PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND ASTRONOMICAL SERVICES ADMINISTRATION

A TECHNICAL REPORT INTRODUCING THE DIRECT AND INDIRECT METHOD

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I. INTRODUCTION:

The best part of applying the theories gathered and being collected inside the classroom is through field work. The site being performed by the trainees was located in Barangay Camba, Arayat province of Pampanga. This place was experiencing a flood a week ago due to the typhoon Santi that made the site more suitable to have a field work due to the different marks being left. The left bank of the river is mostly filled with grass, reeds, and some tress while the right bank of the river is used as vegetable plantation as well as for the crops and had few grass and trees. The figure below illustrates the site on which the trainees perform their tasks.

Figure: Pampanga River

II. OBJECTIVES:

To be able to compute the discharge on the following methods:

- Current Meter Method
- Float Method
- Slope-Area Method
- Acoustic Doppler Current Profiler (ADCP)

III. METHODOLOGY:

a. Current Meter

- Is the summation of the products of the subsection areas of the stream cross section and their respective mean velocities.

Discharge = (Area of the cross section) x (Water velocity).

X Water velocity

Area of the cross section

In doing so, some other channels have divided its section into sub-section, but the discharge is still the same. In computing for the discharge will be:

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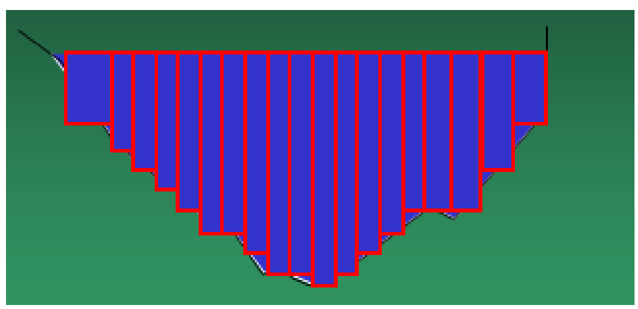


Discharge of each sub-section = Area x Average Mean Velocity

In connection with this, since were the first team to undergone this kind of method. These are the following steps we’ve done.

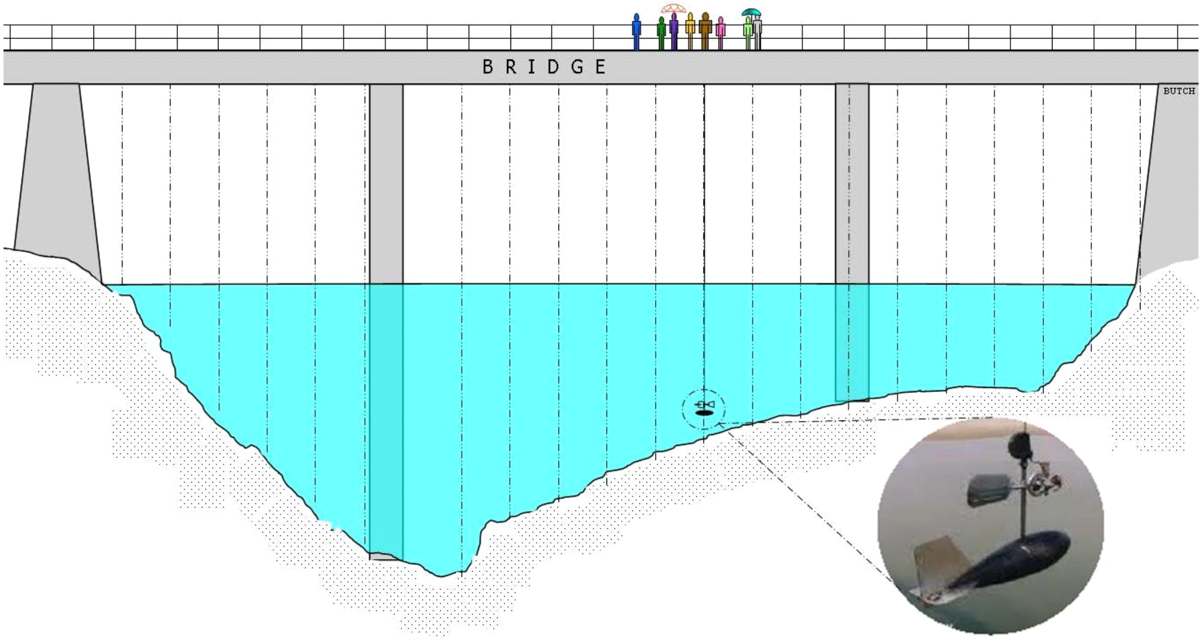


Figure: illustration for the Current Meter

- STEPS FOR THE CURRENT METER METHOD:
  - Assemble all the necessary equipment needed in the method.
  - After assembling the equipment, calibrate it by checking what is the revolution per second being used and other parameters.
  - Starting from the left bank facing downstream going to right bank of the river, made a horizontal measurement with 5 meters increment.
  - After doing all the measurement, proceed in measuring the depth using the three-point method with its corresponding percentage of 0.2, 0.6, and 0.8. Until it reaches the right bank of the river.

Reminder: Make sure that when you start getting the time, the last beep of the speaker connected to the current meter by means of connecting wire should exceed 60 seconds.

- ADVANTAGES:
  - Suitable on depth greater than 2.5
  - Reliable when there is no significant floating objects flowing on the stream that tends to distort the revolutions of the bucket wheel.

- DISADVANTAGES:
  - If the flow of the river is very slow, the bucket will take time to rotate and surely it will affect its revolutions.

- There are lots of objects floating in the river like algae's and water lilies that will considered as an obstructions in the rotation of its bucket wheel.

b. Float Method

- This method measures surface velocity. Mean velocity is obtained using a correction factor; the basic idea is to measure the time that it takes the object to float a specified distance downstream.

  $V_{surface}$ = travel distance/ travel time

Because surface velocities are typically higher than the mean or average velocities $V_{mean} = k V_{surface:}$ where K is a coefficient that generally ranges from 0.8 for rough beds to 0.9 to smooth beds. The most commonly used coefficient is 0.85

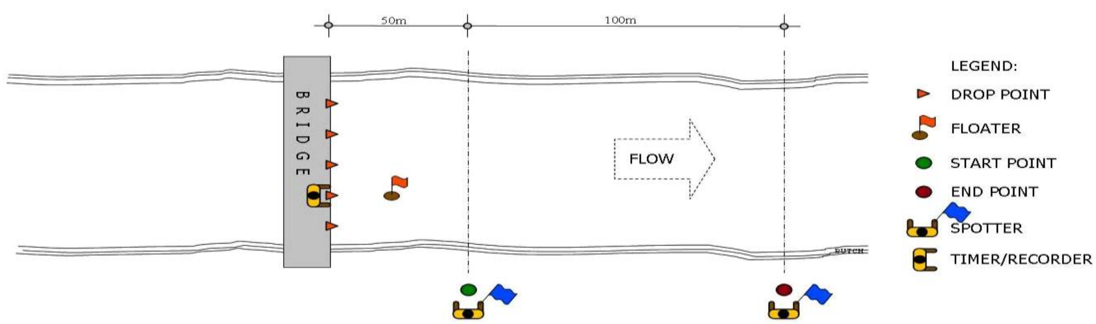


Figure: Illustration for the float method

- STEPS FOR THE FLOAT METHOD:
  - Choose a suitable straight reach with minimum turbulence.
  - Mark the start and end point of your reach.
  - If possible the travel time should exceed 20 seconds.
  - Drop the object into the stream upstream of your upstream marker.
  - Start the time when the object passed the first line and end when it crosses the second one.
  - Use the average data for the time and area in getting the discharge.
  - All velocities should be corrected by multiplying a coefficient of 0.89.
  - Repeat the steps for ten times. Five starting from the left-right and vice versa.

The depth of the river was obtained using the echo sounder, and this corresponds to the depth of the first and second section. But in this case, for our convenient we use a tag line due to the turbulence of the flow of the river. On the other hand, in getting the horizontal distance for its corresponding depth we use a range finder that will dictate the distance automatically.

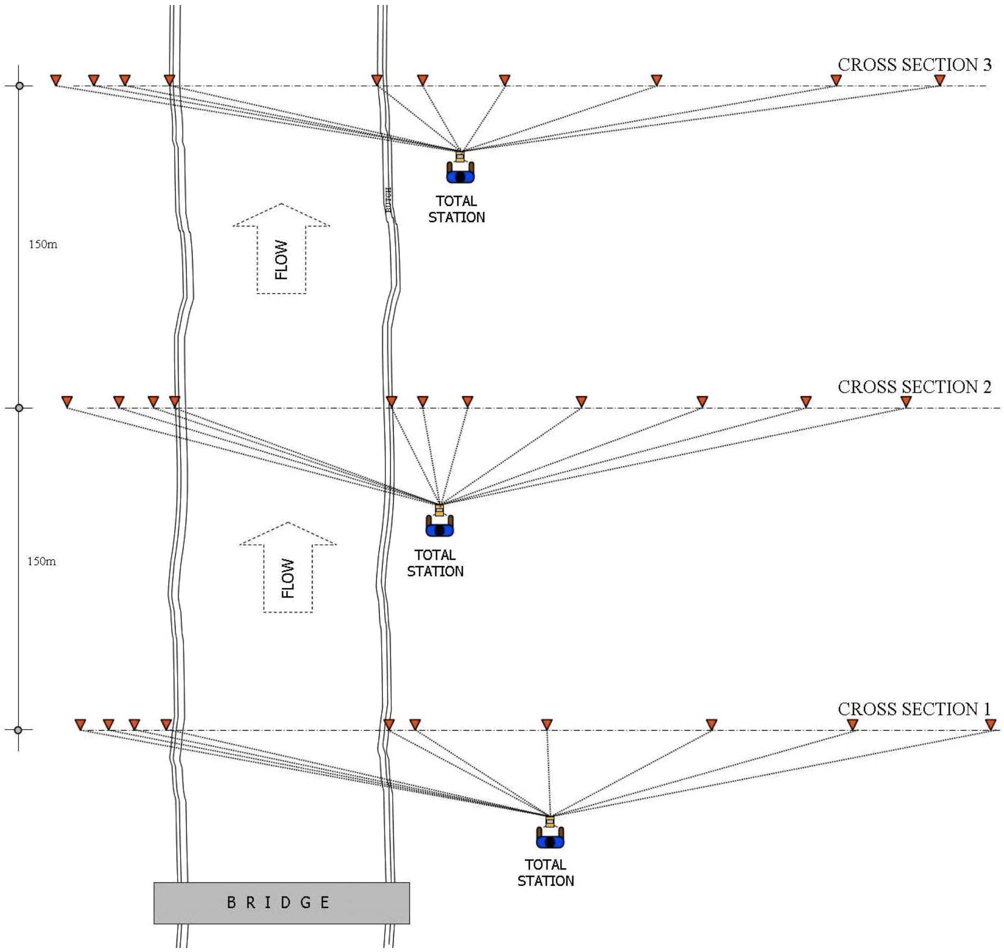
- ADVANTAGES:
  - Simple and Inexpensive.
  - Very good for fairly straight reach.

- DISADVANTAGES:
  - Not applicable in critical level for the float tends to be stocked on the river bed.
  - When the river bank is not accessible to place the start and end points.
  - If the reach experiences turbulent flow between the points of measurement.
- MATERIALS TO BE USED:
  - Bamboo that have a buoyant force that will surely float at least half of its body.
  - Tape Measure.
  - Stopwatch.
  - Echo sounder.
  - Prism rod.
  - Range finder.
  - Notebook (recording purposes).

c. Slope-Area Method

This method will help us determining how high the water mark is. In this case three sections are needed in evaluating the discharge measurement; this can also be used with some degree of accuracy of channels with stable bed and banks having relatively coarse bed material. This method may also be used in other cases, such as alluvial channel, subject to the acceptance of larger errors involved in the selection of the value of the rugosity coefficient "n". It is, however, not desirable to use this method in the case of very large channels or channel with very flat slope and high sediment concentration or channels with significant curvature.

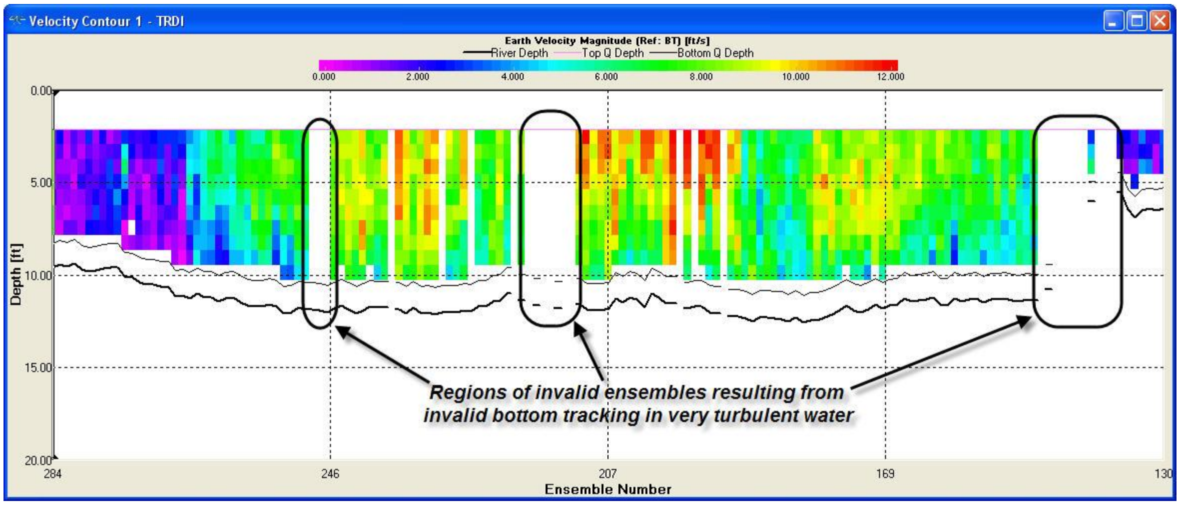
On the other hand, the illustration below shows that on the section 1, points were established from the flood mark (on the other side of the river). In each point, distance and elevation were determined using the total stations. And the other cross-section 2 and 3 are repeated basing the previous one.



d. Acoustic Doppler Current Profiler (ADCP)

The capability of ADCP's to measure water velocity, depth and boat velocity allows them to be used to measure the discharge in river. The data from the first transects and the second one was averaged and the average value will be the final values to be used and eventually to be considered.

There are also errors to be considered due to the water turbulence that will result to invalid tracking. See the figure below.



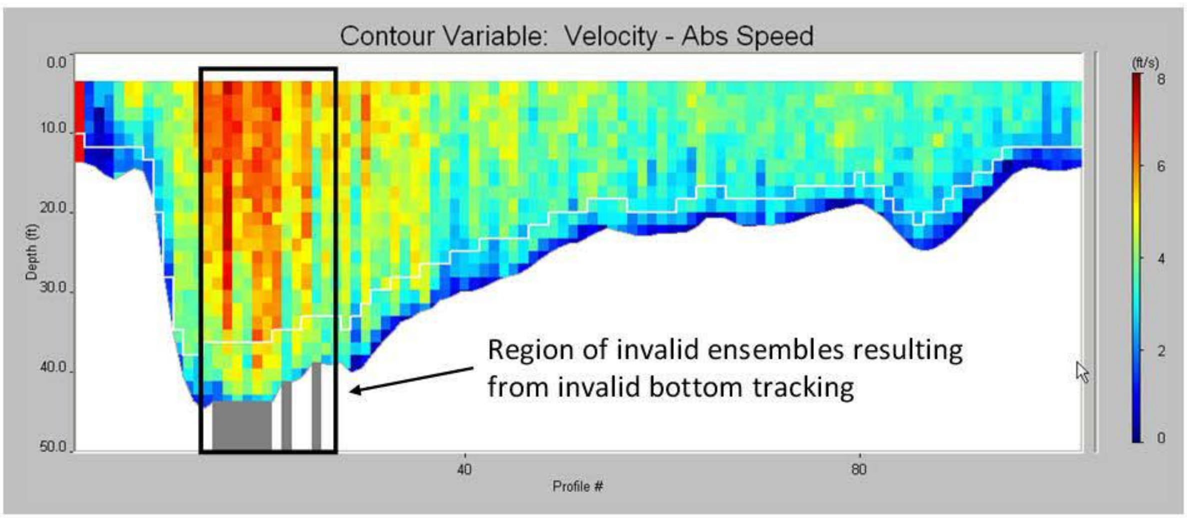


Figure: Region of invalid ensembles resulting from invalid bottom tracking.

- STEPS FOR THE ADCP METHOD
  - Assemble all the necessary equipments needed.
  - After assembling, calibrate it using the theory of yaw, roll and pitch.
  - Put the transmitter that is accessible for transmitting its data to the computer.
  - Do the cross-sectioning throughout the entire bank, using a tag line.
  - Do it for several times (3 laps will do).

The data that has been gathered will be store in the memory of the software comprising the velocity, discharge and its profile.

- ADVANTAGES:

- Allows the data to be collected throughout most of the water columns and cross-section rather than discrete points.
- The time required to complete a measurement is reduced.
- The instrument can be boat-mounted; thus eliminating the installation, maintenance and liability of costly manned cableways.
- Many parameters are available for determining the discharge.
- Complex flow regimes, such as vertical bi-directional flow, can be directly identified and measured.

- DISADVANTAGES:
  - High initial cost
  - No approximate life span.
  - Complexity, requiring some understanding of physics, electronics as well as the system software prior to be used.
  - Frequent changes in ADCP's technology.

IV. DATA GATHERED:

a. Current Meter Method:

Discharge Measurement (Current Meter) for :							***Arayat Station***				River:		***Pampanga***		**PRFFC**
DM #:			Date:		October 17,2013			Team:				Group 1			**FFB**
Gage Height:	Start:		5.40		End:		5.28	Inst. # :			Wx:		fair		**PAGASA**
Observation Time:	Start:		1:35		End:		4:25	Calibration Eqtn.: V =		0.732	N+	0.013	note: just input negative value		hth/ 97
		Vertical dist. to water surface (m) =					10.50						for latter if eqtn. is minus.		
Total Area (m^2) =			**873.66**		**Ave. Gage Height =**				**5.34**		**Sectional Width (m) =**				**115.0**
Total Q (m^3/s) =			**311.48**		**Ave. Vel. (m/s) =**				**0.357**						
Dist. from		Depth	Vert.	Angle	Observation Depth						Velocity				Remarks
Initial	Width	(ep for pier)	Angle	Corrected	0.2		0.6		0.8		at point	Mean (0.2,0.6 & 0.8) or	Area	Q	Excellent, Good
point	(mts.)	(mts.)	4^0-36^0	Depth	Rev.	Time	Rev.	Time	Rev.	Time	for 0.6 only	(0.2 & 0.8)	(m^2)	(cumecs)	Fair, Poor
0				0											
5	5	3.05	0	range out			80	61.2			0.970	x	x	x	
10	5	5.35		5.350	95	63	85	60	85	61	1.050	1.062	26.75	28.42	
15	5	5.08		5.080	95	61	95	60	100	61	1.172	1.178	25.40	29.91	
20	5	8.31		8.310	110	61	35	65	35	69	0.407	0.633	41.55	26.30	
25	7.5	21.63		21.630							x	x	162.23	x	
35	7.5	21.57		11.170							x	x	83.78	x	
40	5	21.94		14.550							x	x	72.75	x	
45	5	22.48		22.480							x	x	112.40	x	
50	5	9.15	17	8.526	75	60	70	61	65	60	0.853	0.860	42.63	36.66	
55	5	8.02	8	7.891	90	62	85	62	75	63	1.017	0.998	39.46	39.39	
60	5	5.8		5.800	90	61	80	60	75	62	0.989	0.992	29.00	28.78	
65	5	5.77	5	5.724	95	62	85	65	70	62	0.970	0.979	28.62	28.01	
70	5	5.7		5.700	95	63	85	63	70	62	1.001	0.989	28.50	28.20	
75	5	5.28		5.280	85	61	80	61	70	62	0.973	0.955	26.40	25.20	
80	5	4.95		4.950							x	x	24.75	x	
85	5	5.1		5.100							x	x	25.50	x	
90	5	4.9		4.900							x	x	24.50	x	
95	5	4.65		4.650							x	x	23.25	x	
100	5	4.57		4.570	80	60	70	62	70	62	0.839	0.877	22.85	20.04	
105	5	3.39		3.390	60	60	60	60	60	63	0.745	0.736	16.95	12.48	
110	5	3.28		3.280	40	68			45	62	x	0.494	16.40	8.10	

		Total Area =	873.66		
Rem:		Total Discharge =		311.48	
		Ave. Velocity =		0.357	

Table 1. Discharge (Q) using Current Meter Method.

Table 1 above made use of Microsoft Excel Suite that obtains an equivalent total discharge simply by completing all the following beige cells:

- Name of station and name of river
- Gage height at the beginning and end of the activity
- Calibration equation (general formula)
- Vertical distance to water surface in meters
- Distances from the initial point in meters
- Depths of each distance in meters
- Vertical angles ranging only from 4 to 36 degrees (otherwise, leave it blank)
- The number of revolutions within not less than 60 seconds, depending on the depth points used. For shallow points, only the 0.6 depth was filled. For deeper points, all the observation depths 0.2, 0.6, and 0.8 were filled up.
- Remarks or rating of the observation (optional)

Observe from Table 1 that not all sections have a recorded observation depth. This may be due to piers, water lilies, and turbulent flows that hindered in getting an accurate number of revolutions at a certain time. Next, filling up the beige cells will reveal the following data in white cells:

- Width of each subsection in meters
- A corrected vertical angle
- Computed velocity at one-point depths and mean velocity for three-point depths
- Area of each subsection in square meters
- Discharge of each subsection in cubic meters per second or cumecs
- Total area of the cross-section or simply the sum of all the subsections
- Total discharge of the cross-section or the sum of all the discharges
- Average of the computed and mean velocities

The recorded discharge from the Acoustic Doppler Current Profiler (ADCP) that day was around 250 to 280 cu.me. Arriving at 311.48-cu.me discharge, which is way larger, compared to the expected value, may be due to insufficient data along the piers and other obstructions below a subsection.

b. Float Method:

station	distance	elevation	water sfc.	depth	mean depth	area	wetted perimeter
0.00		4.73	4.73	0.00			
24.00	24.00	2.33	4.73	2.40	1.20	28.80	24.12
39.00	15.00	1.93	4.73	2.80	2.60	39.00	15.01
40.00	1.00	1.73	4.73	3.00	2.90	2.90	1.02
58.00	18.00	-0.07	4.73	4.80	3.90	70.20	18.09
79.00	21.00	-4.97	4.73	9.70	7.25	152.25	21.56
91.00	12.00	-5.57	4.73	10.30	10.00	120.00	12.01
105.00	14.00	-6.47	4.73	11.20	10.75	150.50	14.03
110.00	5.00	-6.67	4.73	11.40	11.30	56.50	5.00
128.00	18.00	-5.07	4.73	9.80	10.60	190.78	18.07
142.00	14.00	-3.47	4.73	8.20	9.00	125.97	14.09
146.00	4.00	2.43	4.73	2.30	5.25	20.99	7.13
149.00	3.00	4.73	4.73	0	4.73	x	x
Total Width	**149**						
Total Area	**957.896**						
W. P (P)	**150.1368**						
Hydraulic Radius ®	**6.380154**						
Mean sect. Depth	**6.428832**						

Table 2a. Physical Parameters for the First Cross-section using Float Method

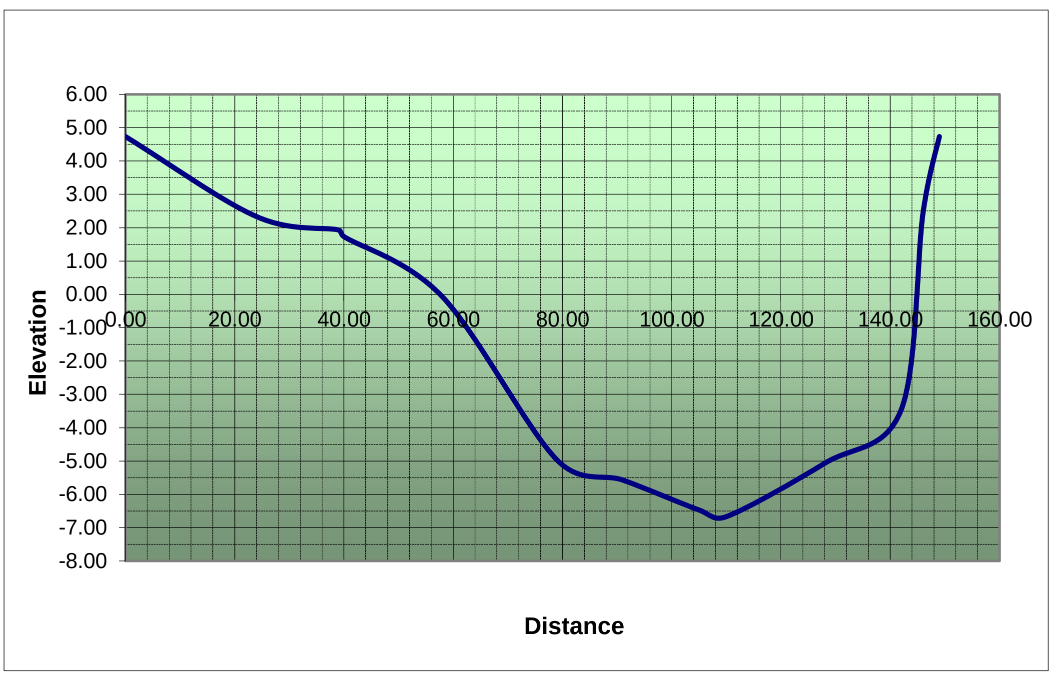


Figure 2a. Equivalent First Cross-section using Distance and Elevation

station	distance	elevation	water sfc.	depth	mean depth	area	wetted perimeter
0.00		4.73	4.73	0.00			
25.00	25.00	2.73	4.73	2.00	1.00	25.00	25.08
43.00	18.00	1.83	4.73	2.90	2.45	44.10	18.02
47.00	4.00	1.83	4.73	2.90	2.90	11.60	4.00
55.00	8.00	0.63	4.73	4.10	3.50	28.00	8.09
65.00	10.00	0.23	4.73	4.50	4.30	43.00	10.01
78.00	13.00	-0.57	4.73	5.30	4.90	63.70	13.02
84.00	6.00	-0.77	4.73	5.50	5.40	32.40	6.00
100.00	16.00	-1.37	4.73	6.10	5.80	92.80	16.01
105.00	5.00	-1.57	4.73	6.30	6.20	31.00	5.00
118.00	13.00	-2.07	4.73	6.80	6.55	85.12	13.01
126.00	8.00	-1.87	4.73	6.60	6.70	53.58	8.00
138.00	12.00	-1.57	4.73	6.30	6.45	77.38	12.00
145.00	7.00	-2.07	4.73	6.80	6.55	45.84	7.02
165.00	20.00	1.43	4.73	3.30	5.05	100.96	20.30
172.00	7.00	3.73	4.73	1.00	2.15	15.04	7.37
174.00	2.00	4.73	4.73	0	4.73	x	x
Total Width	**174**						
Total Area	**749.511**						
W. P (P)	**172.9488**						
Hydraulic Radius ®	**4.333715**						
Mean sect. Depth	**4.307534**						

Table 2b. Physical Parameters for the Second Cross-section using Float Method

Figure 2b. Equivalent Second Cross-section using Distance and Elevation

Station	Traveling time		Ave Time (sec)	Velocity (m/s)	Correction Coeff	Corrected Vel (m/s)	1st Section (m^2)	2nd Section (m^2)	ave Area (m^2)	Divided Q (m^3/s)
	1st trial	2nd trial								
1	FAIL	1:36:59	96.00	1.04	0.92	0.959	54.71	62.35	58.53	56.11
2	01:37:37	1:51:30	104.00	0.96	0.92	0.885	107.50	143.50	125.50	111.01
3	1:34:11	FAIL	93.00	1.08	0.92	0.989	197.50	125.40	161.45	159.72
4	1:37:35	1:38:36	97.50	1.03	0.92	0.944	262.50	165.10	213.80	201.74
5	2:17:50	2:12:27	134.55	0.74	0.92	0.684	91.43	158.40	124.91	85.44
								Total Discharge= 614.02m^3/s		

Table 2c. Discharge (Q) Table for the Two River Cross-sections using Float Method

Float method shows a similar, but simpler approach compared to the slope-area method. Microsoft Excel Suite may be used (Tables 2a and 2b) in determining the total width, area, wetted perimeter, hydraulic radius, mean depth, and a graphic representation of the cross-sections (Figures 2a and 2b).

However, the discharge (Q) table is the most important among the given data since it shows in detail the time it took for one float to travel from one cross-section to another. From this, the mean velocity of the two trials can be obtained. A FAIL on one trial shall be disregarded so the average time will be the other trial itself. Table 2c was manually computed, revealing a total average discharge of **614.02 cumecs**. This is roughly 7 to 8 times higher compared to the discharge measurement using current meter method.

c. Slope-Area Method:

Data for the slope-area method includes three tables for the physical parameters of the three cross-sections, graphic representation of such parameters, and a summary table for determining the equivalent discharge of Pampanga River.

Cross-Section number ONE (1)							hth/ 97
Station	Distance	Elevation	Water Sfc. elev.	Depth	Mean Depth	Area	Wetted Perimeter
0		8.451	5.546	-2.905			
134.1687	134.1687	6.55	5.546	-1.004	-1.9545	-262.233	134.1822
143.8222	9.6535	3.997	5.546	1.549	0.2725	2.630579	9.985383
154.2193	10.3971	0.05	5.546	5.496	3.5225	36.62378	11.12108
167.8637	13.6444	0.006	5.546	5.54	5.518	75.2898	13.64447
185.8268	17.9631	-0.029	5.546	5.575	5.5575	99.82993	17.96313
206.3107	20.4839	-0.069	5.546	5.615	5.595	114.6074	20.48394
227.8004	21.4897	-0.099	5.546	5.645	5.63	120.987	21.48972
244.9382	17.1378	-0.149	5.546	5.695	5.67	97.17133	17.13787
271.3575	26.4193	-0.054	5.546	5.6	5.6475	149.203	26.41947
279.6424	8.2849	5.299	5.546	0.247	2.9235	24.22091	9.863781
284.2909	4.6485	5.546	5.546	0	0.1235	0.57409	4.655058
Total Width =		284.29	meters	Hydraulic Radius(r) =		1.60	meters
Total Area =		458.91	meters^2	Mean Section Depth =		1.61421	meters
Wetted Perimeter(P) =		286.946	meters				

Table 3a. Physical Parameters of the 1st Cross-section Using Slope-Area Method

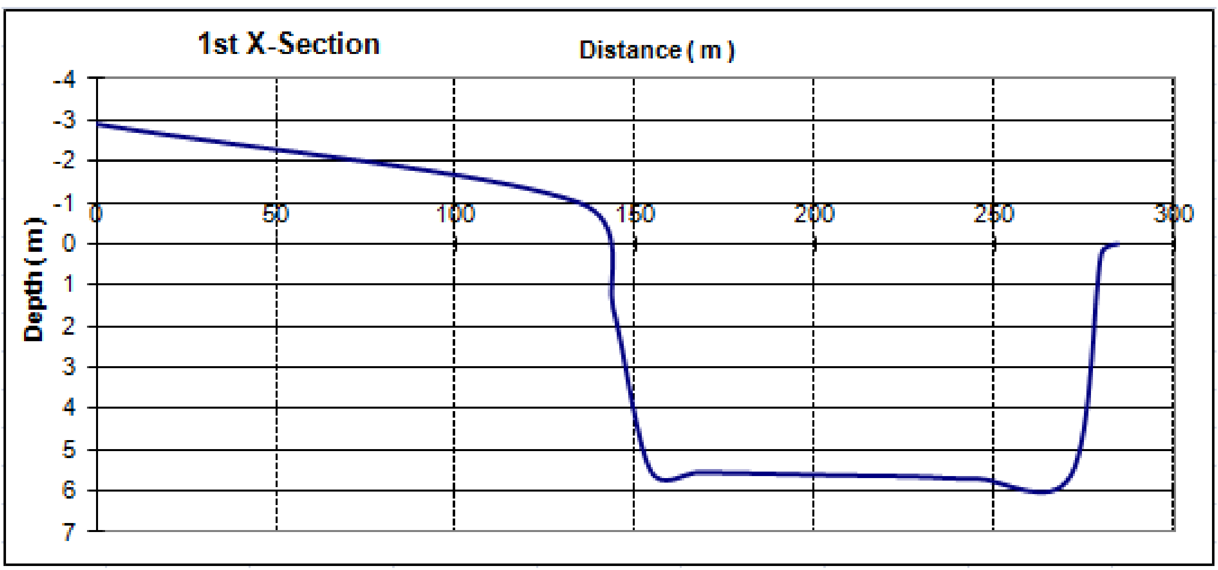


Figure 3a. Graphic Representation of the 1st Cross-section Using Distance-Depth Relation

Cross-Section number TWO (2)							hth/ 97
Station	Distance	Elevation	Water Sfc. elev.	Depth	Mean Depth	Area	Wetted Perimeter
0		5.061	5.061	0			
166.1196	166.1196	4.018	5.061	1.043	0.5215	86.63137	166.1229
176.4954	10.3758	-0.003	5.061	5.064	3.0535	31.68251	11.1277
193.3365	16.8411	-0.029	5.061	5.09	5.077	85.50226	16.84112
209.3011	15.9646	-0.064	5.061	5.125	5.1075	81.53919	15.96464
227.7976	18.4965	-0.057	5.061	5.118	5.1215	94.72982	18.4965
247.5566	19.759	-0.103	5.061	5.164	5.141	101.581	19.75905
271.4966	23.94	-0.149	5.061	5.21	5.187	124.1768	23.94004
293.6271	22.1305	-0.179	5.061	5.24	5.225	115.6319	22.13052
314.3919	20.7648	-0.28	5.061	5.341	5.2905	109.8562	20.76505
321.6627	7.2708	4.653	5.061	0.408	2.8745	20.89991	8.786297
323.2061	1.5434	5.659	5.061	-0.598	-0.095	-0.14662	1.842314
Total Width =		**323.21**	**meters**	**Hydraulic Radius(r) =**		**2.62**	**meters**
Total Area =		**852.08**	**meters^2**	**Mean Section Depth =**		**2.63635**	**meters**
Wetted Perimeter(P) =		**325.776**	**meters**				

Table 3b. Physical Parameters of the 2nd Cross-section Using Slope-Area Method

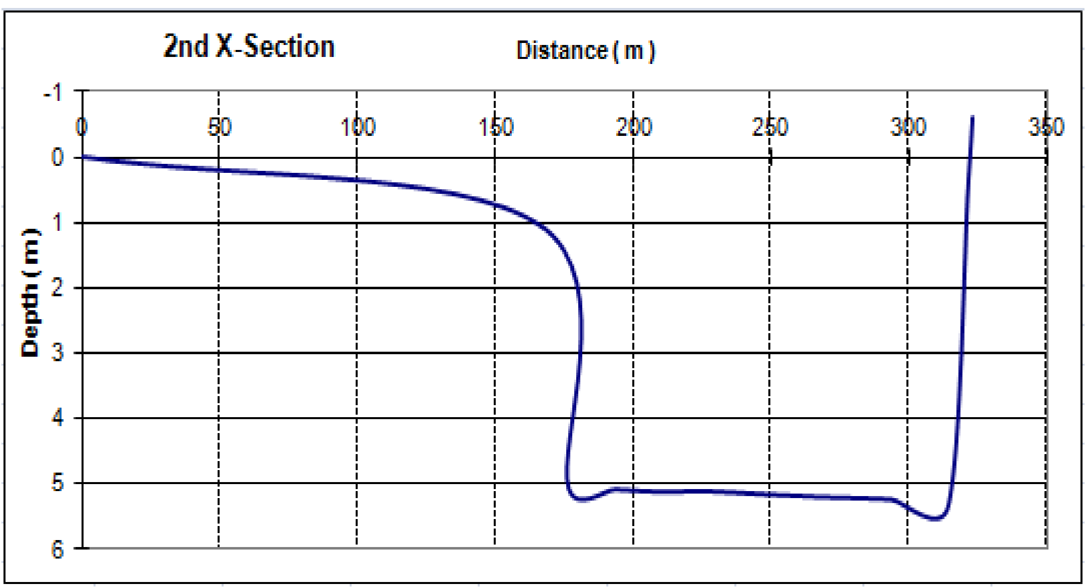


Figure 3b. Graphic Representation of the 2nd Cross-section Using Distance-Depth Relation

Cross-Section number THREE (3)							hth/ 97
Station	Distance	Elevation	Water Sfc. elev.	Depth	Mean Depth	Area	Wetted Perimeter
0		4.967	4.967	0			
100.0491	100.0491	3.318	4.967	1.649	0.8245	82.49048	100.0627
125.3529	25.3038	-0.483	4.967	5.45	3.5495	89.81584	25.58769
138.9185	13.5656	-0.5	4.967	5.467	5.4585	74.04783	13.56561
155.9567	17.0382	-0.549	4.967	5.516	5.4915	93.56528	17.03827
178.0093	22.0526	-0.596	4.967	5.563	5.5395	122.1604	22.05265
201.759	23.7497	-0.671	4.967	5.638	5.6005	133.0102	23.74982
226.1464	24.3874	-0.715	4.967	5.682	5.66	138.0327	24.38744
248.0367	21.8903	-0.766	4.967	5.733	5.7075	124.9389	21.89036
265.2483	17.2116	-0.76	4.967	5.727	5.73	98.62247	17.2116
279.5832	14.3349	4.55	4.967	0.417	3.072	44.03681	15.28677
287.2792	7.696	4.793	4.967	0.174	0.2955	2.274168	7.699835
Total Width =		287.28	meters	Hydraulic Radius(r) =		3.48	meters
Total Area =		1003.00	meters^2	Mean Section Depth =		3.49136	meters
Wetted Perimeter(P) =		288.533	meters				

Table 3c. Physical Parameters of the 3rd Cross-section Using Slope-Area Method

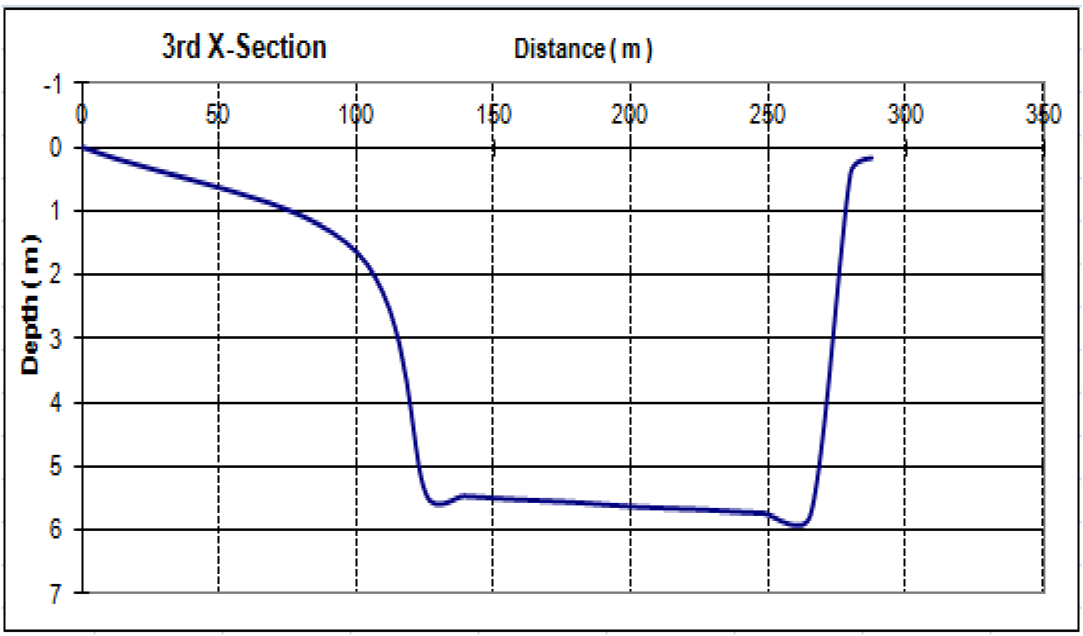


Figure 3c. Graphic Representation of the 3rd Cross-section Using Distance-Depth Relation

Raw data for the slope-area method include horizontal distance from the total station, elevation or vertical distance, and water level for the three cross-sections.

Inputting these to the Microsoft Excel Suite will automatically reveal the width, mean depth, area, and wetted perimeter (WP) of each subsection, as seen in Tables 3a, 3b, and 3c. The total width, area, WP, hydraulic radius, and mean section depth shall also appear at the bottom of these tables.

Other than the table, the raw data also shows on another sheet the graphic representation of the three cross-sections using the parameters of depth and distance. Comparing Figures 3a, 3b, and 3c, the cross-sections are somehow different from one another, though they reveal that the right bank has an abrupt rise in flood as compared to the left bank which has a wide flat plain proceeding to the highest flood mark.

FFB, PAGASA — **Slope-Area Summary Sheet (3-Section)**

Station:	***Arayat Station***	River:	***Pampanga River***
Flood Date:		Drainage Area:	
Gauge Height:		Meas. #:	

X - Section Properties: hth/ 97

X-Sect.	Width	Area	Highwater Marks: Left Bank	Highwater Marks: Right Bank	Average Water Sfc.	d_m (mean depth)	n	r	K	K^3/A^2	α	F	State of Flow
1	284.29	458.91	8.451	5.546	6.9985	1.614	0.035	1.60	17959.04	2.8E+07	1	1.885	rapid
2	323.21	852.08	5.061	5.659	5.36	2.636	0.035	2.62	46364.11	1.4E+08	1	0.794	tranquil
3	287.28	1003.00	4.967	4.793	4.88	3.491	0.035	3.48	66034.39	2.9E+08	1	0.586	tranquil

note: Assume no sub-divided sections, hence α is alw ays 1!!

Reach Properties:

Reach	Length	Δh Fall	k	reach condition	K_U/K_D	K_U/K_D Condition	Ave. A	**Q** by formula	Ave V
1-2	155.157	1.6385	0.5	expanding	0.387348	poor	655.495	4040.949	6.165
2-3	270.726	0.48	0.5	expanding	0.702121	good	927.540	2470.455	2.663
1-2-3	425.883	2.1185	0.5	expanding	0.271965	poor	771.328	**3440.336**	4.460

Discharge Computation:(comparison)

Reach	Assumed Q	h_v U/S	h_v D/S	Δh_v	h_f	$S=h_f/L$	$S^{1/2}$	K_w	**Computed Q**
1-2	4040.949	2.867476	0.831726	2.035749	2.656375	0.017121	0.130846	28855.76	3775.648
2-3	2470.455	0.831726	0.600272	0.231454	0.595727	0.0022	0.046909	55331.96	2595.582

Rem:

Q_{1-2-3} = **3440.34** **cumecs**

Discharge

n - roughness coefficient
K - conveyance
K_w - wtd. conveyance (Geometric mean of K of 2 sections).
F - Froude no.(indicates the state of flow).
α - velocity head coefficient
r - hydraulic radius
k - coefficient for differences in velocity heads between 2 sections.
h_v - velocity head
h_f - energy loss due to boundary friction in the reach.
S - friction slope

Table 3d. Slope-Area Summary Sheet of the Three Cross-sections

The final table shows the slope-area summary sheet, where only the bank elevations, lengths of the reach, and a roughness coefficient *n* shall be inputted. The table is simply about the usage of Manning's formula and computation of discharge Q by multiplying the average area with the average velocity. Estimation of *n* is not easy, so it is assumed to be similar to a normal river which is 0.035. Based on calculations, the total discharge amounted to a whopping 3440.34 cumecs, almost 11 times higher than that of the current meter discharge.

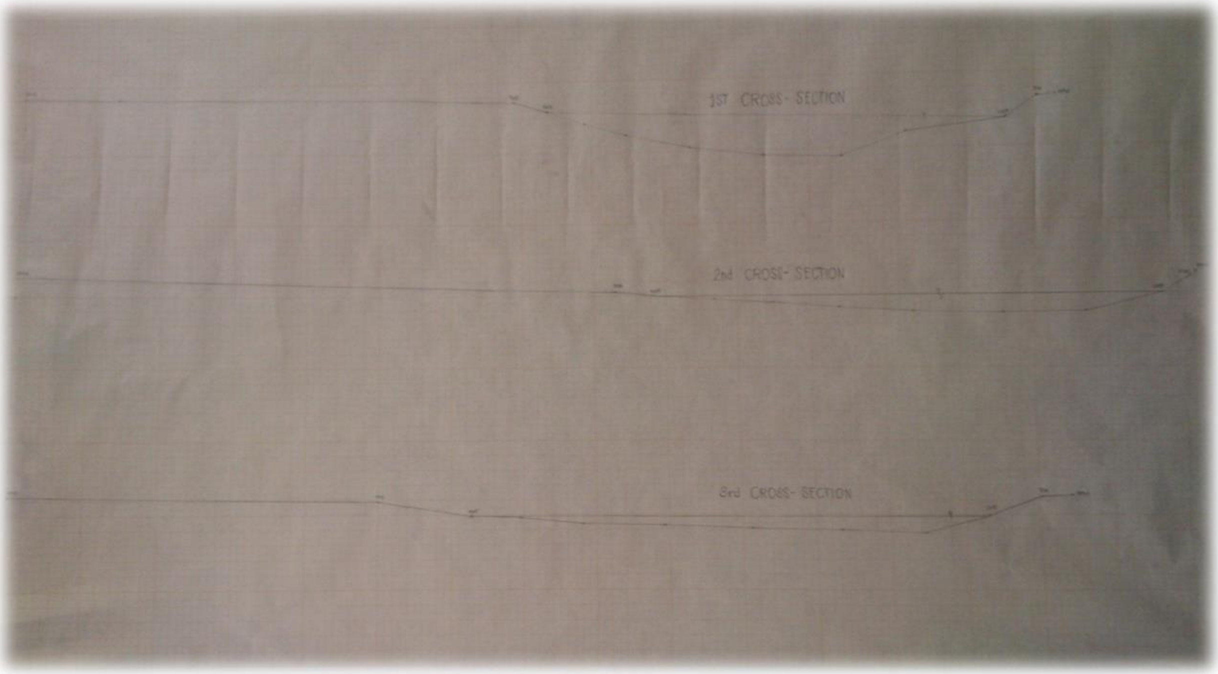


Figure: Profile of the three cross-section using slope-area method

d. Acoustic Doppler Current Profiler (ADCP)

The *RiverSurveyor®* software illustrates in detail the river cross-section as well as its discharge in the shortest amount of time. This software program made by SonTek is Windows-based and operates in real time.

As mentioned, three trials were made across the same river cross-section, some 50 meters downstream from the bridge. A cross from one edge to the other edge is equivalent to one trial thus, one set of data. Captions were taken from the computer as follows:

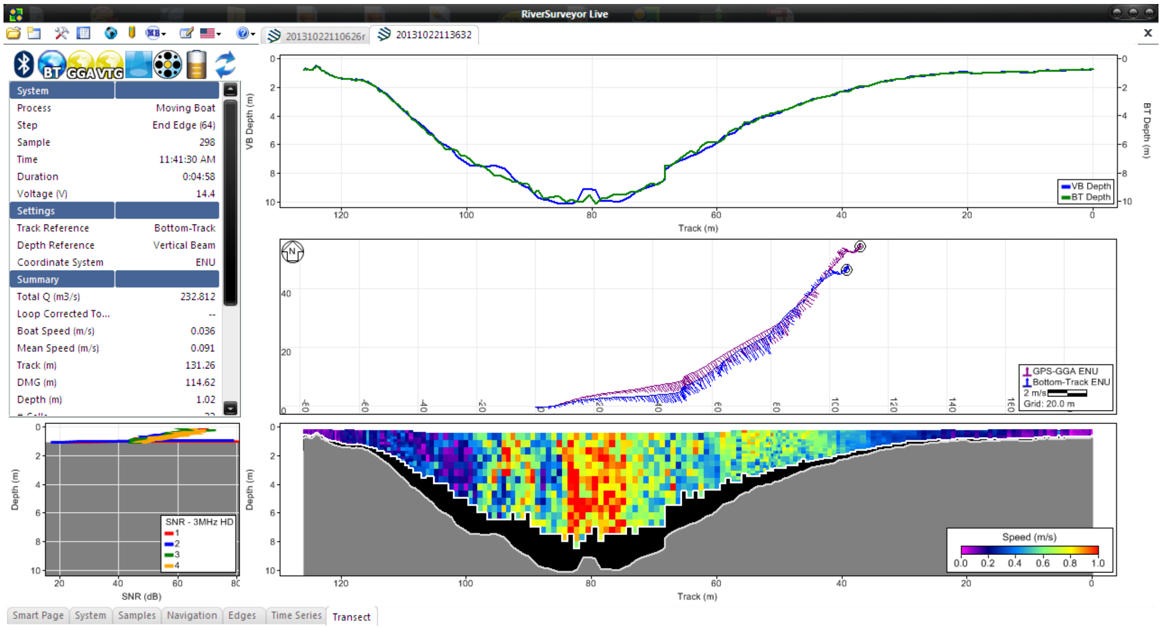


Figure 4a. Cross-section and Discharge from *RiverSurveyor* using ADCP Method (1st trial)

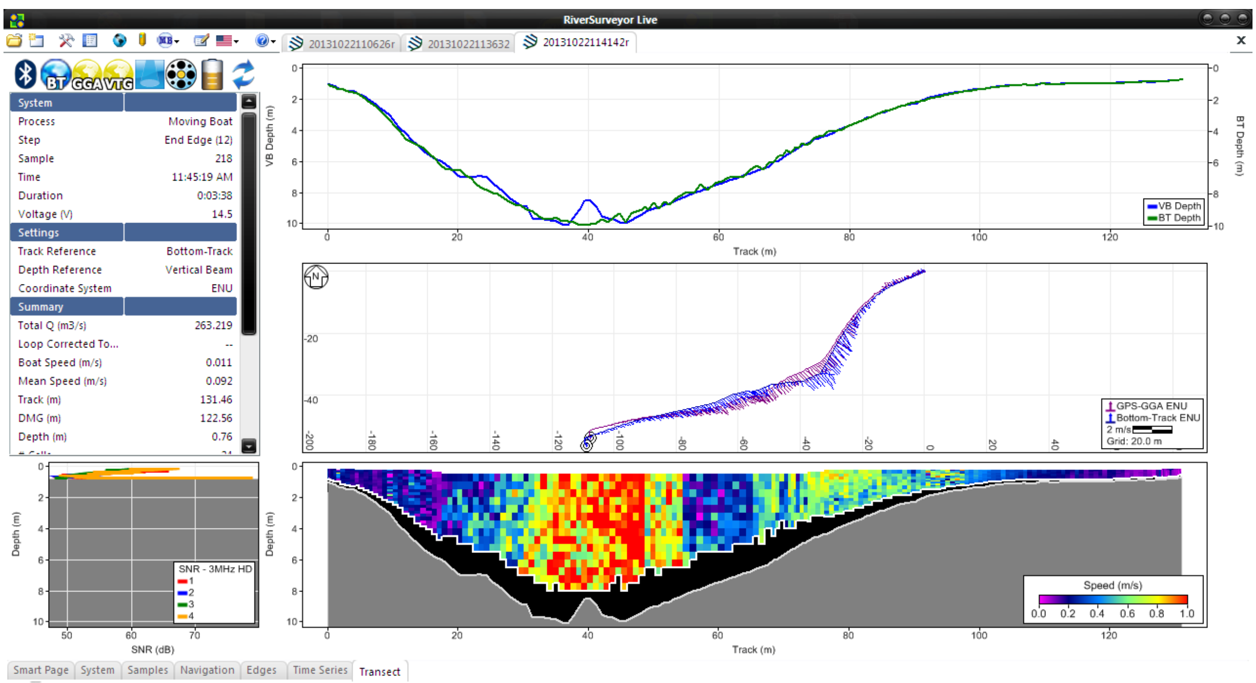


Figure 4b. Cross-section and Discharge from *RiverSurveyor* using ADCP Method (2nd trial)

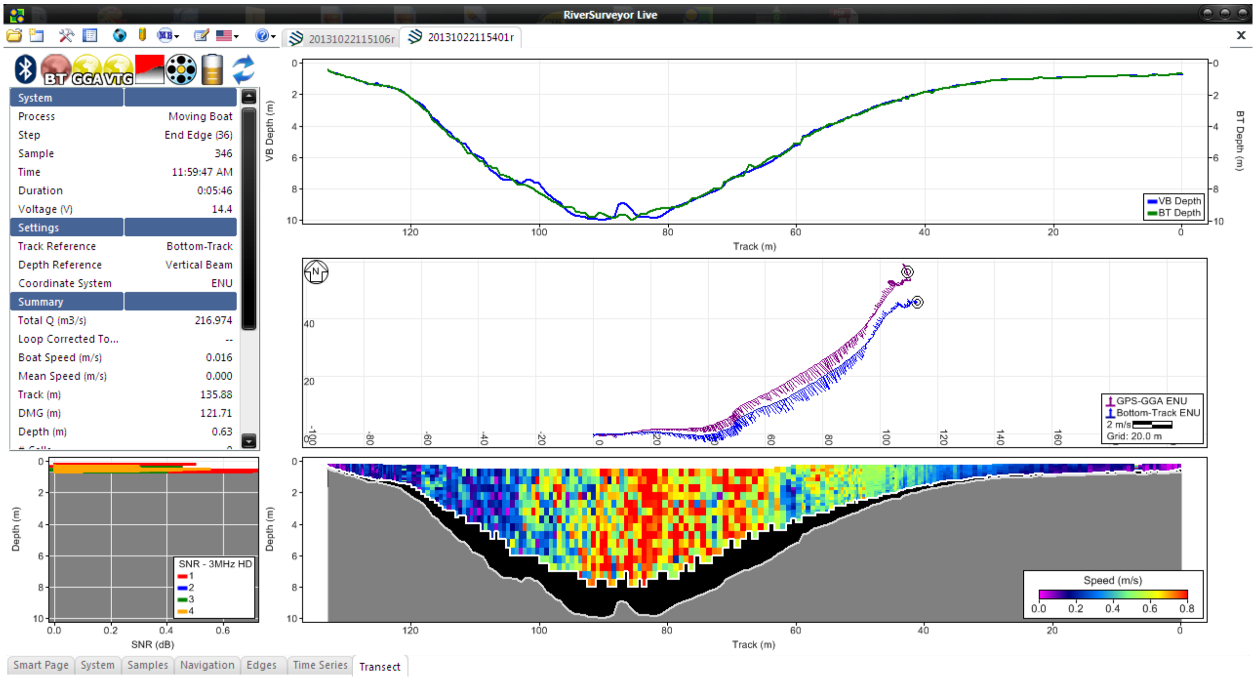


Figure 4c. Cross-section and Discharge from *RiverSurveyor* using ADCP Method (3rd trial)

The *RiverSurveyor*® screen shows the System, Settings, and Summary on the left part and the vessel track and river cross-section on the right. Based on the similarity of the obtained cross-sections (lowest graph on the right), it can be said that the profile of the stream bed is accurate. The colored sections represent water and its velocity, where the red pixels represent flows of up to 0.8 meters per second. The black areas touching the stream bed is also noticeable. These are waters of the river with velocities that could not be determined by the ADCP. Nonetheless, an equivalent discharge for each trial was obtained.

Based on the three trials, with discharges equal to 232.812, 263.219, and 216.974 cumecs respectively, the average discharge is equal to 237.668 cu.me. This is a low discharge compared to the previous methods done due to a sudden drop in the water level of the river during that day.

V. RATING CURVE AND EQUATION:

One of the goals of discharge measurement is to establish a rating curve defined by measured discharges at various water surface elevations. Based on actual discharge data, an equation can be formulated that would best describe the observations in such a way that if the equation would be plotted out in a graph, the curve that forms “best-fit” the distribution of the data. With a rating equation, a hydrologist can estimate discharges at various water levels, even those water elevations not present in the actual data. The discharge for every water level, based on the rating equation, is then presented in a rating table. This would then serve as a guide for the hydrologist.

In the following sections, a rating curve will be established. Values for discharge at various levels of elevation are computed through an excel suite provided by Mr Hilton Hernando, which is based on manning’s equation.

Cross section survey

The cross section directly under the bridge on the downstream side will be used in estimating the discharge at various levels. For that, the elevation profile of the ground below the bridge would be needed. With the use of a sounding rope, group 1 of the HTC class did the survey for the area, measuring distances from the bridge railing to the ground below.

PAMPANGA RIVER BED PROFILING

Arayat, Pampanga

Bridge Measurements:

Start Time:	1342 HH
End Time	1405 HH
Date:	Oct. 23, 2013

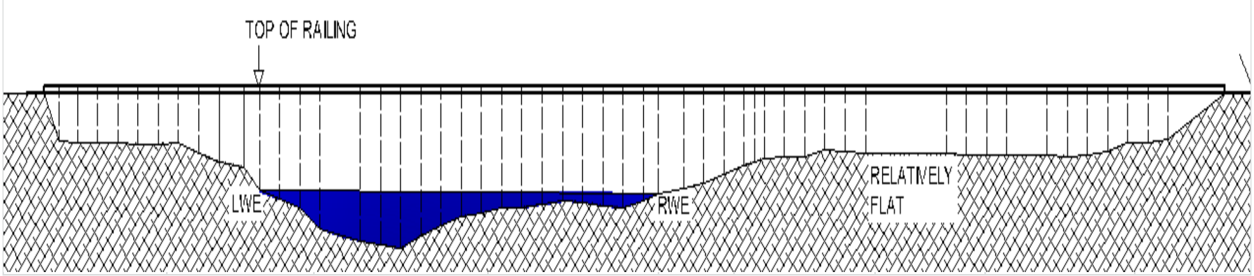
Heigth of Railing to Curb:	0.75 m
Height of Curb to Ground Level:	0.16 m

Measurements are taken from Top of the Bridge Railing, Left To Right of the Banks.

Station Interval	Depth (m)	Accumulated Horizontal Length (m)	Remarks
0	0.91	0	top of dike
3.8	7.6	3.8	Foot of dike
4.54	7.8	8.34	
5	7.8	13.34	
5	7.97	18.34	
5	7.97	23.34	
5	7.89	28.34	
5	9.26	33.34	
5	10.4	38.34	
5	11.17	43.34	
6.2	14.55	49.54	Left Water Edge
3.8	15.57	53.34	
5	16.86	58.34	
5	19.88	63.34	
5	21.63	68.34	
10	21.57	78.34	Edge of Pier
5	21.94	83.34	
5	22.48	88.34	
5	20.7	93.34	
5	19.39	98.34	
5	18	103.34	
5	17.63	108.34	
5	16.99	113.34	
5	16.79	118.34	
5	16.39	123.34	
5	15.97	128.34	
5	16.02	133.34	
5	16.51	138.34	
5	16.84	143.34	
5	15.78	148.34	
3.8	14.83	152.14	Right Water Edge

Station Interval	Depth (m)	Accumulated Horizontal Length (m)	Remarks
6.2	14.18	158.34	
5	13.36	163.34	
5	12.22	168.34	
5	10.95	173.34	
2.5	10.41	175.84	
2.5	9.93	178.34	
5	9.91	183.34	
5	9.91	188.34	
5	8.87	193.34	
5	9.16	198.34	
5	9.33	203.34	
5	9.33	208.34	
5	9.33	213.34	
5	9.33	218.34	
5	9.33	223.34	
5	9.59	228.34	
5	9.56	233.34	
5	9.56	238.34	
10	9.46	248.34	
5	9.71	253.34	
5	9.63	258.34	
5	9.05	263.34	
5	7.9	268.34	
5	7.77	273.34	
5	7.4	278.34	Foot of dike
14	0.91	292.34	top of dike

PAMPANGA RIVER CROSS SECTION
SAN AGUSTIN BRIDGE, ARAYAT PAMPANGA



The survey did by group 1 measured only the distance from bridge railing to ground; the discharge calculations require ground elevation. To convert the given depths to MSL elevations, the MSL elevation of the bridge curb measured by group 4 was taken into account. The bridge curb was at 15.562 meters AMSL, and adding the height of the railing from the curb (0.75 meters), the MSL height of the bridge railing was at 16.312 meters. The difference between this value and the corresponding depths give out the elevations of the ground below the bridge.

The resulting data are the entered on a cross section excel suite that computes for width, area, wetted perimeter and hydraulic radius for a given water surface elevation. Note that in this survey, the bridge was assumed to be straight with no piers obstructing the river

				Date:	Oct. 23, 2013			
station	distance	elevation	water sfc.	depth	mean depth	area	wetted perimeter	remarks
0.00		15.402	15.40	0.00				
3.80	3.80	8.712	15.40	6.69	3.35	12.71	7.69	
8.34	4.54	8.512	15.40	6.89	6.79	30.83	4.54	
13.34	5.00	8.512	15.40	6.89	6.89	34.45	5.00	
18.34	5.00	8.342	15.40	7.06	6.98	34.88	5.00	
23.34	5.00	8.342	15.40	7.06	7.06	35.30	5.00	
28.34	5.00	8.422	15.40	6.98	7.02	35.10	5.00	
33.34	5.00	7.052	15.40	8.35	7.67	38.33	5.18	
38.34	5.00	5.912	15.40	9.49	8.92	44.60	5.13	
43.34	5.00	5.142	15.40	10.26	9.88	49.38	5.06	
49.54	6.20	1.762	15.40	13.64	11.95	74.09	7.06	
53.34	3.80	0.742	15.40	14.66	14.15	53.77	3.93	
58.34	5.00	-0.548	15.40	15.95	15.31	76.53	5.16	
63.34	5.00	-3.568	15.40	18.97	17.46	87.30	5.84	
68.34	5.00	-5.318	15.40	20.72	19.85	99.23	5.30	
78.34	10.00	-5.258	15.40	20.66	20.69	206.90	10.00	
83.34	5.00	-5.628	15.40	21.03	20.85	104.23	5.01	
88.34	5.00	-6.168	15.40	21.57	21.30	106.50	5.03	Thalweg
93.34	5.00	-4.388	15.40	19.79	20.68	103.40	5.31	
98.34	5.00	-3.078	15.40	18.48	19.14	95.68	5.17	
103.34	5.00	-1.688	15.40	17.09	17.79	88.93	5.19	
108.34	5.00	-1.318	15.40	16.72	16.91	84.53	5.01	
113.34	5.00	-0.678	15.40	16.08	16.40	82.00	5.04	
118.34	5.00	-0.478	15.40	15.88	15.98	79.90	5.00	
123.34	5.00	-0.078	15.40	15.48	15.68	78.40	5.02	
128.34	5.00	0.342	15.40	15.06	15.27	76.35	5.02	
133.34	5.00	0.292	15.40	15.11	15.09	75.43	5.00	
138.34	5.00	-0.198	15.40	15.60	15.36	76.78	5.02	
143.34	5.00	-0.528	15.40	15.93	15.77	78.83	5.01	
148.34	5.00	0.532	15.40	14.87	15.40	77.00	5.11	
152.14	3.80	1.482	15.40	13.92	14.40	54.70	3.92	
158.34	6.20	2.132	15.40	13.27	13.60	84.29	6.23	
163.34	5.00	2.952	15.40	12.45	12.86	64.30	5.07	
168.34	5.00	4.092	15.40	11.31	11.88	59.40	5.13	
173.34	5.00	5.362	15.40	10.04	10.68	53.38	5.16	
175.84	2.50	5.902	15.40	9.50	9.77	24.43	2.56	
178.34	2.50	6.382	15.40	9.02	9.26	23.15	2.55	
183.34	5.00	6.402	15.40	9.00	9.01	45.05	5.00	
188.34	5.00	6.402	15.40	9.00	9.00	45.00	5.00	
193.34	5.00	7.442	15.40	7.96	8.48	42.40	5.11	
198.34	5.00	7.152	15.40	8.25	8.11	40.53	5.01	
203.34	5.00	6.982	15.40	8.42	8.34	41.68	5.00	
208.34	5.00	6.982	15.40	8.42	8.42	42.10	5.00	
213.34	5.00	6.982	15.40	8.42	8.42	42.10	5.00	
218.34	5.00	6.982	15.40	8.42	8.42	42.10	5.00	
223.34	5.00	6.982	15.40	8.42	8.42	42.10	5.00	
228.34	5.00	6.722	15.40	8.68	8.55	42.75	5.01	
233.34	5.00	6.752	15.40	8.65	8.67	43.33	5.00	
238.34	5.00	6.752	15.40	8.65	8.65	43.25	5.00	
248.34	10.00	6.852	15.40	8.55	8.60	86.00	10.00	
253.34	5.00	6.602	15.40	8.80	8.68	43.38	5.01	
258.34	5.00	6.682	15.40	8.72	8.76	43.80	5.00	
263.34	5.00	7.262	15.40	8.14	8.43	42.15	5.03	
268.34	5.00	8.412	15.40	6.99	7.57	37.83	5.13	
273.34	5.00	8.542	15.40	6.86	6.93	34.63	5.00	
278.34	5.00	8.912	15.40	6.49	6.68	33.38	5.01	
292.34	14.00	15.402	15.40	0.00	3.25	45.43	15.43	
Total Width	**292.34**							
Total Area	**3363.893**							
W. P (P)	**302.21**							
Hydraulic Radius ®	**11.13098**							
Mean sect. Depth	**11.50678**							

The table on the previous page shows the summary of the elevation profile of the whole cross section, enclosed with a water surface elevation equivalent to the elevation of the bridge railing in order to compute for the width, total area, wetted perimeter, and hydraulic radius when the water reaches the bridge railing. Computations for the mentioned parameters are repeated at other water surface elevations using the cross section sheet. There will be various values of these parameters for a whole range of water elevation, which are then entered in another excel suite that estimates discharge. The group's calculations are summarized below

Pampanga River @ Arayat							
(based on cross-section undertaken on October 2013)							
Elevation of "0" of S.G.=		0.000	m.(AMSL)				
n=	0.030	I=	0.000145				
Elevation	Equivalent	Area	Width	W.P.	hyd radius	Discharge	Remarks
MSL (m)	G.H.(m)	a (m^2)	w (m)	s	r	Q (cumecs)	
15.40	15.402	3363.89	292.34	302.21	11.13	6731.22	bank full/ level with bridge road
15.00	15.000	3247.38	291.50	300.97	10.79	6364.56	
14.00	14.000	2956.91	288.60	297.38	9.94	5488.03	
13.00	13.000	2670.61	286.30	294.09	9.08	4665.80	
12.00	12.000	2385.26	283.15	290.25	8.22	3898.89	
11.00	11.000	2104.14	281.00	287.13	7.33	3186.39	
10.00	10.000	1824.65	278.00	283.48	6.44	2534.26	
9.00	9.000	1548.21	275.30	279.97	5.53	1943.30	
8.00	8.000	1291.18	236.10	240.54	5.37	1588.87	
7.00	7.000	1053.37	162.40	166.46	6.33	1446.52	
6.00	6.000	902.84	137.90	141.81	6.37	1244.84	
5.00	5.000	769.53	128.20	131.89	5.83	1001.07	
4.00	4.000	643.90	122.10	125.45	5.13	769.04	
3.00	3.000	525.10	116.30	119.21	4.40	566.34	
2.00	2.000	412.62	108.00	110.58	3.73	398.45	
1.00	1.000	310.25	98.00	100.34	3.09	264.30	
0.50	0.500	262.09	93.50	95.73	2.74	205.88	
-1.00	-1.000	163.04	56.40	57.80	2.82	130.64	
-2.00	-2.000	110.61	40.90	42.35	2.61	84.20	
-3.00	-3.000	72.23	36.90	37.84	1.91	44.61	
-4.00	-4.000	39.10	30.70	31.30	1.25	18.20	
-5.00	-5.000	11.85	25.00	25.27	0.47	2.87	1.168m from thalweg (thalweg @ 6.168 below MSL)

The Rating Equation

From the previous calculations, a set of stage and discharge are now available for the whole range of the cross section. This time, the H-Q values are entered on another excel suite that computes for the rating equation. Shown on the next page are the H-Q values used for the rating equation computations.

Rating Curve Development for				***Pampanga River***			
	Measuring Station:		***Arayat Station***				
	Drainage Area:		***6487***				
	River:		***Pampanga River***				
	Location:		***San Agustin Bridge, Arayat, Pampanga***				
	Elev. S.G."0" rdg.=		***0.000***	**meters**			

Meas. #	Day	Month	Year	S.G.(m)	Q(m^3/sec)	Remarks
				15.402	6731.219	
				14.000	5488.026	
				13.000	4665.799	
				11.000	3186.386	
				10.000	2534.263	
				9.000	1943.296	
				8.000	1588.867	
				7.000	1446.523	
				6.000	1244.836	
				5.000	1001.068	
				4.000	769.036	
				3.000	566.342	
				2.000	398.449	
				1.000	264.299	
				0.500	205.881	
				-1.000	130.644	
				-2.000	84.195	
				-3.000	44.612	
				-4.000	18.203	
				-5.000	2.871	

After the H-Q Values are entered, the value for Ho (elevation of zero flow) would have to be determined by trial and error on the “rat” tab of the same excel suite

Summary test for Ho						
Ho	**a**	**b**	ΣX^2			
-7.50	0.26	3.239	159.0038	Minimum	$\Sigma X^2 =$	157.77577
-7.39	0.31	3.190	157.7758			
-7.28	0.36	3.140	160.9545			
-7.17	0.42	3.090	169.2081			
-7.06	0.49	3.039	183.3305			
-6.95	0.58	2.986	204.2726			
-6.84	0.68	2.933	233.1833			
-6.73	0.81	2.879	271.4649			
-6.62	0.96	2.824	320.8478			
-6.51	1.14	2.767	383.4949			
-6.40	1.35	2.708	462.1486			
-6.29	1.62	2.648	560.3451			
-6.18	1.94	2.586	682.7326			
-6.07	2.34	2.521	835.5621			

The value for Ho with the least chi square value would then be chosen as the Ho value in the final equation. In our group, Ho is equal to -7.39 by trial and error. This is then entered back on the previous sheet, under the "Assumed Ho" cell.

Assumed Ho =	-7.39	meters					
S.G. elev. (H)	H-Ho	Log H-Ho (X)	Log Q (Y)	X^2	XY		
15.402	22.792	1.358	3.828	1.844	5.198		
14.000	21.390	1.330	3.739	1.769	4.974		
13.000	20.390	1.309	3.669	1.715	4.804	n =	20.000
11.000	18.390	1.265	3.503	1.599	4.430	$\Sigma(X) =$	20.237
10.000	17.390	1.240	3.404	1.538	4.222	$\Sigma(Y) =$	54.273
9.000	16.390	1.215	3.289	1.475	3.994	$\Sigma(X^2) =$	21.930
8.000	15.390	1.187	3.201	1.410	3.800	$\Sigma(XY)=$	59.554
7.000	14.390	1.158	3.160	1.341	3.660		
6.000	13.390	1.127	3.095	1.270	3.488	$X_{bar} =$	1.012
5.000	12.390	1.093	3.000	1.195	3.280	$Y_{bar} =$	2.714
4.000	11.390	1.057	2.886	1.116	3.049	$(\Sigma(X))^2=$	409.529
3.000	10.390	1.017	2.753	1.034	2.799		
2.000	9.390	0.973	2.600	0.946	2.529	b^ =	3.190
1.000	8.390	0.924	2.422	0.853	2.237	a^ =	-0.514
0.500	7.890	0.897	2.314	0.805	2.075	$a = 10^{a\wedge} =$	0.306
-1.000	6.390	0.806	2.116	0.649	1.705	b = b^ =	3.190
-2.000	5.390	0.732	1.925	0.535	1.409		
-3.000	4.390	0.642	1.649	0.413	1.060		
-4.000	3.390	0.530	1.260	0.281	0.668		
-5.000	2.390	0.378	0.458	0.143	0.173		

After this, the completed equation will be shown:

Meas. #	Day	Month	Year	S.G.(m)	Q(m^3/sec)	Remarks
				15.402	6731.219	
				14.000	5488.026	
				13.000	4665.799	
				11.000	3186.386	
				10.000	2534.263	
				9.000	1943.296	
				8.000	1588.867	
				7.000	1446.523	
				6.000	1244.836	
				5.000	1001.068	
				4.000	769.036	
				3.000	566.342	
				2.000	398.449	
				1.000	264.299	
				0.500	205.881	
				-1.000	130.644	
				-2.000	84.195	
				-3.000	44.612	
				-4.000	18.203	
				-5.000	2.871	

Q = 0.306 [H - (-7.39)] 3.190

The Rating Curve Equation !!!

The rating curve equation, from the given set of stage-discharge values, is:

$$\mathbf{Q = 0.306\ (H+7.39)^{3.190}}$$

The Rating Table

After the rating curve equation has been computed, a rating table can be made. This is done on another excel suite that specifically creates a table based on the equation. The constants of the equation and gage height range are entered in the excel file, after which, it automatically gives the table:

Rating Table for:			*Arayat*			Date:	*October 23, 2013*			
River:	*Pampanga*			Location:	*San Agustin, Arayat, Pampanga*					
Elevation of S.G. "0" reading:			*0*							
Rating Curve Equation Coefficients:		**a =**	***0.306***	**Ho=**	***-7.390***	**b^=**	***3.190***			
Range of G.H.:	Min. G.H. =		***0***	Max. possible G.H.=			***11.00***			
Remarks:	*readings based on MSL*									

G.H.(m)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	180.59	181.37	182.16	182.94	183.73	184.52	185.31	186.11	186.90	187.70
0.1	188.50	189.31	190.11	190.92	191.73	192.55	193.36	194.18	195.00	195.82
0.2	196.65	197.48	198.31	199.14	199.97	200.81	201.65	202.49	203.34	204.18
0.3	205.03	205.89	206.74	207.60	208.46	209.32	210.18	211.05	211.92	212.79
0.4	213.66	214.54	215.42	216.30	217.18	218.07	218.96	219.85	220.74	221.64
0.5	222.53	223.44	224.34	225.24	226.15	227.06	227.98	228.89	229.81	230.73
0.6	231.66	232.58	233.51	234.44	235.38	236.31	237.25	238.19	239.14	240.08
0.7	241.03	241.99	242.94	243.90	244.86	245.82	246.78	247.75	248.72	249.69
0.8	250.67	251.64	252.62	253.61	254.59	255.58	256.57	257.57	258.56	259.56
0.9	260.56	261.57	262.57	263.58	264.59	265.61	266.63	267.65	268.67	269.69
1.0	270.72	271.75	272.79	273.82	274.86	275.90	276.95	277.99	279.04	280.09
1.1	281.15	282.21	283.27	284.33	285.40	286.47	287.54	288.61	289.69	290.77
1.2	291.85	292.94	294.02	295.11	296.21	297.30	298.40	299.50	300.61	301.72
1.3	302.83	303.94	305.06	306.17	307.30	308.42	309.55	310.68	311.81	312.95
1.4	314.08	315.23	316.37	317.52	318.67	319.82	320.97	322.13	323.29	324.46
1.5	325.63	326.80	327.97	329.14	330.32	331.50	332.69	333.88	335.07	336.26
1.6	337.45	338.65	339.85	341.06	342.27	343.48	344.69	345.91	347.13	348.35
1.7	349.57	350.80	352.03	353.27	354.51	355.75	356.99	358.23	359.48	360.74
1.8	361.99	363.25	364.51	365.77	367.04	368.31	369.58	370.86	372.14	373.42
1.9	374.71	375.99	377.29	378.58	379.88	381.18	382.48	383.79	385.10	386.41
2.0	387.73	389.04	390.37	391.69	393.02	394.35	395.68	397.02	398.36	399.71
2.1	401.05	402.40	403.75	405.11	406.47	407.83	409.20	410.57	411.94	413.31

Other considerations

The values in the rating table follow closely to the H-Q values that were supplied. Upon further inspection, it can be seen that the values for discharge for a given level varies greatly when compared to actual discharge measurements outlined in the previous sections. This may be due to the many assumptions considered at the start:

1. The H-Q values used in the formulation of the rating equation are in themselves only estimates computed based on manning's equation. The error may have been magnified when the rating curve equation and the rating table are computed.
2. The bridge was assumed to be straight. In reality, the bridge's elevation varies in certain sections.
3. The bridge was assumed to have no piers when it fact, it does. Piers affect water velocity surrounding its perimeter, and consequently, also affect discharge to a certain degree. Only the elevation of the river bed without the pier was considered.
4. The roughness coefficient used may have been inaccurate.
5. There might have been an error in evaluating the Ho. Since this was done by trial and error, other values for Ho that were not tried might have given closer results.

This section illustrates how rating curve equations are formulated and how rating tables are computed. If the values entered in the rating curve equation excel suite were actual discharge measurements on field, the resulting table will yield more accurate and reliable results

VI. AREAS VISITED:

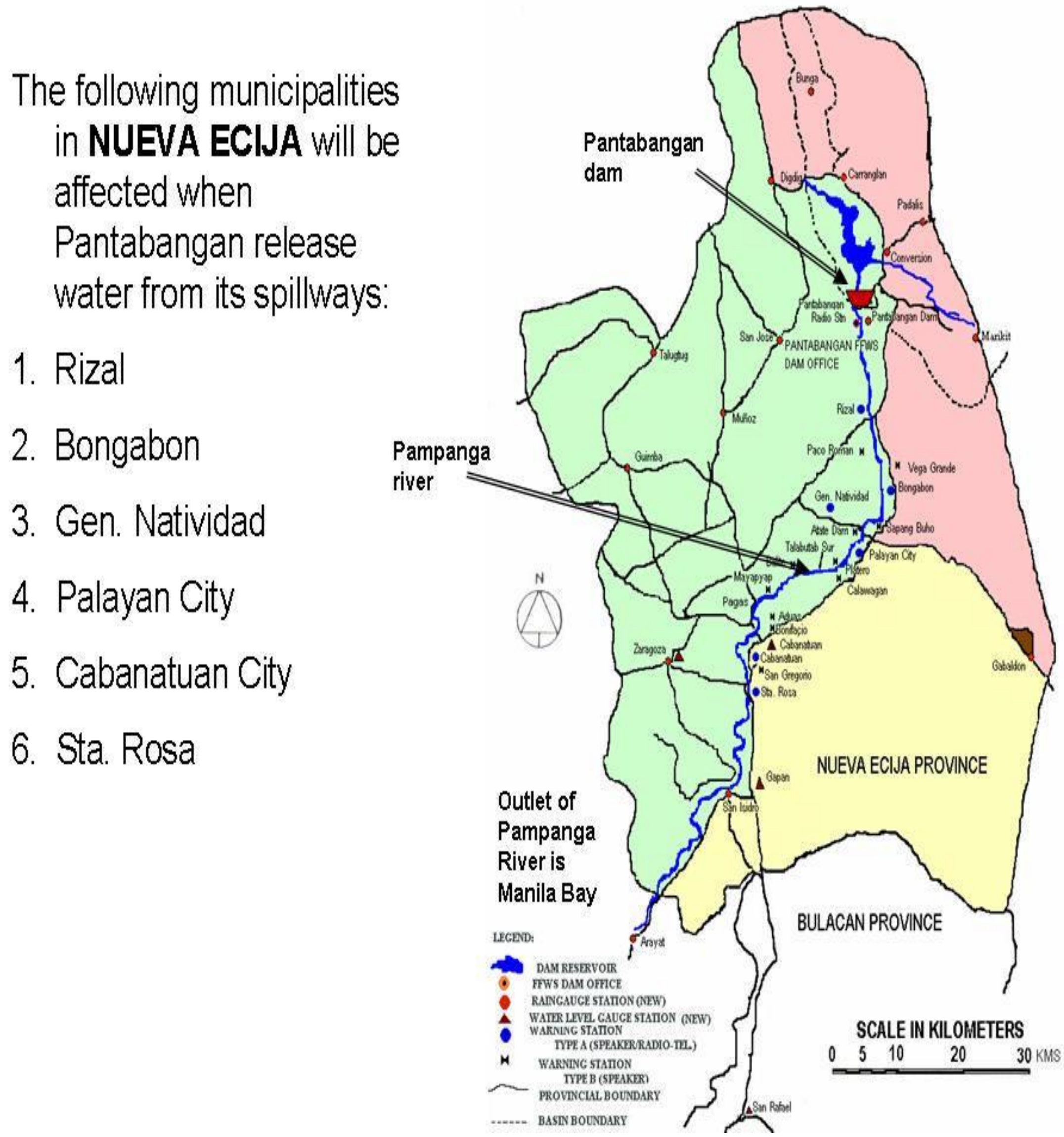
- Pantabangan Dam
  - Is located in Nueva Ecija, province of the Philippines. The multi-purpose dam provides water for irrigation and hydroelectric power generation while its reservoir, Pantabangan Lake, affords flood control. The reservoir is considered one of the largest in Southeast Asia and also one of the cleanest in the Philippines. Construction

on the dam began in 1971 and it was complete in 1977 earth-fill embankment dam on the Pampanga River.

- The dam is a 107 m (351 ft.) tall and 1,615 m (5,299 ft.) long embankment-type with 12,000,000 cu yd. (9,174,658 m^3) of homogeneous earth-fill and an impervious core. The crest of the dam is 12 m (39 ft.) wide while the widest part of its base is 535 m (1,755 ft.). The dam's crest sits at an elevation of 232 m (761 ft.) and is composed of three sections: the main dam, a saddle dam, and an auxiliary dam located with the spillway. The spillway is a chute-type controlled by three radial gates but equipped with an overflow section as well. The design discharge of the spillway is 4,200 m^3/s (148,322 cu ft./s). The dam's reservoir has a gross capacity of 2,996,000,000 m^3 (2,428,897 acre·ft) and 2,083,000,000 m^3 (1,688,716 acre·ft) of that volume is active (or useful) for irrigation and power. The dam sits at the head of an 853 km^2 (329 sq. mi) catchment area and its reservoir has a surface area of 69.62 km^2 (27 sq. mi) and elevation of 230 m (755 ft.) when at its maximum level. The reservoir's life is estimated at 107 years due to silt from denudation. The dam was design to withstand an intensity 10 earthquake.

- The power house is located at the base of the main dam and contains two 50 MW Francis turbine-generators for an installed capacity of 100 MW. Each turbine receives water via a 6 m (20 ft.) diameter penstock. When the water is discharged, it is released into a 250 m (820 ft.) long tailrace channel where it re-enters the river.

Figure: Pantabangan Dam and its spillway gates

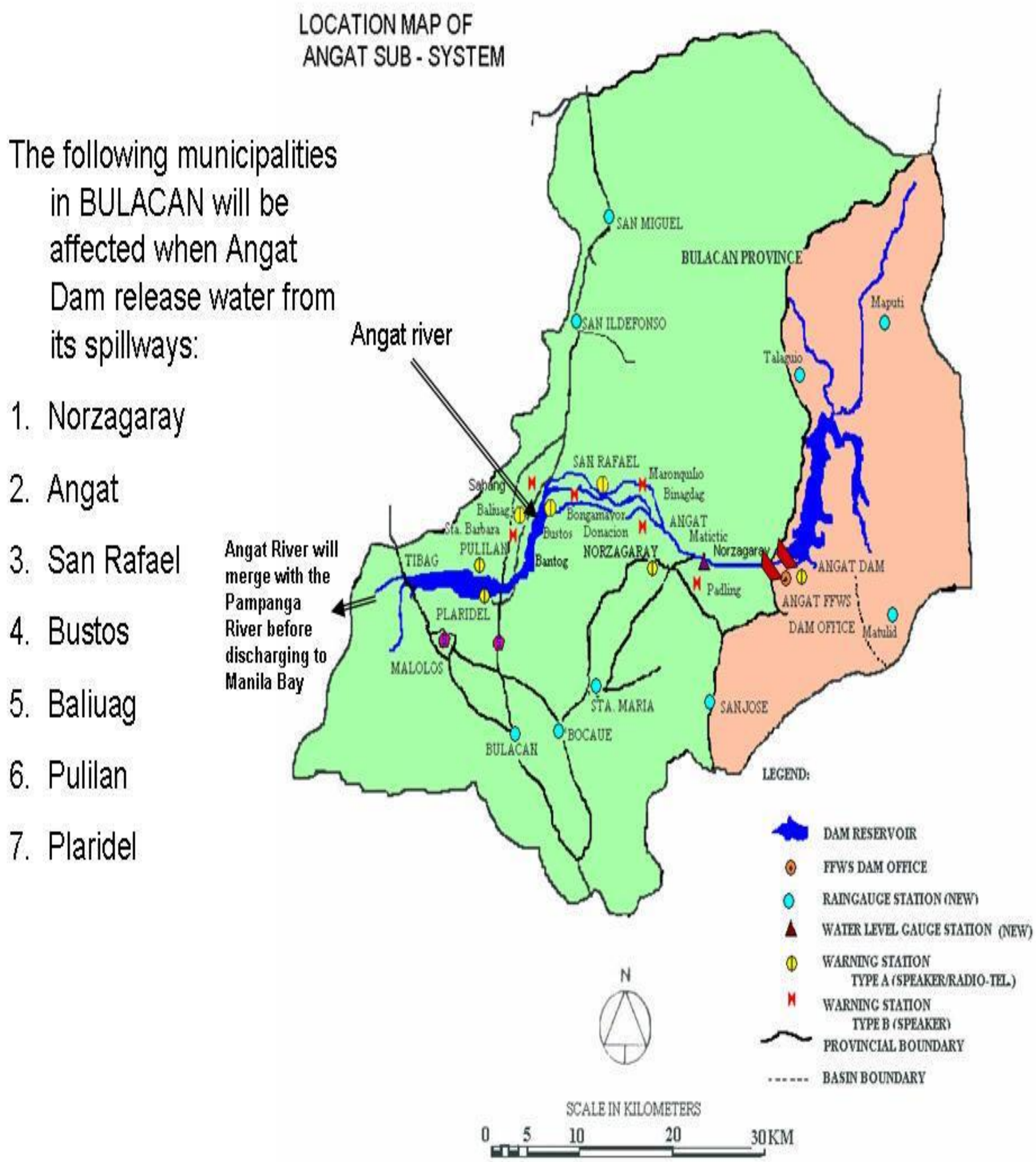


- Angat Dam
  - is a concrete water reservoir embankment hydroelectric dam that supplies the Manila metropolitan area water. It was a part of the Angat-Ipo-La Mesa water system. The reservoir supplies about 90 percent of raw water requirements for Metro Manila through the facilities of the Metropolitan Waterworks and Sewerage System and it irrigates about 28,000 hectares of farmland in the provinces of Bulacan and Pampanga.

- This dam was located in Barangay San Lorenzo, Bulacan served by the Angt River. The main dam is about 18 meters above sea level. It has a normal high water level of 210 meters, according to the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA).

- It has 3 opening gates a total of 1.5 meters to gradually release water that had accumulated due to incessant rains during typhoon. It also supplies portable water and energy in Metro Manila and nearby areas.

Figure: Angat Dam Power Generation and its spillway gates



- La Mesa Dam
  - Is an earth dam whose reservoir can hold up to 50.5 million cubic meters and occupying an area of 27 square kilometers. The water collected in the reservoir is treated on site by Maynilad Water Services, and at the Balara Treatment Plant further south by Manila Water. Both water companies are private concessionaires awarded by the Metropolitan Waterworks and Sewerage System, the government agency in charge of water supply. It is a vital link to the water requirements of 12 million residents of Metro Manila considering that 1.5 million liters of water pass through this reservoir everyday.

Figure: La Mesa Dam and Eco-Park

- Cong Dadong Dam
  - The P3.4-billion foreign-funded Cong Dadong Dam, named after President Arroyo late father, former President Diosdado Macapagal, is located in Arayat Pampanga. That basically helps to solve the problem in water irrigation.

Figure: Cong Dadong Dam and its spillway gates

VII. INSIGHTS AND IMPRESSIONS:

The field work plays a vital role in a sense that it helps the trainee not just to visualize but rather than to see the actual world of being a hydrologist. It also saw the comradely of the trainee in doing such work. Being a hydrologist is such a position that perhaps life-threatening it simply because the lives of others lies in our hand, every decision you make and every step you take be sure that you will do it in heart.

VIII. CONCLUSIONS:

The objectives were totally obtained. Based on my observations the Slope-Area is the most tedious one since it have three cross-sections to be needed and the flood marks will be obtained in this method. But during flooding this method can't be used, but instead of float method is the most convenient one, the other two namely ADCP and Current Meter Method will not be used due to the presence of water turbulence.

The results of discharge measurement in four methods have a lot of discrepancy because the observations made every other day meaning the presence of evapotranspiration affect the volume of water over a period of time, in connection with this the place was very humid that make it warmer and it will surely affect the discharge measurement.

IX. REFERENCES:

a. ^ Jump up to: [a] [b] [c] [d] "Pantabangan Dam". Database of Water-Related Projects in The Republic of the Philippines. Retrieved 4 November 2011.
b. **Jump up ^** "PANTABANGAN DAM". Retrieved 2011-11-03.
c. **Jump up ^** McDowell, ed. by Christopher (1996). *Understanding impoverishment : the consequences of development induced displacement* (1. publ. ed.). Providence, RI [u.a.]: Berghahn. p. 170. ISBN 1-57181-916-9.
d. http://en.wikipedia.org/wiki/Angat_Dam.
e. http://en.wikipedia.org/wiki/La_Mesa_Ecopark