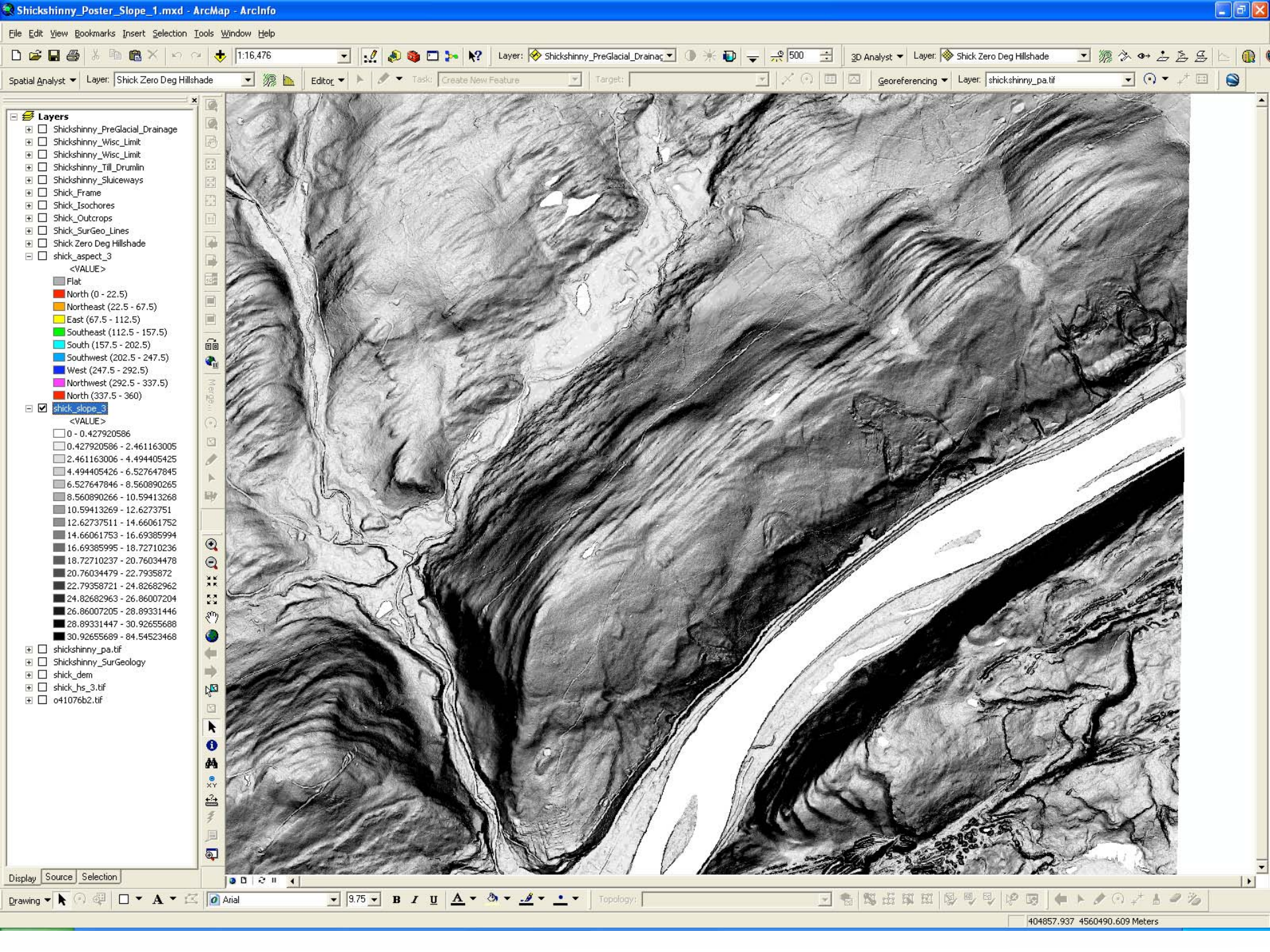
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

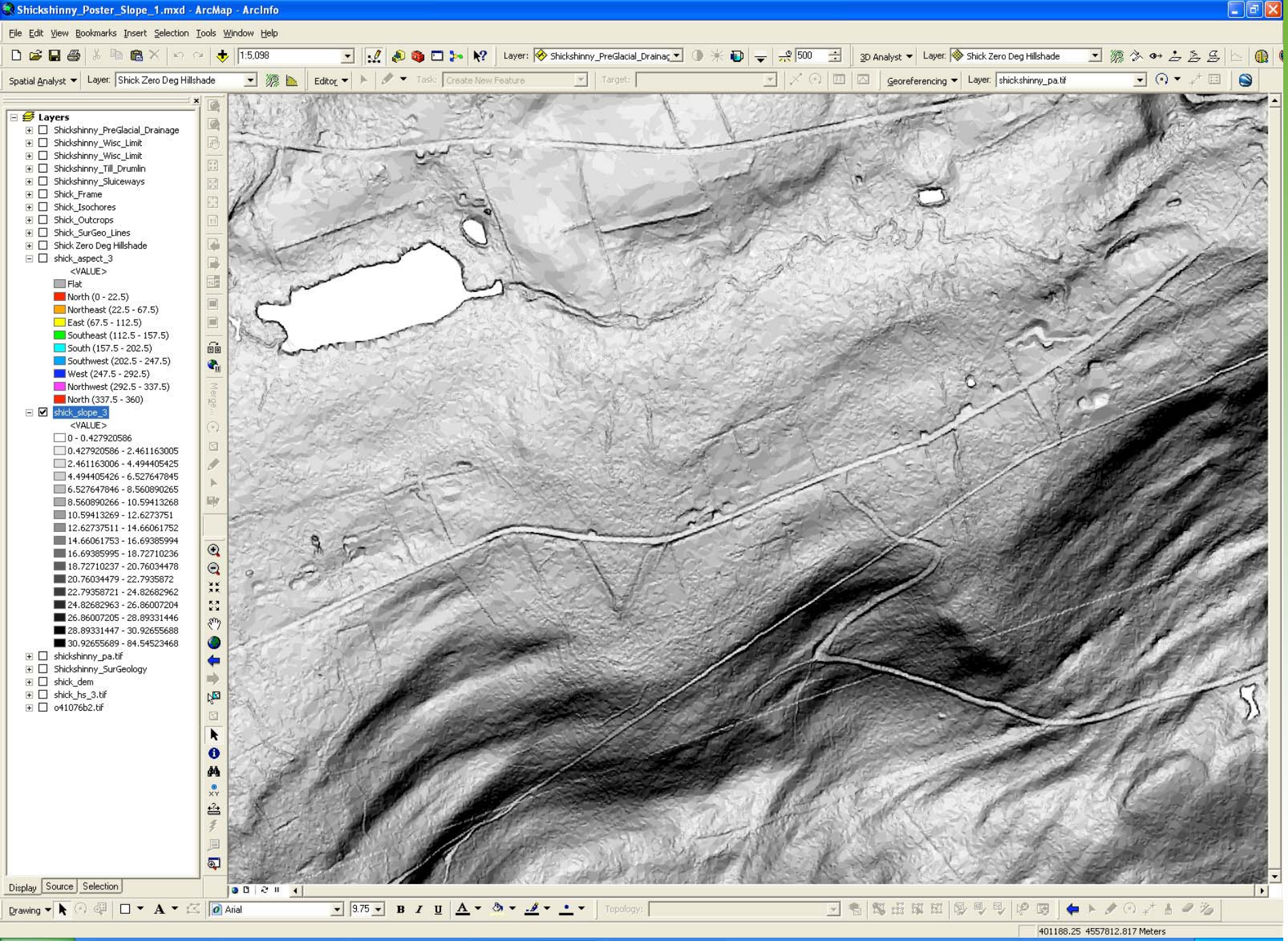
If necessary, push the symbol button and invert the color ramp so white is flat and low angles progress in gray

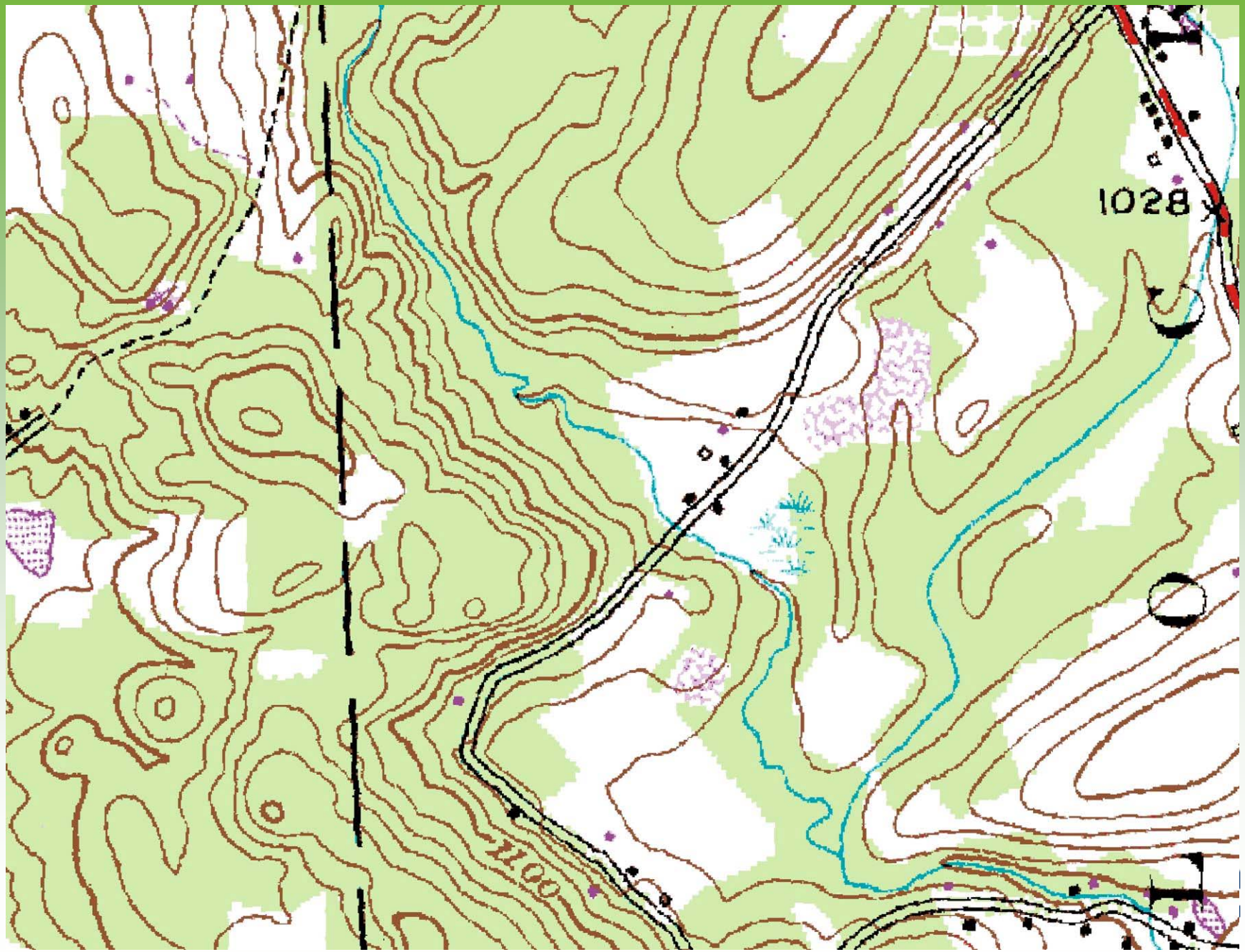


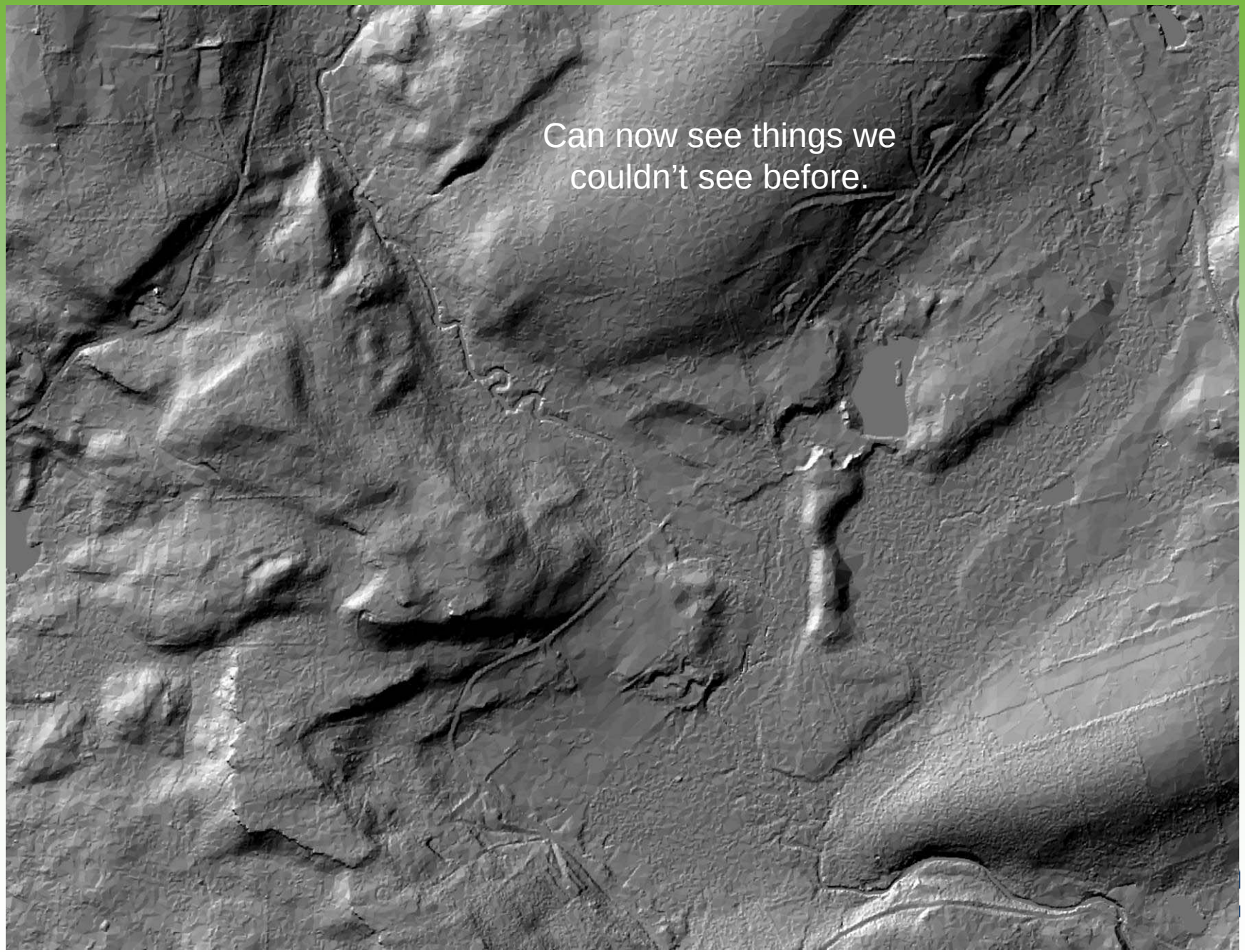
www.dcnr.state.pa.us/topogeo

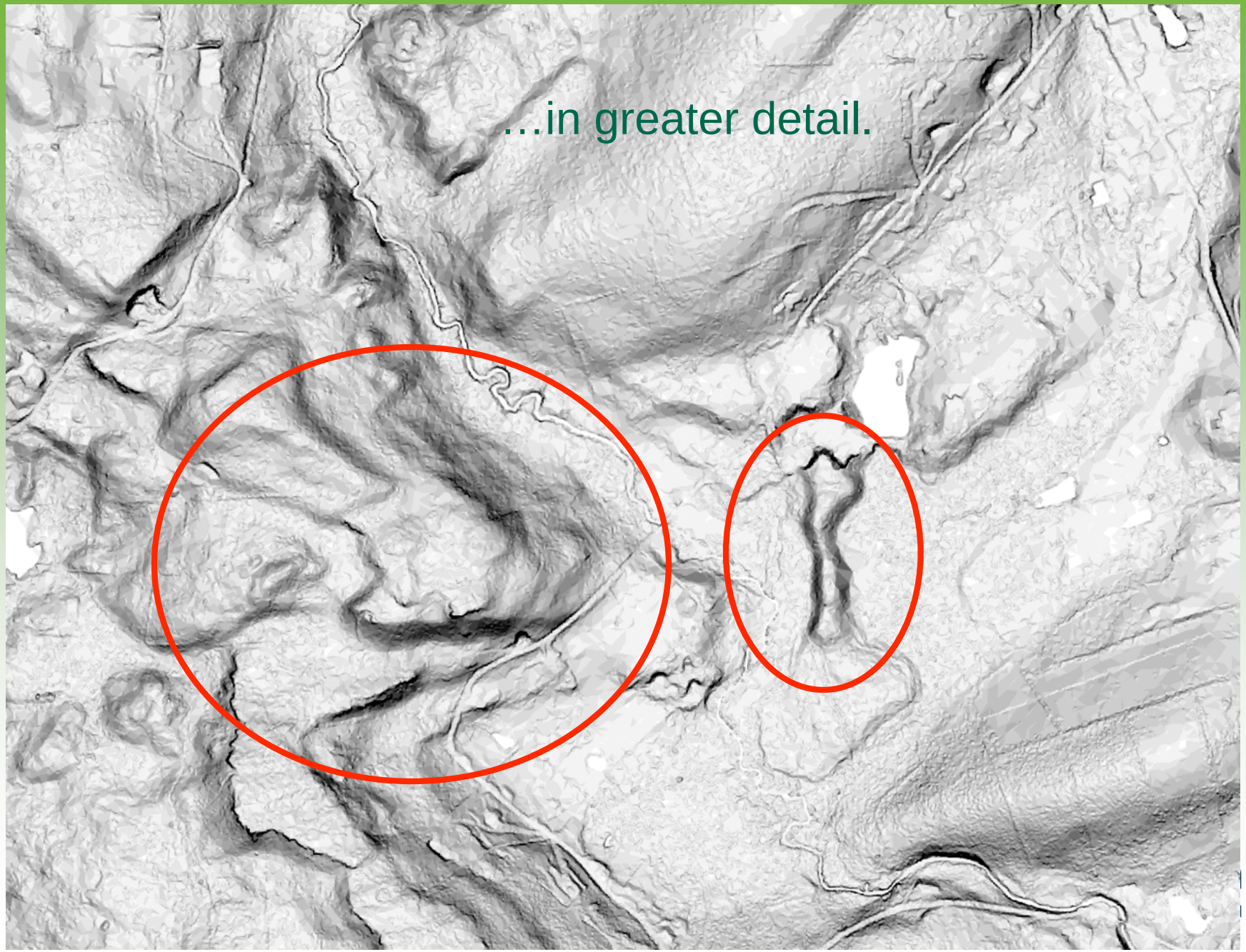
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

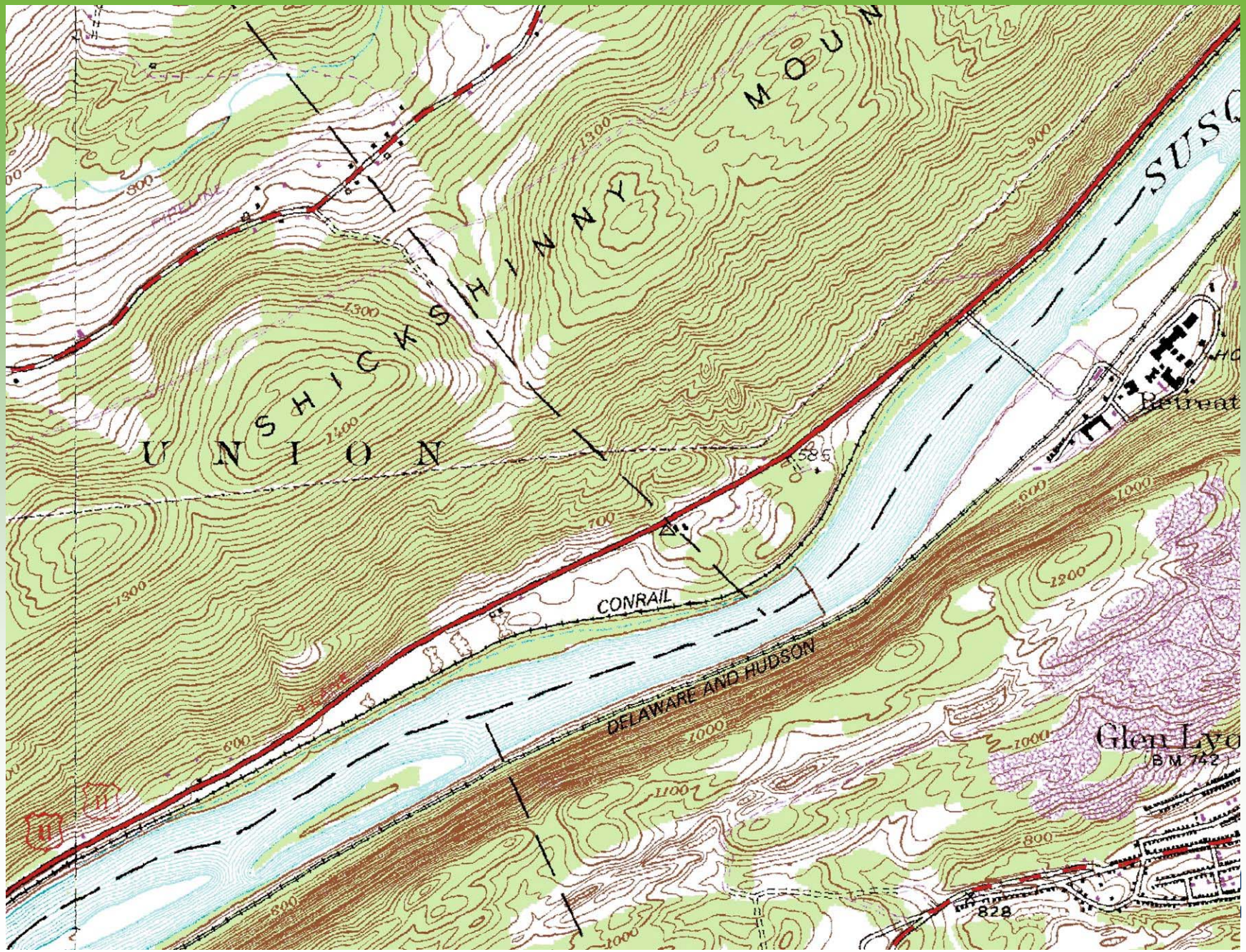

Shickshinny_Poster_Slope_1.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help
1:16,476
Layer: Shickshinny_PreGlacial_Drainac
500
3D Analyst
Layer: Shick Zero Deg Hillshade
Spatial Analyst
Layer: Shick Zero Deg Hillshade
Editor
Task: Create New Feature
Target:
Georeferencing
Layer: shickshinny_pa.tif
Layers
Shickshinny_PreGlacial_Drainage
Shickshinny_Wisc_Limit
Shickshinny_Wisc_Limit
Shickshinny_Till_Drumlin
Shickshinny_Sluiceways
Shick_Frame
Shick_Isochores
Shick_Outcrops
Shick_SurGeo_Lines
Shick Zero Deg Hillshade
shick_aspect_3
<VALUE>
Flat
North (0 - 22.5)
Northeast (22.5 - 67.5)
East (67.5 - 112.5)
Southeast (112.5 - 157.5)
South (157.5 - 202.5)
Southwest (202.5 - 247.5)
West (247.5 - 292.5)
Northwest (292.5 - 337.5)
North (337.5 - 360)
shick_slope_3
<VALUE>
0 - 0.427920586
0.427920586 - 2.461163005
2.461163006 - 4.494405425
4.494405426 - 6.527647845
6.527647846 - 8.560890265
8.560890266 - 10.59413268
10.59413269 - 12.6273751
12.62737511 - 14.66061752
14.66061753 - 16.69385994
16.69385995 - 18.72710236
18.72710237 - 20.76034478
20.76034479 - 22.7935872
22.79358721 - 24.82682962
24.82682963 - 26.86007204
26.86007205 - 28.89331446
28.89331447 - 30.92655688
30.92655689 - 84.54523468
shickshinny_pa.tif
Shickshinny_SurGeology
shick_dem
shick_hs_3.tif
o41076b2.tif
Display
Source
Selection
Drawing
Arial
9.75
Topology:
404857.937 4560490.609 Meters

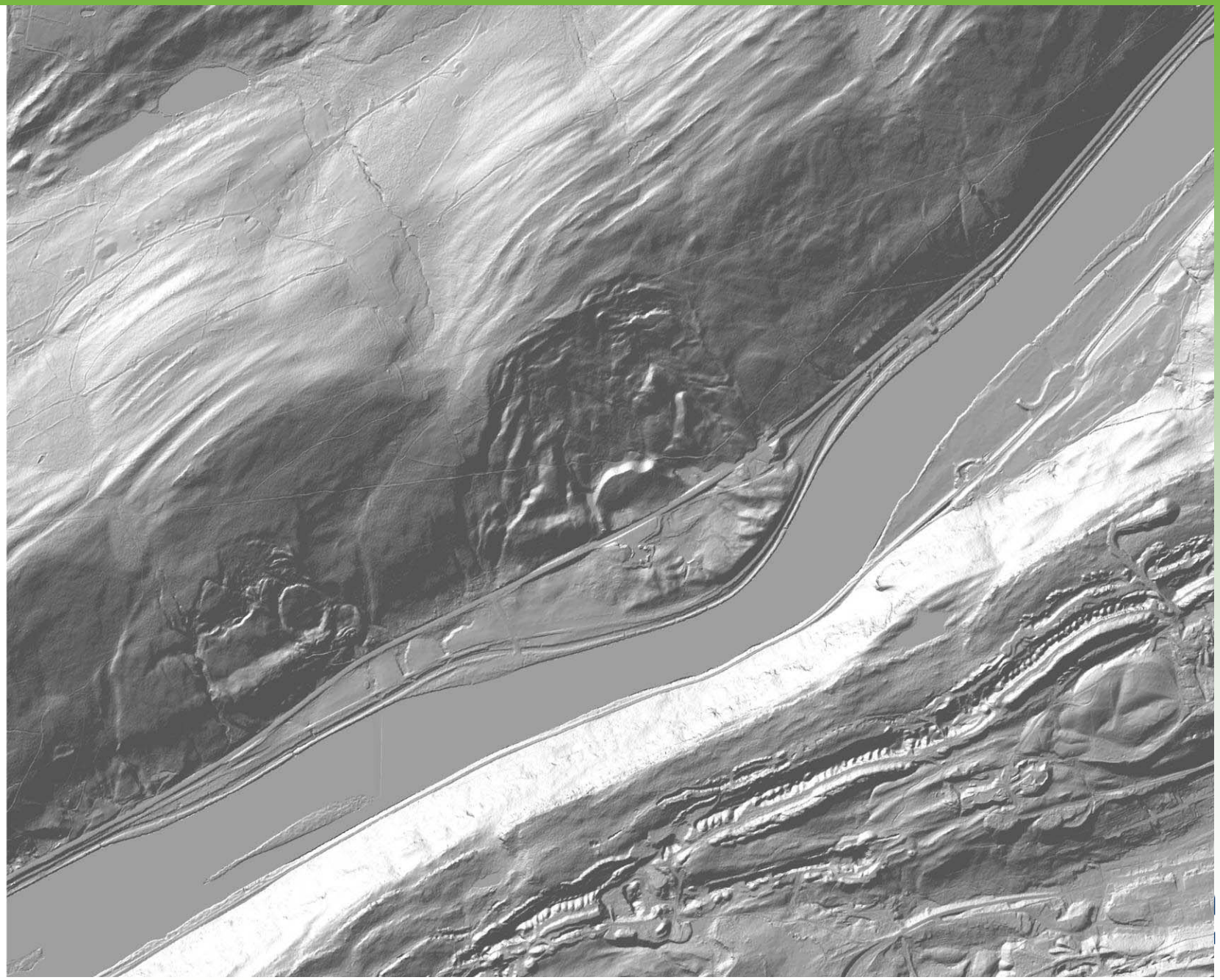

Shickshinny_Poster_Slope_1.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help
1:5,098
Layer: Shickshinny_PreGlacial_Drainac
500
3D Analyst
Layer: Shick Zero Deg Hillshade
Spatial Analyst
Layer: Shick Zero Deg Hillshade
Editor
Task: Create New Feature
Target:
Georeferencing
Layer: shickshinny_pa.tif
Layers
Shickshinny_PreGlacial_Drainage
Shickshinny_Wisc_Limit
Shickshinny_Wisc_Limit
Shickshinny_Till_Drumlin
Shickshinny_Sluiceways
Shick_Frame
Shick_Isochores
Shick_Outcrops
Shick_SurGeo_Lines
Shick Zero Deg Hillshade
shick_aspect_3
<VALUE>
Flat
North (0 - 22.5)
Northeast (22.5 - 67.5)
East (67.5 - 112.5)
Southeast (112.5 - 157.5)
South (157.5 - 202.5)
Southwest (202.5 - 247.5)
West (247.5 - 292.5)
Northwest (292.5 - 337.5)
North (337.5 - 360)
shick_slope_3
<VALUE>
0 - 0.427920586
0.427920586 - 2.461163005
2.461163006 - 4.494405425
4.494405426 - 6.527647845
6.527647846 - 8.560890265
8.560890266 - 10.59413268
10.59413269 - 12.6273751
12.62737511 - 14.66061752
14.66061753 - 16.69385994
16.69385995 - 18.72710236
18.72710237 - 20.76034478
20.76034479 - 22.7935872
22.79358721 - 24.82682962
24.82682963 - 26.86007204
26.86007205 - 28.89331446
28.89331447 - 30.92655688
30.92655689 - 84.54523468
shickshinny_pa.tif
Shickshinny_SurGeology
shick_dem
shick_hs_3.tif
o41076b2.tif
Display
Source
Selection
Drawing
Arial
9.75
Topology:
401188.25 4557812.817 Meters

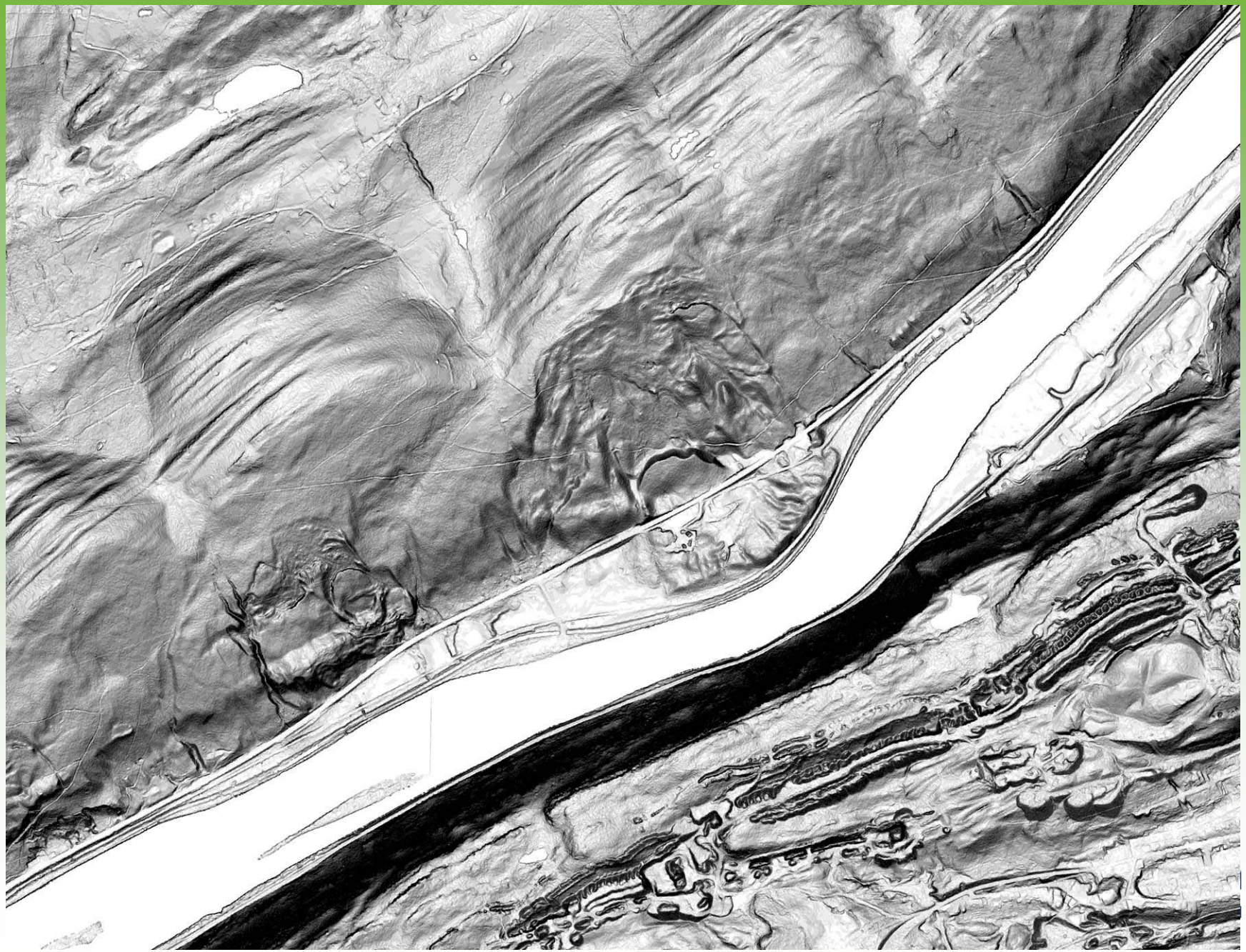

1028
1100

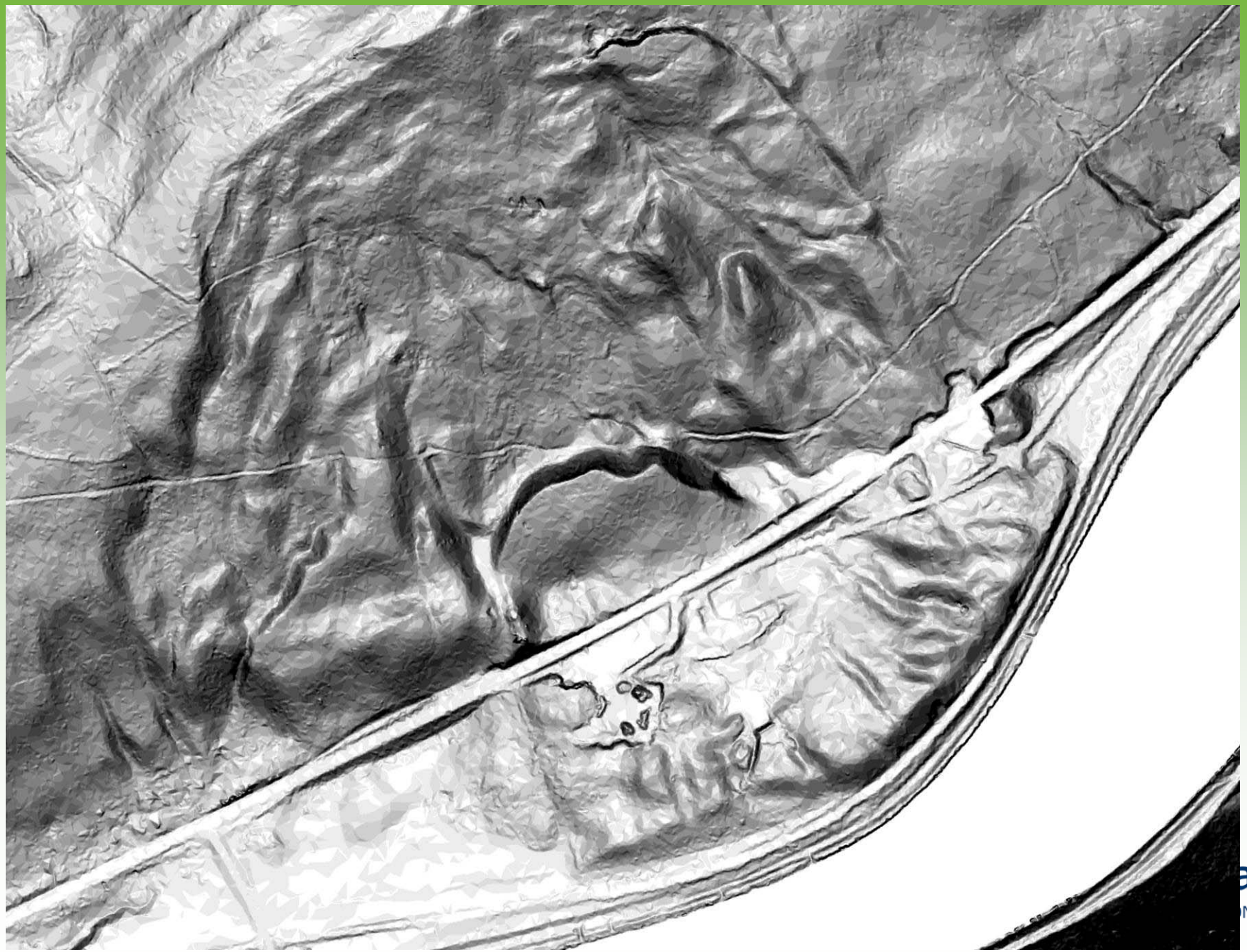

Can now see things we
couldn’t see before.


…in greater detail.


UNION
CONRAIL
DELAWARE AND HUDSON
828







Combining geology and GIS

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Geologist's Toolbox

- Topo map
- Aerial photography
- Boots-on-the-ground field work
- Previous work
- Digital imagery
- Digital DEM derivatives
- GIS software

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

…and spiffy duds!

www.dcnr.state.p

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

A geologist’s tourist attraction…

Geologist's Toolbox cont.

- The ability of the geologist to think in 3-D, look at the "big picture", assimilate difficult concepts, melding observation and logical thinking….
- …and deriving absolutely brilliant conclusions and contributions to the science that no one will EVER have the courage to challenge….


Up close and personal…

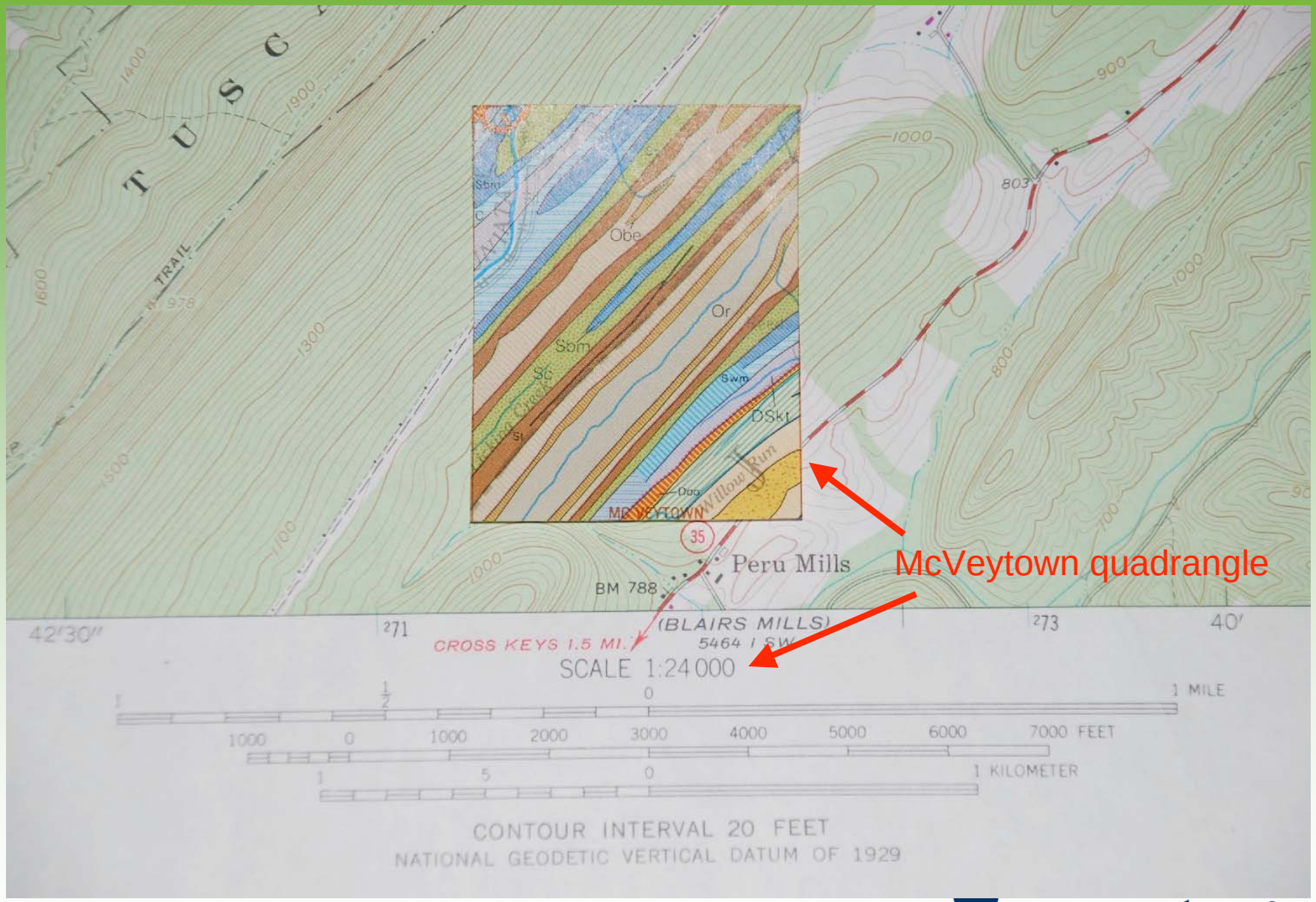
A GIS pitfall – mixing scales

- Remember……
- Thou shall not commit accuracy scale sacrilege.
- 1:250,000 geology is not accurate beyond 1:250,000.
- 250k ***is still*** 250k

The McVeytown quadrangle geology
@ 1:250,000 from Map 1

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

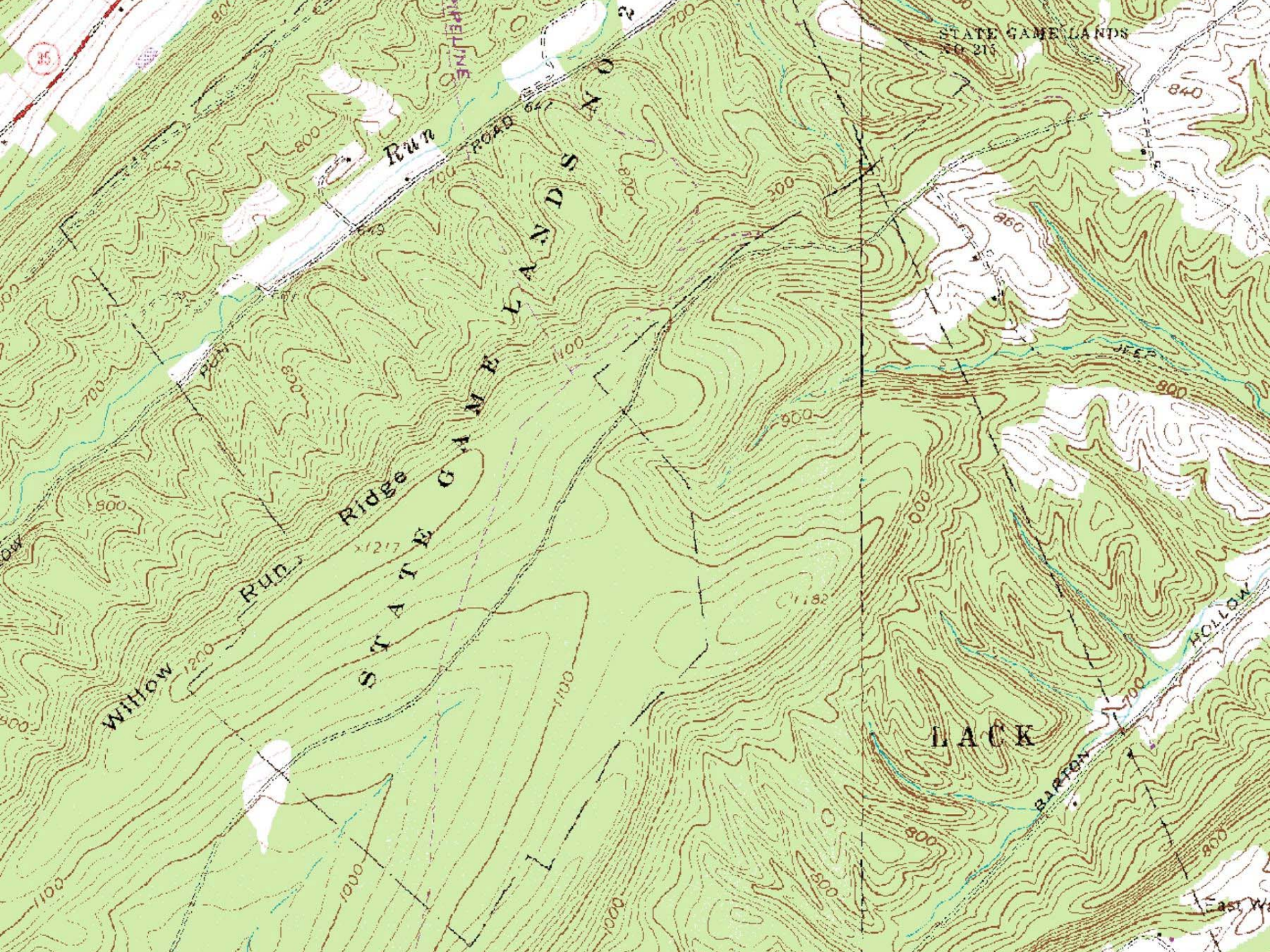


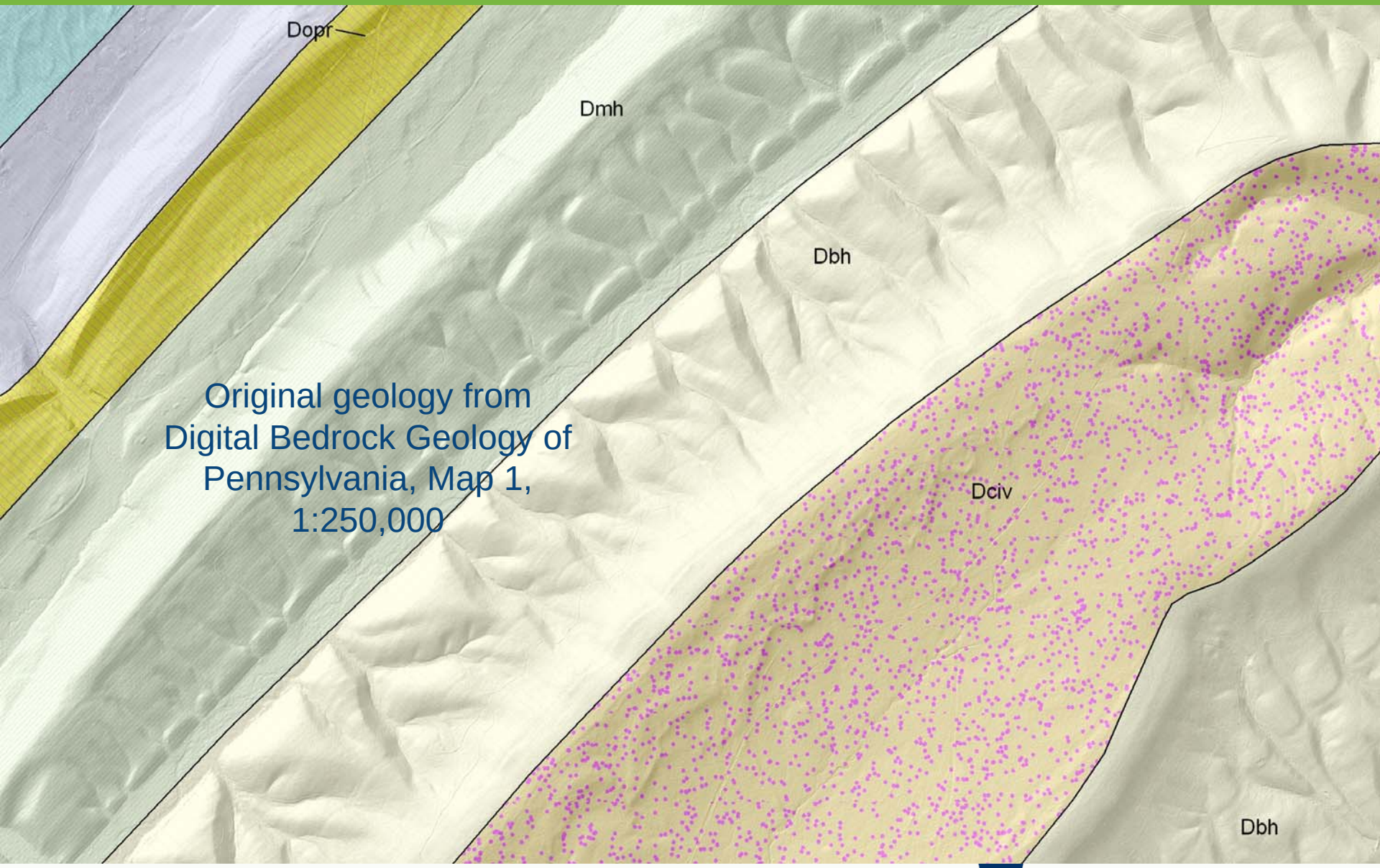
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

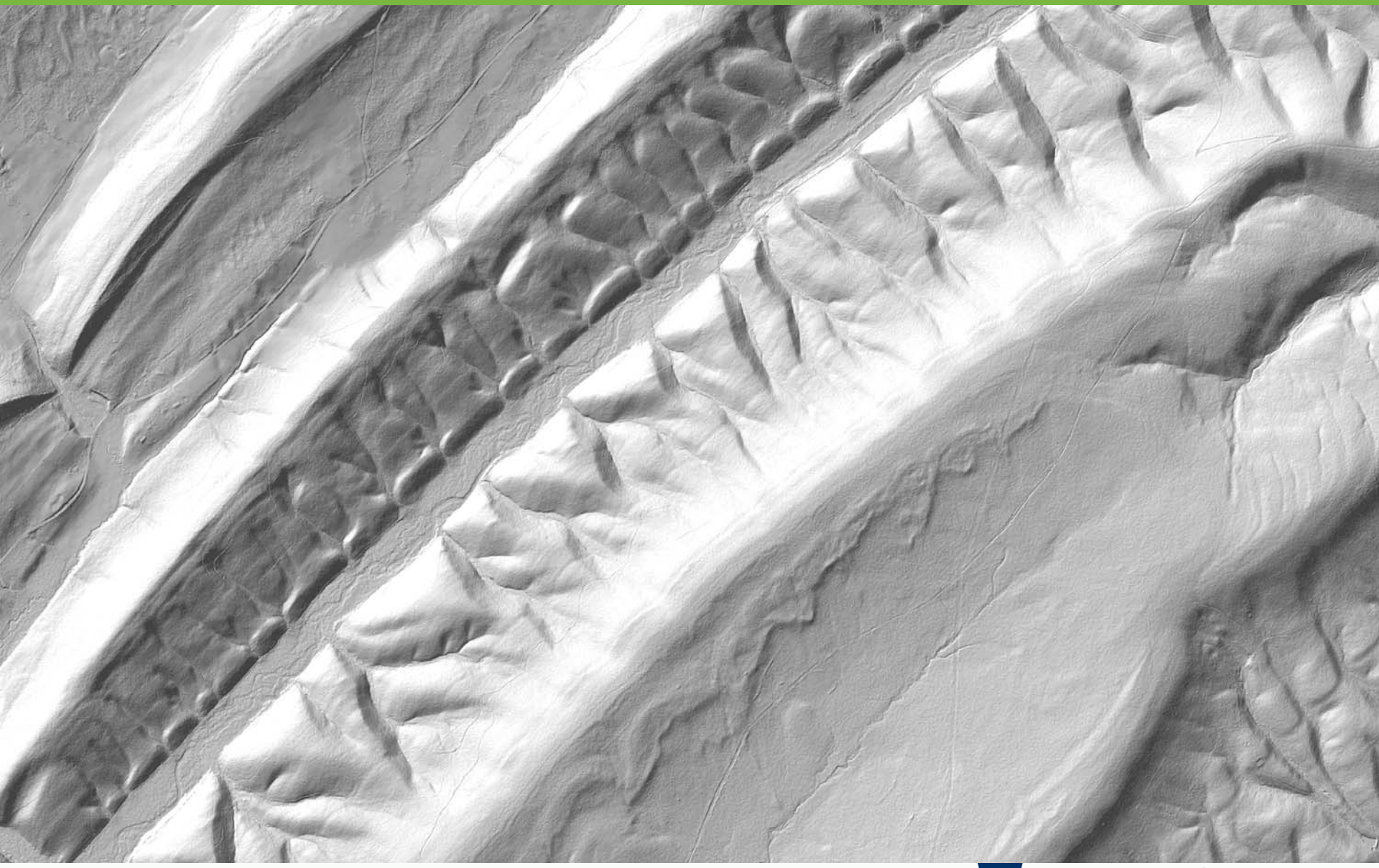
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES


STATE GAME LANDS
NO. 215
Run
ROAD
Ridge
Run
Willow
STATE GAME LANDS NO. 215
LACK
BARTON
HOLLOW
JEEP
PIPELINE

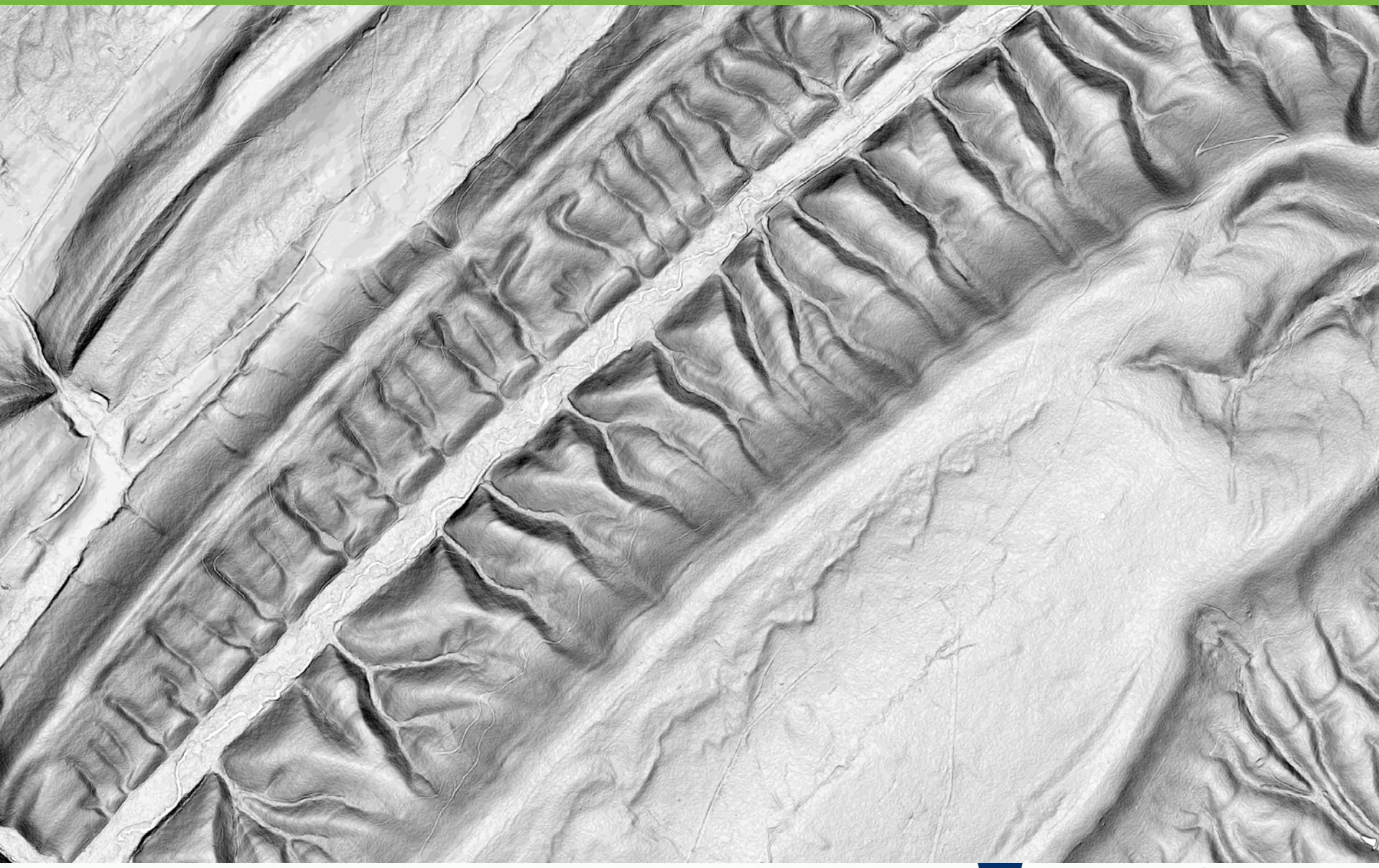


Original geology from Digital Bedrock Geology of Pennsylvania, Map 1, 1:250,000



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

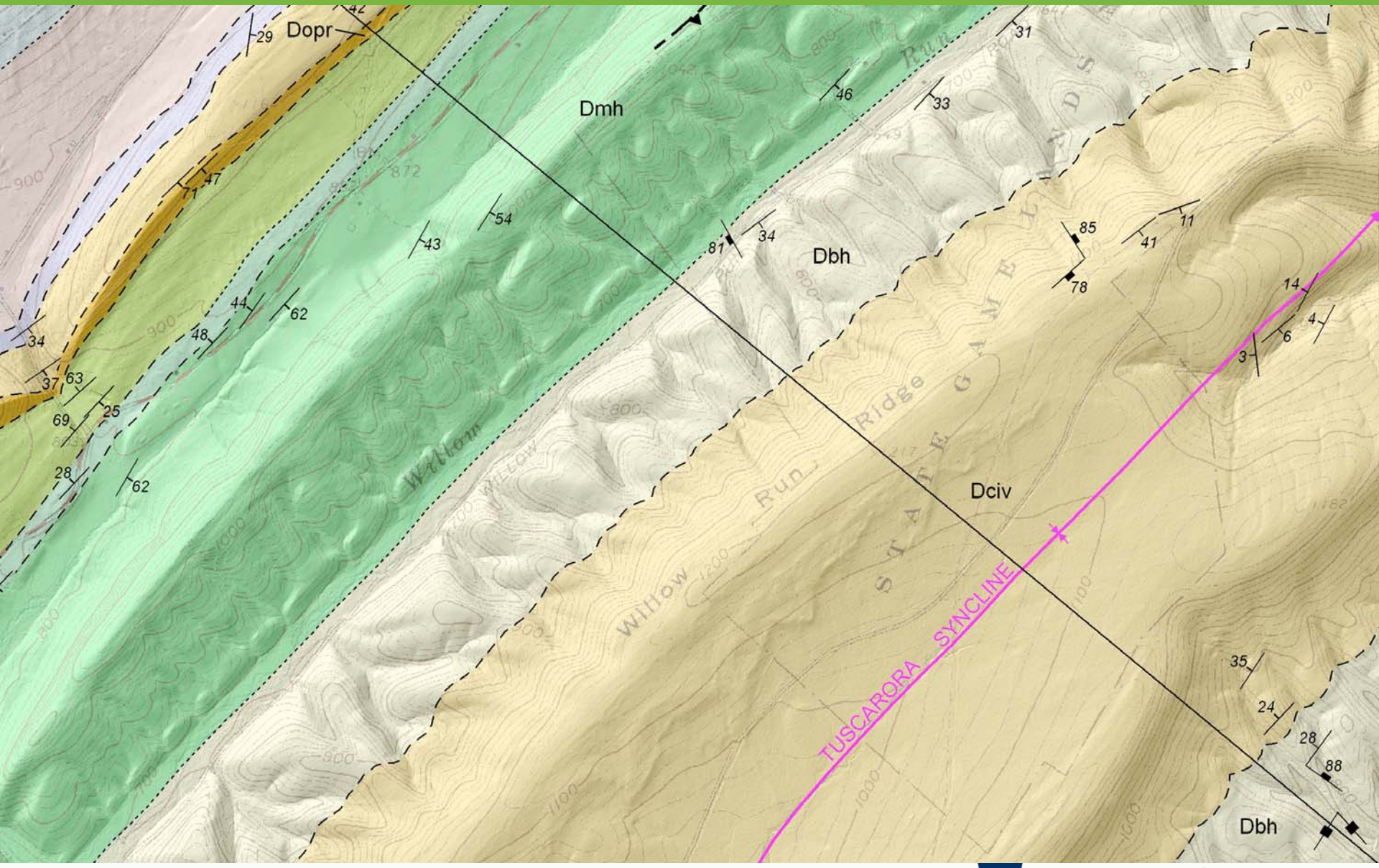


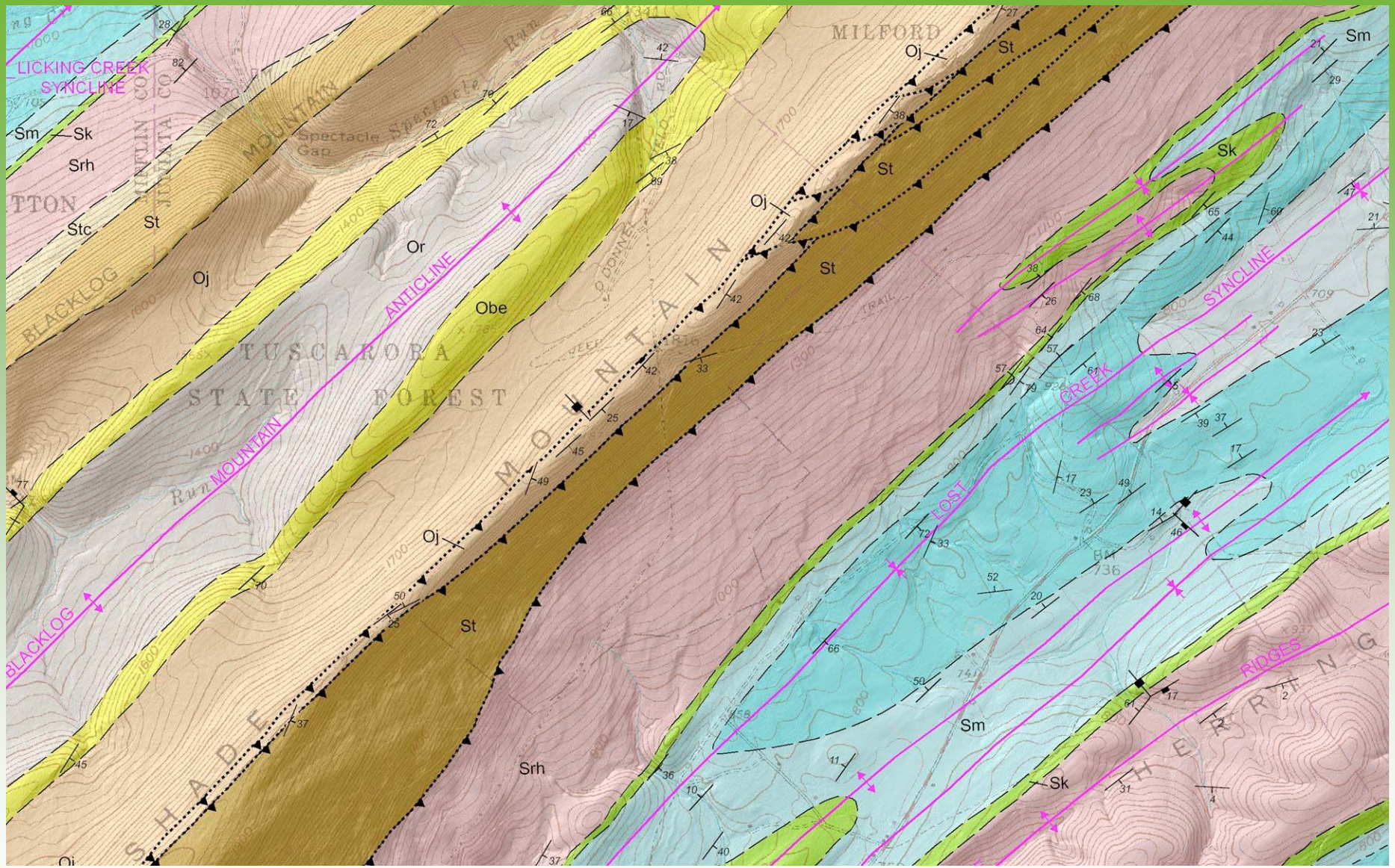
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

www.dcnr.state.pa.us/topogeo

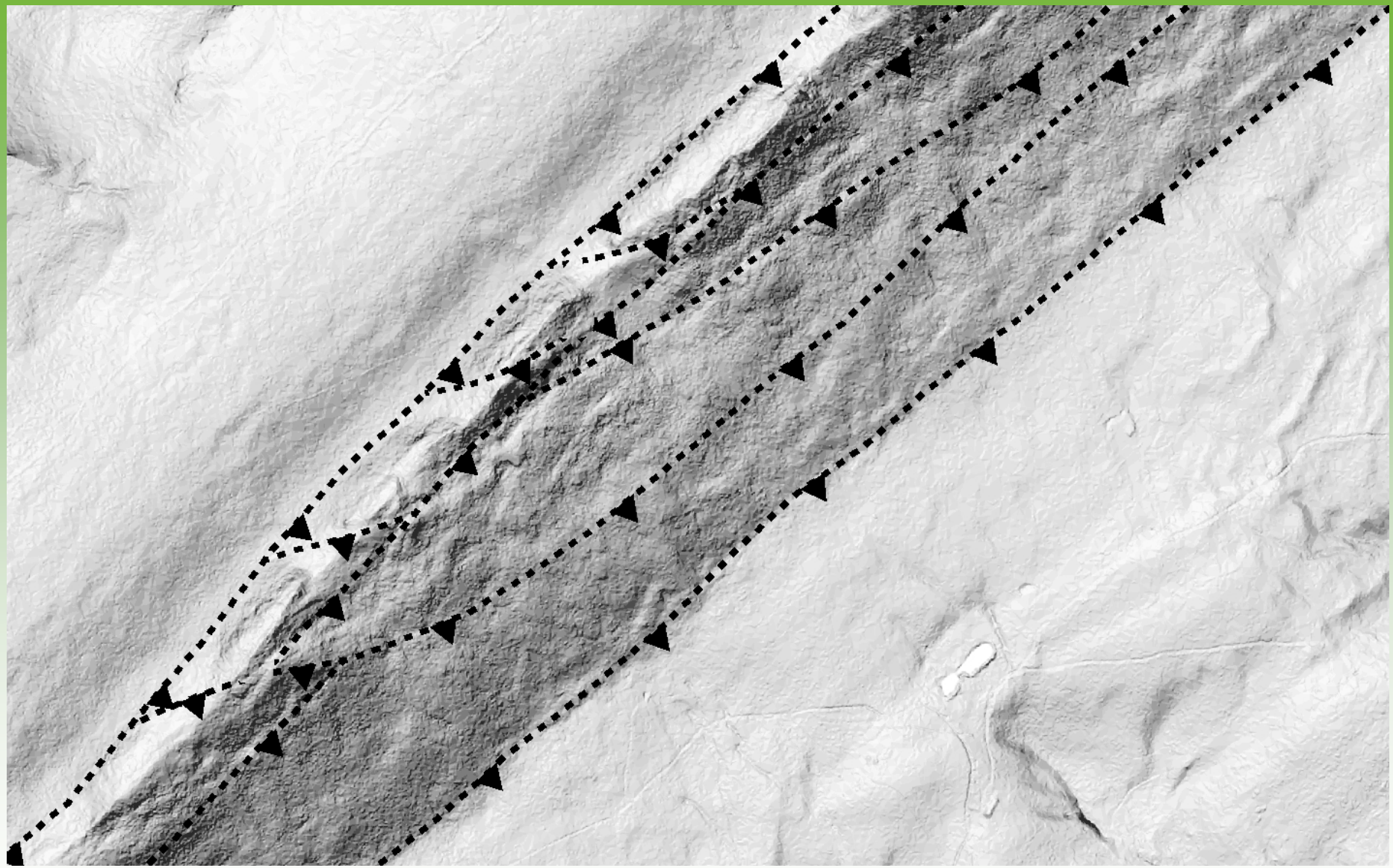
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES


Dopr
Dmh
Dbh
Dciv
Dbh
TUSCARORA SYNCLINE
Willow Run
Ridge
STATE GAMELANDS
29
47
71
54
43
81
34
46
33
31
85
78
41
11
14
4
6
3
34
37
63
69
25
28
62
44
62
48
35
24
28
88



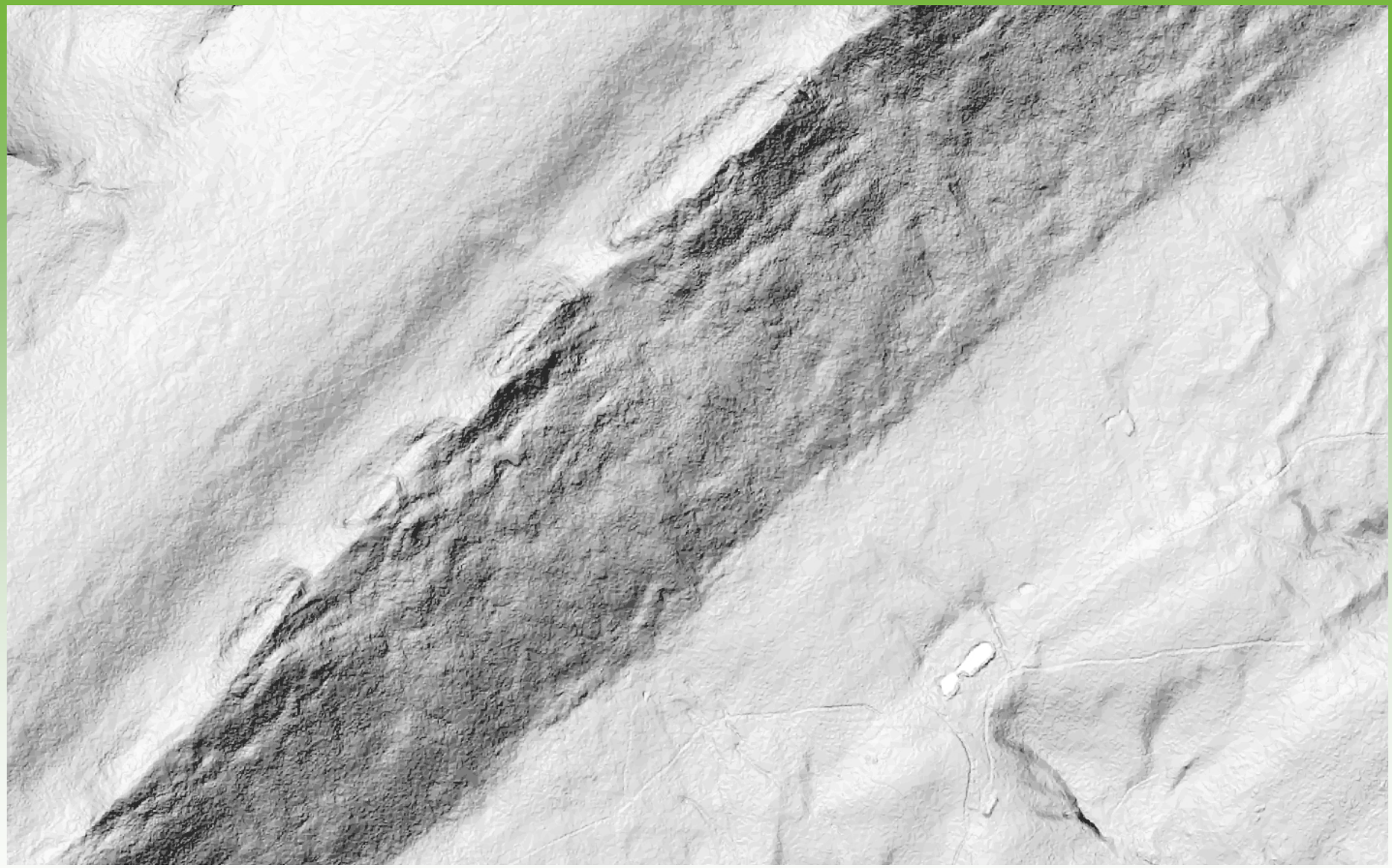
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



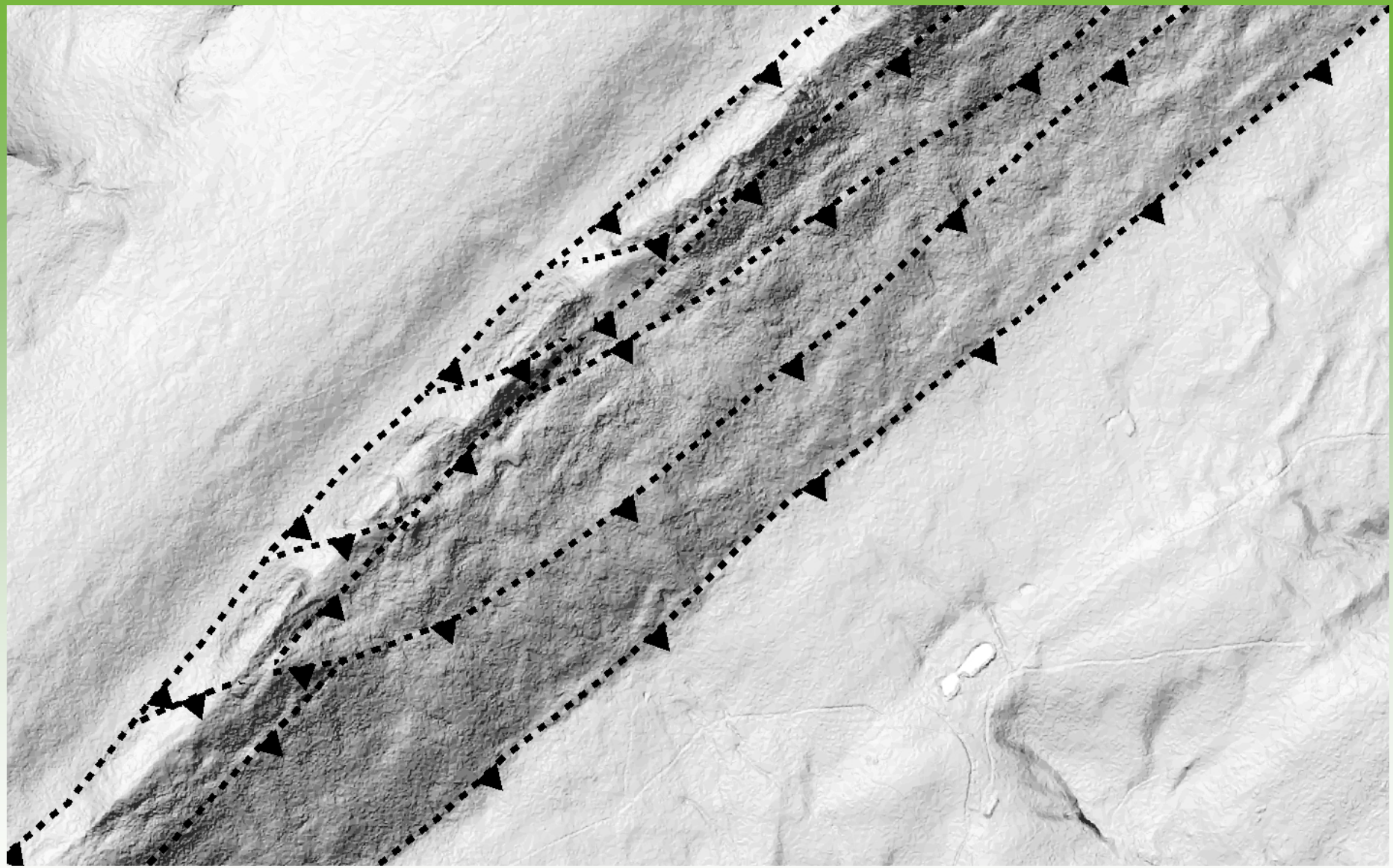
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



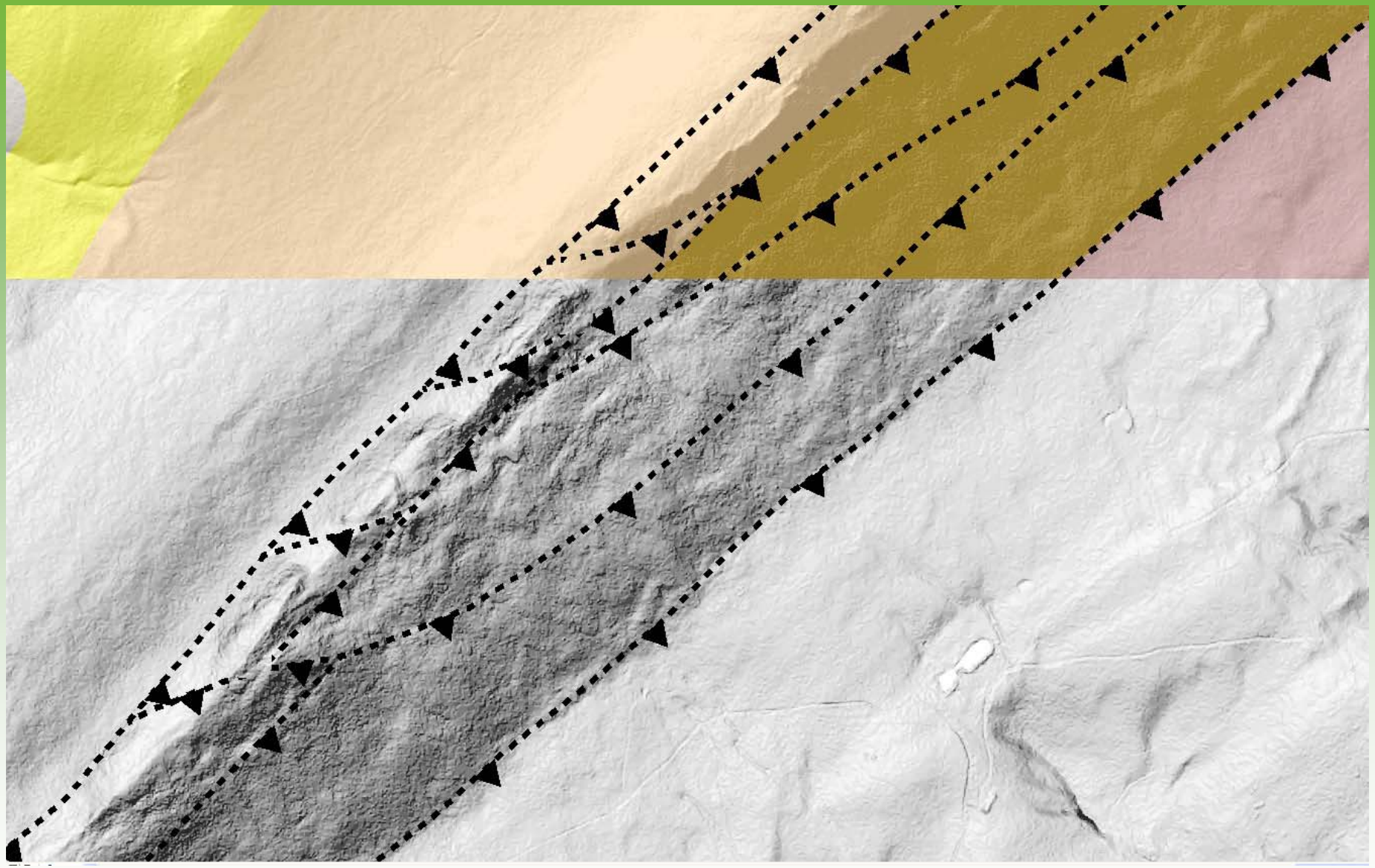
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

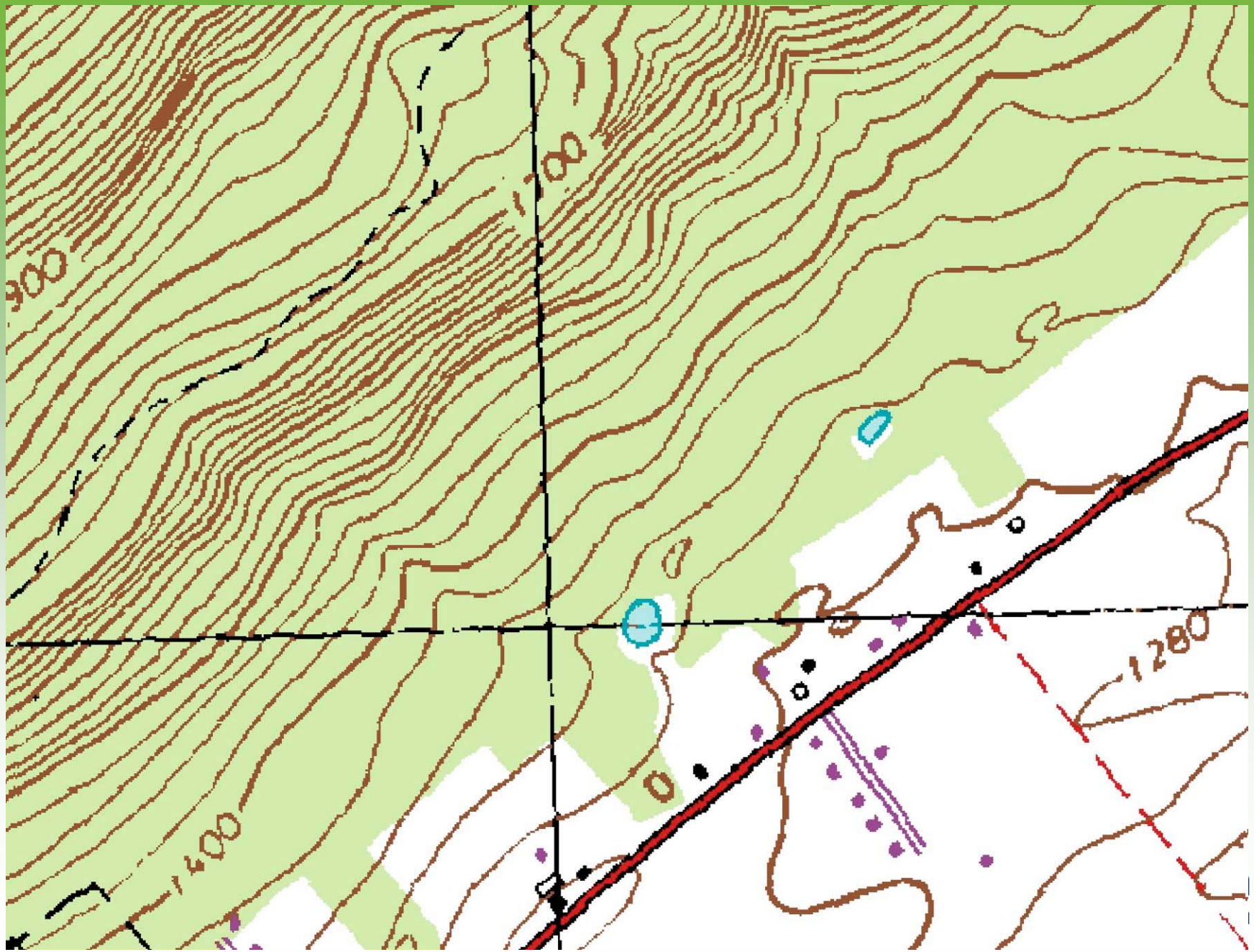


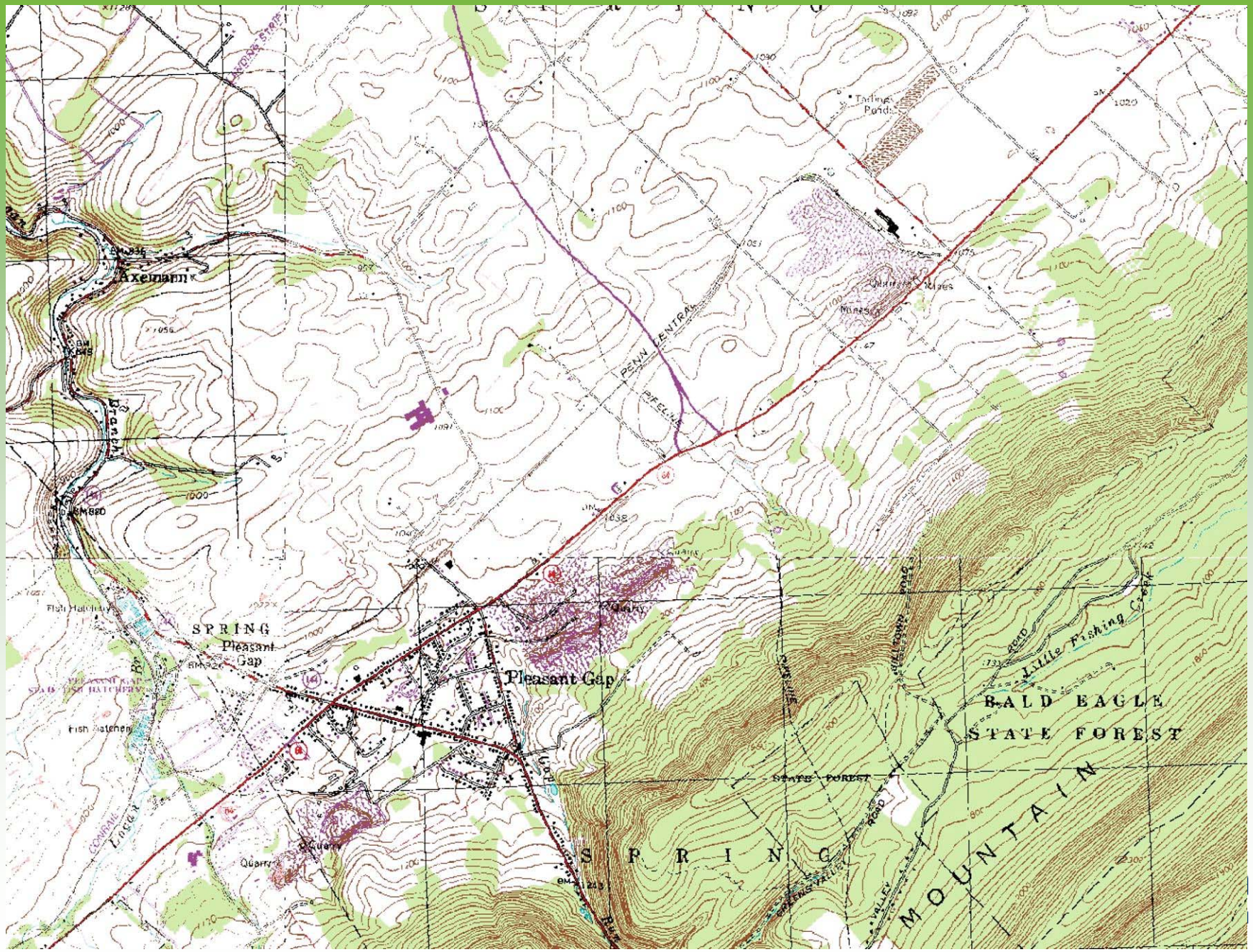
www.dcnr.state.pa.us/topogeo

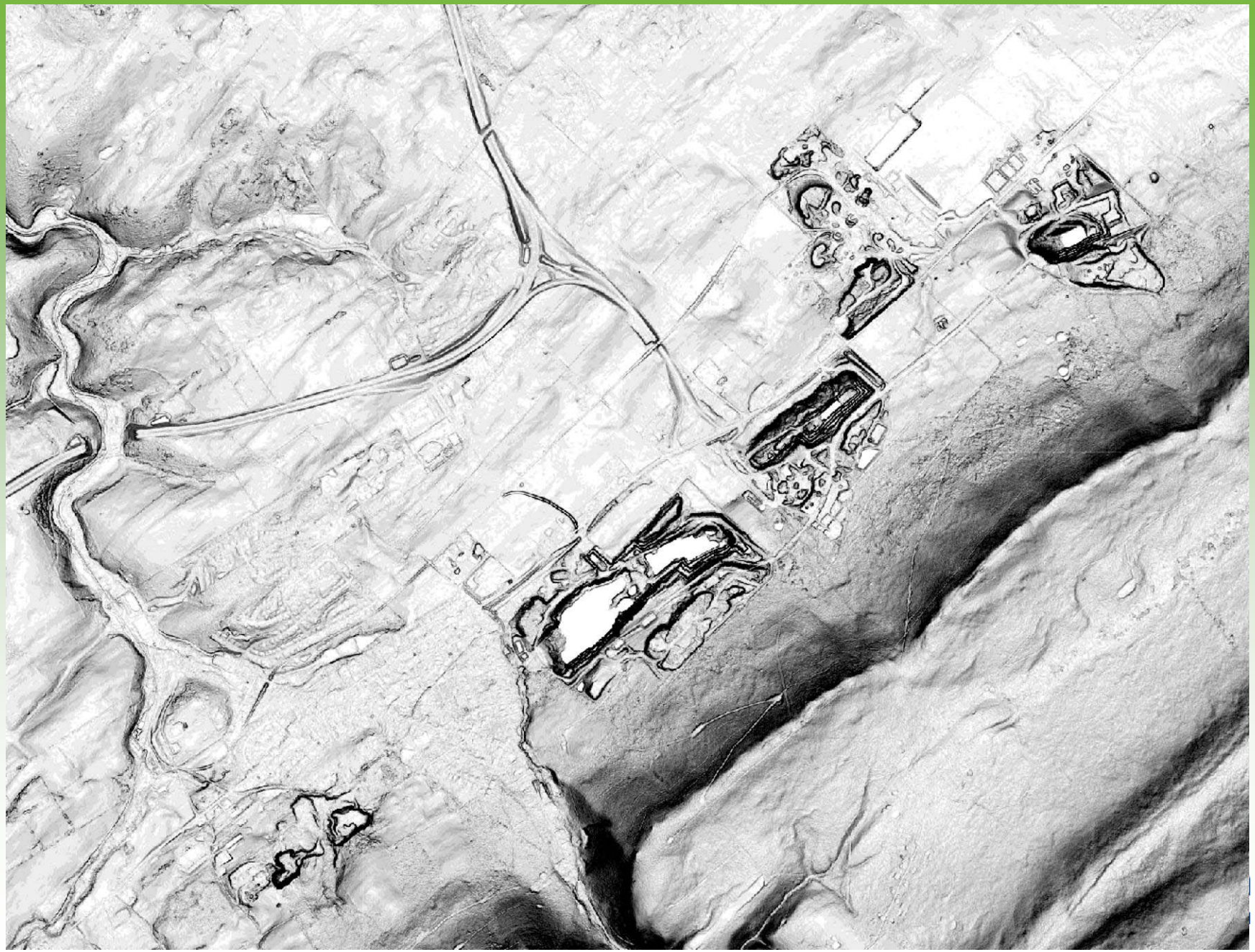
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

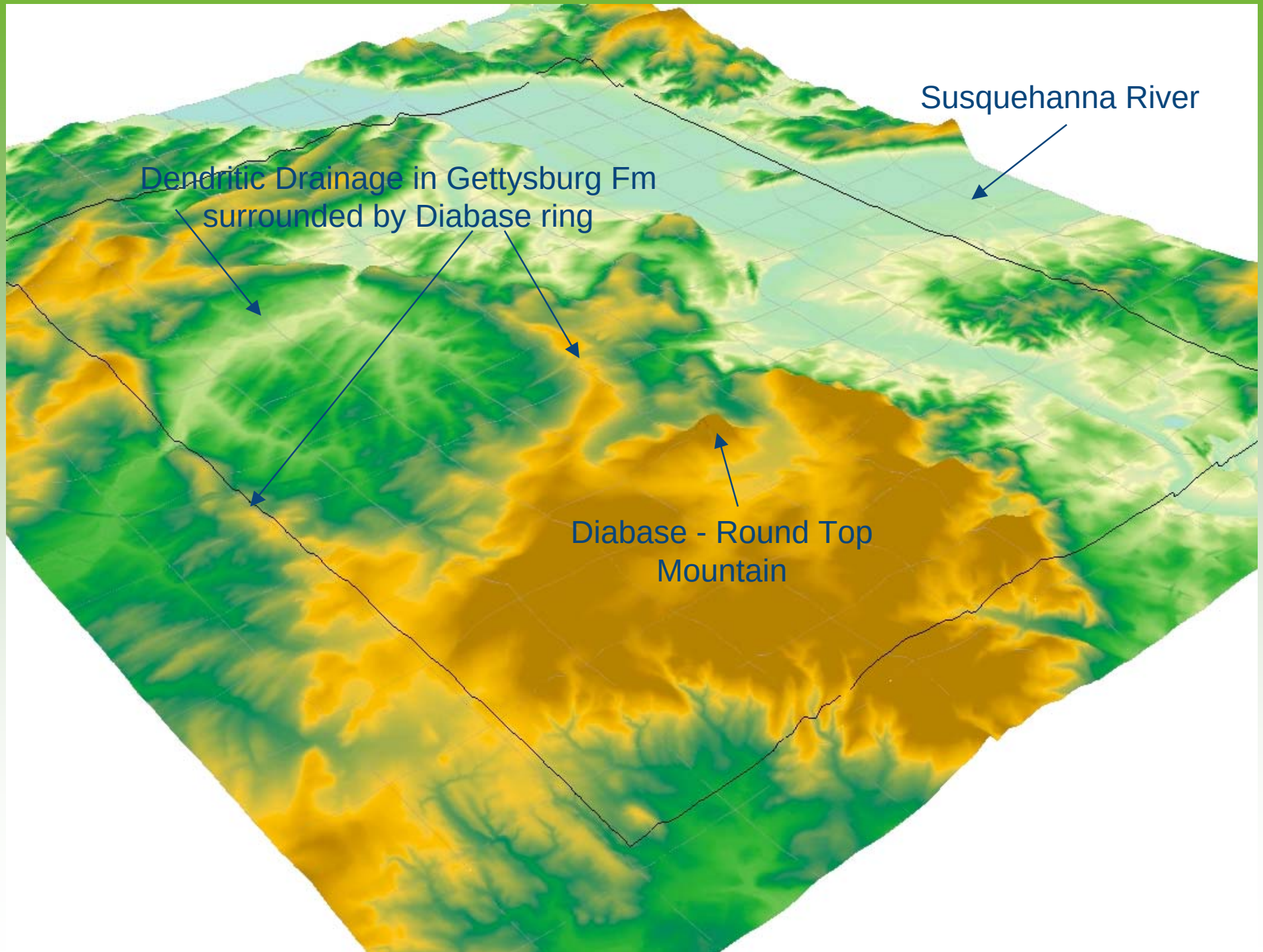
www.dcnr.state.pa.us/topogeo

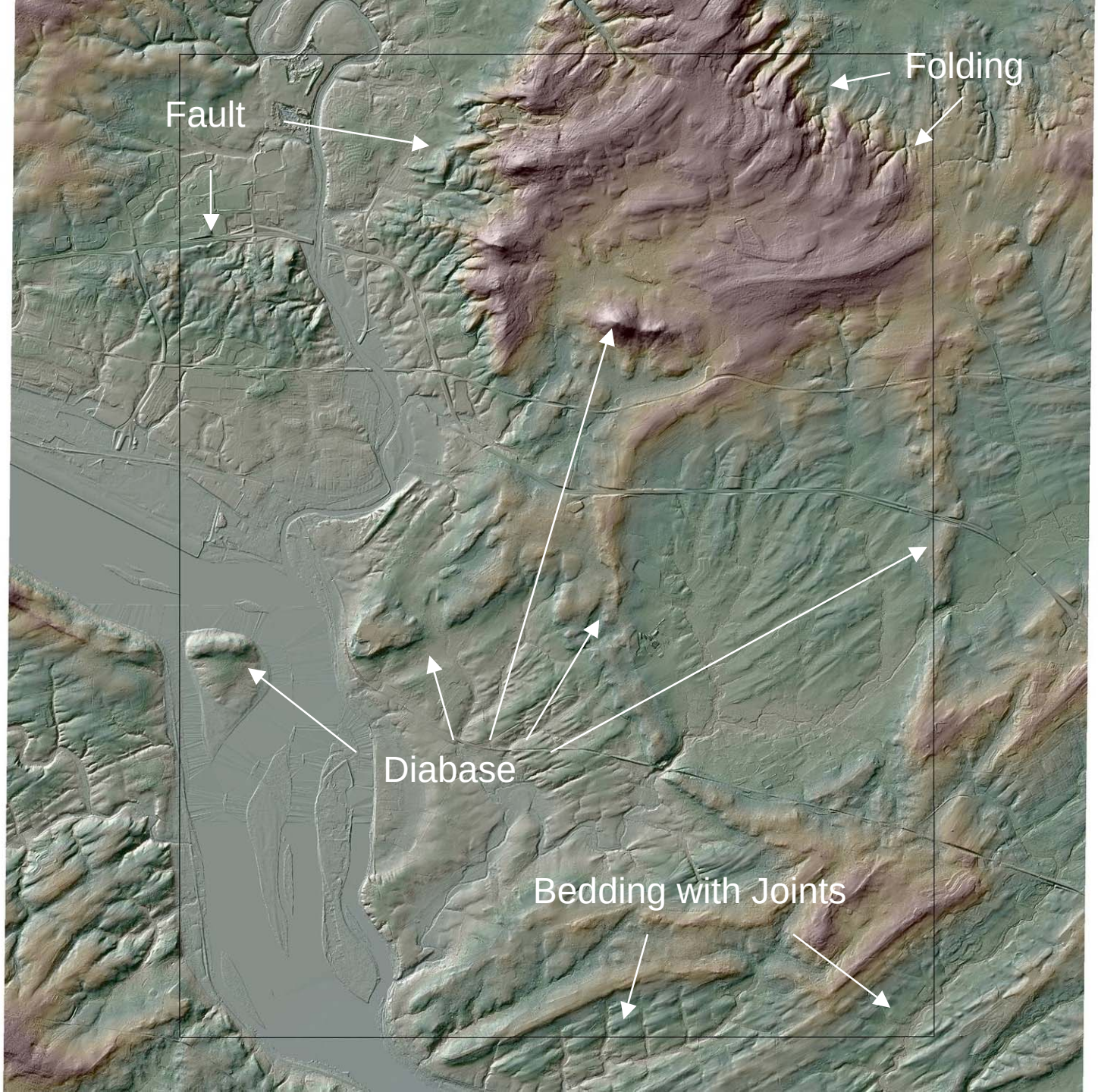
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

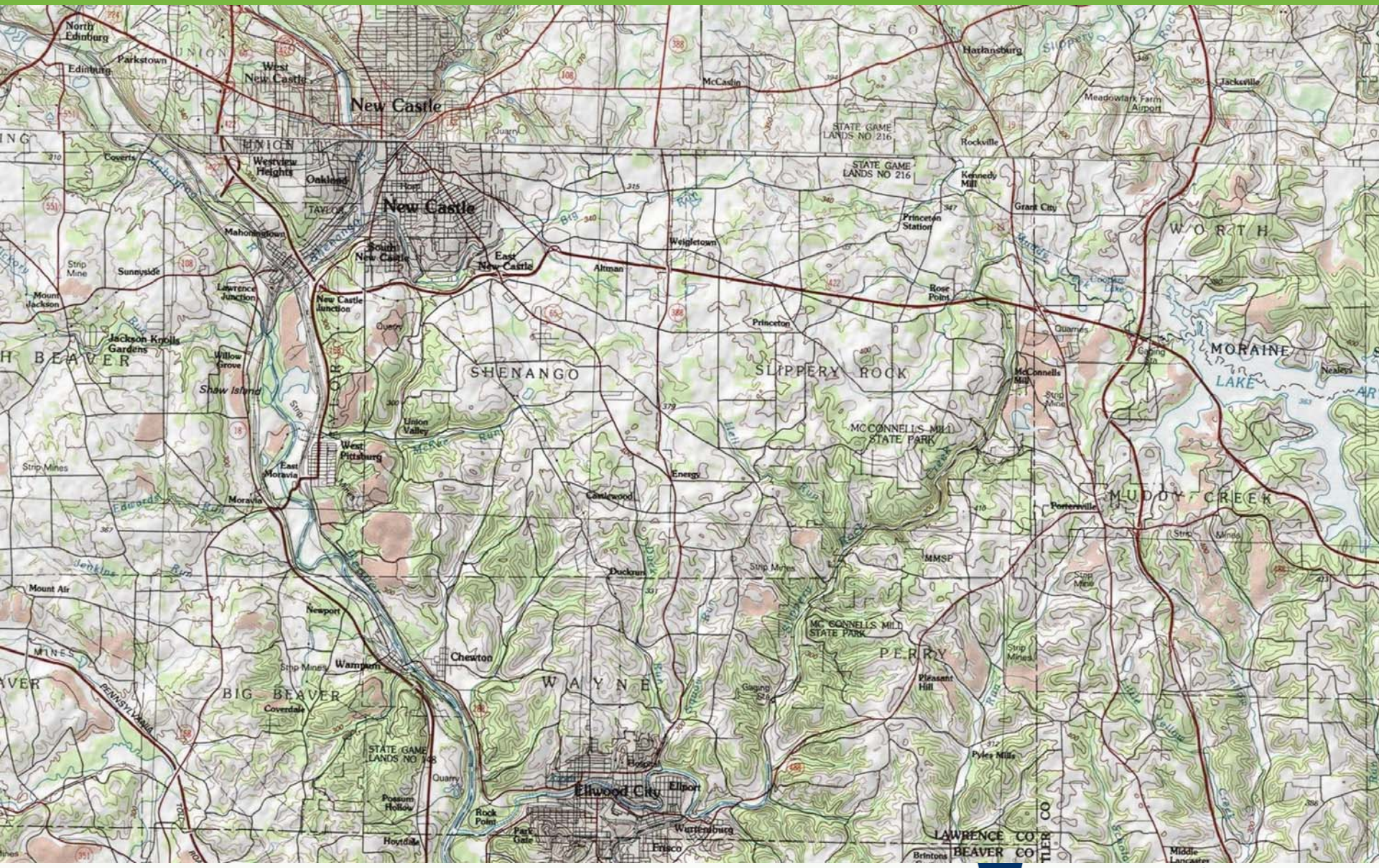

1700
1400
1280


Axemann
Branch
Fish Hatchery
SPRING
Pleasant
Gap
Pleasant Gap
Quarry
Quarry
Tailing
Ponds
PENN CENTRAL
PIPELINE
Little Fishing Creek
BALD EAGLE
STATE FOREST
STATE FOREST
MOUNTAIN
S P R I N G
VALLEY
ROAD




Susquehanna River
Dendritic Drainage in Gettysburg Fm
surrounded by Diabase ring
Diabase - Round Top
Mountain


Folding
Fault
Diabase
Bedding with Joints



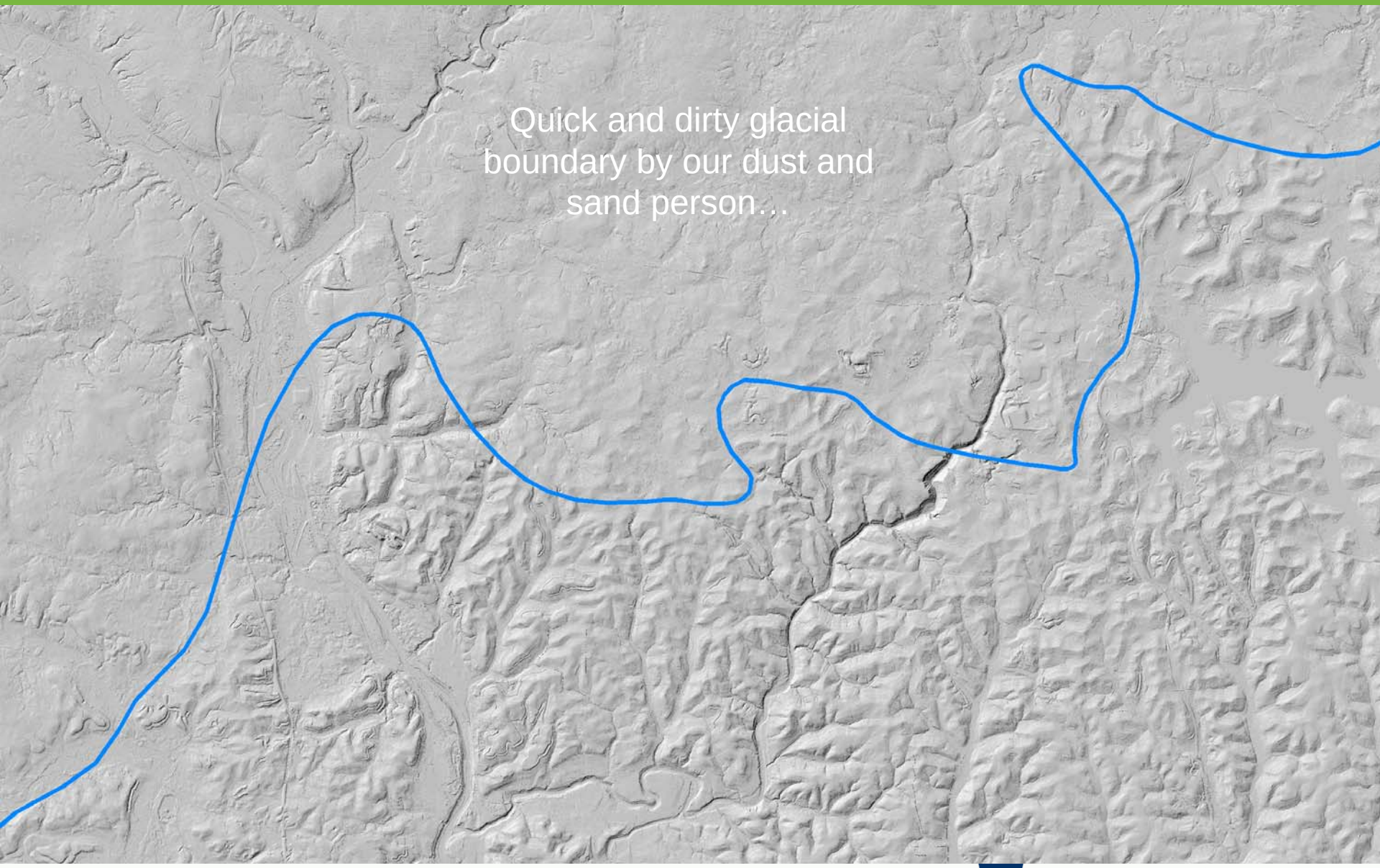
www.dcnr.state.pa.us/topogeo

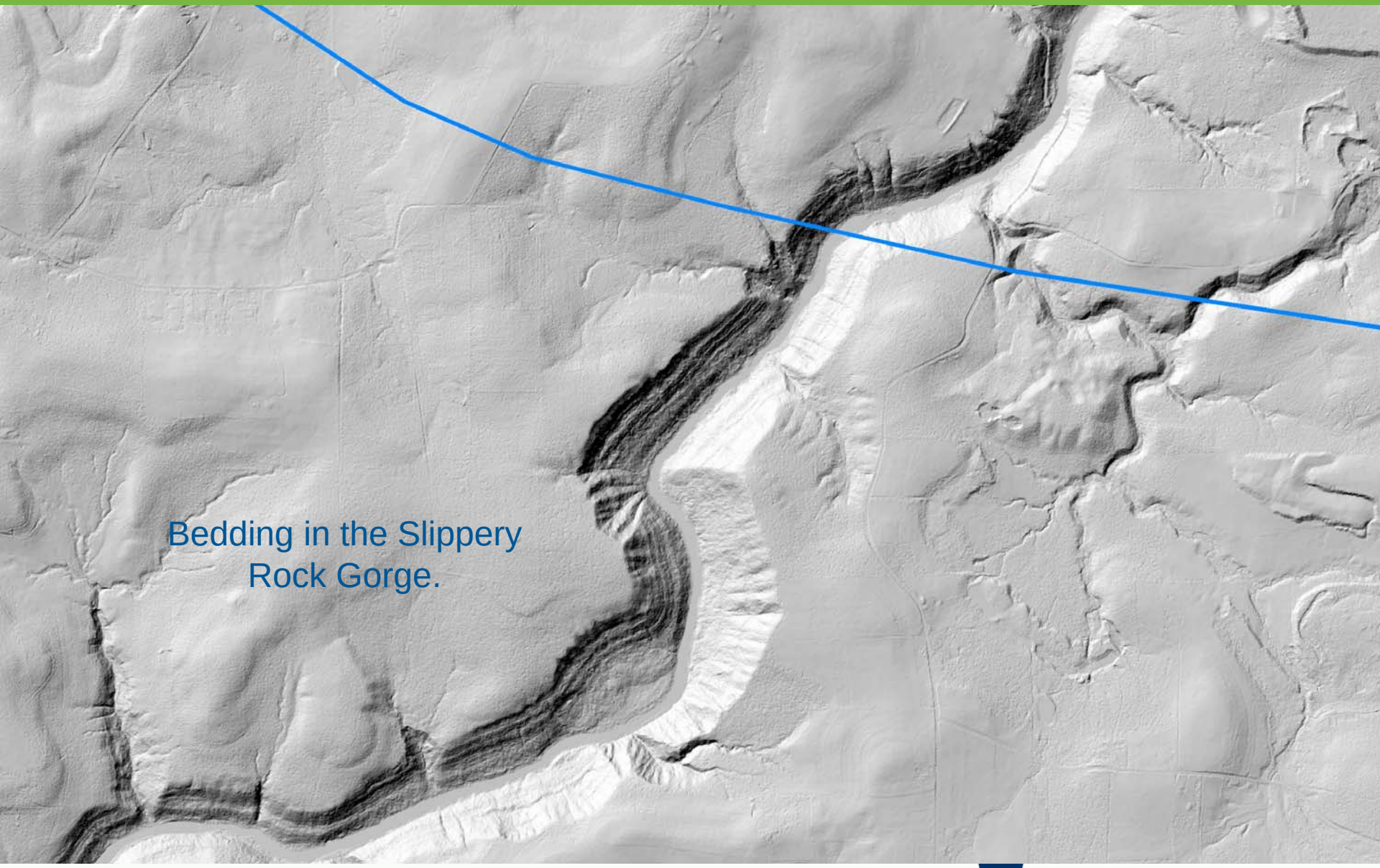
pennsylvania
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

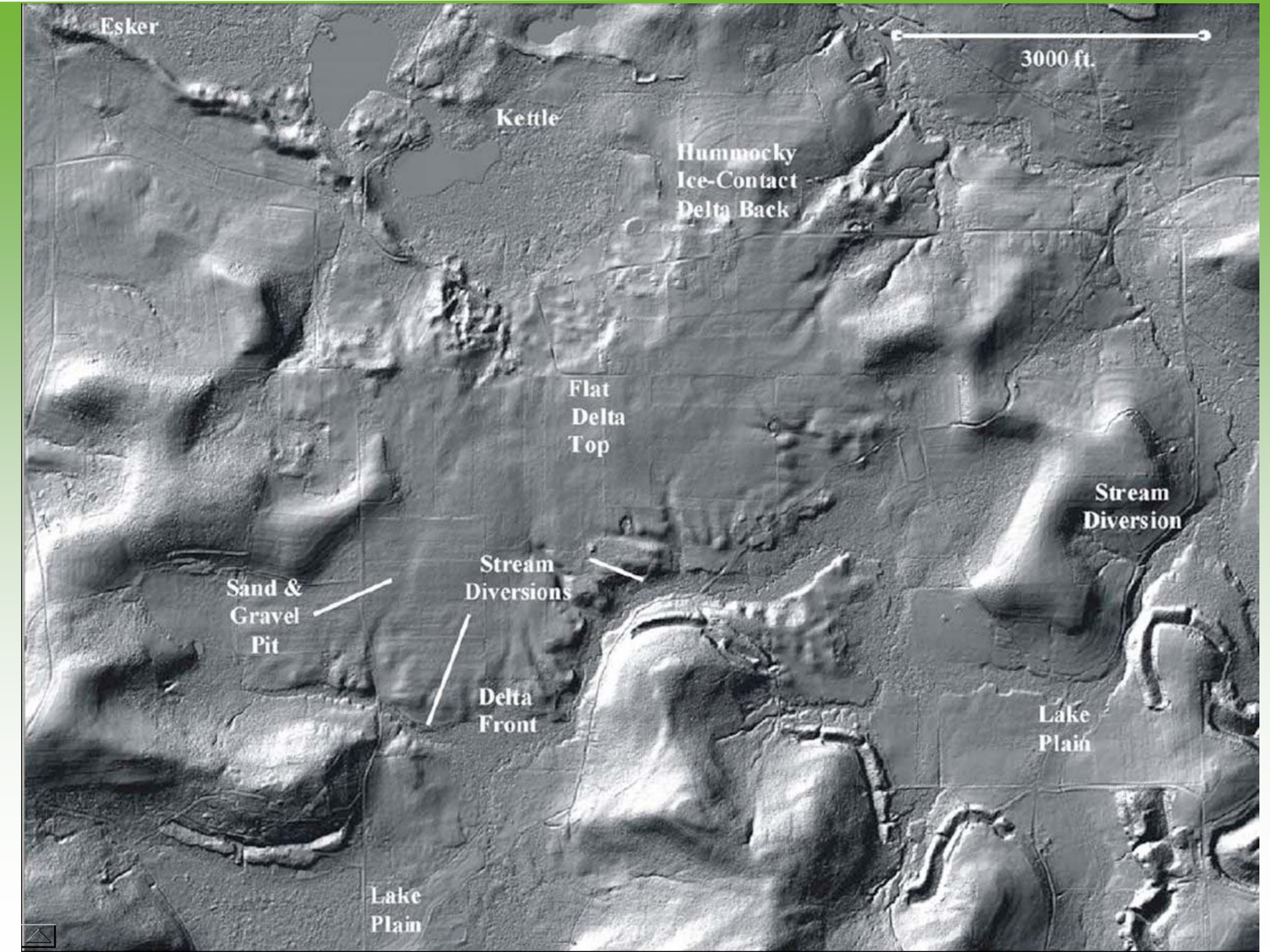

Distinct texture change…


Quick and dirty glacial boundary by our dust and sand person…



www.dcnr.state.pa.us/topogeo

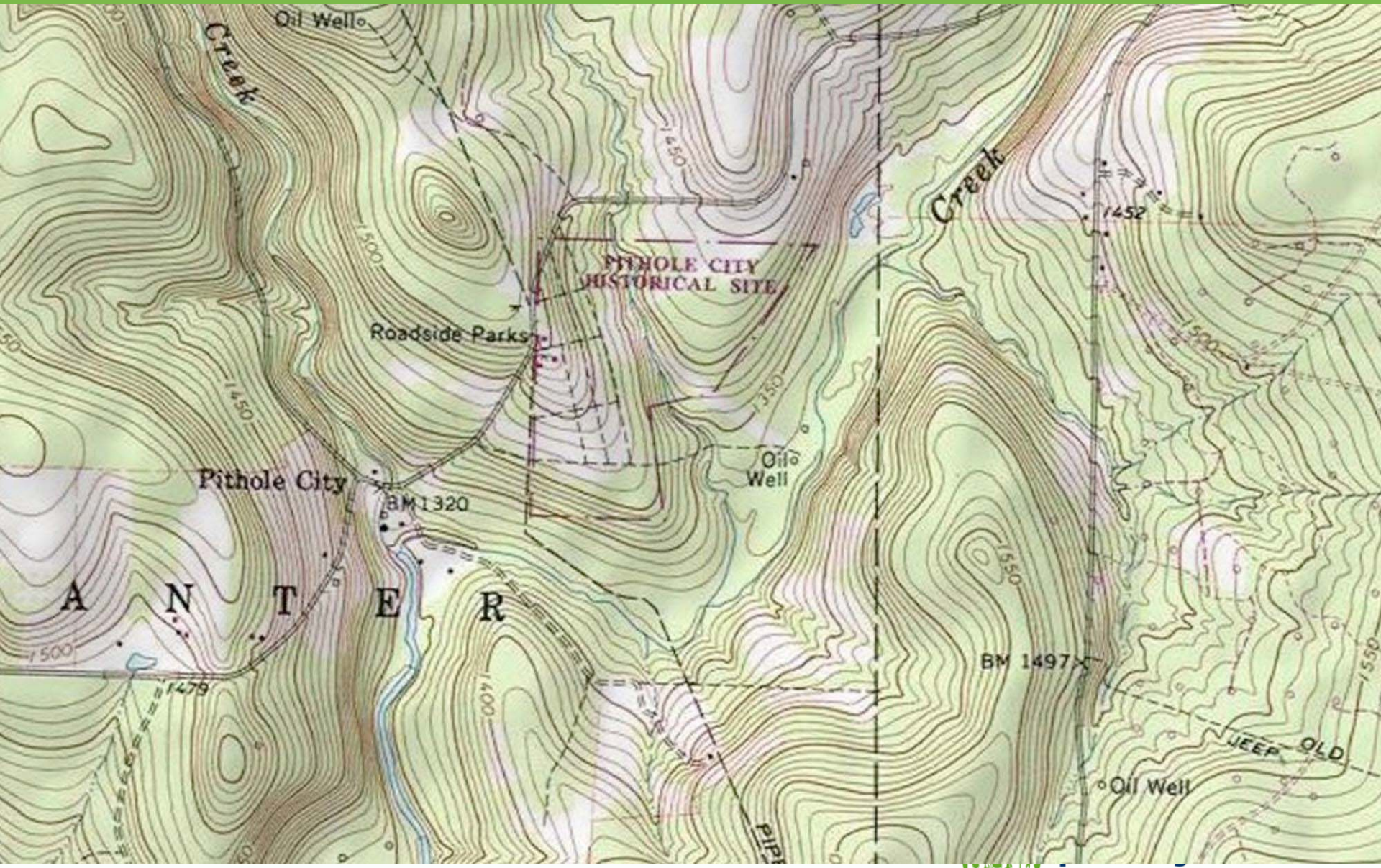
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES


Esker
3000 ft.
Kettle
Hummocky
Ice-Contact
Delta Back
Flat
Delta
Top
Stream
Diversion
Stream
Diversions
Sand &
Gravel
Pit
Delta
Front
Lake
Plain
Lake
Plain

Geo-archeology

(Some interesting stuff)

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

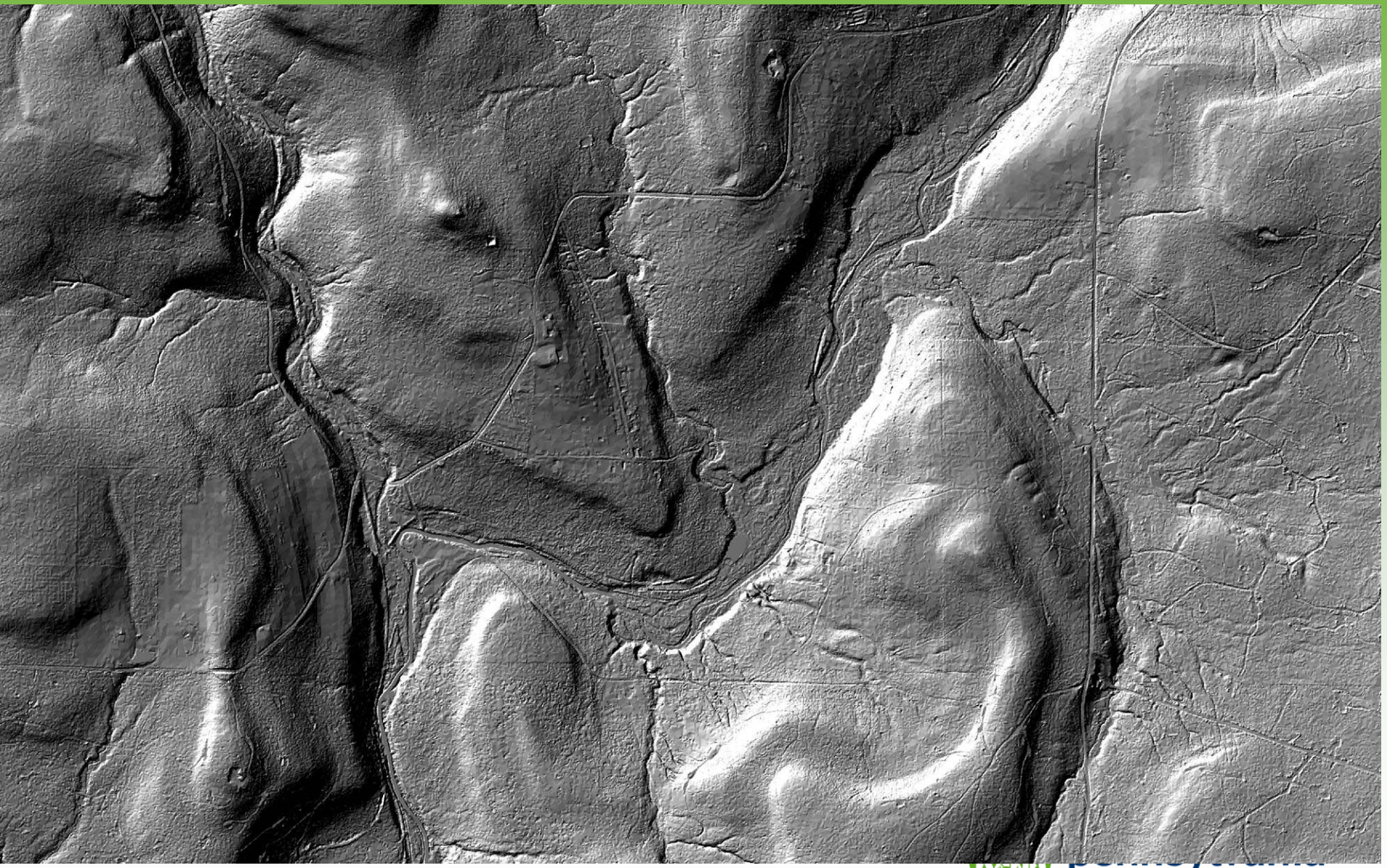


www.dcnr.state.pa.us/topogeo

DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

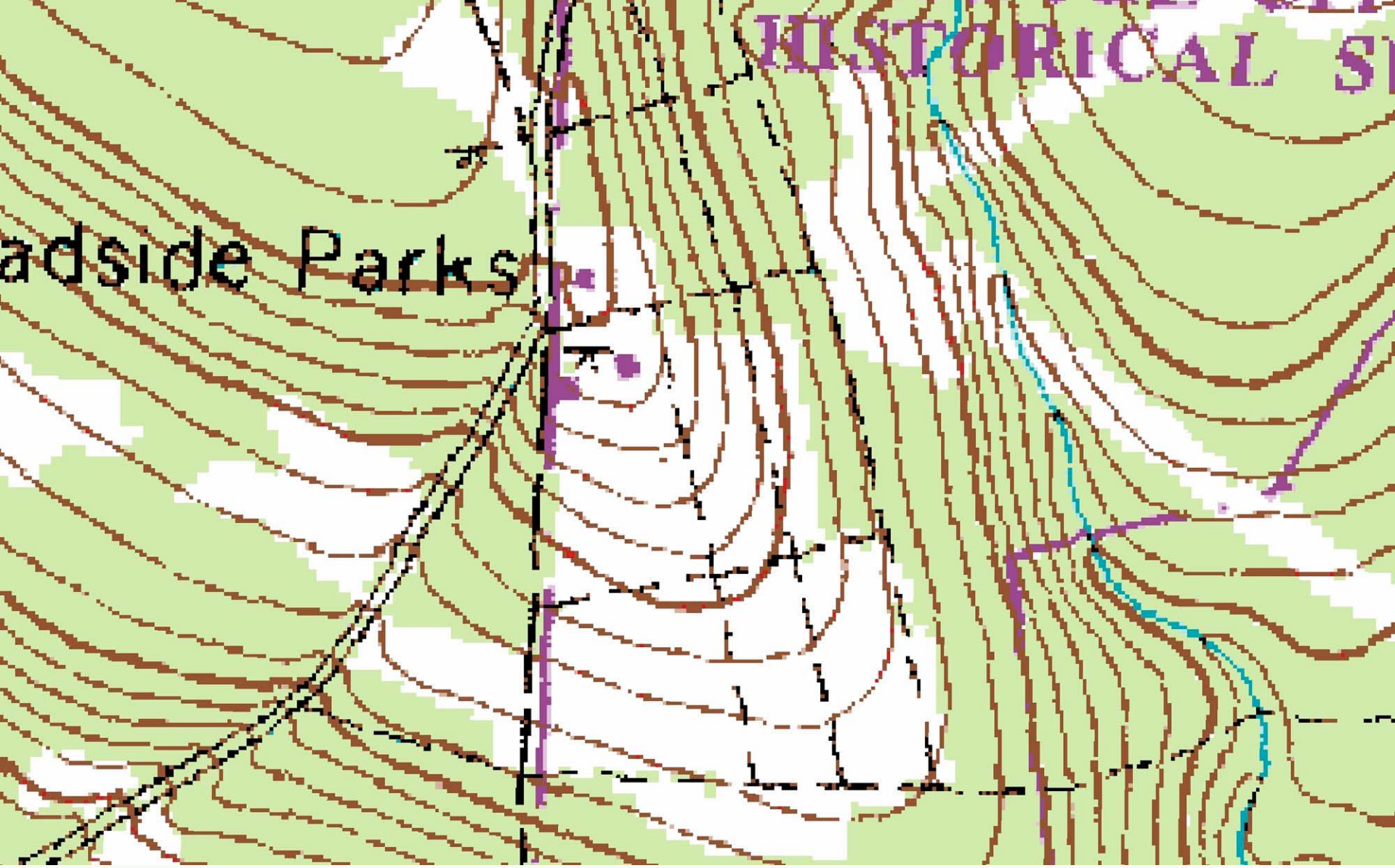
Pitthole – near Titusville, PA

- 1864 first oil well drilled
- Jan 1865 second oil well - 250 Bbl/day, population 2,000
- Sept 1865 – 6,000 Bbl/day, 15,000 people
- Jan 1866 – 4,000 people
- 1870 – population 281
- 1879 – town sold for $4.37



www.dcnr.state.pa.us/topogeo

DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



www.dcnr.state.pa.us/topogeo

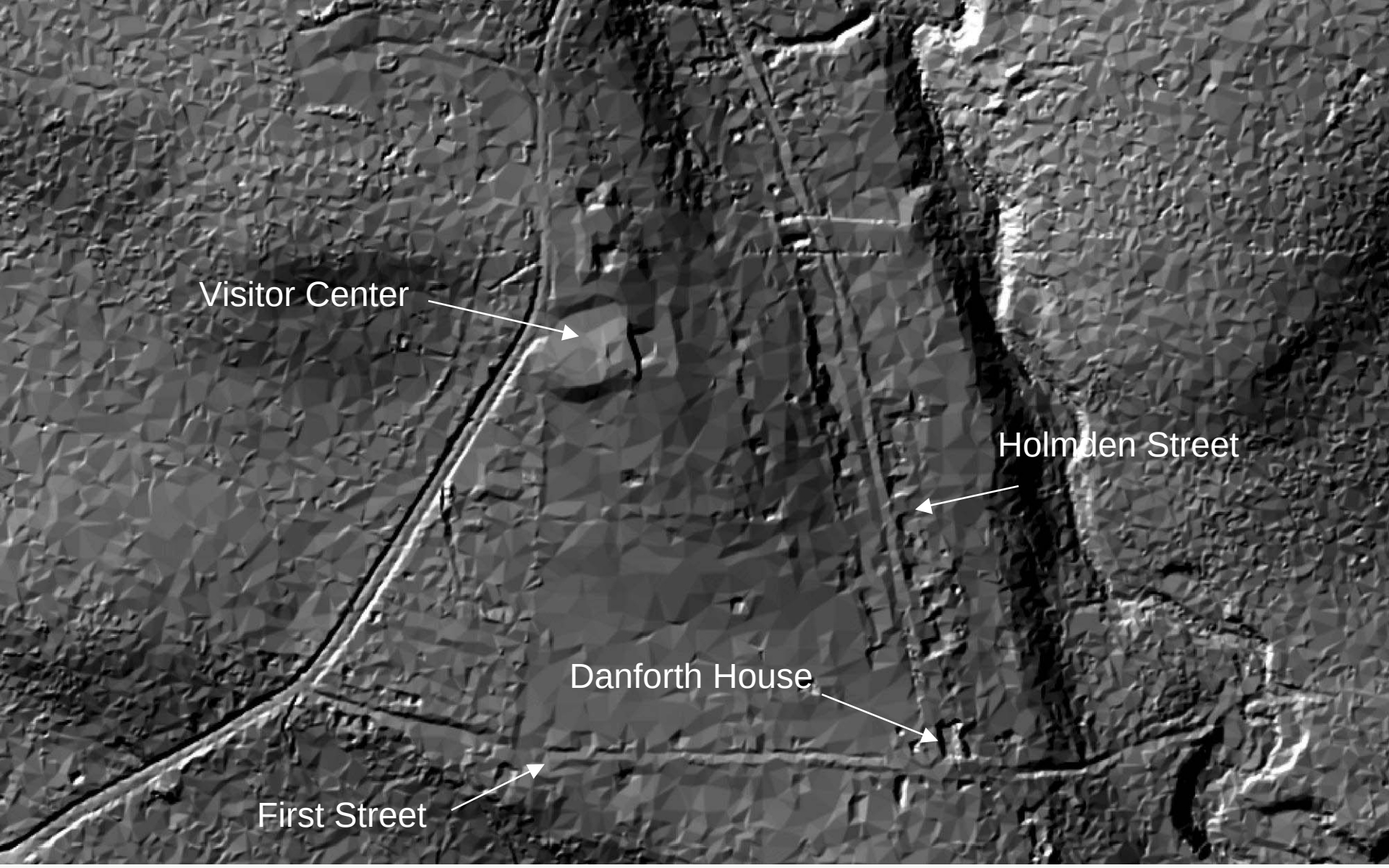
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



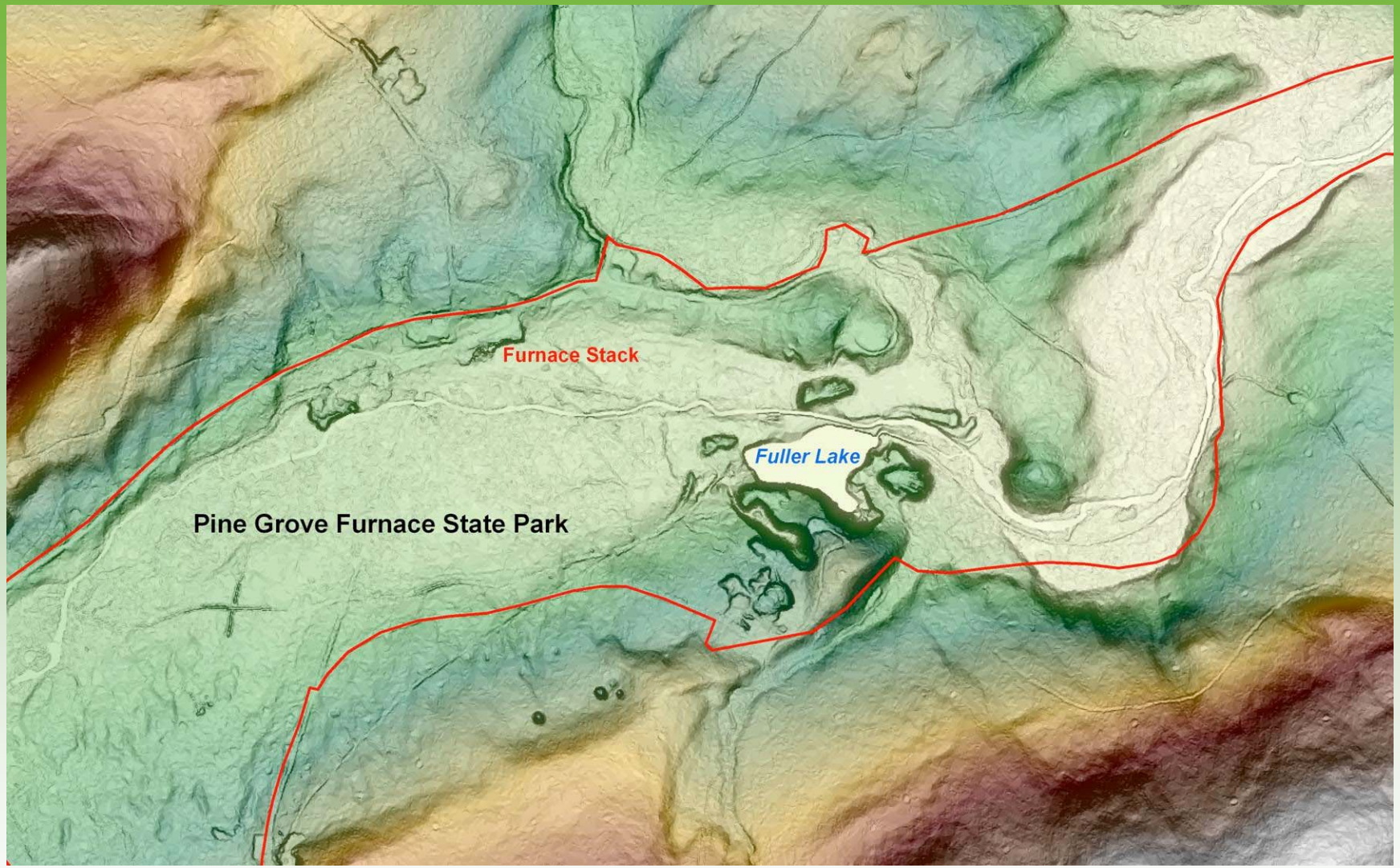
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES


Holmdem Street at Danforth
House looking north



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

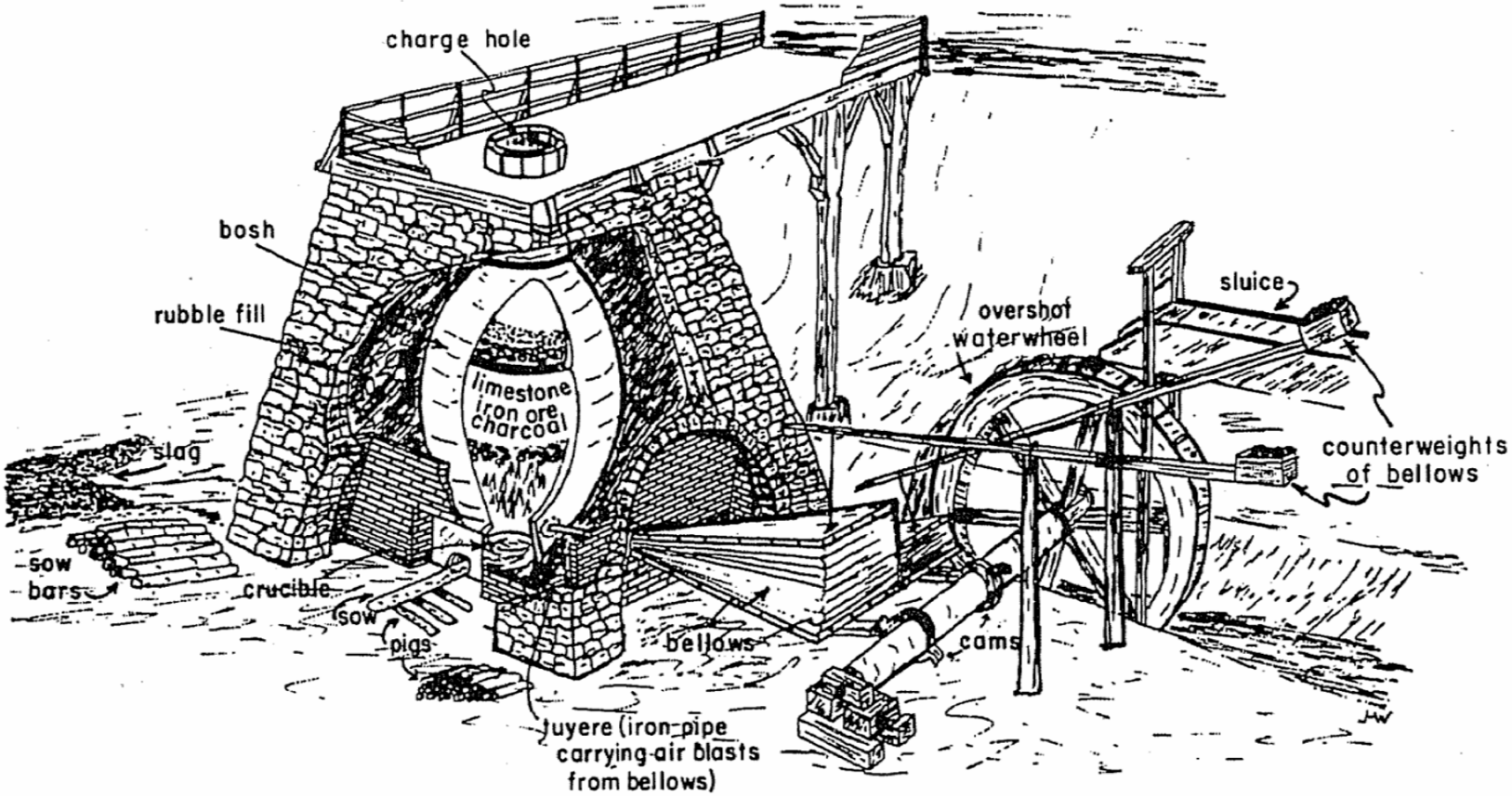


Figure 36. Sketch of a typical cold-blast furnace used to manufacture pig iron in colonial times (from Way, 1986, Figure 6-1, p. 12).

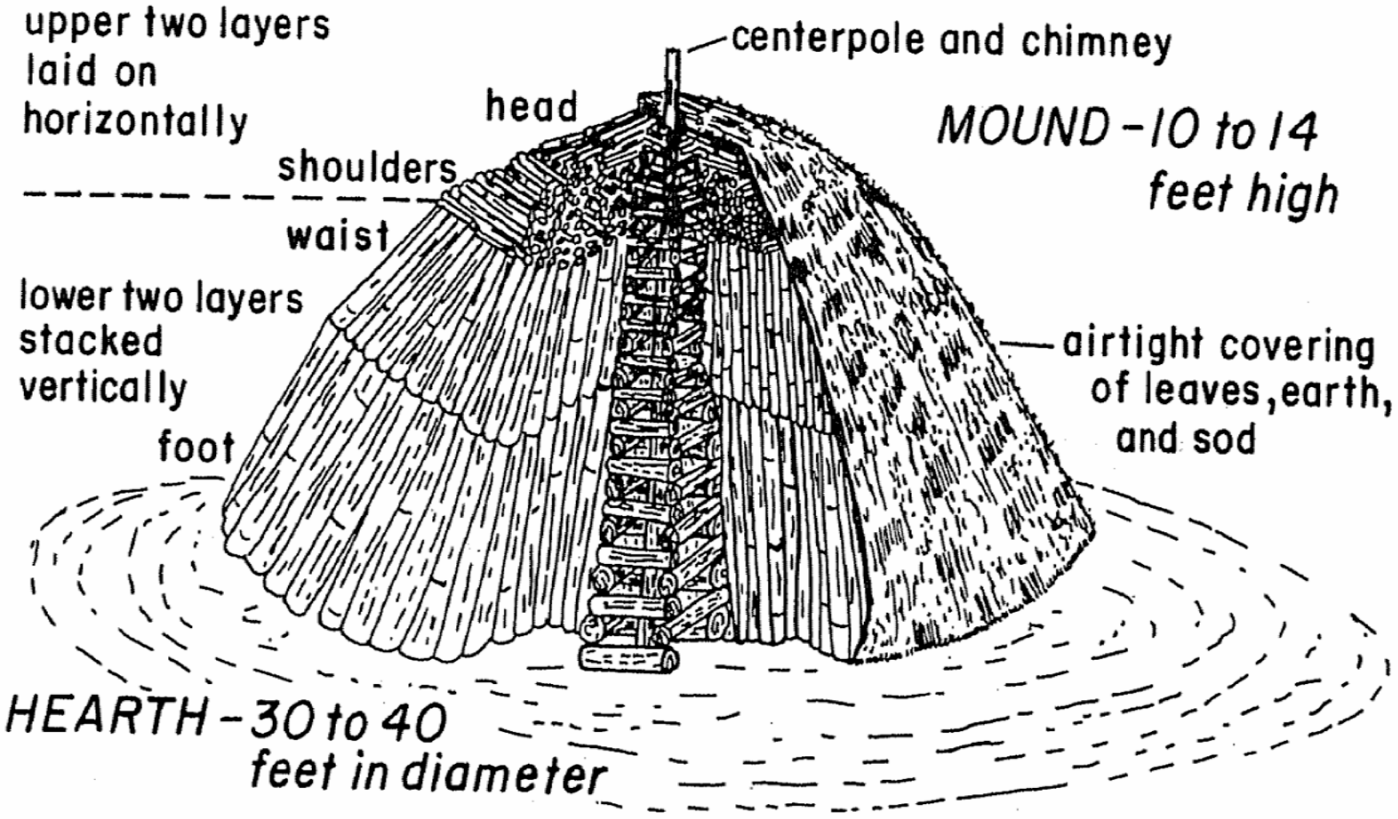
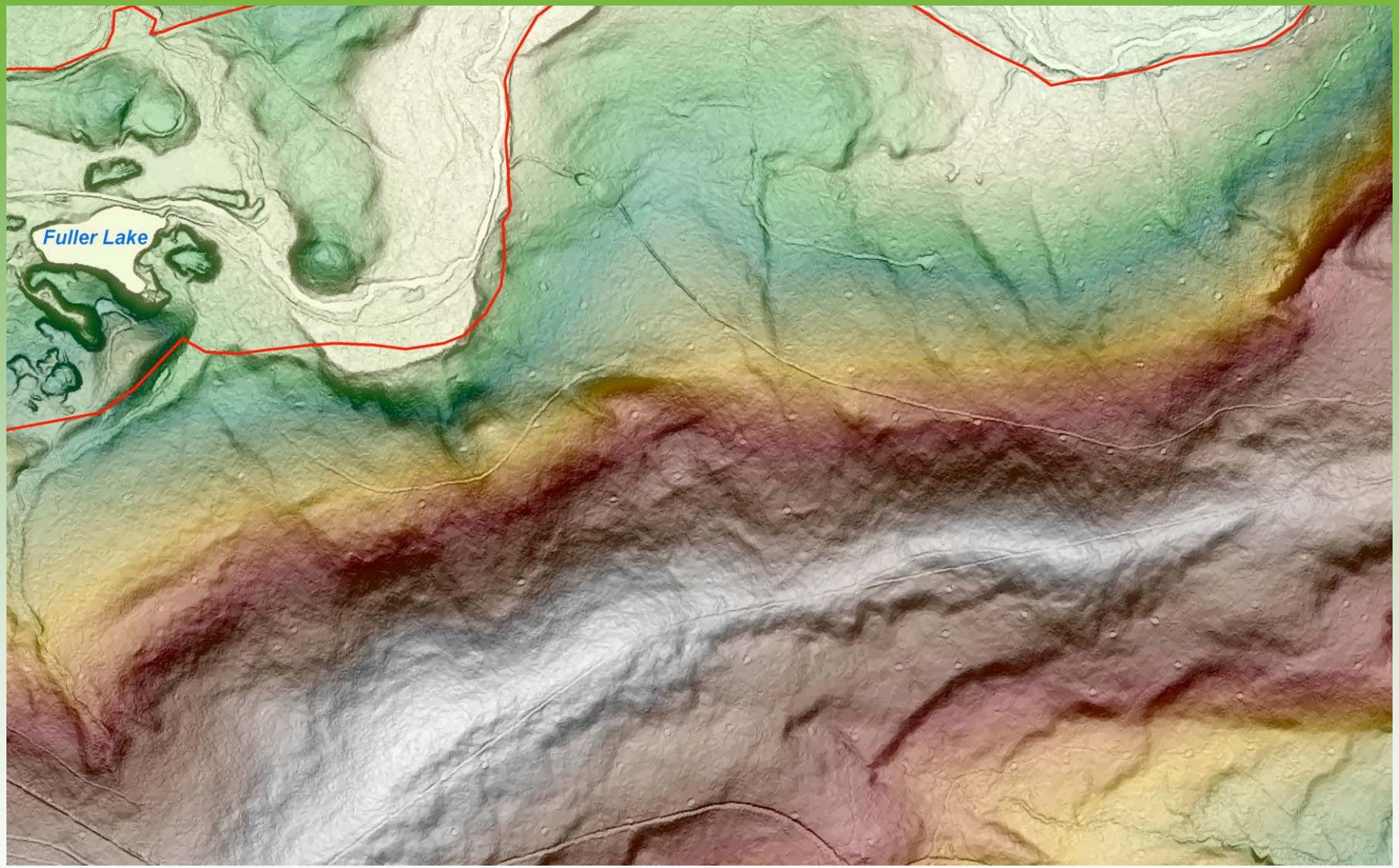
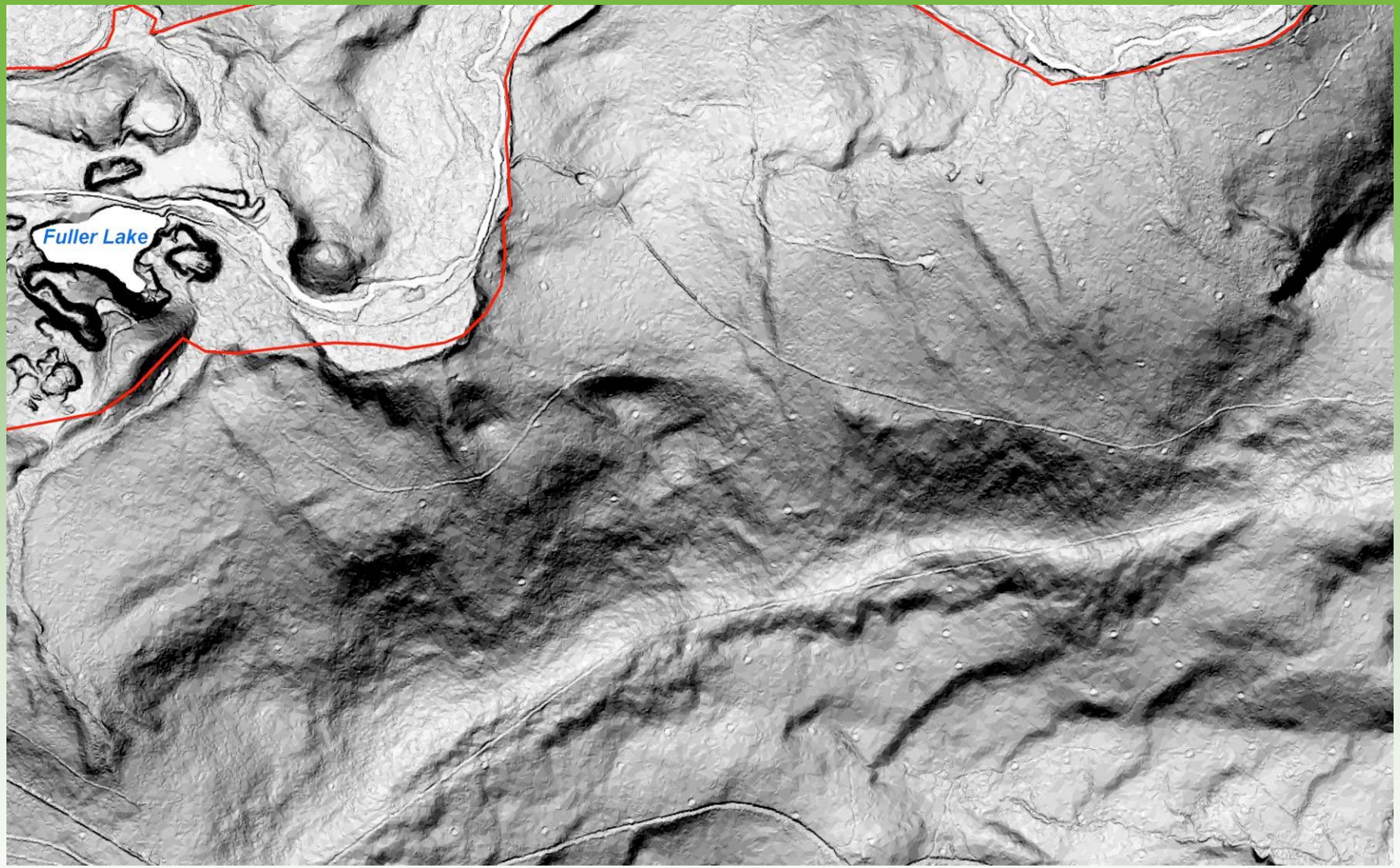


Figure 38. Sketch of a charcoal pit where timbers cut into 4-foot lengths are piled and "coaled." Charcoal produced in this manner was used as fuel for furnaces and forges of the area (Way, 1986, Figure 6-3, p. 12).



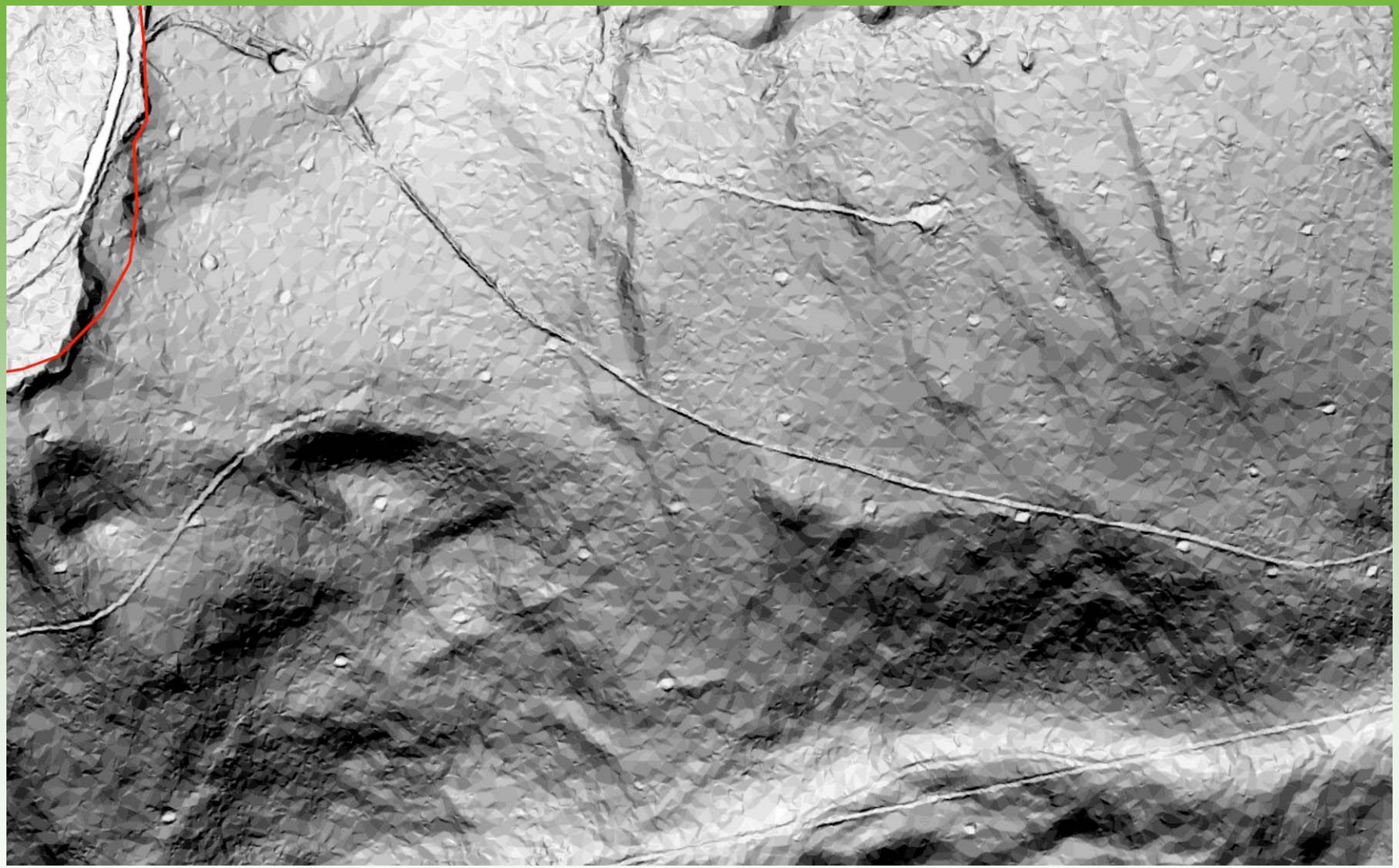
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



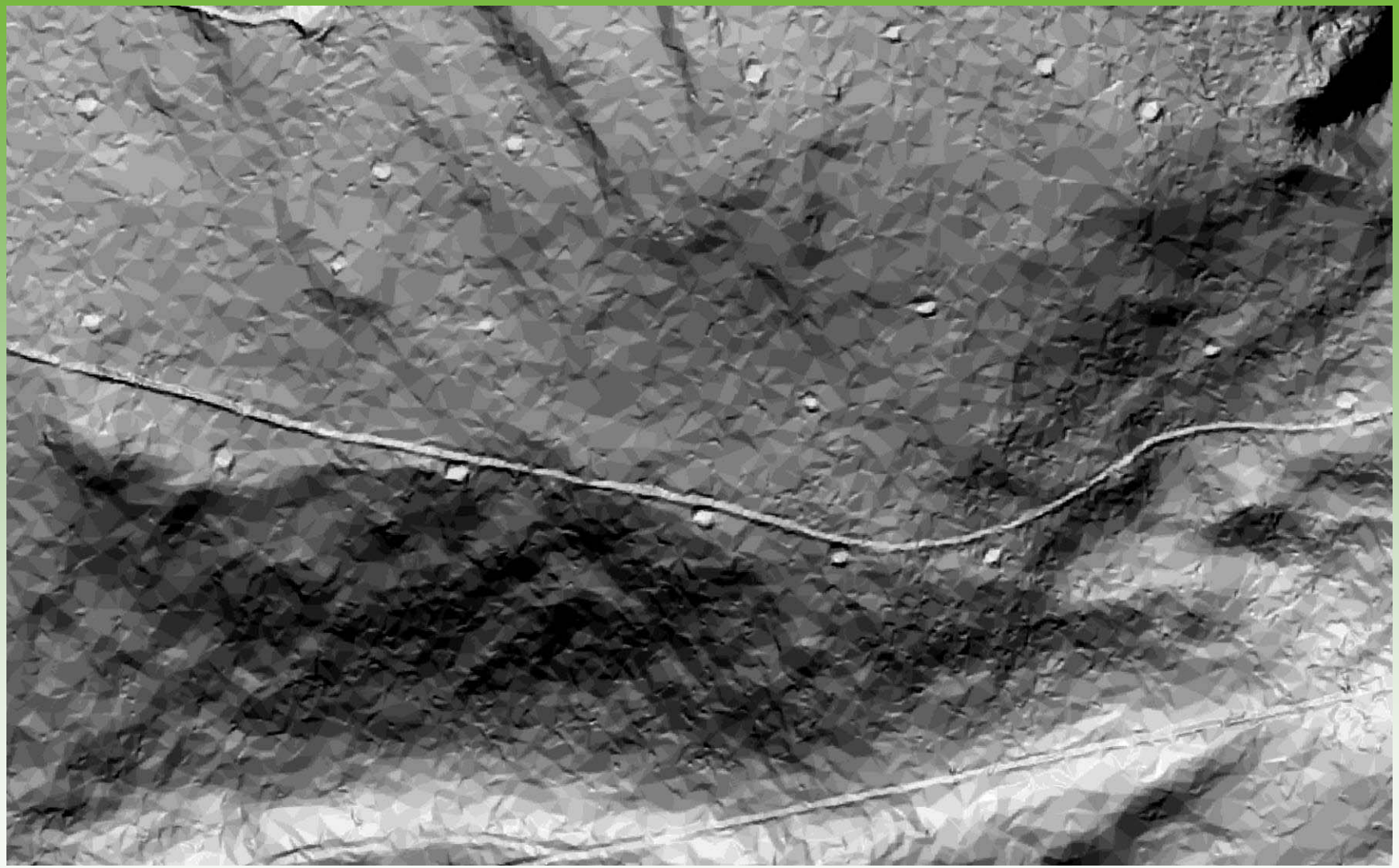
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



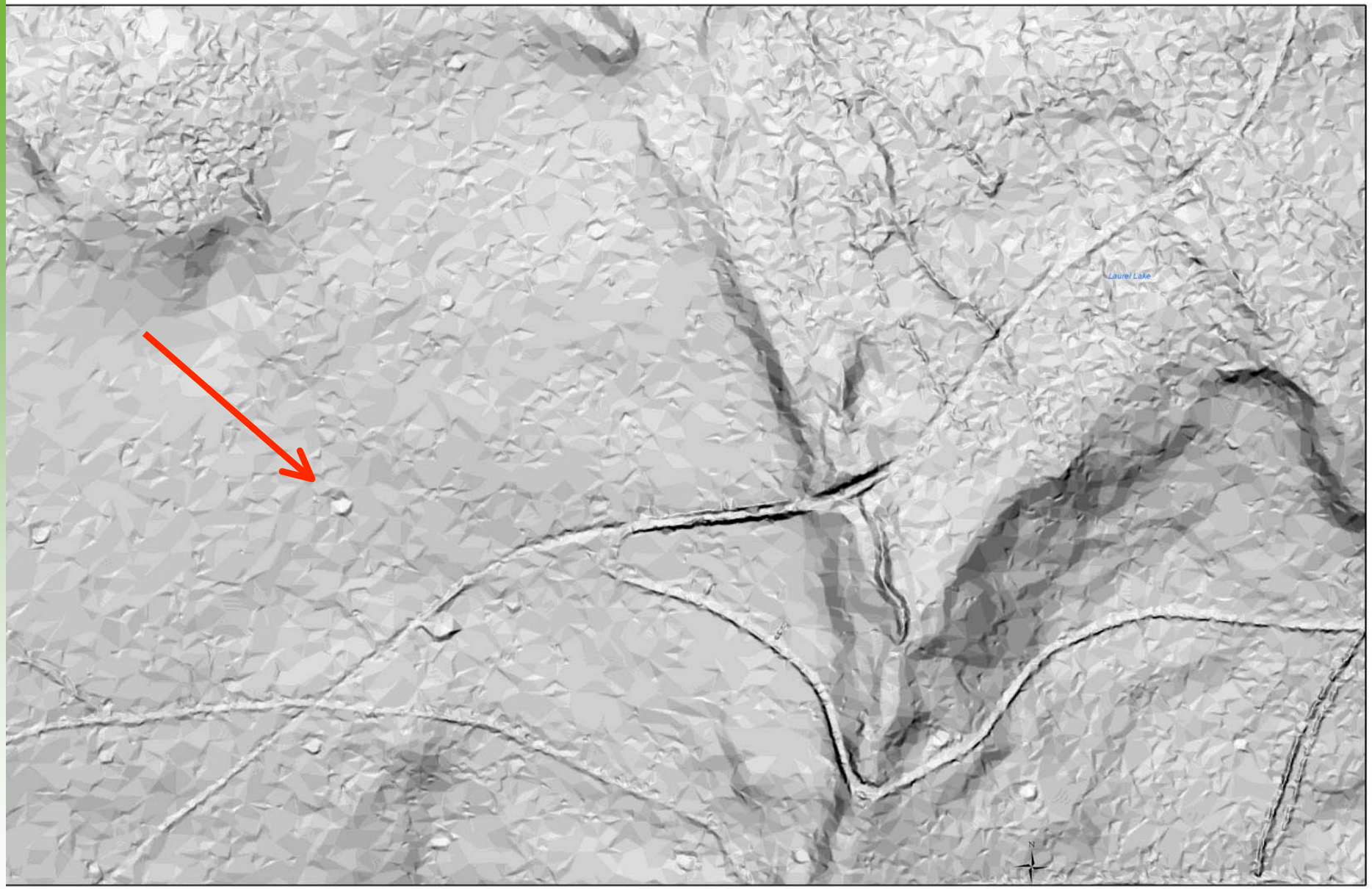
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES



Pine Grove Furnace State Park and vicinity
Cumberland County, PA
PAMAP orthoimagery and Lidar elevation data.

0 50100 200 300
Feet

Pine Grove Furnace State Park and vicinity
Cumberland County, PA
PAMAP orthoimagery and Lidar elevation data.

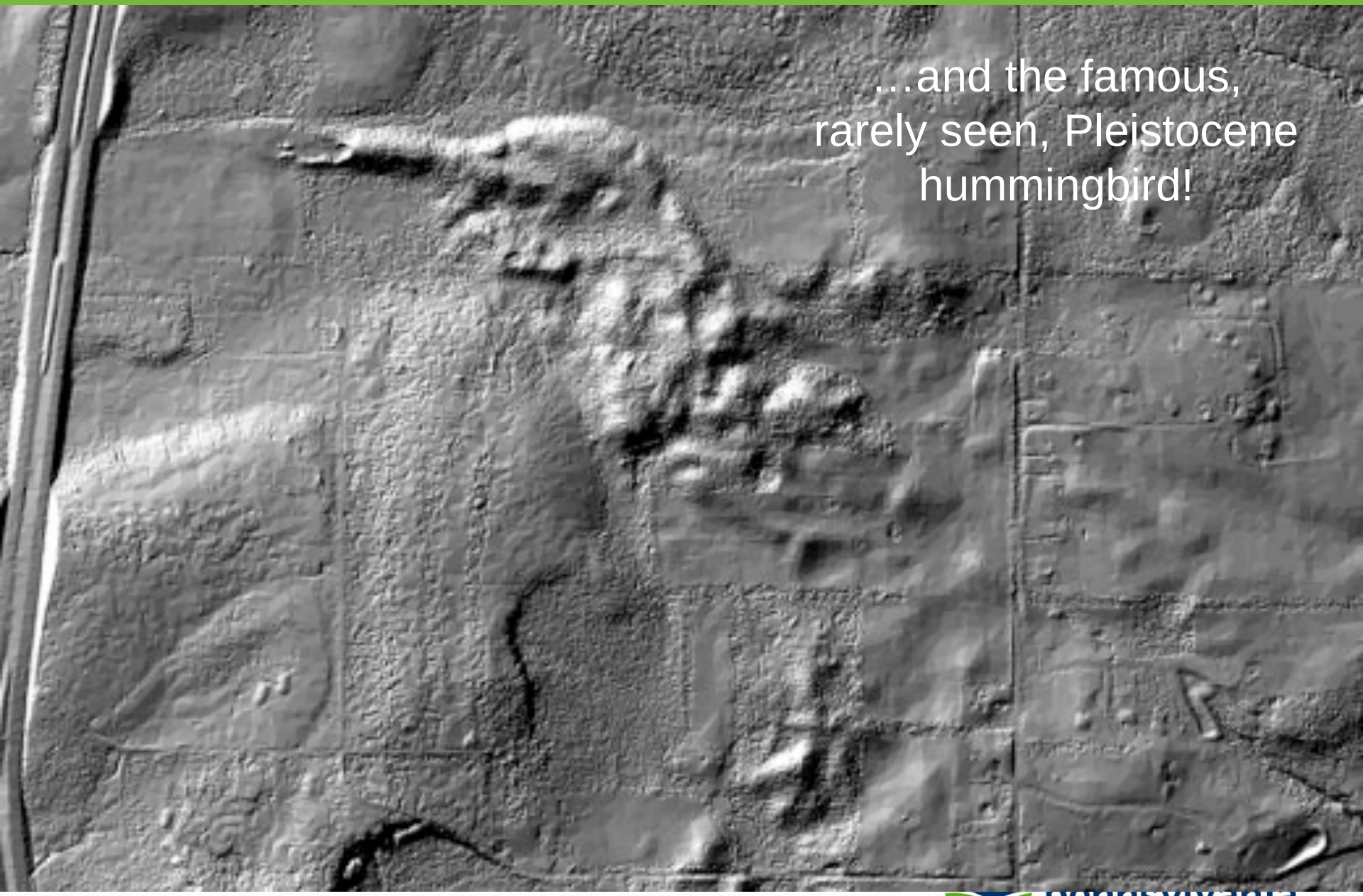
0 50100 200 300
Feet

AND NATURAL RESOURCES

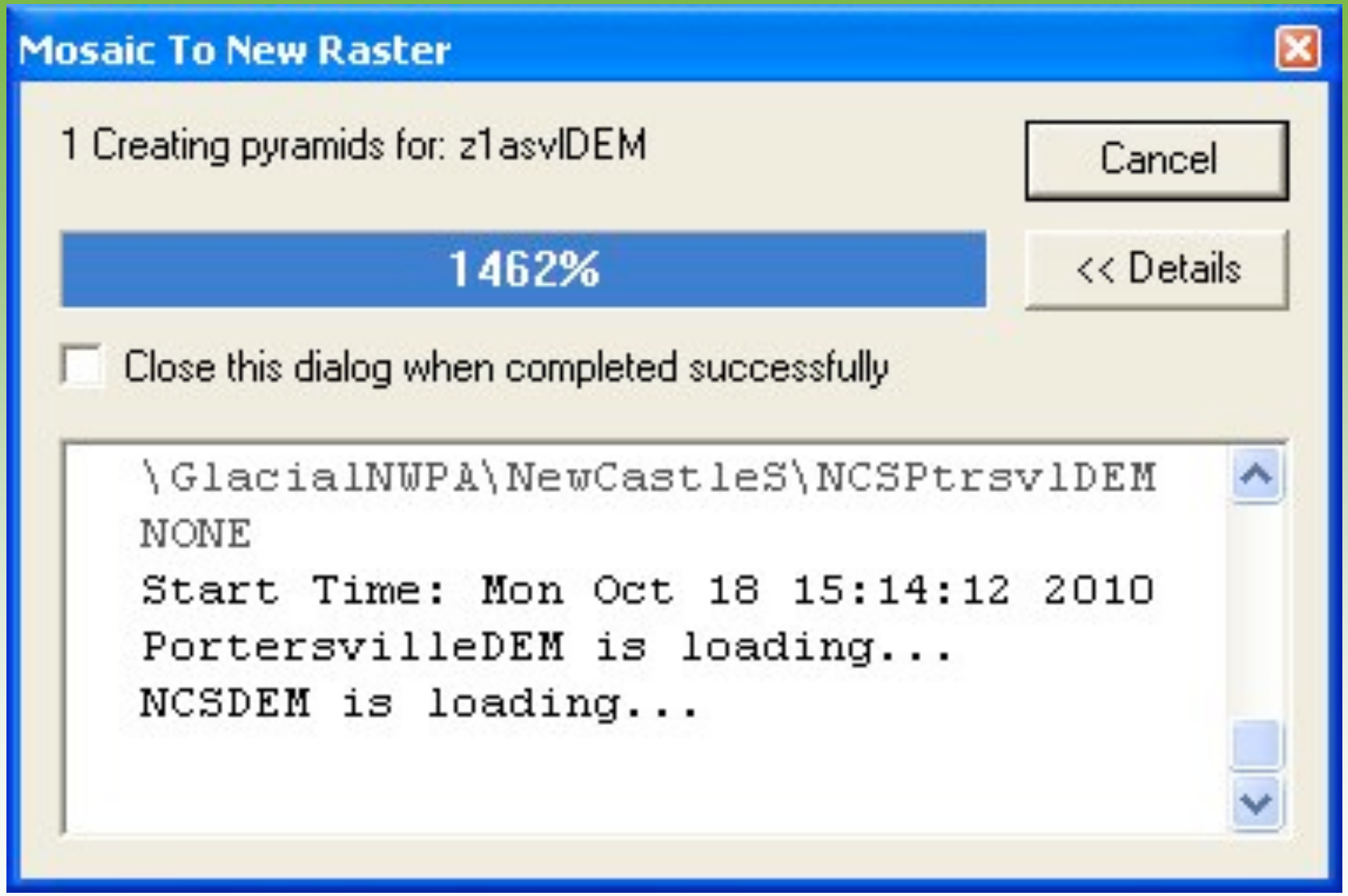
www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Surface View of Bombing Target


...and the famous,
rarely seen, Pleistocene
hummingbird!

"Mr. Osborne, may I be excused? My brain is full."



www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

Questions?

twhitfield@state.pa.us

www.dcnr.state.pa.us/topogeo

pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES