Angélique ALCIDI – 40107004
Manasi BOBHATE – 40122884

GEOG 375 – Hydrology
Pascale BIRON
Assignment 4

1) In order to complete a study on the Nicolet River, further information is needed. From the photography of the river at low stage (Assign4_Nicolet.jpg, available on Moodle) and from three hydraulic characteristics at low stage:

i) Estimate the values of each n_i of Manning and determine the resulting Manning n.

Assign values to the n_i

Material involved	n_0 = 0.028 coarse gravel
Degree of irregularity	n_1 = 0.003 smooth-minor
Variations of channel cross-section	n_2 = 0.000 gradual
Relative effect of Obstruction	n_3 = 0.027 appreciable
Vegetation	n_4 = 0.005 low
Degree of sinuosity	m = 1 minor

$n = (n_0+n_1+n_2+n_3+n_4)m = (0.028+0.003+0.027+0.005)$
$n = 0.063$

ii) Calculate the mean velocity (V) and discharge (Q) using Manning equation.

S = 0.0017
Y = 0.25 m
W = 18 m

Velocity
R = A/P = WY/(2Y+W)
$R = \frac{18 \times 0.25}{(2 \times 0.25)+18} = \frac{9}{37}$

R = 0.243m

$V = \frac{R^{2/3} \times S^{1/2}}{n} = \frac{(0.243)^{2/3} \times (0.0017)^{1/2}}{0.063}$

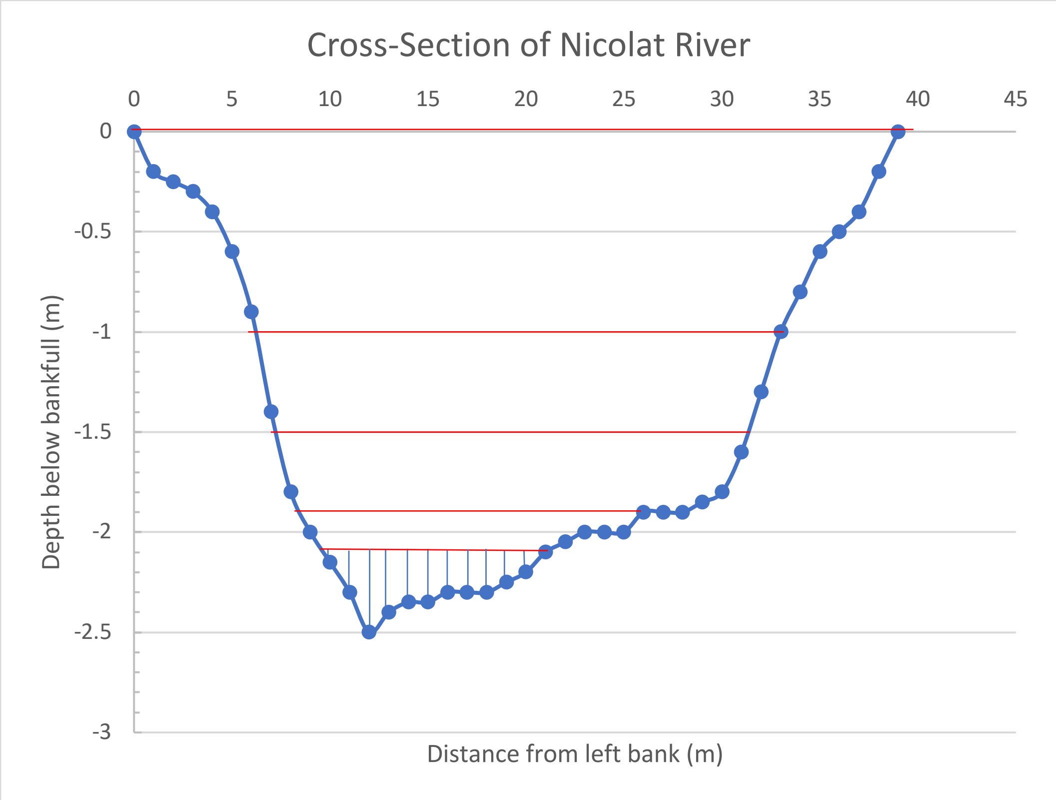
V = 0.254 m/s

Discharge
Q = WYV
Q = 18(0.25)(0.254)
$Q = 1.143 m^3/s$

iii) Would the value of Manning n increase or decrease at bank full stage? Why?
At bank full stage, the Manning n will decrease because the relative effect of the obstacle (gravel bed, vegetation etc) would be less. Water would circulate freely.

2) Table 1 presents data for the cross-section on the photography of the Nicolet River (from bankfull level, where the left bank is looking downstream). The data from this table is available on Moodle as an Excel file.

i) Plot this cross-section and calculate mean depth (Y) and width (W) for 5 different water levels: when maximal depth (Y_{max}) is equal to 0.4, 0.6, 1.0, 1.5 and 2.5 m.



Mean Y and W

Max Y in m	Mean Y in m	Mean W in m
2.5	1.557	39
1.5	0.989	26.9
1	0.59	24.8
0.6	0.3	17.5
0.4	0.25	11.1

ii) Assuming that:
a- the slope does not vary with water level;
b- Manning n found in 1) is valid for the two shallower depths (Y_{max}= 0.4 and 0.6 m);
c- Manning n for the other three depths (Y_{max}= 1.0, 1.5 and 2.5 m) can be estimated by Strickler's equation knowing that D_{50}= 65 mm,

c- Manning n for (Y_{max}= 1.0, 1.5 and 2.5 m)

n can be estimated using Strickler equation

$$n = 0.0151 D_{50}^{\ 1/6} = 0.0151 \times 65^{1/6} = 0.030$$

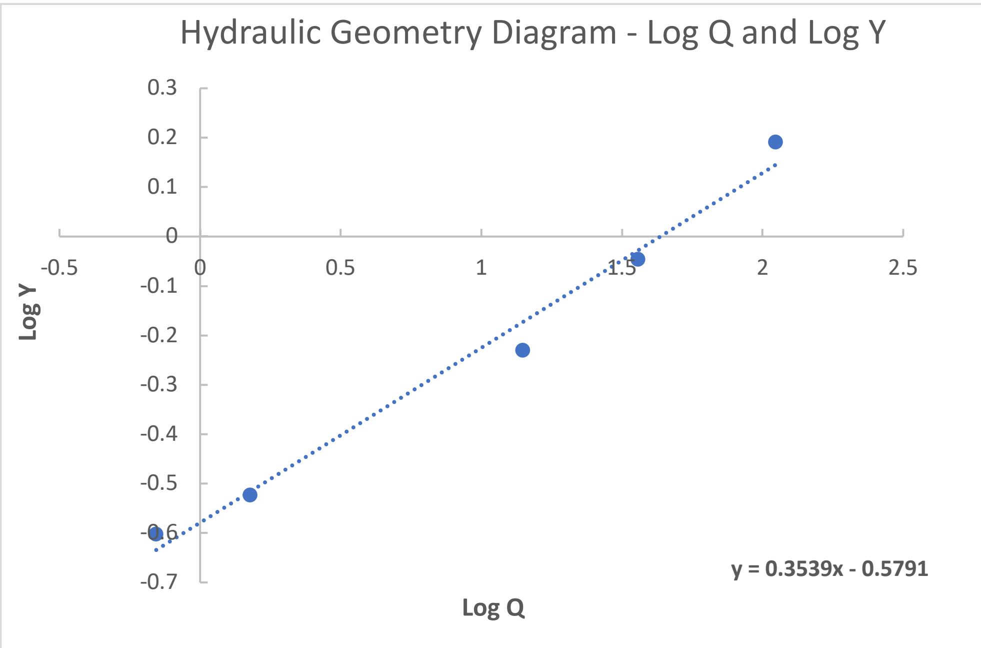
$R = A/P = WY/(2Y+W)$

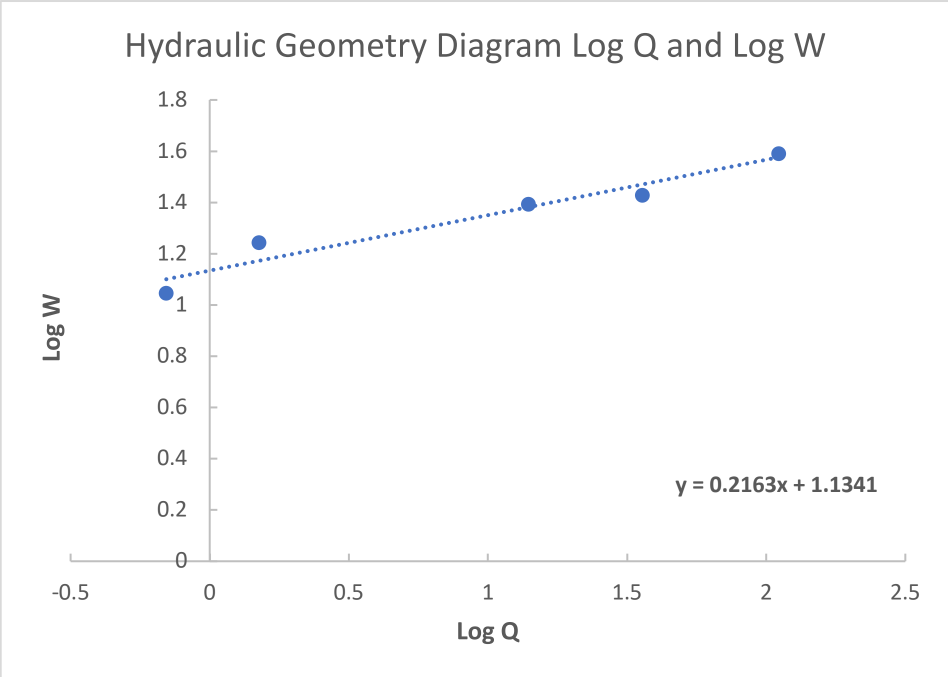
$V = \frac{R^{2/3} \times S^{1/2}}{n}$

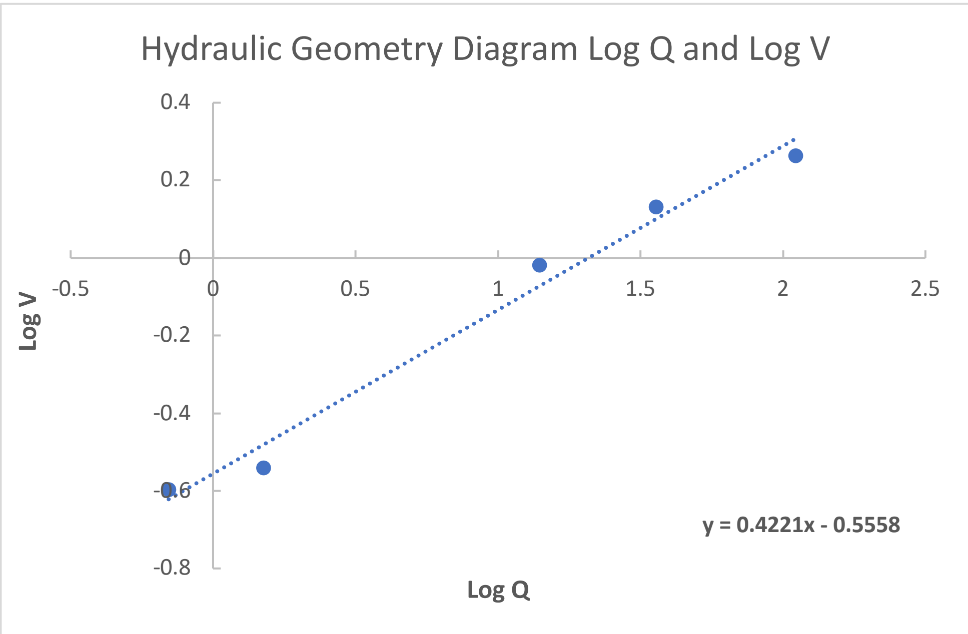
$Q = WYV$

Y_{max} (m)	Mean Y (m)	LogY	Mean W (m)	LogW	Slope	Manning n	R (m)	V (m/s)	LogV	Q (m^3/s)	LogQ
2.5	1.557	0.192	39	1.591	0.0017	0.030	1.442	1.828	0.262	111.002	2.045
1.5	0.989	-0.005	26.9	1.430	0.0017	0.030	0.921	1.351	0.131	35.937	1.556
1	0.59	-0.229	24.8	1.394	0.0017	0.030	0.563	0.957	-0.019	14.003	1.146
0.6	0.3	-0.523	17.5	1.243	0.0017	0.063	0.290	0.286	-0.544	1.505	0.178
0.4	0.25	-0.602	11.1	1.045	0.0017	0.063	0.239	0.252	-0.599	0.699	-0.156

plot the hydraulic geometry diagrams for W, Y and V using log-log axes.




Hydraulic Geometry Diagram Log Q and Log W
Log W
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.5
0
0.5
1
1.5
2
2.5
Log Q
y = 0.2163x + 1.1341


Hydraulic Geometry Diagram Log Q and Log V
Log V
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-0.5
0
0.5
1
1.5
2
2.5
Log Q
y = 0.4221x - 0.5558

iii) Determine the hydraulic geometry equations for W, Y and V. Based on the values of the exponents and on Rhodes diagram (Figure 1), what is the type of channel pattern of the Nicolet River? Does this correspond to your observations from the photography?

a) **$Y = cQ^f$**

$\Delta Y / \Delta X$

0.185/ 0.5 = 0.37 [slope]

$\log c = \overline{Y} - f\,\overline{X}$

log c = (-0.2416) – (0.37 x 0.9538)
log c = -0.595

$10^{-0.595} = 0.254$

Therefore: $Y = 0.25\ Q^{0.37}$

c= 0.25 f=0.37

b) **$W = aQ^b$**

$\Delta Y / \Delta X$

0.102/ 0.5 = 0.204 [slope]

$\log c = \overline{Y} - f\,\overline{X}$

log c = (1.34) – (0.204 x 0.9538)

log c = 1.145

$10^{1.145} = 13.964$

Therefore: $W = 13.964\ Q^{0.204}$

a= 13.964 b=0.204

c) **$V = kQ^m$**

$\Delta Y / \Delta X$

0.203/ 0.5 = 0.406 [slope]

$\log c = \overline{Y} - f\,\overline{X}$

log c = (-0.1532) – (0.406 x 0.9538)
log c = -0.540

$10^{-0.540} = 0.288$

Therefore: $V = 0.288\ Q^{0.406}$

k= 0.288 m=0.406

Rhodes Diagram

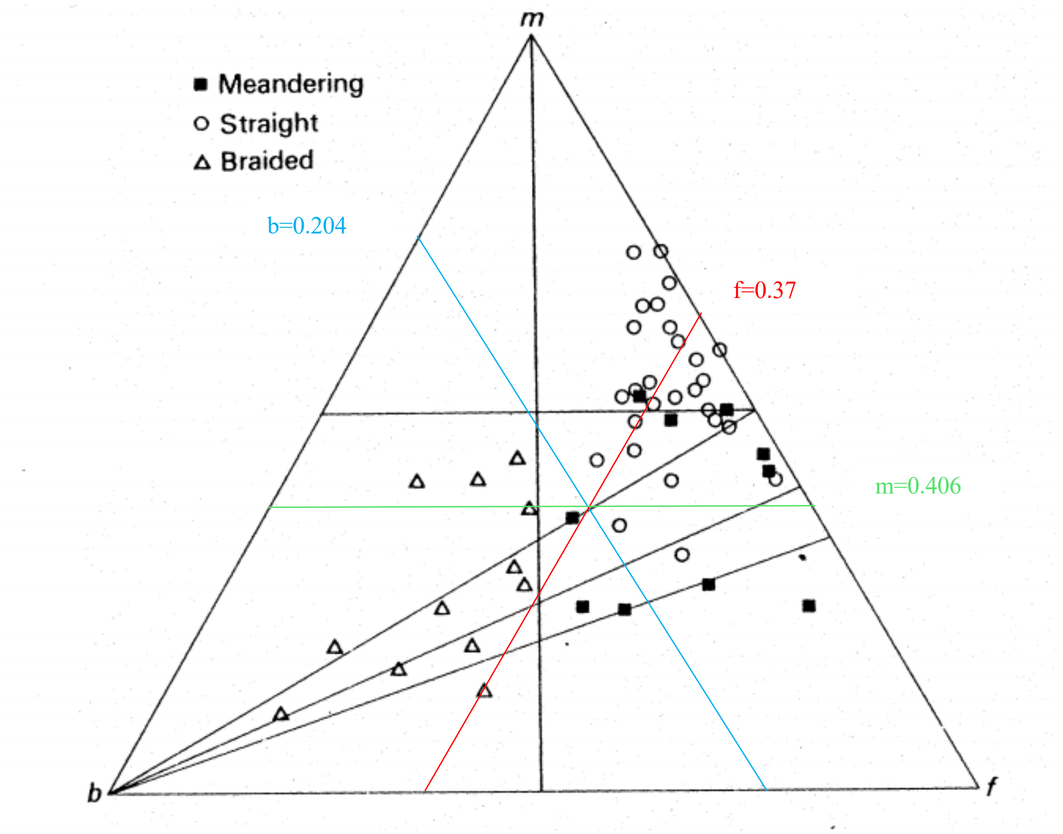


Figure 1 Rhodes diagram

According to the picture above, we think that the Nicolet River is straight in some parts and meandering to others. From the picture and the calculation, we will go for a straight river at that specific location.

3) When the maximum depth was 1.0 m, velocity measurements have been taken at 0.4 times the depth at 5 locations along the cross-section (starting from the left bank), that is:

at 10 m from the left bank: V = 0.50 m/s
at 15 m from the left bank: V = 0.75 m/s
at 20 m from the left bank: V = 0.65 m/s
at 25 m from the left bank: V = 0.50 m/s
at 30 m from the left bank: V = 0.25 m/s

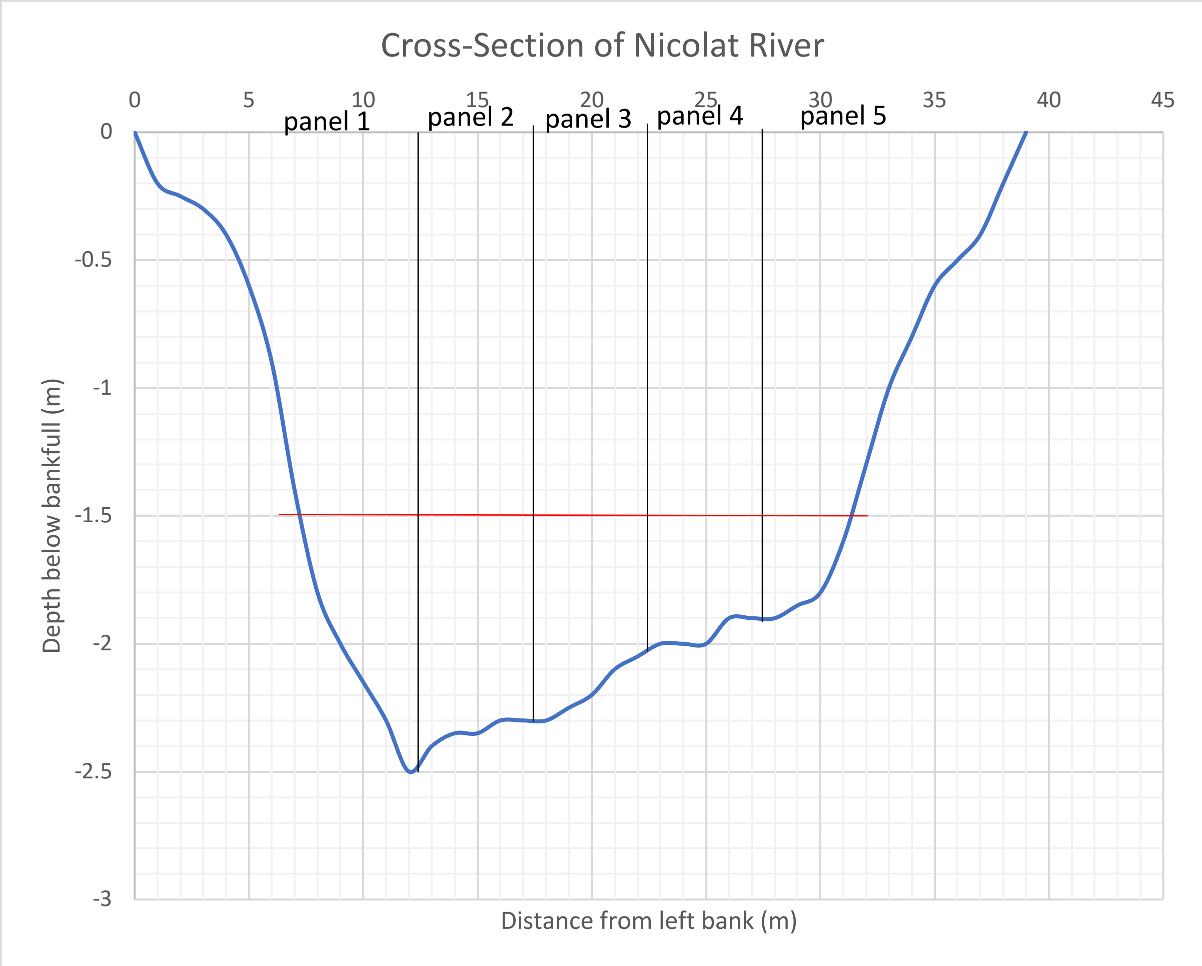
i) Compute the discharge and mean velocity from these data.

Panel	**1**	**2**	**3**	**4**	**5**
Distance from left bank (m)	10	15	20	25	30
Y_{max} (m)	1	1	1	1	1
Mean W (m)	5.4	5	5	5	3.8
Mean Y (m)	0.65	0.84	0.68	0.46	0.23
Area (m^2)	3.511	4.2	3.4	2.3	0.874
V per panel (m/s)	0.50	0.75	0.65	0.5-	0.25
q per panel (m^3/s)	1.7555	3.15	2.21	1.15	0.2185
Discharge (m^3/s)	8.484				
Mean Velocity (m/s)	0.580				

Discharge m^3/s
q= area * velocity
Panel 1: q1 = 3.511*0.50 = 1.7555
Panel 2: q2 = 4.2 *0.75 = 3.15
Panel 3: q3 = 3.4 *0.65 = 2.21
Panel 4: q4 = 2.3 *0.50 = 1.15
Panel 5: q5 = 0.874 *0.25 = 0.2185

Q= q1+q2+q3+q4+q5 = 1.7555 + 3.15 + 2.21 + 1.15 + 0.2185
Q= 8.484 m^3/s

Mean Velocity
Q = WYV → V = Q/WY
V = Mean Discharge / (Width at Y_{max} 1m) (Mean Depth at Y_{max} 1m)
V = 8.484/ (24.8) (0.59)
V = 0.580 m/s



ii) Find the Froude (Fr) and Reynolds (Re) numbers knowing that the water temperature is 20C. Is the flow supercritical or sub-critical? Laminar or turbulent?

Froude (Fr)

Fr$= \frac{V}{\sqrt{g*Y}} = \frac{0.580}{\sqrt{9.8*0.59}} = 0.241$

Fr < 1 so it is subcritical

Reynolds (Re) at 20˚C

Re = VY/$\nu = \frac{(0.580\times0.59)}{(1.787\times10^{-6})\times(0.5616)} = 340{,}979.5659$

The flow is turbulent because it is greater than 2000.