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GIS Final Project

Relationship between Delta Geometry and Associated Water Discharge

Purpose

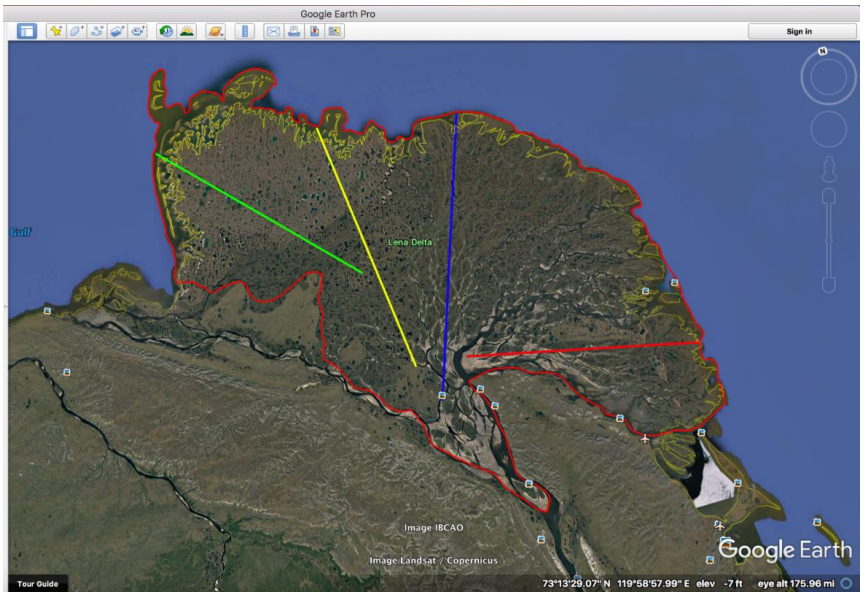
A delta's geometry can be based on a variety of factors such as topographic relief or drainage basin climate. The purpose of this analysis is to determine a relationship between a delta's average discharge of sediment and water and the resulting geometry.

Data Sources

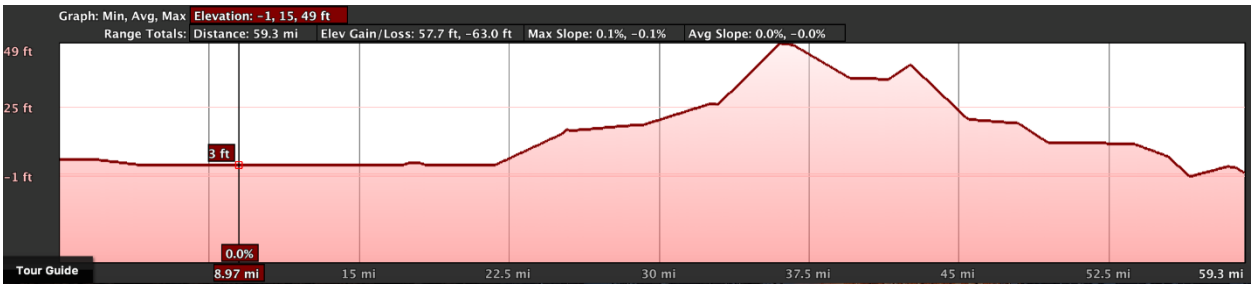
Google Earth Pro

Defining a Delta

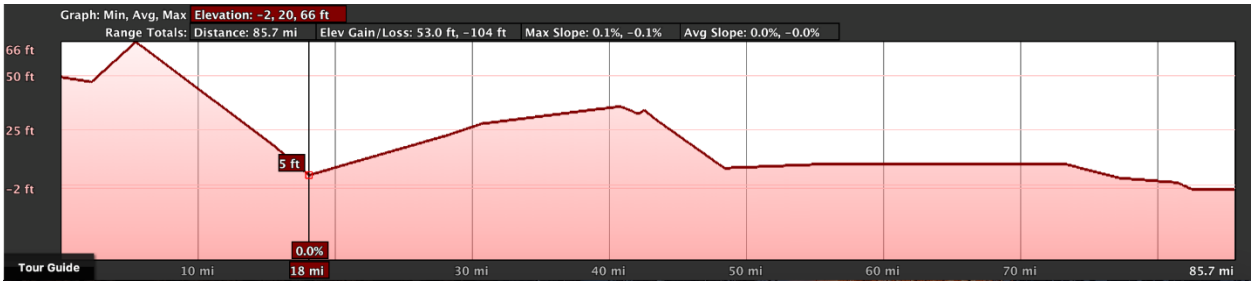
In order to keep my measurements consistent, I defined the start of my delta outlines to be where the first main node occurs. Additionally, the general slope of the delta has to be relatively lower compared to the surrounding topography. I used transect lines in google earth pro to gather surface elevations on and around the delta. This was to make sure I didn't outline any area that had a significantly high elevation. In the Lena River Delta shown below, the green, yellow, blue and red transect lines are shown below with their corresponding elevation profiles to show a similarity in slope across the delta.



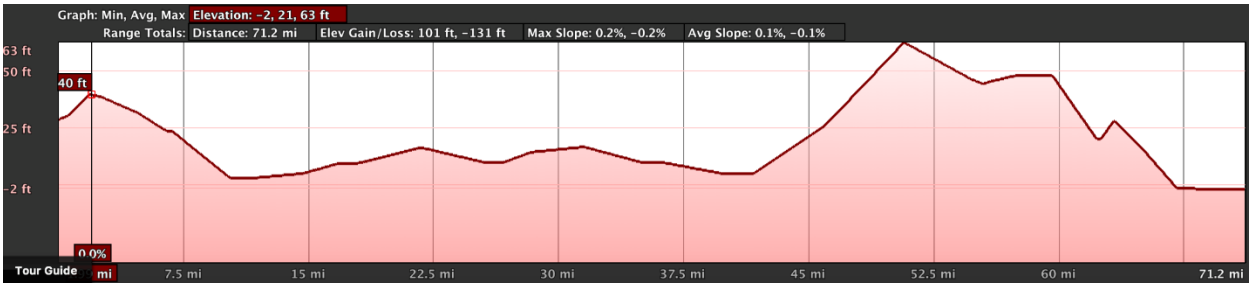
Red Transect:



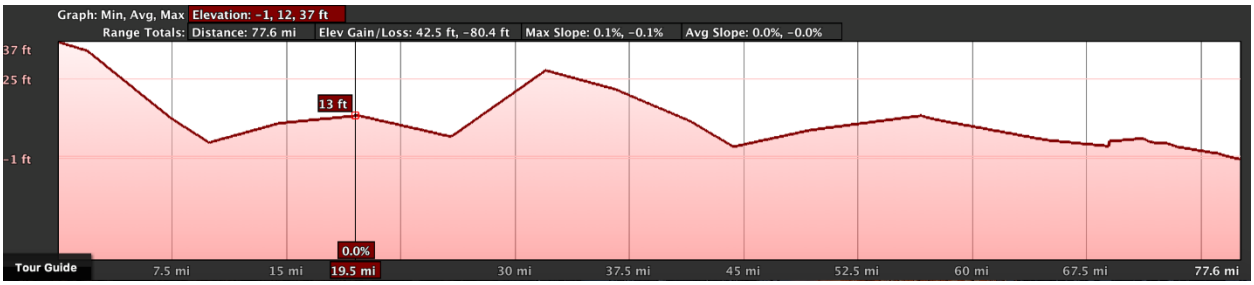
Blue Transect:



Green transect:



Yellow transect:



For the Lena River Delta, I also referenced figure 8 from Bolshiyanov et al. to generally gauge where I should be delineating the "rocks" from the delta.

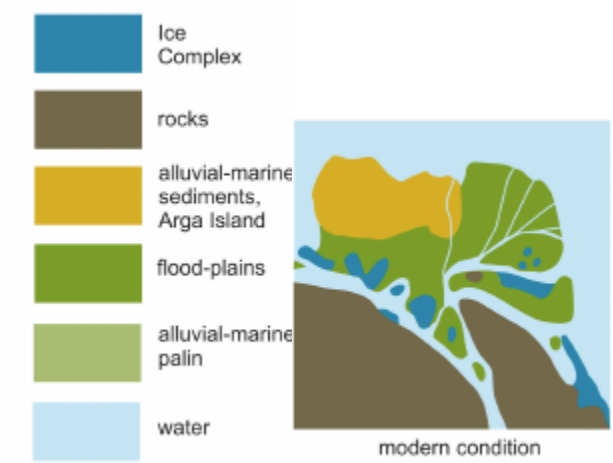
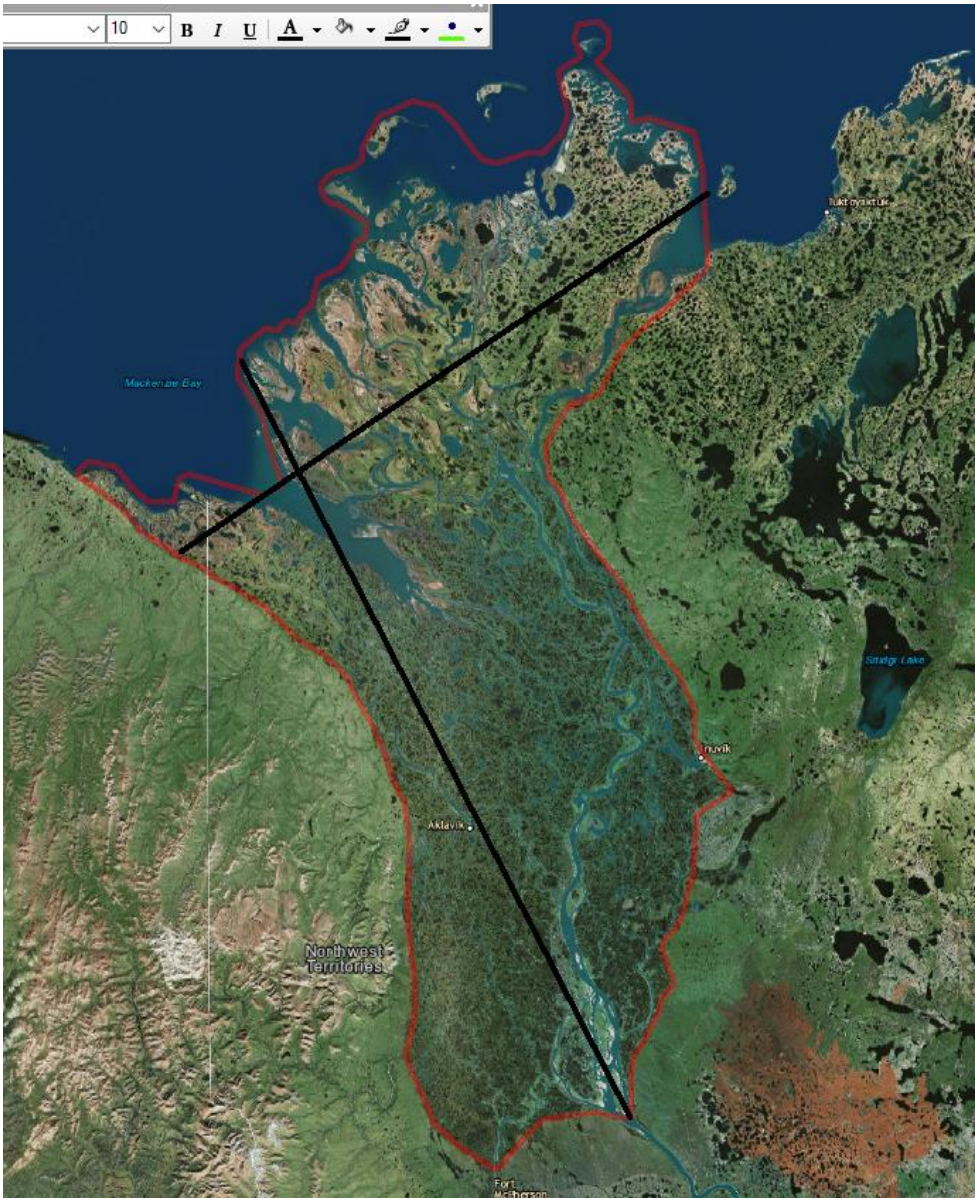


Fig. 8 from Bolshiyanov et al. (2014)

GIS Application

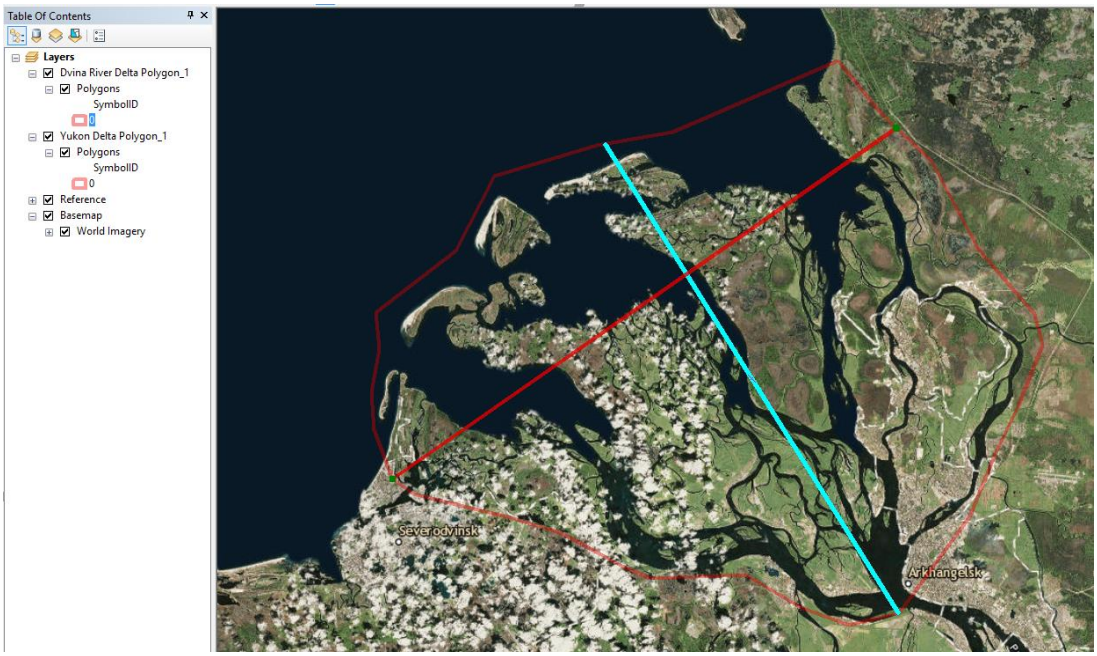
After outlining the deltas in Google Earth Pro, I saved the five outlines as KML files and then converted them to layer files in GIS. The files in both Google Earth Pro and GIS used WGS 84 as the datum. I then took length, width, area, and perimeter measurements of each delta using the line, polygon, and ruler tool. For the length and width, I measured each along the longest axis in both directions, ensuring that they crossed at a 90 degree angle. Below are screenshots of the deltas in GIS and where I took the length and width measurements.

Mackenzie Delta, Northwest Territories, Canada, entering the Beaufort Sea



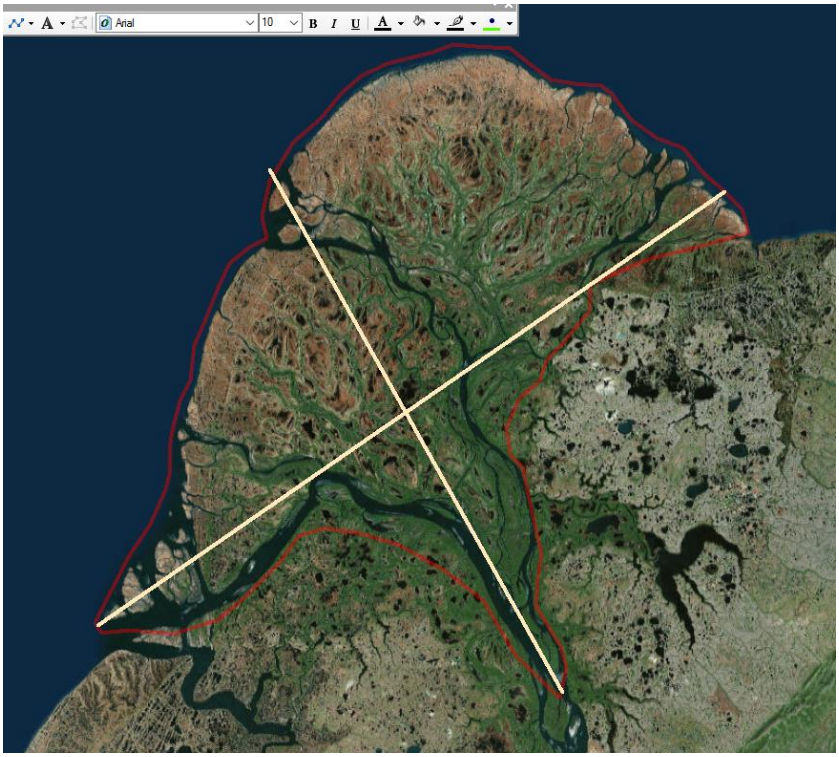
Lena Delta, Lena Delta Wildlife Reserve, Russia

Dvina Delta, Russia



Mississippi Delta, Louisiana

Yukon Delta, Alaska



Discharge Rates

River	Water discharge	Sediment discharge	Source
Yukon River	227,000 ft3/s, based on the period of record, 1976-96. U	60,000,000 tons of sediment per year at pilot station	https://ak.water.usgs.gov/Publications/pdf.reps/wrir99.4204.pdf
Dvina River	3332.89284 m^3/s	---	https://en.wikipedia.org/wiki/Northern_Dvina_River
Mississippi River	16,792 cubic meters	---	https://www.nps.gov/miss/riverfacts.htm
Lena River	16,400 cubic metres/s	---	https://www.britannica.com/place/Lena-River
Mackenzie	9701.35164 m/s	---	https://www.sciencedirect.com/science/article/pii/S1040618214006715

In determining the water discharged by the Yukon River, Burrows et al. (1981) measured the volume of water discharged in cubic feet per second from various locations. I used the data taken at the Pilot Station since it was the closest location to the mouth of the Yukon River Delta. The plot below shows the water discharges at varying locations on the Yukon River.

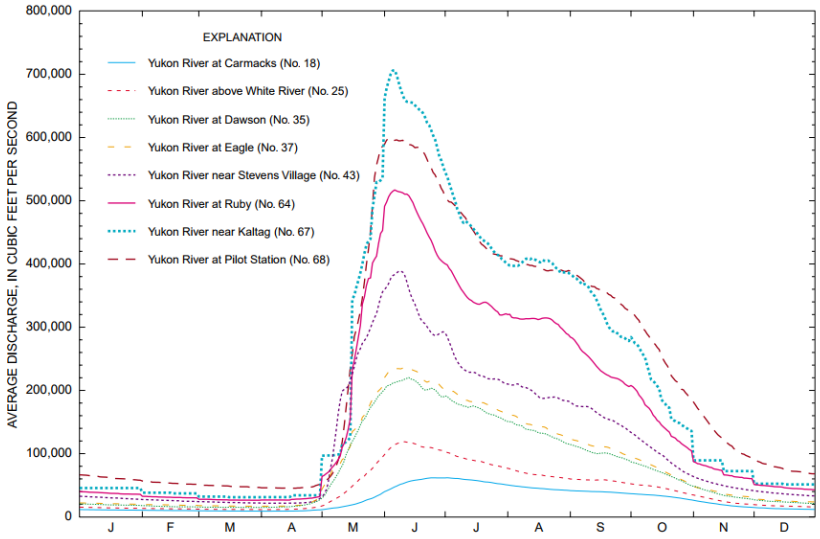


Figure 21. Average discharge of the Yukon River at eight locations (see figure 18 for locations).

Pilot Station is shown as location #68 below:

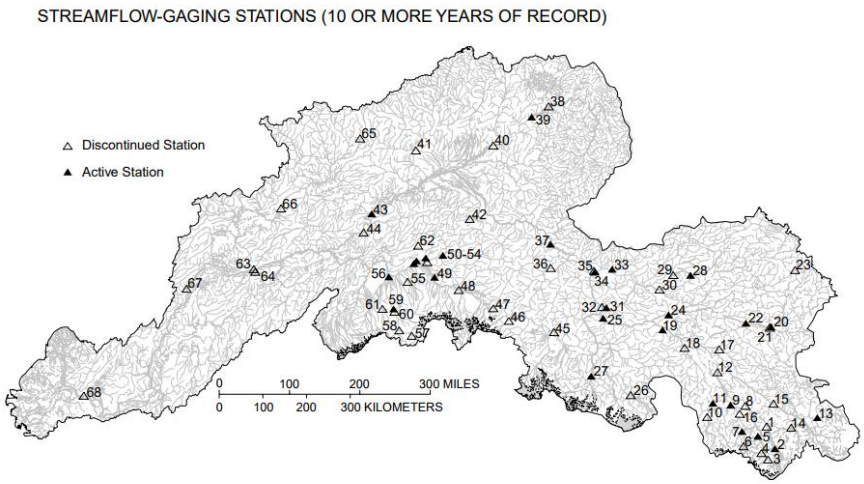
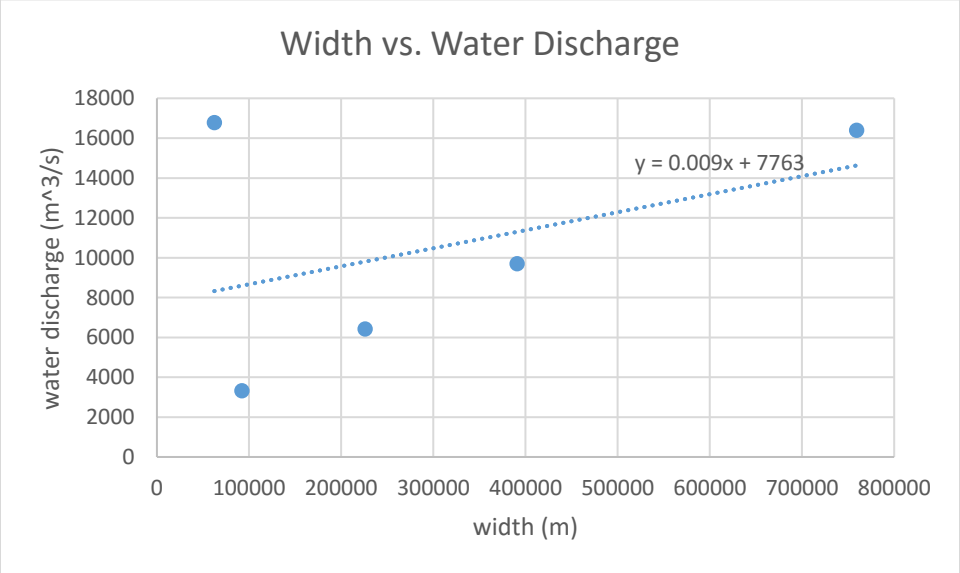
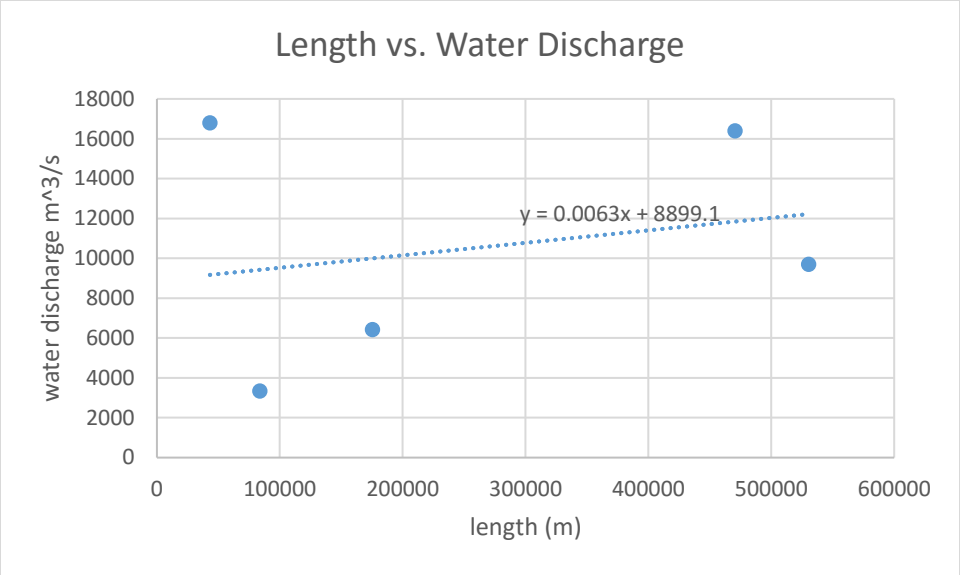
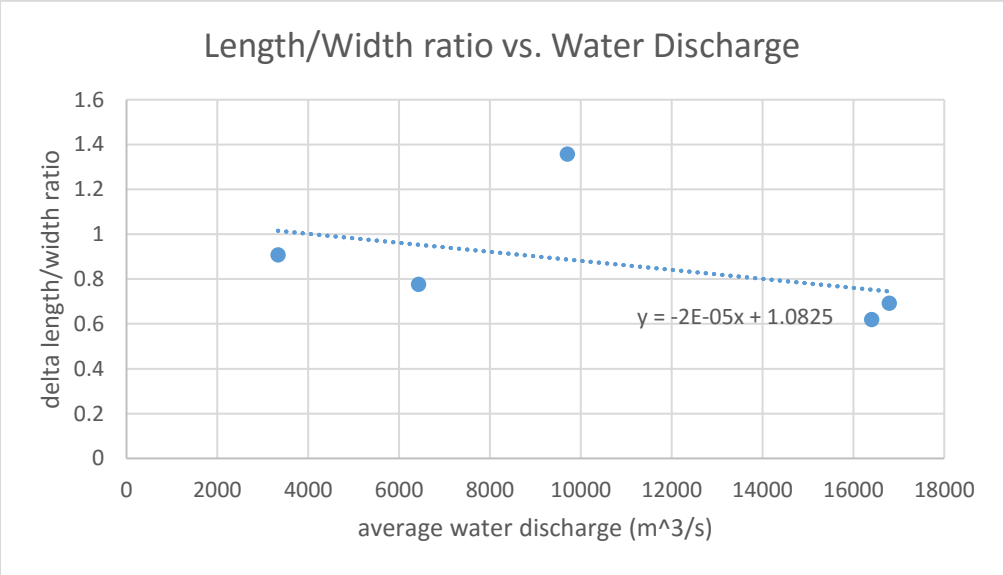


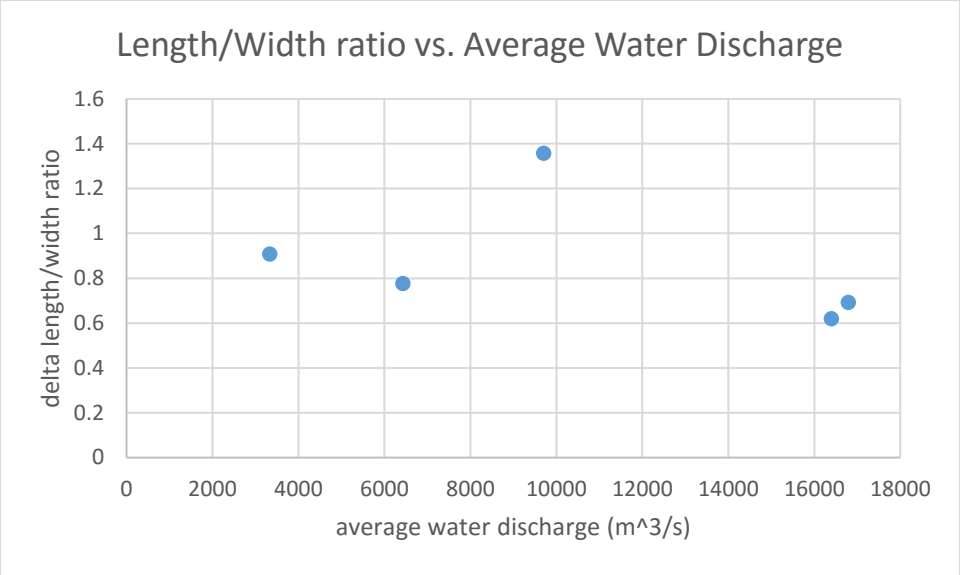
Figure 18. Location of streamflow-gaging stations with 10 or more years of record in the Yukon River Basin. (See table 6 for station names.)

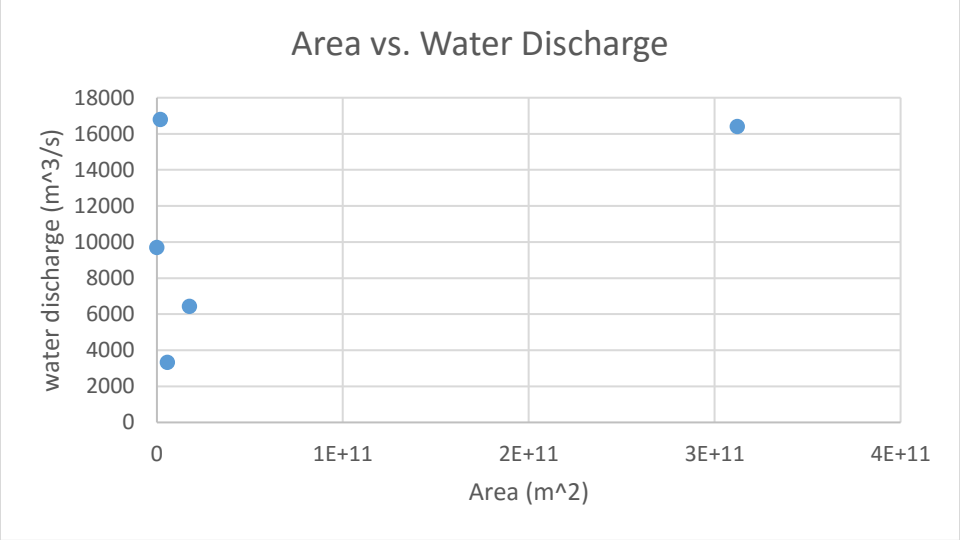
After converting the water discharge rates to m^3/s, I plotted them with each delta's corresponding length to width ratio, area, length, width, and perimeter.

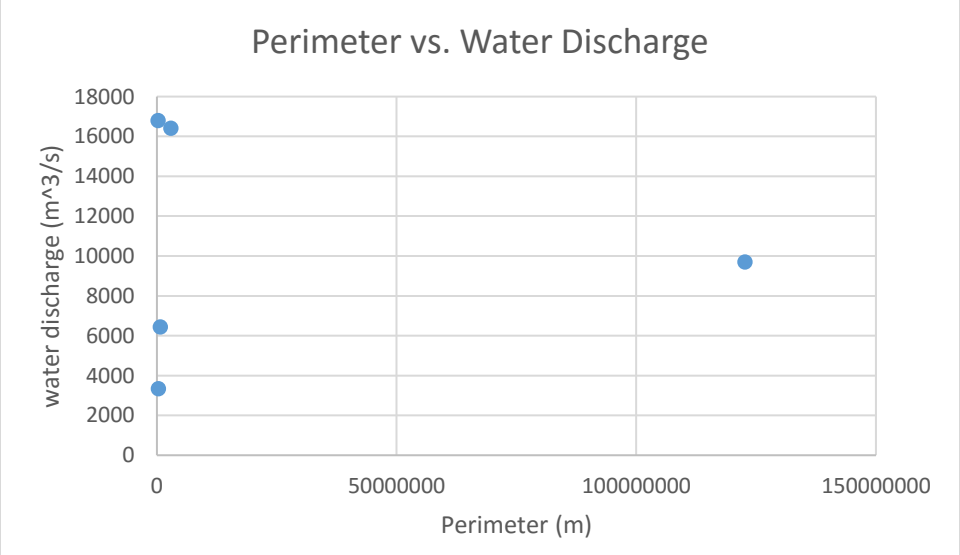



Length vs. Water Discharge
water discharge m^3/s
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
y = 0.0063x + 8899.1
0
100000
200000
300000
400000
500000
600000
length (m)


Length/Width ratio vs. Water Discharge
delta length/width ratio
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
y = -2E-05x + 1.0825
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
average water discharge (m^3/s)


Length/Width ratio vs. Average Water Discharge
delta length/width ratio
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
average water discharge (m^3/s)


Area vs. Water Discharge
water discharge (m^3/s)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
1E+11
2E+11
3E+11
4E+11
Area (m^2)


Perimeter vs. Water Discharge
water discharge (m^3/s)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
50000000
100000000
150000000
Perimeter (m)

This following table shows the length, width, area, and perimeter values for each delta, as well as its water discharge.

Delta	length (m)	width (m)	area (m^2)	perimeter (m)	water discharge	l/w	l*w	area/(l*w)
Yukon	175404	225900	17489479948	682009.8	6427.92418	0.776467	39623763600	0.441388661
Dvina	83762.8	92251.99	5662204537	288974.55	3332.89284	0.907978	7727284988	0.732754719
Mississippi	43107.9	62262	1823317110	244397.9	16792	0.692363	2683984070	0.679332314
Lena	470430	759272.55	3.12114E+11	2888898	16400	0.61958	3.57185E+11	0.873817502
Mackenzie	530272	390763.3	1984564.9	122702923	9701.35164	1.357016	2.07211E+11	9.57752E-06

I suspected that the GIS measurement for the Mackenzie River Delta's area seemed extreme, so I multiplied each delta's length and width and divided the measured area by that value to estimate an error (length * width would give an area estimate for a square over the delta region, so presumably, a measured value for the area should be a reasonable fraction of this calculated value). The Mackenzie River Delta's area measurement did not seem to be accurate, however, I wasn't able to open up GIS to re-measure the area.

Results

The length and width of a delta's topset seems to scale with its water discharge. Rivers with high water discharge may create deltas with relatively longer or wider delta geometries. There also seems to be a negative relationship between length/width ratio and water discharge. If a delta has a high length to width ratio, it is less circular and more oval in shape. I hypothesized that deltas with high water discharge would result in higher length to width ratios due to a delta tendency to prograde faster with higher water discharge. However, the results show that less elongation resulted from deltas with higher rates of water discharge.

Reference

Bolshiyanov, D., Makarov, A., Savelieva, L. Lena River delta formation during the Holocene, 2014, Biogeosciences, 12, 579 - 593