GIS in Water Resources Exercise #4 Solution

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1. *Cell length (N-S) in m, width (E-W) in m, area in m^2 for the DEM cells in the merged DEM.*

   N-S

$$\Delta y = R_e \Delta\phi = 6370 * 9.259 \times 10^{-5} \times \frac{\pi}{180} = 0.0103\ km = 10.3\ m$$

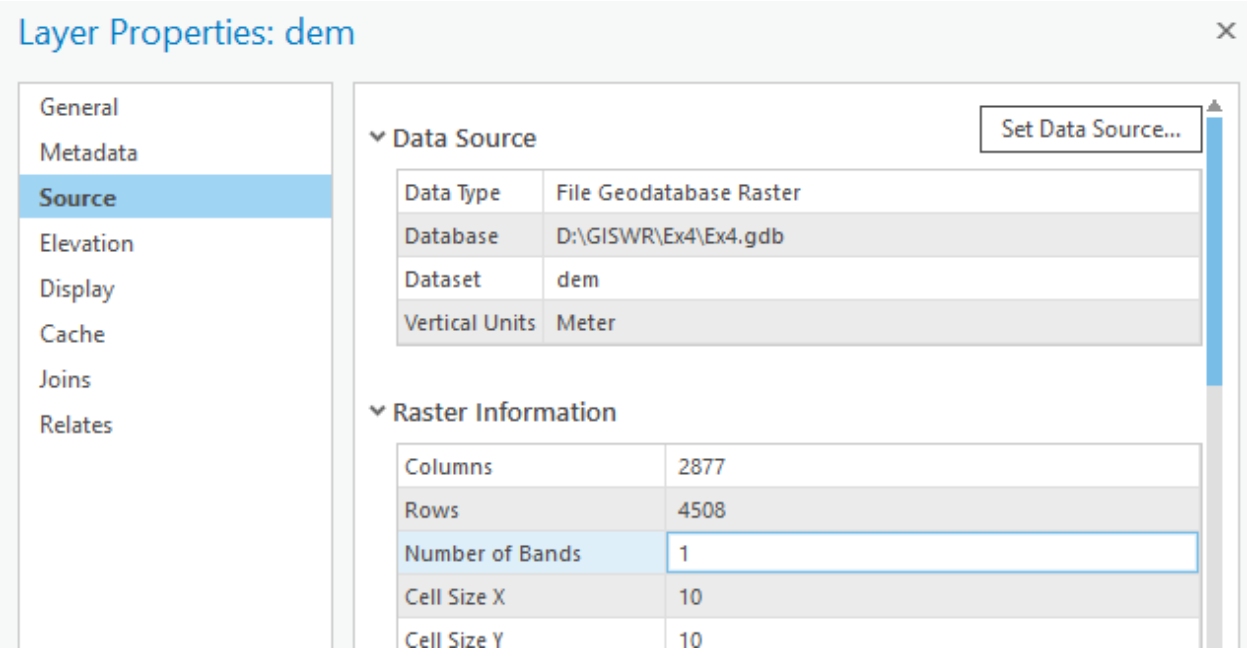
   E-W

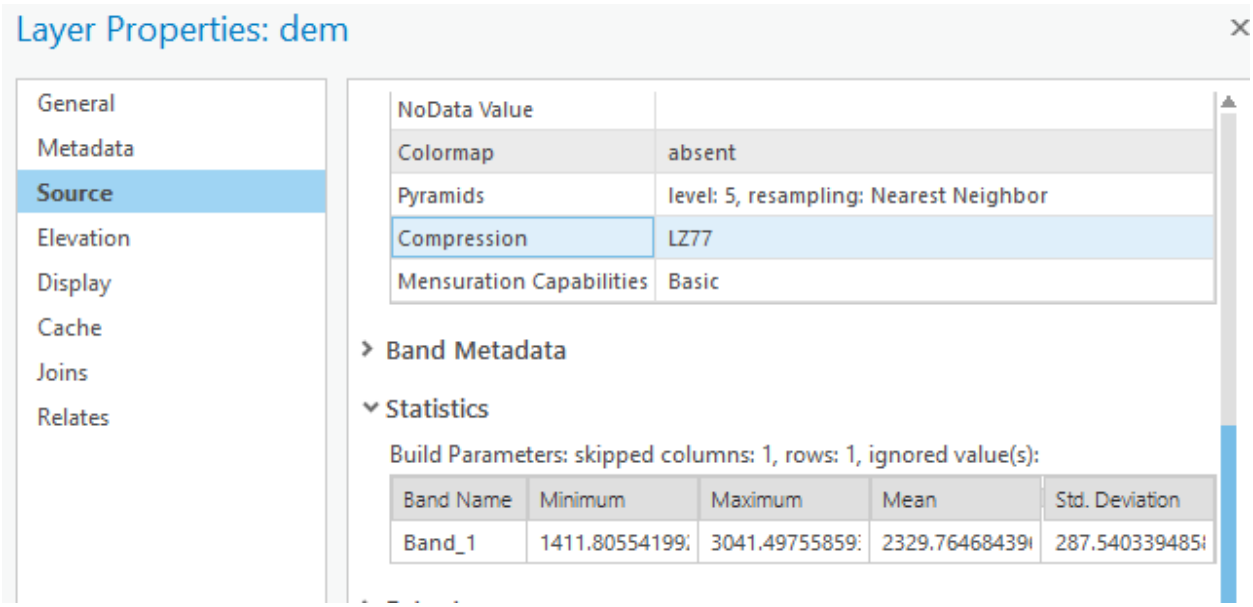
$$\Delta x = R_e \Delta\lambda Cos(\phi) = 6370 * 9.259 \times 10^{-5} \times \cos(42) \times \frac{\pi}{180} = 0.00765\ km = 7.65\ m$$

   Area = 10.3 x 7.65 = 78.7 m^2

2. *The number of columns and rows, grid cell size, minimum and maximum elevation values in the Logan River Basin DEM (just named dem above).*

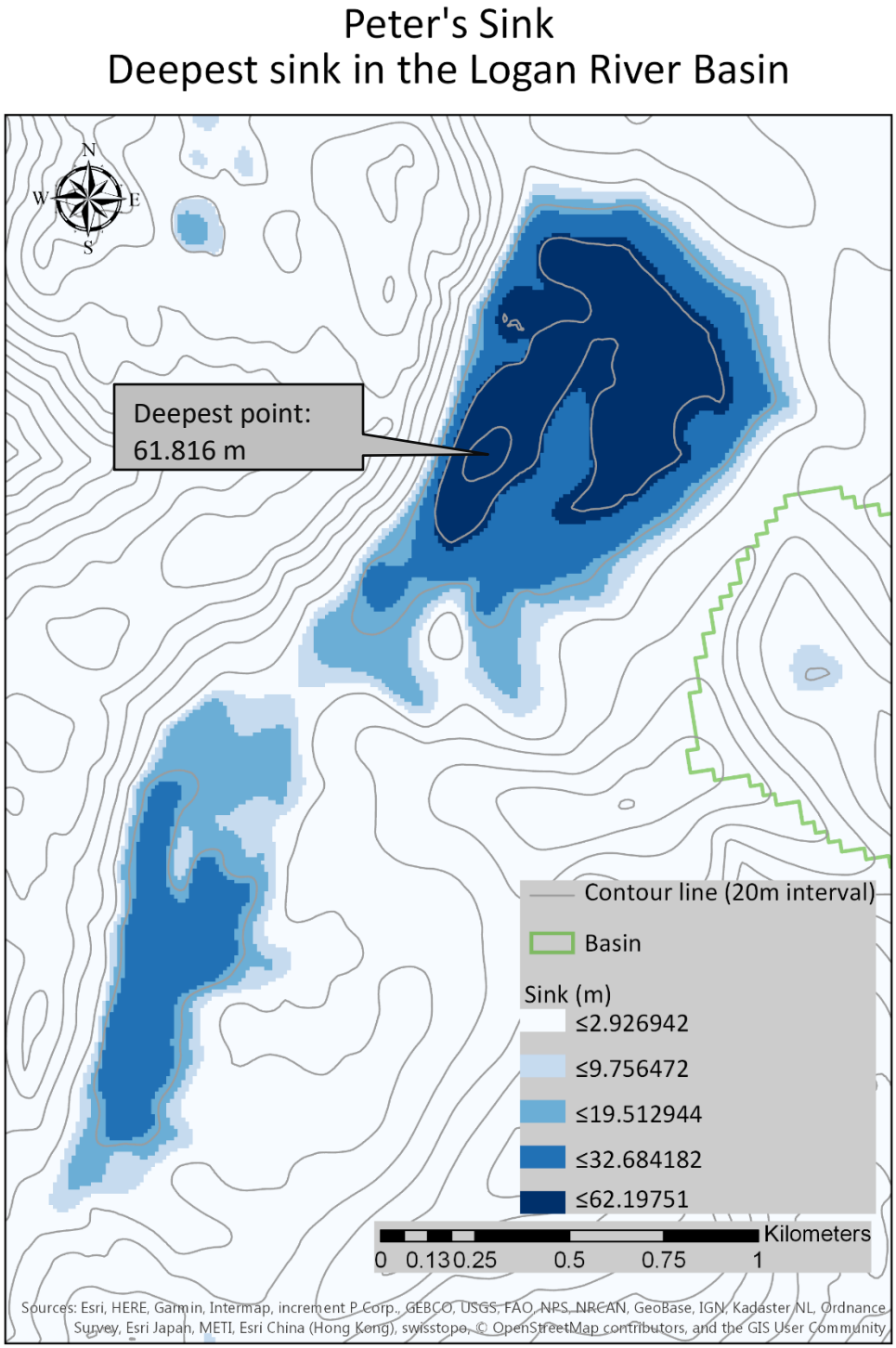
   Information is from dem properties





Number of rows: 4508
Number of columns: 2877
Cell Size: 10 m
Min Elevation: 1411.81 m
Max Elevation 3041.5 m

3. *A layout showing the deepest sink in the Logan River basin. Report the depth of the deepest sink as determined by fil-dem.*

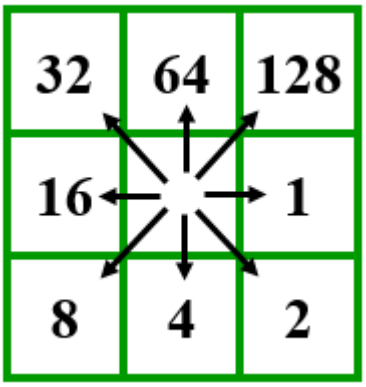


The depth of Peter Sink at the deepest point is 61.82 m.

4. *Make a screen capture of the attribute table of fdr and give an interpretation for the values in the Value field using a sketch.*

Field: Add Delete Calculate

OBJECTID	Value	Count
1	1	1067120
2	2	815658
3	4	901230
4	8	849129
5	16	1006916
6	32	660797
7	64	676662
8	128	911861
Click to add new row.		



The diagram to the right shows how to interpret flow directions encoded in the Value Field. For example, there are 1,067,120 grid cells where the flow moves to the east based on the flow direction encoded value of 1.

5. *Report the drainage area of the Logan River basin in both number of 10 m grid cells and km^2 as estimated by flow accumulation. Report the area of the Logan River basin in km^2 as calculated by the arcgis.com watershed function. Report the area of the Logan River basin in km^2 as reported by the USGS for the Logan River stream site. Discuss reasons for any differences.*

Estimated by flow accumulation:
The drainage area in number of 10m grid cells is 5,580,171.
The drainage in km^2: 5,580,171 * 10m * 10m * 10^{-6} km^2/m^2 = 558.02 km^2

Calculated by the arcgis.com watershed function:
The drainage area in km^2: 555.45 km^2

Basin

Field: Add Delete Calculate Selection: Zoom To Switch Clear Delete Copy

OBJECTID	Shape	Pour Point ID	Description	Data Resolution	Area Square Kilometers	Shape_Length	Shape_Area
1	Polygon	1	NED 30m processed...	30.0	555.4548	175202.91582	555044418.898516
Click to add new row.							

Reported by the USGS for Logan River stream site:
The USGS area is 214 mi^2, which is 214 mi^2 * 1.60934^2 km^2/ mi^2 = 554.25 km^2.

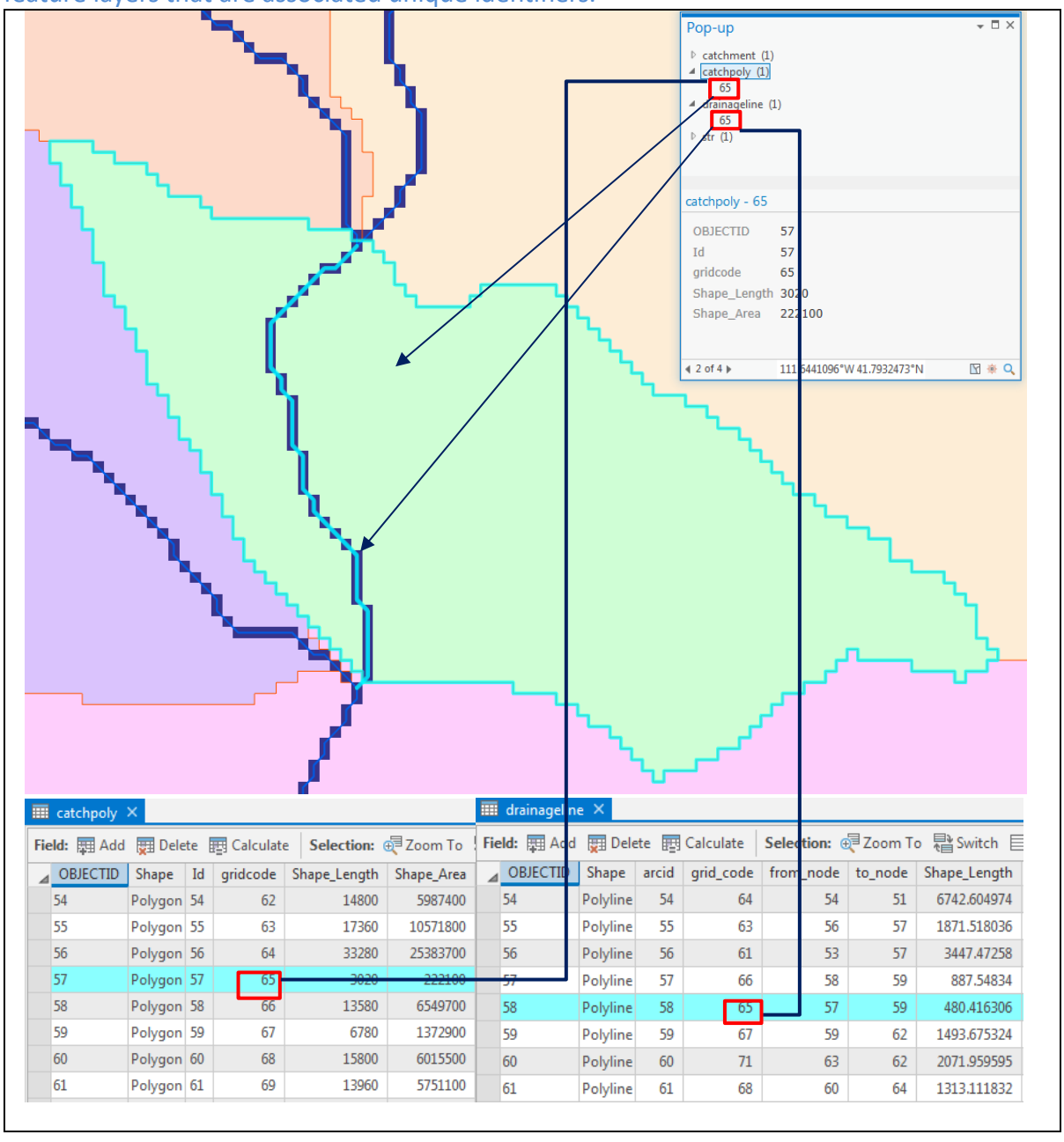
These differences are small and arise due to rounding and differences in flow directions along the edge of the watershed.

6. *The number of drainageline segments and catchments delineated from this DEM. [This was omitted from the "to turn in" summary at the end when the exercise was handed out so students are forgiven for not doing this.]*

   There are 77 drainage segments and 77 catchments in Logan River basin based on the inputs and methods used in this exercise.

7. *Describe (with simple illustrations) the relationship between StrLnk, DrainageLine, Catchment and CatchPoly attribute and grid values. What is the unique identifier in each that allows them to be relationally associated?*

The grid values for Catchments and the corresponding StrLnk rasters are the same. These values are inherited by the grid code attribute of DrainageLine and CatchPoly thereby providing a one to one association between drainage lines and the subwatershed polygon that drains to them. It is the grid values in the raster layers and grid code fields in the feature layers that are associated unique identifiers.

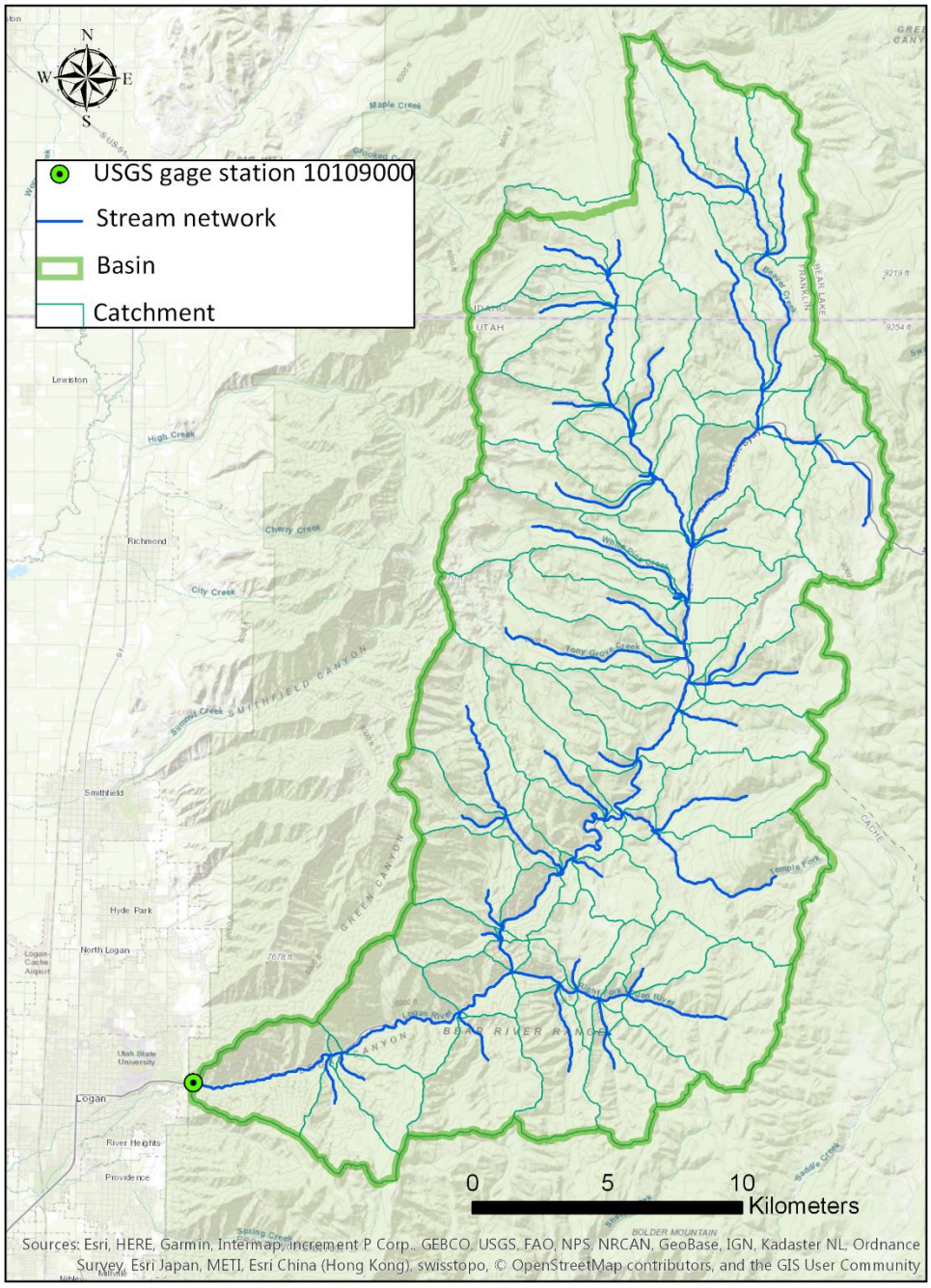


OBJECTID	Shape	Id	gridcode	Shape_Length	Shape_Area
54	Polygon	54	62	14800	5987400
55	Polygon	55	63	17360	10571800
56	Polygon	56	64	33280	25383700
57	Polygon	57	65	3020	222100
58	Polygon	58	66	13580	6549700
59	Polygon	59	67	6780	1372900
60	Polygon	60	68	15800	6015500
61	Polygon	61	69	13960	5751100

OBJECTID	Shape	arcid	grid_code	from_node	to_node	Shape_Length
54	Polyline	54	64	54	51	6742.604974
55	Polyline	55	63	56	57	1871.518036
56	Polyline	56	61	53	57	3447.47258
57	Polyline	57	66	58	59	887.54834
58	Polyline	58	65	57	59	480.416306
59	Polyline	59	67	59	62	1493.675324
60	Polyline	60	71	63	62	2071.959595
61	Polyline	61	68	60	64	1313.111832

8. *Prepare a layout showing the stream network and catchments delineated directly from the DEM.*

Stream network and catchments delineated from the DEM
Logan, Utah



9. *Report the total stream length, basin area and drainage density for the Logan River Basin as determined from the DEM delineated streams. Based on drainage density calculate the*

average overland flow distance water originating on a hillslope has to travel before reaching a stream. [Hint: Refer to slide 35 from ExtendedTerrainAnalysis.pptx in lecture 10.]

Total stream length from Shape_Length field of the drainageline attribute table: 201.95 km.

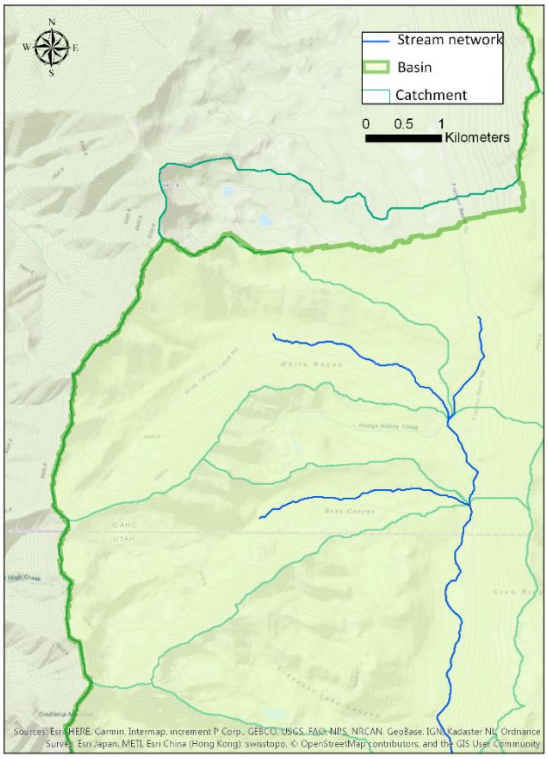
Basin area from Shape_Area field of the catchpoly attribute table: 558.02 km^2.

Drainage density: 201.95 km / 558.02 km^2 = 0.3619 km/ km^2

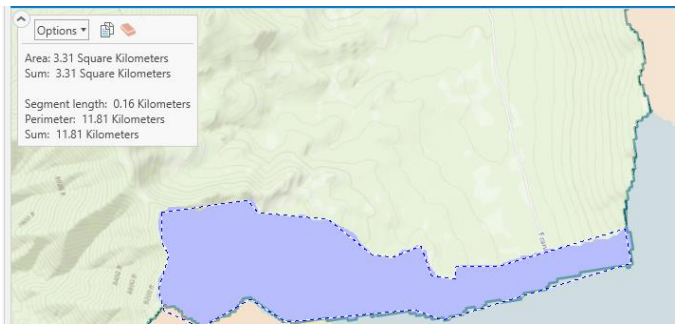
The average overland flow (hillslope length, B): 1/(2*0.3619) = 1.4 km

10. *Layout illustrating discrepancy in watershed boundary at the North end of Logan River basin. Report your estimate of the Logan Watershed area difference in km^2 due to this discrepancy.*

Discrepencay in watershed boundary at the North end of Logan River basin



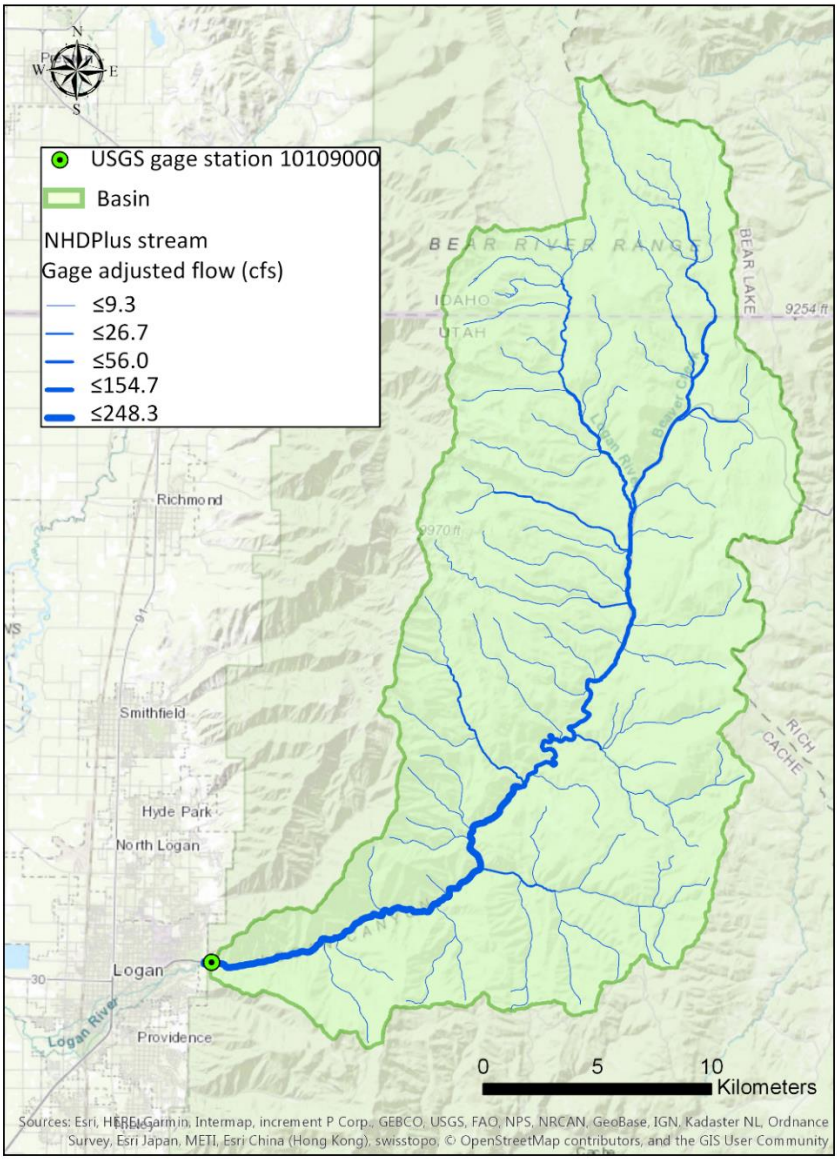
Using the measure tool the area is estimated as 3.3 km^2.



Also length is about 4.7 km and width about 0.7 km. Multiplying, an area estimate is 3.29 km^2 (remarkably consistent). Also, the drainage area of the watershed boundary delineated from 10m DEM is 558.02 km^2. The drainage area of the watershed boundary delineated from the online watershed delineation tool: 555.45 km^2. The estimated discrepancy is: 558.02 km^2 - 555.45 km^2 = 2.57 km^2 ~ 3 km^2. This also reflects other differences around the edge of the basin.

11. *Prepare a layout showing NHDPlus streams within the Logan River Basin symbolized using line width scaled by gage-adjusted flow. Report the mean annual gage adjusted flow at the most downstream segment in the Logan River drainage from NHD plus. Compare this mean annual flow to the mean annual flow from the Logan River stream gage.*

Map of NHDPlus streams within the Logan River basin



The mean annual gage adjusted flow at the most downstream segment (COMID = 664424) is 248.26 ft^3/s. The mean annual flow from the USGS stream gauge is

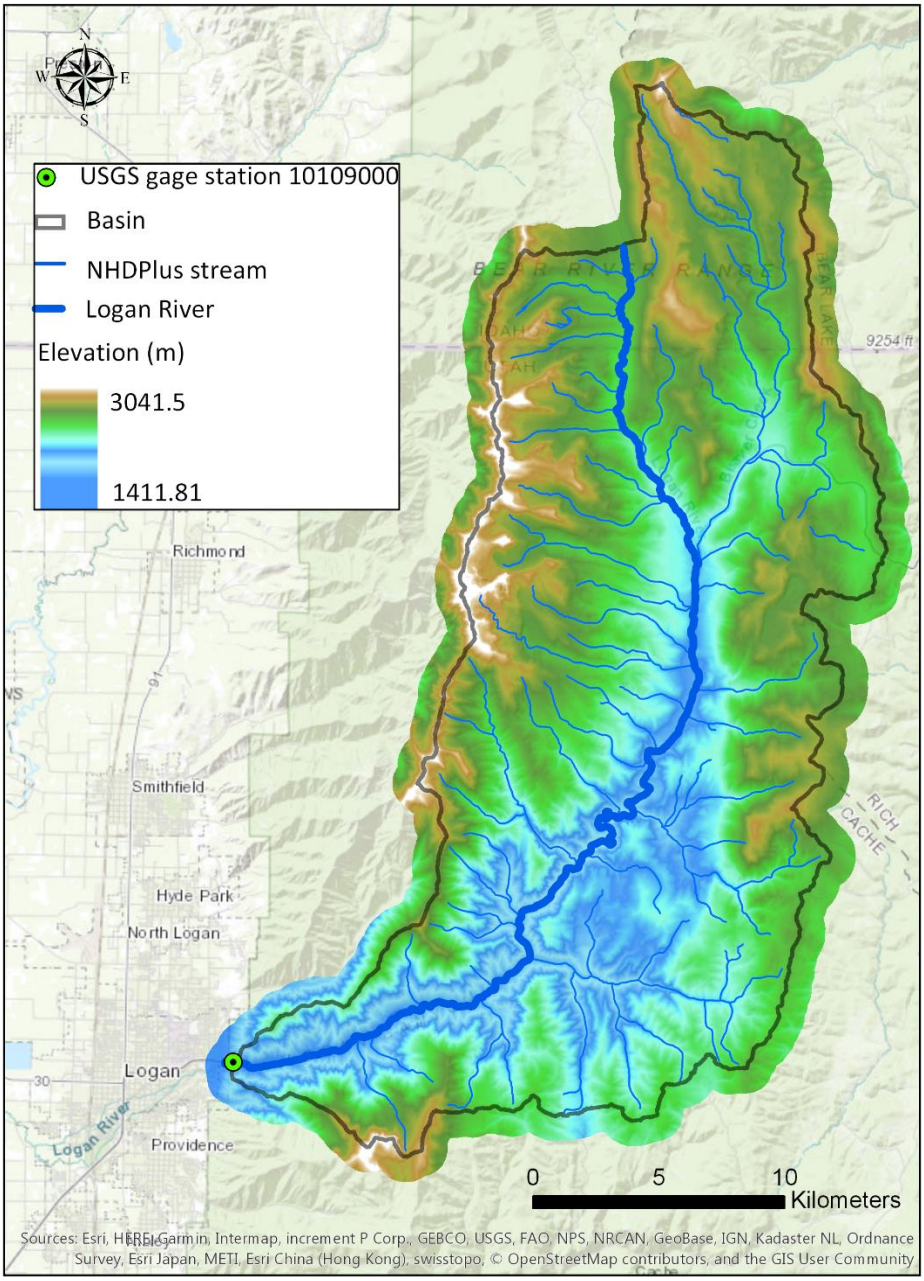
```
##
# US Geological Survey, Water Resources Data
# retrieved: 2018-10-11 23:15:22 EDT      (sdww02)
#
# This file contains USGS Surface-Water Annual Statistics
#
# Note:The statistics generated from  this site are based on approved
daily-mean data and may not match those published by the USGS in
official publications.
# The user is responsible for assessment and use of statistics from
this site.
# For more details on why the statistics may not match, visit
https://waterdata.usgs.gov/nwis/?dv_statistics_disclaimer.
#
# ** Incomplete data have been used for statistical calculation
#
# This file includes the following columns:
#
#
# agency_cd  agency code
# site_no    USGS site number
# parameter_cd
# ts_id
# year_nu    Water year for value
# mean_va    annual-mean value.
#             if there is not complete record
#             for a year this field is blank
#
#
# Sites in this file include:
# USGS 10109000 LOGAN RIVER ABOVE STATE DAM, NEAR LOGAN, UT
#
# Explanation of Parameter Code and ts_id used in the Statistics Data
# parameter_cd   Parameter Name                                    ts_id
  Location Name
# 00060          Discharge, cubic feet per second                 143453
#
#
agency_cdsite_no parameter_cd   ts_id   year_nu mean_va
5s       15s     5s      3n     4s      12n
USGS     10109000       00060   143453  1971    385.2
USGS     10109000       00060   143453  1972    349.4
USGS     10109000       00060   143453  1973    205.4
USGS     10109000       00060   143453  1974    278.6
USGS     10109000       00060   143453  1975    274.3
USGS     10109000       00060   143453  1976    239.8
USGS     10109000       00060   143453  1977    106.4
USGS     10109000       00060   143453  1978    244.7
USGS     10109000       00060   143453  1979    189.1
USGS     10109000       00060   143453  1980    248.5
USGS     10109000       00060   143453  1981    152.8
USGS     10109000       00060   143453  1982    318.5
USGS     10109000       00060   143453  1983    349.2
USGS     10109000       00060   143453  1984    424.3
```

USGS	10109000	00060	143453	1985	272.4
USGS	10109000	00060	143453	1986	440.5
USGS	10109000	00060	143453	1987	172.3
USGS	10109000	00060	143453	1988	137.9
USGS	10109000	00060	143453	1989	194.0
USGS	10109000	00060	143453	1990	118.6
USGS	10109000	00060	143453	1991	138.4
USGS	10109000	00060	143453	1992	99.6
USGS	10109000	00060	143453	1993	251.0
USGS	10109000	00060	143453	1994	149.7
USGS	10109000	00060	143453	1995	258.1
USGS	10109000	00060	143453	1996	279.1
USGS	10109000	00060	143453	1997	354.3
USGS	10109000	00060	143453	1998	305.6
USGS	10109000	00060	143453	1999	331.1
USGS	10109000	00060	143453	2000	176.1
USGS	10109000	00060	143453	2001	137.0
USGS	10109000	00060	143453	2002	132.3
USGS	10109000	00060	143453	2003	148.2
USGS	10109000	00060	143453	2004	135.2
USGS	10109000	00060	143453	2005	263.3
USGS	10109000	00060	143453	2006	305.3
USGS	10109000	00060	143453	2007	171.1
USGS	10109000	00060	143453	2008	183.9
USGS	10109000	00060	143453	2009	239.8
USGS	10109000	00060	143453	2010	173.8
USGS	10109000	00060	143453	2011	397.3
USGS	10109000	00060	143453	2012	186.7
USGS	10109000	00060	143453	2013	124.1
USGS	10109000	00060	143453	2014	163.9
USGS	10109000	00060	143453	2015	147.8
USGS	10109000	00060	143453	2016	180.2
USGS	10109000	00060	143453	2017	385.8
USGS	10109000	00060	143453	2018	223.7

Imported into Excel and averaged, (1971-2017) from the USGS Logan River stream gage is 232.2 ft^3/s. The mean annual flow from the NHD dataset is about 6% bigger than the mean annual flow from the USGS gage.

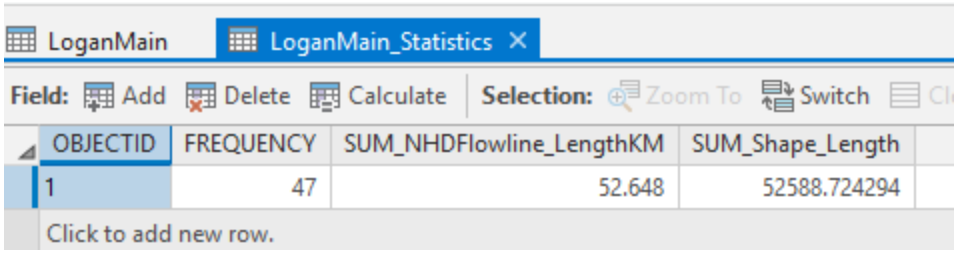
12. *Prepare a layout showing the topography, Basin Outline, NHDPlusV2 streams, and Logan River Main stem stream for the Logan River Basin. Include a scale bar and North arrow and appropriate title, labeling and legend so that the map is self-describing.*

Map of the topography, NHDPlus V2 streams, and Logan River main stem stream for the Logan River basin

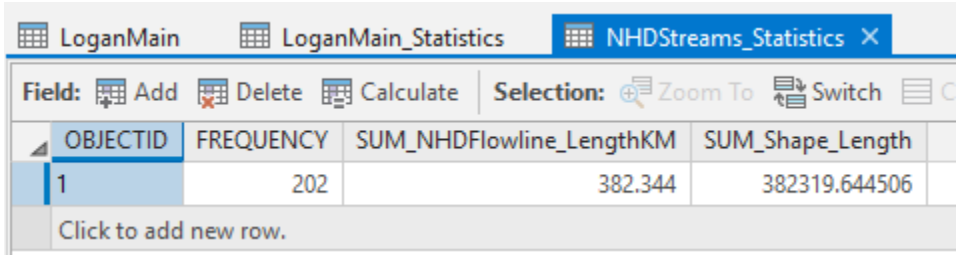


13. *Report the mainstream length, total stream length, basin area and drainage density for the Logan River Basin as determined from NHDPlus flowlines. Comment on the differences between this drainage density and the DEM derived drainage density.*

    Logan River mainstream length, from Summary Statistics on the LoganMain feature class is 52.6 km.



Total NHDPlus stream length from summary statistics on the NHDStreams feature class is 382.3 km



Drainage area from above (Flow accumulation or catchment polygons) is 558.0 km^2. Thus drainage density is:
382.3/558.0 = 0.685 km/ km^2 or km^{-1}. This is higher than 0.362 km^{-1} obtained from the DEM derived network. The threshold used to derive the DEM network was somewhat arbitrary. This NHDPlus stream network has been mapped cartographically, but at nominally 1:100000 scale. One inference from this is that the threshold used to map the DEM network was too large. A smaller threshold would have given a higher drainage density.