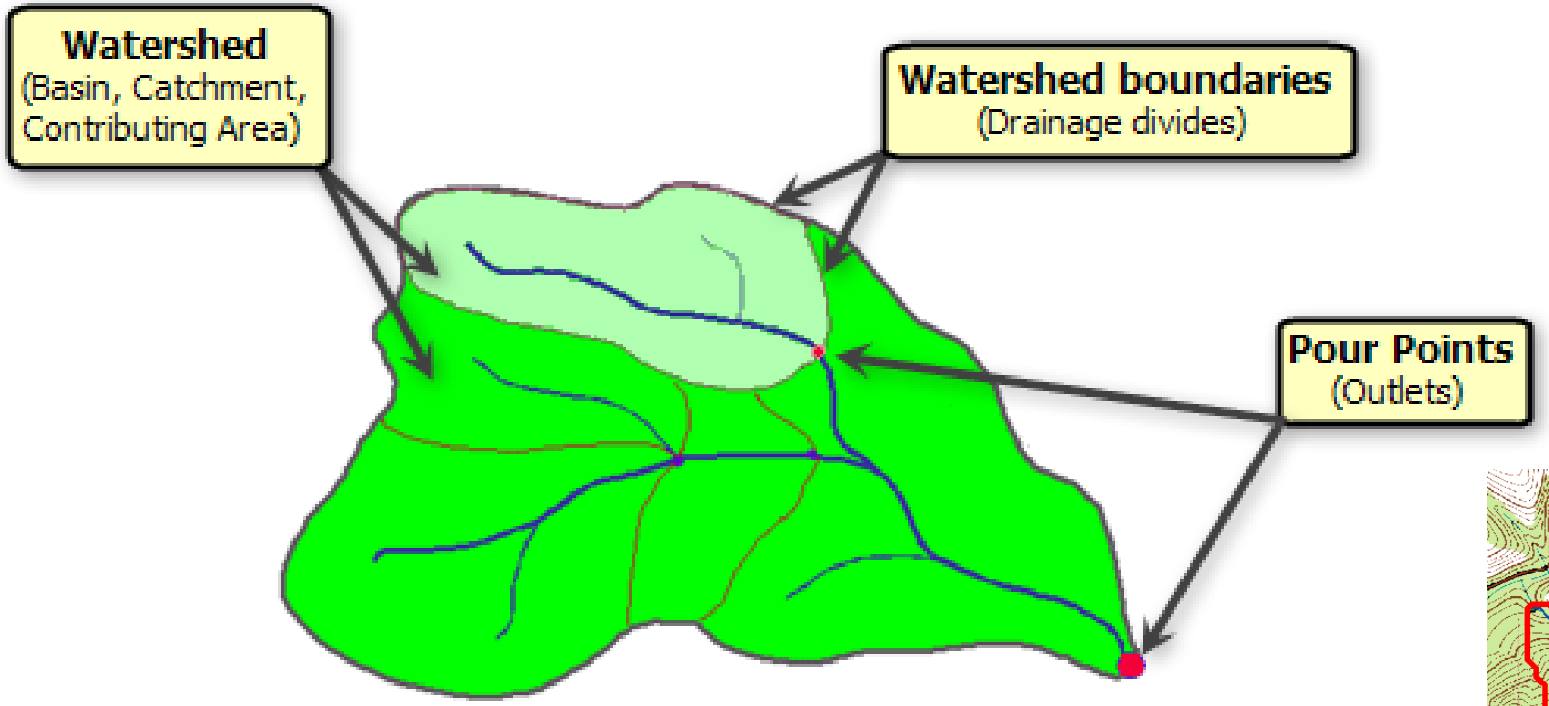
OpenTopography

TauDEM Processing Tools on OpenTopography and Visualization in QGIS

AGIC Short Course: Intro to Lidar, Data Access, and Processing with OpenTopography

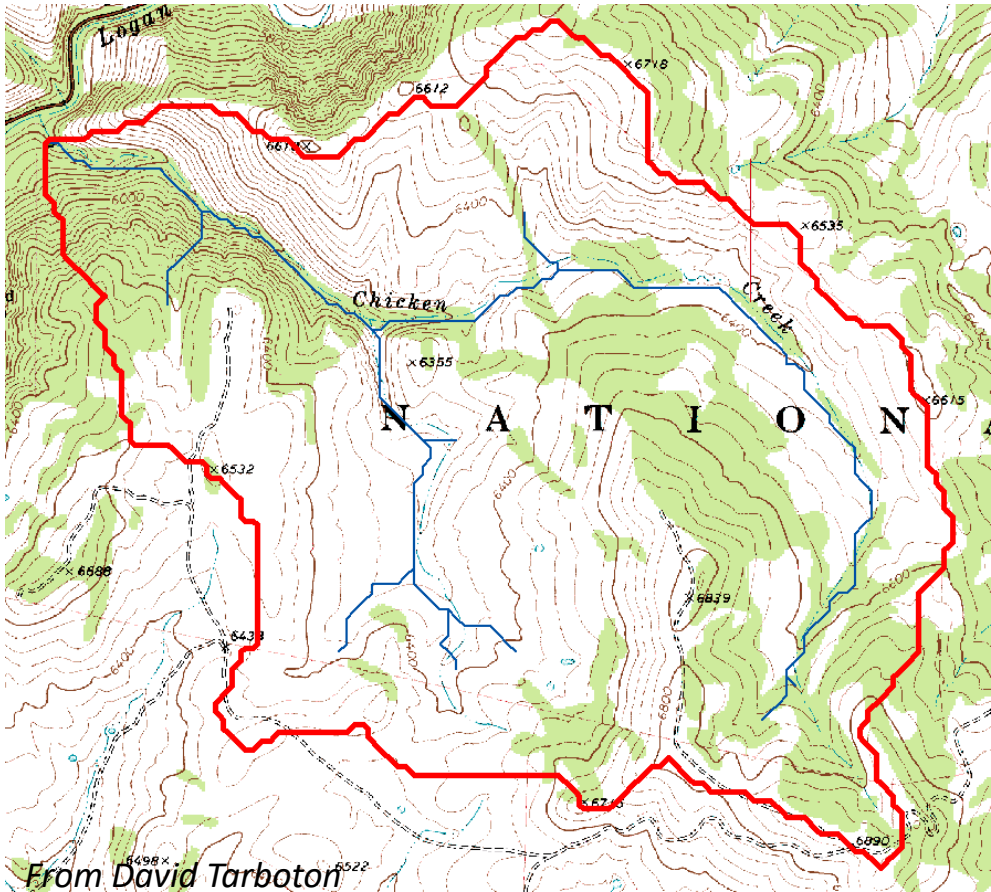
Wednesday, August 31, 2022

Watersheds

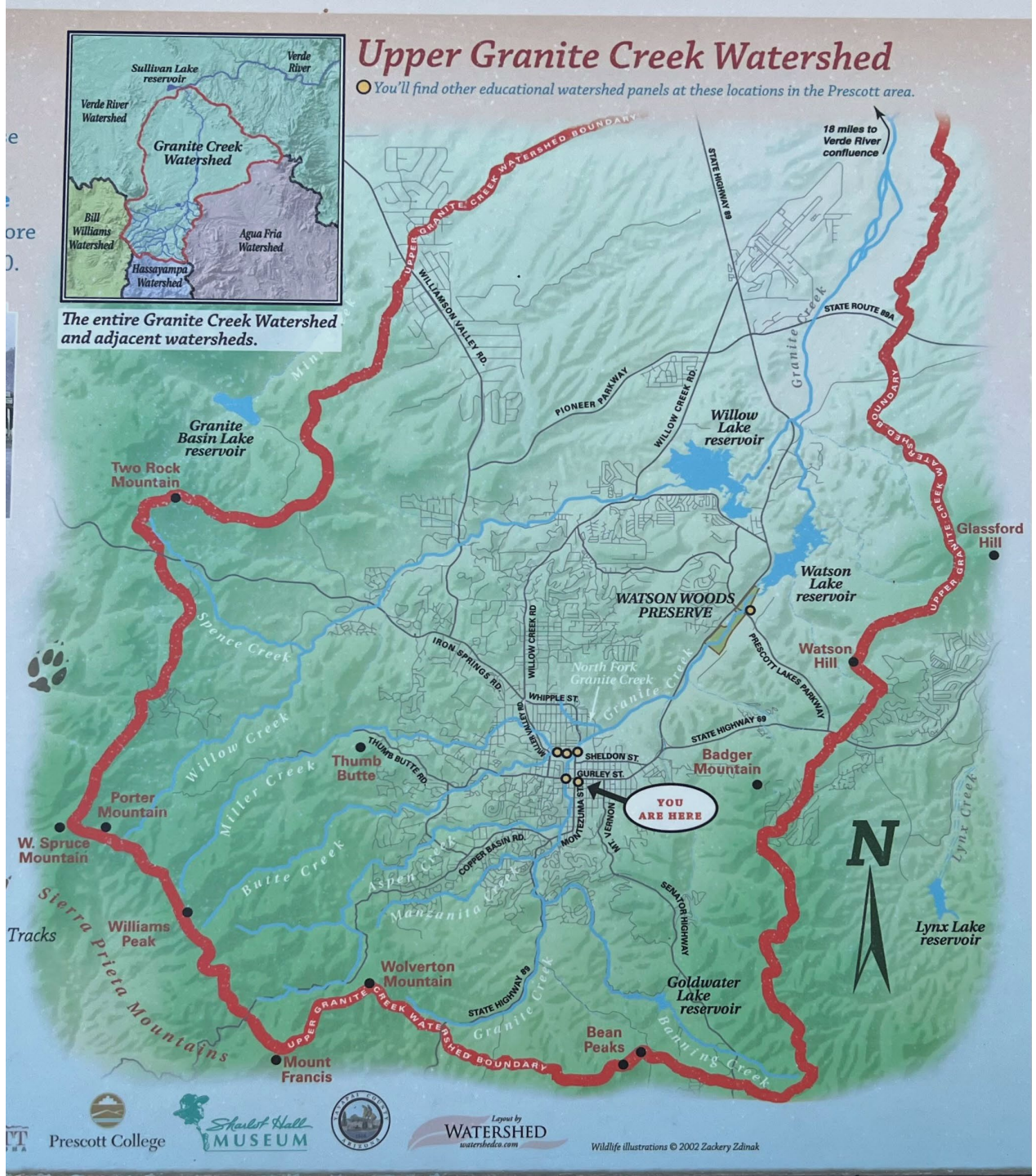


Credit: ArcMap

Topography defines the watershed, fundamental control on hydrology



From David Tarboton


Upper Granite Creek Watershed
You'll find other educational watershed panels at these locations in the Prescott area.
Sullivan Lake reservoir
Verde River
Verde River Watershed
Granite Creek Watershed
Bill Williams Watershed
Agua Fria Watershed
Hassayampa Watershed
The entire Granite Creek Watershed and adjacent watersheds.
18 miles to Verde River confluence
UPPER GRANITE CREEK WATERSHED BOUNDARY
STATE HIGHWAY 89
WILLIAMSON VALLEY RD.
PIONEER PARKWAY
WILLOW CREEK RD.
STATE ROUTE 89A
Granite Basin Lake reservoir
Two Rock Mountain
Willow Lake reservoir
Glassford Hill
Watson Lake reservoir
WATSON WOODS PRESERVE
Watson Hill
IRON SPRINGS RD.
WHIPPLE ST.
North Fork Granite Creek
PRESCOTT LAKES PARKWAY
STATE HIGHWAY 69
SHELDON ST.
GURLEY ST.
Badger Mountain
Thumb Butte
THUMB BUTTE RD.
YOU ARE HERE
Porter Mountain
W. Spruce Mountain
MONTEZUMA ST.
MT. VERNON
COPPER BASIN RD.
SENATOR HIGHWAY
Williams Peak
Wolverton Mountain
Goldwater Lake reservoir
Lynx Lake reservoir
Bean Peaks
Mount Francis
Granite Creek
Willow Creek
Miller Creek
Butte Creek
Aspen Creek
Manzanita Creek
Spence Creek
Lynx Creek
Banning Creek
Sierra Prieta Mountains
Tracks
N
Prescott College
Sharlot Hall MUSEUM
Layout by WATERSHED watershedco.com
Wildlife illustrations © 2002 Zackery Zdinak

Rasters, Digital Elevation Model (DEM)

0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0
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0	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	0
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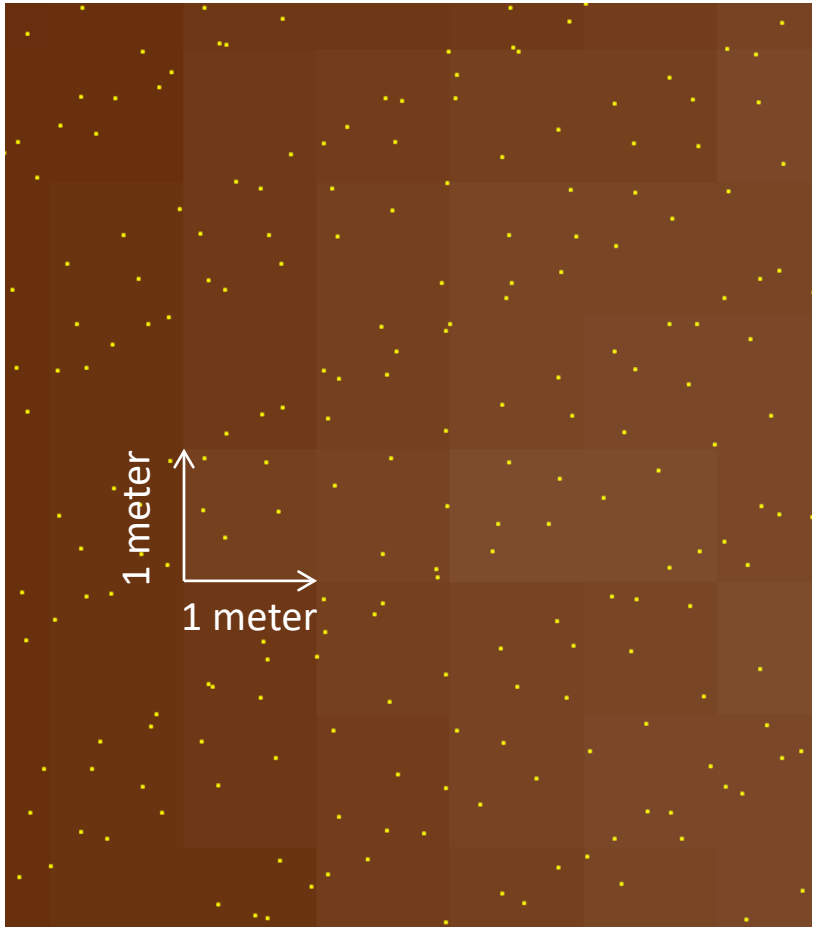
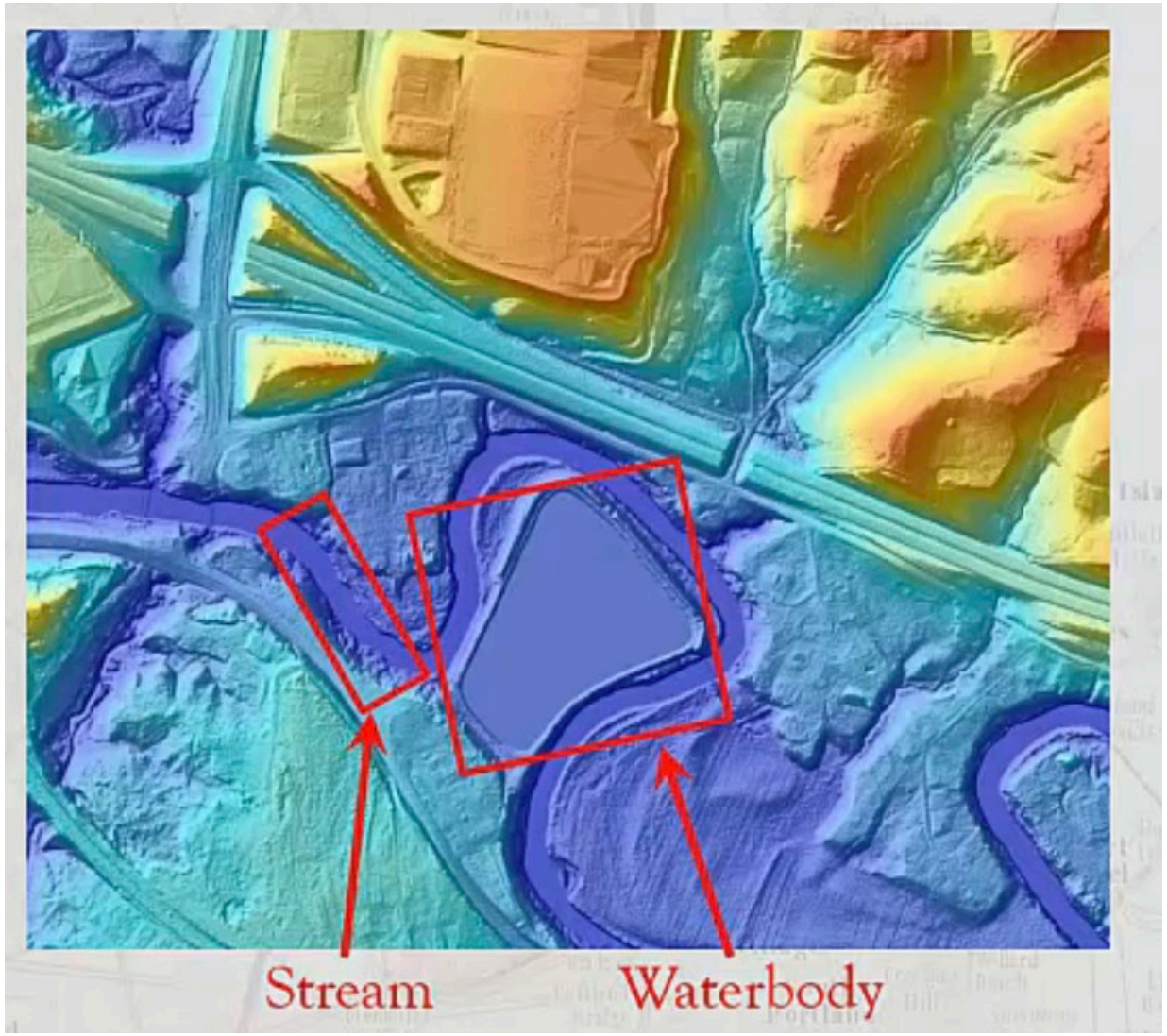


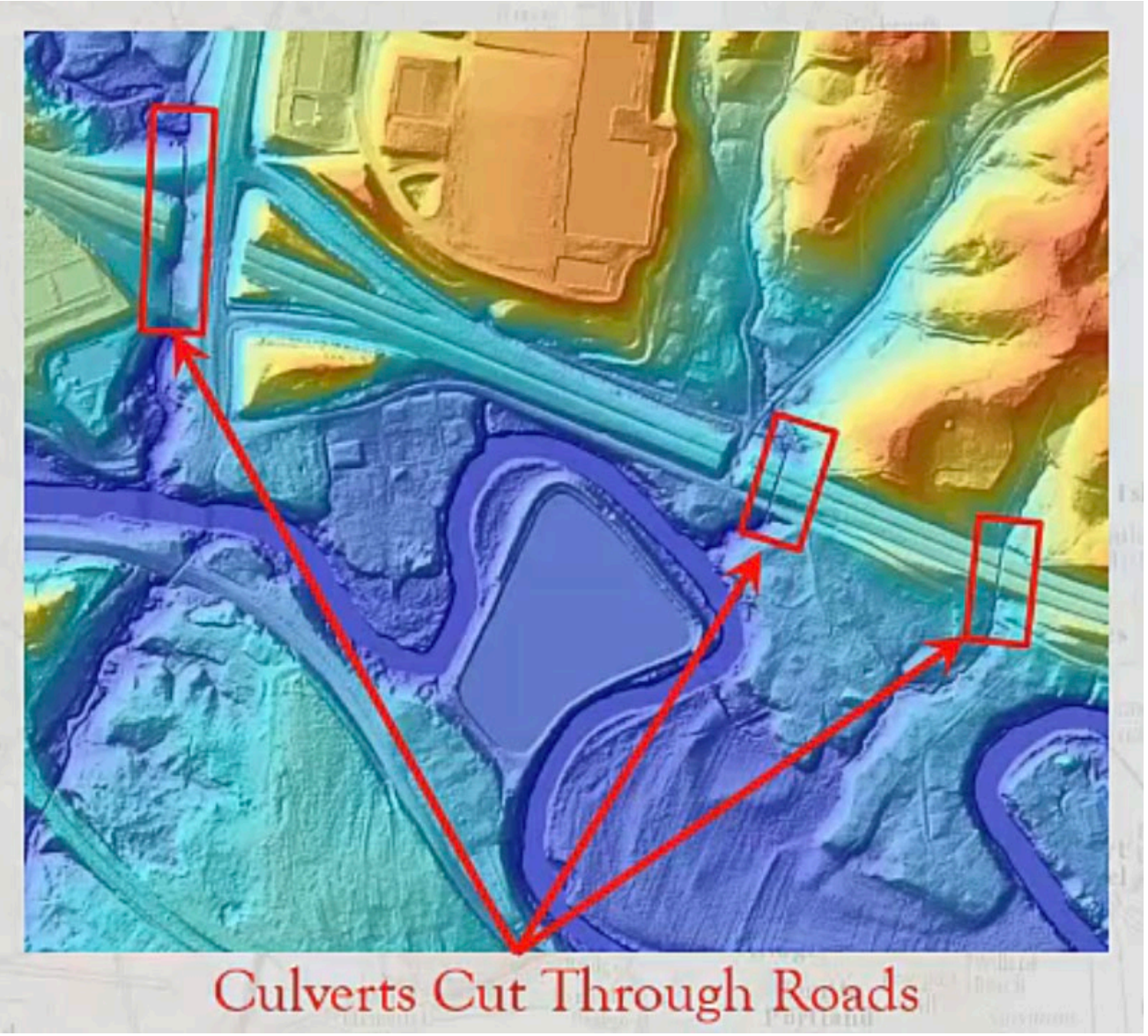
Source: http://www.ncgia.ucsb.edu/giscc/extra/e001/e001.html



Credit: USGS

Hydro-flattened DEMs

- Cartographic enhancement, removes lidar artifacts
- Waterbodies are considered to have a single elevation
- Elevation is estimated from the adjacent terrain and is not representative of any measured water



Hydrologically Enforced DEMs

- Modified so waterbodies are level and streams flow downhill
- Contains surface modifications to allow water to flow across the surface, as it does in the real world
  - Road fills are cut through at drainage culverts

Credit: USGS

TauDEM (**T**errain **A**nalysis **U**sing **D**igital **E**levation **M**odels)

Suite of Digital Elevation Model (DEM) tools to extract and analyze hydrologic information from topography

Many of these tools are available on OpenTopography for high resolution and global topography datasets

OpenTopography's guided browser-based tools generate these TauDEM products in the cloud, which can be visualized in GIS software

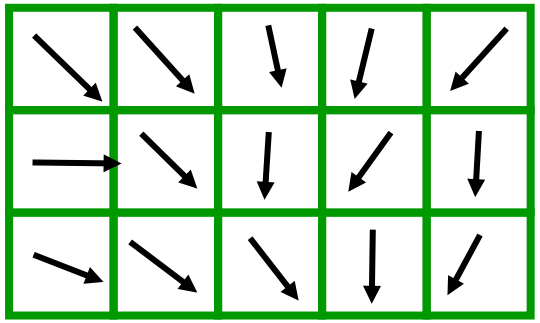
From David Tarboton

TauDEM Workflow

Raw DEM

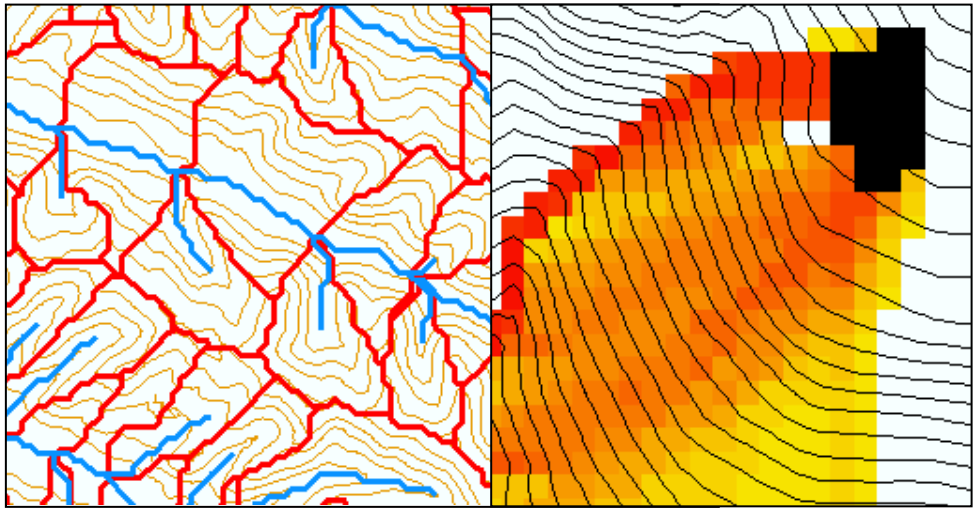
Pit Removal (Filling)

Flow Field



- D8
- D-Infinity

Channels, Watersheds, Flow Related Terrain Information



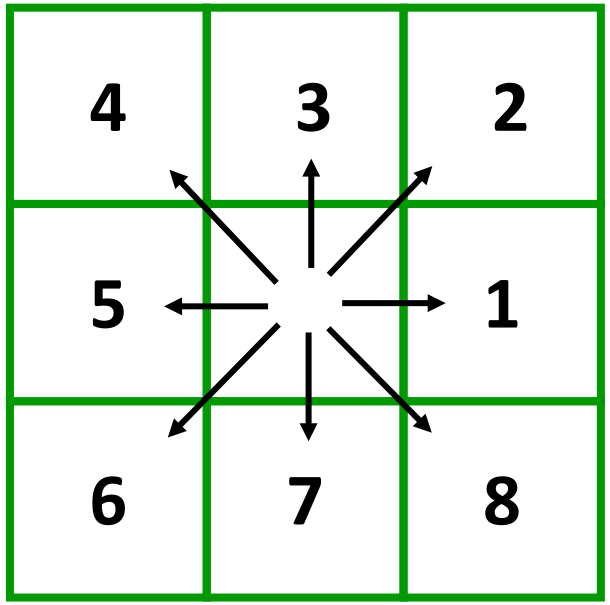
OpenTopography

SDSC SAN DIEGO SUPERCOMPUTER CENTER

Supercomputer resources are available to all users via a user-friendly web browser interface

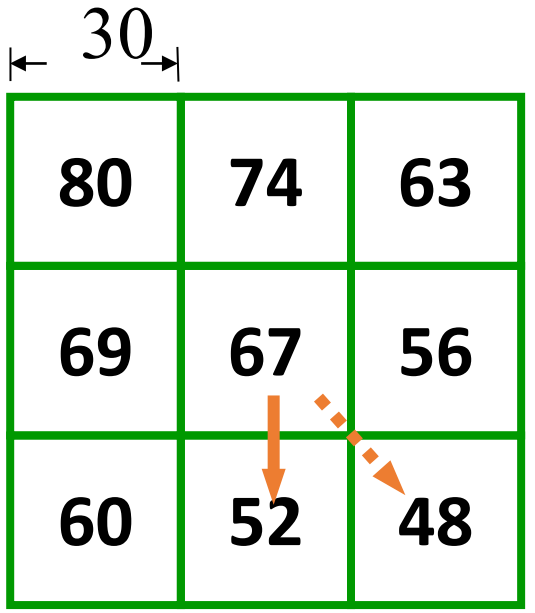
D8 Flow Direction

- Simplest model for water flow
- Models flow direction from each cell to its steepest downslope neighbor
- Encoded as a number 1 – 8



Flow Direction Coding:
1 – East
2 – Northeast
3 – North
4 – Northwest
5 – West
6 – Southwest
7 – South
8 - Southeast

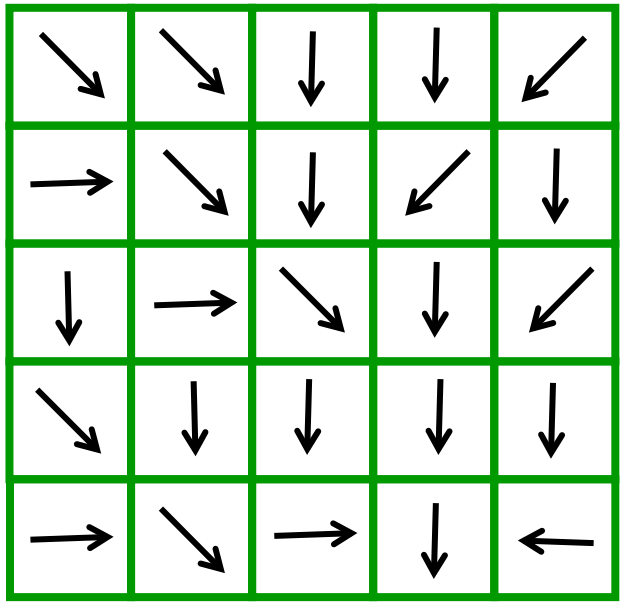
From David Tarboton

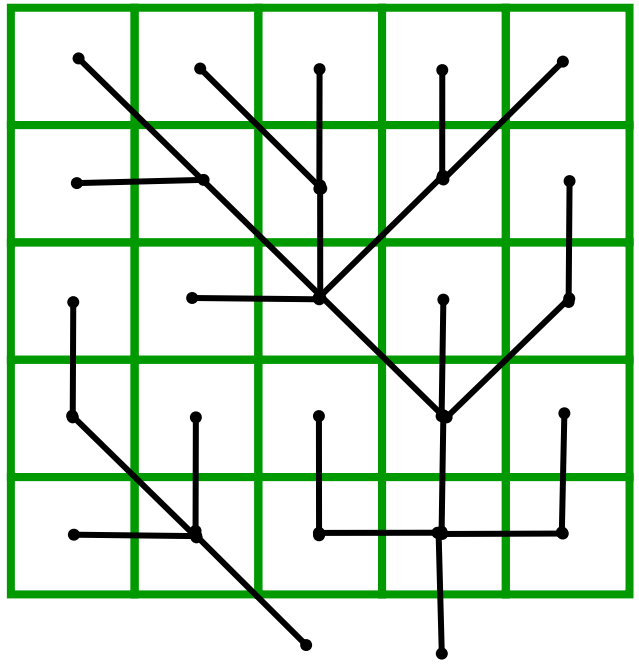


$$\frac{67-52}{30}=0.50$$

$$\frac{67-48}{30\sqrt{2}}=0.45$$

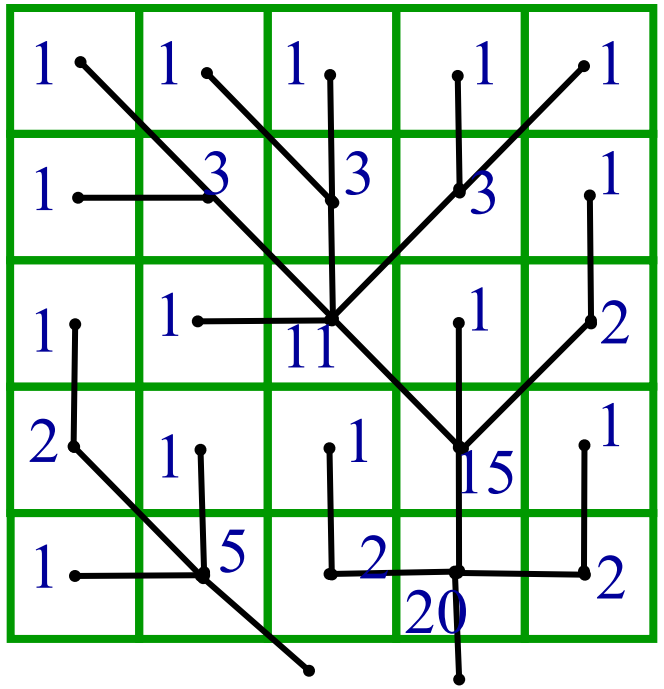
Grid Network





Contributing Area (Flow Accumulation)

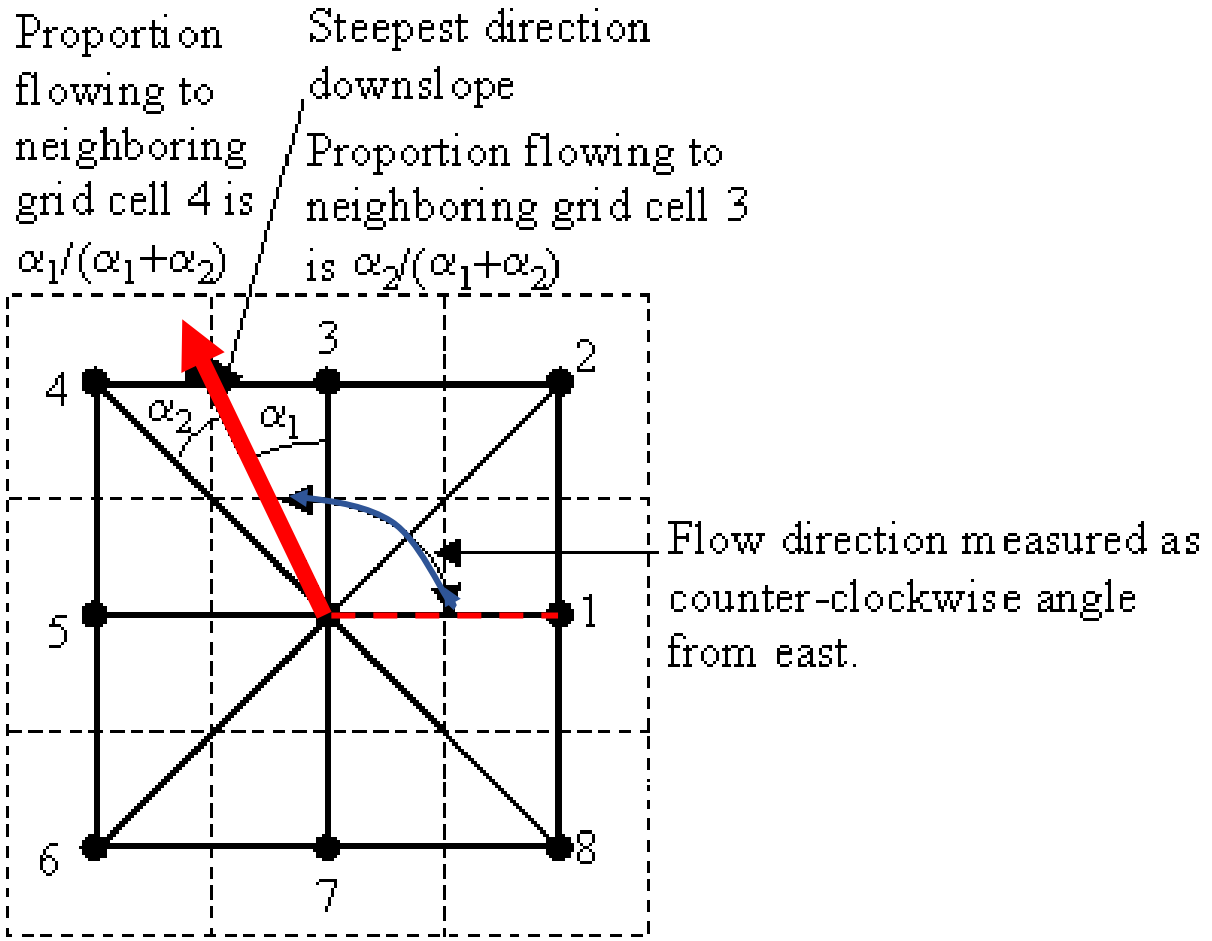
1	1	1	1	1
1	3	3	3	1
1	1	11	1	2
2	1	1	15	1
1	5	2	20	2



From David Tarboton

D-Infinity Flow Direction

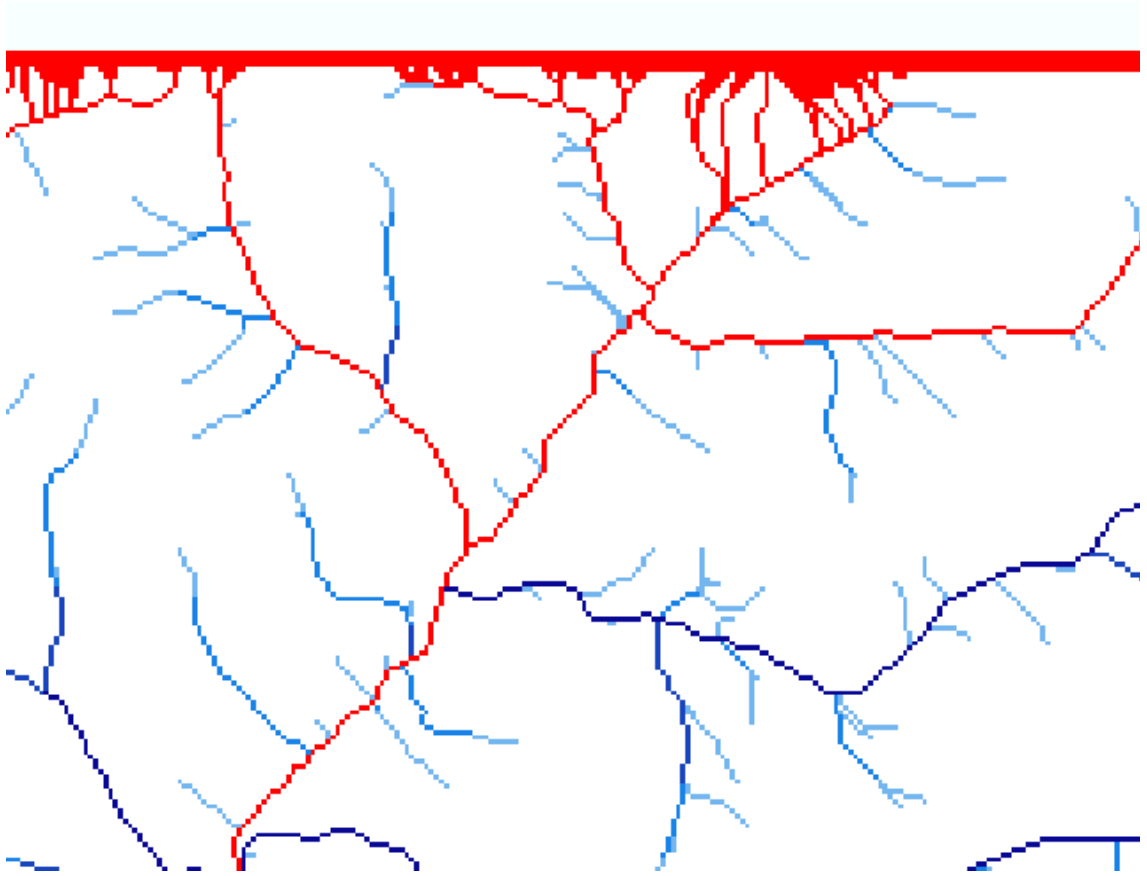
- Calculates steepest outward flow direction, distributes flow between neighboring grid cells based on flow direction angles
- Encoded as an angle in radians counter-clockwise from East between 0 and 2 pi



Numbers 1-8 represent grid cells, not direction like D8 method

Edge Contamination

- Occurs when the contributing area may be underestimated due to grid cells outside of the domain not being counted
- Ensure that DEM area selected includes all of headwater region, or trunk streams may result in “no data”



From David Tarboton

Mapping of San Gabriel Mountains, CA 2009 Fire

DOI: https://doi.org/10.5069/G94M92N4
OT Collection ID: OT.012019.26911.1
OT Collection Name: Mapping of San Gabriel Mountains, CA 2009 Fire
Short Name: CA09_Heimsath
Collection Platform: Airborne Lidar

Metadata Download:
- ISO 19115 (Data)
- Plain Text

Download and Access Products:

Point Cloud Data | Bulk Download **opentopoID**: OTLAS.012019.26911.1

Raster Data | Bulk Download **opentopoID**: OTSDEM.012019.26911.1

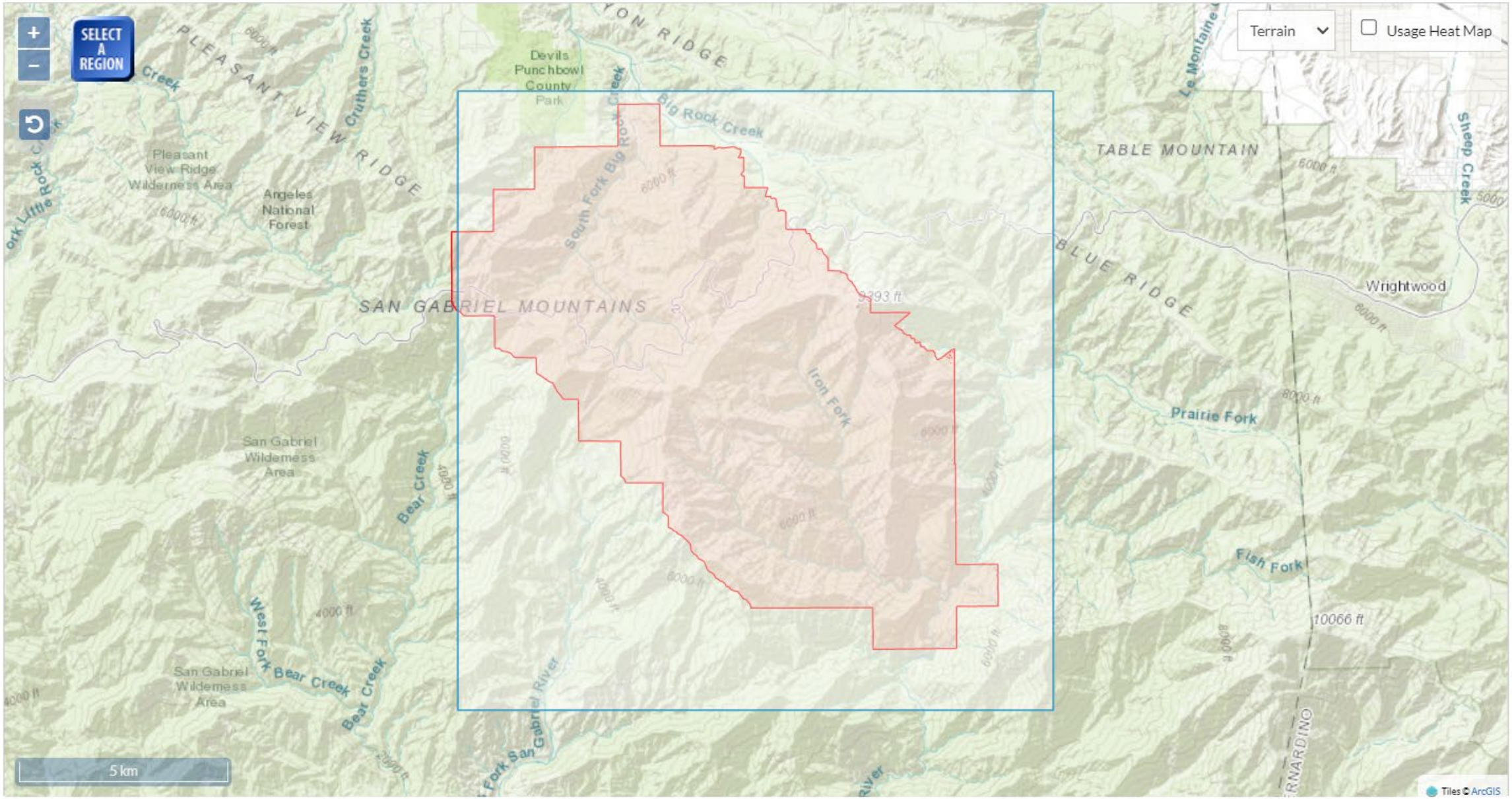
https://doi.org/10.5069/G94M92N4

Collection Overview: Survey conducted by NCALM for investigators Arjun Heimsath and Kelin Whipple, Arizona State University; Michael Lamb, California Institute of Technology; and Ken Hudnut, U.S. Geological Survey, through funding from their institutions to investigate tectonics and geomorphology of the San Gabriel Mountains, California.

Dataset Acknowledgement: Any use of this data should acknowledge lidar data acquisition and processing completed by the National Center for Airborne Laser Mapping (NCALM). NCALM funding provided by NSF's Division of Earth Sciences, Instrumentation and Facilities Program (EAR# 1830734).

Dataset Citation: Heimsath, A., Hudnut, K., Lamb, M., Whipple, K. (2019). Mapping of San Gabriel Mountains, CA 2009 Fire. National Center for Airborne Laser Mapping (NCALM), Distributed by OpenTopography. https://doi.org/10.5069/G94M92N4.. Accessed: 2022-08-22

1a. Select area of data to download or process



1. Coordinates & Classification

Horizontal Coordinates: NAD83 / UTM Zone 11N [EPSG: 26911]
Vertical Coordinates: NAVD88 [EPSG: 5703]
Units: meter

Data Selection Coordinates: ☐ Manually enter selection coordinates (in the horizontal coordinate system listed above)

X_{min} = 420173.053934 Y_{min} = 3792626.445341 X_{max} = 434302.602724 Y_{max} = 3807234.659877

The selection area contains 133,616,327 points.

Choose Return Classification ☐ Building ☑ Ground ☐ Unclassified

2. Point Cloud Data Download

☑ Point cloud data in LAZ format ☐ Point cloud data in LAS format ☐ Point cloud data in ASCII format

3A. DEM Generation (TIN)

Gridding Method
☑ Calculate TIN

Gridding Parameters
Grid Resolution (Default = 1 meter) 10
Max. triangle size (Default 50 units) 50

Grid Format
GeoTiff

7. Hydrologic Terrain Analysis Products (tauDEM)

- Hydrologically correct DEM with pits filled
- D-Infinity Flow Direction
- D8 Flow Direction:
- D-Infinity Specific Catchment Area
- D8 Contributing Area
- Topographic Wetness Index

Dataset Citation: Heimsath, A., Hudnut, K., Lamb, M., Whipple, K. (2019). Mapping of San Gabriel Mountains, CA 2009 Fire. National Center for Airborne Laser Mapping (NCALM), Distributed by OpenTopography. https://doi.org/10.5069/G94M92N4.. Accessed: 2022-08-22

Use License: CC BY 4.0

Job Id	Dataset	Title	Submission	Completion	Duration	Num. Points	Final Status
pc1661208983891	CA09_Heimsath	SanGab 10m all	2022-08-22 22:56:24	2022-08-22 23:14:19	1075 secs	133,616,327	Done ✔

18 min

Download Data

Point Cloud Results	• Download point cloud data in LAZ format points.laz (555.5 MB)
DEM Results	• Download DEM (TIN) output.tin.tar.gz (3.1 MB)
TauDEM Products	• Download PitRemove file pitRemove.tar.gz (3.1 MB) • Download D-Infinity: Flow Direction file dinfFlowDirection.tar.gz (3.3 MB) • Download D-Infinity: Slope file dinfSlope.tar.gz (3.6 MB) • Download D-Infinity Specific Catchment Area file Dinfarea.tar.gz (3.6 MB) • Download Topographic Wetness Index file TWI.tar.gz (3.5 MB) • Download D8 - Flow Direction file d8FlowDirection.tar.gz (343.7 KB) • Download D8: Slope file d8Slope.tar.gz (3.2 MB) • Download D8 Contributing Area file D8area.tar.gz (1.1 MB)

1. Coordinates

RASTER

Horizontal Coordinates: NAD83 / UTM Zone 11N [EPSG: 26911]
Vertical Coordinates: NAVD88 [EPSG: 5703]
Units: meter

Data Selection Coordinates: ☐ Manually enter selection coordinates (in the horizontal coordinate system listed above)

2. Data Output Formats

Select Data Output Format: GeoTiff

3. Layer Types & Additional SRTM Data

Digital Elevation Models (DEMs)

Digital Terrain Model (DTM) ☑

Digital Surface Model (DSM) ☐

Include Global 30m SRTM Data ☐

7. Hydrologic Terrain Analysis Products (tauDEM)

☑ Hydrologically correct DEM with pits filled

☑ D-Infinity Flow Direction

☑ D8 Flow Direction:

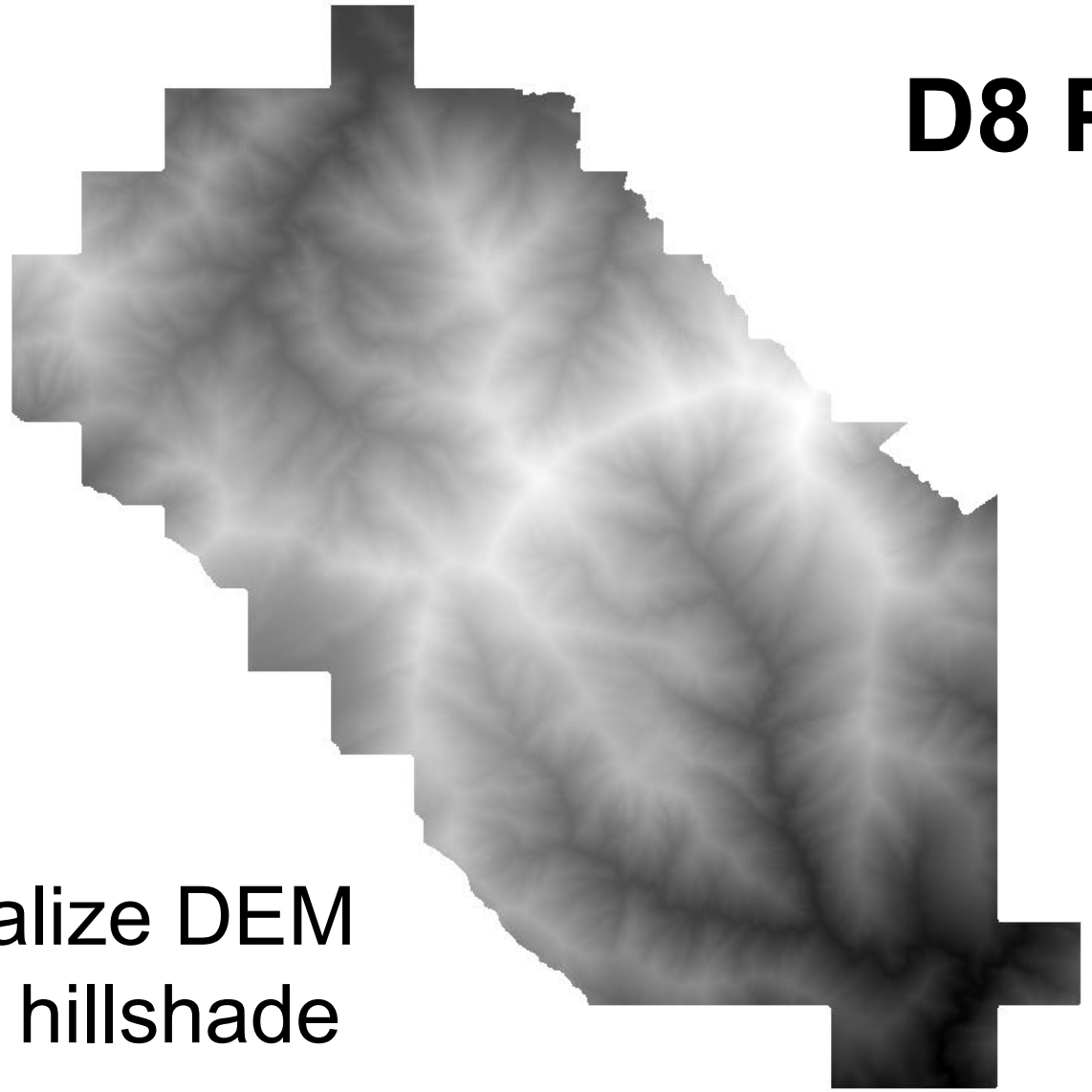
☑ D-Infinity Specific Catchment Area

☑ D8 Contributing Area

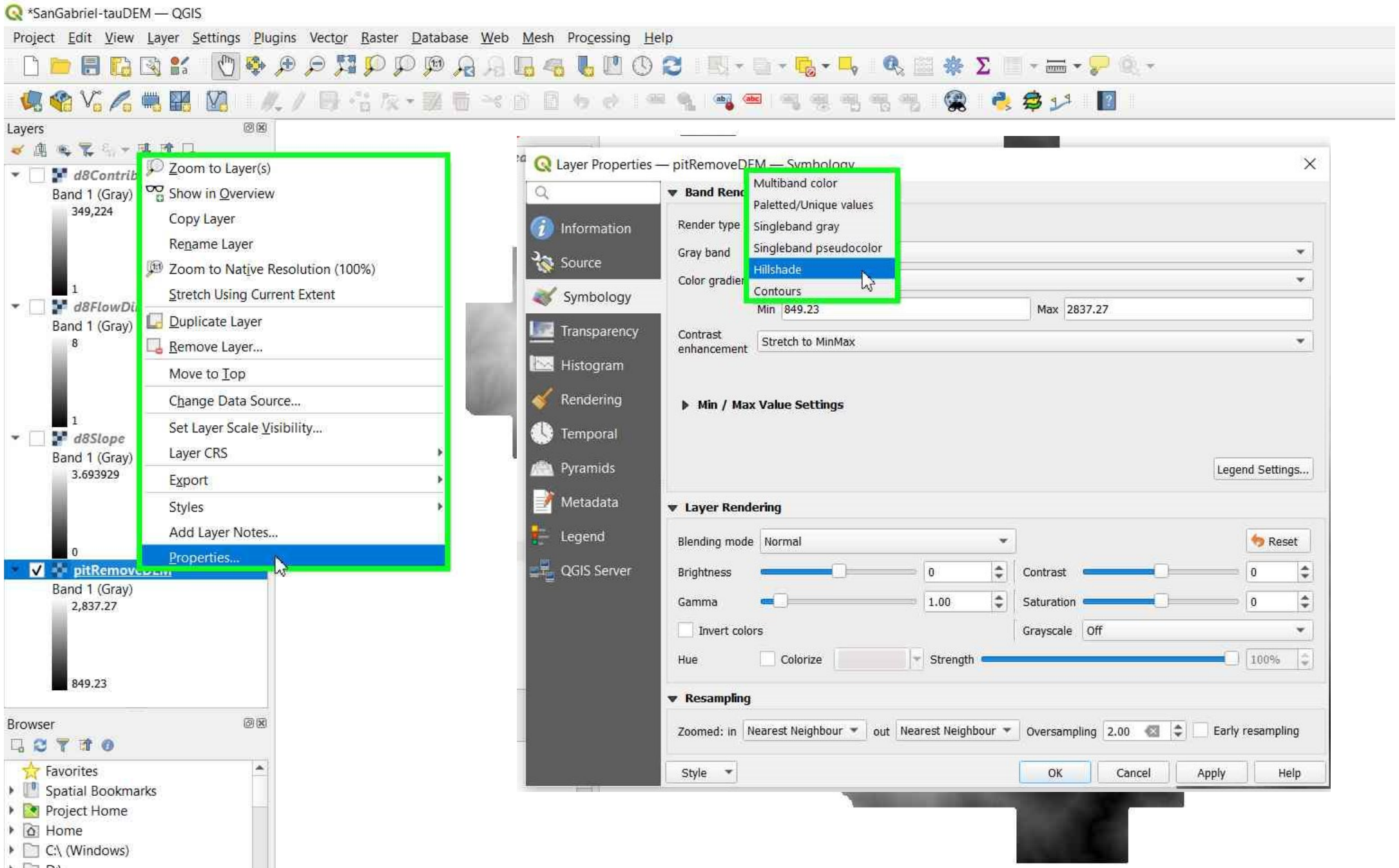
☑ Topographic Wetness Index

Download pre-generated data products
https://opentopography.org/workshops/AGIC2022

D8 Products



Visualize DEM as a hillshade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Rename Layer
Zoom to Native Resolution (100%)
Stretch Using Current Extent
Duplicate Layer
Remove Layer...
Move to Top
Change Data Source...
Set Layer Scale Visibility...
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Scale
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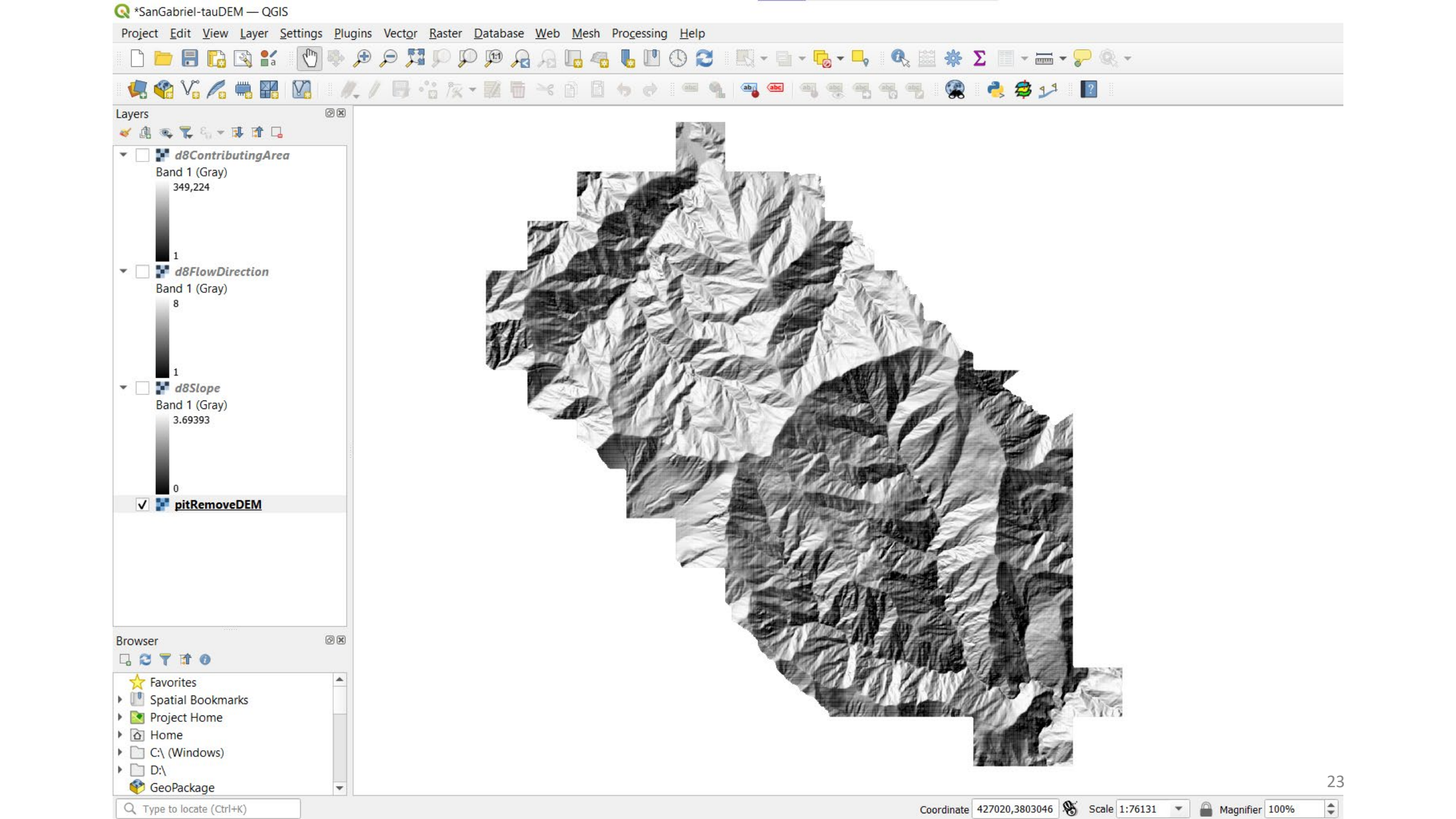
Magnifier
100%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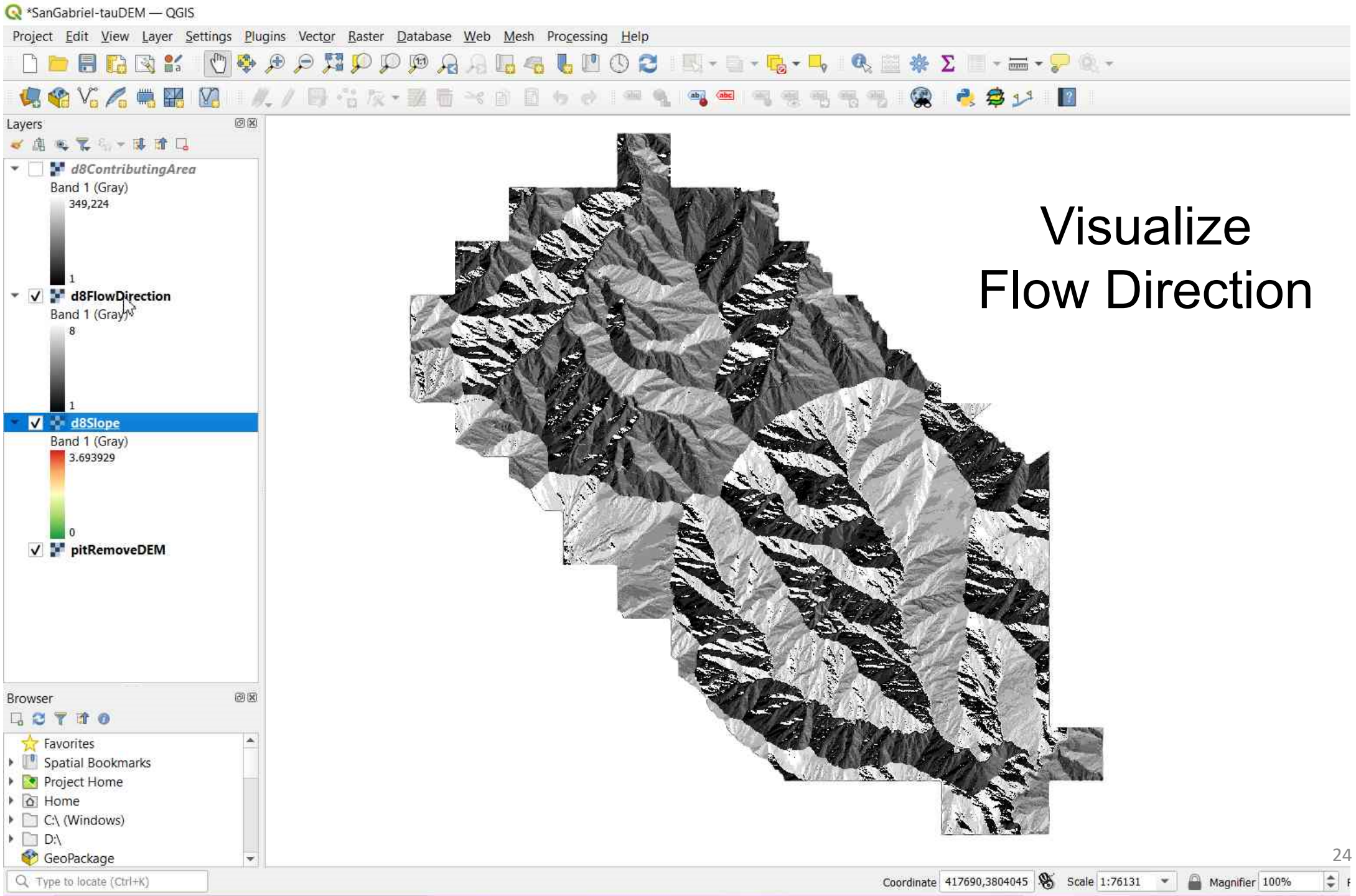
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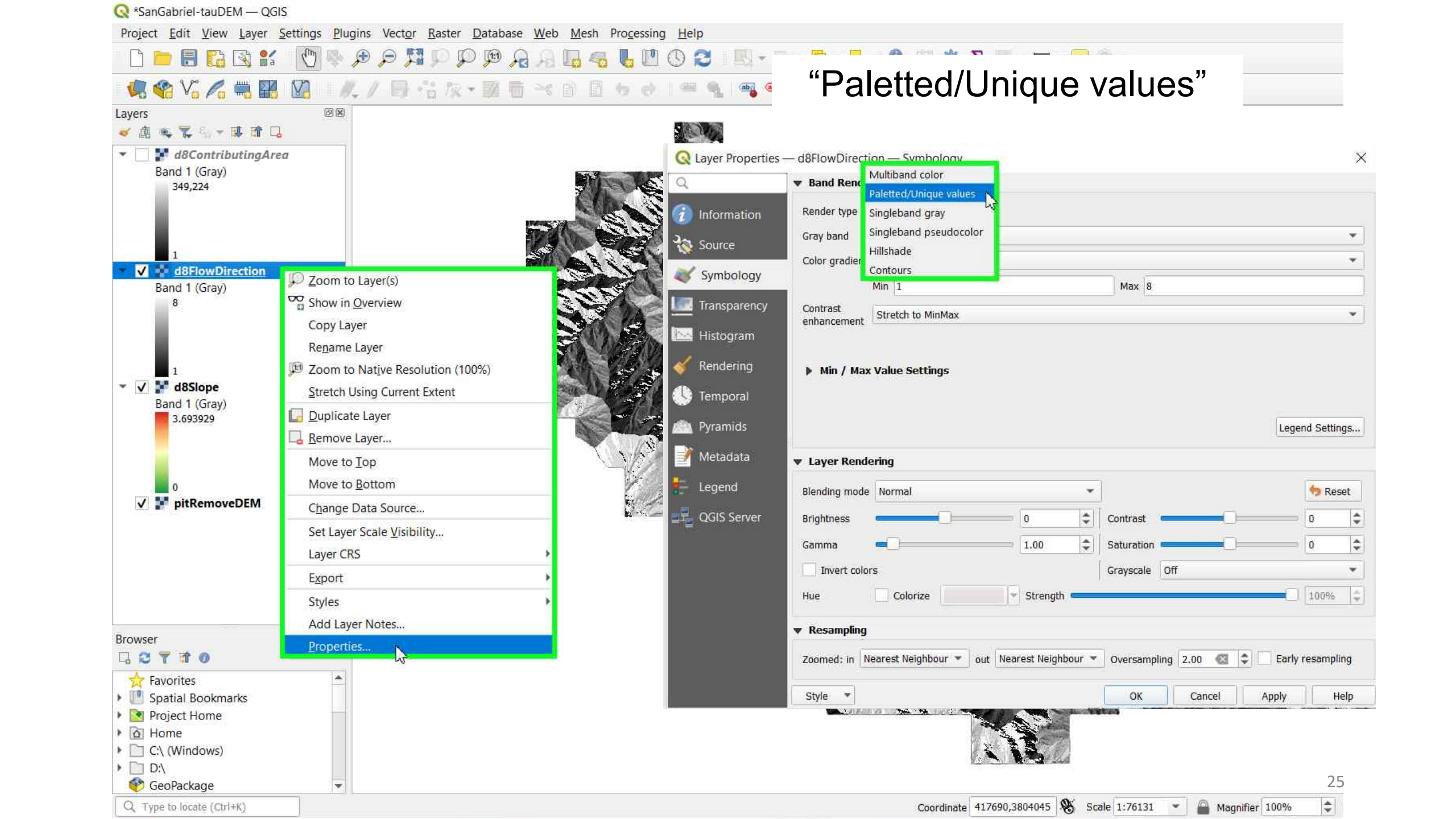
Flow Direction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Gray band
Color gradier
Min 1
Max 8
Contrast enhancement
Stretch to MinMax
Min / Max Value Settings
Legend Settings...
Layer Rendering
Blending mode
Normal
Reset
Brightness
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Contrast
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Gamma
1.00
Saturation
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Invert colors
Grayscale
Off
Hue
Colorize
Strength
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out
Nearest Neighbour
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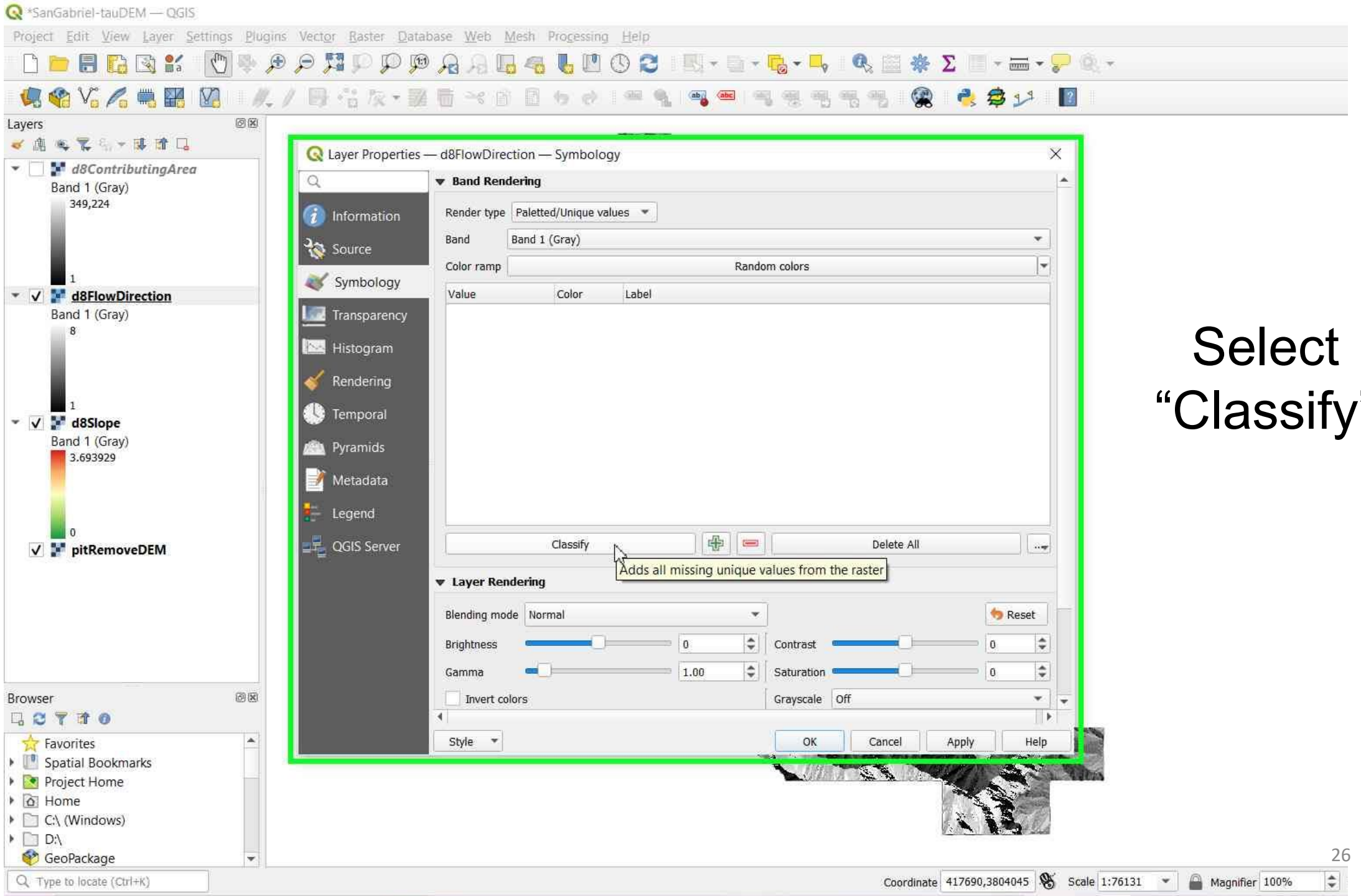
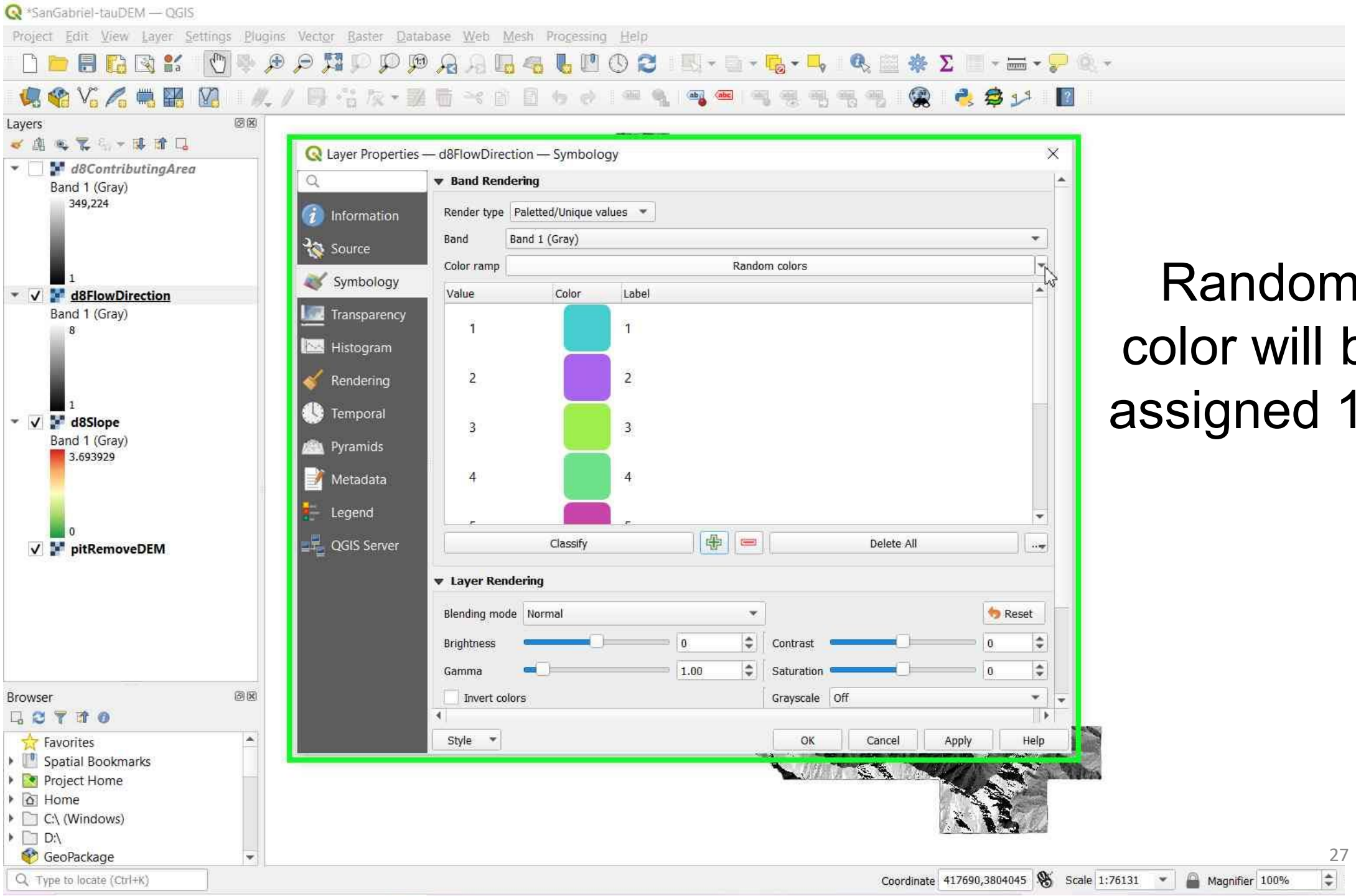
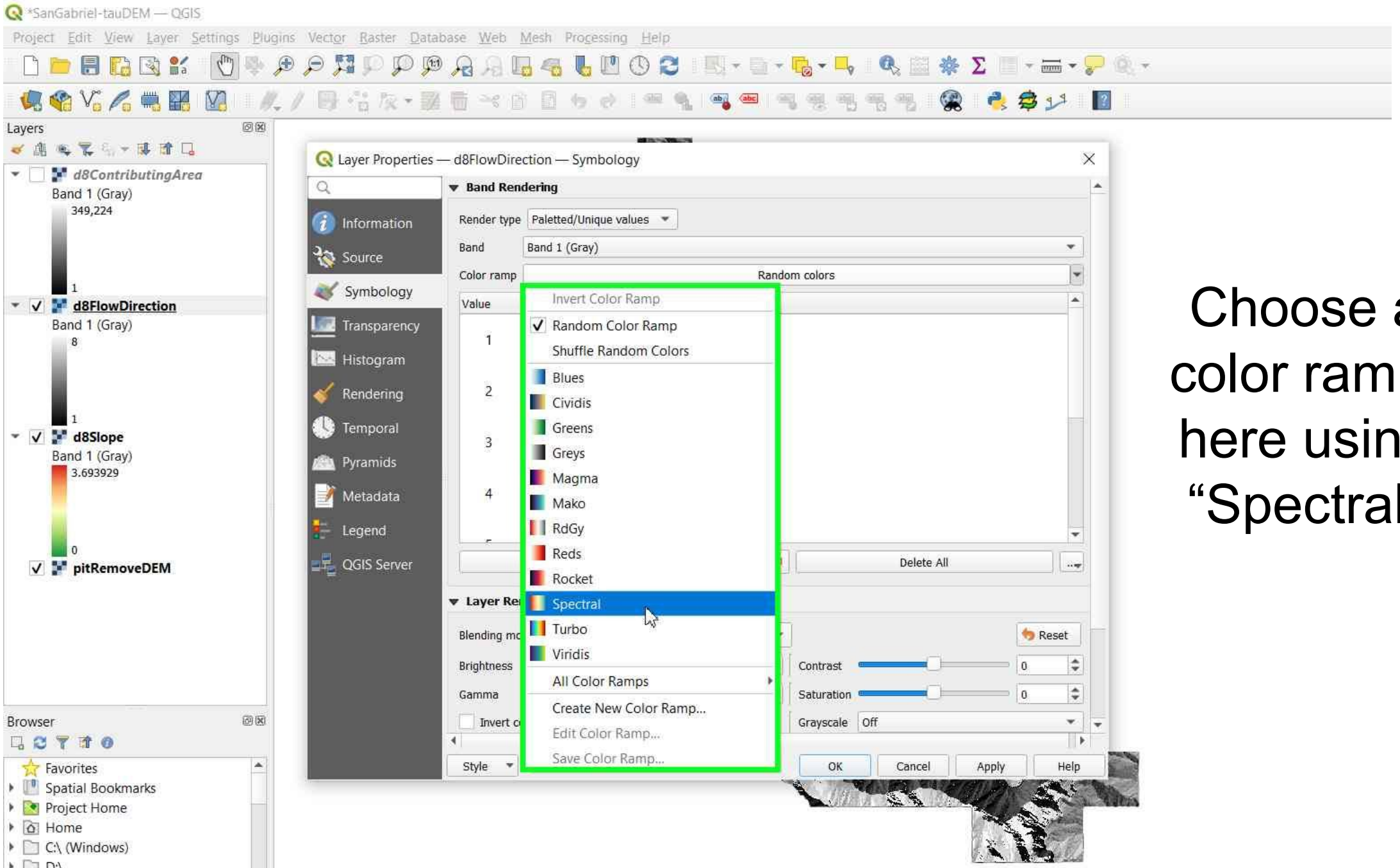


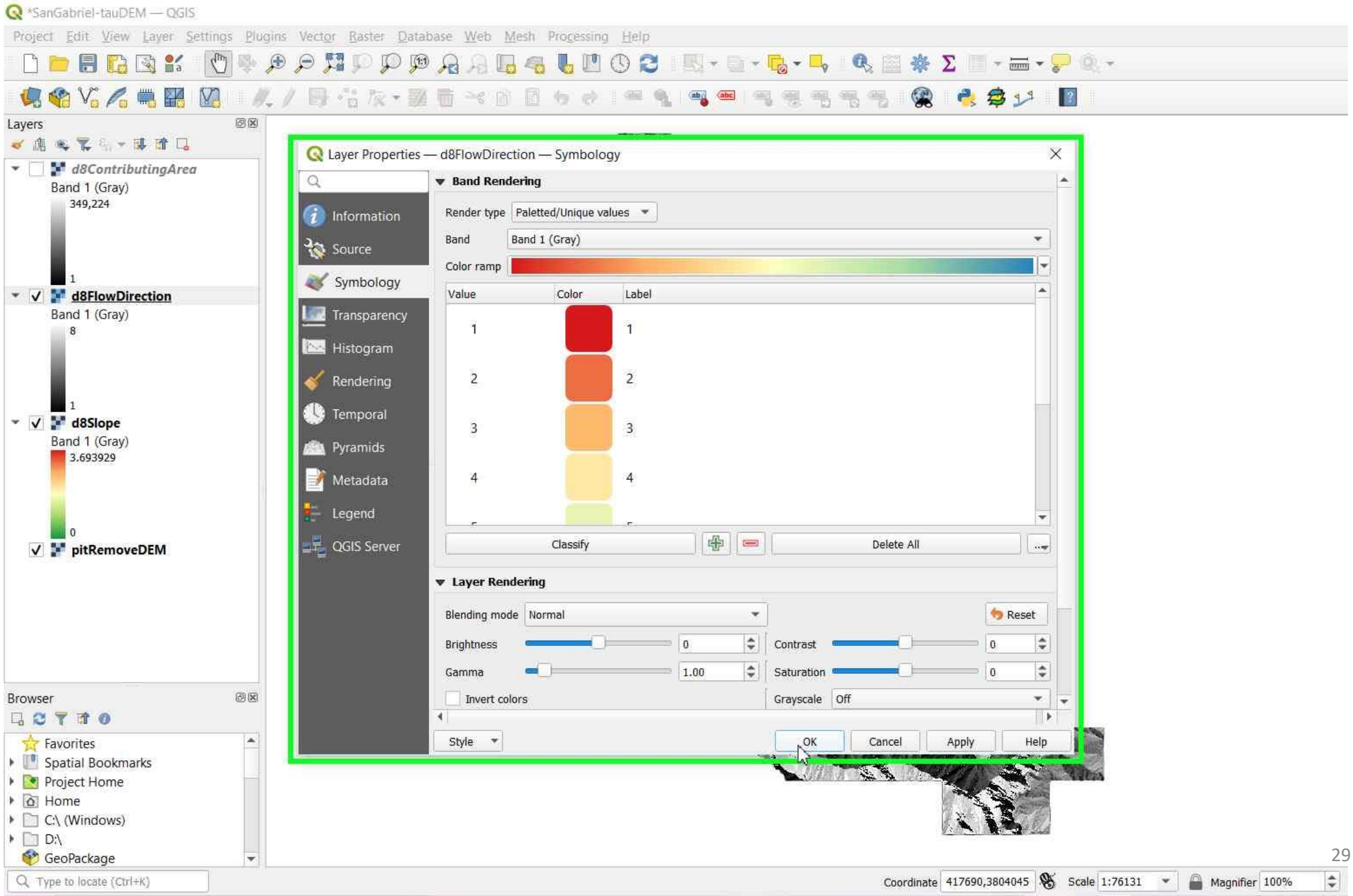
Select “Classify”



Random color will be assigned 1-8



Choose a color ramp, here using “Spectral”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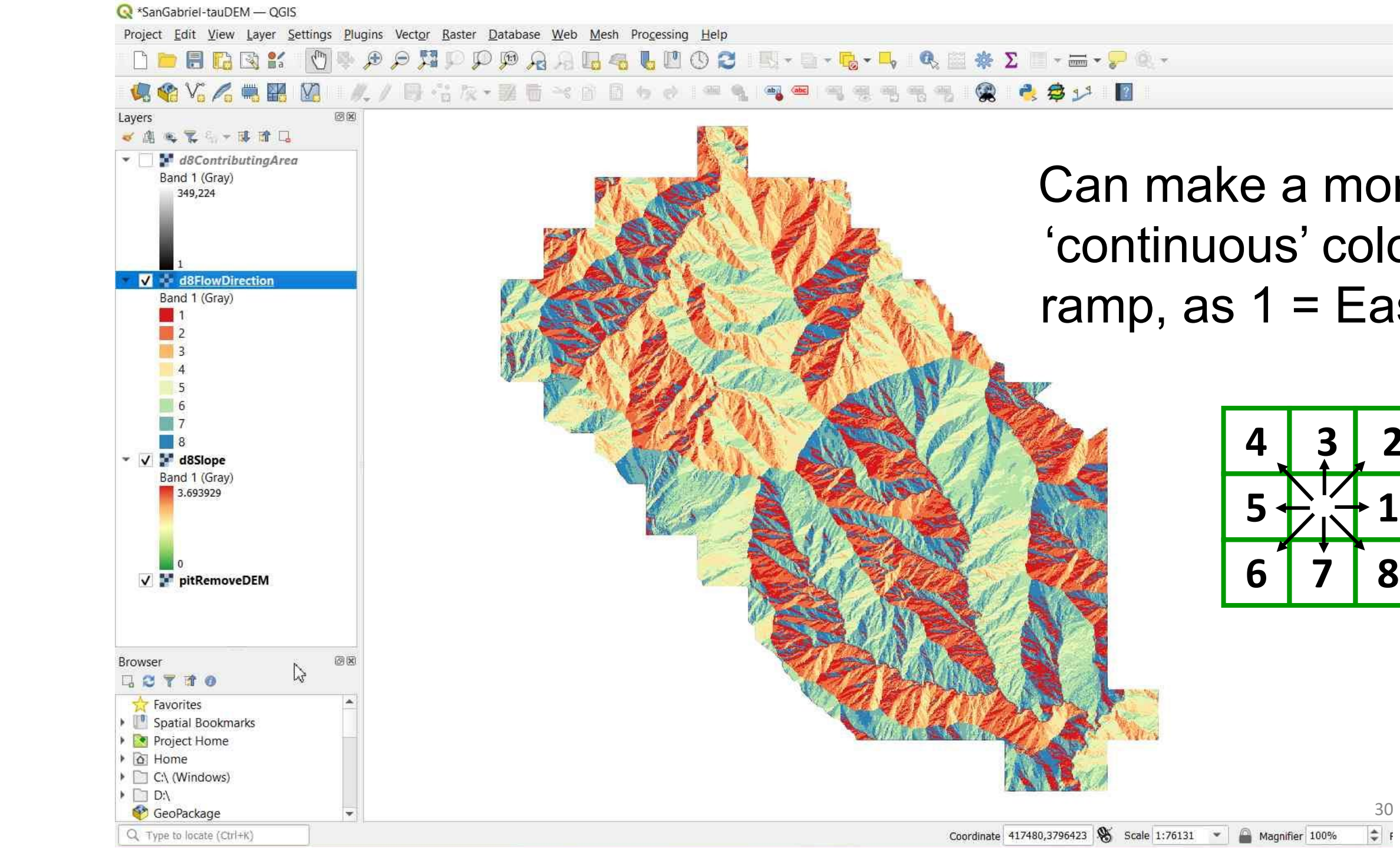
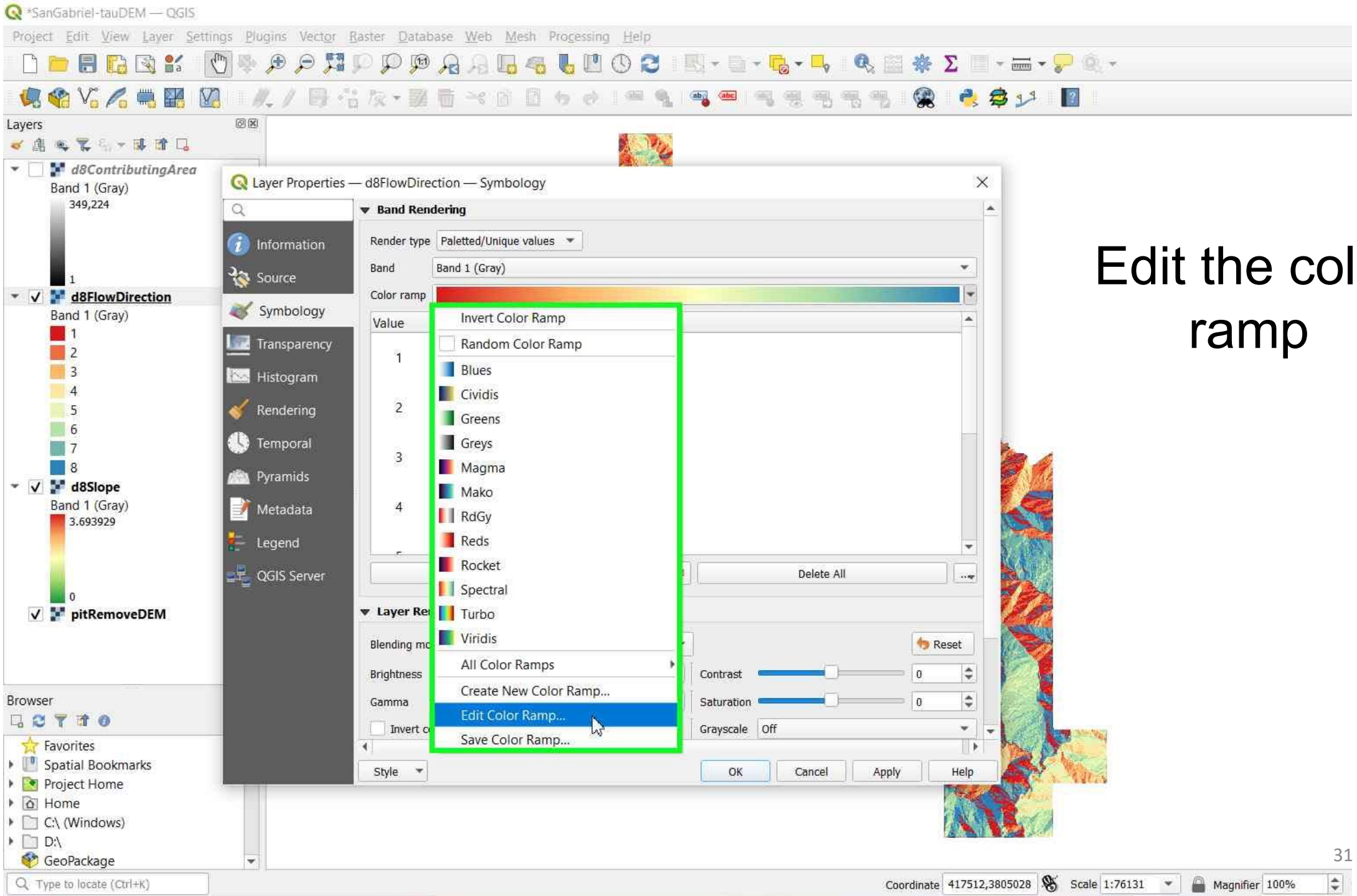
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Layer Properties — d8FlowDirection — Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Metadata
Legend
QGIS Server
Band Rendering
Render type
Paletted/Unique values
Band
Band 1 (Gray)
Color ramp
Value
Color
Label
1
2
3
4
Classify
Delete All
Layer Rendering
Blending mode
Normal
Reset
Brightness
0
Contrast
0
Gamma
1.00
Saturation
0
Invert colors
Grayscale
Off
Style
OK
Cancel
Apply
Help
Type to locate (Ctrl+K)
Coordinate
417690,3804045
Scale
1:76131
Magnifier
100%

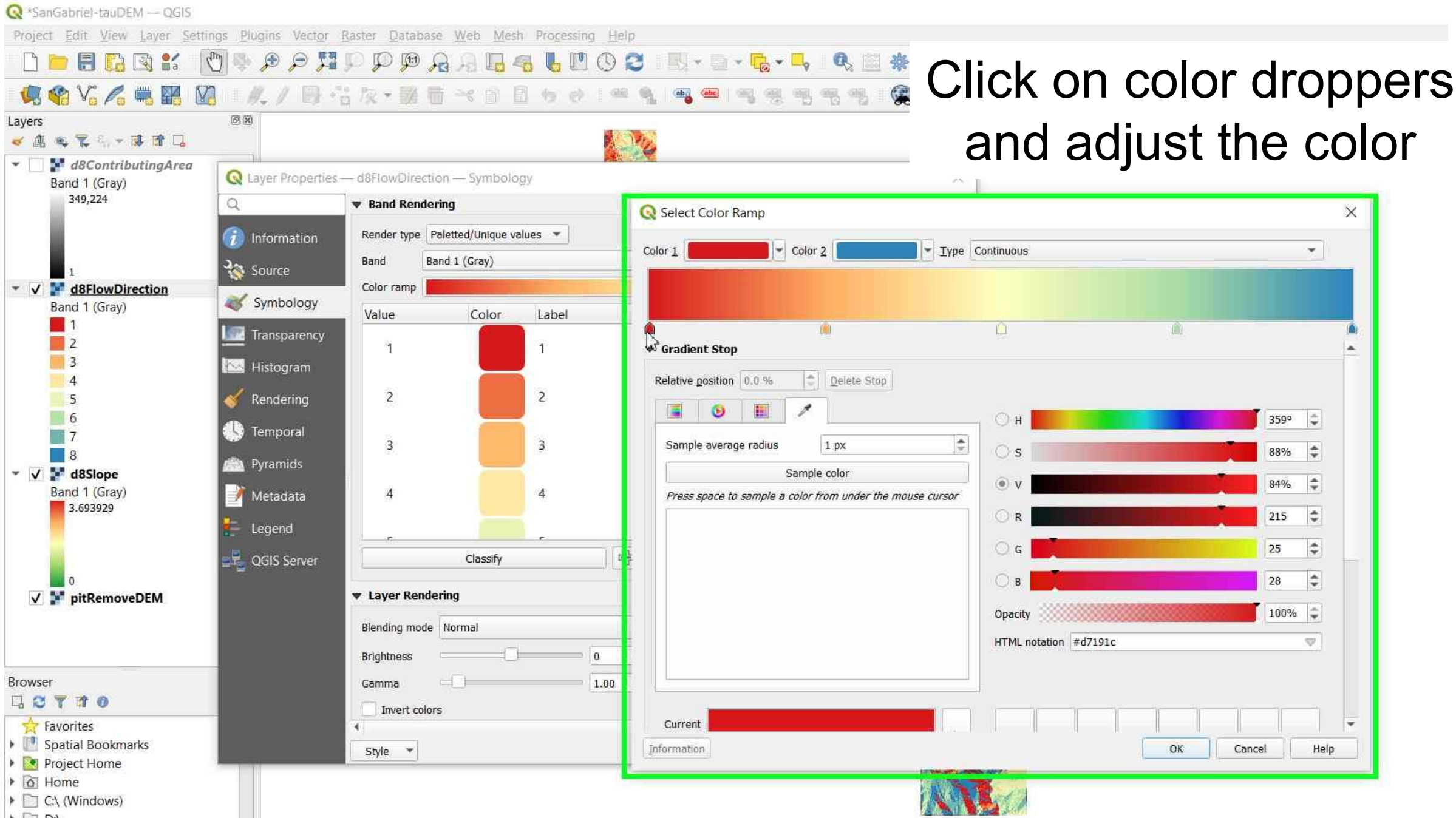


Can make a more ‘continuous’ color ramp, as 1 = East

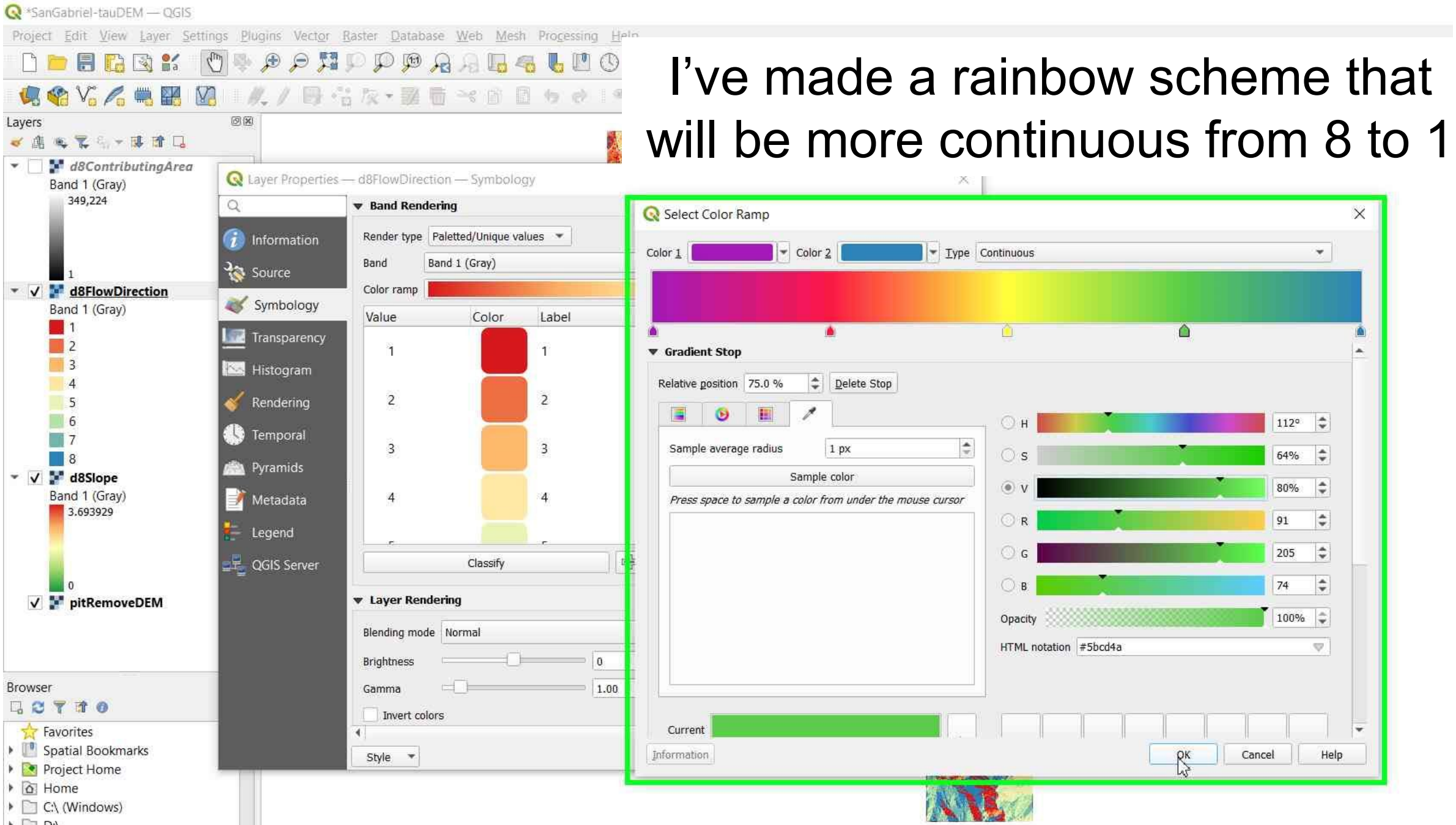


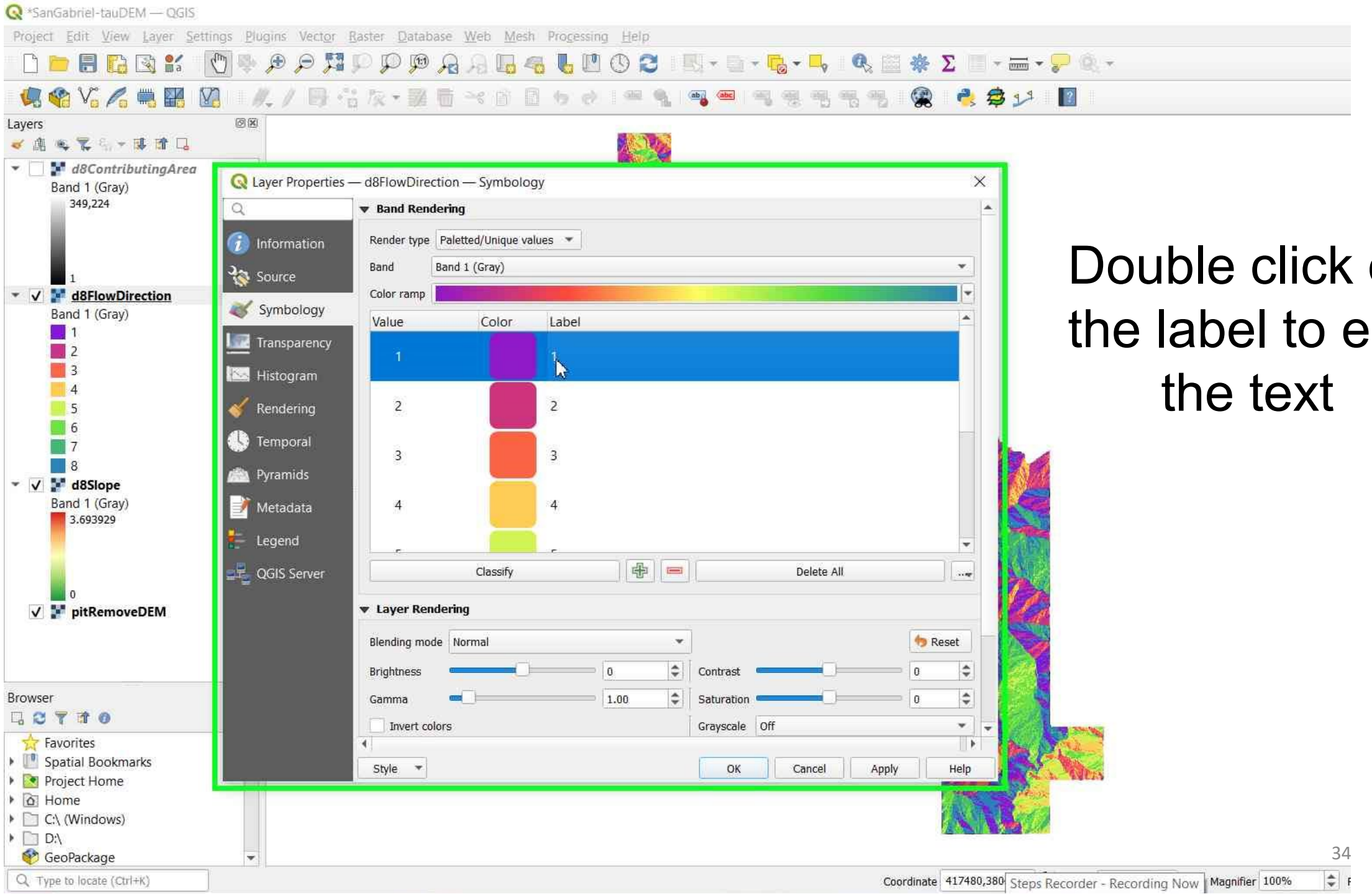
Edit the color ramp

Click on color droppers and adjust the color



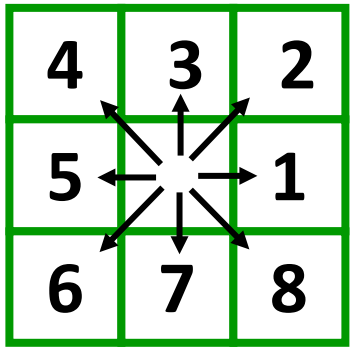
I've made a rainbow scheme that will be more continuous from 8 to 1



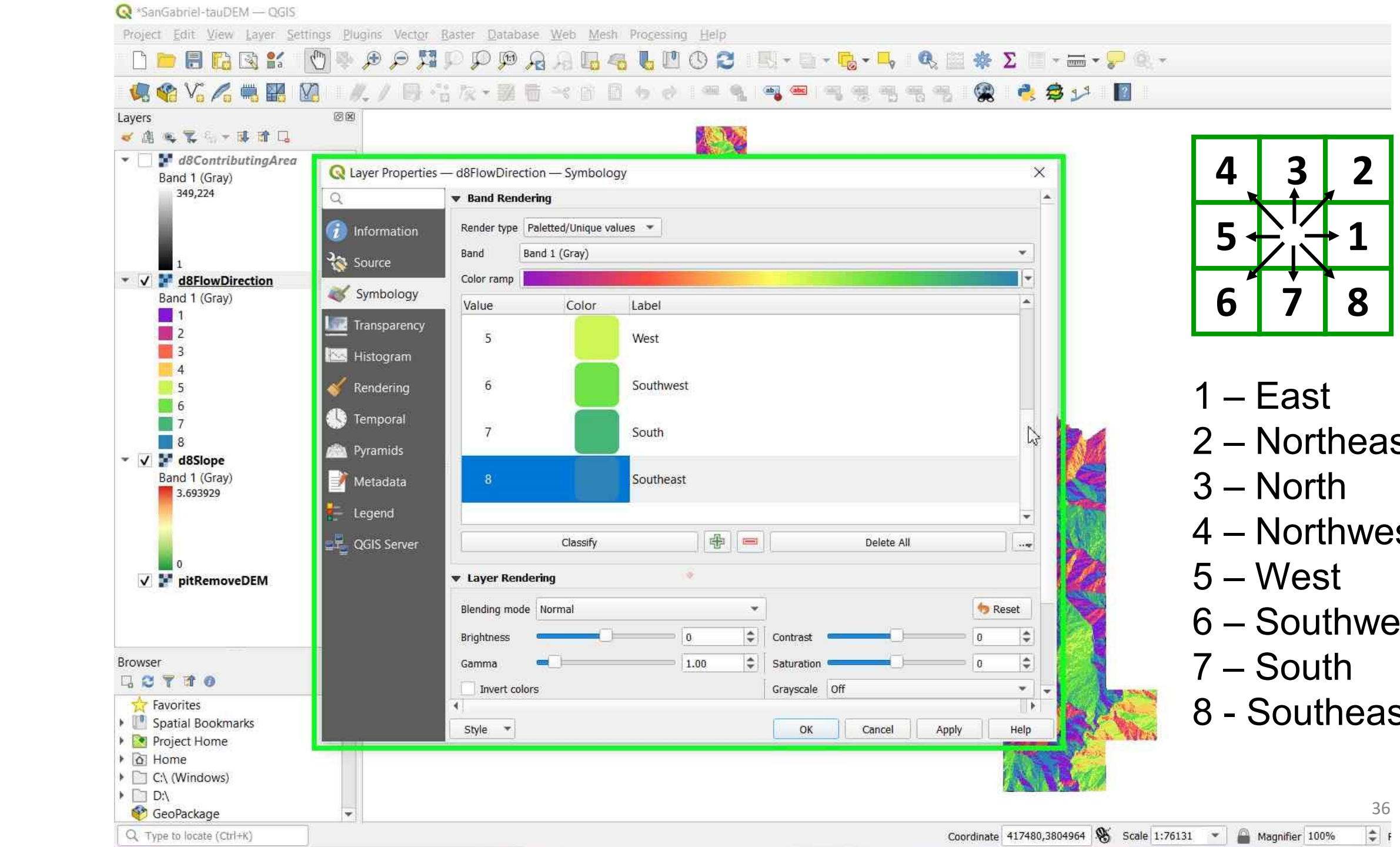


Double click on the label to edit the text

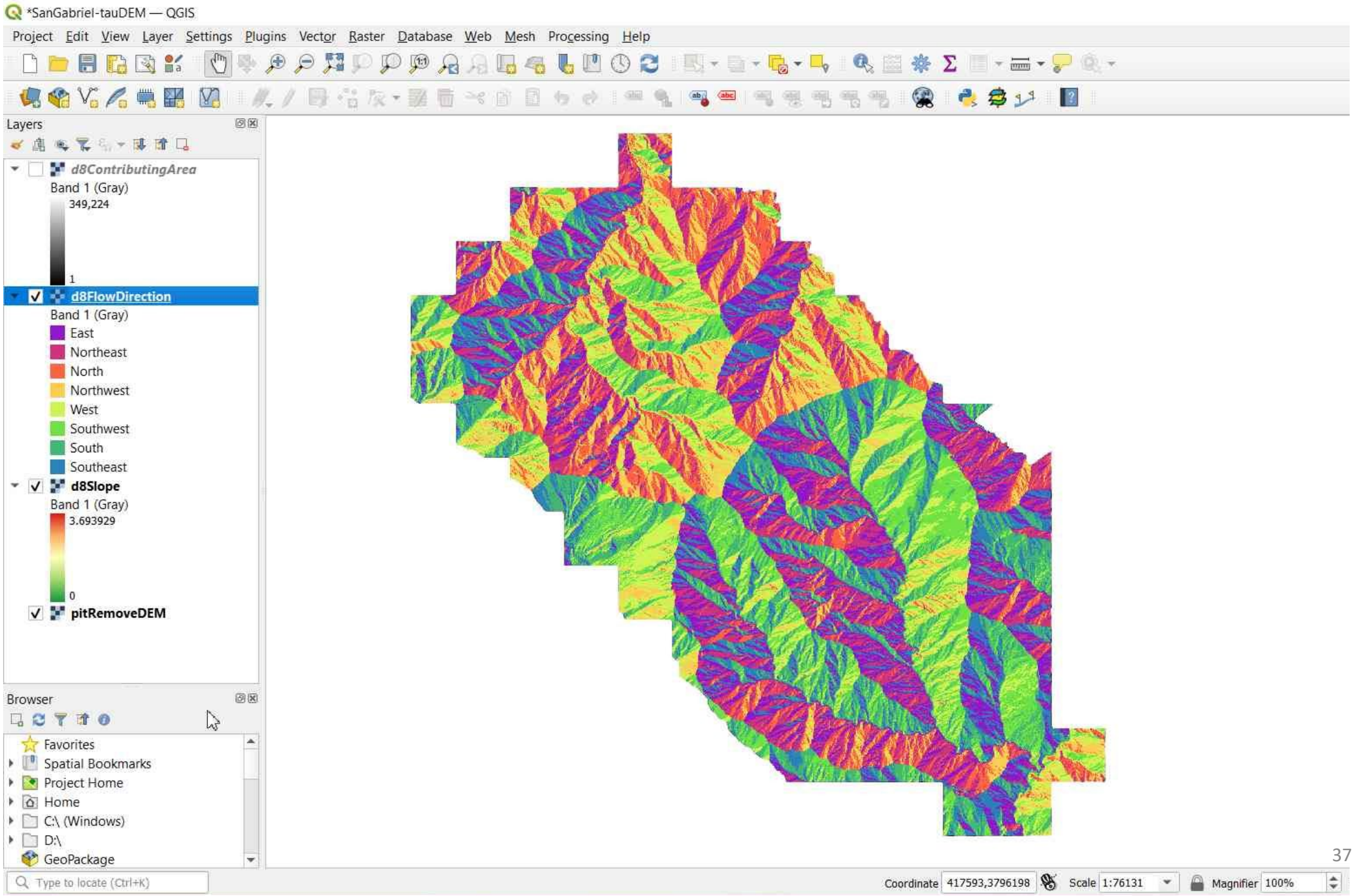
Assign labels accordingly

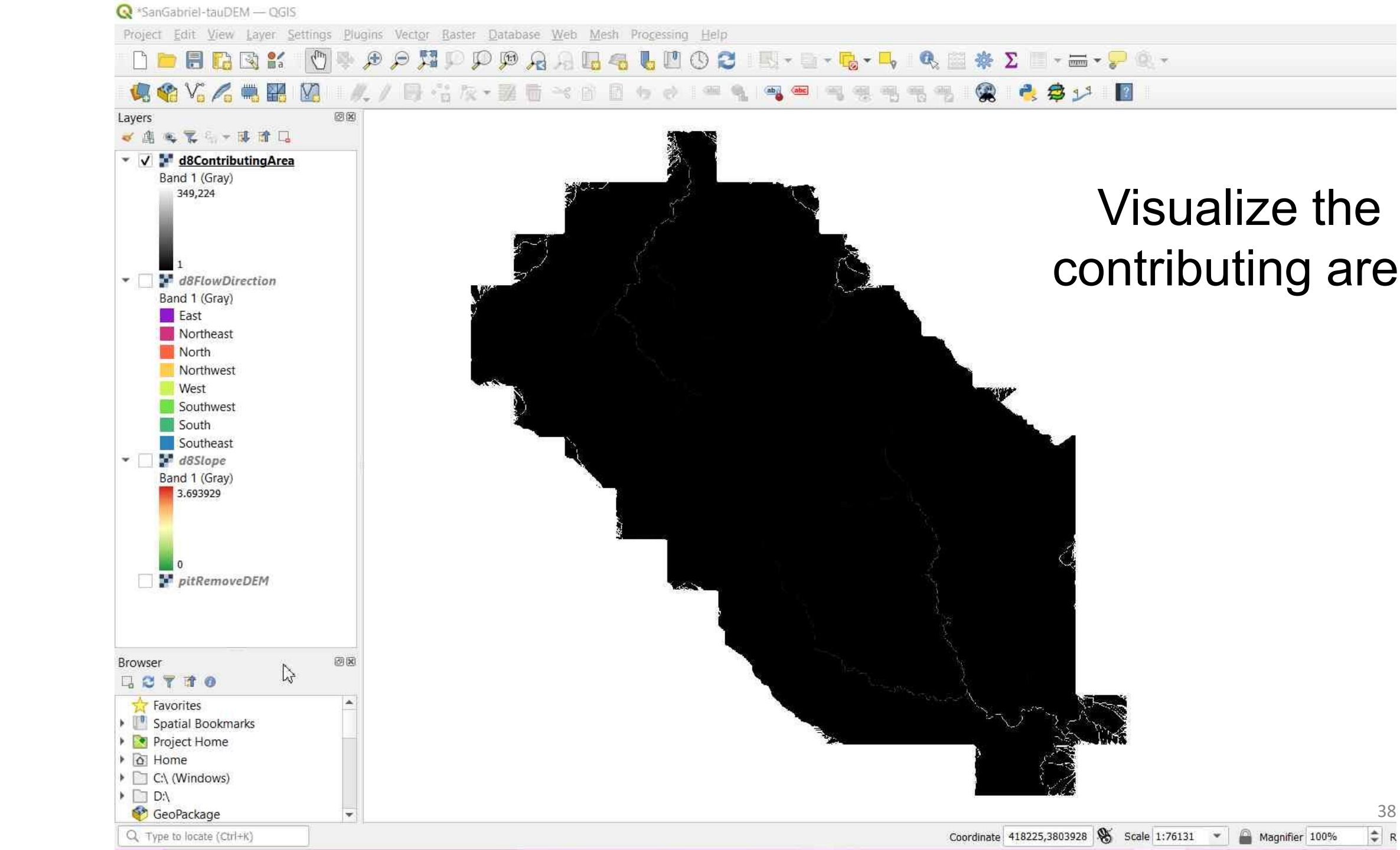


1 – East
2 – Northeast
3 – North
4 – Northwest
5 – West
6 – Southwest
7 – South
8 - Southeast

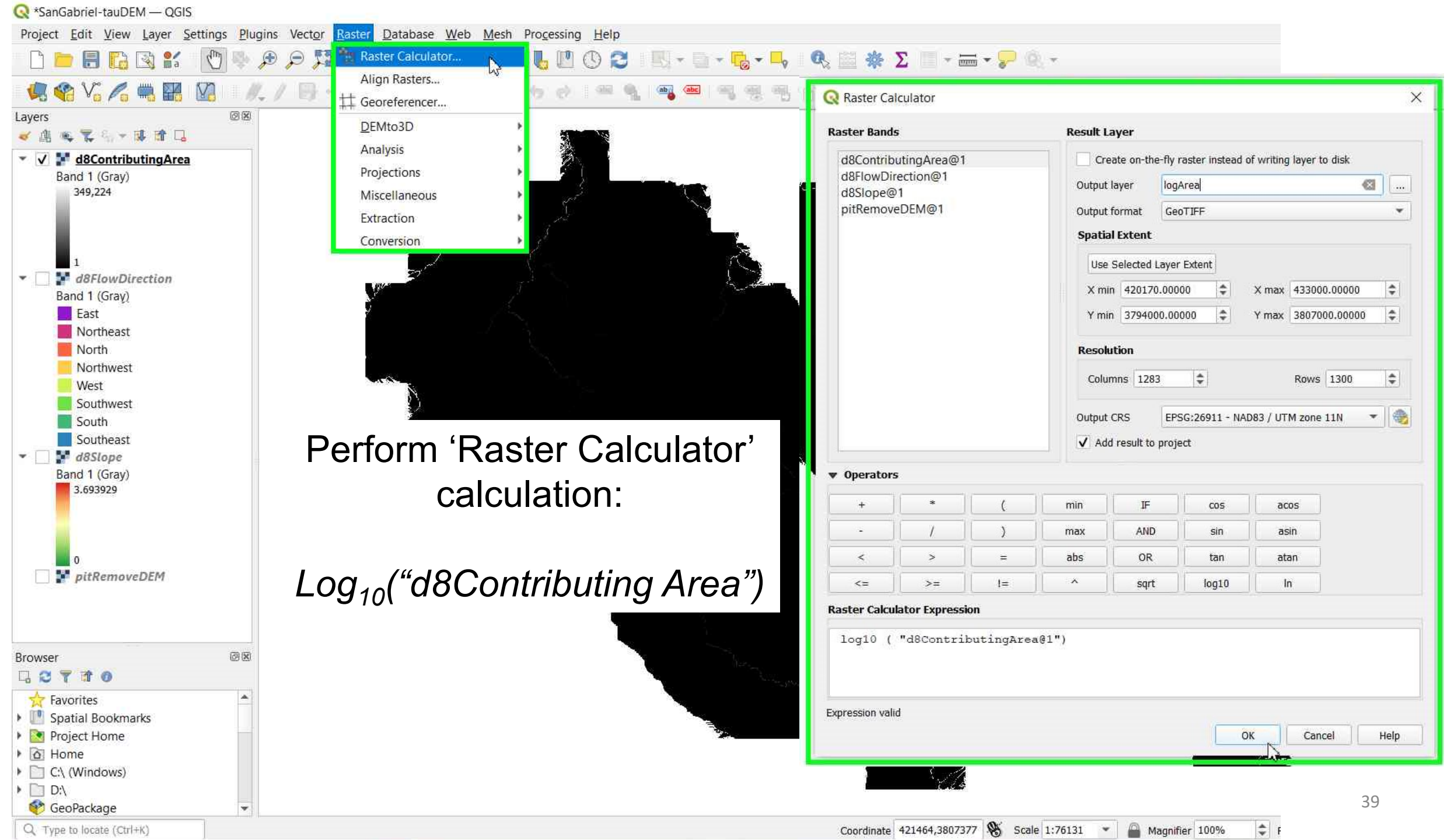


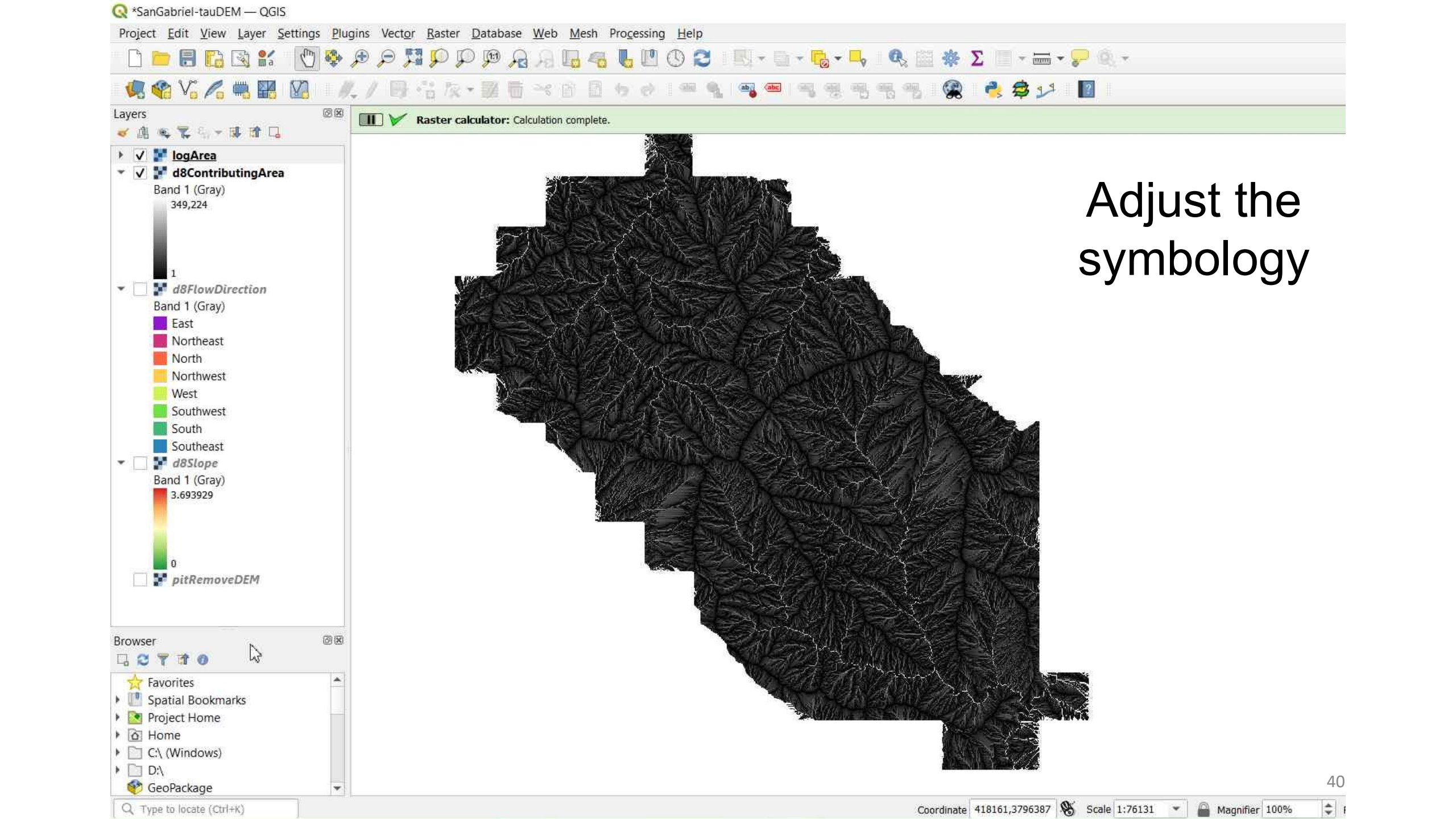
1 – East
2 – Northeast
3 – North
4 – Northwest
5 – West
6 – Southwest
7 – South
8 - Southeast


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
East
Northeast
North
Northwest
West
Southwest
South
Southeast
d8Slope
Band 1 (Gray)
3.693929
0
pitRemoveDEM
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Type to locate (Ctrl+K)
Coordinate 417593,3796198
Scale 1:76131
Magnifier 100%

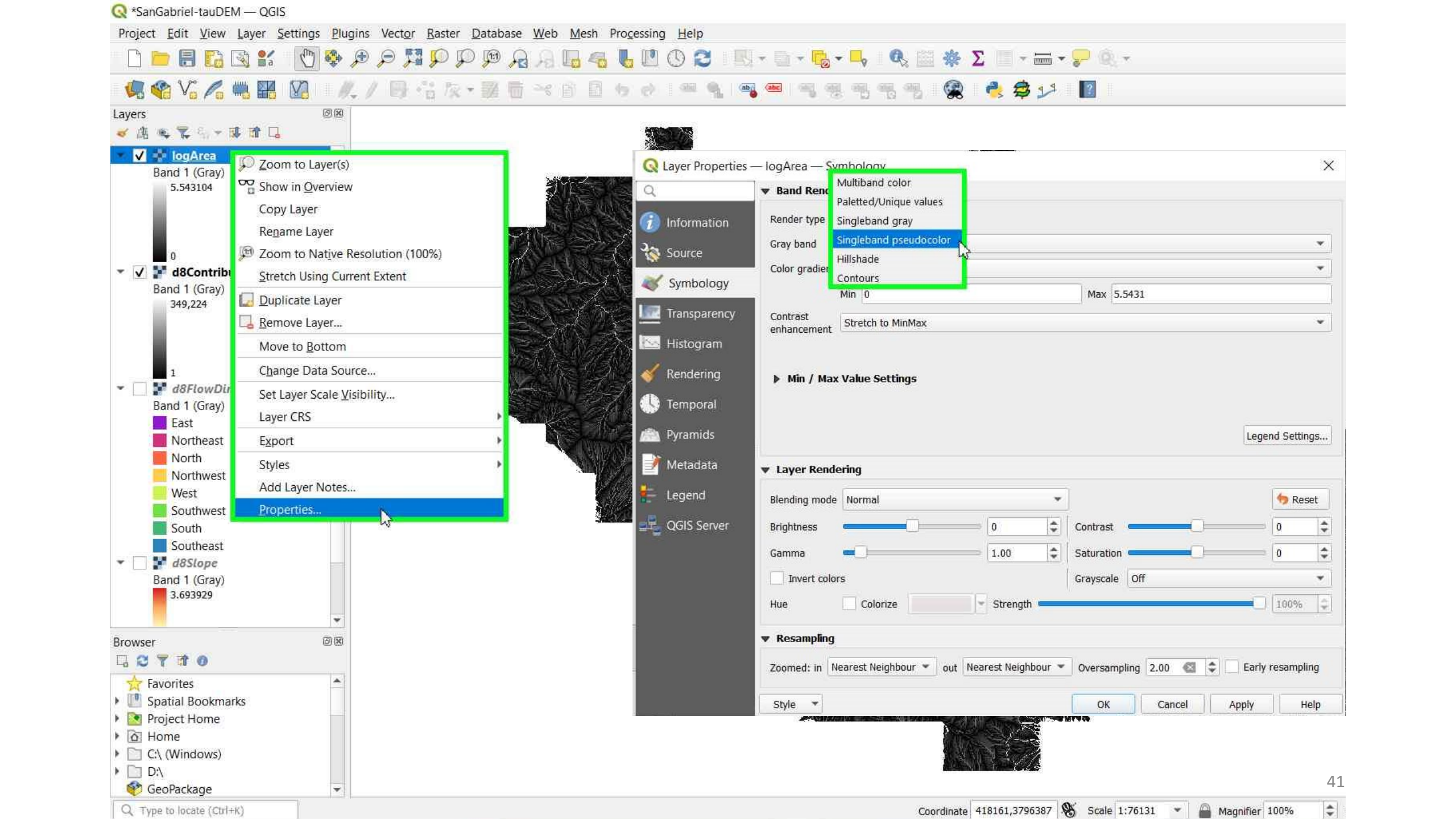


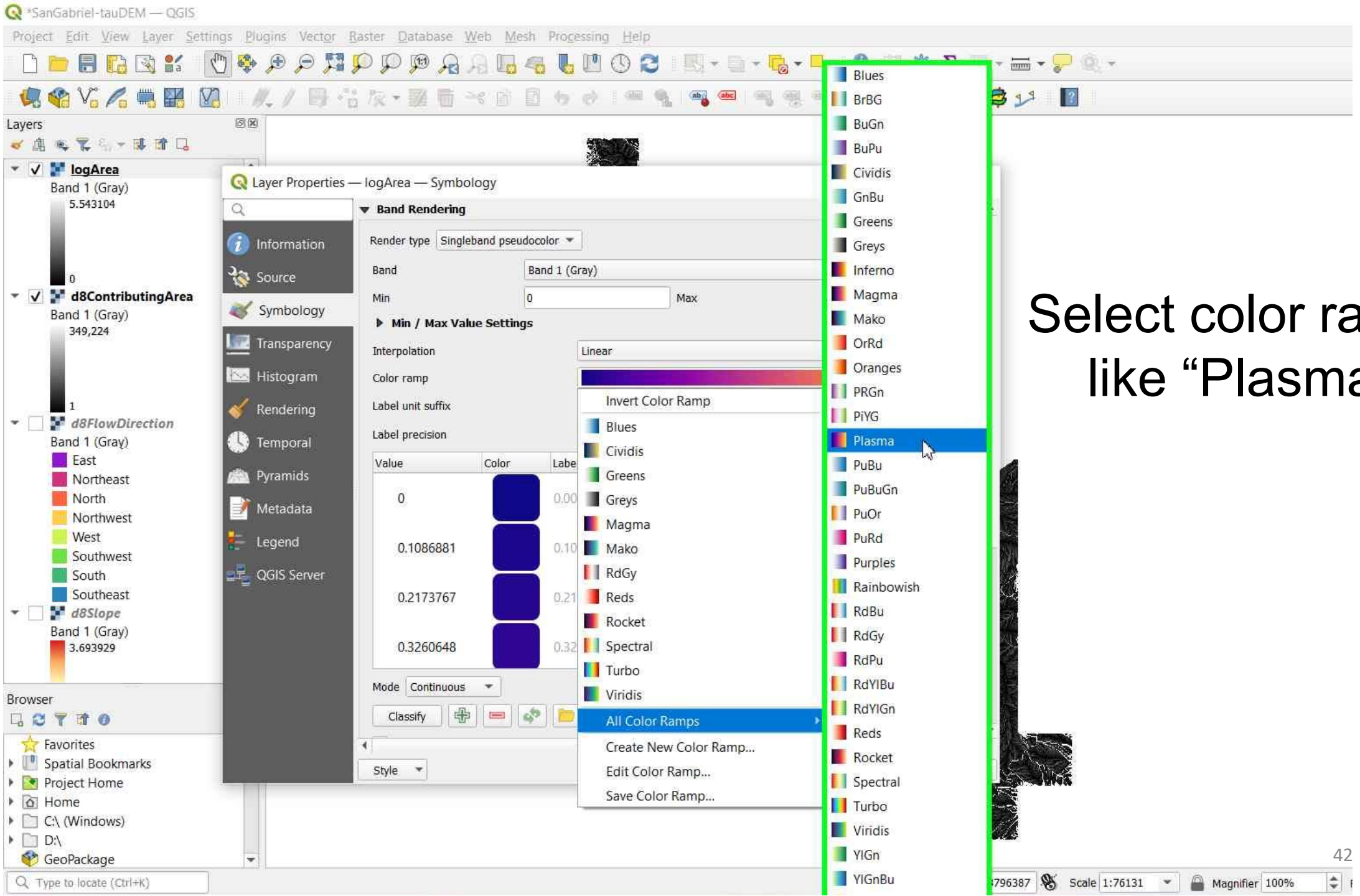
Visualize the contributing area


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Raster Calculator...
Align Rasters...
Georeferencer...
DEMto3D
Analysis
Projections
Miscellaneous
Extraction
Conversion
Layers
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
East
Northeast
North
Northwest
West
Southwest
South
Southeast
d8Slope
Band 1 (Gray)
3.693929
0
pitRemoveDEM
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Perform 'Raster Calculator' calculation:
Log10("d8Contributing Area")
Raster Calculator
Raster Bands
d8ContributingArea@1
d8FlowDirection@1
d8Slope@1
pitRemoveDEM@1
Result Layer
Create on-the-fly raster instead of writing layer to disk
Output layer
logArea
Output format
GeoTIFF
Spatial Extent
Use Selected Layer Extent
X min 420170.00000
X max 433000.00000
Y min 3794000.00000
Y max 3807000.00000
Resolution
Columns 1283
Rows 1300
Output CRS
EPSG:26911 - NAD83 / UTM zone 11N
Add result to project
Operators
+ * (min IF cos acos
- /) max AND sin asin
< > = abs OR tan atan
<= >= != ^ sqrt log10 ln
Raster Calculator Expression
log10 ("d8ContributingArea@1")
Expression valid
OK
Cancel
Help
Coordinate 421464,3807377
Scale 1:76131
Magnifier 100%

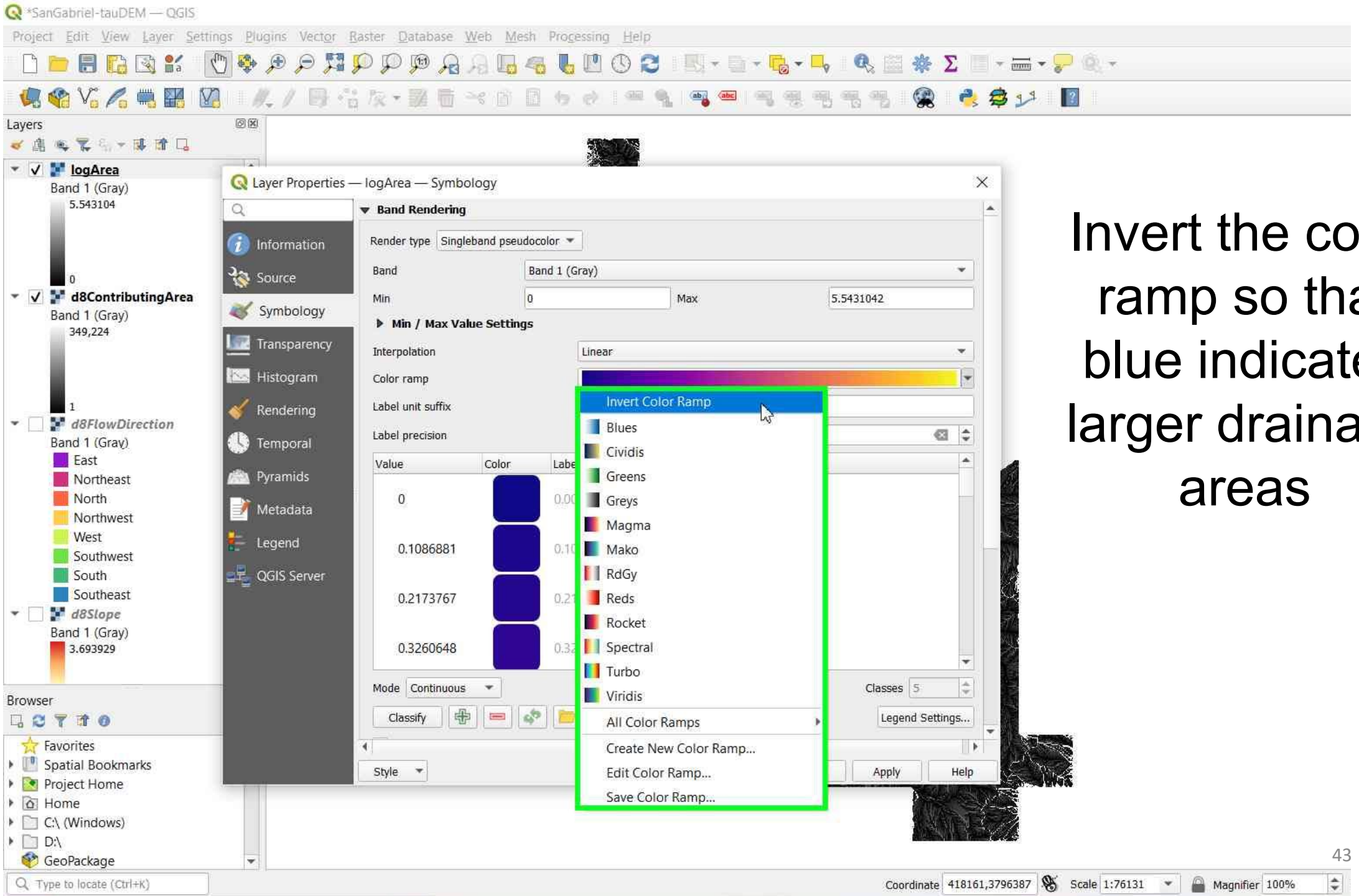


Adjust the symbology

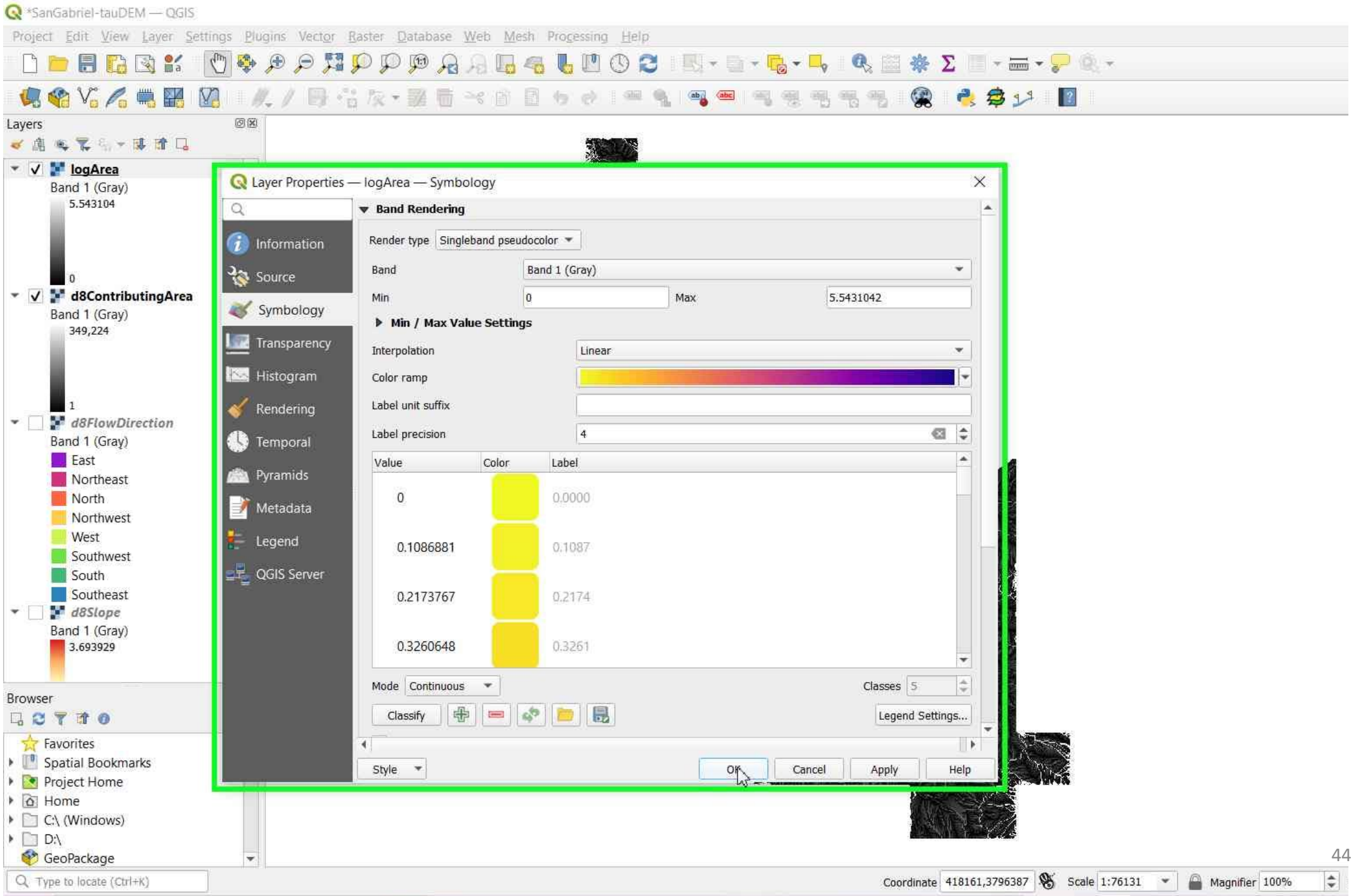

*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
logArea
Band 1 (Gray)
5.543104
0
d8Contrib
Band 1 (Gray)
349,224
1
d8FlowDir
Band 1 (Gray)
East
Northeast
North
Northwest
West
Southwest
South
Southeast
d8Slope
Band 1 (Gray)
3.693929
Zoom to Layer(s)
Show in Overview
Copy Layer
Rename Layer
Zoom to Native Resolution (100%)
Stretch Using Current Extent
Duplicate Layer
Remove Layer...
Move to Bottom
Change Data Source...
Set Layer Scale Visibility...
Layer CRS
Export
Styles
Add Layer Notes...
Properties...
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Layer Properties — logArea — Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Metadata
Legend
QGIS Server
Band Rend
Render type
Multiband color
Paletted/Unique values
Singleband gray
Singleband pseudocolor
Hillshade
Contours
Gray band
Color gradier
Min 0
Max 5.5431
Contrast enhancement
Stretch to MinMax
Min / Max Value Settings
Legend Settings...
Layer Rendering
Blending mode
Normal
Reset
Brightness
0
Contrast
0
Gamma
1.00
Saturation
0
Invert colors
Grayscale
Off
Hue
Colorize
Strength
100%
Resampling
Zoomed: in
Nearest Neighbour
out
Nearest Neighbour
Oversampling
2.00
Early resampling
Style
OK
Cancel
Apply
Help
Type to locate (Ctrl+K)
Coordinate
418161,3796387
Scale
1:76131
Magnifier
100%

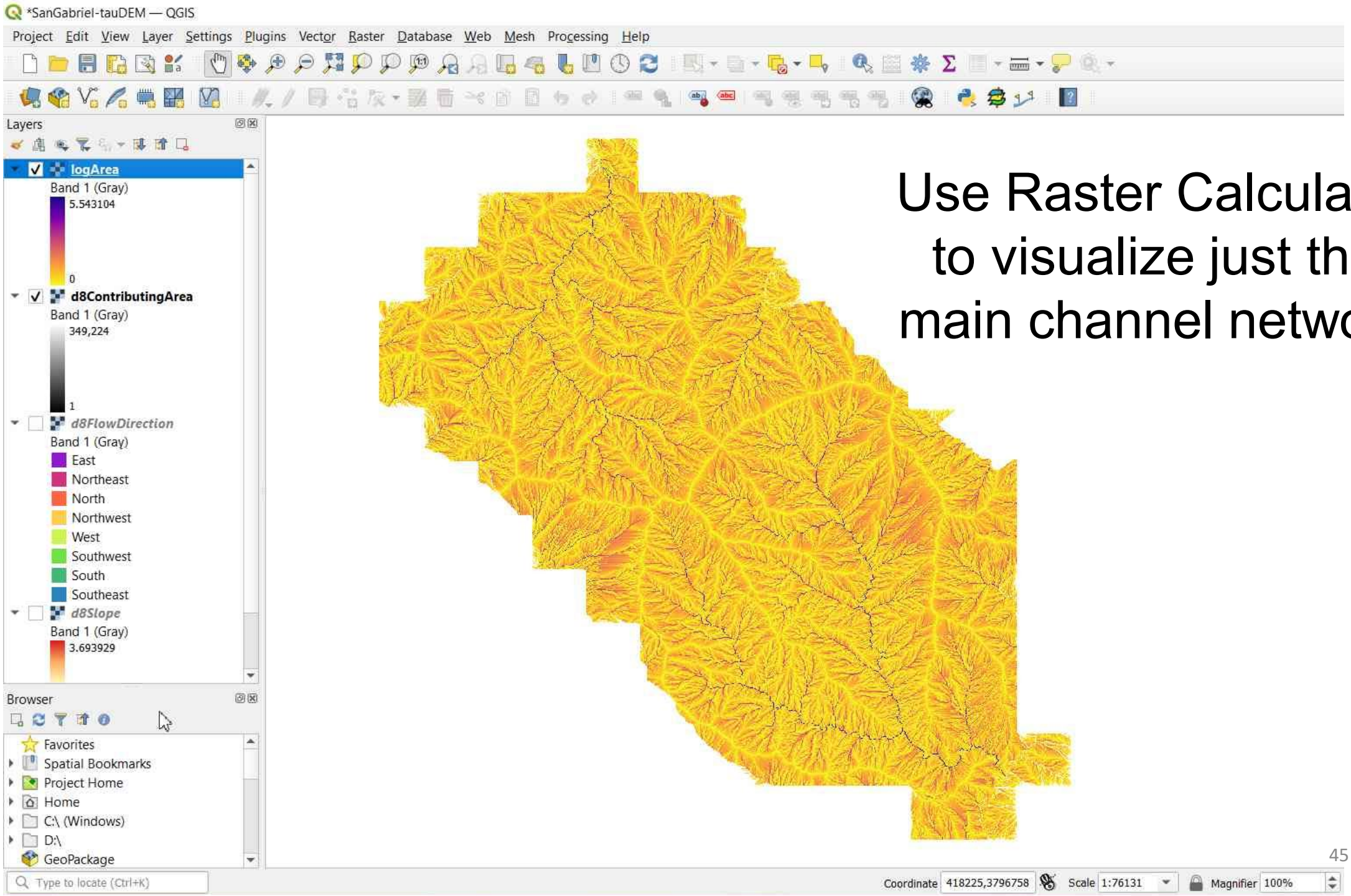


Select color ramp, like “Plasma”

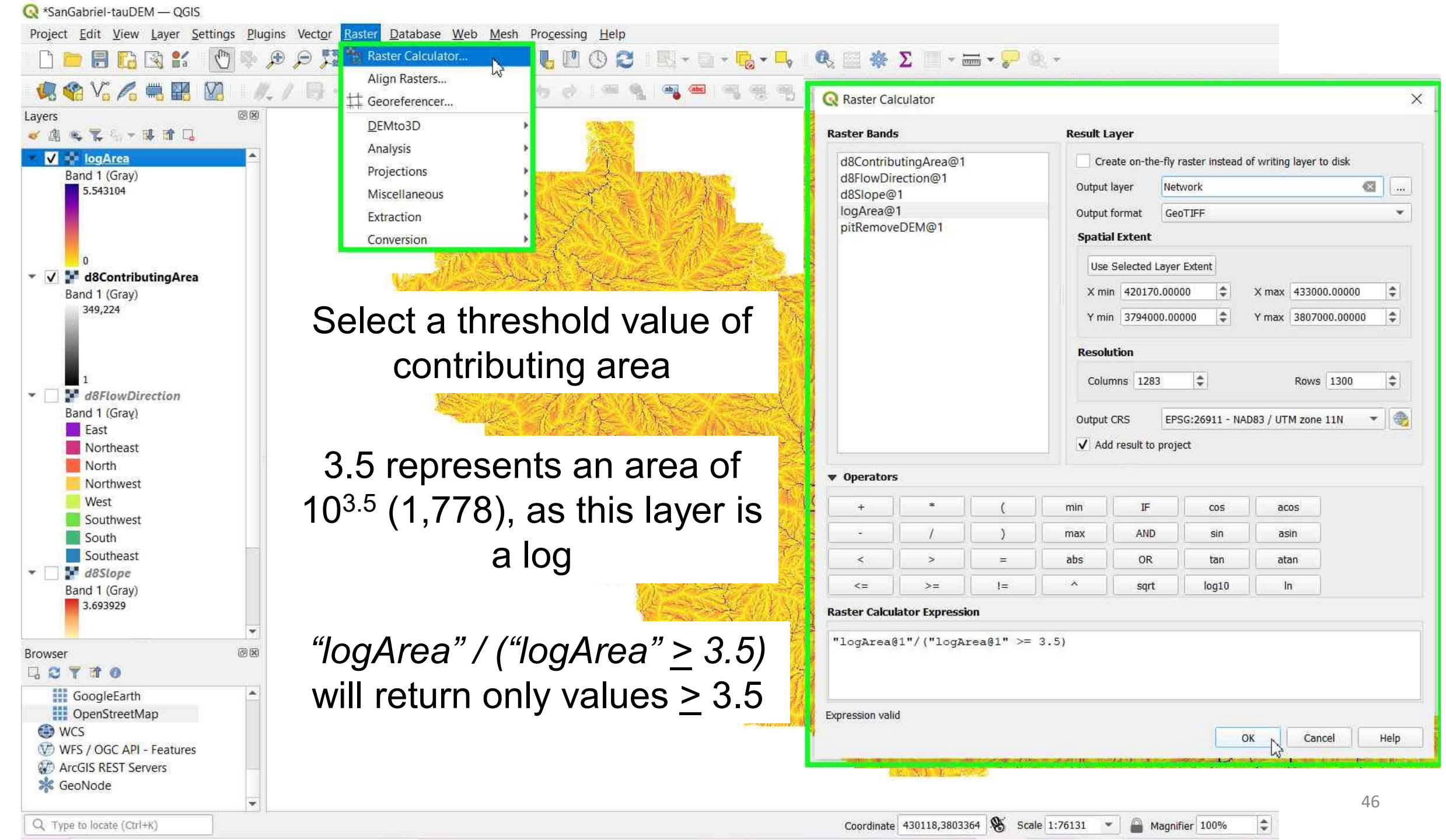


Invert the color ramp so that blue indicates larger drainage areas


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
logArea
Band 1 (Gray)
5.543104
0
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
East
Northeast
North
Northwest
West
Southwest
South
Southeast
d8Slope
Band 1 (Gray)
3.693929
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Type to locate (Ctrl+K)
Layer Properties — logArea — Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Metadata
Legend
QGIS Server
Band Rendering
Render type Singleband pseudocolor
Band Band 1 (Gray)
Min 0
Max 5.5431042
Min / Max Value Settings
Interpolation Linear
Color ramp
Label unit suffix
Label precision 4
Value Color Label
0 0.0000
0.1086881 0.1087
0.2173767 0.2174
0.3260648 0.3261
Mode Continuous
Classes 5
Classify
Legend Settings...
Style
OK
Cancel
Apply
Help
Coordinate 418161,3796387
Scale 1:76131
Magnifier 100%



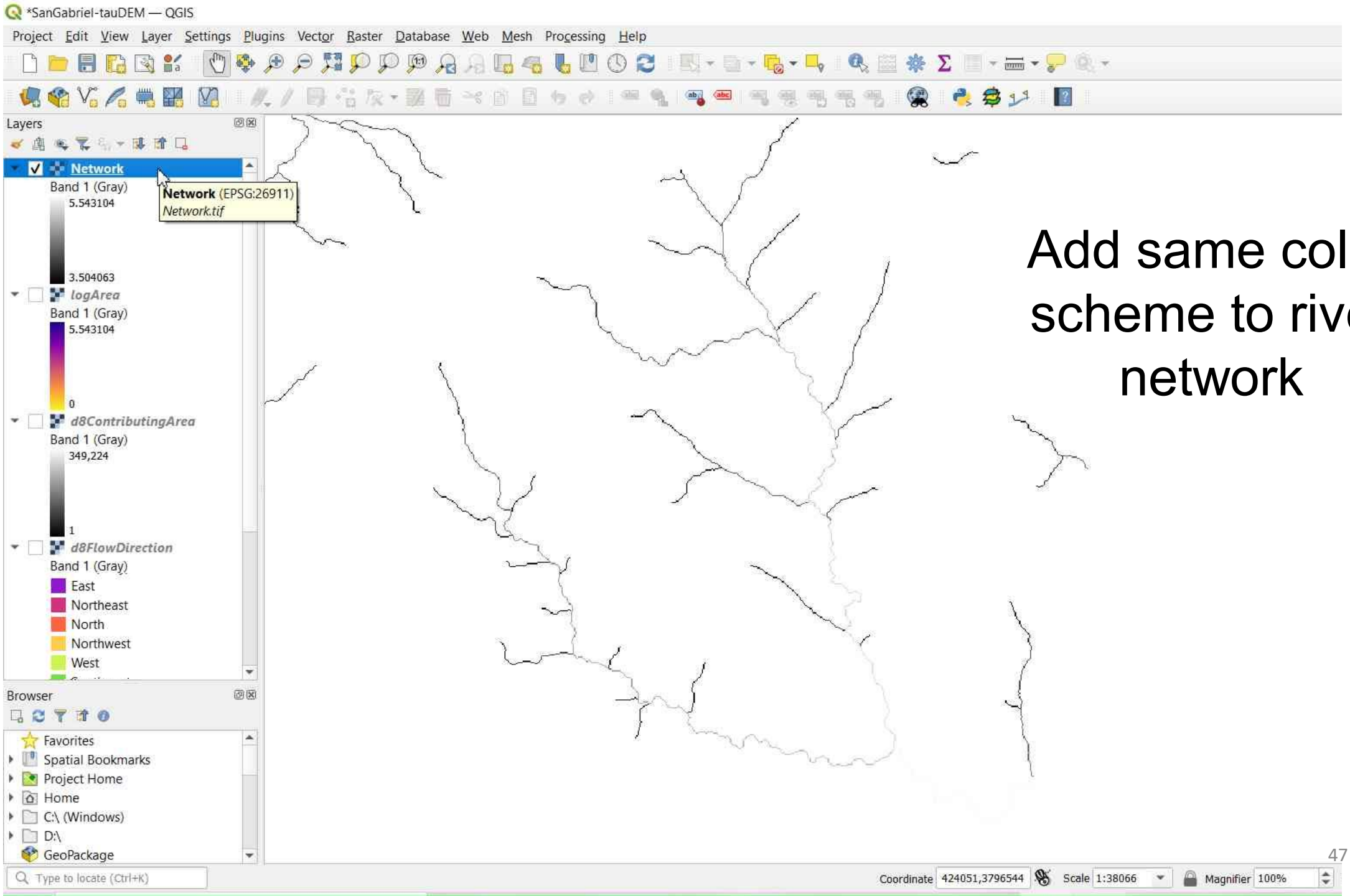
Use Raster Calculator to visualize just the main channel network



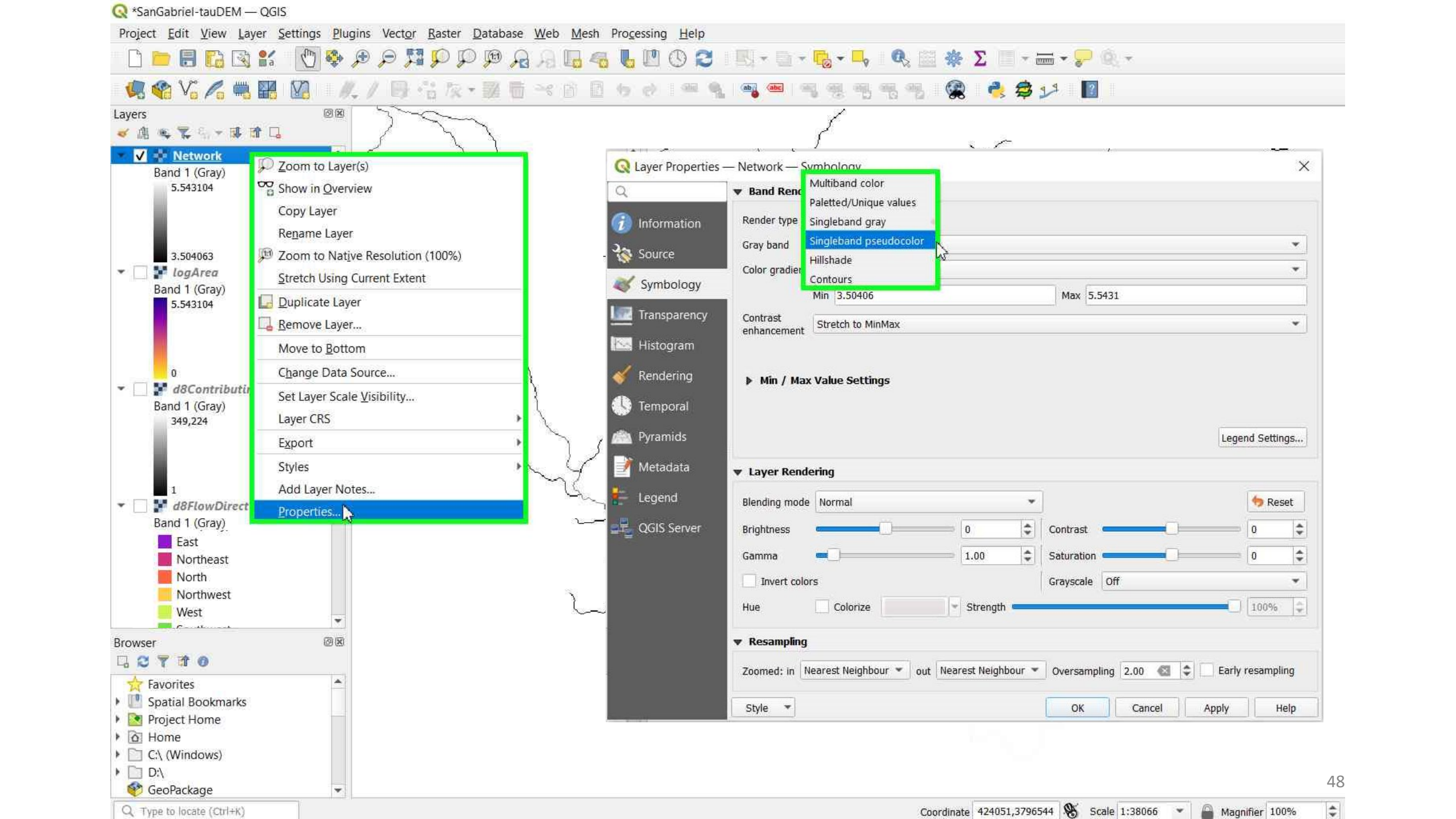
Select a threshold value of contributing area

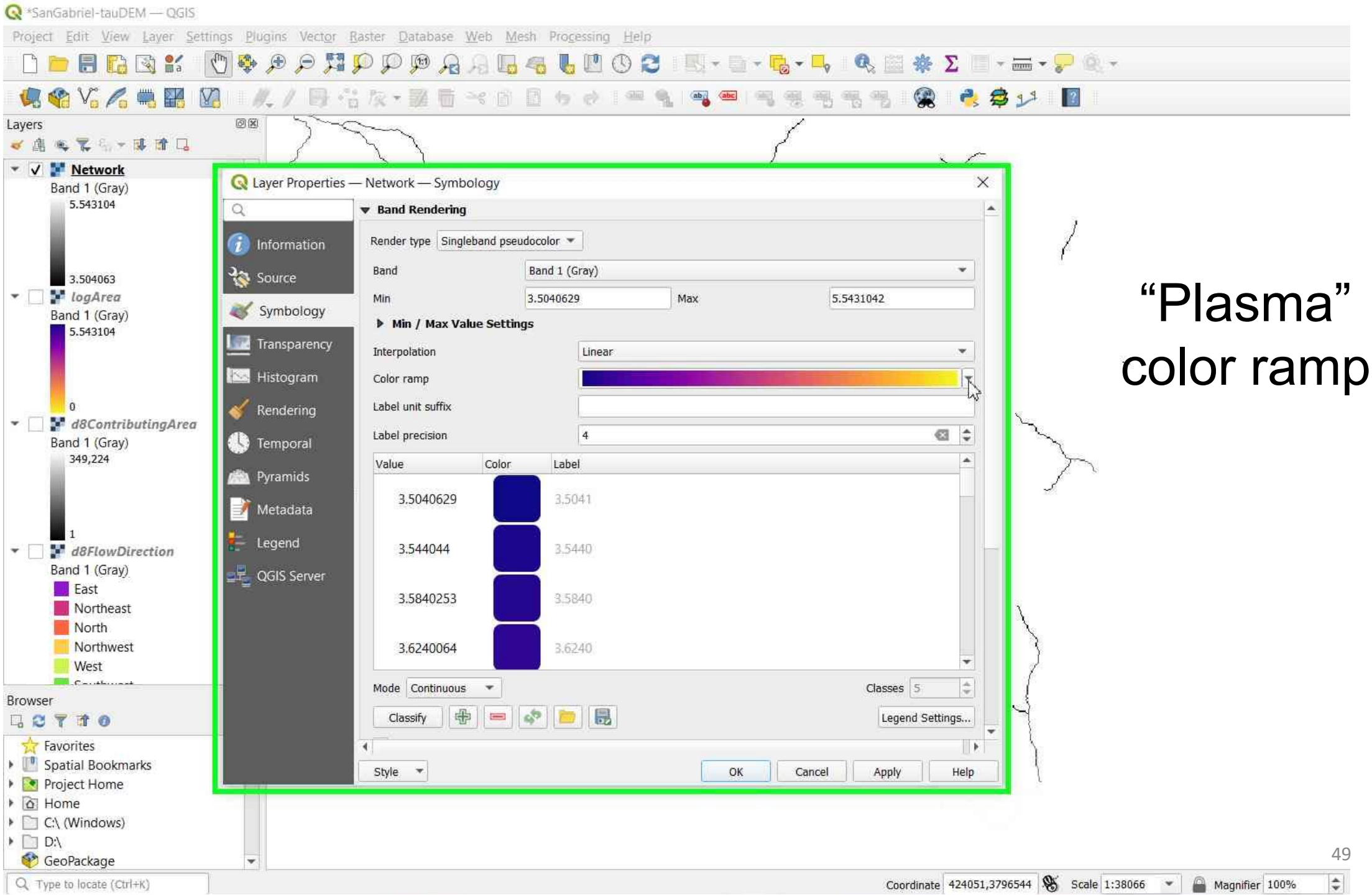
3.5 represents an area of $10^{3.5}$ (1,778), as this layer is a log

"logArea" / ("logArea" ≥ 3.5) will return only values ≥ 3.5

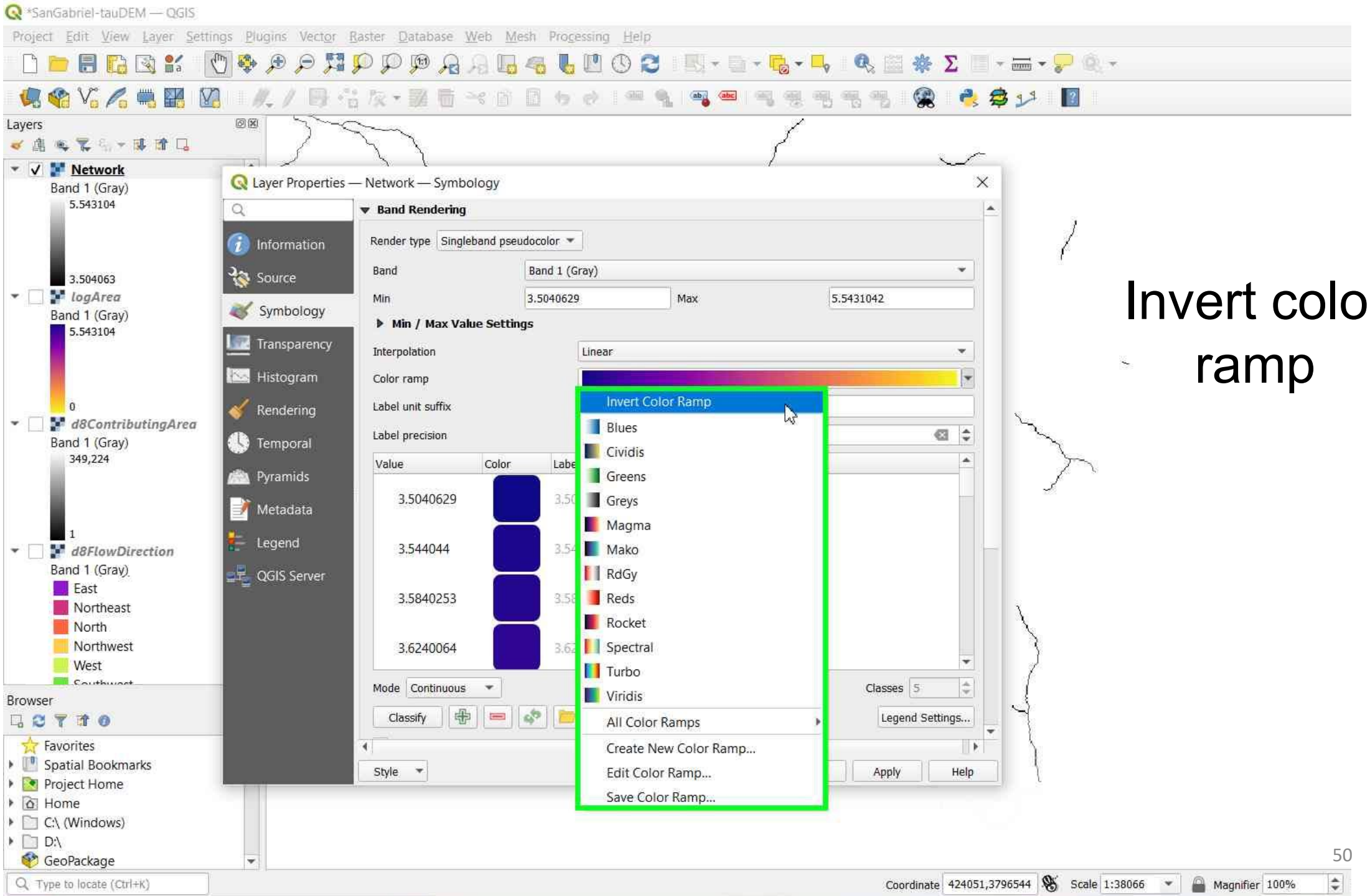


Add same color scheme to river network

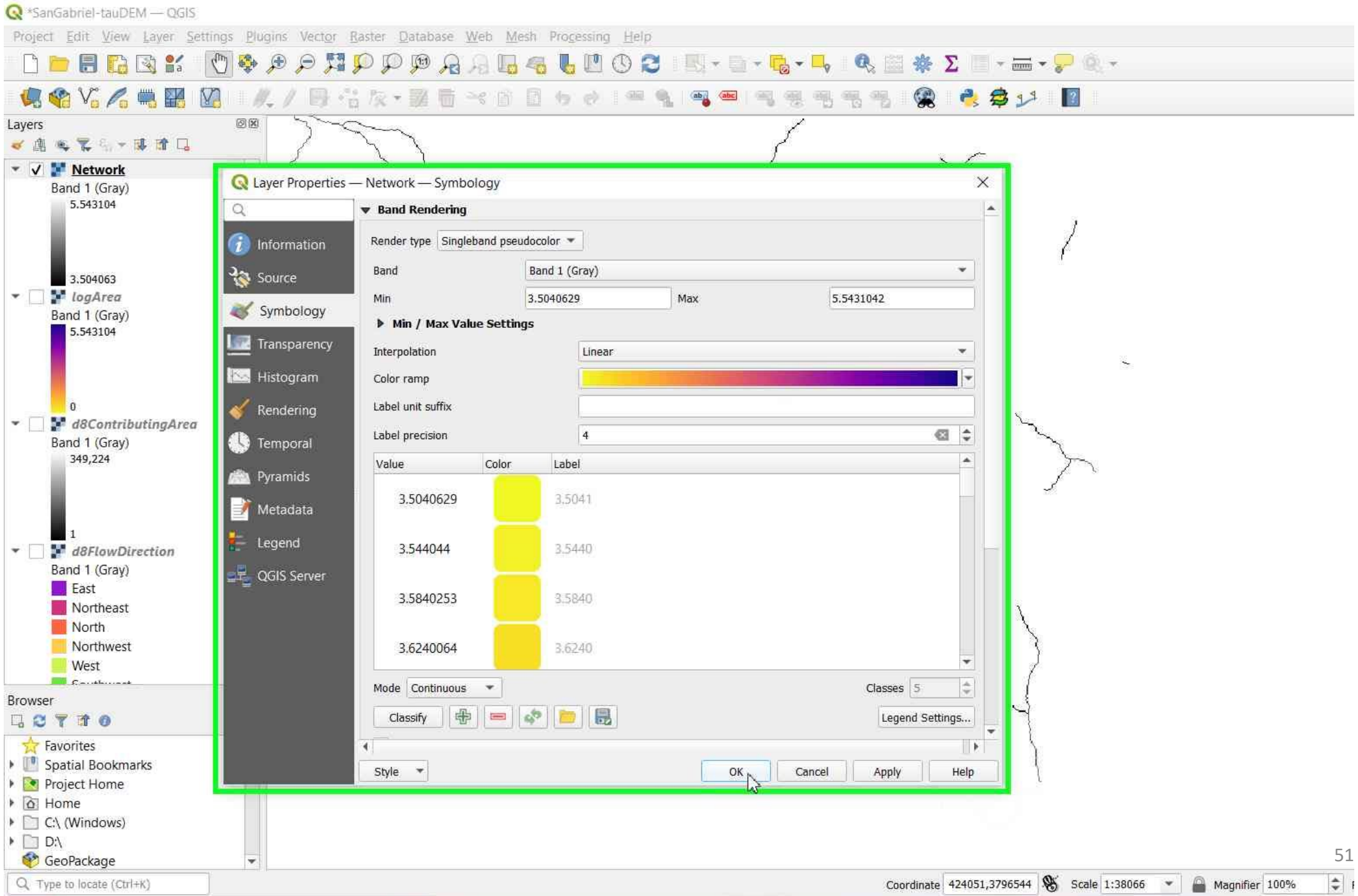

*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
Network
Band 1 (Gray)
5.543104
3.504063
logArea
Band 1 (Gray)
5.543104
0
d8Contributi
Band 1 (Gray)
349,224
1
d8FlowDirect
Band 1 (Gray)
East
Northeast
North
Northwest
West
Zoom to Layer(s)
Show in Overview
Copy Layer
Rename Layer
Zoom to Native Resolution (100%)
Stretch Using Current Extent
Duplicate Layer
Remove Layer...
Move to Bottom
Change Data Source...
Set Layer Scale Visibility...
Layer CRS
Export
Styles
Add Layer Notes...
Properties...
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Layer Properties — Network — Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Metadata
Legend
QGIS Server
Band Rend
Render type
Multiband color
Paletted/Unique values
Singleband gray
Singleband pseudocolor
Hillshade
Contours
Gray band
Color gradien
Min 3.50406
Max 5.5431
Contrast enhancement
Stretch to MinMax
Min / Max Value Settings
Legend Settings...
Layer Rendering
Blending mode
Normal
Reset
Brightness
0
Contrast
0
Gamma
1.00
Saturation
0
Invert colors
Grayscale
Off
Hue
Colorize
Strength
100%
Resampling
Zoomed: in
Nearest Neighbour
out
Nearest Neighbour
Oversampling
2.00
Early resampling
Style
OK
Cancel
Apply
Help
Type to locate (Ctrl+K)
Coordinate
424051,3796544
Scale
1:38066
Magnifier
100%

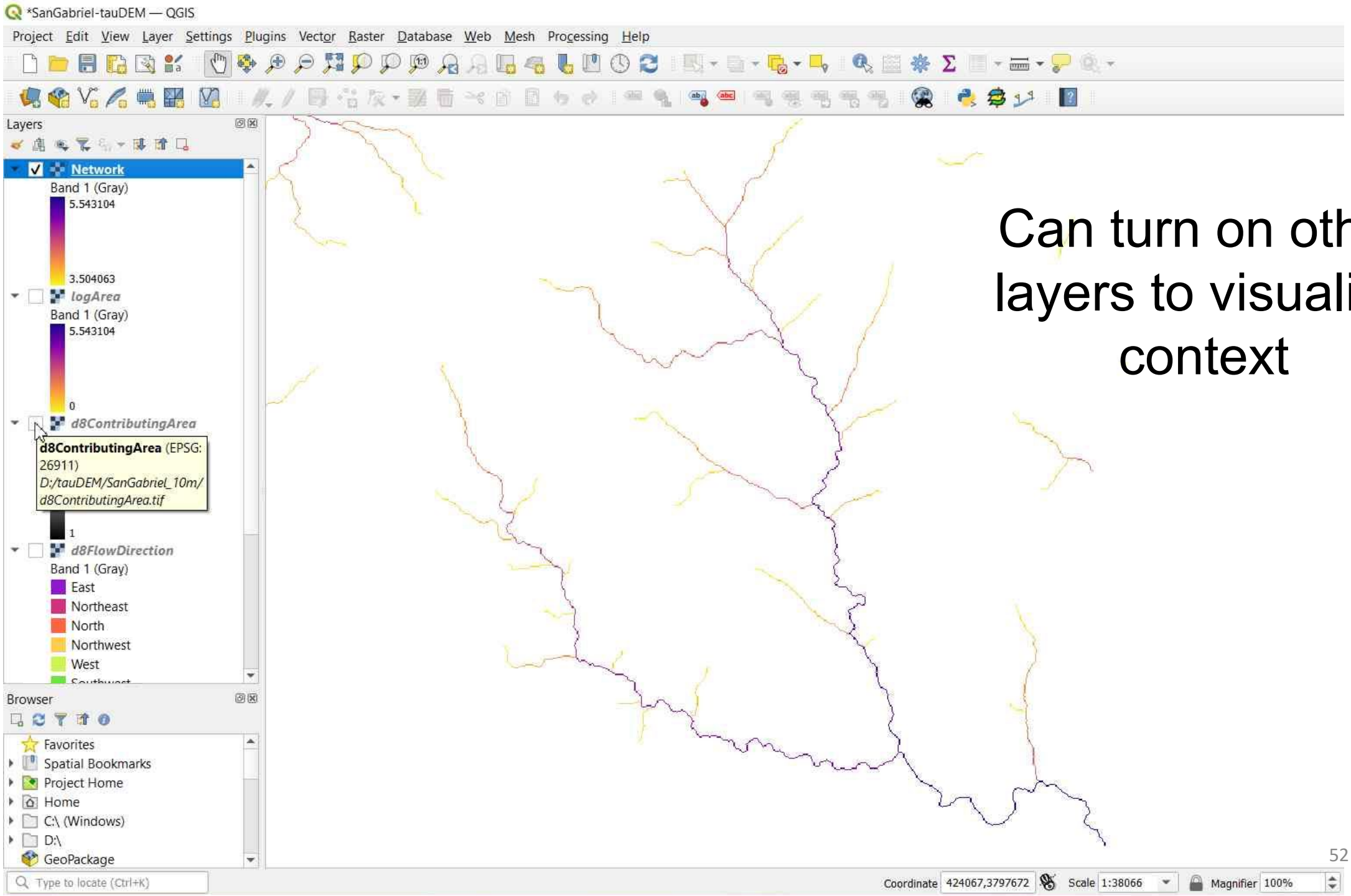


"Plasma" color ramp

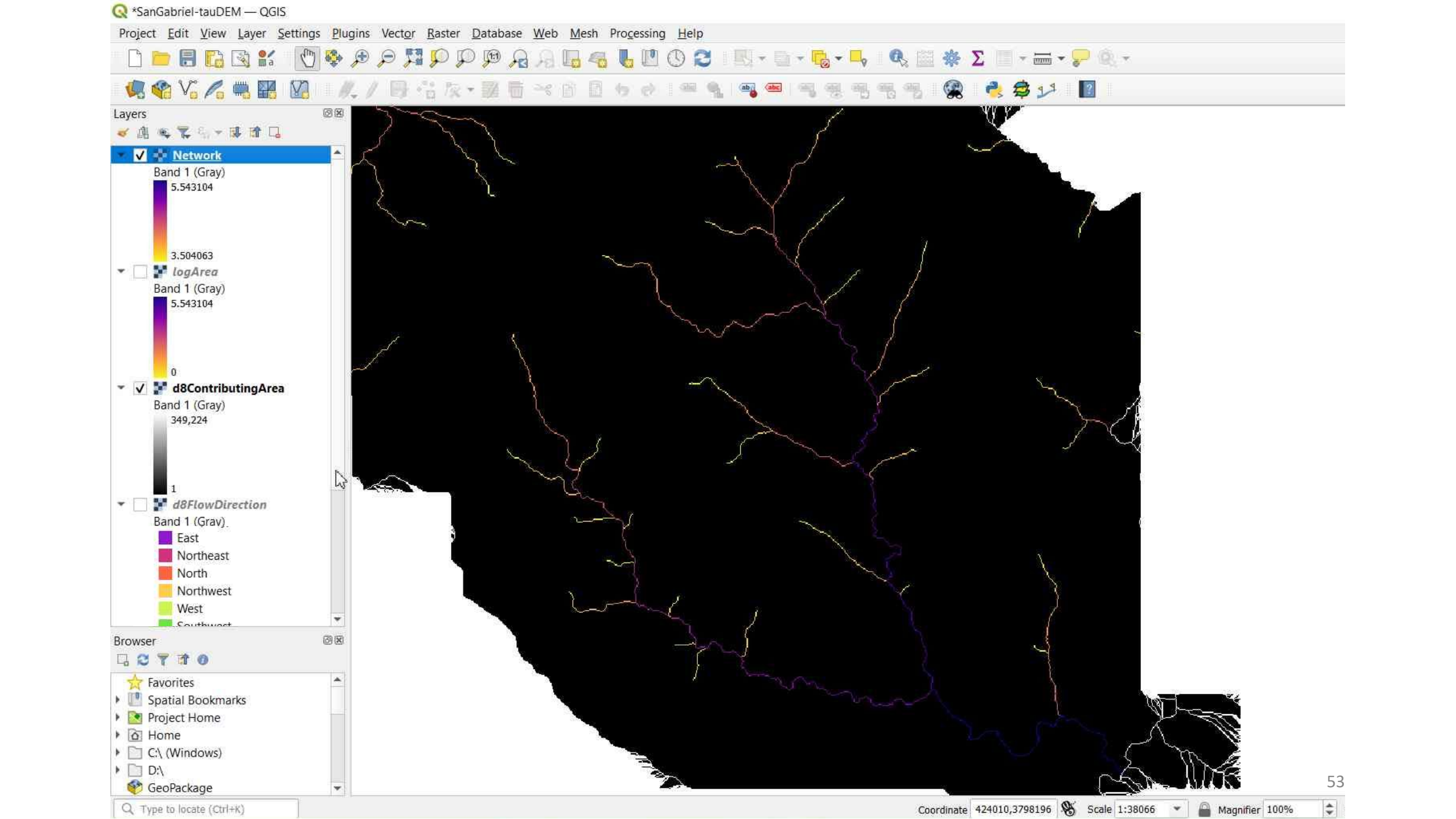


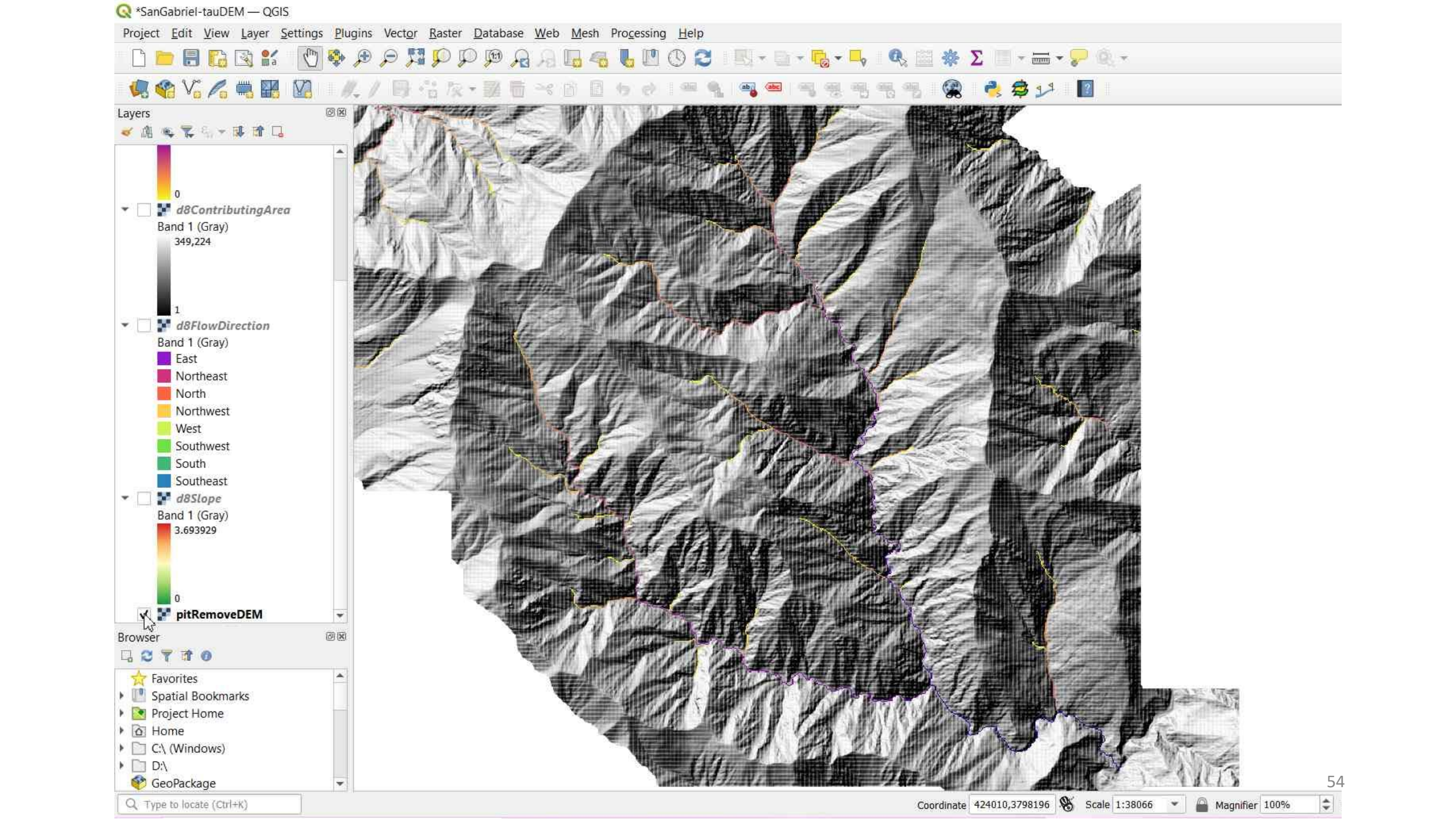
Invert color ramp


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
Network
Band 1 (Gray)
5.543104
3.504063
logArea
Band 1 (Gray)
5.543104
0
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
East
Northeast
North
Northwest
West
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Layer Properties — Network — Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Metadata
Legend
QGIS Server
Band Rendering
Render type Singleband pseudocolor
Band Band 1 (Gray)
Min 3.5040629 Max 5.5431042
Min / Max Value Settings
Interpolation Linear
Color ramp
Label unit suffix
Label precision 4
Value Color Label
3.5040629 3.5041
3.544044 3.5440
3.5840253 3.5840
3.6240064 3.6240
Mode Continuous
Classes 5
Classify
Legend Settings...
Style
OK
Cancel
Apply
Help
Type to locate (Ctrl+K)
Coordinate 424051,3796544
Scale 1:38066
Magnifier 100%

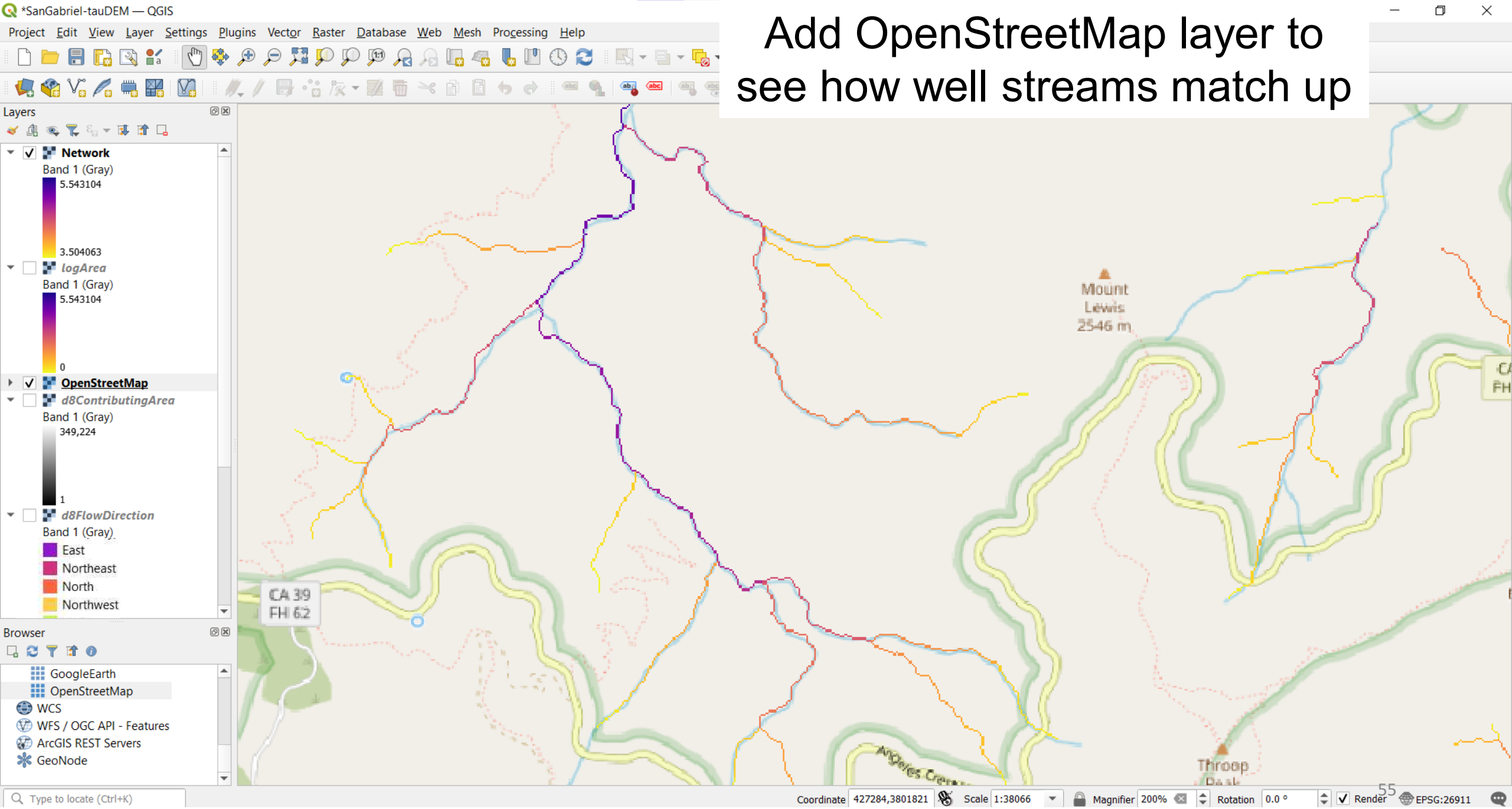


Can turn on other layers to visualize context


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
Network
Band 1 (Gray)
5.543104
3.504063
logArea
Band 1 (Gray)
5.543104
0
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
East
Northeast
North
Northwest
West
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Type to locate (Ctrl+K)
Coordinate 424010,3798196
Scale 1:38066
Magnifier 100%


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
0
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
East
Northeast
North
Northwest
West
Southwest
South
Southeast
d8Slope
Band 1 (Gray)
3.693929
0
pitRemoveDEM
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Type to locate (Ctrl+K)
Coordinate 424010,3798196
Scale 1:38066
Magnifier 100%

Add OpenStreetMap layer to see how well streams match up



*SanGabriel-tauDEM — QGIS

Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help

Layers

- **Network**
  - Band 1 (Gray)
  - 5.543104
  - 3.504063
- *logArea*
  - Band 1 (Gray)
  - 5.543104
  - 0
- **OpenStreetMap**
- *d8ContributingArea*
  - Band 1 (Gray)
  - 349,224
  - 1
- *d8FlowDirection*
  - Band 1 (Gray)
  - East
  - Northeast
  - North
  - Northwest

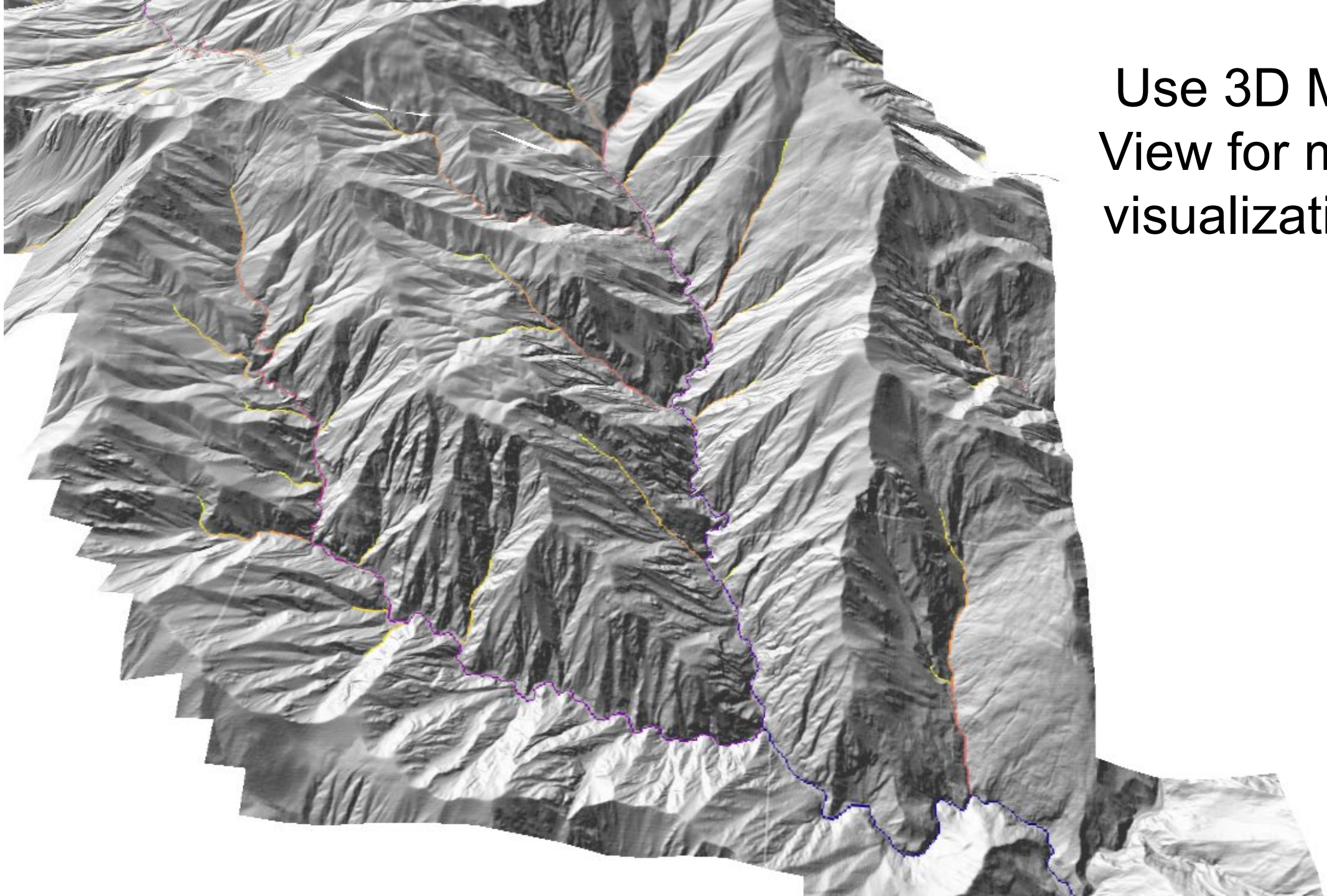
Browser

- GoogleEarth
- OpenStreetMap
- WCS
- WFS / OGC API - Features
- ArcGIS REST Servers
- GeoNode

Ross Mountain
2248 m

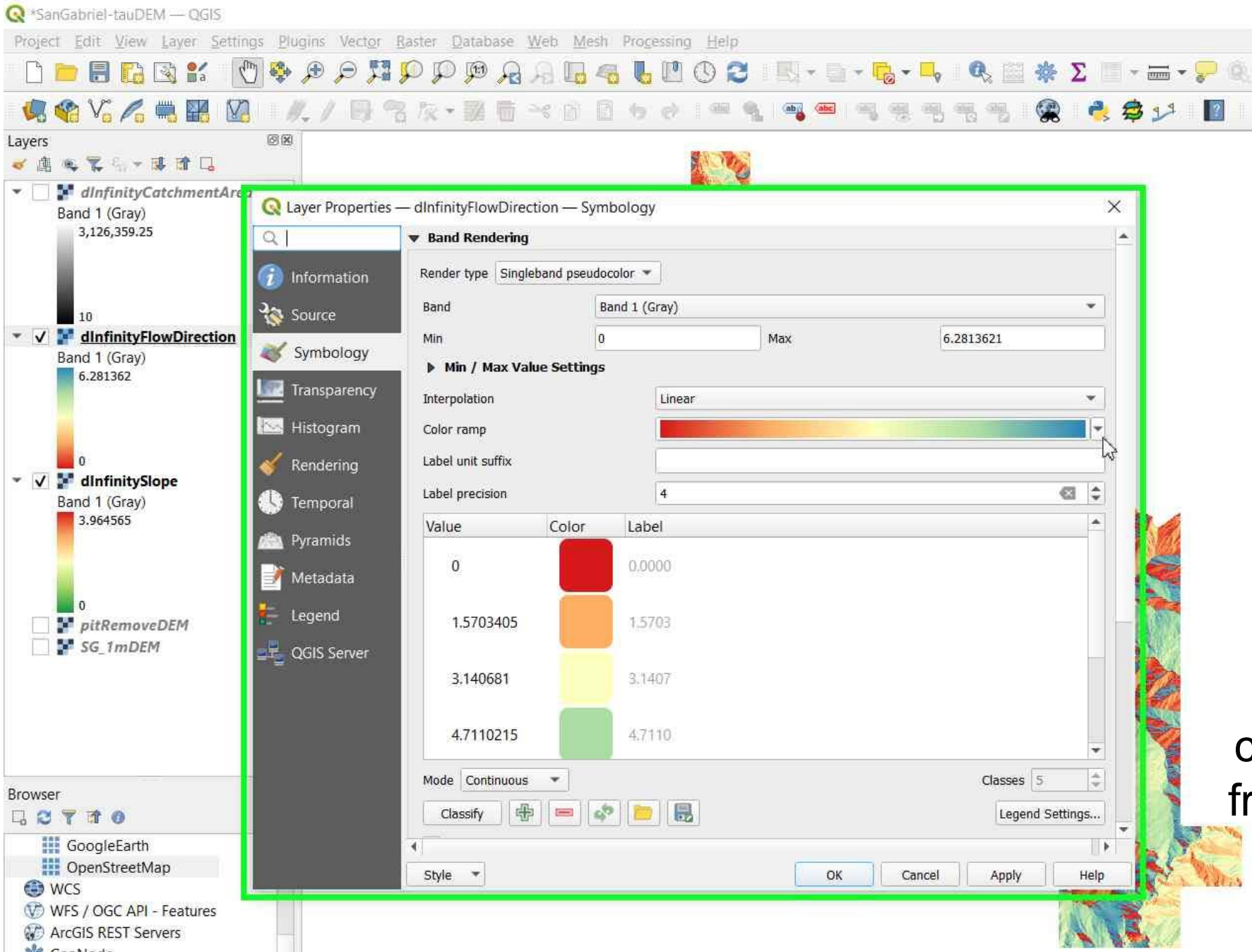
Type to locate (Ctrl+K)

Coordinate 429852,3797687 Scale 1:38066 Magnifier 150% Rotation 0.0 ° Render EPSG:26911



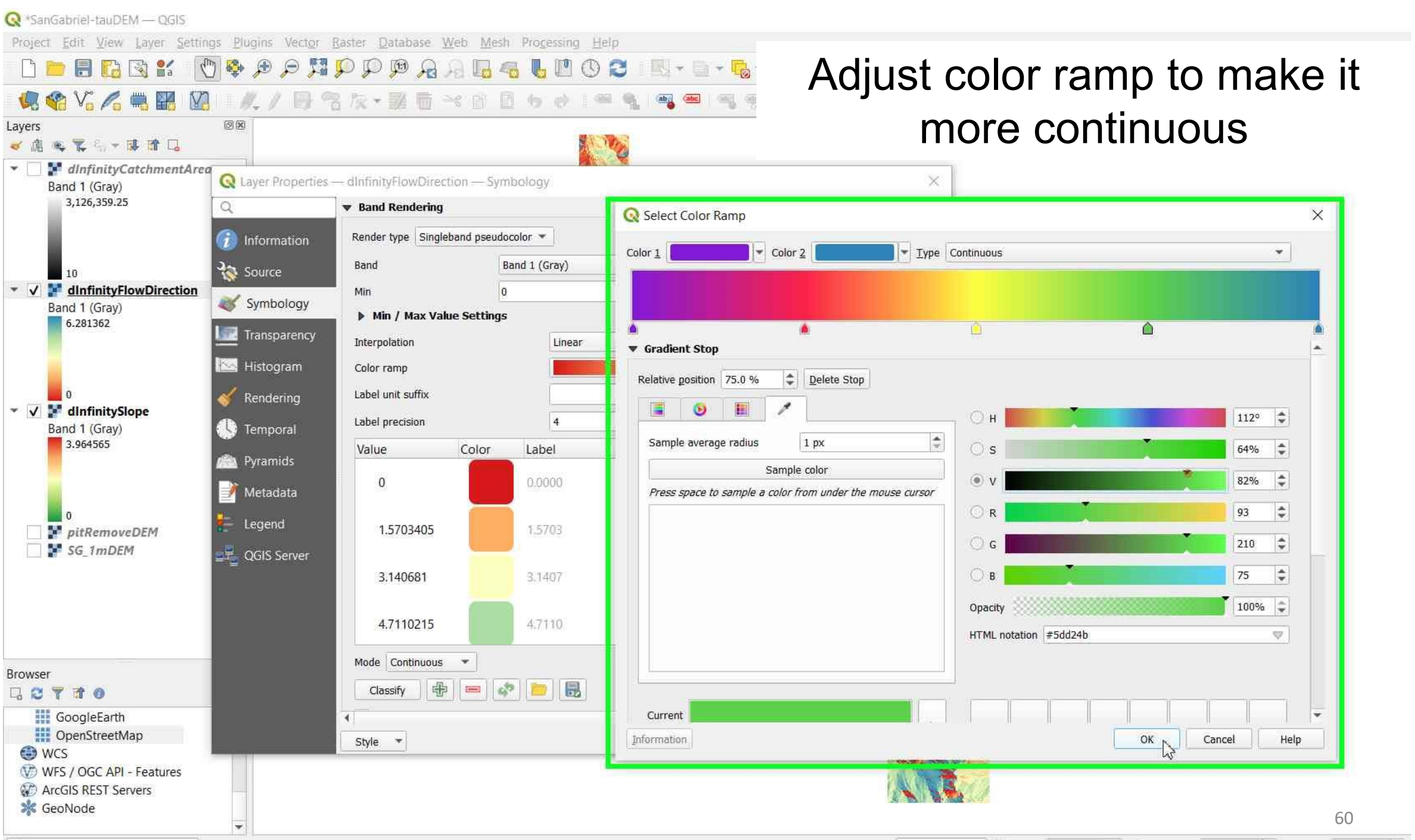
Use 3D Map View for more visualizations

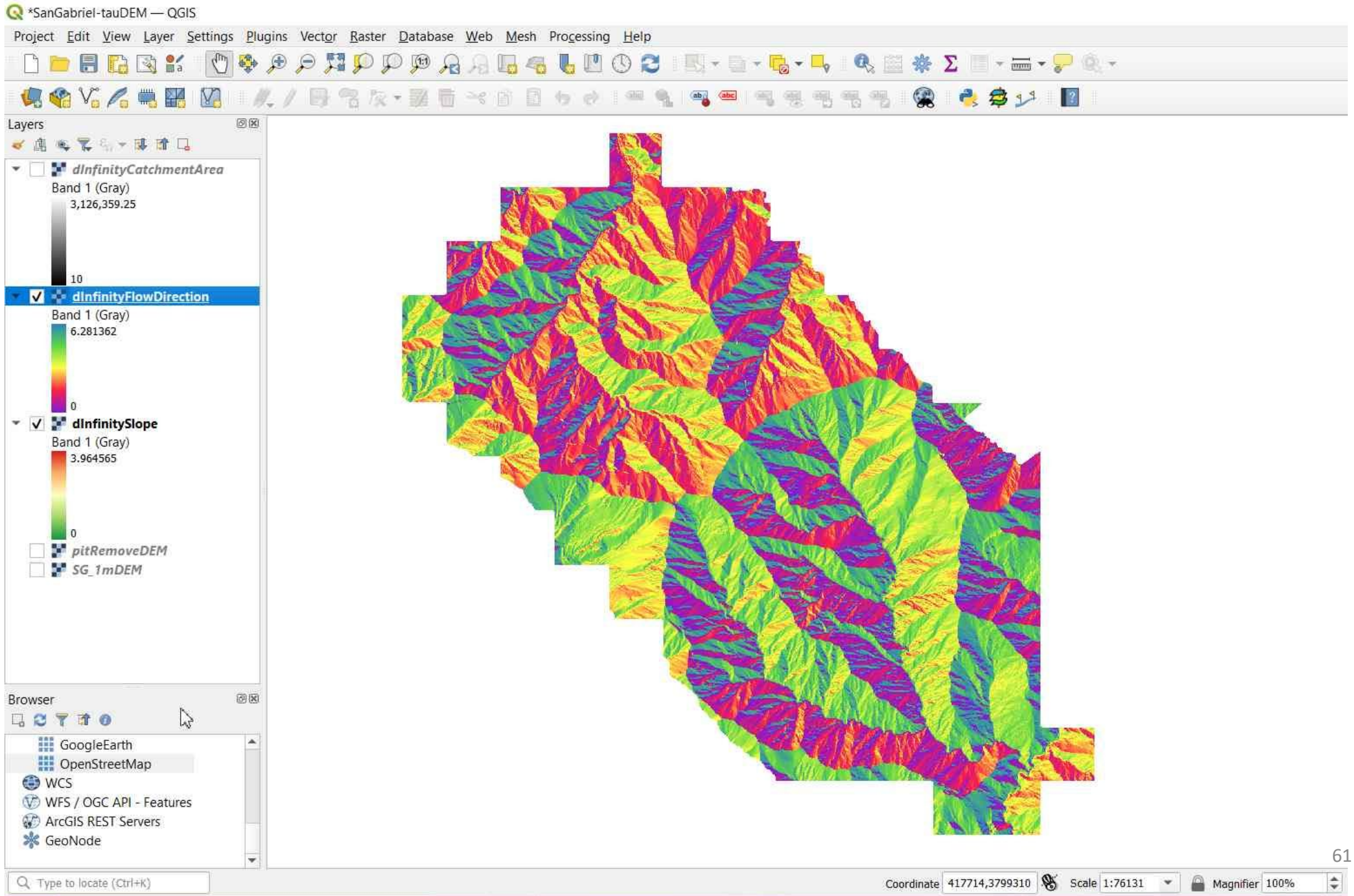
D-Infinity Products

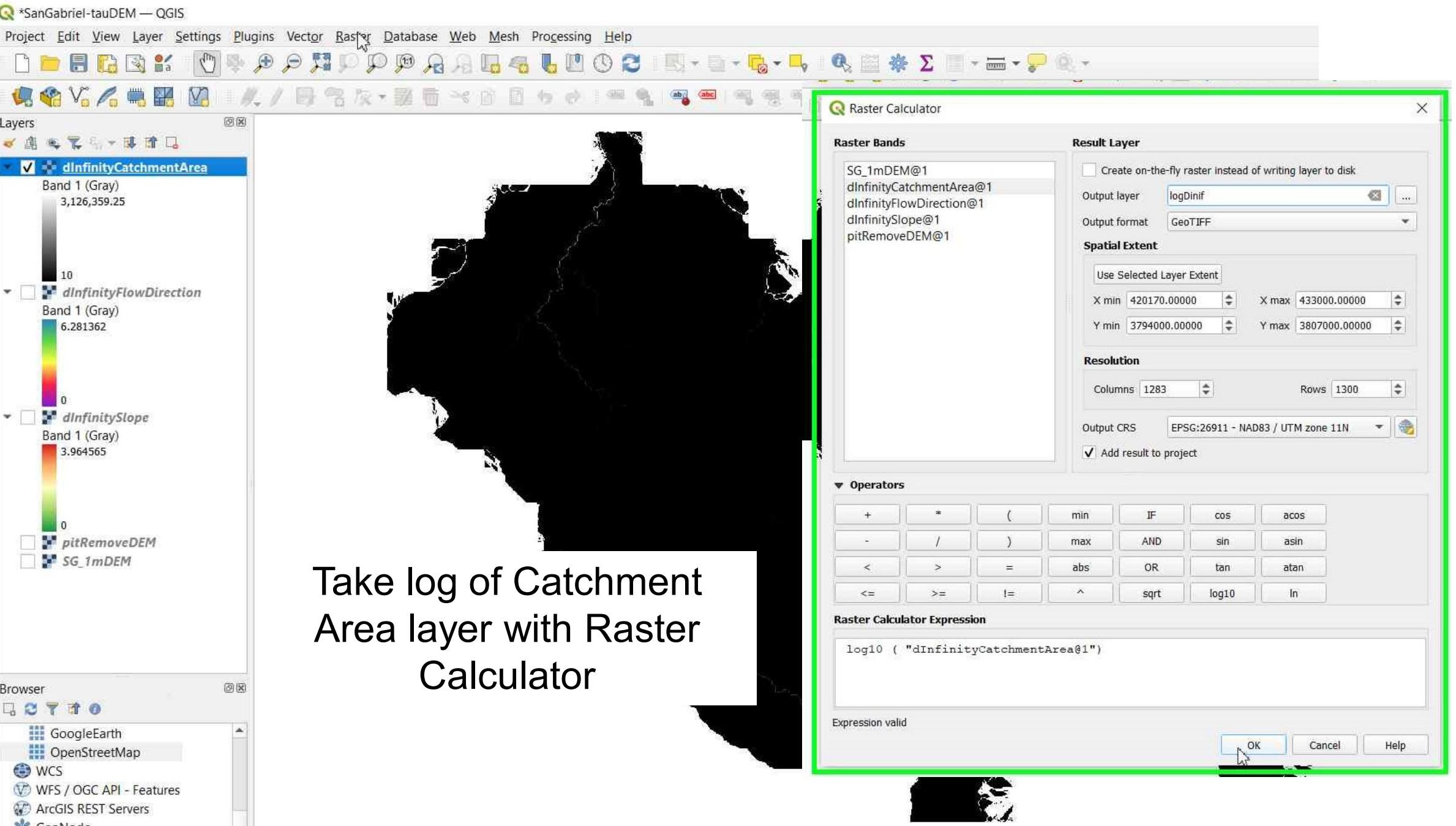


Flow Direction, Singleband pseudocolor, values are an angle in radians counter-clockwise from east between 0 and 2 pi

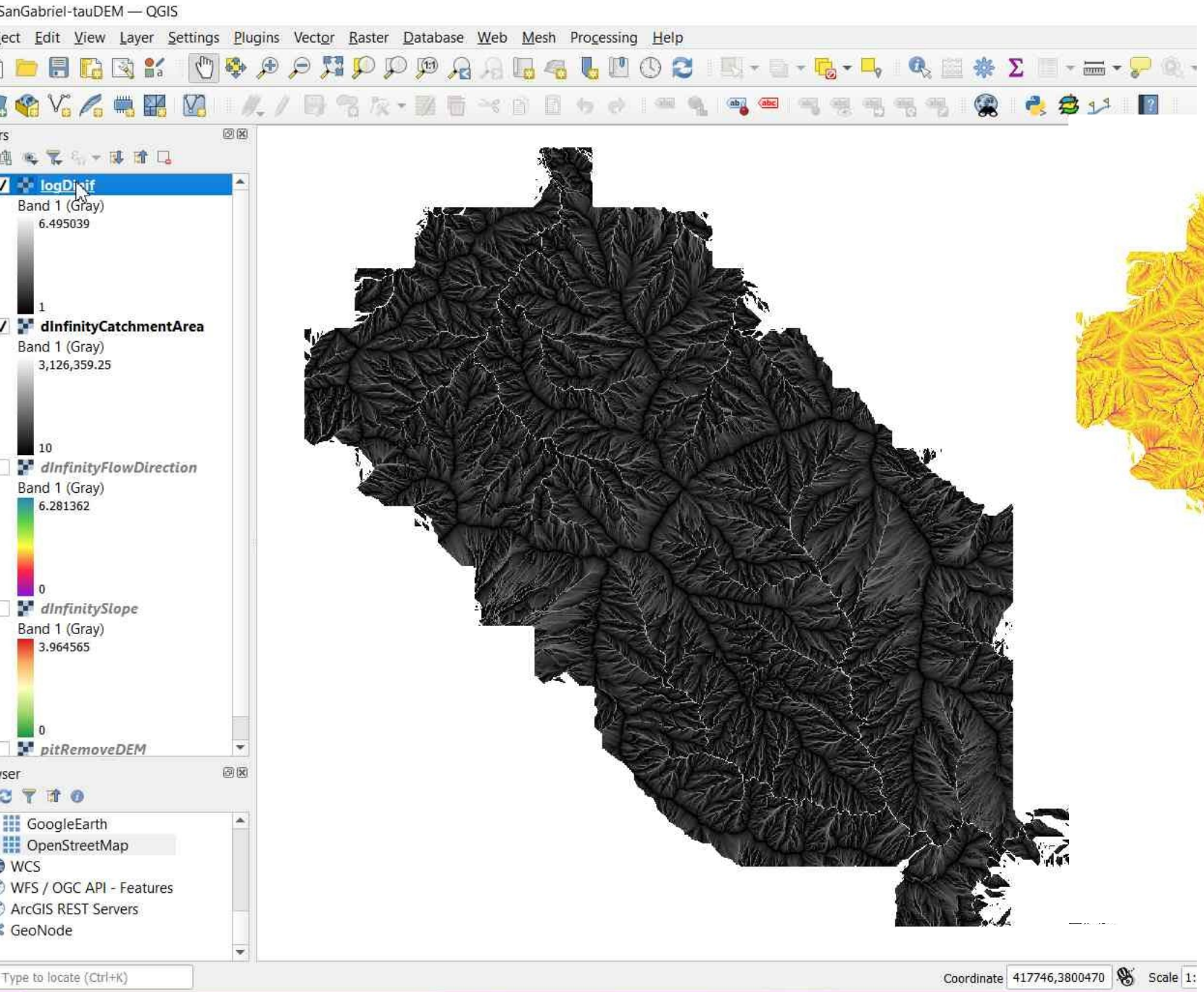
Adjust color ramp to make it more continuous

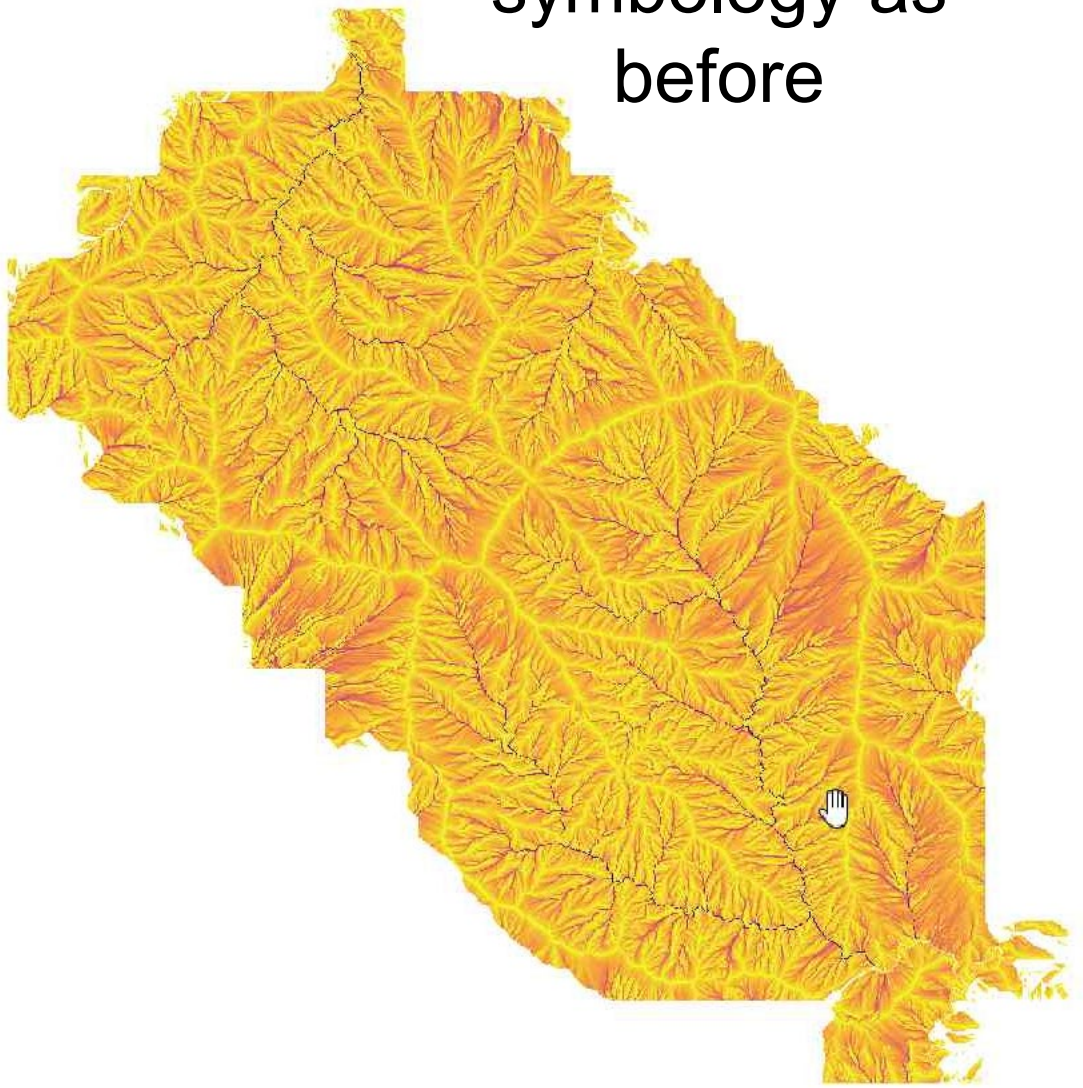


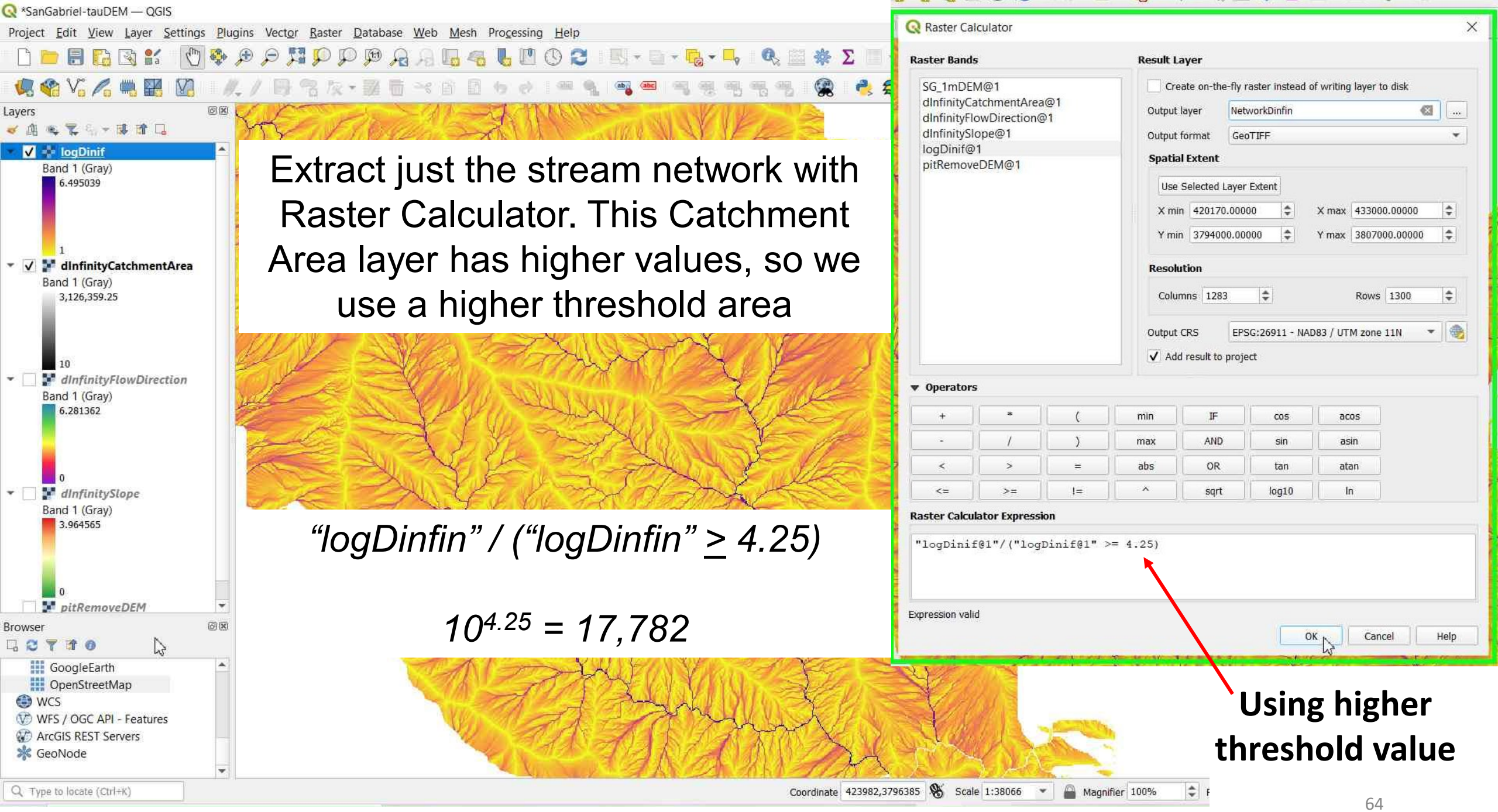

*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
dInfinityCatchmentArea
Band 1 (Gray)
3,126,359.25
10
dInfinityFlowDirection
Band 1 (Gray)
6.281362
0
dInfinitySlope
Band 1 (Gray)
3.964565
0
pitRemoveDEM
SG_1mDEM
Browser
GoogleEarth
OpenStreetMap
WCS
WFS / OGC API - Features
ArcGIS REST Servers
GeoNode
Type to locate (Ctrl+K)
Coordinate 417714,3799310
Scale 1:76131
Magnifier 100%


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
dInfinityCatchmentArea
Band 1 (Gray)
3,126,359.25
10
dInfinityFlowDirection
Band 1 (Gray)
6.281362
0
dInfinitySlope
Band 1 (Gray)
3.964565
0
pitRemoveDEM
SG_1mDEM
Browser
GoogleEarth
OpenStreetMap
WCS
WFS / OGC API - Features
ArcGIS REST Servers
GeoNode
Raster Calculator
Raster Bands
SG_1mDEM@1
dInfinityCatchmentArea@1
dInfinityFlowDirection@1
dInfinitySlope@1
pitRemoveDEM@1
Result Layer
Create on-the-fly raster instead of writing layer to disk
Output layer
logDinif
Output format
GeoTIFF
Spatial Extent
Use Selected Layer Extent
X min 420170.00000
X max 433000.00000
Y min 3794000.00000
Y max 3807000.00000
Resolution
Columns 1283
Rows 1300
Output CRS
EPSG:26911 - NAD83 / UTM zone 11N
Add result to project
Operators
+ * (min IF cos acos
- /) max AND sin asin
< > = abs OR tan atan
<= >= != ^ sqrt log10 ln
Raster Calculator Expression
log10 ("dInfinityCatchmentArea@1")
Expression valid
OK
Cancel
Help
Take log of Catchment Area layer with Raster Calculator
Type to locate (Ctrl+K)
Coordinate 420453,3807254
Scale 1:76131
Magnifier 100%

Change layer symbology as before





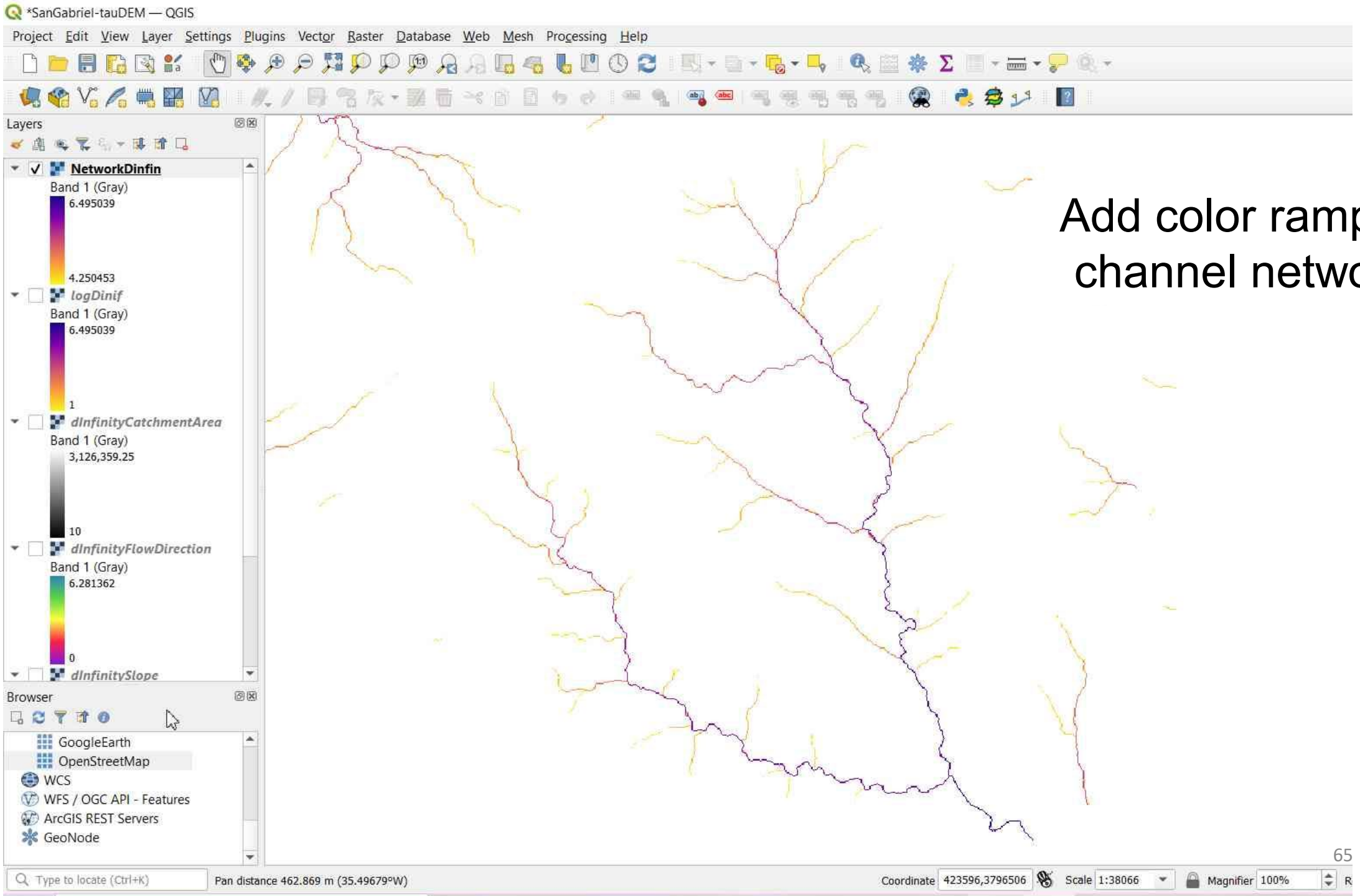


Extract just the stream network with Raster Calculator. This Catchment Area layer has higher values, so we use a higher threshold area

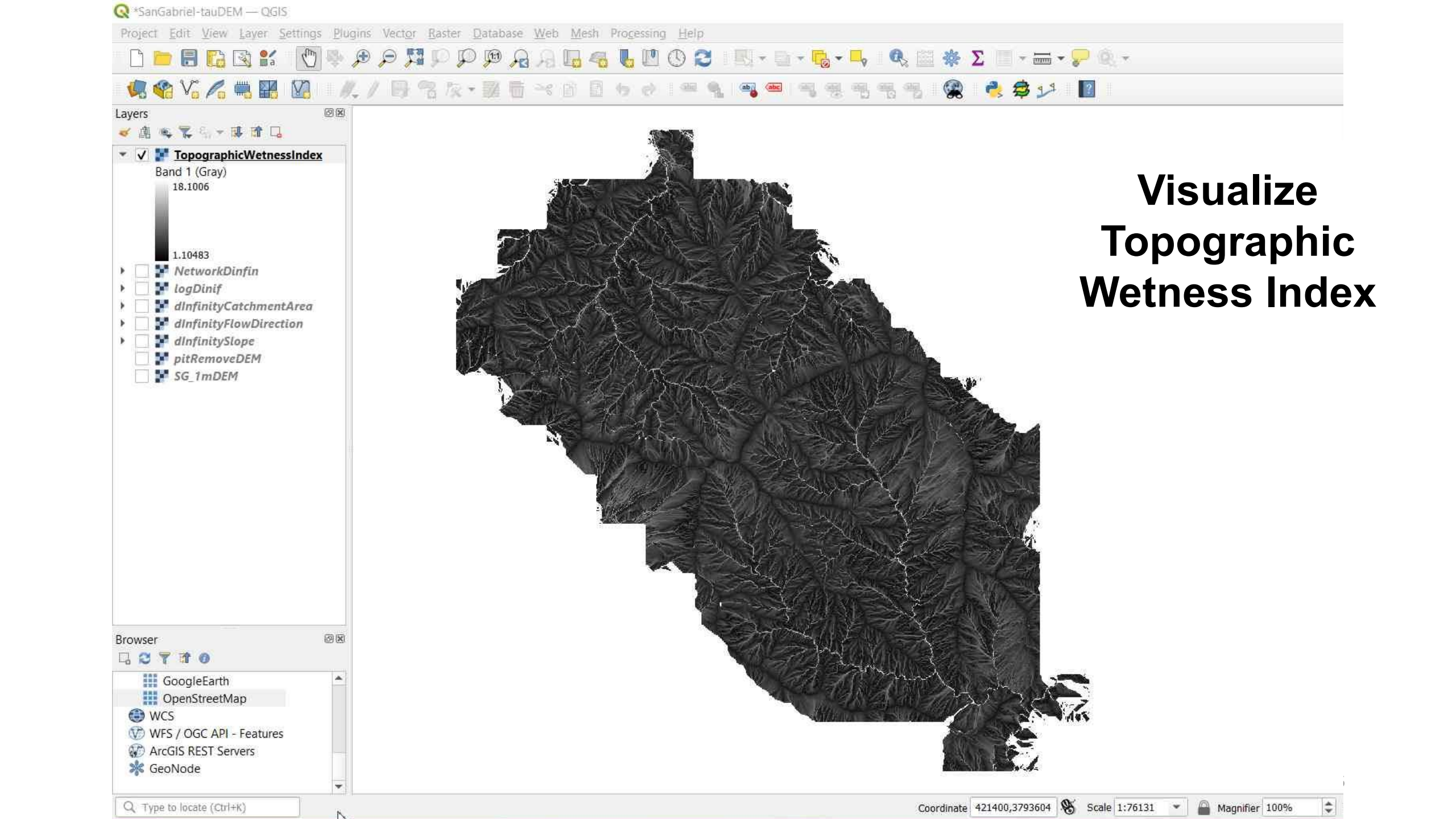
"logDinfin" / ("logDinfin" ≥ 4.25)

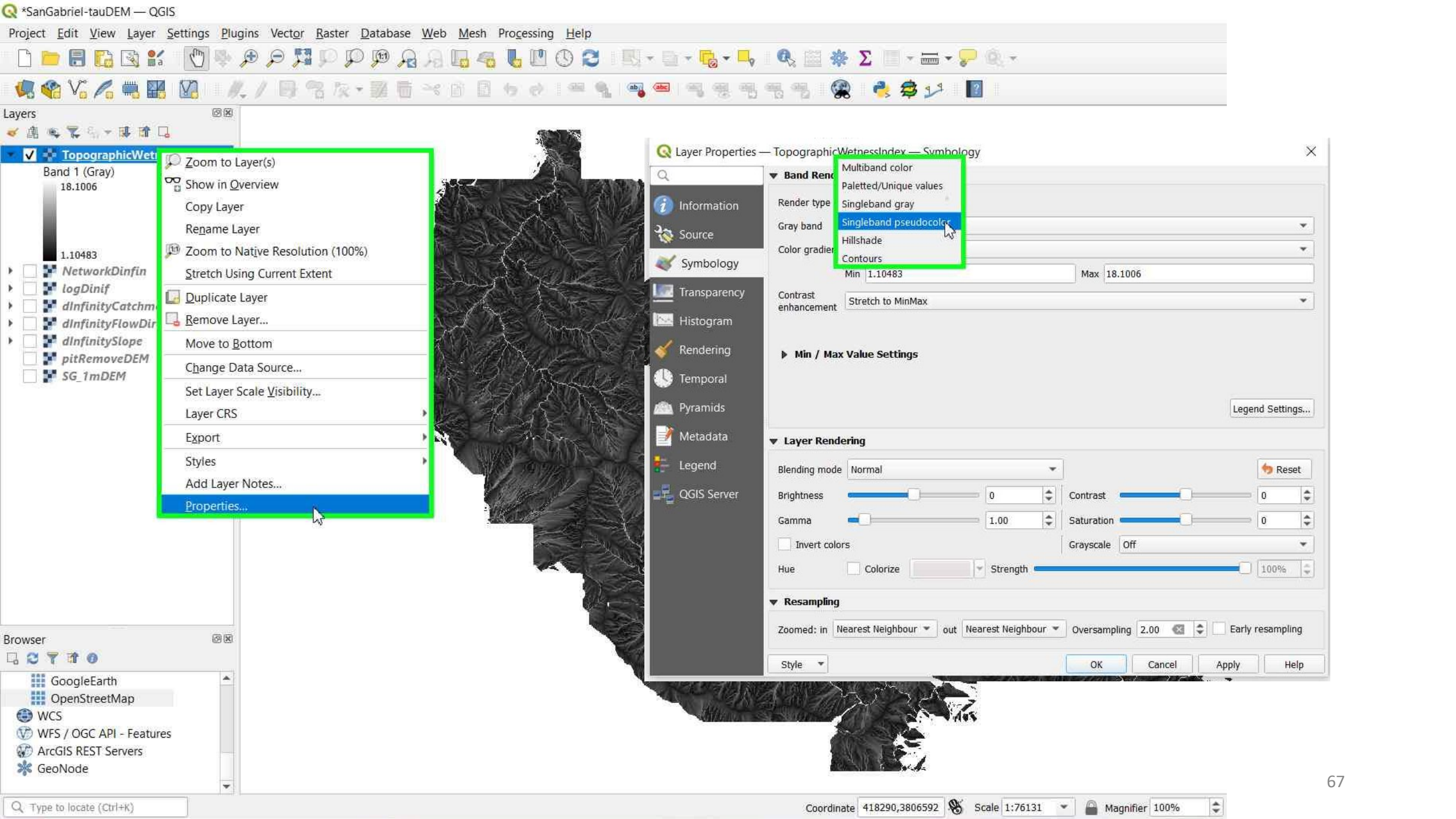
$10^{4.25} = 17{,}782$

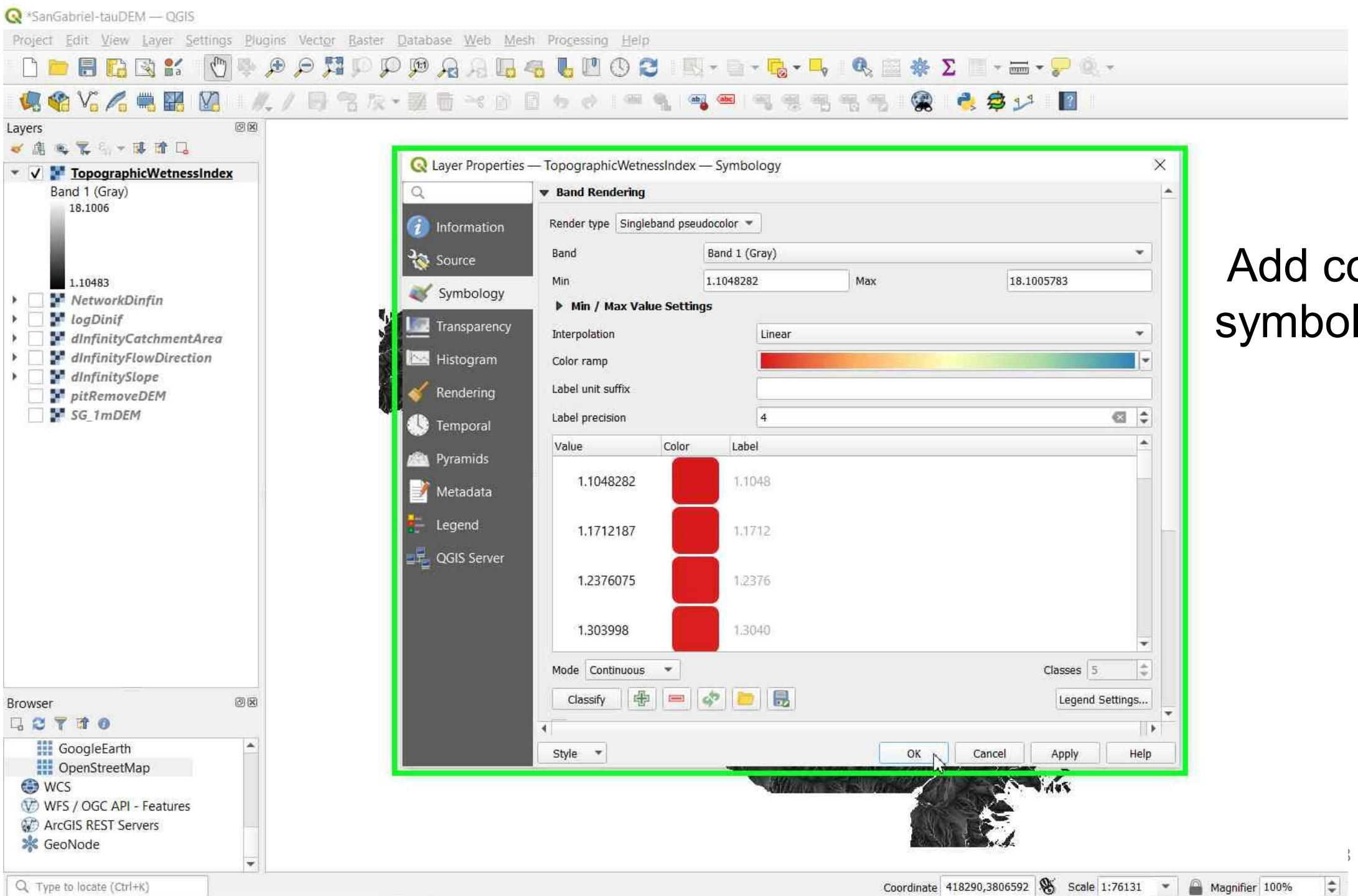
Using higher threshold value



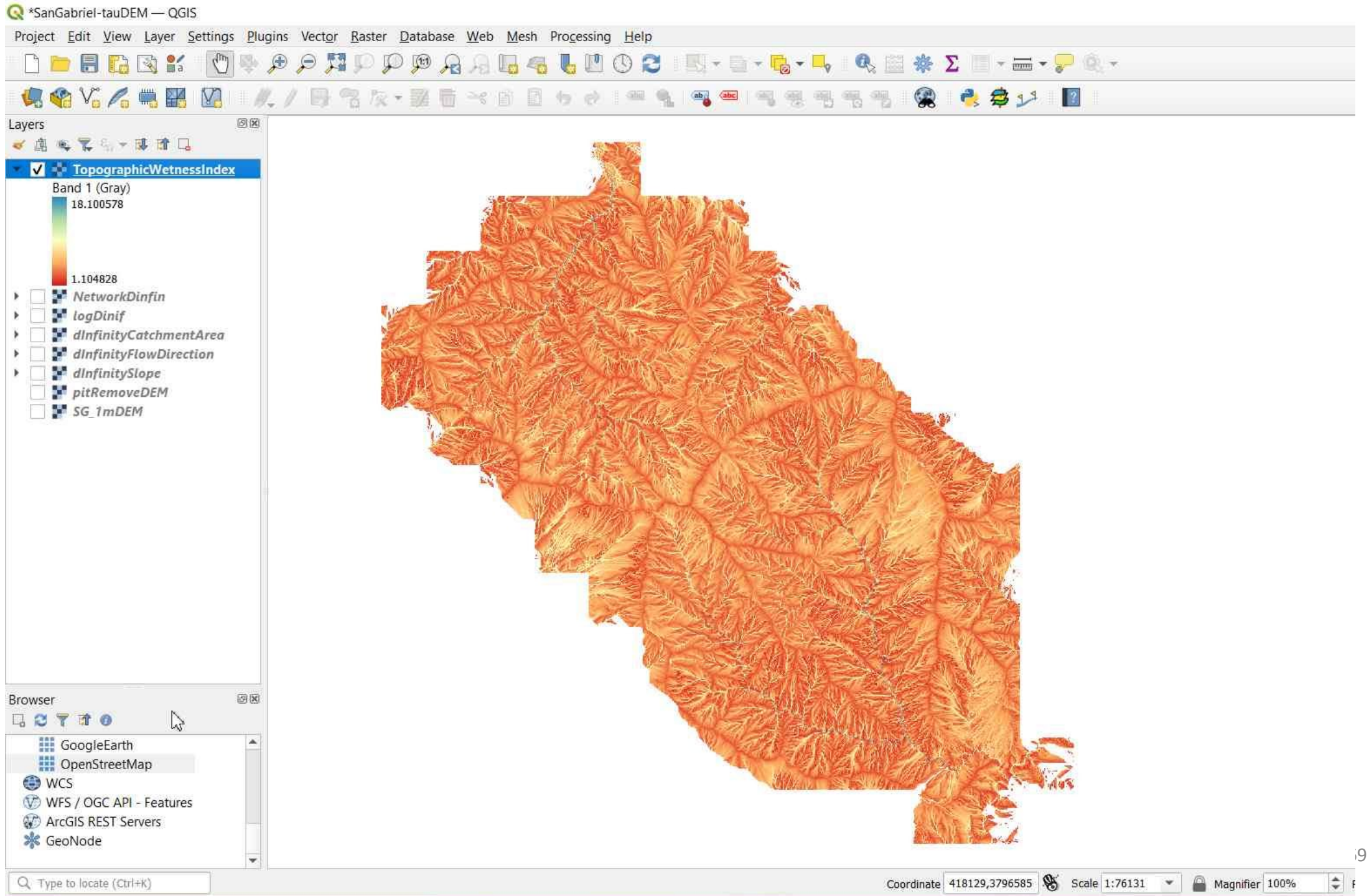
Add color ramp to channel network

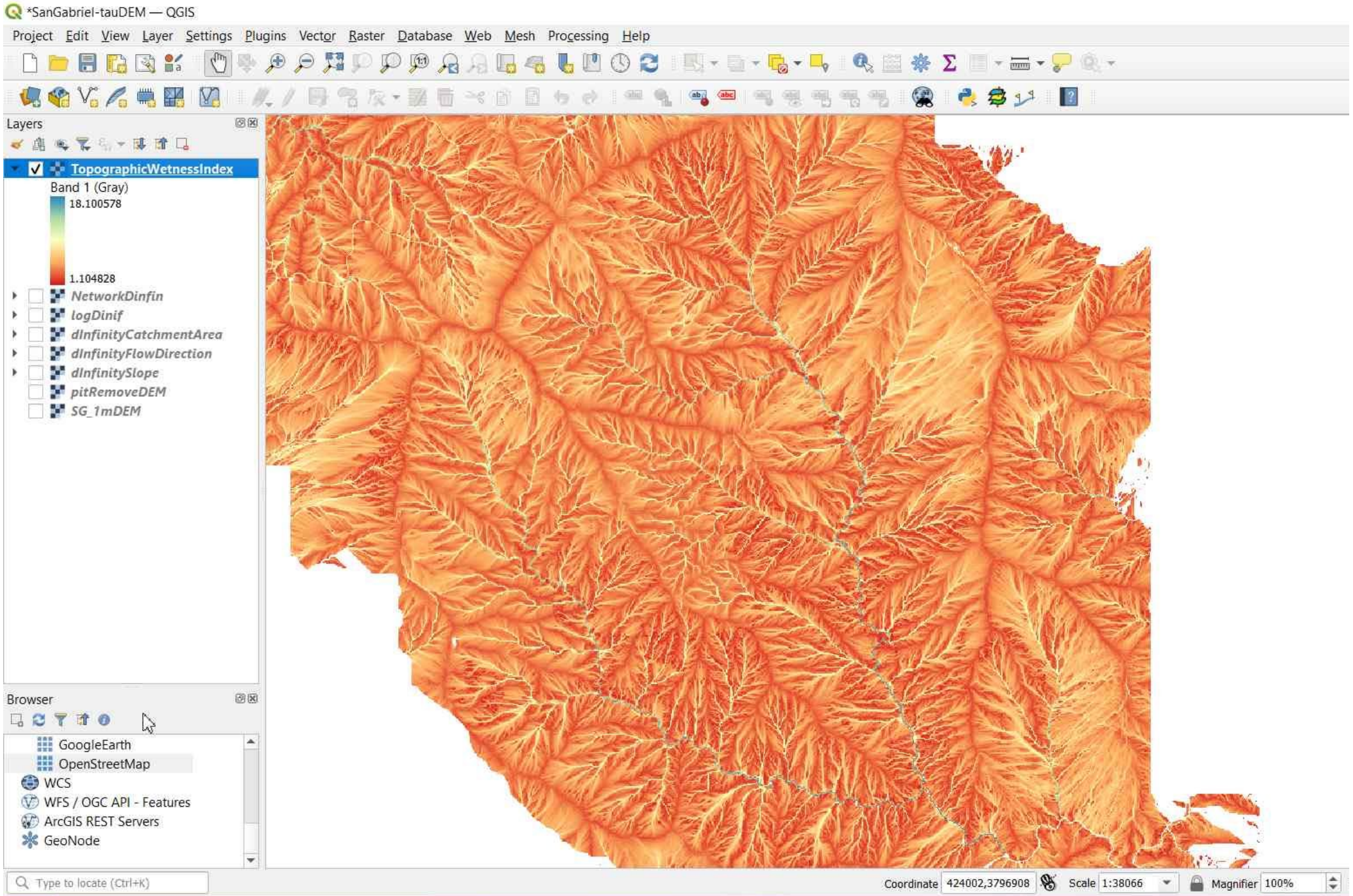

*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
TopographicWetnessIndex
Band 1 (Gray)
18.1006
1.10483
NetworkDinfin
logDinif
dInfinityCatchmentArea
dInfinityFlowDirection
dInfinitySlope
pitRemoveDEM
SG_1mDEM
Browser
GoogleEarth
OpenStreetMap
WCS
WFS / OGC API - Features
ArcGIS REST Servers
GeoNode
Type to locate (Ctrl+K)
Coordinate 421400,3793604
Scale 1:76131
Magnifier 100%
Visualize Topographic Wetness Index

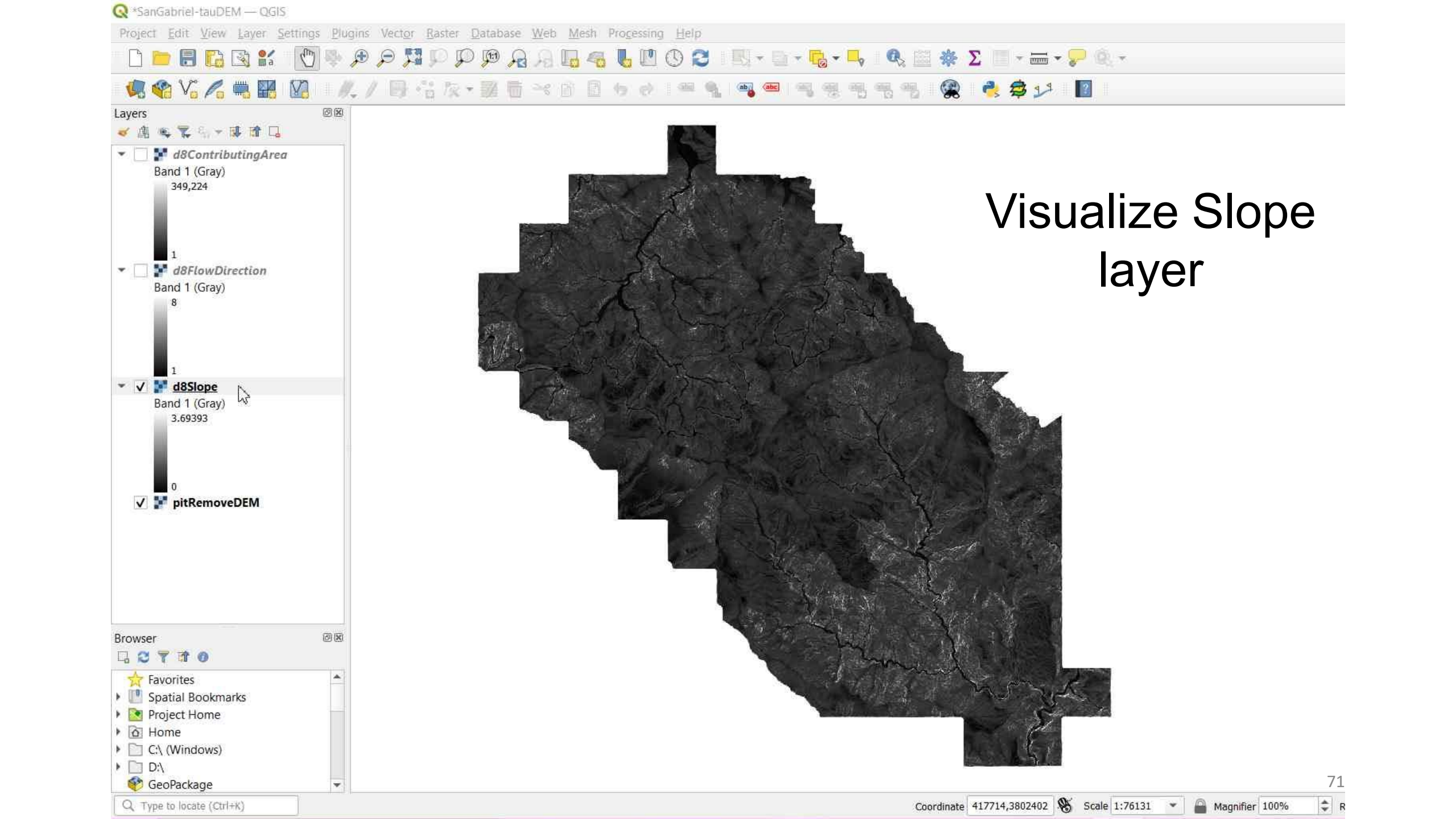

*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
TopographicWet
Band 1 (Gray)
18.1006
1.10483
NetworkDinfin
logDinif
dInfinityCatchm
dInfinityFlowDir
dInfinitySlope
pitRemoveDEM
SG_1mDEM
Zoom to Layer(s)
Show in Overview
Copy Layer
Rename Layer
Zoom to Native Resolution (100%)
Stretch Using Current Extent
Duplicate Layer
Remove Layer...
Move to Bottom
Change Data Source...
Set Layer Scale Visibility...
Layer CRS
Export
Styles
Add Layer Notes...
Properties...
Browser
GoogleEarth
OpenStreetMap
WCS
WFS / OGC API - Features
ArcGIS REST Servers
GeoNode
Layer Properties — TopographicWetnessIndex — Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Metadata
Legend
QGIS Server
Band Rend
Render type
Multiband color
Paletted/Unique values
Singleband gray
Singleband pseudocolor
Hillshade
Contours
Gray band
Color gradier
Min 1.10483
Max 18.1006
Contrast enhancement
Stretch to MinMax
Min / Max Value Settings
Legend Settings...
Layer Rendering
Blending mode
Normal
Reset
Brightness
Contrast
Gamma
1.00
Saturation
Invert colors
Grayscale
Off
Hue
Colorize
Strength
100%
Resampling
Zoomed: in
Nearest Neighbour
out
Nearest Neighbour
Oversampling
2.00
Early resampling
Style
OK
Cancel
Apply
Help
Type to locate (Ctrl+K)
Coordinate
418290,3806592
Scale
1:76131
Magnifier
100%

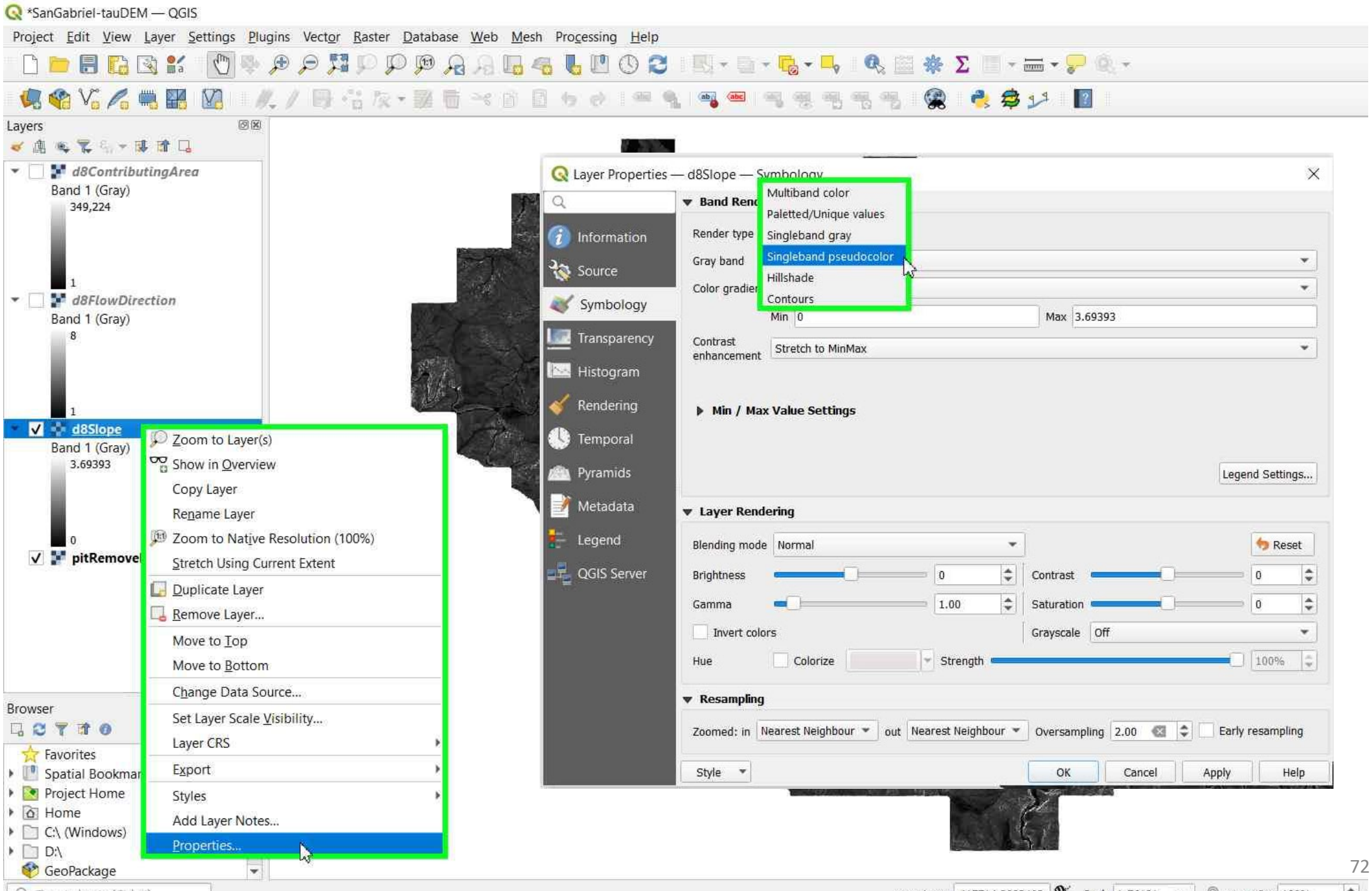


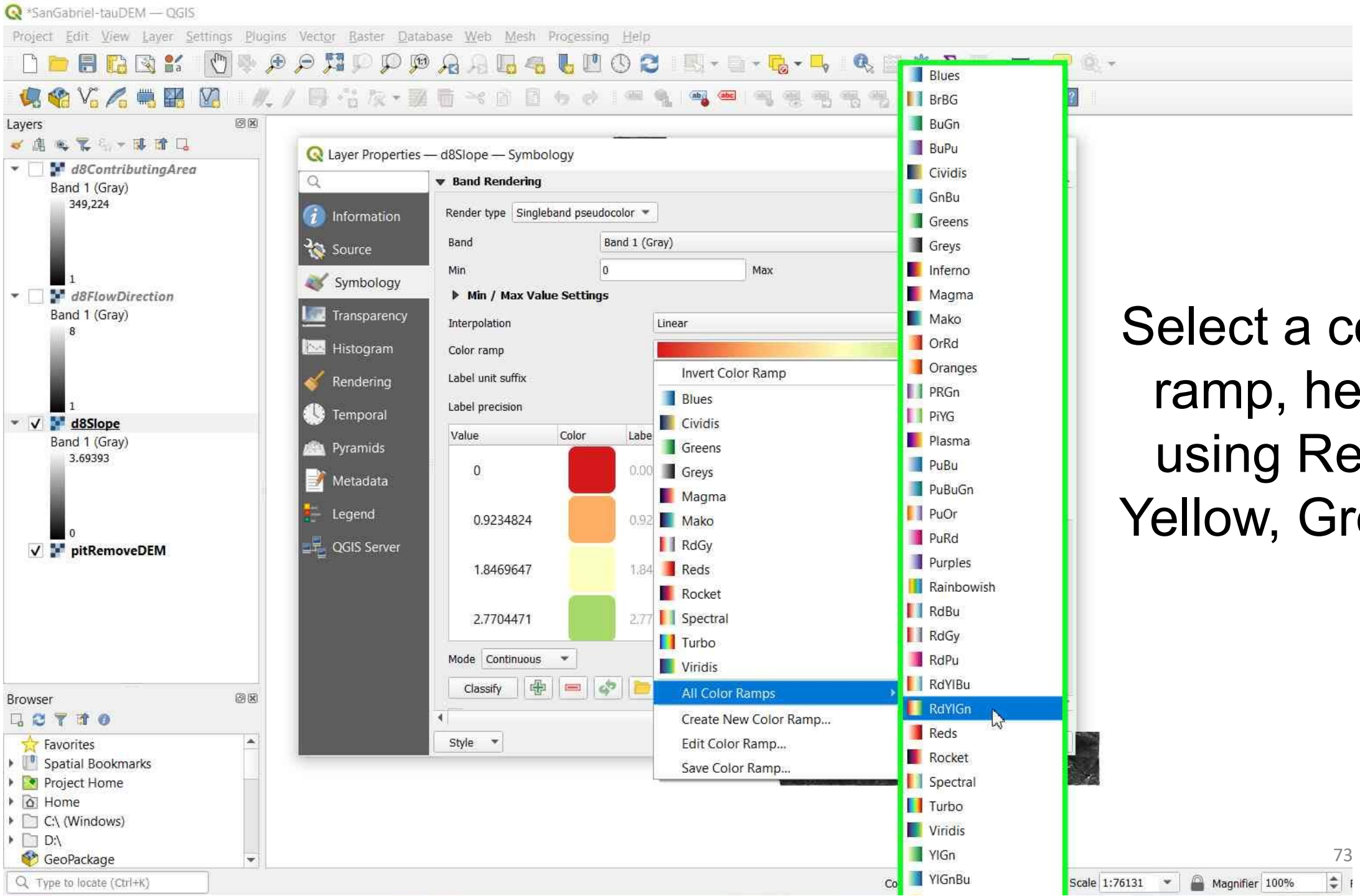
Add color symbology


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
TopographicWetnessIndex
Band 1 (Gray)
18.100578
1.104828
NetworkDinfin
logDinif
dInfinityCatchmentArea
dInfinityFlowDirection
dInfinitySlope
pitRemoveDEM
SG_1mDEM
Browser
GoogleEarth
OpenStreetMap
WCS
WFS / OGC API - Features
ArcGIS REST Servers
GeoNode
Type to locate (Ctrl+K)
Coordinate 418129,3796585
Scale 1:76131
Magnifier 100%

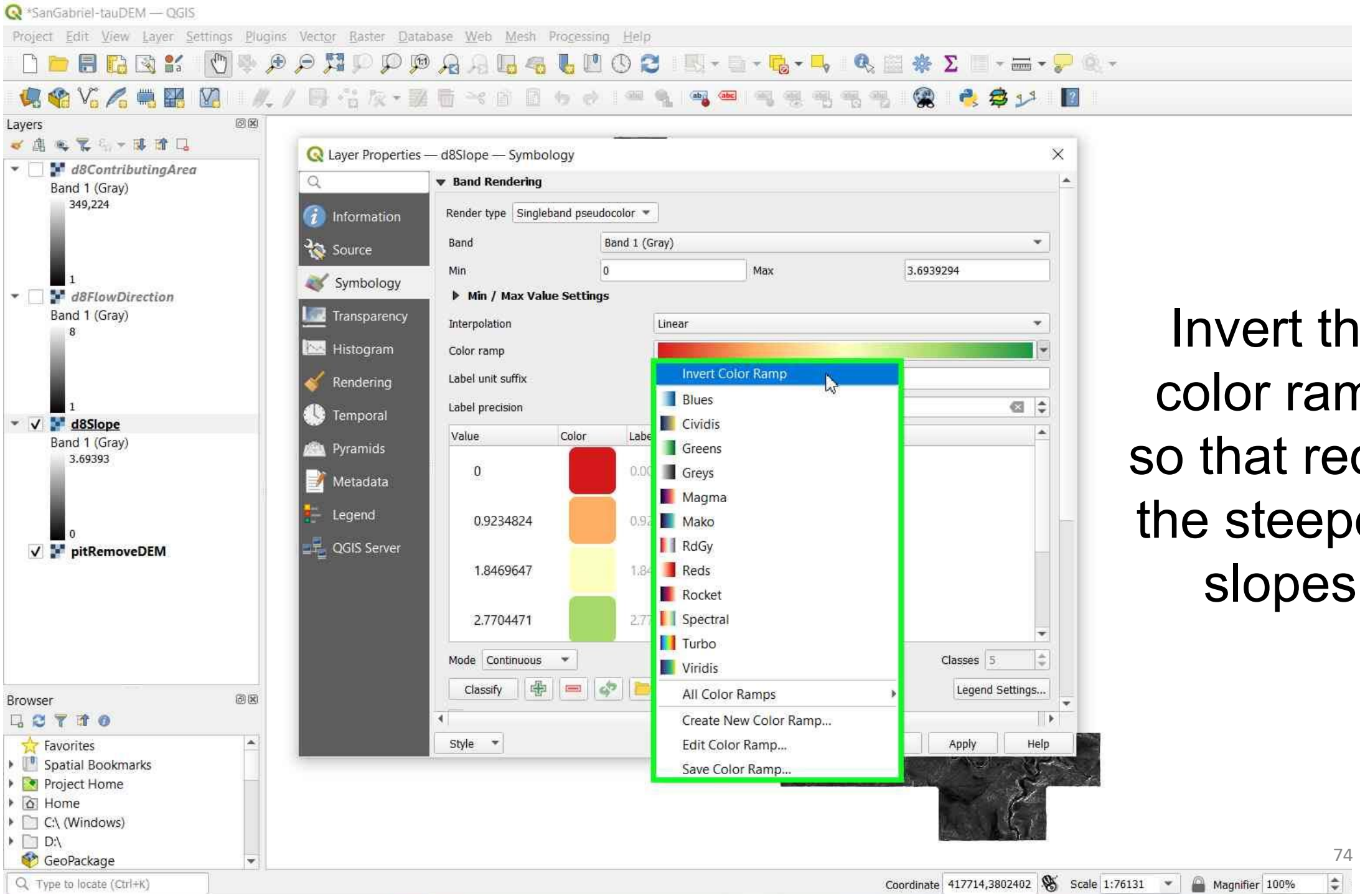

*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
TopographicWetnessIndex
Band 1 (Gray)
18.100578
1.104828
NetworkDinfin
logDinif
dInfinityCatchmentArea
dInfinityFlowDirection
dInfinitySlope
pitRemoveDEM
SG_1mDEM
Browser
GoogleEarth
OpenStreetMap
WCS
WFS / OGC API - Features
ArcGIS REST Servers
GeoNode
Type to locate (Ctrl+K)
Coordinate 424002,3796908
Scale 1:38066
Magnifier 100%


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
8
1
d8Slope
Band 1 (Gray)
3.69393
0
pitRemoveDEM
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Type to locate (Ctrl+K)
Coordinate 417714,3802402
Scale 1:76131
Magnifier 100%
Visualize Slope layer

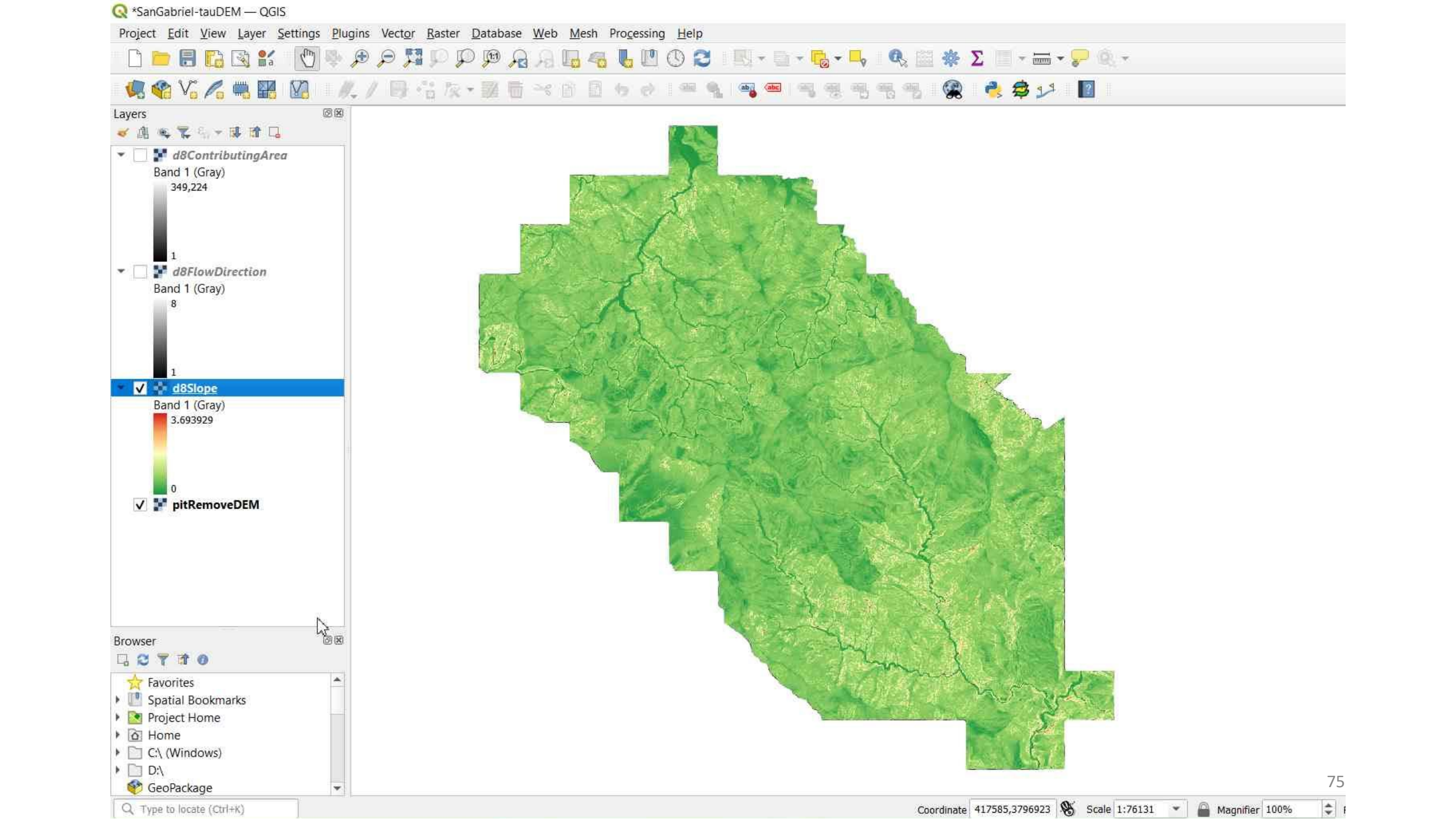

*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
8
1
d8Slope
Band 1 (Gray)
3.69393
0
pitRemovel
Zoom to Layer(s)
Show in Overview
Copy Layer
Rename Layer
Zoom to Native Resolution (100%)
Stretch Using Current Extent
Duplicate Layer
Remove Layer...
Move to Top
Move to Bottom
Change Data Source...
Set Layer Scale Visibility...
Layer CRS
Export
Styles
Add Layer Notes...
Properties...
Browser
Favorites
Spatial Bookmar
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Layer Properties — d8Slope — Symbology
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Metadata
Legend
QGIS Server
Band Rend
Render type
Multiband color
Paletted/Unique values
Singleband gray
Singleband pseudocolor
Hillshade
Contours
Gray band
Color gradier
Min 0
Max 3.69393
Contrast enhancement
Stretch to MinMax
Min / Max Value Settings
Legend Settings...
Layer Rendering
Blending mode Normal
Reset
Brightness 0
Contrast 0
Gamma 1.00
Saturation 0
Invert colors
Grayscale Off
Hue
Colorize
Strength 100%
Resampling
Zoomed: in Nearest Neighbour
out Nearest Neighbour
Oversampling 2.00
Early resampling
Style
OK
Cancel
Apply
Help
Type to locate (Ctrl+K)
Coordinate 417714,3802402
Scale 1:76131
Magnifier 100%



Select a color ramp, here using Red, Yellow, Green



Invert the color ramp so that red is the steepest slopes


*SanGabriel-tauDEM — QGIS
Project Edit View Layer Settings Plugins Vector Raster Database Web Mesh Processing Help
Layers
d8ContributingArea
Band 1 (Gray)
349,224
1
d8FlowDirection
Band 1 (Gray)
8
1
d8Slope
Band 1 (Gray)
3.693929
0
pitRemoveDEM
Browser
Favorites
Spatial Bookmarks
Project Home
Home
C:\ (Windows)
D:\
GeoPackage
Type to locate (Ctrl+K)
Coordinate 417585,3796923
Scale 1:76131
Magnifier 100%