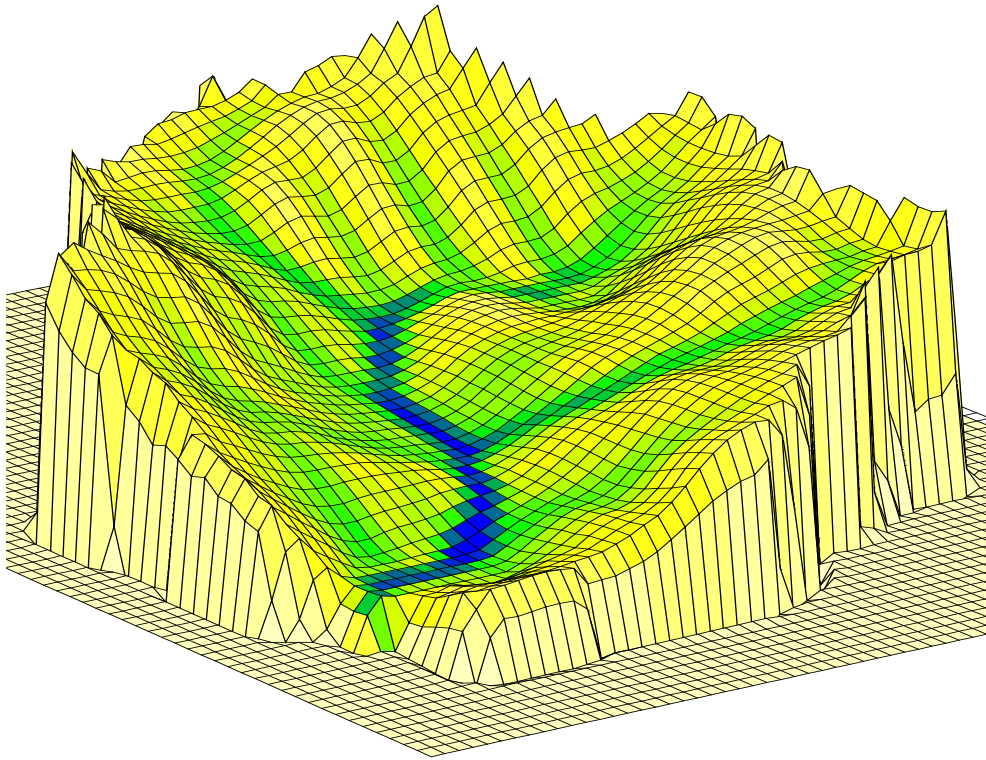
# Digital Elevation Model Based Watershed and Stream Network Delineation

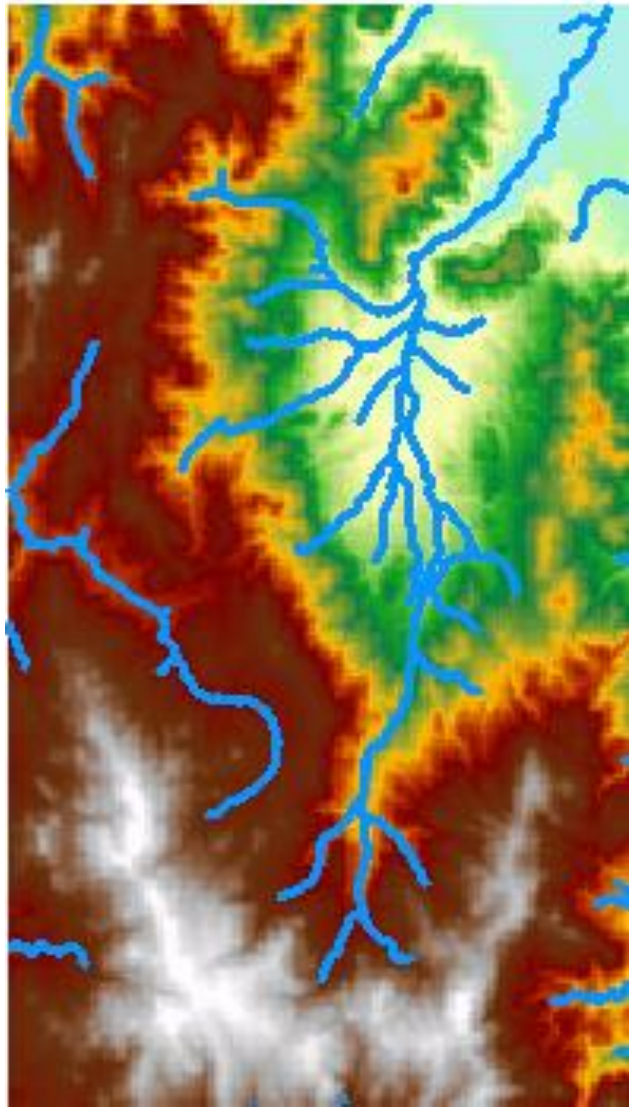
# Watershed and Stream Network Delineation

- Conceptual Basis
- Eight direction pour point model (D8)
- Flow accumulation
- Pit removal and DEM reconditioning
- Stream delineation
- Catchment and watershed delineation
- Geomorphology, topographic texture and drainage density
- Generalized and objective stream network delineation

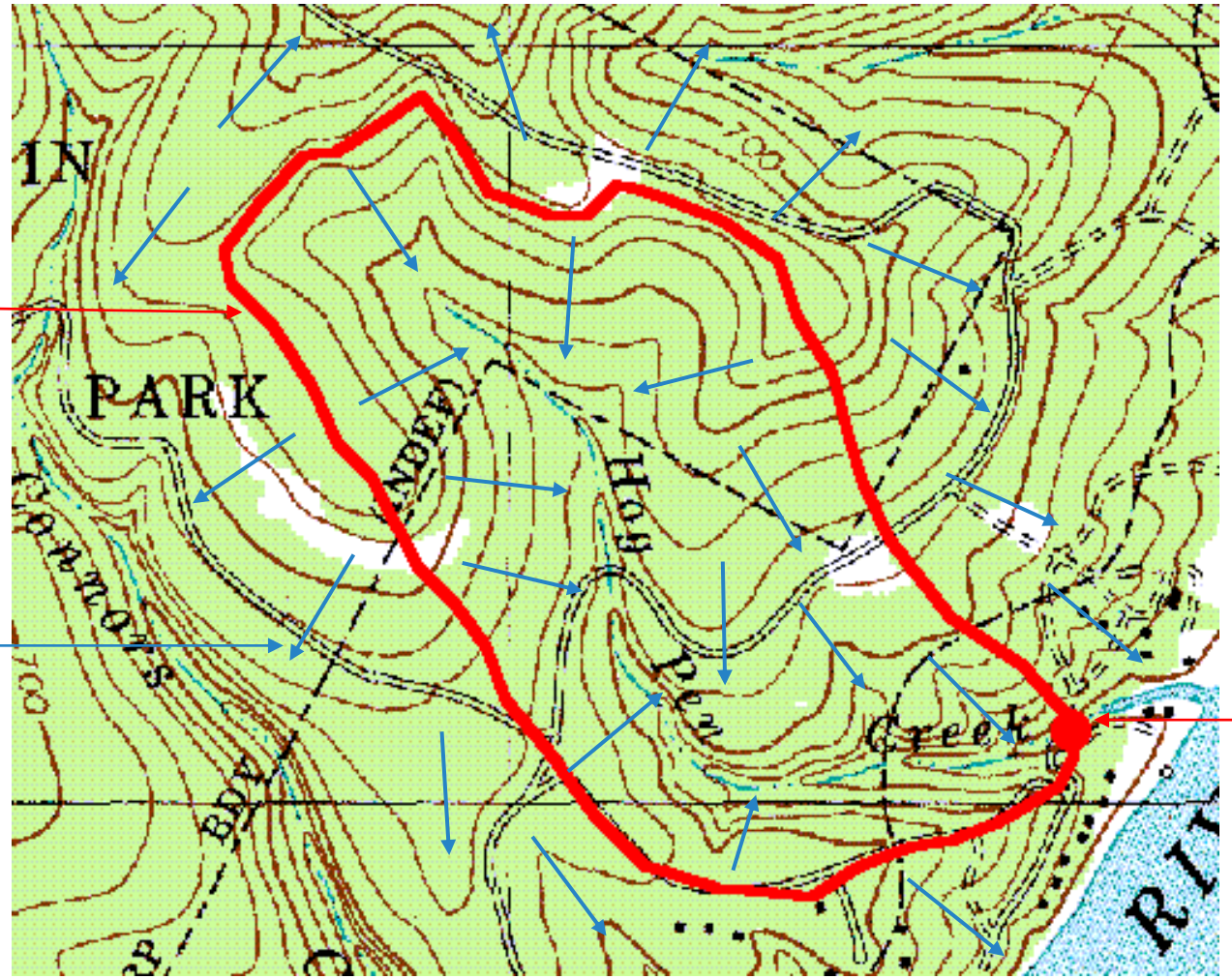


# Duality between Terrain and Drainage Network

- Flowing water erodes landscape and carries away sediment sculpting the topography
- Topography defines drainage direction on the landscape and resultant runoff and streamflow accumulation processes



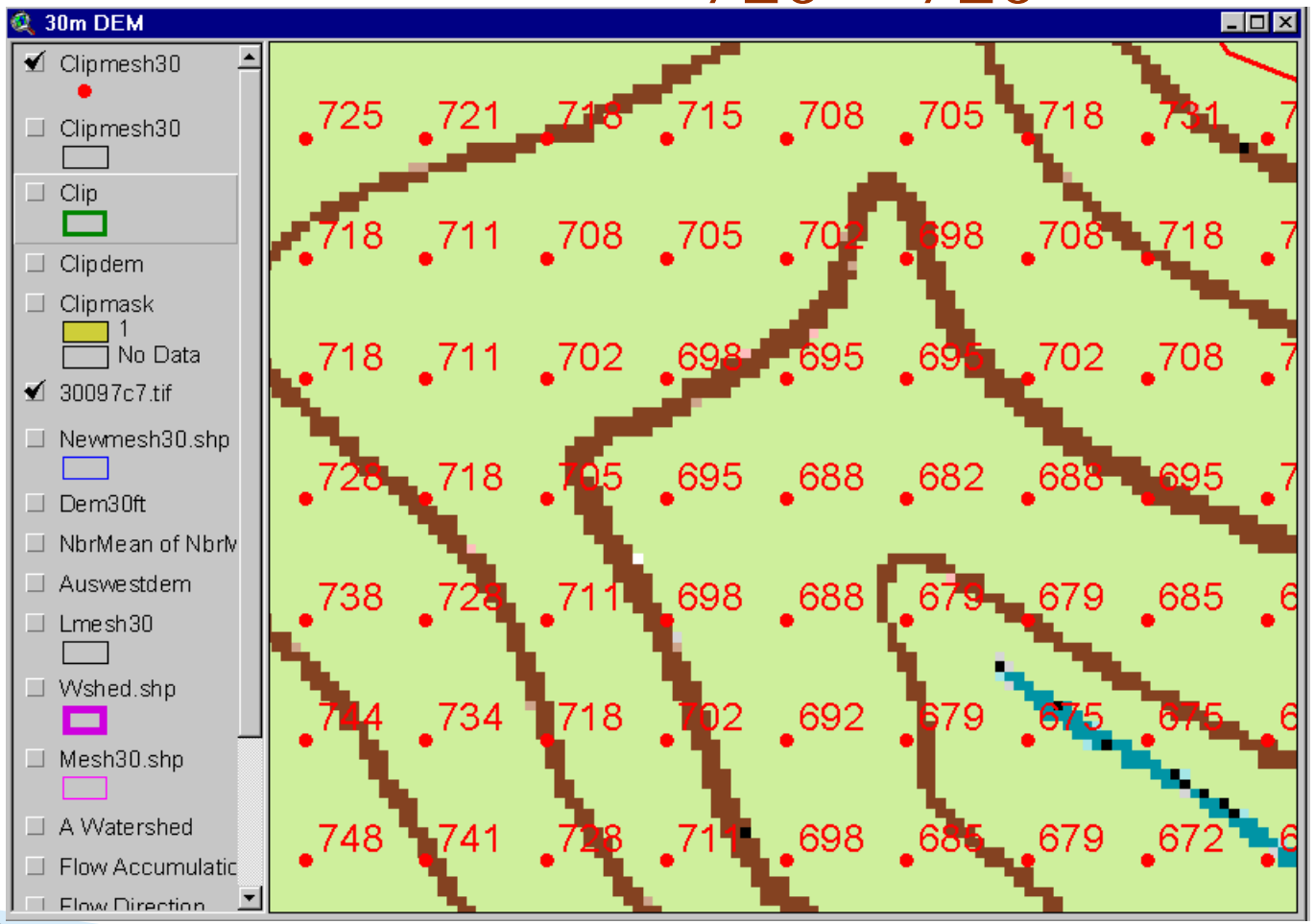
# Topography defines watersheds which are fundamentally the most basic hydrologic landscape elements.




1:24,000 scale map of a study area in West Austin

# DEM Elevations

720 720



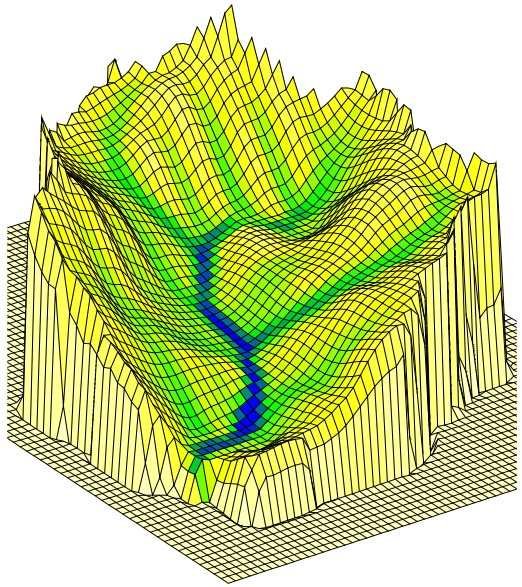

Contours

- 740
- 720
- 700
- 680

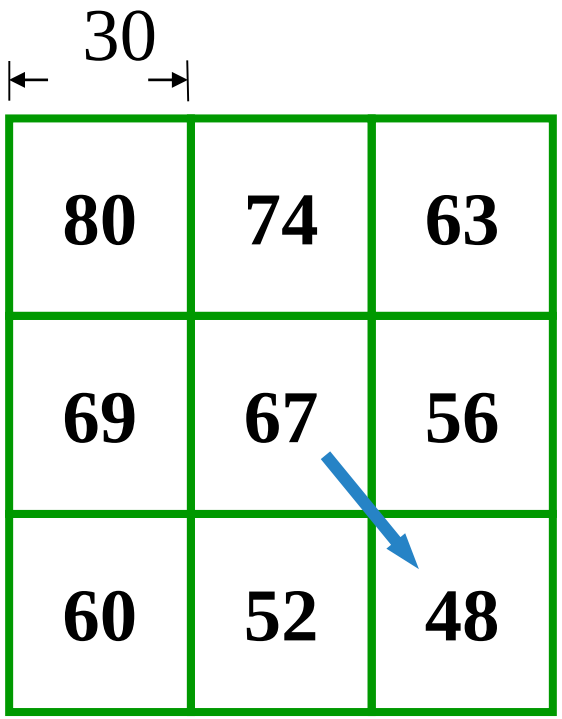
740 720 700 680

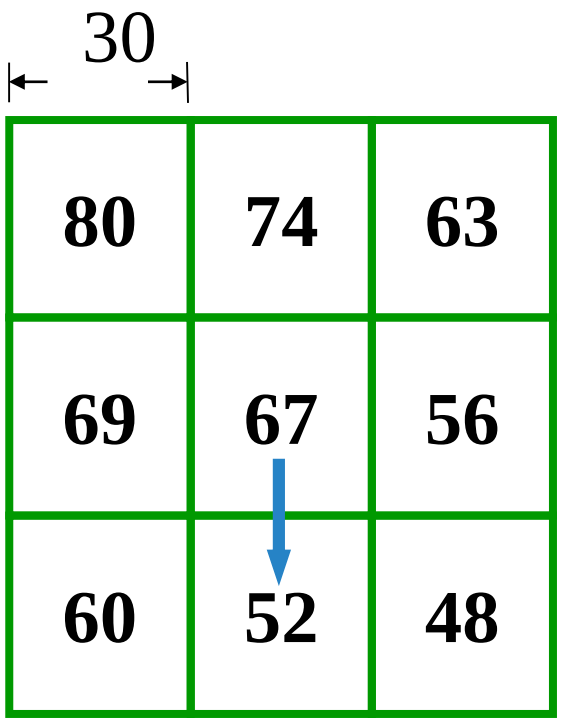
# Hydrologic Terrain Analysis

- Based on an information model for the topographic representation of downslope flow derived from a DEM
- Enriches the information content of digital elevation data.
  - Sink removal
  - Flow field derivation
  - Calculating of flow based derivative surfaces



# Direction of Steepest Descent

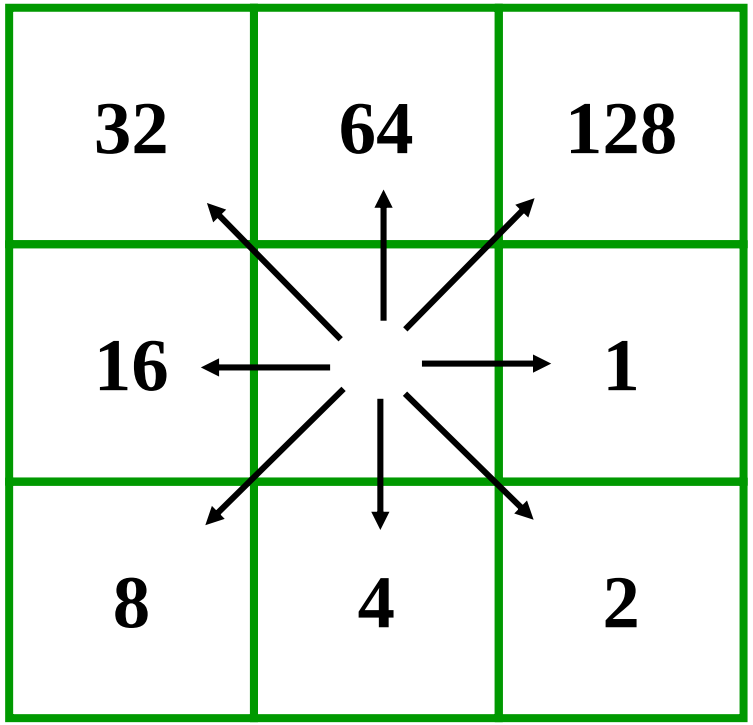



Slope: $\dfrac{67-48}{30\sqrt{2}} = 0.45$

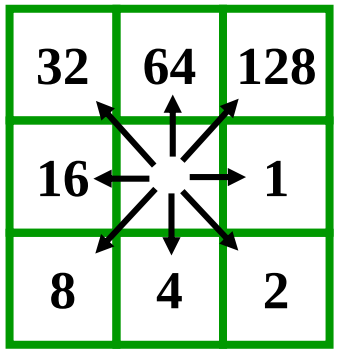
$$\frac{67-52}{30} = 0.50$$

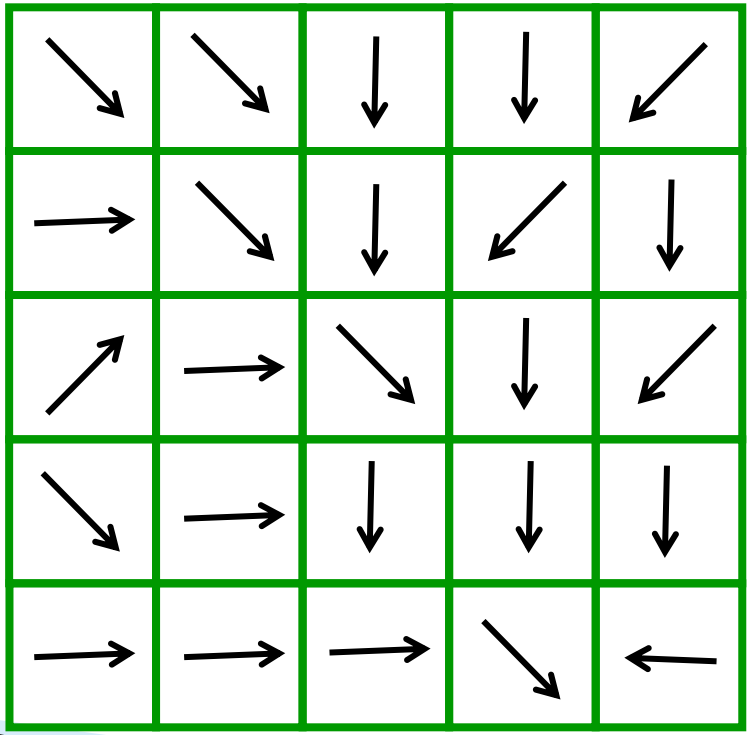
# Eight Direction Pour Point Model




**ESRI Direction encoding**

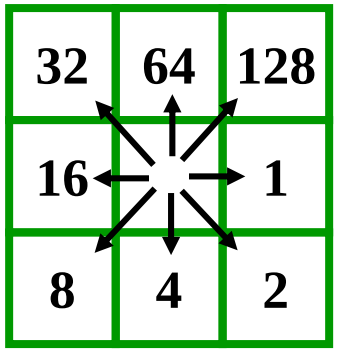
# Flow Direction Grid

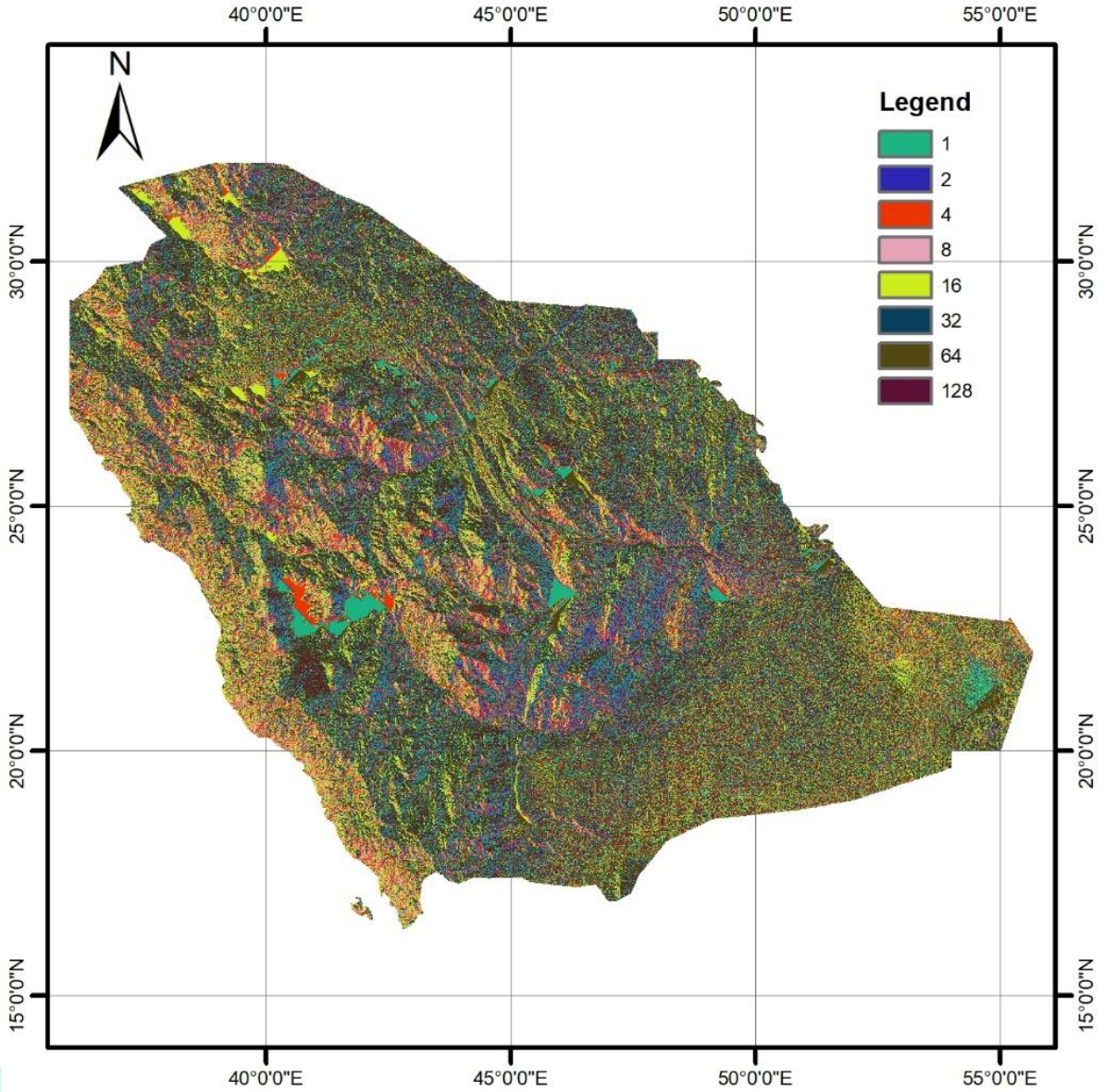


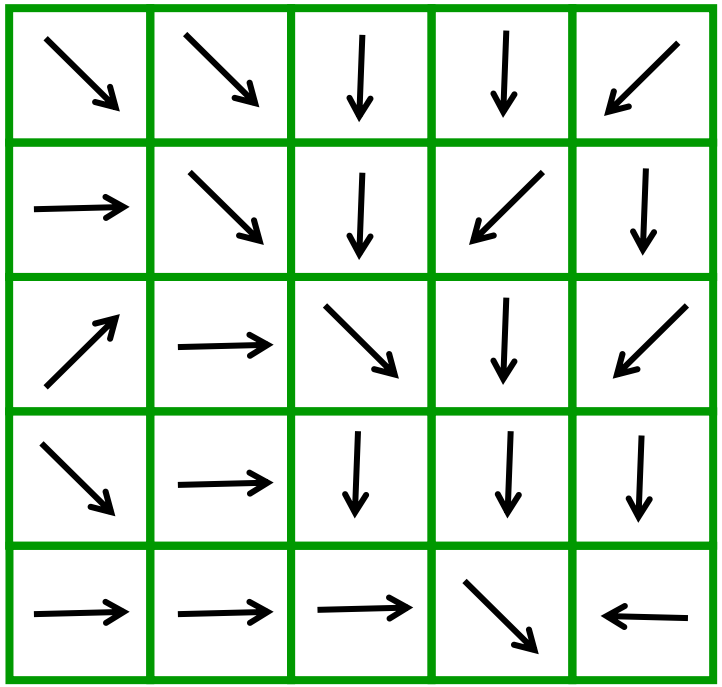
| | | | | |
|---|---|---|---|---|
| 2 | 2 | 4 | 4 | 8 |
| 1 | 2 | 4 | 8 | 4 |
| 128 | 1 | 2 | 4 | 8 |
| 2 | 1 | 4 | 4 | 4 |
| 1 | 1 | 1 | 2 | 16 |

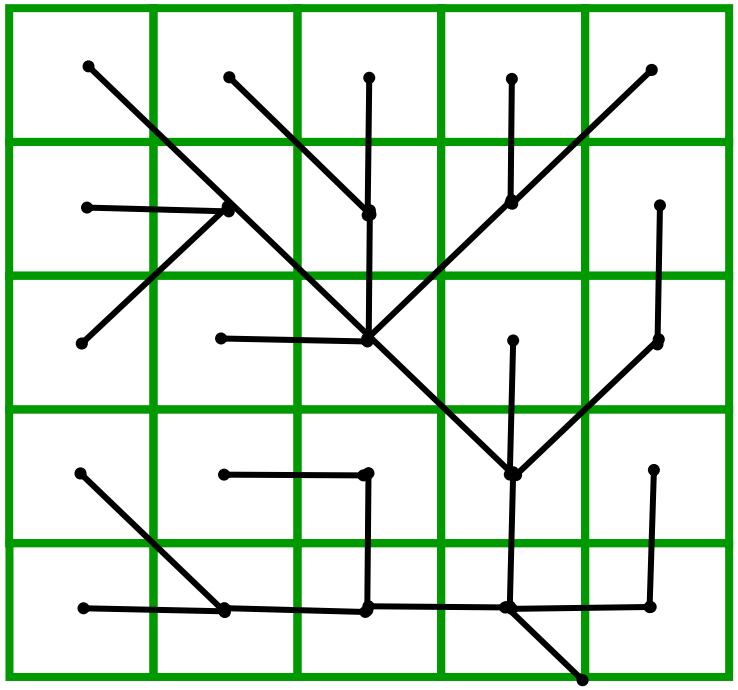
# Flow Direction Grid



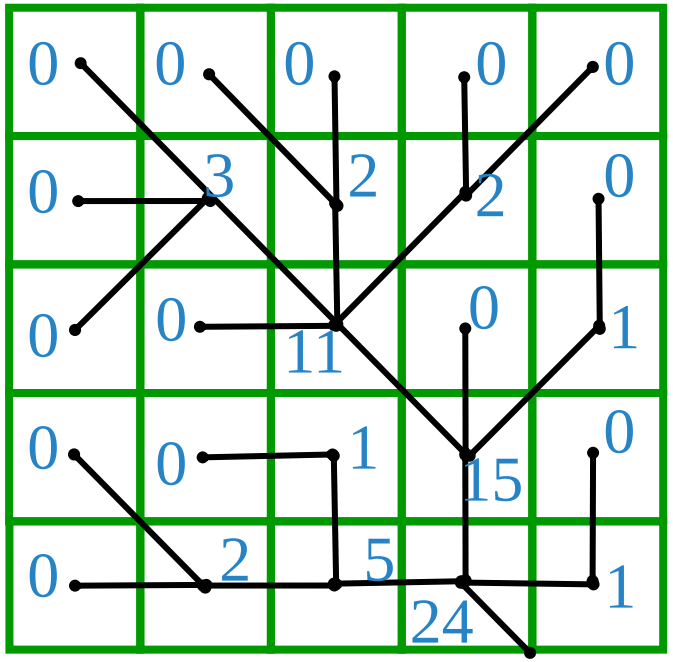
# Grid Network





# Flow Accumulation Grid

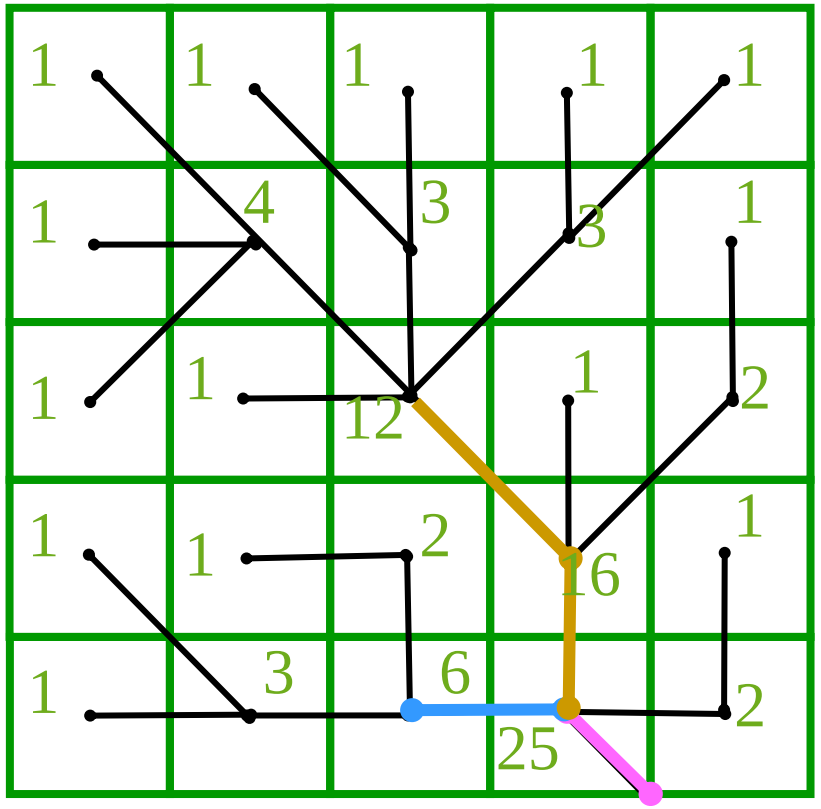
## Area draining **in** to a grid cell




| | | | | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 3 | 2 | 2 | 0 |
| 0 | 0 | 11 | 0 | 1 |
| 0 | 0 | 1 | 15 | 0 |
| 0 | 2 | 5 | 24 | 1 |

# Contributing Area Grid

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 1 | 4 | 3 | 3 | 1 |
| 1 | 1 | 12 | 1 | 2 |
| 1 | 1 | 2 | 16 | 1 |
| 1 | 3 | 6 | 25 | 2 |

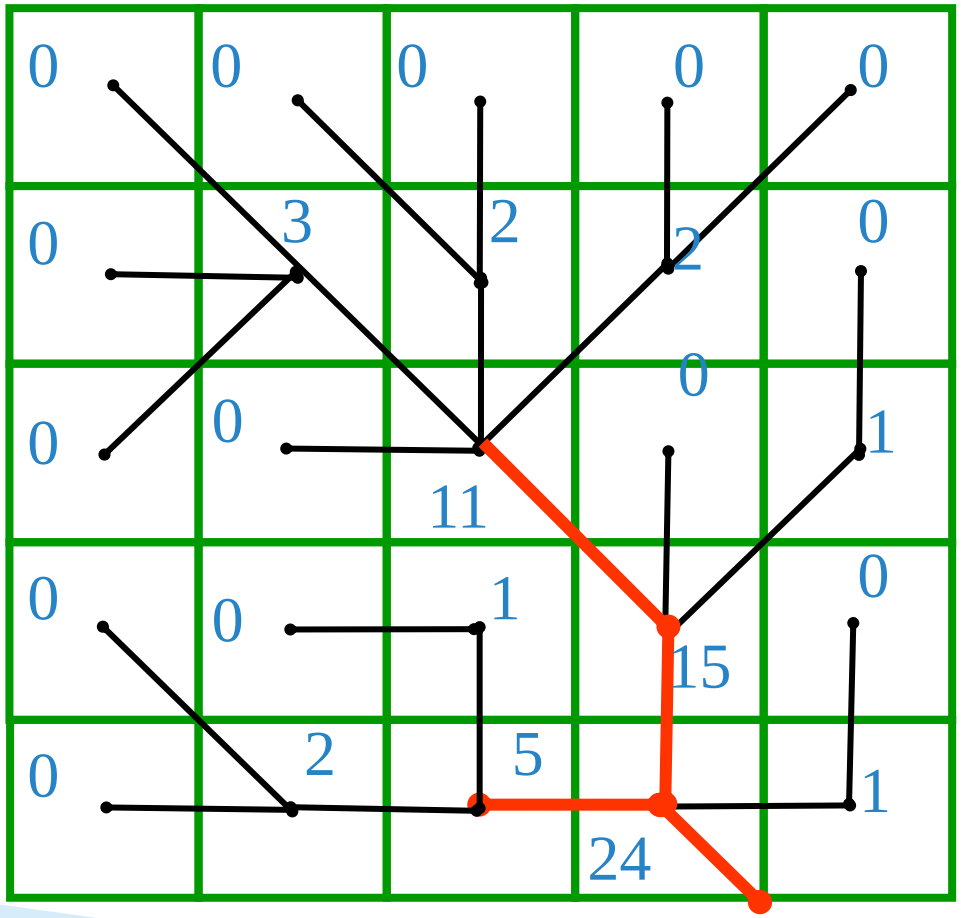


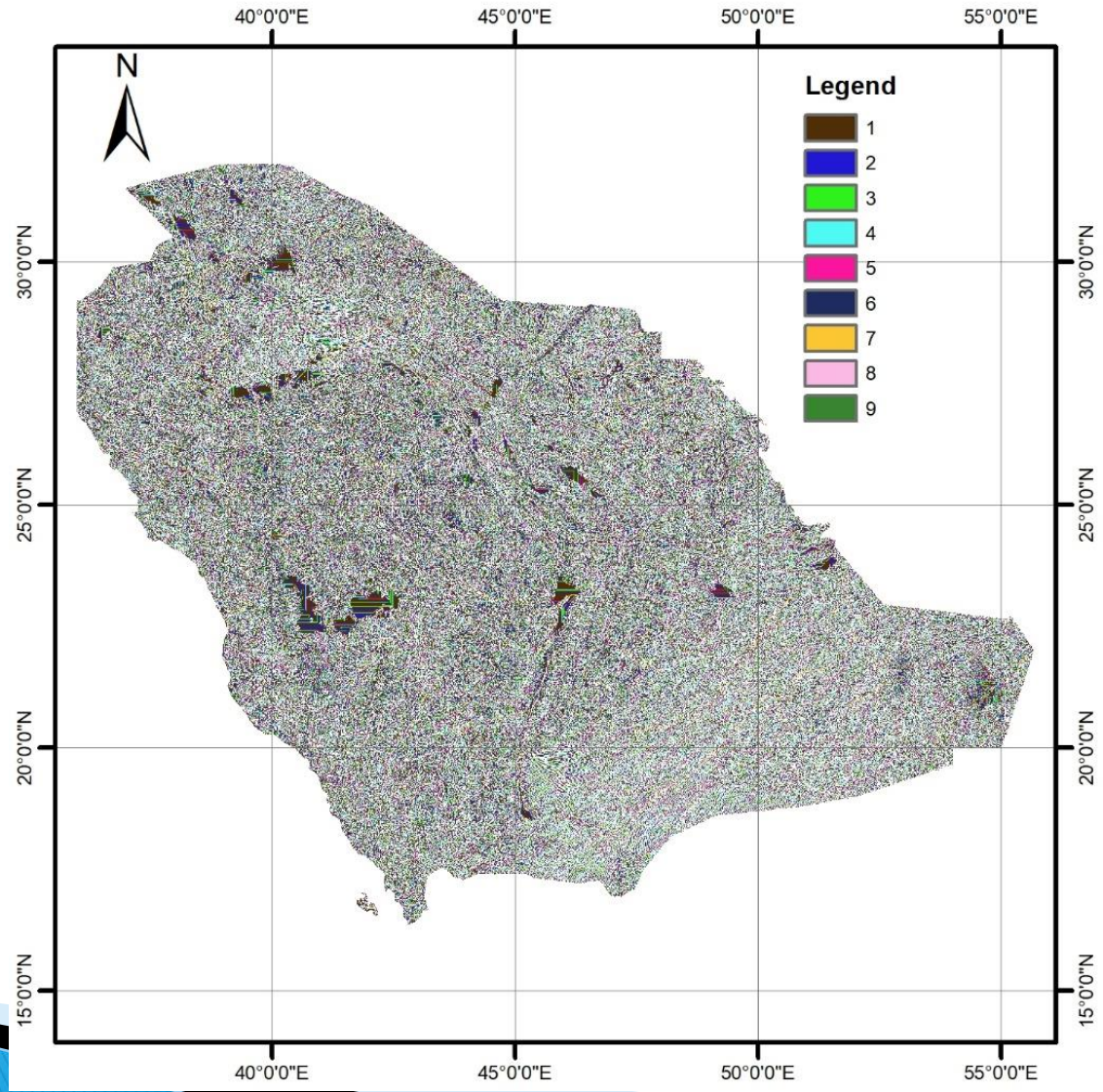

TauDEM convention. The area draining each grid cell including the grid cell itself.

# Flow Accumulation > 5 Cell Threshold

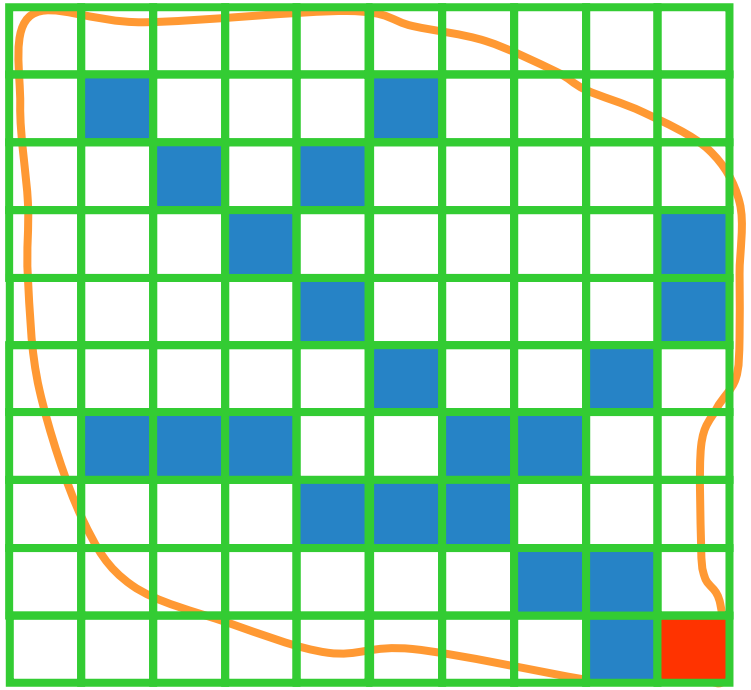
| | | | | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 3 | 2 | 2 | 0 |
| 0 | 0 | 11 | 0 | 1 |
| 0 | 0 | 1 | 15 | 0 |
| 0 | 2 | 5 | 24 | 1 |

# Stream Network for 5 cell Threshold Drainage Area

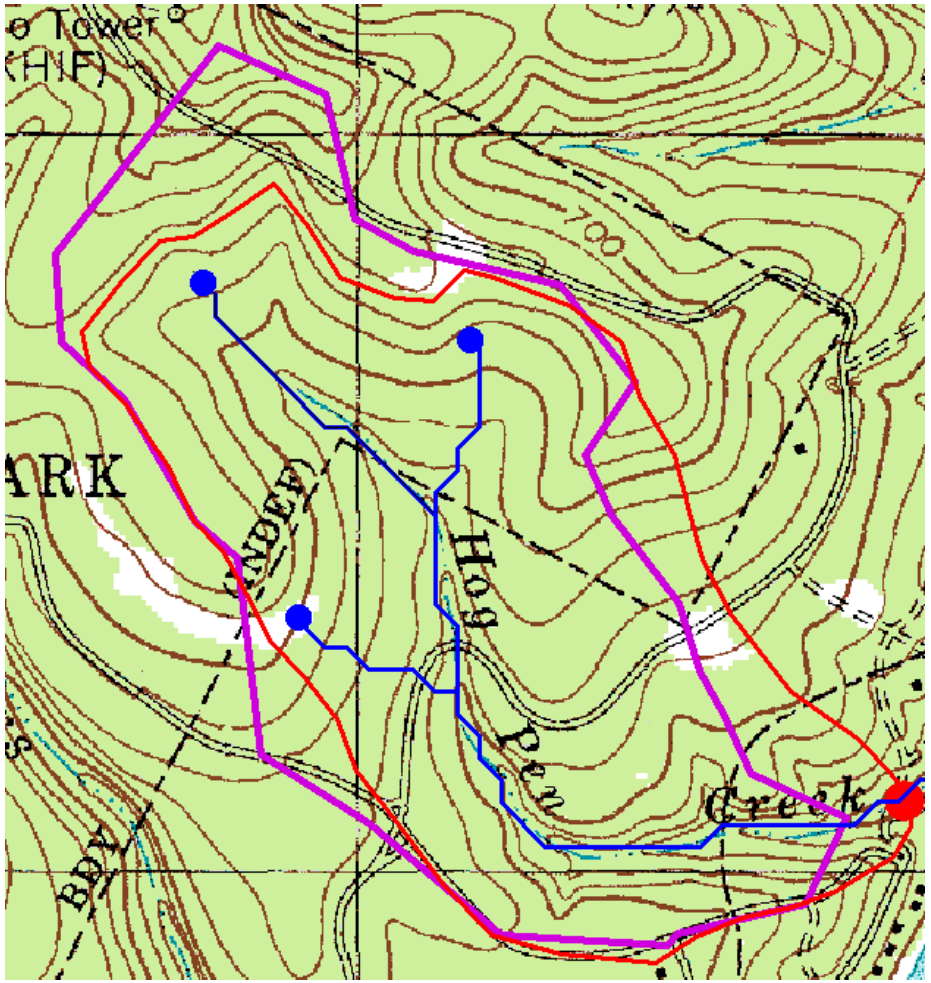



40°0'0"E
45°0'0"E
50°0'0"E
55°0'0"E
N
Legend
1
2
3
4
5
6
7
8
9
30°0'0"N
25°0'0"N
20°0'0"N
15°0'0"N

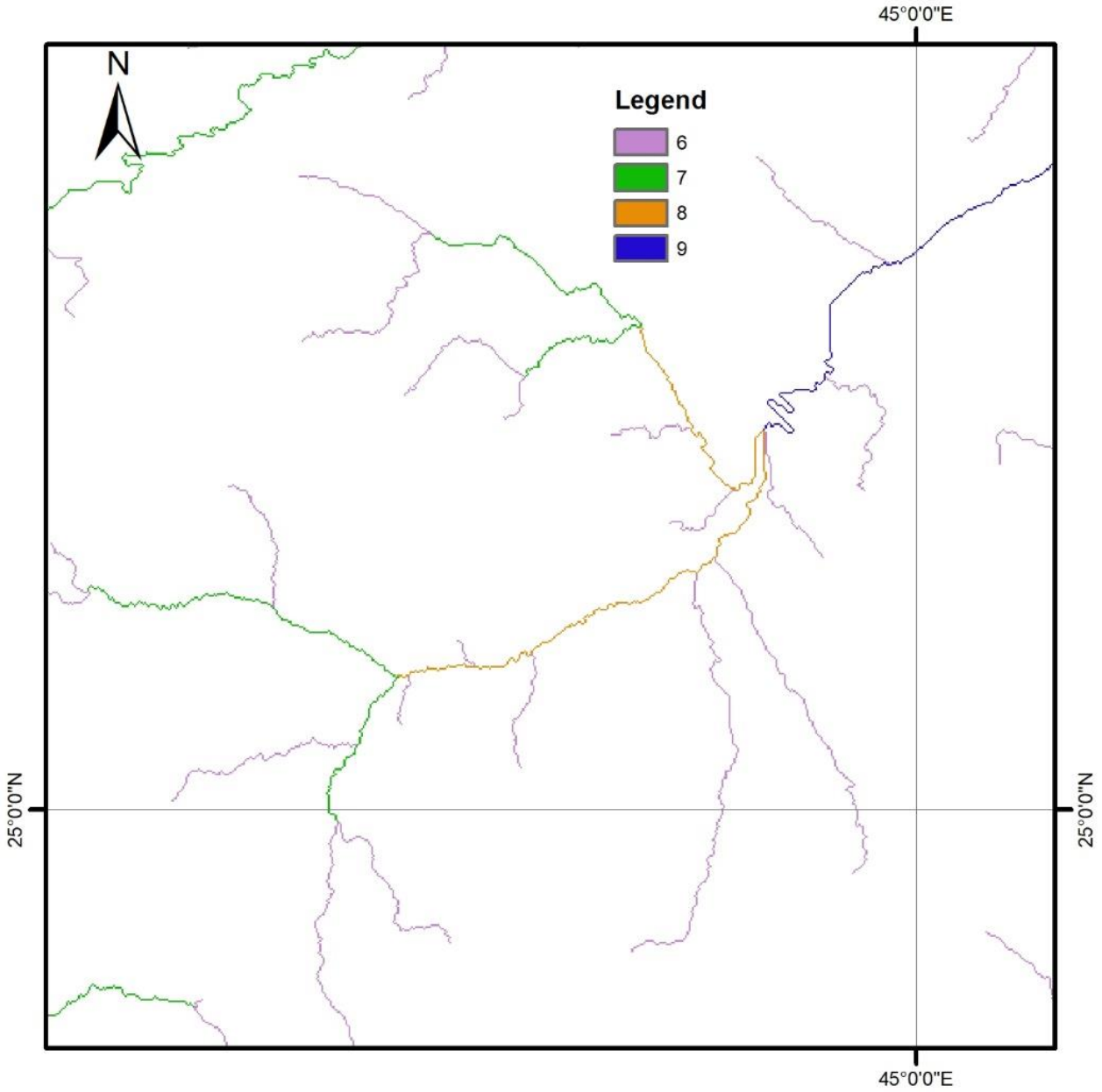
# Watershed Draining to Outlet



# Watershed and Drainage Paths Delineated from 30m DEM

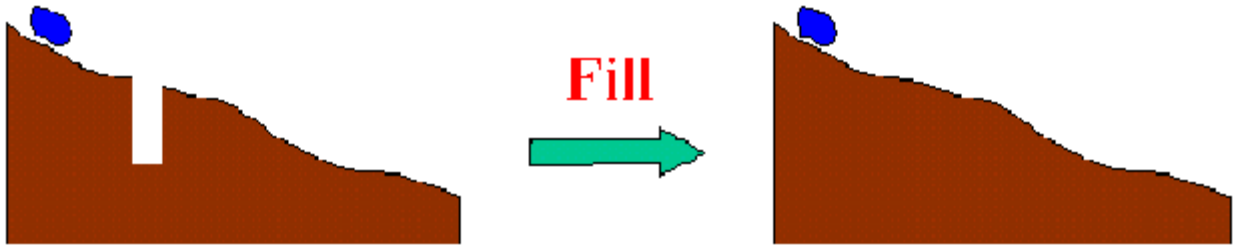



Automated method is more consistent than hand delineation


45°0'0"E
N
Legend
6
7
8
9
25°0'0"N
25°0'0"N
45°0'0"E

# The Pit Removal Problem

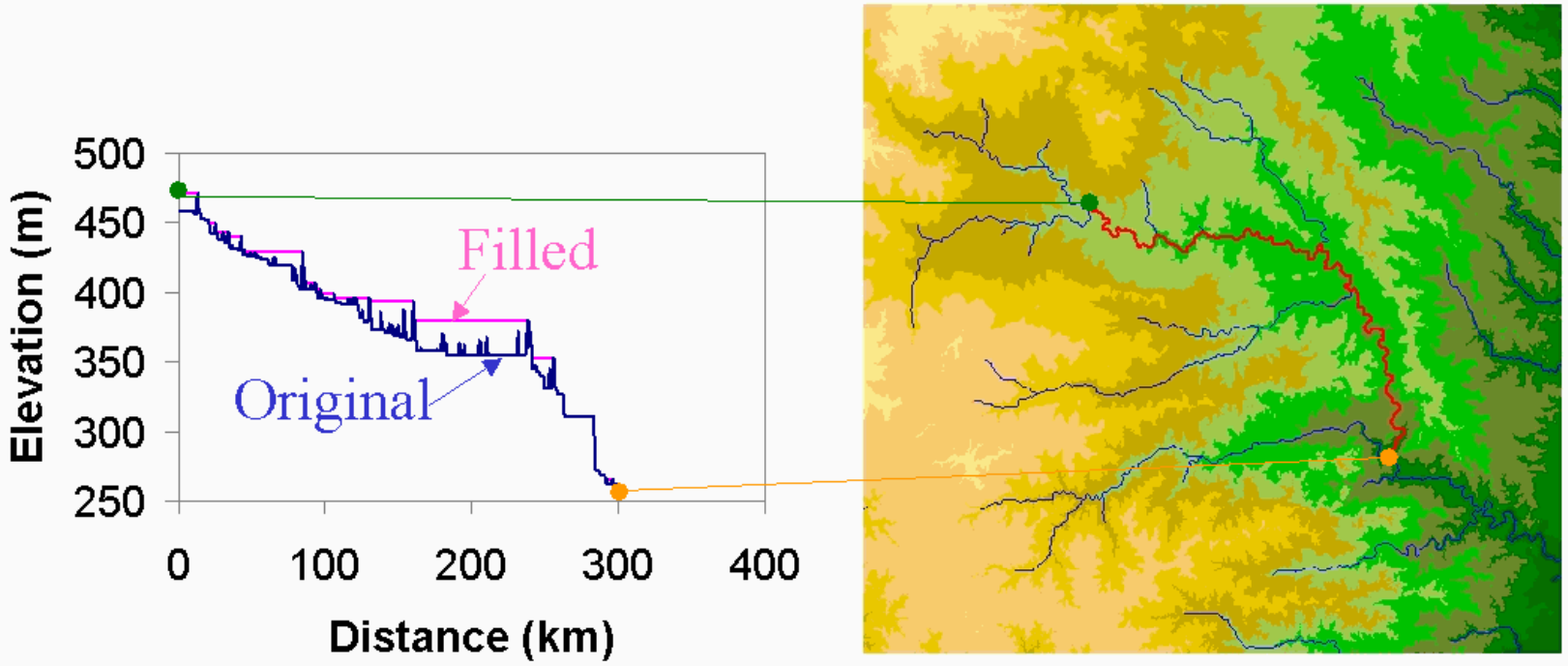
- DEM creation results in artificial pits in the landscape
- A pit is a set of one or more cells which has no downstream cells around it
- Unless these pits are removed they become sinks and isolate portions of the watershed
- Pit removal is first thing done with a DEM



# Pit Filling

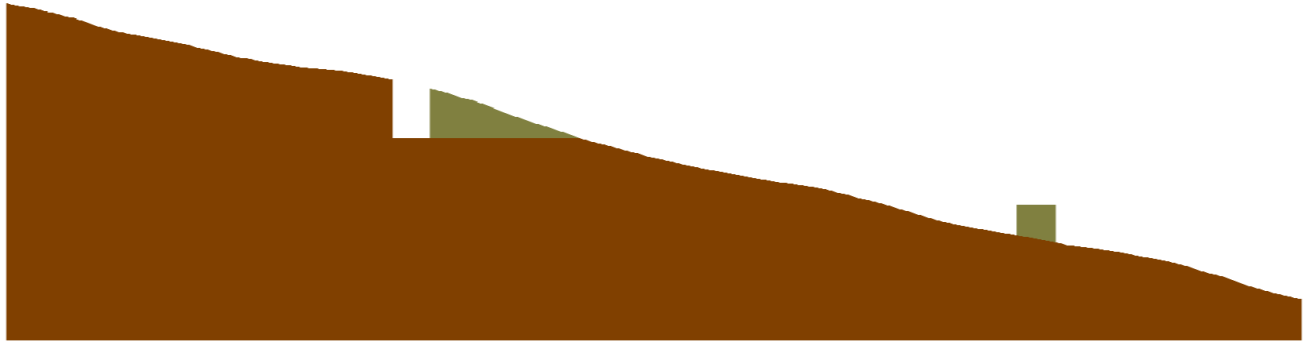
- Increase elevation to the pour point elevation until the pit drains to a neighbor

# Effect of Pit Filling on Elevation

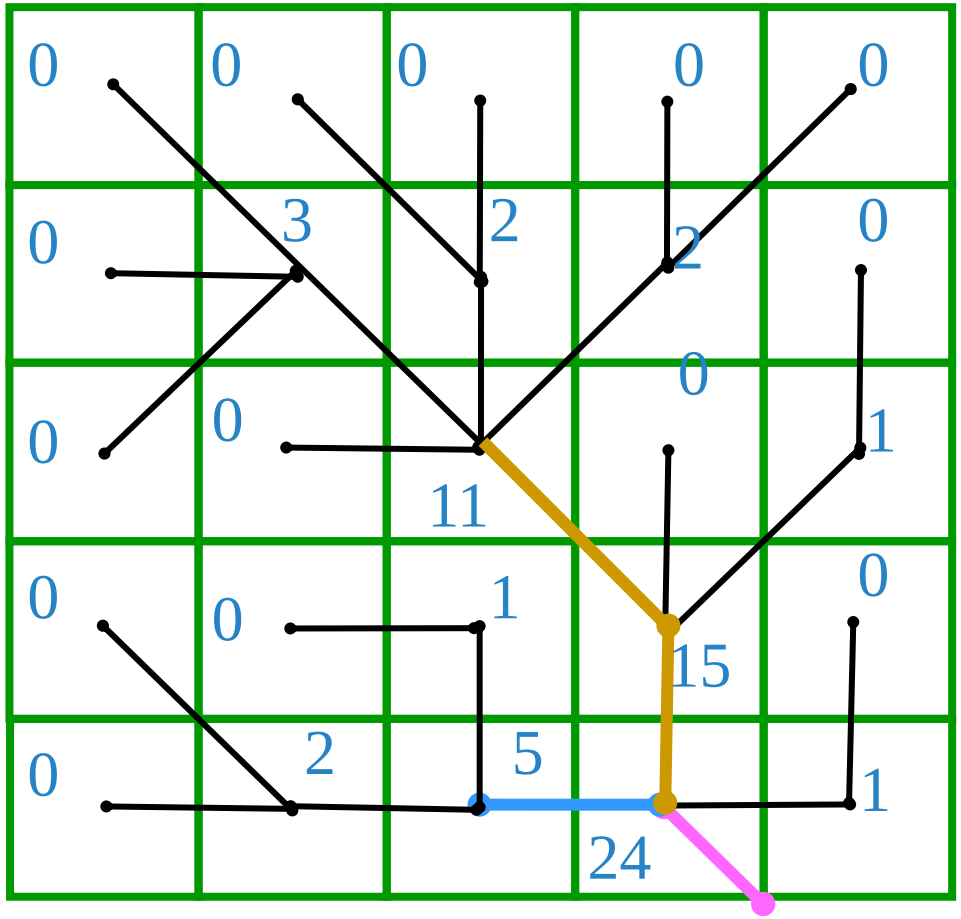


# Carving

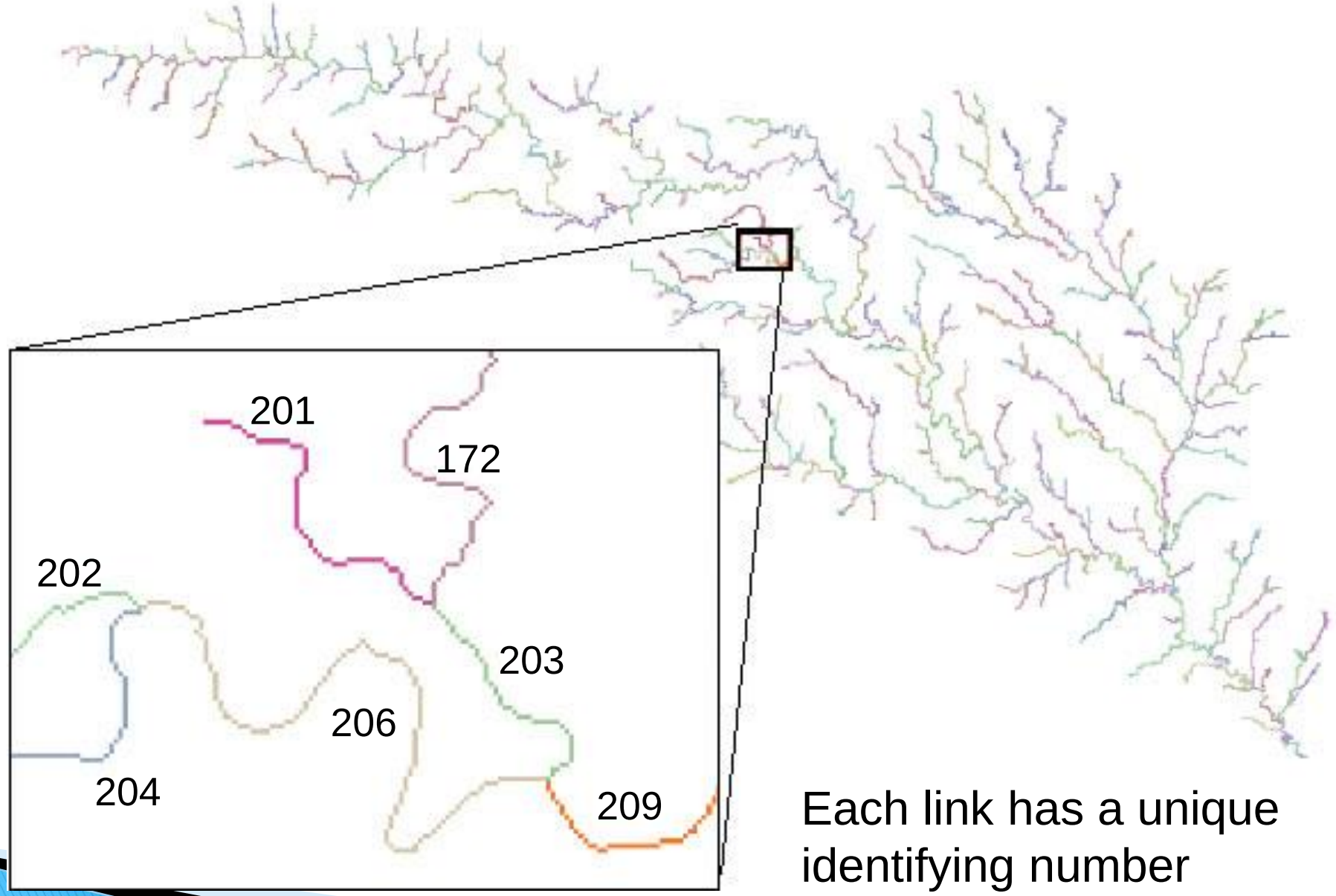
Lower elevation of neighbor along a predefined drainage path until the pit drains to the outlet point



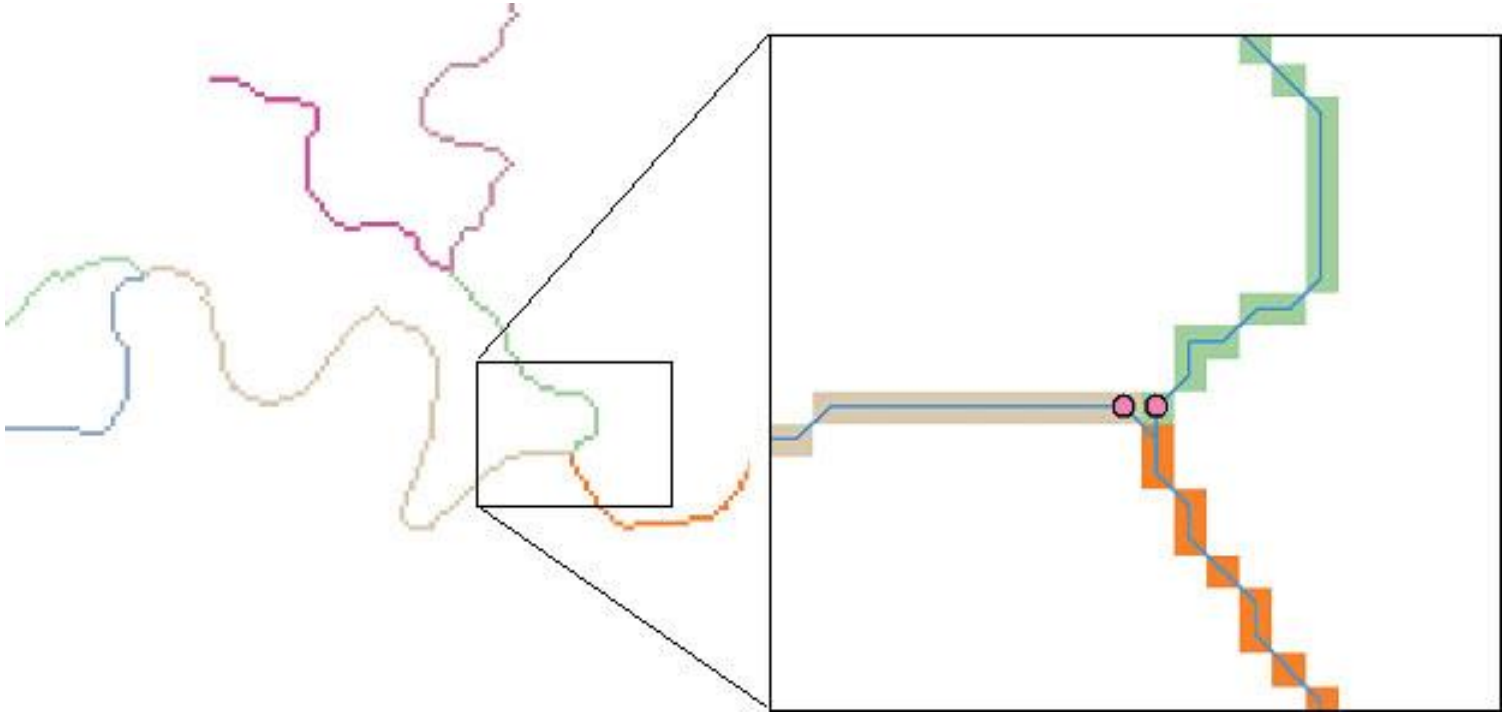
# Stream Segments



# Stream links grid for the San Marcos subbasin



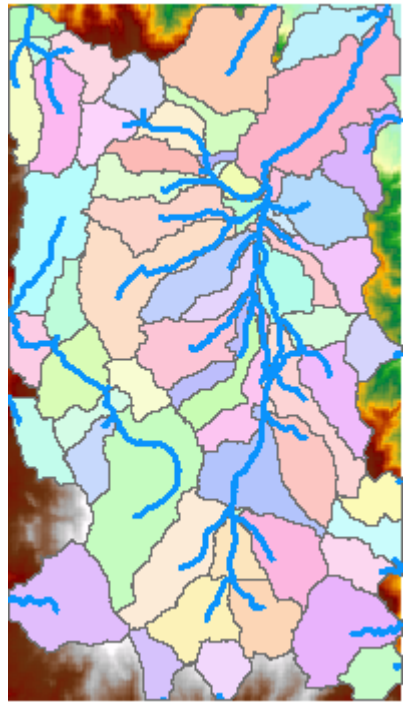

Each link has a unique identifying number



DrainageLines are drawn through the centers of cells on the stream links. DrainagePoints are located at the centers of the outlet cells of the catchments

# Catchments

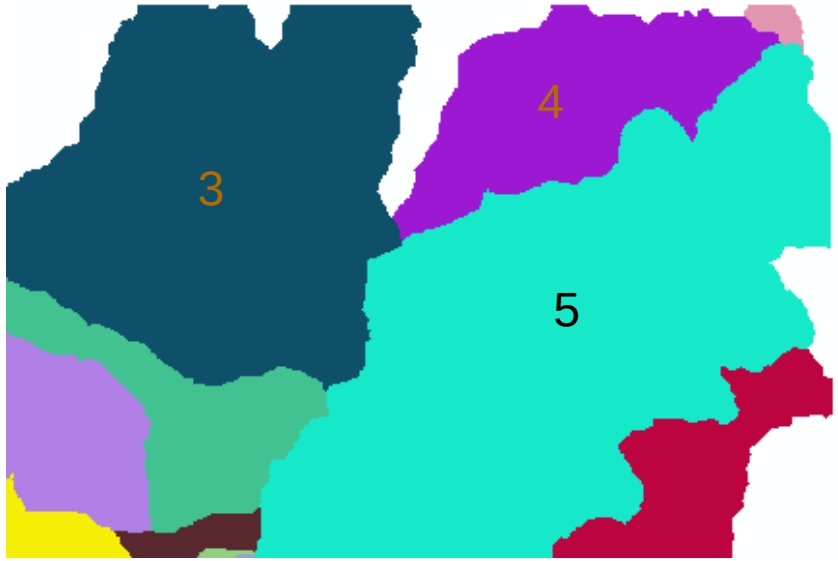
- For every stream segment, there is a corresponding catchment
- Catchments are a tessellation of the landscape through a set of physical rules



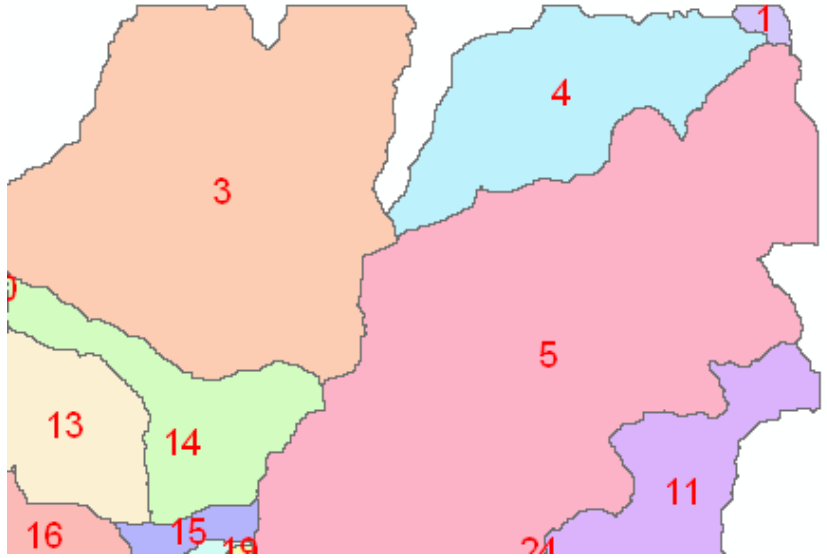
# Raster Zones and Vector Polygons

One to one connection

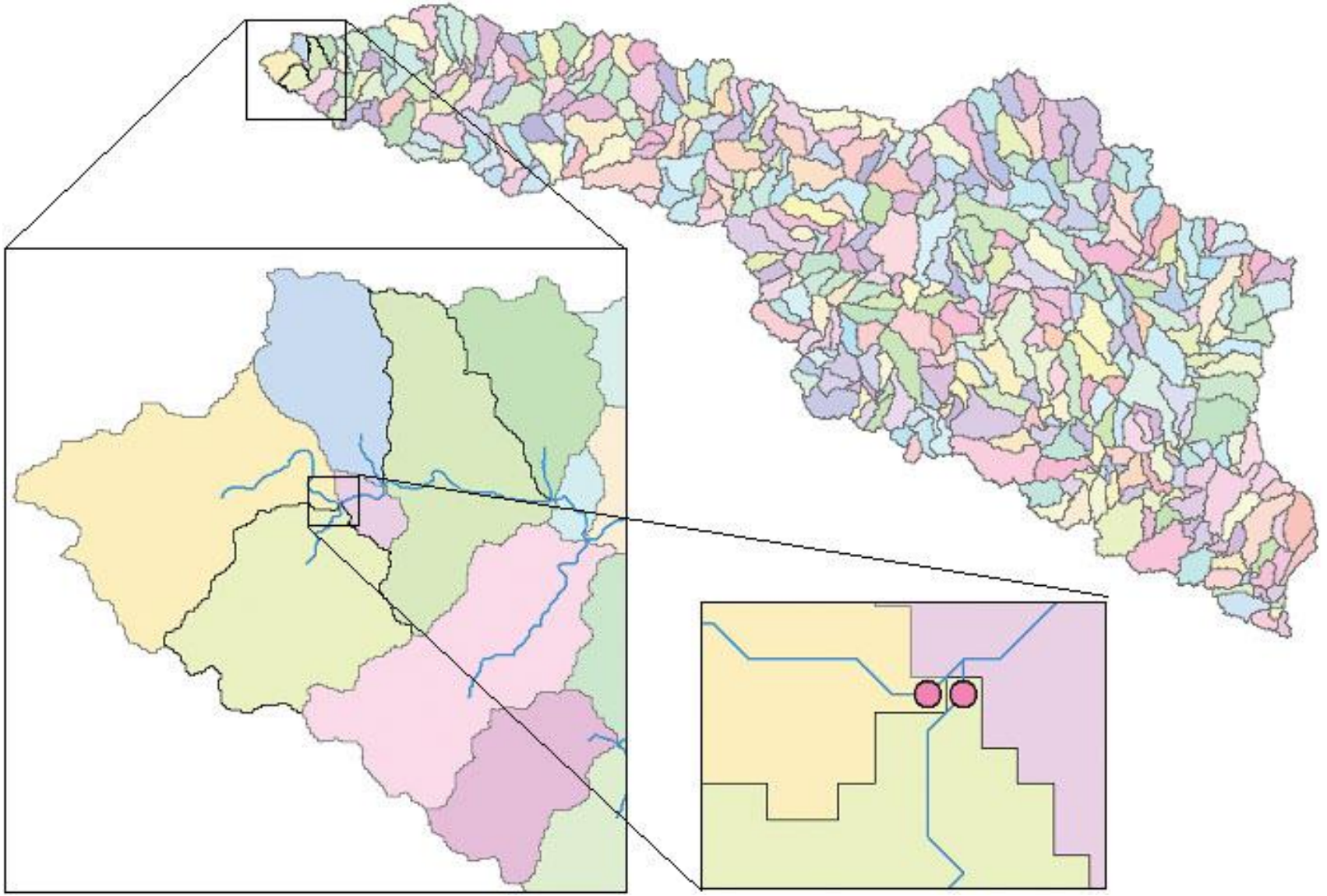
DEM GridCode ⟷ Catchment GridID



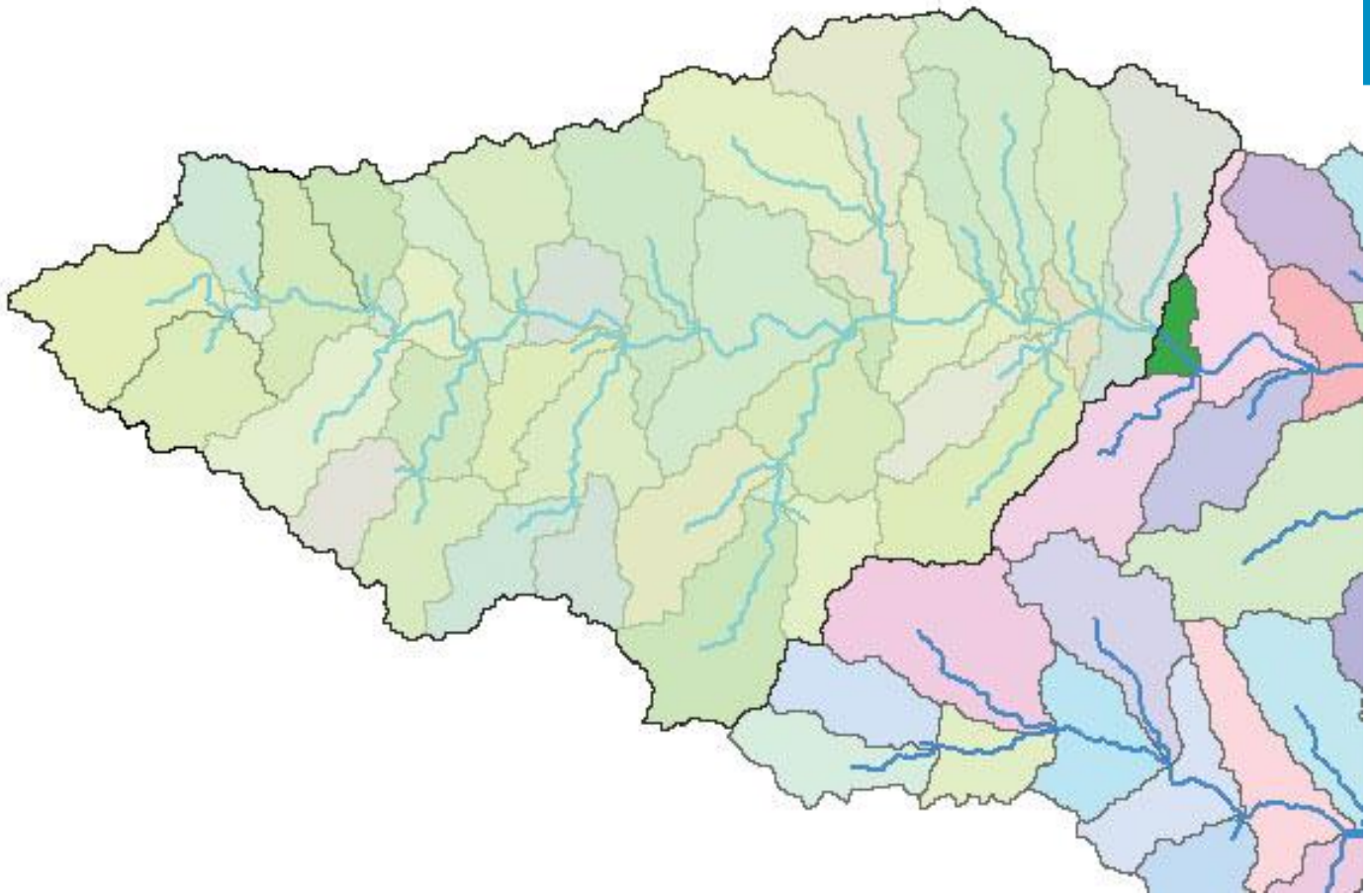

Raster Zones




Vector Polygons

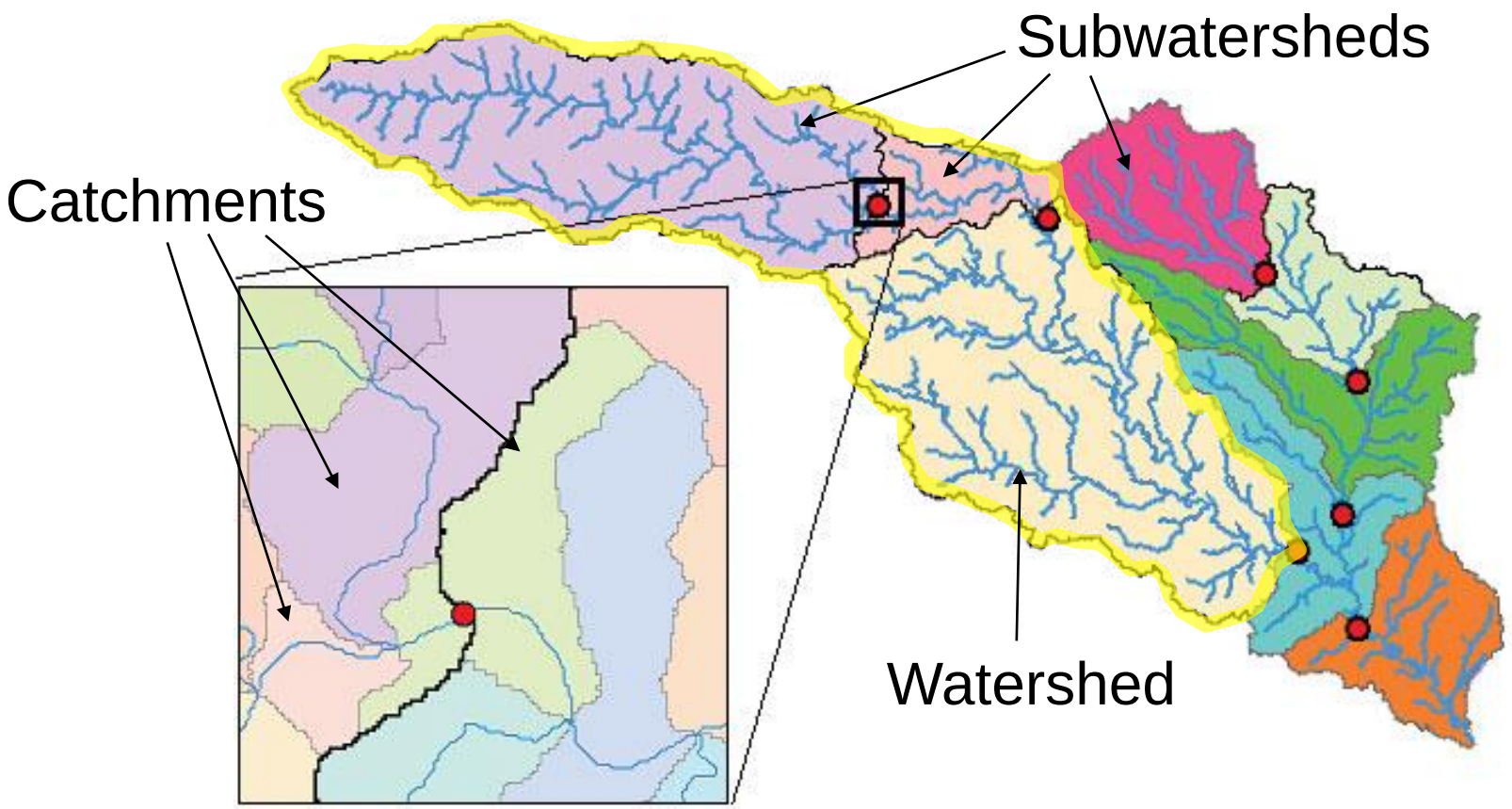


Catchments, DrainageLines and DrainagePoints of the San Marcos basin



Adjoint catchment: the remaining upstream area draining to a catchment outlet.

# Catchment, Watershed, Subwatershed.

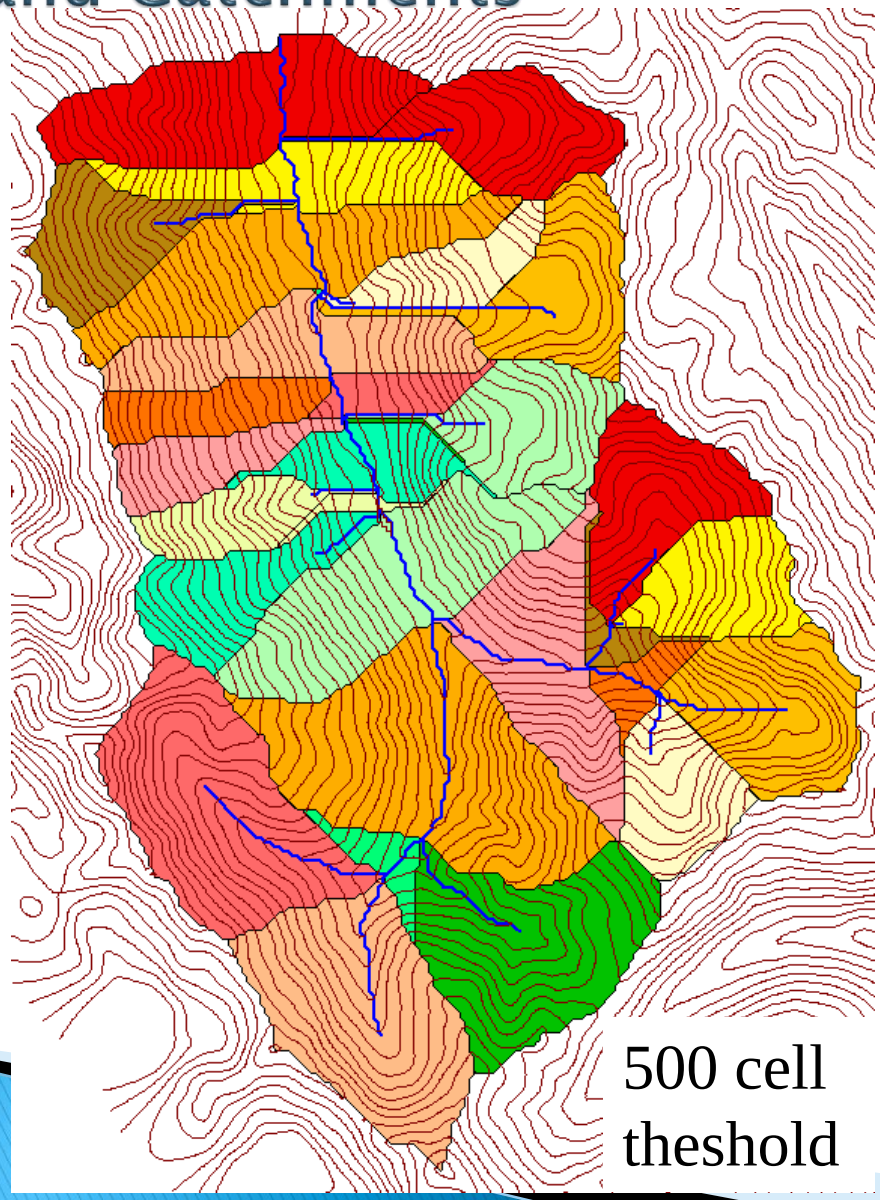



Watershed outlet points may lie within the interior of a catchment, e.g. at a USGS stream-gaging site.

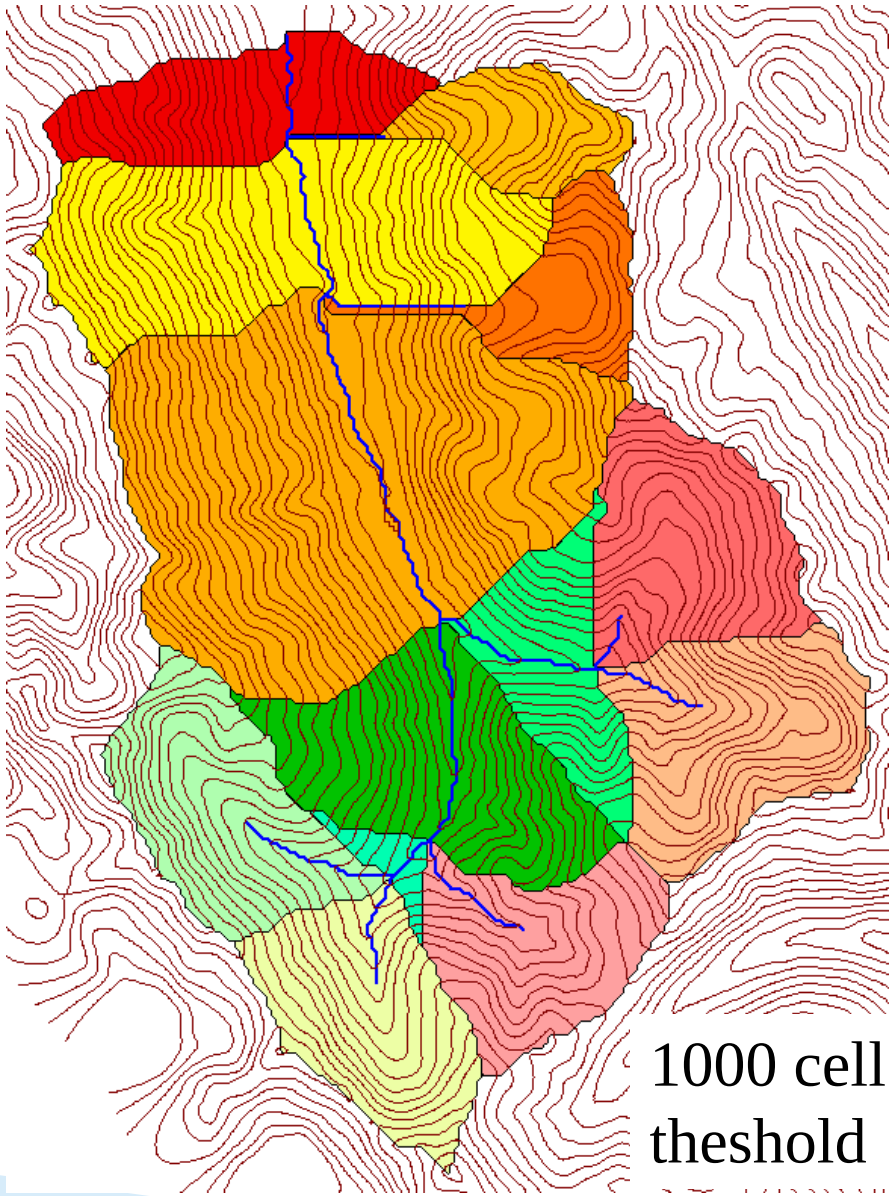
# Summary of Key Processing Steps

- [DEM Reconditioning]
- Pit Removal (Fill Sinks)
- Flow Direction
- Flow Accumulation
- Stream Definition
- Stream Segmentation
- Catchment Grid Delineation
- Raster to Vector Conversion (Catchment Polygon, Drainage Line, Catchment Outlet Points)

# Delineation of Channel Networks and Catchments

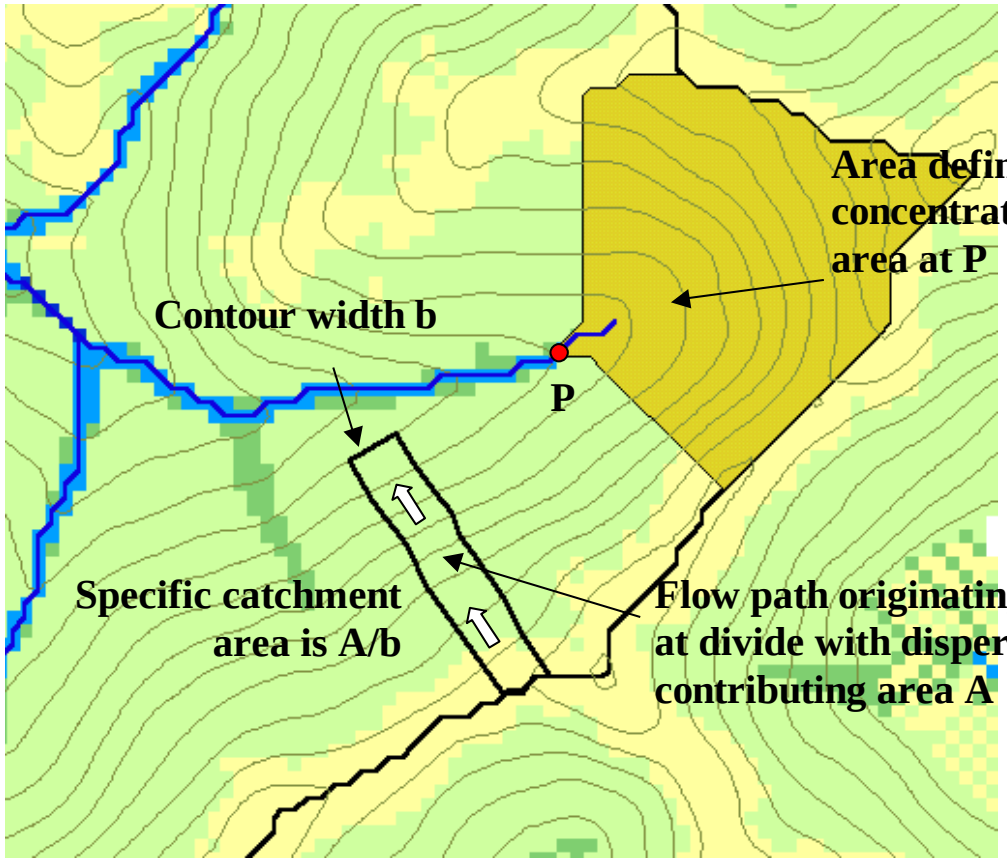


500 cell theshold



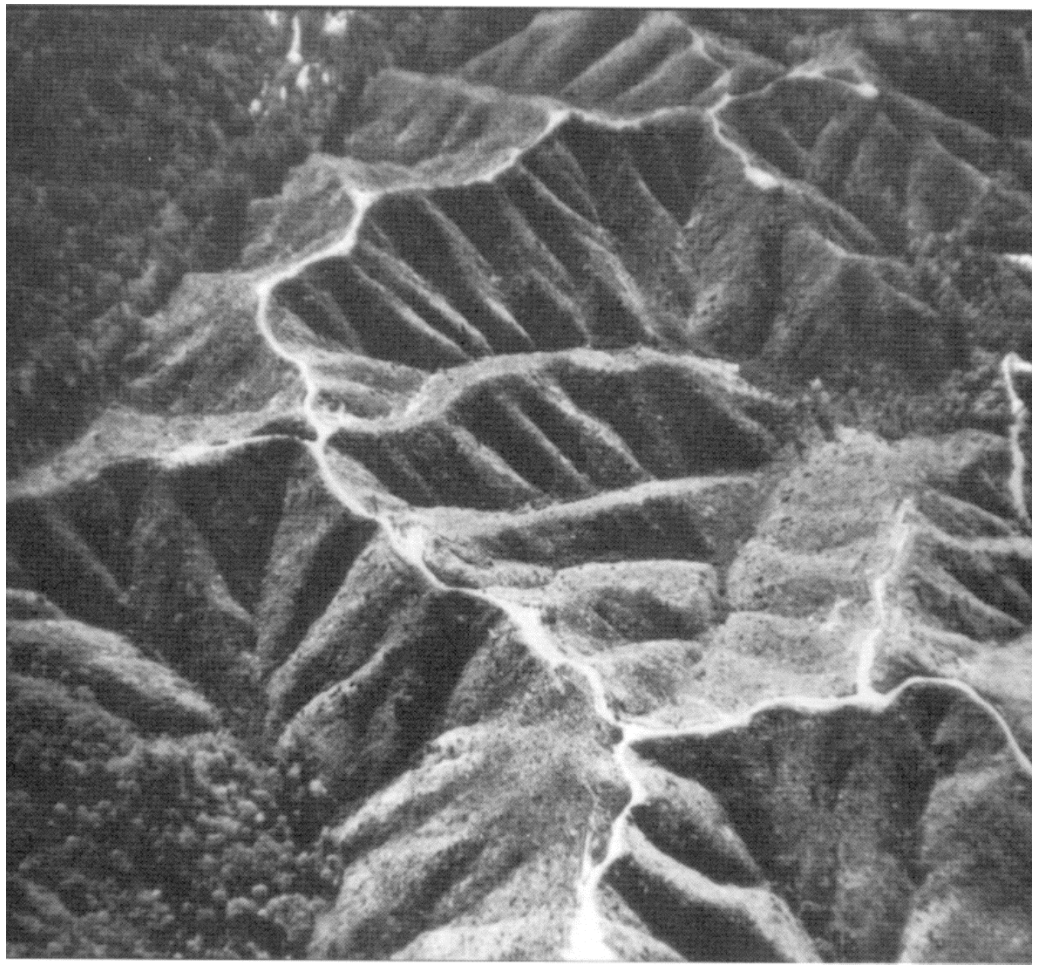
1000 cell theshold

# Hydrologic processes are different on hillslopes and in channels. It is important to recognize this and account for this in models.




Drainage area can be concentrated or dispersed (specific catchment area) representing concentrated or dispersed flow.

# Examples of differently textured topography



From W E. Dietrich