GIS in Water Resources
Exercise 3 Solutions

1. Hand calculations of slope at point A using each of the two methods and comments on the differences.

(i) ESRI Standard Slope Function

dz/dx = ((a+2d+g)-(c+2f+i))/8*c_size
= ((46.1+2*45.8+48)-(47.9+2*48.6+50.6))/(8*10) = -0.125

dz/dy = ((g+2h+i)-(a+2b+c))/8*c_size
= ((46.1+2*46.4+47.9)-(48+2*47.7+50.6))/(8*10) = 0.09

These represent the x and y components of the slope vector shortened as follows
Δx = dz/dx = -0.125
Δy = dz/dy = 0.09

slope (rise/run) = sqrt(Δx^2+Δy^2) = sqrt((-0.125)^2+(0.09)^2) = 0.154
slope (angle) = atan(slope (rise/run)) = atan(0.154) = 0.153 rads = 8.76 degrees

aspect = atan(Δx/Δy) = atan(-0.125/0.09) = -0.95 rads = -54.2 degrees
This is an angle in the NW quadrant since x component is negative and y component positive.
Add 360 degrees to get the angle clockwise from north

aspect = 360+(-54.2) = 305.75

(ii) The 8 direction pour point model
D8 Slope is calculated separately to each adjacent grid cell using the formula
Slope = (Center elevation - Side elevation)/Distance
Distance to diagonal side cells is the diagonal distance √2 * cell size

$$\frac{\text{center cell} - \text{side cell 16}}{\text{cell size}} = \frac{46.8 - 45.8}{10} = 0.10$$

D8 Slope: 0.1
D8 Direction: 16

Differences

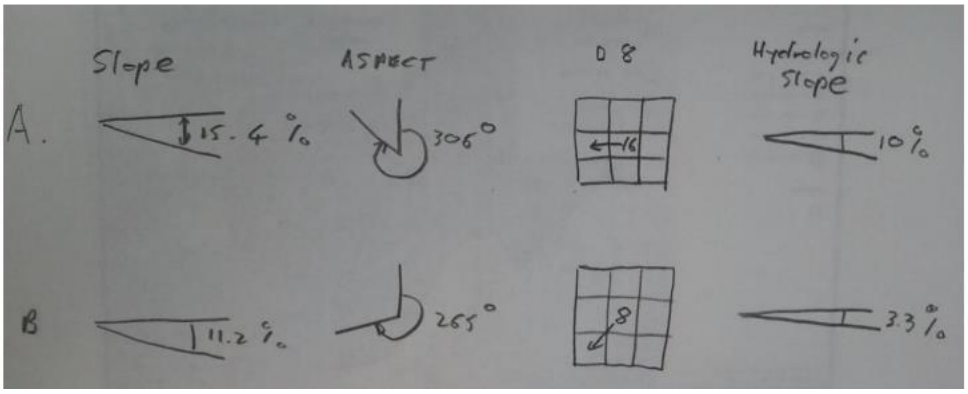
Represented as an aspect the D8 direction would be 270 degrees, but simply stating the direction as 16 or to the W is sufficient. The main difference is that the ESRI slope considers all 8 surrounding grid cell values, and curiously, not the actual grid cell value. It represents the slope of a polynomial surface fit to

all these grid cells. The D8 method only considers adjacent elevations lower than the center cell which is consistent with the assumption of where water would flow not being influenced by adjacent neighbors that are higher. The D8 flow direction is to the W, while the ESRI slope aspect is to the NW significantly influenced by the cell with value of 50.6 to the SE. The ESRI slope is probably most appropriate for computation of quantities such as illumination due to sunlight in energy balance calculations where the slope of the surface fit based on all surrounding values seems best, but for the flow of water, the D8 method is better.

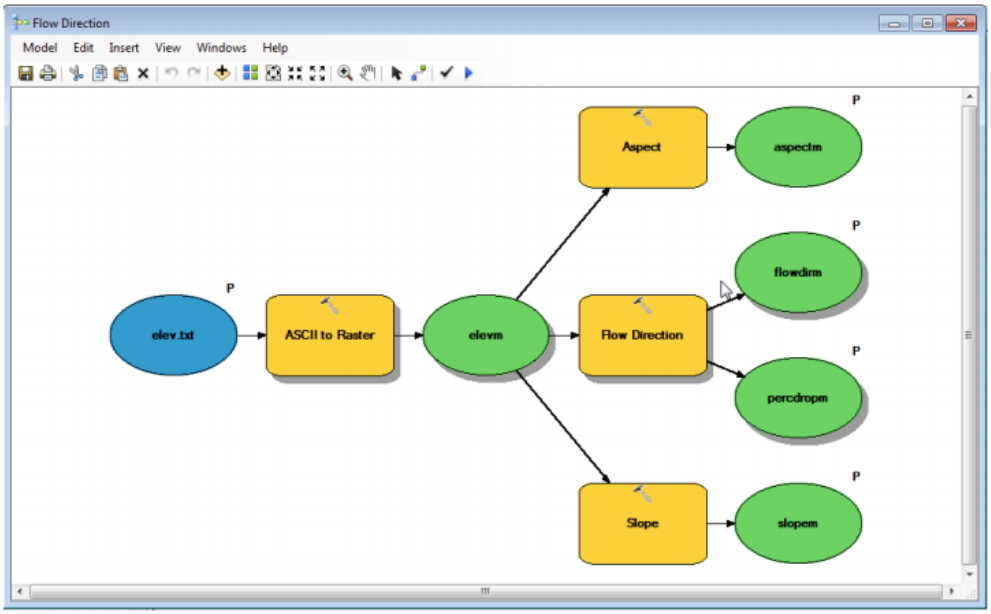
2. Table giving slope, aspect, hydrologic slope and flow direction at grid cells A and B. Please turn in a diagram or sketch that defines or indicates what each of these numbers means for the specific values obtained for cells A and B.

Summary of ArcGIS Calculated:

Point	Slope (%)	Aspect (deg)	D8 Slope (%)	Flow Dir (D8)
A	15.4	305.8	10	16
B	11.2	265.5	3.33	8



3. A screen capture of your final model builder model.



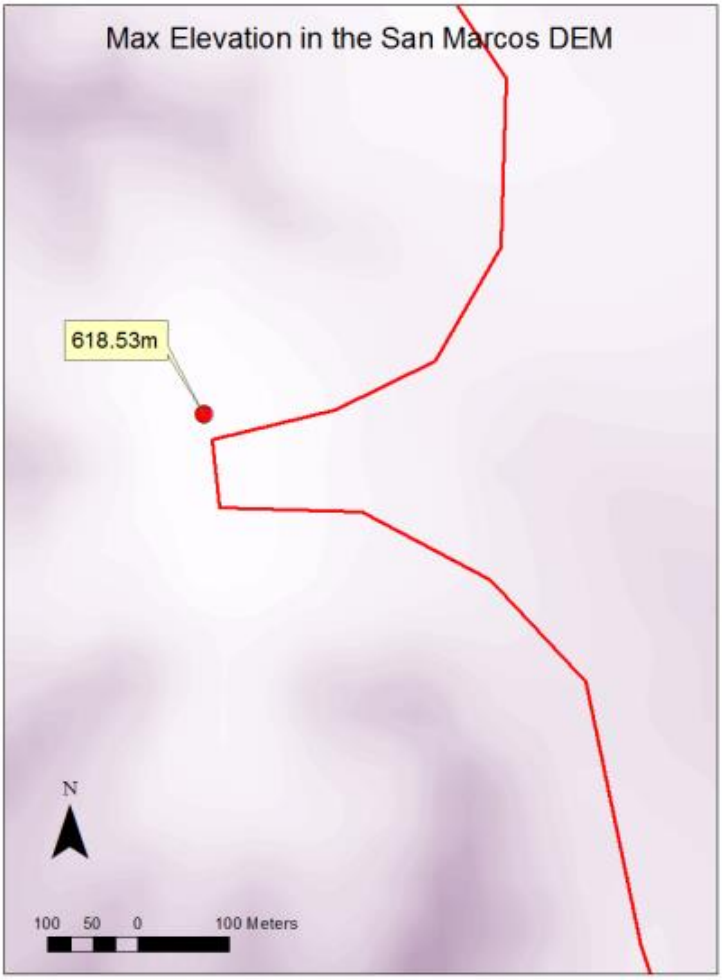
4. A table giving the minimum and maximum values of each of the four outputs Slope, Aspect, Flow Direction, and Hydrologic Slope (Percentage drop), for the digital elevation model in demo.asc.

Layer	Min	Max
Slope	0	149
Aspect	-1	360
Flow Dir	1	128
PercDrop	0.066	146.6

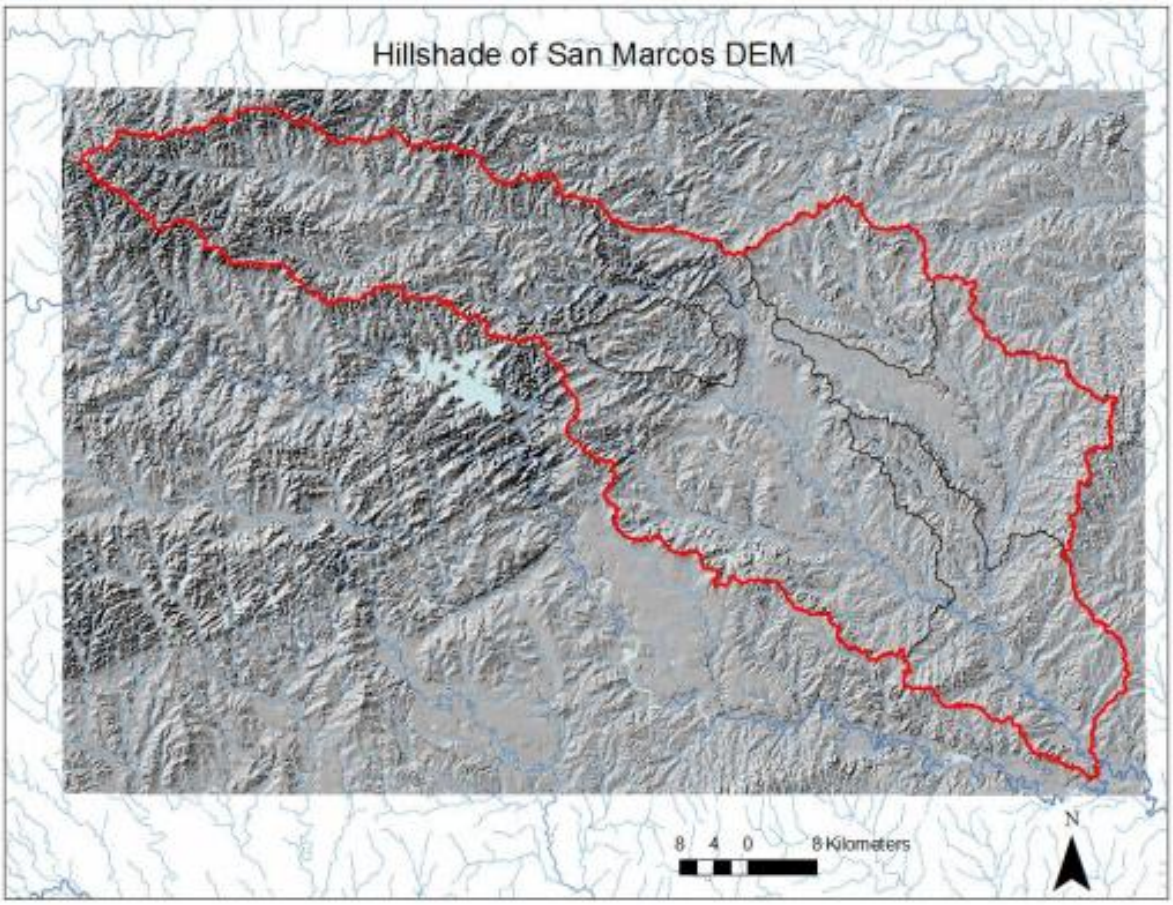
5. The number of columns and rows in the projected DEM. The cell size of the projected DEM. The minimum and maximum elevations in the projected DEM.

DEM	
Rows	2745
Columns	4222
Cell Size (m)	30 x 30
Minimum Elevation	69.77
Maximum Elevation	618.5

6. A layout showing the location of the highest elevation value in the San Marcos DEM. Include a scale bar and north arrow in the layout.



7. A layout with a depiction of topography either with elevation, contour or hillshade in nice colors. Include the streams from the NHDPlus Service and Basin and sub-watersheds from the SanMarcos.gdb Basemap feature dataset.



8. A table giving the HydroID, Name, mean elevation, and elevation range for each subwatershed in the SanMarcos Subwatershed feature class. Which subwatershed has the highest mean elevation? Which subwatershed has the largest elevation range?

HydroID	SiteName	Elev. Range (m)	Elev Mean (m)
330	Plum Ck at Lockhart, Tx	137.71	189.94
331	Blanco Rv at Wimberley, Tx	372.97	418.56
332	Blanco Rv nr Kyle, Tx	216.83	288.60
333	San Marcos Rv at San Marcos, Tx	218.73	266.31
334	Plum Ck nr Luling, Tx	115.95	151.96
335	San Marcos Rv at Luling, Tx	311.83	183.54

Highest: Blanco Rv at Wimberley, TX Largest Range: Blanco Rv at Wimberley, TX

9. A table giving the HydroID, Name, and mean precipitation by the Thiessen method for each subwatershed in the SanMarcos Subwatershed feature class. Which subwatershed has the highest mean precipitation?

HydroID	SiteName	SubW Precip (in)
330	Plum Ck at Lockhart, Tx	36.37
331	Blanco Rv at Wimberley, Tx	37.83
332	Blanco Rv nr Kyle, Tx	40.48
333	San Marcos Rv at San Marcos, Tx	40.48
334	Plum Ck nr Luling, Tx	36.52
335	San Marcos Rv at Luling, Tx	37.59

The highest mean precipitation is found for the San Marcos River at San Marcos and Blanco River near Kyle watersheds. These are identical, because they are both in the same polygon.

10. A table giving the HydroID, Name, and mean precipitation by the Tension Spline method for each subwatershed in the SanMarcos Subwatershed feature class. Which subwatershed has the highest mean precipitation using a Tension Spline interpolation?

HYDROID	SiteName	Precip (inches)
330	Plum Ck at Lockhart, Tx	36.22
331	Blanco Rv at Wimberley, Tx	37.89
332	Blanco Rv nr Kyle, Tx	39.79
333	San Marcos Rv at San Marcos, Tx	39.66
334	Plum Ck nr Luling, Tx	36.46
335	San Marcos Rv at Luling, Tx	37.99

Blanco River nr Kyle, TXhas the highest mean precipitation.

11. Flow volume is obtained from flow in cfs by multiplying by 365.25*24*3600*3600. The subwatersheds that comprise each watershed are identified and precip volume obtained by summing these. Watersheds that are comprised of multiple subwatersheds are grouped together to facilitate totaling of Precip volume, Runoff ratio is then flow volume/precip volume.

SiteName	Q(ft^3)	Precip Vol (ft^3)	Runoff Ratio
Plum Ck at Lockhart,TX	1.55E+09	9.485.E+09	0.163
Blanco Rv nr Kyle, TX	5.21E+09	3.667.E+10	0.142
Blanco Rv at Wimberely, TX	4.48E+09	3.125.E+10	0.143
San Marcos Rv at San Marcos, TX	5.55E+09	4.599.E+09	1.208
San Marcos Rv Luling, TX	1.29E+10	7.432.E+10	0.173
Plum Ck nr Luling, TX	3.60E+09	2.656.E+10	0.135

The runoff ratio for the San Marcos river at San Marcos is anomalously high due to flow from springs that are fed by precipitation that recharges the Edwards Aquifer outside the watershed. This anomalous high flow attenuates downstream. Plum Creek at Lockhart is also in the vicinity of where the Edwards aquifer outcrops and has a slightly higher runoff ratio so likely gets some spring contributions too. Over all the other watersheds, runoff ratio is pretty consistent between 0.11 and 0.15, which seems about right for this region.