Stream Gauging Field Work Report

Arayat Station, Pampanga

Submitted by:

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Abstract

The purpose of this report is to investigate the velocity, depth and discharge in Arayat River located specifically in downstream of San Agustine bridge, including the discharge of the previous flood event in that area caused by Typhoon Santi. The velocity, depth and discharge will be measured and calculated using Slope-Area Method, Acoustic Doppler Current Profiler (ADCP) Method, Current Meter Method and Float Method. One method each day will be used by each four group. In addition, this report states the process that our group made in each method. Finally, is to compare the four different methods and evaluate its limitations in actual situation in the field.

Introduction

As part of the completion of Stream Gauging II subject, the trainees of HTC required to have a field work in Pampanga. The target area of our practical field work is under the Pampanga River Basin and Flood Forecasting and Warning Center (PRFFWC). The field work lasts for ten days started on October 15 until October 25 but we already leave on October 24.

Schedule of the Field Work

Date	Destination
October 15	Visited Lamesa Dam
	Pampanga River Basin and Flood Forecasting and Warning Center (PRFFWC) office
October 16	At PRFFWC office, Lecture the things to do in the field
October 17	At Arayat River; our group assigned in Slope Area Method
October 18	At Arayat River; our group assigned in ADCP Method
October 19	Visited Pantabangan Dam, Nueva Ecija
October 20	Trip to Subic after church
October 21	At Arayat River; our group assigned in Current Meter Method
	Visted Cong Dadong Dam
October 22	At Arayat River; our group assigned in Float Method
October 23	Educational Tour in MDRRMC at Calumpit, Bulacan
October 24	Visited Angat Dam
	Back to PAGASA Science Garden

Site Description

The study area that we conducted our field work is one of the tributaries of Pampanga River Basin located in Brgy. Catamba, downstream of San Agustine Bridge. The upstream is the Cong Dadong Dam. Because of the recent Typhoon Santi, the experienced flooding that caused to overtop the both river banks and it is recorded in that area the water level of 8.3meters. That is why the river banks specially at the first day was still wet and muddy and the staff gauge that is located in the center pier of the bridge stacked with debris. Some water lilies floating in the river and other pier has water lilies residing in it. The river was deep that wading method cannot be used. The geometry of the river is slightly curve and that's why the flow of the river is not uniformly straight. The flow is going to the left bank – facing the downstream and that part is deeper than the right bank of the river and because of that the flow at the right bank is stagnant. Both river banks are full of shrubs. River banks surface is loam with silt type of soil. The bed stream was visible in the last day of the field because the water receded in afternoon and it is composed of mixed gravel, sand and pebbles.

Materials and Methods

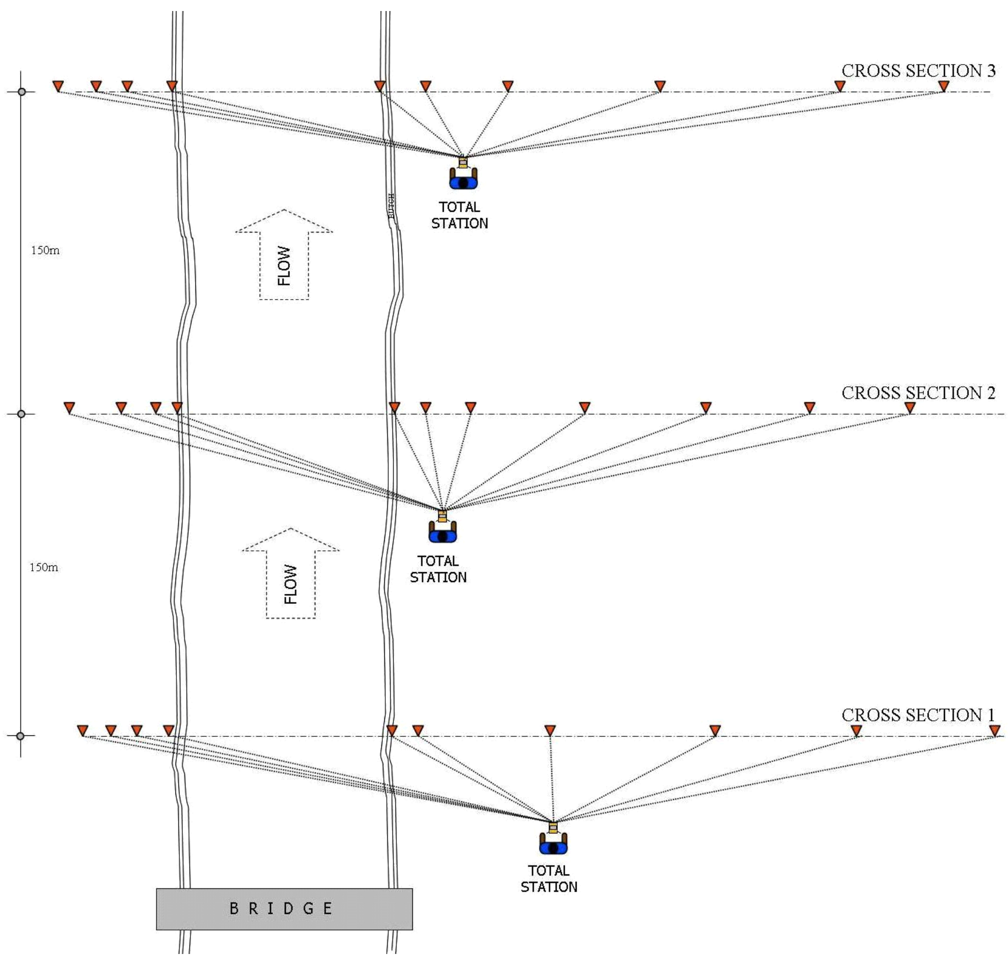
The materials that we used are the range finder, steel tape, current meter, ADCP, stop watch/timer, total station, echo sounder, tagline, bamboo, and gloves. The range finder and steel tape is used to measure the distance, current meter for measuring the velocity, ADCP for discharge measurement, stop watch or timer for counting the time elapse of the bamboo to float from the starting to ending point and also for the time in counting the beep corresponds to the revolution of current meter, total station measures the horizontal distance, horizontal angle and vertical distance for surveying the river profile and specially knowing the elevation in each desired point of the area, echo sounder for knowing the depth of the river specially at the bridge where some part is too deep, tagline rope to guide the boat to traverse the river, bamboo used as floater in float method, gloves to protect the hands in cutting the shrubs in the river bank.

There are four methods that we use to measure the discharge of the river. The four methods are ADCP Method, Slope Area Method, Current Meter Method, ad Float Method.

Methods:

Slope Area Method

Slope Area Method is an indirect method which estimates the discharge after the flood event. Using the Manning formula which requires "roughness factor" that depends in the hydraulics of the river, the discharge can be calculated. The ideal procedures in this method are at least three cross sections, its length is greater than 75 times the mean depth, and the fall is equal to or greater than 0.15 meters. And also the water did not overflow in the river banks during the flood but unfortunately it overflows. Because it is difficult to follow all the conditions and to ease the work, what we did was we had three cross sections and the total length is 300 meters which is 150 meters interval.



October 17, first day in the field, our group was assigned in Slope Area (SA) Method. The first thing that we did were finding the bench mark which is located near the old gauging station of PAGASA. The bench mark has an elevation of 9.114 AMSL. After we found the bench mark, we transfer the elevation to the first cross section using the total station. But before using the total station it should be calibrated and should always orient to the north even in transferring. The first cross section was located 53meters away from the bridge. We made a three cross section with a 150 meters interval in each cross section. We use range finder in measuring the distance. After locating the cross sections and transferring the total station from the bench mark, we established flood marks in each cross section. Getting the elevation, the distance and the corresponding angle from the north using the total station, we can get the profile of the river in each cross section from highest flood mark of the right bank to the left bank but the profile of the river, in our case, we did not use the total station. Instead, we rode a boat to traverse the river and using the range finder we get the distance and by the use of echo sounder, we got its depth in each distance. The data's that we gathered in this method are shown in data and analysis section.

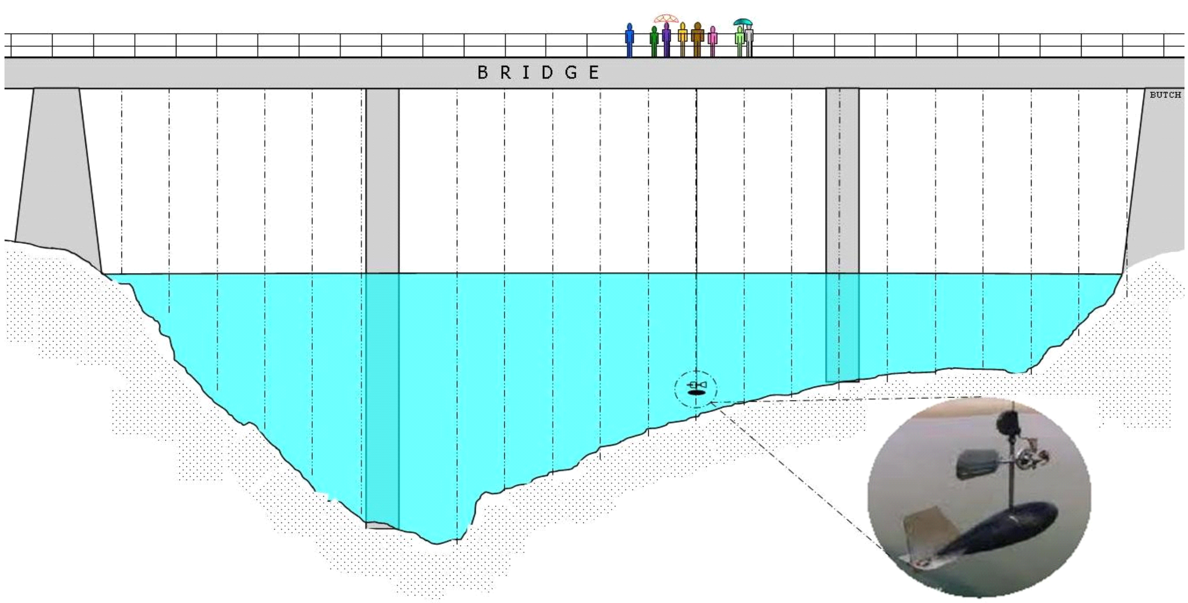
Acoustic Doppler Current Profiler Method

Acoustic Doppler Current Profiler (ADCP) Method measures the discharge so easy and more accurate because as what I've noticed, the discharge that measured with the other method was compared to ADCP if it is close.

October 18, our group was assigned in ADCP method. We assembled first the ADCP – mounting the transducer and transceiver (transmitter and receiver) and synchronized it with a laptop. Before we start in measuring the discharge, we calibrate the ADCP in the standard calibrating- the pitch, yaw and roll axes, within two minutes. After calibrating, we carefully brought down the ADCP to the river and went to the desired cross section point. Before traversing, the operator of the ADCP communicates to the operator of the computer when to start and gives the data that is needed – the safety distance from the edge of the water. As the ADCP travels, the people that assigned in the boat assist the ADC. Then as the ADCP traverse the river, at the computer, it automatically pre-calculated the depth, velocity and the discharge. When the ADCP reach the safety distance from the water edge of the other bank, that distance is needed to finish in the computer to calculate the total discharge. Our group made a four transect because of other circumstances that happened which will elaborate in later part of the report.

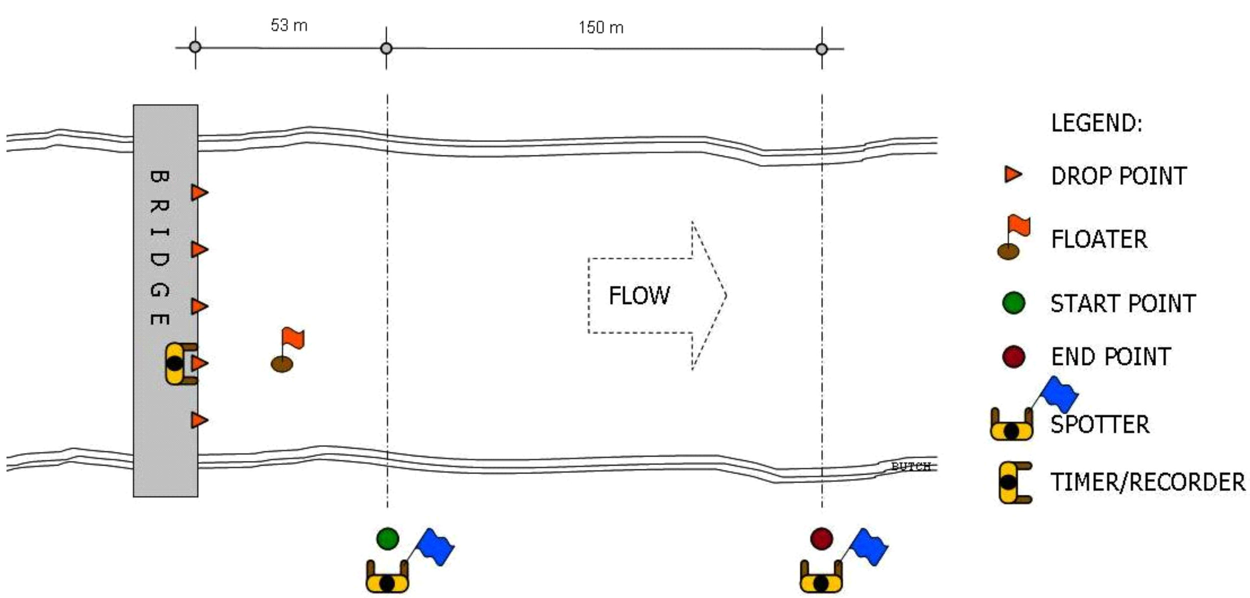
Current Meter Method

Current Meter Method measures the discharge by sub-dividing the river cross-section into a segment. Each segment measures its width, the depth and velocity of the water and then sum the calculated discharge in each segment to get the total discharge.



October 21, our group was assigned in Current Meter Method. We set up and assembled first the sounding reel, current meter and the columbus weight. We set the current meter into five revolutions per beep. We can’t wade the river because it’s too deep, that why we use the bridge in this method. Before we start, we checked the water level in the staff gauge. We sub-divided the bridge into the segment from the projected water edge of the left bank to the water edge of the right bank. The leftmost and rightmost part of the segment have bigger width (5 meters) while the at the center part have the closer width (3 meters) and we have a total of 24 segments. We did this so that the partial discharges may not exceed 10 percent of the total. The segment that project to the pier, island of water lilies and has the turbulent flow was skipped. Then in each segment we get the depth of the water using echo sounder and its velocity using the current meter. We did not use the sounding reel in measuring the depth like what the other group did because of the limited length of the cable. After getting the depth of the water in each segment we get its 0.2 and 0.8 depth. We used two-point method and if the depth is less than 1 meter, we use the one point method but in our group experienced, the current meter cannot measured the velocity in less than 1 meter which the data will be seen in the later part. Then we submerge the current meter in its correspond 0.2 and 0.8 depth. Then we wait for approximately 30 seconds to stable the current meter and the count the number of beep within at least 60 seconds. We also get the projectile angle of the cable for correction purposes. Then we pull the current meter and transfer to the other segment but before submerging it again, we checked it if there is a debris that attached in it. After getting the velocity and depth of all the segments, we measured the width of the pier. Then the total discharge can calculate and also the profile of the cross-section using the depth that is measured.

Float Method



Float Method measures the discharge in high flow. It is suitable to use if the river is full of debris that floats and also in flood event that other method is impossible to use. This method actually measures surface velocity and in getting the mean velocity is by multiplying the surface velocity by a correction factor. The surface velocity measured by getting the time travelled by the floater in a specific distance.

We used bamboo as the floater with sand inside and flag as indicator. Our group used the first and second cross sections in our slope area measurements, the first section was about 53 meters away from the bridge and the measurement section which is form first to second section has a distance of 150 meters. Our group was divided into two teams; the first team drops the bamboo floater off the bridge and the second team acts as spotters on the first and second cross sections. There must be communication at all times during the activity since at all three points (bridge, start point, end point), the time measured must ideally synchronize.

The team on the bridge divided the river width into five unequal intervals, taking into consideration the contracting feature of the river. It was inside these intervals that the bamboo floaters were dropped. The team on the bridge notifies everyone that the float was dropped in a given section, the spotter on the first cross section notifies everyone to start the time, and lastly, the spotter on the second cross section signals everyone to stop the time. Individual records for the start as well as the end time were averaged, and the time elapsed computed for a given section.

There were a total of five drop points and measurements were first done from the right bank towards the left bank and the gage height for the whole duration of the first pass was at 2.78 meters. The five bamboo floaters in the first pass have no problem.

The second set of measurements was done from the left bank towards the right bank. Unlike the first pass, however, the floater did not resurface on the first and second drop while the floater at the fifth drop did not. In our second set of measurements, this is the time that the water level at the Arayat station started to significantly reduce due to the closing of the gates of the Cong Dadong dam in the upstream

Development of a Rating Curve, Equation and Table

Another approach in measuring the discharge is developing the rating curve 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.

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.

Gathered Data

Slope Area Method

The tables show the summary of the survey that was done for each cross section, going from left bank to right bank:

FIRST CROSS-SECTION				
POINT	**DISTANCE**			**ELEVATION**
	ACTUAL	**CORRECTED**	**ACCUMULATED CORRECTED**	
P1	0	0	0	8.6
P2	20	20.00	20	8.272
P3	2.2	2.20	22.2	7.072
P4	2.66	2.66	24.86	4.782
P5	5	5.00	29.86	-2.618
P6	9	9.00	38.86	-0.618
P7	9	9.00	47.86	-2.418
P8	7	7.00	54.86	-6.118

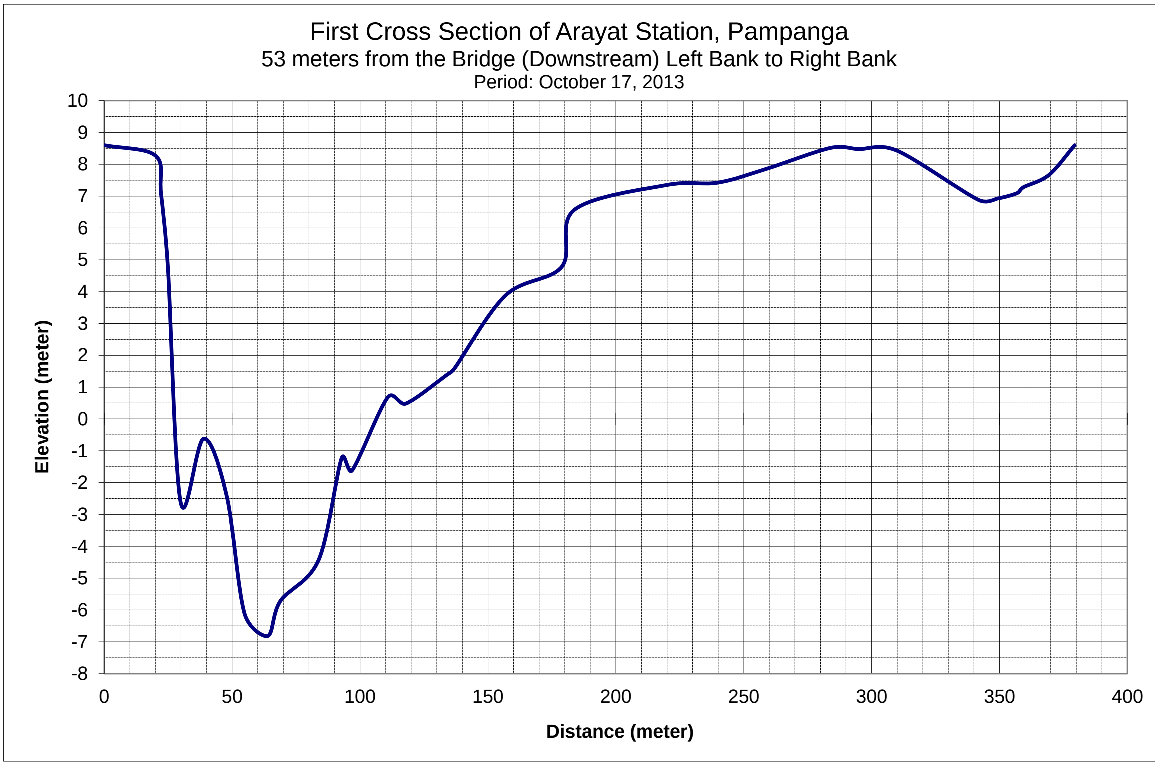
P9	9	9.00	63.86	-6.818
P10	5	5.00	68.86	-5.718
P11	15	15.00	83.86	-4.418
P12	9	9.00	92.86	-1.218
P13	4	4.00	96.86	-1.618
P14	14	14.00	110.86	0.682
P15	7	7.00	117.86	0.482
P16	16	16.00	133.86	1.382
P17	3	3.00	136.86	1.582
P18	20	20.00	156.86	3.882
P19	22	22.00	178.86	4.782
P20	5	5.00	183.86	6.575
P21	36	36.00	219.86	7.349
P22	20	20.00	239.86	7.424
P23	19	19.00	258.86	7.857
P24	25	25.00	283.86	8.514
P25	11	11.00	294.86	8.478
P26	15	15.00	309.86	8.431
P27	32	32.00	341.86	6.879
P28	7.5	7.50	349.36	6.928
P29	7.5	7.50	356.86	7.094
P30	2.5	2.50	359.36	7.279
P31	10	10.00	369.36	7.667
P32	10	10.00	379.36	8.6

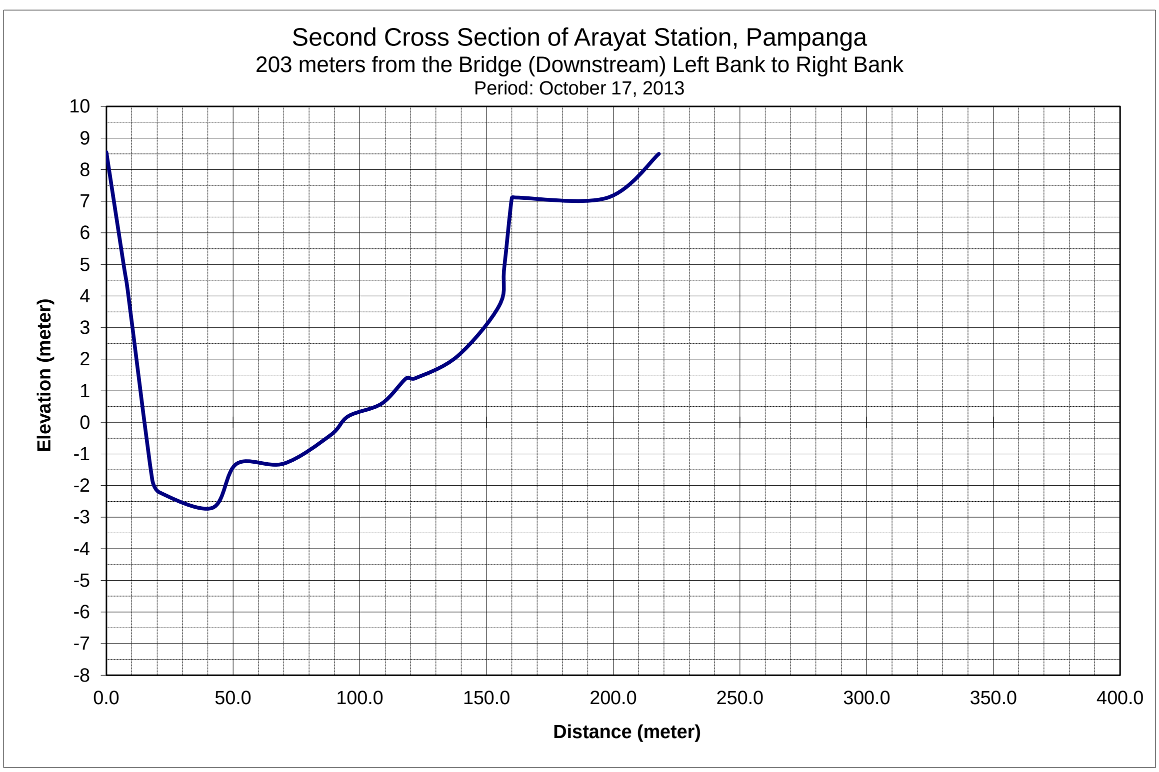
SECOND CROSS-SECTION				
POINT	DISTANCE			ELEVATION
	ACTUAL	CORRECTED	ACCUMULATED CORRECTED	
P1	0	0	0.0	8.552
P2	7.00	7.00	7.0	4.895
P3	1.41	1.41	8.4	4.185
P4	9.67	9.67	18.1	-1.805
P5	2.64	2.64	20.7	-2.205
P6	21.10	21.10	41.8	-2.705
P7	9.67	9.67	51.5	-1.305
P8	18.46	18.46	70.0	-1.305
P9	18.46	18.46	88.4	-0.405
P10	7.03	7.03	95.5	0.195
P11	13.19	13.19	108.6	0.595
P12	9.67	9.67	118.3	1.395

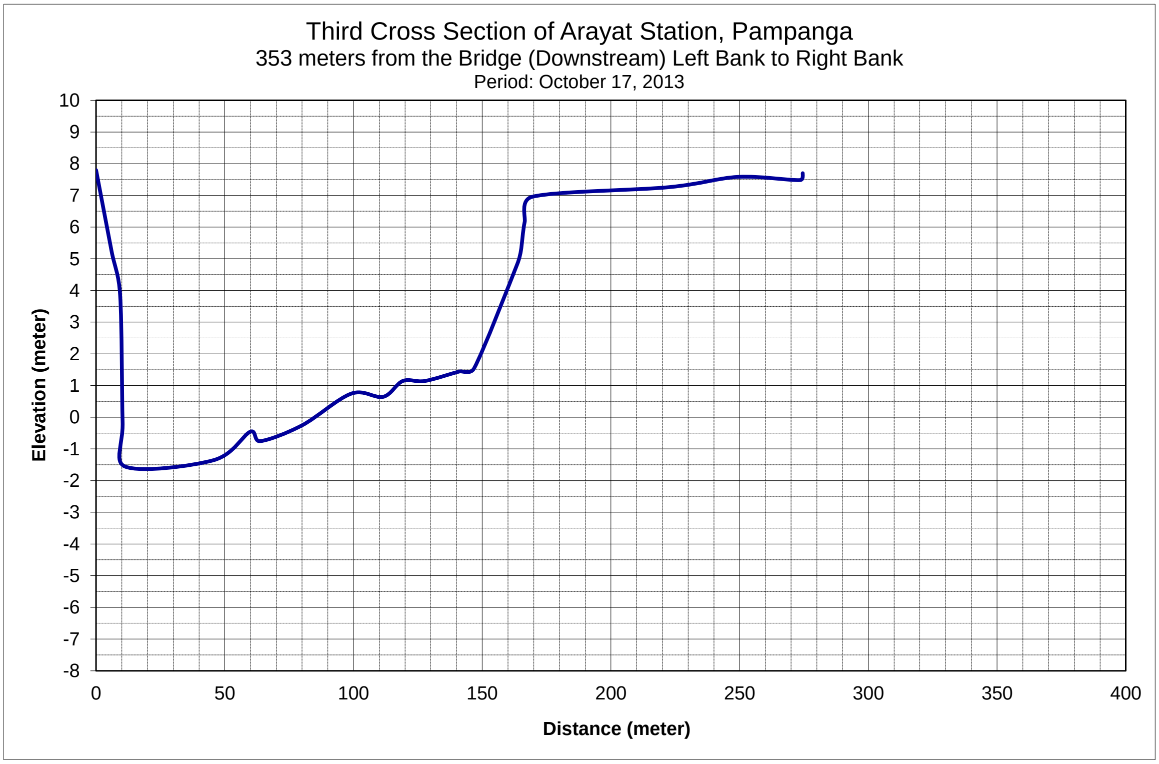
P13	3.52	3.52	121.8	1.395
P14	16.71	16.71	138.5	2.095
P15	16.48	16.48	155.0	3.695
P16	1.99	1.99	157.0	4.895
P17	6.00	3.00	160.0	7.103
P18	6.10	1.50	161.5	7.117
P19	36.00	36.00	197.5	7.106
P20	25.00	20.50	218.0	8.5

THIRD CROSS-SECTION				
POINT	**HORIZONTAL DISTANCE**			**ELEVATION**
	ACTUAL	**CORRECTED**	**ACCUMULATED CORRECTED**	
P1	0	0	0	7.797
P2	11	6.00	6	5.244
P3	3.34	3.34	9.34	3.844
P4	0.957	0.96	10.297	-0.156
P5	0.955	0.96	11.252	-1.556
P6	34.378	34.38	45.63	-1.356
P7	14.32	14.32	59.95	-0.456
P8	3.82	3.82	63.77	-0.756
P9	16.24	16.24	80.01	-0.256
P10	19.098	19.10	99.108	0.744
P11	12.412	12.41	111.52	0.644
P12	7.642	7.64	119.162	1.144
P13	8.595	8.60	127.757	1.144
P14	13.369	13.37	141.126	1.444
P15	5.73	5.73	146.856	1.544
P16	16.712	16.71	163.568	4.824
P17	1.432	1.43	165	5.244
P18	1.5	1.50	166.5	6.166
P19	3	3.00	169.5	6.958
P20	53.5	53.00	222.5	7.259
P21	30.5	27.00	249.5	7.584
P22	24.5	24.00	273.5	7.483
P23	1	1.00	274.5	7.7

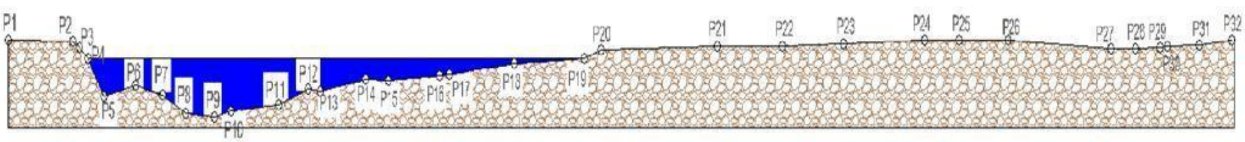
The data above in horizontal distance have been corrected so that the cross section will become straight and perpendicular to the river reach. Also presented below are the illustrations for each cross section, once again shown from left bank to right bank with values for elevation referenced to Mean Sea Level:



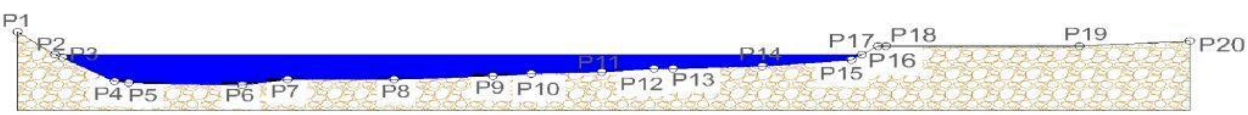




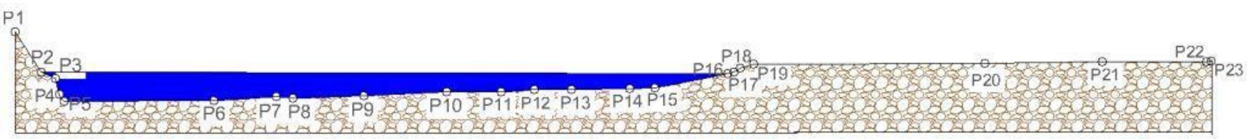
The illustrations below show the same cross sections plotted out in AutoCAD:



FIRST CROSS SECTION



SECOND CROSS SECTION



THIRD CROSS SECTION

ADCP Method

There are no data recorded in ADCP because it automatically measures the discharge. The result of the measurement can be seen in the Result and Discussion section.

Current Meter

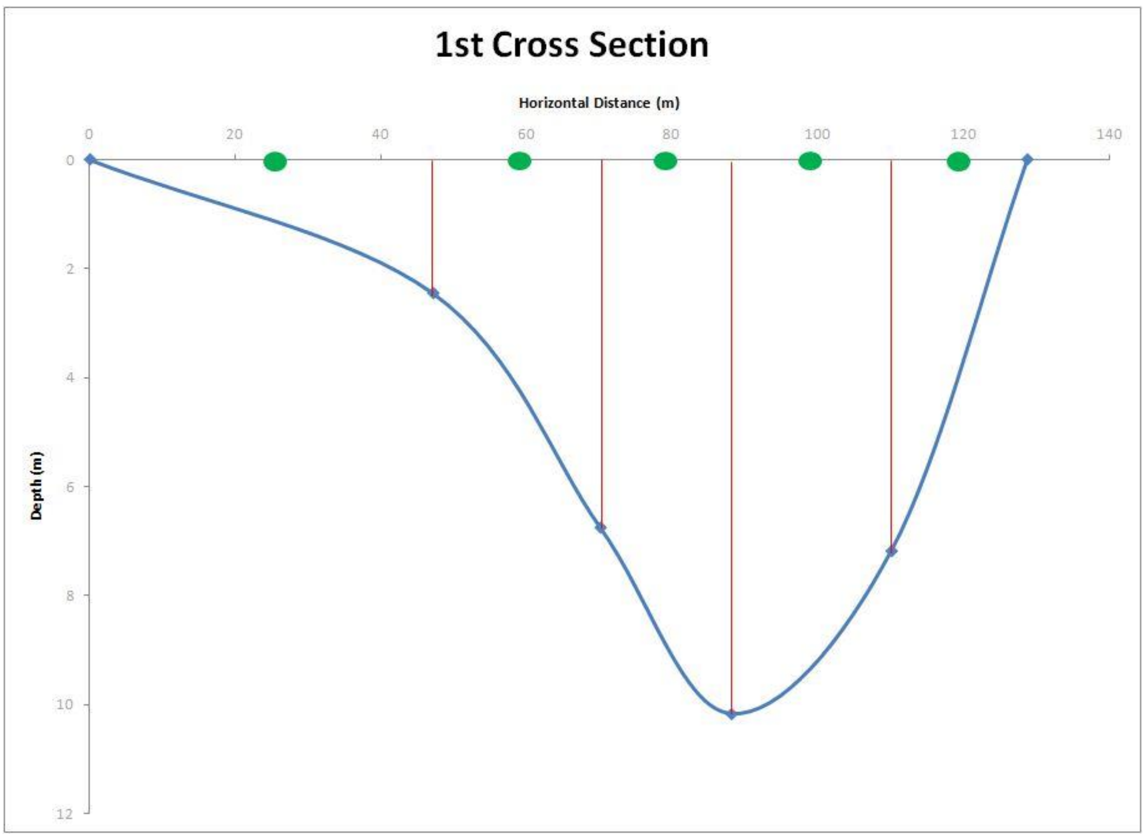
The tables show the summary of the survey that was in the river going from left bank to right bank:

Dist. From initial point	Depth (meters)	Vertical Angle	Observation Depth					
			0.2		0.6		0.8	
			Rev.	Time	Rev.	Time	Rev.	Time
0								
5	2.2	14.5	6	18			12	61.57
10	3.6	23	13	18			12	63.94
15	6	26	12	10			5	61.33
18	7.7	21.5	18	18			16	60.62
21	7.6	21	29	17			17	64.44
33	8.4	24	15	16			9	65.35
36	8.7	22	26	16			12	61.62
39	9.3	13.5	23	17			12	62.39
42	8.8	9.5	19	16			13	61.63
45	8.1	6.5	24	16			10	65.27
48	6.6	8.5	15	15			14	64.52
51	6	12.5	8	15			12	65.6
54	5.3		3	15			12	63.98
57	4.6		2	16			12	64.26
60	3.5		1	16			12	62.32
65	3.6		2	15			11	61.06
70	3.3		1	15			10	63.29
75	2.7		4	15			11	63.57
80	2.5	4	4	15			11	64.65
85	2.4		4	14			11	65
100	2.7		4	10			6	63.84
105	1.2		3	5			4	88.39
110	0.9							
115	0.27							
117.5								

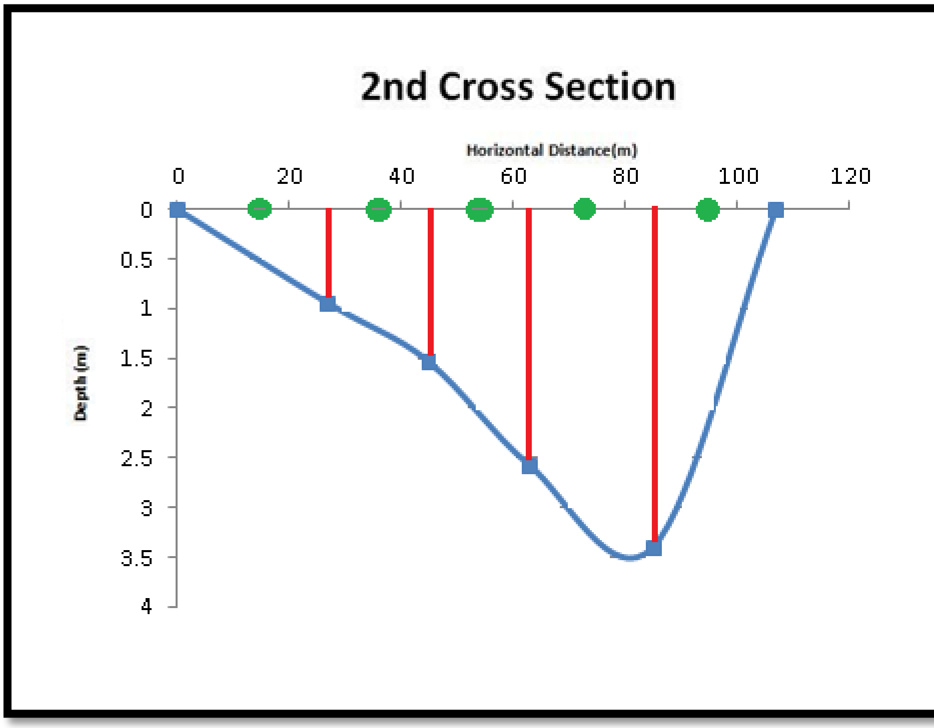
Float Method

A given section area would then be computed by multiplying the distance between verticals (interval) with the average of the depths at those verticals. There are a total of 5 sections for each cross section. The profiles of the cross sections are detailed below.

FIRST CROSS SECTION				
Interval	Distance	Accumulated distance	Depth	Section Area
0	0	0	0	0
1	47.17	47.17	2.452	57.83042
2	23	70.17	6.752	105.846
3	18	88.17	10.172	152.316
4	22	110.17	7.182	190.894
5	18.68	128.85	0	67.07988



SECOND CROSS SECTION				
Interval	Distance	Accumulated distance	Depth	Section area
0	0	0	0	0.00
1	26.8	26.8	0.942	12.62
2	18	44.8	1.532	22.27
3	18	62.8	2.572	36.94
4	22	84.8	3.402	65.71
5	22	106.8	0	37.42



Rating Curve, Equation and Table

The data that gathered by the other group in getting the rating equation are shown below:

PAMPANGA RIVER BED PROFILING

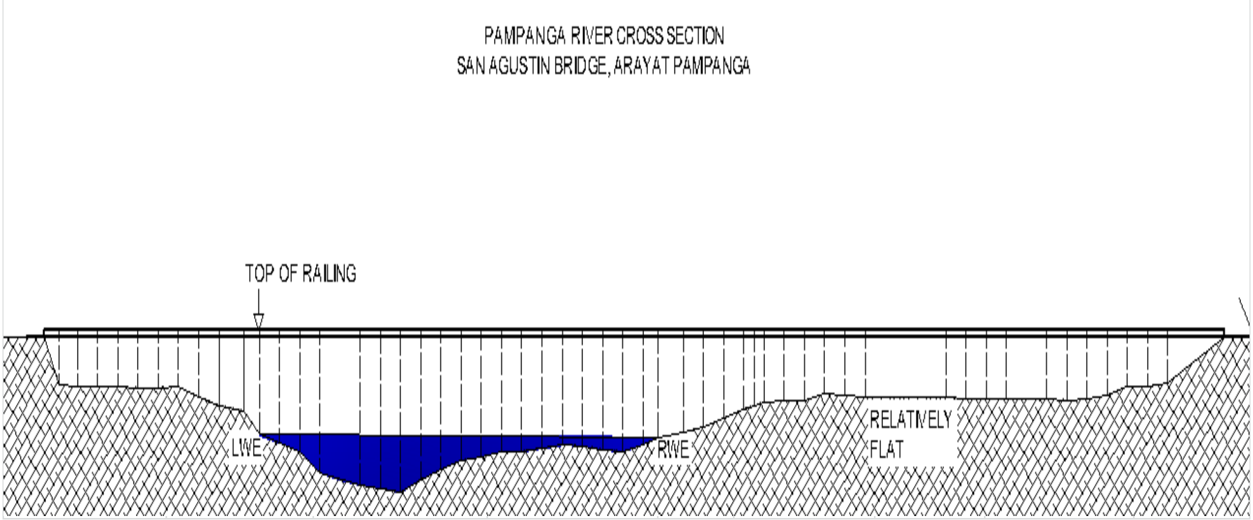
Arayat, Pampanga

Start Time:	1342 HH	**Bridge Measurements:**	
End Time	1405 HH	**Heigth of Railing to Curb:**	0.75 m
Date:	Oct. 23, 2013	**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



Results and Discussion

Slope Area Method

Data gathered for the cross sections were entered in the Slope-Area excel suite provided by our instructor, Mr Hilton T. Hernando. The cross section data were entered from left bank to right bank. The result was as follows:

Republic of the Philippines
Department of Science and Technology
PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND ASTRONOMICAL SERVICES ADMINISTRATION (PAGASA)
Pampanga River Flood Forecasting and Warning Center (PRFFC)
Agham Road, Diliman, Quezon City

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

Station:	***Arayat***	River:	***Pampanga River***
Flood Date:	***13-Oct-13***	Drainage Area:	***6,487***
Gauge Height:	***8.78***	Meas. #:	

X - Section Properties:

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	379.36	1623.42	8.272	8.6	8.436	4.279	0.04	4.19	106006.9	4.5E+08	1	0.379	tranquil
2	218.00	1355.39	8.552	8.5	8.526	6.217	0.04	6.10	113808.7	8E+08	1	0.377	tranquil
3	274.50	1221.98	7.797	7.7	7.7485	4.452	0.04	4.36	81973.56	3.7E+08	1	0.494	tranquil

note: Assume no sub-divided sections, hence α is always 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	150	-0.09	0	contracting	0.931448	good	1489.403	x	x
2-3	150	0.7775	0	contracting	1.388359	good	1288.681	5881.839	4.564
1-2-3	300	0.6875	0	contracting	1.293184	good	1400.260	**3983.727**	2.845

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	x	0.307229	0.440754	-0.13353	-0.22353	-0.00149	x	109838.6	x
2-3	5881.839	0.440754	0.542249	-0.10149	0.676006	0.004507	0.067132	96588.32	6484.168

Rem:

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

$Q_{1\text{-}2\text{-}3}$ = 3983.73 **cumecs**

Discharge

Slope-Area Cross-Section Computation

Station: ***Arayat*** Survey Date: ***17-Oct-13***

River: ***Pampanga*** Gage Ht.= ***5.31*** meters

Cross-Section number ONE (1)

Station	Distance	Elevation	Water Sfc. elev.	Depth	Mean Depth	Area	Wetted Perimeter
0		8.6	8.6	0			
20	20	8.272	8.6	0.328	0.164	3.28	20.00269
22.2	2.2	7.072	8.6	1.528	0.928	2.0416	2.505993
24.86	2.66	4.782	8.6	3.818	2.673	7.11018	3.509943
29.86	5	-2.618	8.6	11.218	7.518	37.59	8.930845
38.86	9	-0.618	8.6	9.218	10.218	91.962	9.219544
47.86	9	-2.418	8.6	11.018	10.118	91.062	9.178235
54.86	7	-6.118	8.6	14.718	12.868	90.076	7.917702
63.86	9	-6.818	8.6	15.418	15.068	135.612	9.027181
68.86	5	-5.718	8.6	14.318	14.868	74.34	5.11957
83.86	15	-4.418	8.6	13.018	13.668	205.02	15.05623
92.86	9	-1.218	8.6	9.818	11.418	102.762	9.551963
96.86	4	-1.618	8.6	10.218	10.018	40.072	4.01995
110.86	14	0.682	8.6	7.918	9.068	126.952	14.18767
117.86	7	0.482	8.6	8.118	8.018	56.126	7.002857
133.86	16	1.382	8.6	7.218	7.668	122.688	16.02529
136.86	3	1.582	8.6	7.018	7.118	21.354	3.006659
156.86	20	3.882	8.6	4.718	5.868	117.36	20.13182
178.86	22	4.782	8.6	3.818	4.268	93.896	22.0184
183.86	5	6.575	8.6	2.025	2.9215	14.6075	5.311765
219.86	36	7.349	8.6	1.251	1.638	58.968	36.00832
239.86	20	7.424	8.6	1.176	1.2135	24.27	20.00014
258.86	19	7.857	8.6	0.743	0.9595	18.2305	19.00493
283.86	25	8.514	8.6	0.086	0.4145	10.3625	25.00863
294.86	11	8.478	8.6	0.122	0.104	1.144	11.00006
309.86	15	8.431	8.6	0.169	0.1455	2.1825	15.00007
341.86	32	6.879	8.6	1.721	0.945	30.24	32.03761
349.36	7.5	6.928	8.6	1.672	1.6965	12.72375	7.50016
356.86	7.5	7.094	8.6	1.506	1.589	11.9175	7.501837
359.36	2.5	7.279	8.6	1.321	1.4135	3.53375	2.506836
369.36	10	7.667	8.6	0.933	1.127	11.27	10.00752
379.36	10	8.6	8.6	0	0.4665	4.665	10.04343

Total Width =	379.36	meters	Hydraulic Radius(r) =	4.19	meters
Total Area =	1623.42	meters^2	Mean Section Depth =	4.279362	meters
Wetted Perimeter(P) =	387.344	meters			

Slope-Area Cross-Section Computation

Station: ***Arayat*** Survey Date: ***17-Oct-13***

River: ***Pampanga*** Gage ht.= ***5.31*** meters

Cross-Section number TWO (2)

Station	Distance	Elevation	Water Sfc. elev.	Depth	Mean Depth	Area	Wetted Perimeter
0.0		8.552	8.5	-0.052			
7.0	7	4.895	8.5	3.605	1.7765	12.4355	7.897699
8.4	1.4068	4.185	8.5	4.315	3.96	5.570928	1.575813
18.1	9.6718	-1.805	8.5	10.305	7.31	70.70086	11.37646
20.7	2.6374	-2.205	8.5	10.705	10.505	27.70589	2.66756
41.8	21.104	-2.705	8.5	11.205	10.955	231.1943	21.10992
51.5	9.670166	-1.305	8.5	9.805	10.505	101.5851	9.770983
70.0	18.4643	-1.305	8.5	9.805	9.805	181.0424	18.4643
88.4	18.4643	-0.405	8.5	8.905	9.355	172.7335	18.48622
95.5	7.034018	0.195	8.5	8.305	8.605	60.52773	7.059562
108.6	13.18878	0.595	8.5	7.905	8.105	106.8951	13.19485
118.3	9.671775	1.395	8.5	7.105	7.505	72.58667	9.704805
121.8	3.517009	1.395	8.5	7.105	7.105	24.98835	3.517009
138.5	16.70579	2.095	8.5	6.405	6.755	112.8476	16.72045
155.0	16.47719	3.695	8.5	4.805	5.605	92.35464	16.55469
157.0	1.98711	4.895	8.5	3.605	4.205	8.355798	2.321337
160.0	3	7.103	8.5	1.397	2.501	7.503	3.724952
161.5	1.5	7.117	8.5	1.383	1.39	2.085	1.500065
197.5	36	7.106	8.5	1.394	1.3885	49.986	36
218.0	20.49956	8.5	8.5	0	0.697	14.28819	20.5469

Total Width =	218.00	meters	Hydraulic Radius(r) =	6.10	meters
Total Area =	1355.39	meters^2	Mean Section Depth =	6.21737	meters
Wetted Perimeter(P) =	222.194	meters			

Slope-Area Cross-Section Computation

Station: ***Arayat*** Survey Date: ***17-Oct-13***

River: ***Pampanga*** Gage ht.= ***5.31*** meters

Cross-Section number THREE (3)

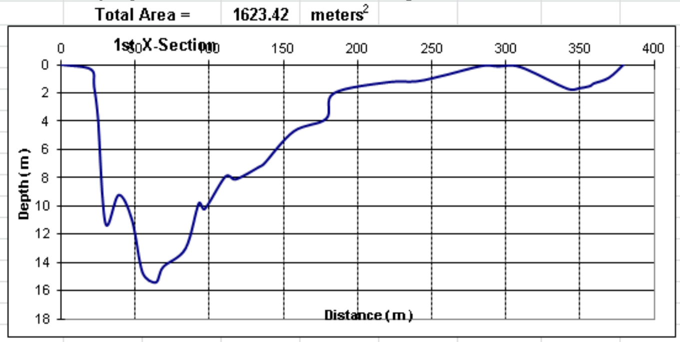
Station	Distance	Elevation	Water Sfc. elev.	Depth	Mean Depth	Area	Wetted Perimeter
0.0		7.797	7.7	-0.097			
6.0	6	5.244	7.7	2.456	1.1795	7.077	6.520568
9.3	3.34	3.844	7.7	3.856	3.156	10.54104	3.621547
10.3	0.957	-0.156	7.7	7.856	5.856	5.604192	4.112888
11.3	0.955	-1.556	7.7	9.256	8.556	8.17098	1.694705
45.6	34.378	-1.356	7.7	9.056	9.156	314.764968	34.37858
60.0	14.32	-0.456	7.7	8.156	8.606	123.23792	14.34825
63.8	3.82	-0.756	7.7	8.456	8.306	31.72892	3.831762
80.0	16.24	-0.256	7.7	7.956	8.206	133.26544	16.2477
99.1	19.098	0.744	7.7	6.956	7.456	142.394688	19.12416
111.5	12.412	0.644	7.7	7.056	7.006	86.958472	12.4124
119.2	7.642	1.144	7.7	6.556	6.806	52.011452	7.65834
127.8	8.595	1.144	7.7	6.556	6.556	56.34882	8.595
141.1	13.369	1.444	7.7	6.256	6.406	85.641814	13.37237
146.9	5.73	1.544	7.7	6.156	6.206	35.56038	5.730873
163.6	16.712	4.824	7.7	2.876	4.516	75.471392	17.03084
165.0	1.432	5.244	7.7	2.456	2.666	3.817712	1.492322
166.5	1.5	6.166	7.7	1.534	1.995	2.9925	1.760706
169.5	3	6.958	7.7	0.742	1.138	3.414	3.102783
222.5	53	7.259	7.7	0.441	0.5915	31.3495	53.00085
249.5	27	7.584	7.7	0.116	0.2785	7.5195	27.00196
273.5	24	7.483	7.7	0.217	0.1665	3.996	24.00021
274.5	1	7.7	7.7	0	0.1085	0.1085	1.023274

Total Width =	274.50	meters	Hydraulic Radius(r) =	4.36	meters
Total Area =	1221.98	meters^2	Mean Section Depth =	4.451640036	meters
Wetted Perimeter(P) =	280.062	meters			

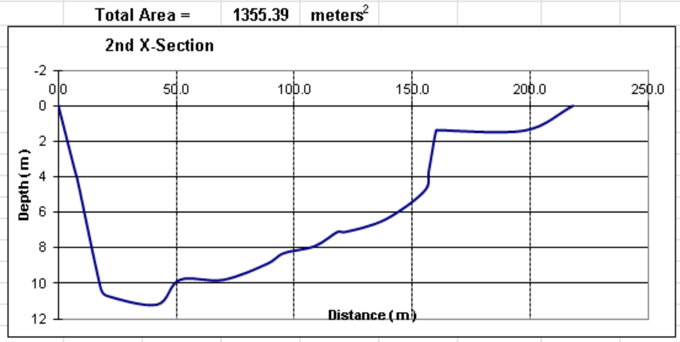
Station: *Arayat* **Date:** *17-Oct-13*

River: *Pampanga* **Gage Ht.** 5.31 **meters**

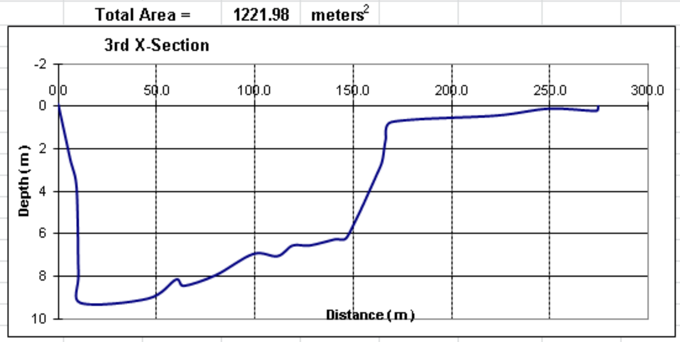
Total Area = **1623.42** **meters^2**



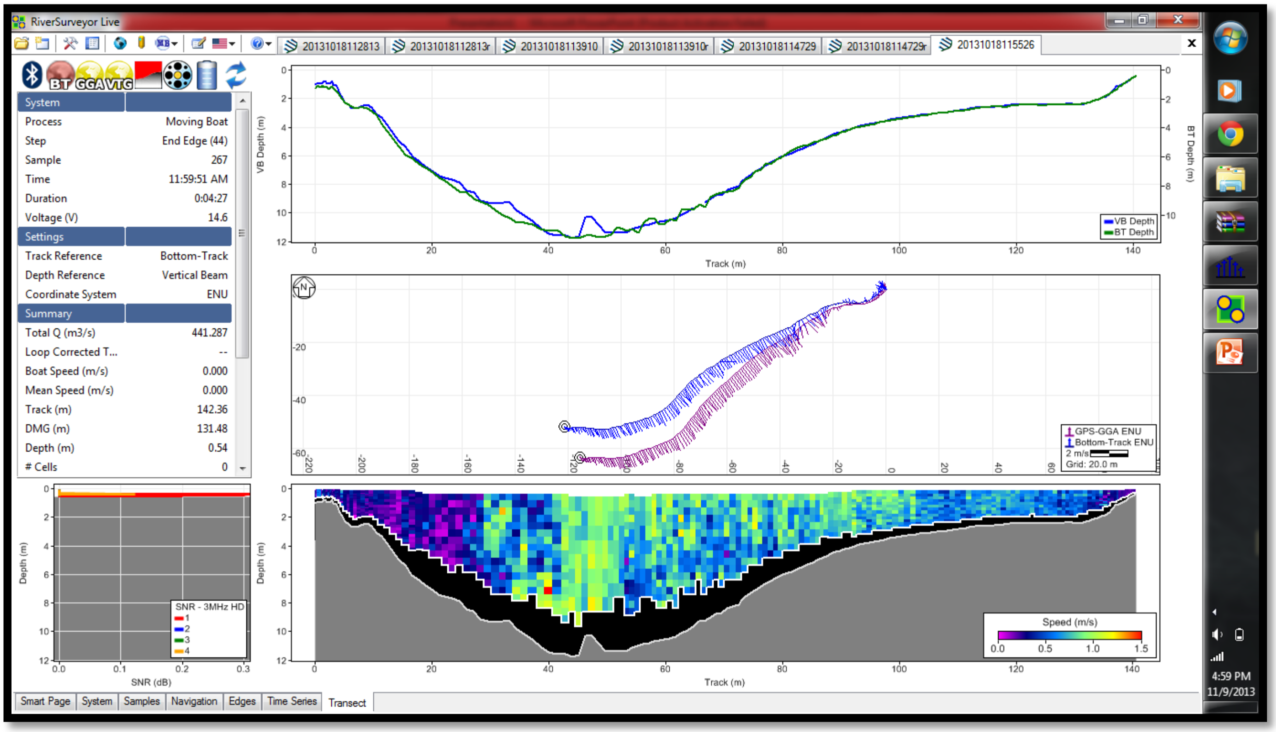
Total Area = **1355.39** **meters^2**



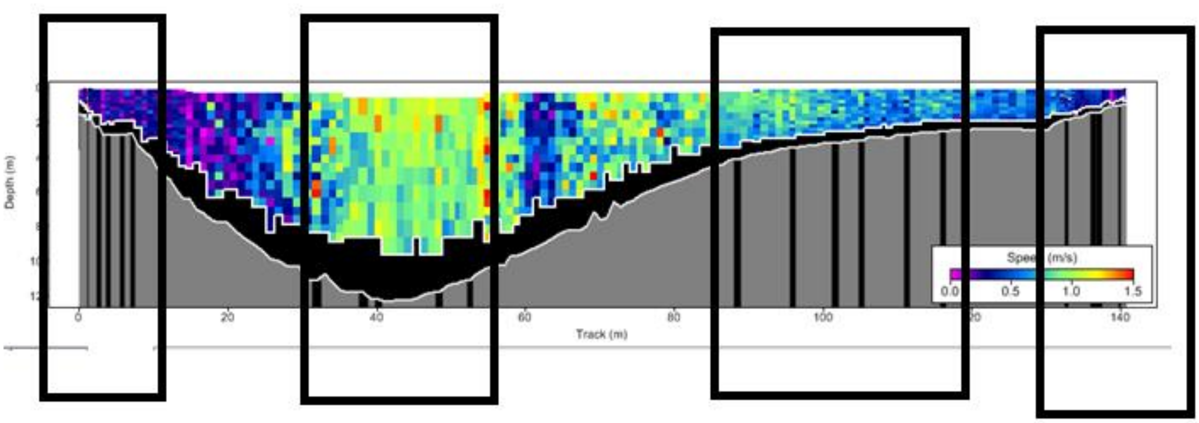
Total Area = **1221.98** **meters^2**



ADCP Method



The group made four transects along the cross section, three of which have regions of invalid ensembles resulting from invalid bottom tracking. The last transect (shown above) has no invalid ensembles and was more accurate than the first three. Discharge measured at this transect was 441.287 cubic meters per second, at gauge height equal to 4.65 m.



Highlighted portions show vertical bars below the stream bed, representing invalid ensembles resulting from invalid bottom tracking. Image taken from the first transect.

Current Meter Method

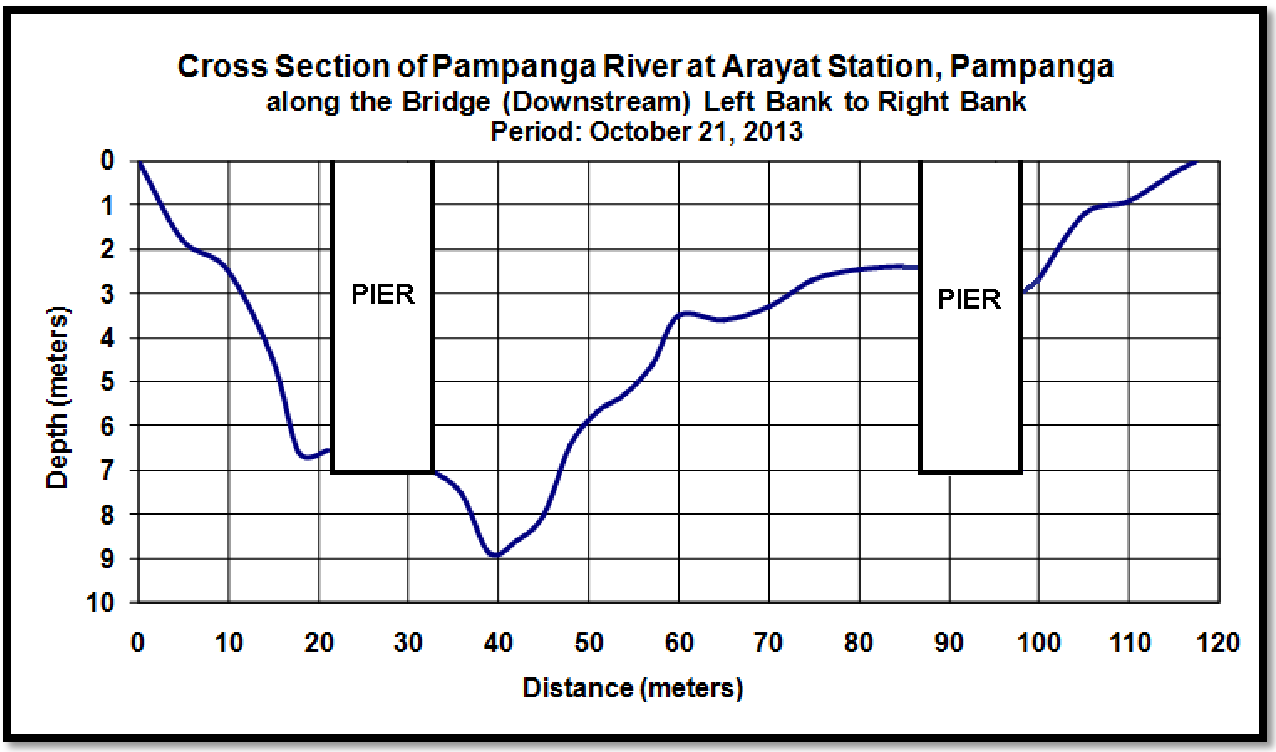
All the data gathered were entered in the excel suite for current meter discharge calculations provided by our instructor, Mr Hilton T. Hernando. The program used the mid-section method for discharge calculations and the group used the two-point method of velocity measurement (taking velocity measurements at 0.2 and 0.8 depths). Velocity formula for the current meter used was V=0.702N+0.013. Since the current meter was set to 1 beep per 5 revolutions, all the values for revolutions were multiplied by 5 prior to data entry. The summary of all data and calculations are shown below.

Discharge Measurement (Current Meter) for :		ARAYAT STATION	River:	PAMPANGA RIVER		PRFFC
DM #:	03	Date:	October 21, 2013	Team:	Group 3	FFB
Gage Height: Start:	3.16	End: 3.11	Inst. # :	1	Wx: Fair	PAGASA
Observation Time: Start:	11:15	End: 14:42	Calibration Eqtn.: V = 0.702	N+ 0.013	note: just input negative value for latter if eqtn. is minus.	hth/ 97
Vertical dist. to water surface (m) =		12.32				
Total Area (m^2) =	394.47	Ave. Gage Height =	3.14	Sectional Width (m) =	117.5	
Total Q (m^3/s) =	293.42	Ave. Vel. (m/s) =	0.744			

Dist. from Initial point	Width (mts.)	Depth (ep for pier) (mts.)	Vert. Angle 4^0-36^0	Angle Corrected Depth	Observation Depth 0.2 Rev.	0.2 Time	0.6 Rev.	0.6 Time	0.8 Rev.	0.8 Time	Velocity at point for 0.6 only	Velocity Mean (0.2,0.6 & 0.8) or (0.2 & 0.8)	Area (m^2)	Q (cumecs)	Remarks Excellent, Good Fair, Poor
0				0											
5	5	2.2	14.5	1.777	60	62.0			60	65	x	0.677	8.89	6.01	
10	5	3.6	23	2.464	90	60.7			60	63.94	x	0.863	12.32	10.63	
15	4	6	26	4.451	50	61.5			25	61.33	x	0.442	17.81	7.86	
18	3	7.7	21.5	6.602	90	62.2			80	60.62	x	0.984	19.81	19.50	
21	3.5	7.6	21	6.549	85	62.1			85	64.44	x	0.957	22.92	21.93	
25	2.85														PIER
26.7	4														PIER
33	4.65	8.4	24	7.020	80	60.82			45	65.35	x	0.716	32.64	23.38	
36	3	8.7	22	7.522	80	61.92			60	61.62	x	0.808	22.57	18.24	
39	3	9.3	13.5	8.874	85	63.71			60	62.39	x	0.819	26.62	21.80	
42	3	8.8	9.5	8.593	80	64.51			65	61.63	x	0.818	25.78	21.10	
45	3	8.1	6.5	8.007	80	63.45			50	65.27	x	0.724	24.02	17.40	
48	3	6.6	8.5	6.442	75	64.55			70	64.52	x	0.802	19.33	15.49	
51	3	6	12.5	5.660	75	61.17			60	65.6	x	0.764	16.98	12.98	
54	3	5.3		5.300	75	64.23			60	63.98	x	0.752	15.90	11.96	
57	3	4.6		4.600	80	63.35			60	64.26	x	0.784	13.80	10.82	
60	4	3.5		3.500	80	63.55			60	62.32	x	0.793	14.00	11.10	
65	5	3.6		3.600	75	61.99			55	61.06	x	0.754	18.00	13.57	
70	5	3.3		3.300	75	62.48			50	63.29	x	0.712	16.50	11.74	
75	5	2.7		2.700	75	64.57			55	63.57	x	0.724	13.50	9.78	
80	5	2.5	4	2.468	75	65.2			55	64.65	x	0.715	12.34	8.83	
85	7.4	2.4		2.400	70	61.5			55	65	x	0.710	17.76	12.60	
94.8	5.75														PIER
96.5	2.6														PIER
100	4.25	2.7		2.700	50	61.87			30	63.84	x	0.462	11.48	5.30	
105	5	1.2		1.200	25	62.54			20	88.39	x	0.233	6.00	1.40	
110	5	0.9		0.900			0	0			x	x	4.50	x	
115	3.75	0.27		0.270			0	0			x	x	1.01	x	
117.5	x	0		0.000			0	0			x	x	x	x	
											Total Area =		394.47		
Rem:											Total Discharge =			293.42	
											Ave. Velocity =			0.744	

Computation of Mean Gage Height by Q weighting Process

Station :	ARAYAT STATION			Date :	October 21, 2013	
River :	PAMPANGA RIVER					
DM # :	03			M.G.H.	3.12	meters
Time (0000)	Gage Height Reading	Ave. Gage Height		Q_{total} ending at Time	Ave. G.H. * Q	Remarks
1115	3.15					
1200	3.12	3.135		65.93	206.69	
1300	3.12	3.120		101.93	318.01	
1400	3.11	3.115		97.44	303.52	
1442	3.08	3.095		28.12	87.04	
		x			x	
		x			x	
		x			x	
		x			x	
		x			x	
		x			x	
		x			x	
		x			x	
		x			x	
			Totals =	293.42	915.26	
		Mean Gage Height =		3.12	meters	



Our group also noted that starting at 110 meters from the origin towards the water edge of the right bank, the current meter no longer registers a beep. Consequently, velocities at those points were recorded as 0. The discharge at the cross section under the bridge on the downstream side, as measured by current meter method at an average gage height of 3.14, was 293.42 cubic meters per second.

Float

After the areas at the time of velocity measurements have been determined for each subsection and in every cross section, the discharge can then be calculated. The velocity of the floats would be equal to the distance traversed (150 meters) divided by the time elapsed. The correction coefficient used to determine the average velocity was 0.92. The summary of the computations is shown on the next page.

Result of Discharge Observation By Float

Measuring Line	Time of Drop	Travelling Time (sec)	Velocity of Float (m/s)	Correction Coefficient	Corrected Velocity (m/s)	Divided Area (sq. meters)			Divided Q (cu. meters per second)
						Section 1	Section 2	Ave Area	
1	11:00 AM	732.07	0.20	0.92	0.19	57.83042	12.6228	35.22661	6.64
2	11:15 AM	198.95	0.75	0.92	0.69	105.846	22.266	64.056	44.43
3	11:20 AM	215.625	0.70	0.92	0.64	152.316	36.936	94.626	60.56
4	11:25 AM	194.23	0.77	0.92	0.71	190.894	65.714	128.304	91.16
5	11:30 AM	190.63	0.79	0.92	0.72	67.07988	37.422	52.25094	37.83
Total Discharge									240.62

The computed discharge by float method, at 2.78 gage height, was 240.62 cubic meters per second.

Rating Curve Equation and Table

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 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	ΣX^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	Σ(X) =	20.237
10.000	17.390	1.240	3.404	1.538	4.222	Σ(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	Σ(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:

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

Inferences and Conclusions

In slope area method, the reach under the survey was slightly curve. The highest flood mark was difficult to determine its elevation because of obstacles like the houses near the river. The range finder readings was inaccurate in measuring the distance in traversing the river. The path traversed on the river was not actually straight because there is no tag line used. The roughness coefficient chosen might actually be inaccurate, since it is only an estimate done through visual inspection.

In ADCP, measurements are all done in a computer, so the human error in the calculations are eliminated. But in calibrating the ADCP, it must be well done within two minutes to operate well the ADCP. Care must be taken in the assembly, set-up, and actual traverse of the boat so as to yield optimum results. When all these are taken into consideration, ADCP measurements could serve as a benchmark for other traditional discharge measurement methods. It also gives the most accurate results. But the problem that our group encounter, that is why we made four transect, is we bump a water lilies along the way. The second problem that we encounter was the miscommunication of the people that assigned in the computer side and in the boat side. We did not synchronized the simulation of the computer to the stating of the boat so the lack of the river profile can be clear seen in the output of the computer. The calibration of the ADCP device can also be a problem if it is done properly but fortunately we did not encounter that problem.

If current meter have poor condition or calibration, it may lead to error in the measurements. And the current meter that used in the field failed the spin test. In measurements, it is prone to human error, like getting the projectile angle. The current meter can't measure the velocity if the depth is low like near the edge of the river. Errors also occurred by the effects of the pier on the water current.

Float method is best in medium to high flows. The problem in this method is if the flow of the river is not uniformly distributed like in the field, the water flows in the left side. The problem that our group encountered was the water level recede gradually that's why some of the floater did not reappeared on the water.

Field Visit

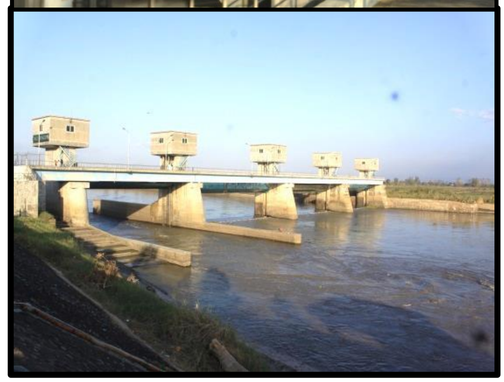
Field Visit in La Mesa Dam (October 15, 2013; Tuesday)

La Mesa Dam is located in Quezon City which is an ecological nature reserve. It is part of the Angat-Ipo-La Mesa water system, which supplies most of the water supply of Metro Manila. The dam does not have any gates in controlling the spill water so if the water reaches to the highest level; it overflows automatically into the river. The main usage of the dam is to supply drinkable water to Manila. The water from the dam is treated by the Maynilad Water Service and the Manila Water before distributing to the consumer.

Field Visit in Pantabangan Dam (October 19, 2013; Saturday)

Pantabangan Dam is located in Pantabangan, Nueva Ecija which is a one of the contributors of Pamapanga River Basin and it is mainly manage by National Irrigation Authority (NIA). It is one of the largest dams in the Philippines. Pantabangan dam has two dams; the Aya dam which is natural made and the main dam which is man-made dam. The purpose of the dam is for irrigation, electricity and also for flood control. It has a flood forecasting station that always monitors the water level in the dam and in the upstream. Unlike the La Mesa Dam, the Pantabangan Dam has 3 spillway gates. They release water if there will be a forecast that it will be reach in critical level in the coming storm.

Field Visit in Cong Dadong Dam (October 21, 2013; Monday**)**



Cong Dadong dam is located upstream in the area that we conducted the field work. The main purpose of the dam is to divert the water if it is needed in irrigation. When the huge gates close, the water will flow to the diversion canal located in the right side, facing the downstream. The diversion canal also has gates to protect the rice fields if there's a huge flood. It is also manage by the NIA. The first gate from the right does not have hump that's why almost of the water flows there. And the last two gates have different designed, double door, the purpose is to separate the debris.

Educational Tour in Municipal Disaster Risk Reduction and Management Council Calumpit Bulacan (October 23, 2013; Wednesday)

We visited the MDRRMC of Calumpit Bulacan. Calumpit is one of the amazing municipalities that is concerned about flooding in their area. They are already aware and prepared in the flood. LGU's, private company and the people that live there are helping in each other. They have their own flood model so that they will aware if there will be flood. They gather there data with the help also by PAGASA.