Flow Rating Curves for Three Small Lake Erie Streams

Grant #SG419-2012 funded through the Ohio Lake Erie Commission (OLEC) and the Lake Erie Protection Fund (LEPF). The LEPF is supported by the citizens of Ohio through their purchase of the Lake Erie License Plate.

Principle Investigator:
Linda P. Cornell, PhD, PE
BGSU Firelands
May, 2013

Abstract: Flow rating curves have been established for three small Lake Erie streams: Sawmill Creek, Pipe Creek, Mills Creek to allow the Firelands Coastal Tributaries Watershed Volunteer Stream Monitoring Program to calculate relative nutrient and sediment loadings from its monthly chemical/sediment concentration data. This expands the FCTW-VSM data base and use of volunteer-generated data for watershed education and identification of target areas for restoration and evaluation. Protocols for low and high flow stream measurements, discharge calculations, rating curves, and load calculations are discussed.

Purpose/Objectives:

This project develops flow rating curves for three creeks: Sawmill Creek (SMC)(HUC #: 041000110101), Pipe Creek (PC)(HUC #: 04100110102) and Mills Creek (MC)(HUC #: 041000110103) in the Lake Erie watershed and develops rating curve measurement protocols appropriate for volunteer stream monitoring programs. These curves provide a necessary component for determining nutrient and sediment loading in the three targeted watersheds. Additionally, the protocols for developing rating curves for volunteer stream monitoring programs have been demonstrated.

Importance:

Firelands Coastal Tributaries Watershed Volunteer Stream Monitoring Program (FCTW-VSM) collects monthly chemical/sediment concentrations in these watersheds. However, the use of the data is limited because flow is not included in the analysis. Flow data is often difficult to collect through volunteers because of site access, time constraints, and safety concerns. However, volunteers can easily and safely read water levels on a staff gage. Rating curves for each staff gage with the water level readings permit volunteers to collect flow data which expands the FCTW-VSM's data base and its ability to use volunteer-generated data for watershed education and identification of target areas for restoration and evaluation. With the addition of flow data to the monitoring program, relative nutrient and sediment loading can be calculated for site comparisons within the watershed, seasonal trends and watershed scale comparisons. Determination of nutrient and sediment loads supports the OEPA goal to develop and implement Total Maximum Daily Loads (TMDL) for tributaries into Lake Erie and is very useful for active watershed groups to plan and implement improvement projects in the absence of an approved TMDL.

Collaborators and Volunteers:

The collaboration of many community groups and agencies with BGSU Firelands has made this project possible. BGSU Firelands (PI: Cornell) collaborated with Old Woman Creek National Estuarine Research Reserve (OWC NERR), FCTW coordinator (Breann Hohman) and volunteer stream monitors, Erie County Metroparks and Perkins Township Engineering (Eric Dodrill). BGSU-Firelands (Cornell) conducted the project (monthly fieldwork, flow measurements, flow rating curves, data analysis, reports, presentations to partners and community groups). In addition, BGSU Firelands lab technician, Bruce Mollison, assisted Cornell with fieldwork flow data collection and instrument calibration. OWC NERR loaned equipment (e.g. flow meter), lab space for analysis of water samples from the VSM program, data review, and support to the FCTW- VSM. FCTW assisted with site selection and installation of water level staff gages and provided technical assistance for the project. Erie Metroparks staff (Richard Shiltz) installed the staff gage and transect posts in Sawmill Creek. Perkins Township Engineer, Eric Dodrill facilitated the installation of staff gages and transect posts in Pipe Creek and Mills Creek. The FCTW-VSM continues to monitor the streams and provide water quality data for analysis. Also, BGSU Firelands general chemistry students collected and analyzed water quality and flow data in April as a service learning project requirement of the course (Cornell, professor). The OEPA NWDO Div. of Surface Water (Katie McKibben) was the Agency Advisor and provided

technical expertise in chemical monitoring and TMDL assessment. USGS Ohio Water Science Center (Richard Barts) provided technical expertise and resources in flow measurement and rating curves.

Background

What is a Flow Rating Curve?

A flow rating curve correlates the level of the water to the discharge (volumetric flow rate, ft^3/sec) of the stream. The water level (also referred to as a "stage" or depth) is measured on the staff gage (Figure 1). To determine the discharge of a stream, the velocity (ft/sec) and cross-sectional area (ft^2) of the stream must be measured. Multiplying the velocity times the cross sectional area yields the discharge (ft^3/sec). Figure 1 illustrates a stream with a simple rectangular cross-section and constant velocity. The cross-sectional area is determined by multiplying the width by the depth. Streambeds, however, are not usually rectangular and the velocity varies throughout the stream, fastest near the surface and slower at the bottom and banks due to frictional drag as illustrated in Figure 2.

How to Determine the Discharge of a Stream using the Mid-Section Method

To determine the discharge of an irregularly shaped stream bed, the stream cross-sectional area can be subdivided into many small rectangular sub-cross sections and the average (mean) velocity measured in each sub-cross section (Figure 3). The velocity is measured at 0.6 of the depth below the surface which approximates the mean velocity for that small sub-cross sectional area (Rantz,1982, p. 134). The discharge for each subsection is determined by multiplying the cross-sectional area by the mean velocity (velocity at 0.6 below the surface). The total discharge is determined by summing the subsection discharges (Rantz,1982, p. 80-82).

As shown in Figure 3, the horizontal distance to each observation vertical is measured from a fixed point on the bank of the stream. The area of each sub-cross section is computed by use of equations 1 or 3. The discharge for each sub-cross section is calculated using equations 2 or 5. The total discharge of the stream is determined using equation 6.

Equations for cross-sectional areas (A_1 and A_n) and discharges (q_1 and q_n):

1…. $A_1 = d_1 * [w_2 - w_0]/2$
2…. $q_1 = v_1 * d_1 * [w_2 - w_0]/2$
3…. $A_n = d_n * [w_{n+1} - w_{n-1}]/2$
4…. $q_n = v_n * d_n * [w_{n+1} - w_{n-1}]/2$
5… $Q = q_1 + q_2 + q_3 + \ldots + q_n$

Where:

n = observation verticals
A_1 = cross sectional area of subsection 1
A_n = cross sectional area of subsection n
q_1 = discharge (volumetric flow rate) through subsection 1

q_n = discharge (volumetric flow rate) through subsection n
Q = total stream discharge
v_1 = mean velocity at vertical 1
v_n = mean velocity at vertical n
w_2 = distance from the initial point to the observation vertical 2
w_0 = distance from the initial point to the observation vertical 0
w_{n-1} = distance from the initial point to the observation vertical n-1
w_{n+1} = distance from the initial point to the observation vertical n+1
d_1 = depth of water at vertical 1
d_n = depth of water at vertical n

Discharge through the end subsections are calculated using the

$$A_0 = d_0 * [w_1 - w_0]/2$$
$$q_0 = v_0 * d_0 * [w_1 - w_0]/2$$

For the streams in this study, the edge velocity was zero; thus the discharge through the edge subsections is zero.

High Flow Discharge Calculations

During high flow and flooding conditions, in-stream depth and velocity measurements are difficult and dangerous to obtain. To determine discharge for high flow conditions, the surface velocity, v_s , is measured from the bank using the "orange" or "stick" method and the staff gage reading is recorded. The cross-sectional area, A_c, is extrapolated from a linear correlation between the cross sectional area and staff gage height determined from in-stream measurements (Figure 4). The discharge is then determined from equation 6:

$$6\ldots \quad Q = A_c * v_s * 0.9$$

The 0.9 factor accounts for the effect of frictional drag. (Water Action Volunteers, 2006).

Rating Curve

To create a rating curve, the discharge must be determined for many stream stages (water levels). The rating curve is developed by plotting the discharge (y-axis, ordinate axis) versus the staff gage height (x-axis, abscissa axis) on logarithmic scales (Rantz,1982, p. 287). Regression analysis (Excel, power trend line function) yields the best fit trend line relating the discharge to the staff gage reading (stage height). This approximation is suitable within the precision of volunteer generated data yet robust enough for scientific analysis. The approximation assumes that the gage height for effective zero flow is zero (Rantz, 1982, p. 289-291). The rating curve for the Sawmill Creek staff gage is illustrated in Figure 5.

Load Calculations

"Load" is the mass flow rate of a substance in a stream and is often expressed in units of lb/sec. Volunteer stream monitors sample water for nutrient concentrations which are typically expressed in units of mg/L or ppm. The stream discharge (volumetric flow rate) multiplied by the nutrient concentration generates the load, as expressed in equation 7.

7…. Load (lb/hr) = $C * Q * 6.2427 \times 10^{-5}$ (lb *L)/(mg*ft^3) * 3600 sec/hr

Where

C = concentration (mg/L)
Q = discharge (ft^3/sec)

Note: 1 mg/L = 6.2427×10^{-5} lb/ft^3 (unit conversion factor)

Methodology

Flow rating curves were developed for Sawmill Creek (SMC), Pipe Creek (PC), and Mills Creek (MC). The methodology includes: site selection and staff gage installation, flow measurement techniques, and data analysis to determine stream discharge, flow rating curves, and nutrient loads.

Site Selection

Stream sites for the placement of the level gages (1 per stream) and for stream flow rate measurements were located at volunteer stream monitoring sampling locations that are the furthest downstream without the influence of Lake Erie. Site selection criteria also included safety and public access.

The Sawmill Creek site is located on the upstream side of the Boos Rd bridge. The site is accessed from McBride Arboretum trails on the east side of the stream. Figure 6 shows Sawmill Creek at low flow, high flow and flooded conditions. The staff gage was still visible at flooded conditions.

The Pipe Creek site is located downstream of the Columbus Rd. bridge and is accessed from the nature trail behind the Perkins Township Engineering building on the north side of the stream. Figure 7 shows Pipe Creek at low, high flow, and bank full conditions and with summer algae growth.

The Mills Creek site (Figure 8) is located on the downstream side of the Strub Rd. bridge and is accessed from the first driveway on the west side of the bridge with permission of the property owners. Figure 8 illustrates low and moderate flow conditions.

Staff Gages

The staff gages were positioned so that volunteers could see them from the bank and proximate to the location of stream flow measurement. The Sawmill Creek gage was bolted to the concrete drainage culvert upstream of the Boos Rd bridge on the east bank (Figure 6) by Erie Metroparks (Richard Shiltz) on Nov. 9 2011. It is visible from the bridge where volunteers take water samples. At the Pipe Creek site, the gage is affixed to a metal post with a base plate that is bolted directly onto the stream bedrock near the south bank (Figure 7). It is visible from the nature trail on the north side of the stream. The Mills Creek gage is bolted to the Strub Rd bridge abutment and is visible from the west bank downstream of the bridge (Figure 8). The Pipe Creek and Mills Creek gage installations were completed by the Perkins Township Engineering Department (Eric Dodrill, chief engineer) by February 2012. Binoculars are used to accurately see the scale on the gages from the banks of the streams. The Firelands Coastal Tributaries Watershed Volunteer Stream Monitors began reading the staff gages in April 2012 during their monthly monitoring time.

Stream Flow Measurement Techniques

At the stream, three types of measurements are required to determine the stream discharge:

1. horizontal distance across the stream:
2. water depth
3. mean velocity.

The location of the cross-sectional profile where the stream measurements are taken should be located in a straight section of the stream where the total flow is confined in one channel. Ideally, the streambed and banks should be stable and as uniform as possible with minimal obstructions (boulders, heavy aquatic growth, etc.) in the flow. The location should be within the proximity of the staff gage and safely and readily accessible, as seen in Figures 6-8. (Rantz,1982, p. 5-6). The cross-sectional profile is perpendicular to the flow of the stream.

Metal stakes (4 ft fence posts) were installed on each bank above the highest water line to mark the position of the cross-sectional profile and insure that the profile is in the same position for all measurements. A measuring tape (0.1 ft divisions) was stretched across the stream perpendicular to the flow and attached to the stakes using bungee cords. The horizontal position (w_n) of each sub-cross section was measured on the measuring tape using one of the stakes as the initial point (Figures 6-8).

The depth (d_n) of each sub-cross section was measured using a top-setting wading rod which is composed of two connected rods: the main rod and the setting rod as shown in Figure 9. The velocity was measured using a Marsh-McBirney MMI Model 2000 Flow-Mate Portable Water Flow meter. The flow meter was attached to the bottom of the setting rod. The rod was placed in the stream with its base plate resting on the streambed. The depth of water was read on the graduated main rod. When the setting rod was then adjusted to read the depth of water, the flow meter was automatically positioned at 0.60 depth. (Rantz,1982, p. 97). The flow meter was

oriented parallel to the flow facing upstream. The velocity was read from the flow meter according to the manufacturer directions. (Marsh-McBirney Inc. 1990).

The number and spacing of measurements across the stream is determined so that the discharge in any subsection does not exceed 10% of the total discharge (Rantz,1982, p. 140). The number of subsections recommended is 25-30. However, if the stream cross-section and flow are uniform, fewer are sufficient (Rantz,1982, p. 40). The spacing of the measurements is closer together in areas where the bottom of the streambed is not uniform or the stream is deeper and the velocity faster. The width of the three small streams in this study is between 20 and 34 feet; the spacing interval is approximately one foot.

Measurements were taken across the stream, starting at one bank and moving across the stream to the opposite bank. Horizontal position, depth, and velocity at 0.6 depth were measured for each sub-cross section. The top-setting wading rod with the flow meter attached was held at the measuring tape. The rod was held in a vertical position with the meter facing upstream parallel to the flow. The horizontal position was read from the tape. The depth of the water was read from the main rod and the setting rod adjusted accordingly so that the flow meter was 0.6 times the depth below the surface. The velocity was measured after the meter reached stability. The flow meter was zeroed on the day of each measurement following manufacturer instructions. To achieve an accurate velocity reading, the person holding the rod in the stream stood about 1.5 feet downstream of the rod so that their feet did not interfere with the natural flow of the stream passing over the flow meter. (Rantz,1982, p. 146). A second person recorded the data and assisted in setting the tape, handling equipment and providing safety backup (Figures 6-8).

A sample data sheet is illustrated in Figure 10. The data recorded includes: Stream name, site location, date, time, name(s) of data collectors, weather at time of readings, weather within the past 24 hours, staff gage reading, other descriptions, the lateral (horizontal) distance, depth and velocity and from which side of the stream the measurements are started. One convention to record the side of the stream is to face downstream and use left/right (Rantz,1982, p.141). However, in this project the data collector faced upstream in the same orientation as the flow meter and identified the initial bank as left or right. Also physical attributes (same side as staff gage/telephone poles, etc.) and cardinal compass points (east/west, north/south) were used to describe the banks and location of profile site.

Safety of the data collectors is paramount; fieldwork was always done in pairs. The in-stream data collector wore chest waders and boots and only entered the streams at safe flow conditions. Moving carefully across the stream using the wading rod or pole for support to prevent slipping was helpful. The data collectors had a cell phone to call for help if needed. Towels, extra set of dry clothes and socks, bug spray, sun screen, and drinking water were also taken along for field work. A camera was used to document sites and record interesting/unusual conditions.

High flow Conditions (unsafe for entering the stream)

During high flow conditions when wading in the stream was unsafe, the velocity of the stream was estimated by measuring the time it took for a floating object (stick or foam bubbles) to travel a known distance down the stream. The known distance was measured along the bank and marked. One person threw in a stick beyond the starting line and the second person stood at the

finish line and timed the travel. The person throwing the stick tried to get the stick in the main flow region. If the stick got hung up in its travel, another attempt was made using another stick. This was repeated many times (4—8) and the time averaged. In one case in Sawmill Creek, foam bubbles were very stable and used to time the flow at the surface. Oranges are typically recommended; however when oranges were thrown from the bank or bridge, they became submerged and then popped up unpredictably somewhere else. Also, the cost, availability and "pollution" effect made them less desirable. Sticks from the surrounding banks were handy, free and natural to the environment. In this study, the depth did not over-top the staff gages. Thus, the water depth was estimated from the staff gage. The width in high flow and flooded conditions was estimated to be the total width of the stream at bank full conditions.

If the staff gage were totally submerged in a high flow condition, the data collector could note the water level on a bridge abutment or other permanent feature in the stream. Then during a safe, low flow condition, measure that depth again and compare it to the staff gage. At Sawmill Creek, the distance from the railing of the bridge to the surface of the water was measured during a high flow event using a long measuring tape and measured again during a low flow event and compared to the staff gage reading during the low flow event.

Flow measurement and equipment testing began at the end of October and stream measurements began in November 2011 in Sawmill Creek due to temperatures above freezing and some heavy rains. Stream measurements in Pipe Creek and Mills Creek began in March 2012. A minimum of 5 in-stream discharge measurements were made for each stream at different water levels. High flow measurements (flow too fast to safely enter stream) were also made in each creek using the "stick" method.

Water Quality Parameters Measured:

Several water quality parameters were measured in-stream at the same time that the flow data was collected. A YSI Professional Plus Instrument with a Quatro cable was used to measure dissolved oxygen, temperature, pH, conductivity and nitrate. The sensors were calibrated in lab prior to each stream test following the manufacturer's instruction (YSI Incorporated, 2009). At the stream, the sensors were placed in the stream to reach temperature equilibrium, then the sensor readings were recorded.

Materials and Equipment:

The supplies and equipment used in this study is summarized below.

- Fence posts (2 per stream)
- Tape Measure: 165 ft, 0.1 ft
- Bungee cords (2)
- MMI Model 2000 Flow-Mate Portable Water Flowmeter by Marsh-McBirney
- Top-setting wading rod
- 4 ft x 1 inch dowel rod (extra stream wading support if needed)
- Clip board

- Data record sheets
- Pencil/pens
- Chest waders
- Water proof boots
- 5 gal bucket to carry supplies to site
- Garden clippers to clear prickers away from posts
- Gloves
- Bug spray
- Cell phone
- Watch
- **YSI multifunctional meter (DO, T, pH, conductivity, nitrate)
- **Calibration standards (nitrate, conductivity) for YSI electrodes

** for water quality parameter measurements but not needed for flow measurements

Discussion

Flow measurements were taken in Sawmill Creek at 14 stages, Pipe Creek at 14 stages, and Mills Creek at 15 stages from November 2011 through June 2012 (Appendix A-C). The stage heights ranged from 0.64 ft. to 4.8 ft. (flooded) in Sawmill Creek with bank full at about 4.5 ft. For Pipe Creek, the stage heights ranged from 0.02 ft. to 1.4 ft. (flooded) and its bank full stage height is about 1.14 ft. In Mills Creek, the stage heights ranged from 1.38 ft. to 4.77 ft. (near -flood) with a bank full stage height of 4.48 – 4.77 ft.

Cross-sectional area, determined from in-stream measurements, is correlated with staff gage height for each stream (Figures 4, 11, and 12). These correlations are used to predict the cross-sectional area under high flow conditions when direct in-stream measurements cannot be performed safely. During flooding when the stream overtops the banks, the area predicted by the correlation may not be very accurate. The cross-sectional area has a strong linear correlation with the staff gage height ($R^2 > 0.97$) for Sawmill Creek and Mills Creek. The correlation is slightly lower for Pipe Creek ($R^2 = .90$) probably due to the presence of thick algae mats during four June measurements.

The discharge for each stream stage, calculated using the mid-section method and "stick" method, is shown in Table 1 along with the width, average depth and average velocity at the stream site. The bank to bank width of Sawmill Creek is about 19 ft., Pipe Creek is about 25 ft. wide and Mills Creek is about 33 ft. wide. In Mills Creek, the water was deeper (about 1 ft.) and the flow tended to be smoother than in Sawmill Creek (depth about 0.6 ft.) and Pipe Creek (depth about 0.3 ft.).

Rating curves were developed for each stream by plotting the discharge (y-axis) versus the staff gage height (x-axis) on logarithmic scales and applying regression analysis (Excel, power trend line function) to determine the best-fit trend line (Figures 13, 14 and 15). The correlation equations for stream cross-sectional area and the rating curves are summarized in Table 2. The

correlation coefficients for Sawmill Creek and Mills Creek rating curves are greater than 0.96 while Pipe Creek's correlation coefficient is lower at $R^2 = 0.88$. The average standard deviation for each rating curve was determined by comparing the discharges measured directly with those predicted using the rating curves (Table 3). The average standard deviations for the rating curves are: 25% for Sawmill Creek rating curve, 32% for Pipe Creek rating curve, and 15% for the Mills Creek rating curve. The presence of algae mats may have caused greater variability in the Pipe Creek results.

Nutrient and sediment loads are calculated using data collected by the Firelands Coastal Tributaries Volunteer Stream Monitors during monthly collections from April to November, 2012. Ammonia, nitrate, soluble reactive phosphorus (SRP), and sediment concentrations as well as the staff gage heights were measured within a two day window, except for the Sawmill Creek April collection which was monitored the first week of April. Staff gage heights for Pipe Creek were not available July – October, 2012. The concentrations and loads for the water quality parameters are illustrated in Figures 16-19.

Ammonia loads and concentrations are illustrated in Figure 16 for all three streams. Ammonia loads were lowest for Sawmill Creek (< 0.10 lb/hr). Pipe Creek was highest in April-June (<0.25 lb/hr) while Mills Creek had a spike of 0.49 lb/hr in November. The importance of measuring discharge is evident in Figure 16. On 6/18/12, the ammonia concentration in Pipe Creek was 0.24 mg/L with a load of 0.25 lb/hr. In Mills Creek on 11/18/12, the concentration was lower (0.21 mg/L) but its load (0.49 lb/hr) was nearly twice that of Pipe Creek due to a larger discharge rate. Pipe Creek had higher ammonia concentration in May and but had higher loads in April, May and June. Sawmill Creek had the lowest ammonia concentrations and loads.

Nitrate loads and concentrations were consistently highest in Mills Creek as seen in Figure 17. The load decreased from 7.24 lb/hr in April to 1.0 lb/hr in July then increased to its highest level 12.8 lb/hr in November. All three streams had the highest loads in November. Though the concentration in Mills Creek was lower than Pipe and Sawmill Creeks, the nitrate load in Mills Creek was highest due to its larger discharge rate. Sawmill Creek had negligible nitrate loads in July September, and October. During 2012, the concentrations at all the creeks did not exceed the drinking water standard of 10 mg/L.

Nitrates were also measured using a YSI nitrate electrode when flow measurements were conducted in March through June 2012. The probe was placed directly in the stream in the vicinity of the flow measurements. These nitrate concentrations and loads are illustrated in Figure 18 for Pipe and Mills Creeks. The concentration exceeded the drinking water standard in Mills Creek during most of the sampling times (April 4 – June 19) and in Pipe Creek in May and June. The nitrate load in Mills Creek was as high as 30 lb/hr and exceeded the load in Pipe Creek for most sampling times. Although the nitrate concentrations and loads were higher than those based on the VSM data, both sets of data show that the nitrate loads and concentrations are highest in Mills Creek.

Soluble reactive phosphorus loads and concentrations were also highest in Mills Creek as shown in Figure 18. The SRP load ranged from 0.08 to 0.67 lb/hr and the concentrations ranged from 0.048 to 0.611 mg/L. The highest load occurred during the June sampling. In Pipe Creek, the

maximum SRP load was 0.2 lb/hr in May and the maximum concentration was 0.55 mg/L. The SRP loads and concentrations were lowest in Sawmill Creek (maximum: 0.048 lb/hr, 0.44 mg/L).

Total suspended solid loads and concentrations are shown in Figure 20. The total suspended solids were very low for all of the streams during most of the sampling dates due to non-storm conditions. The concentrations were less than 10 mg/L and loads were lower than 0.009 lb/hr. One sampling date corresponded with a storm in Sawmill Creek watershed. The concentration of TSS jumped to 84 mg/L and the load spiked at 0.091 lb/hr.

Conclusions

The addition of flow rating curves with staff gages mounted in small streams adds a strong tool for volunteer stream monitoring groups to extend the usefulness of their data bases. The in-stream flow measurements needed to create the rating curves can be done by a small group of trained volunteers or staff from supporting agencies. Once the rating curves are created, the volunteers simply read the staff gages during their routine monitoring. The rating curves can then be used to estimate loads for any concentration parameter being measured.

REFERENCES

Rantz, S.E. and others, 1982. Measurement and Computation of Streamflow: Volume I Measurement of Stage and Discharge. Geological Survey Water-Supply Paper 2175, United States Government Printing Office, Washington D.C. 1-284.

Rantz, S.E, and others, 1982. Measurement and Computation of Streamflow: Volume 2. Computation of Discharge. Geological Survey Water-Supply Paper 2175, United States Government Printing Office, Washington D.C. 285-631.

Water Action Volunteers, 2006. Volunteer Monitoring Factsheet Series: Stream Flow: Flow Speaks Volumes. University of Wisconsin Extension and Wisconsin Dept of Natural Resources. 1-4.

Marsh-McBirney Inc. 1990. MMI Model 2000 Flow-Mate Portable Water Flowmeter Instruction Manual. 1-17.

YSI Incorporated, 2009. Professional Plus User Manual, Item # 605596. 1-79.

Figure 1: Simple Rectangular Stream Flow Profile with Constant Velocity

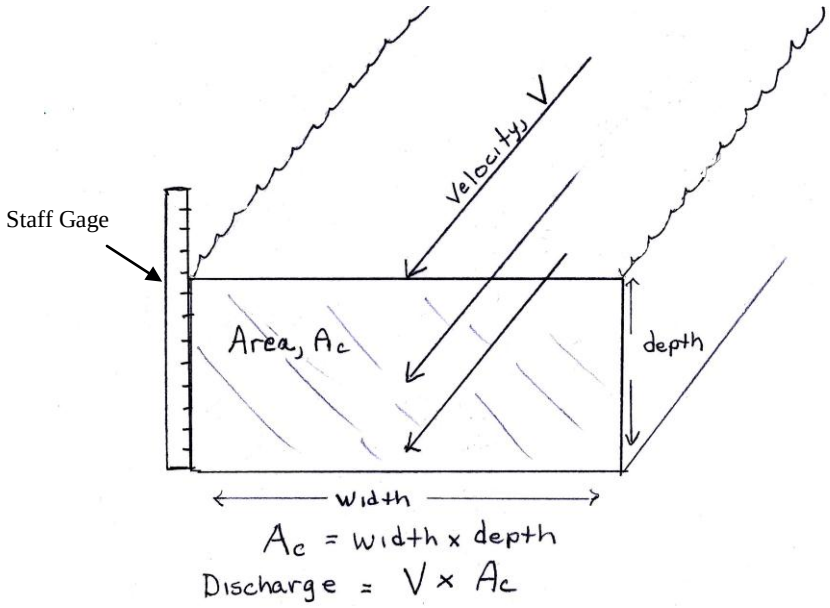


Figure 2: Typical Stream Flow Profile

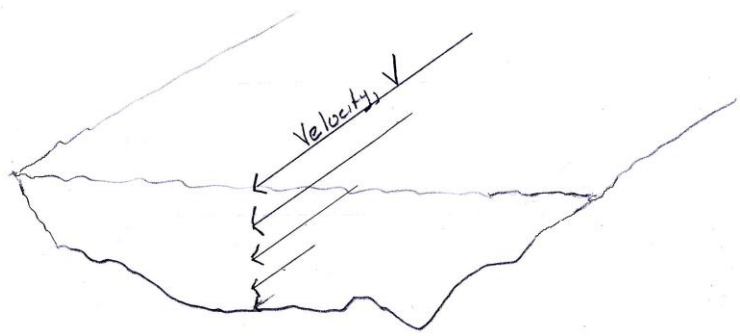
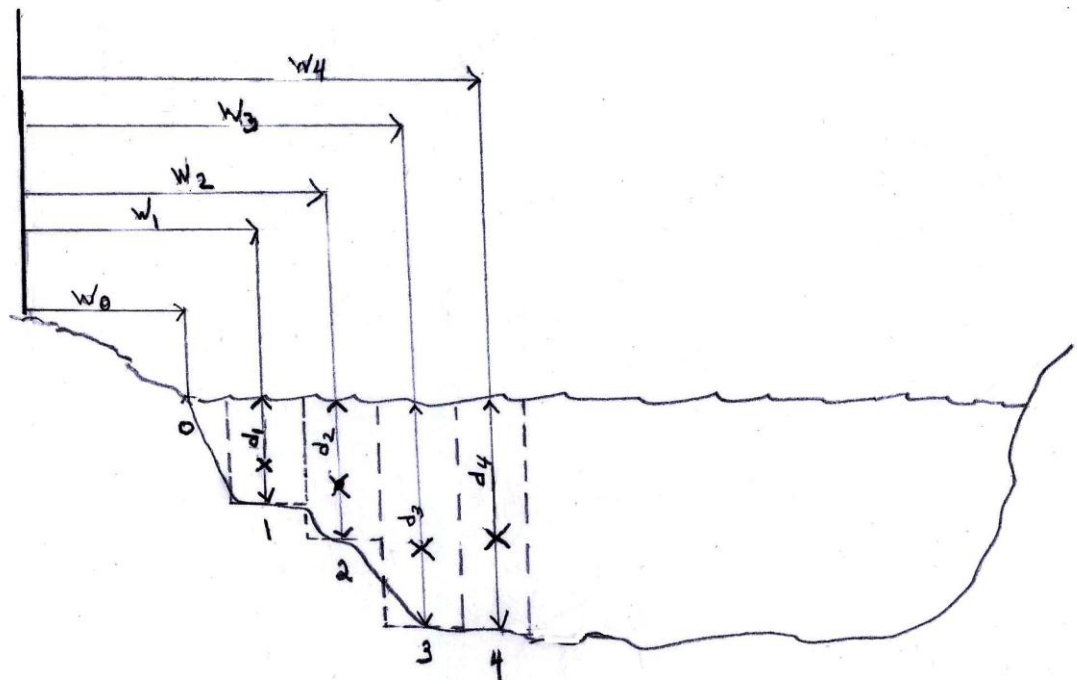


Figure 3: Stream Profile with Sub-cross Sections (Mid-Section Method)



1,2,3…n	observation verticals
d_n	depth of water at observation vertical n
w_n	horizontal distance from initial point to observation vertical n
x	0.6 of depth below surface
dashed lines	boundaries of subsection

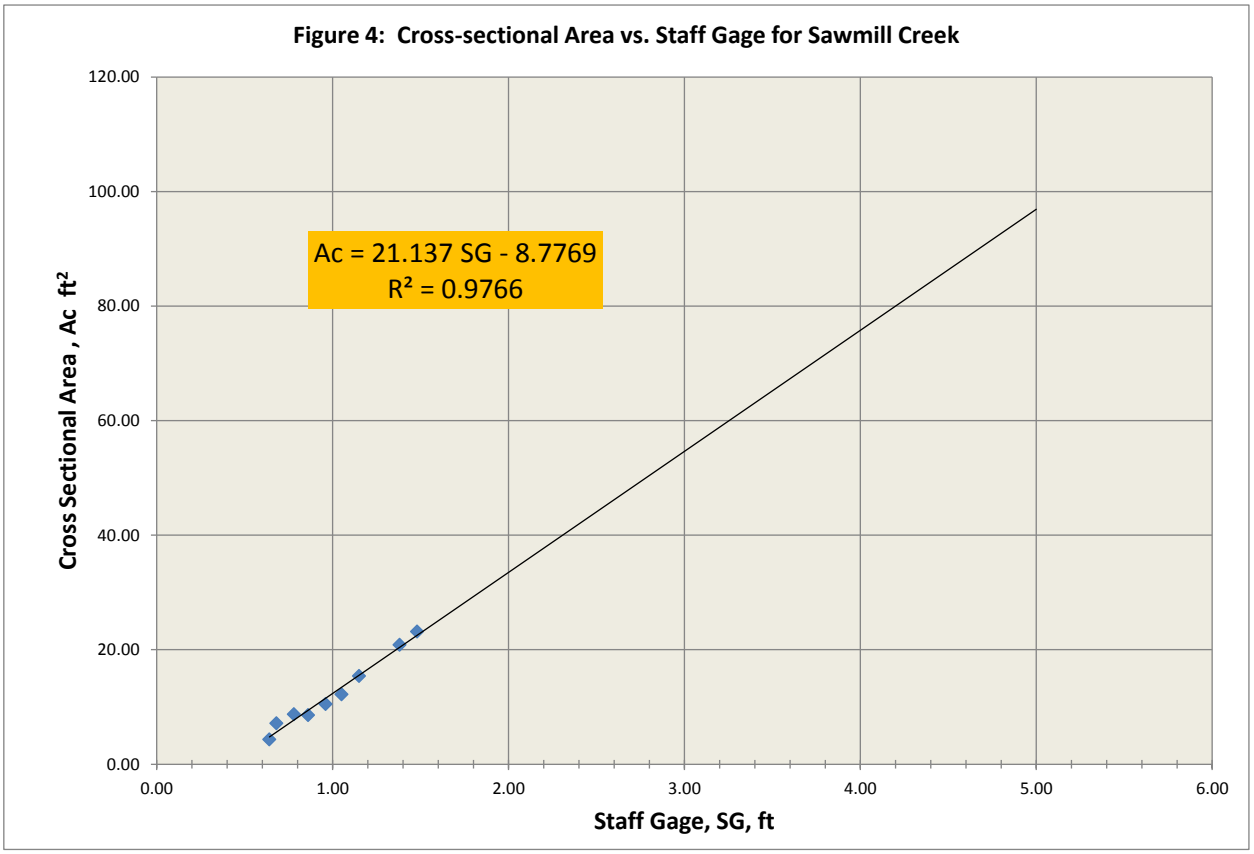


Figure 4: Cross-sectional Area vs. Staff Gage for Sawmill Creek
Ac = 21.137 SG - 8.7769
R² = 0.9766
Cross Sectional Area , Ac ft²
Staff Gage, SG, ft
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00

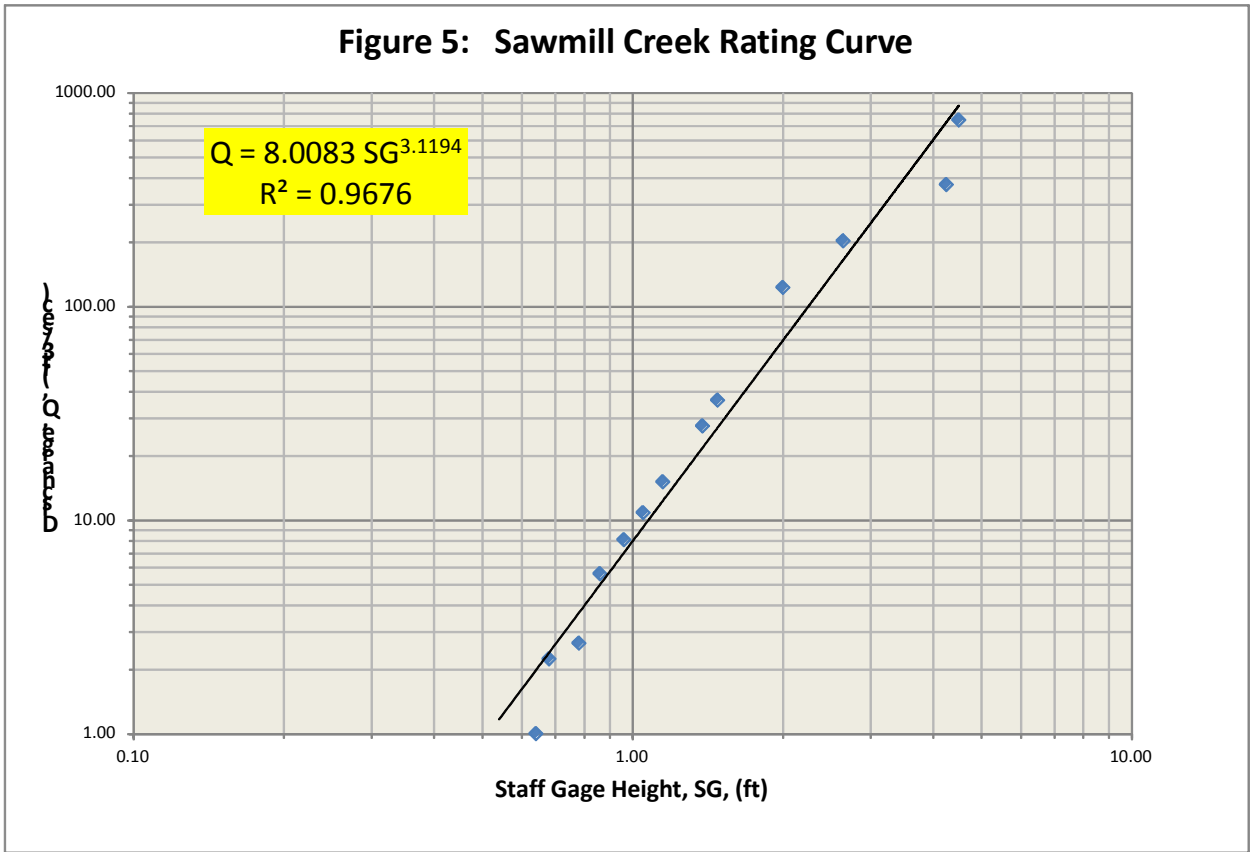


Figure 5: Sawmill Creek Rating Curve
Q = 8.0083 SG^3.1194
R² = 0.9676
1000.00
100.00
10.00
1.00
0.10
1.00
10.00
Staff Gage Height, SG, (ft)

Figure 6: Sawmill Creek at Boos Rd Site

Figure 7: Pipe Creek at Columbus Rd Site

Figure 8: Mill Creek at Strub Road Site

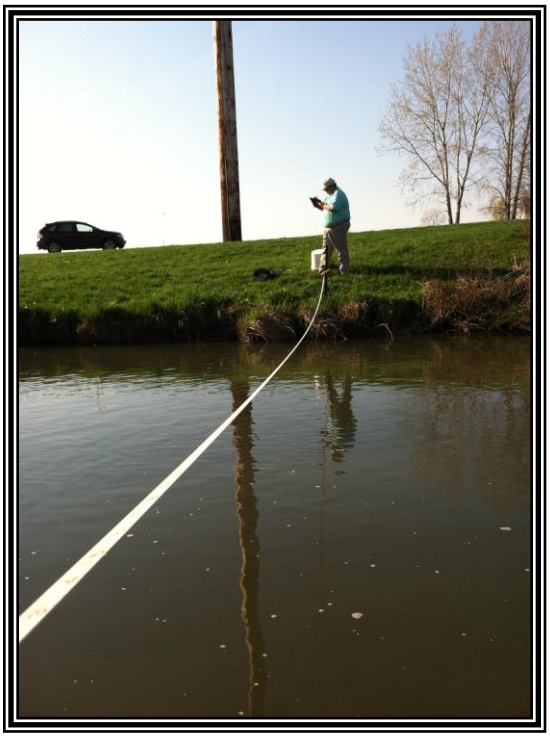
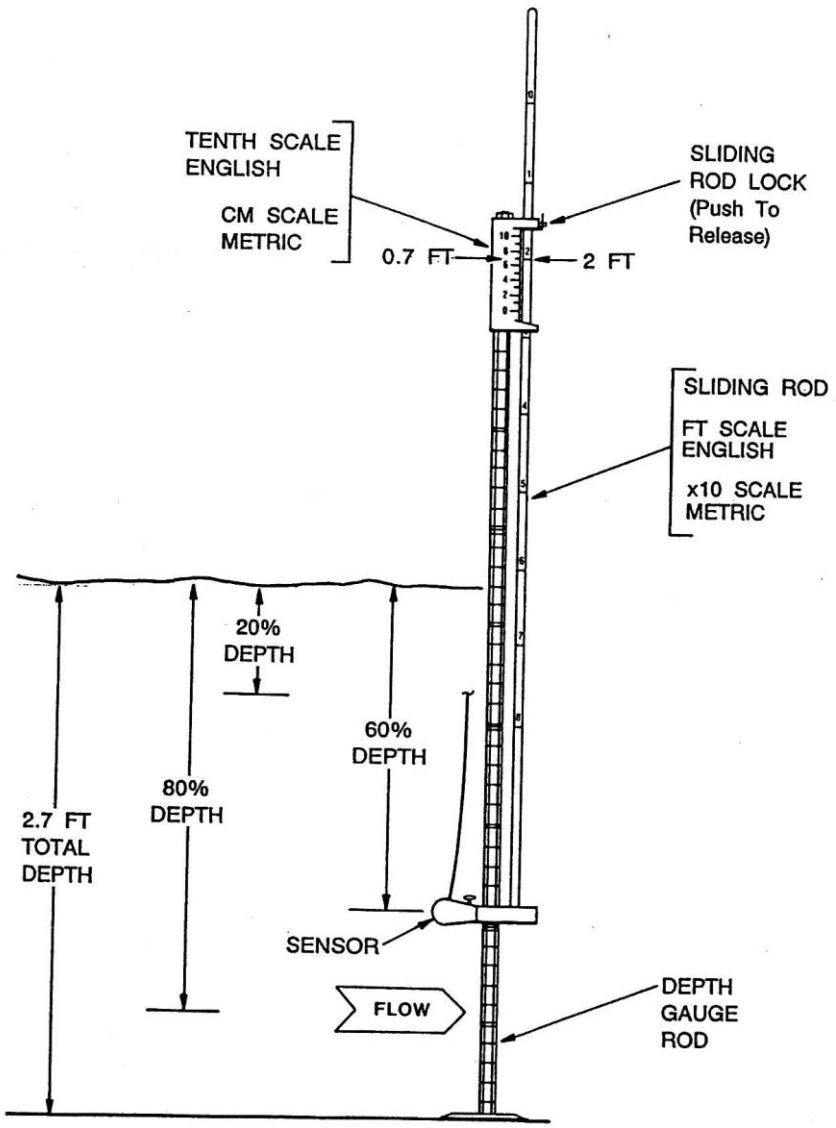


Figure 9: Top-Setting Wading Rod with Flow Meter



MMI Model 2000 Flo-Mate Portable Water Flowmeter Instruction Manual, Marsh-McBirney Inc. (1990)

Figure 10: Sample Data Sheet

Flow Rate Discharge Data Form

Stream: Pipe Creek

Sampling Location: Columbus Ave

Date: 5·11·12

Start Time: 10:30 am

End Time:

Sampling Method: 0.6 method

Monitors: Cornell / Mollison

Weather Conditions :

(air temp, sunny, rainy, cloudy, partly cloudy)

Weather Conditions in the past 24 hours:

(sunny, rainy, couldy, partly cloudy)

Other Descriptions: NO ALGAE MAT ON Surface

Gauge = 0.10 ft

Discharge = 8.2671 ft³

width = 25.4 ft

ave depth = 0.312 ft

ave vel = 0.9284

T- 14.1 °C

B.P. 750.0 mm Hg

% DO 104.3 10.72 ppm

Cond 635 µ Sim

pH 8.13

NO3 11.3 ppm

South

Left side facing up stream

Time	Bank	Staff Gauge (ft)		Transect Distance (ft)		Depth (ft)	Velocity (ft/sec)
	4.0	.10		4.0		0	0
				5.0		.23	0
				6.0		.25	1.02
				7.0		.32	1.03
				8.0		.25	1.27
				9.0		.38	1.27
				10.0		.38	1.42
				11.0		.35	1.25
				12.0		.38	1.41
				13.0		.32	1.29
				14.0		.45	.98
				15.0		.70	1.32
				16.0		.38	1.21
				17.0		.32	1.06
				18.0		.32	1.05
				19.0		.30	.88
				20.0		.30	.93
				21.0		.35	1.07
				22.0		.40	.96
				23.0		.32	.91
				24.0		.30	1.15
				25.0		.30	.91
				26.0		.30	.82
				27.0*		.20	0 *By Pipe

Figure 11: Cross-Sectional Area vs. Staff Gage for Pipe Creek

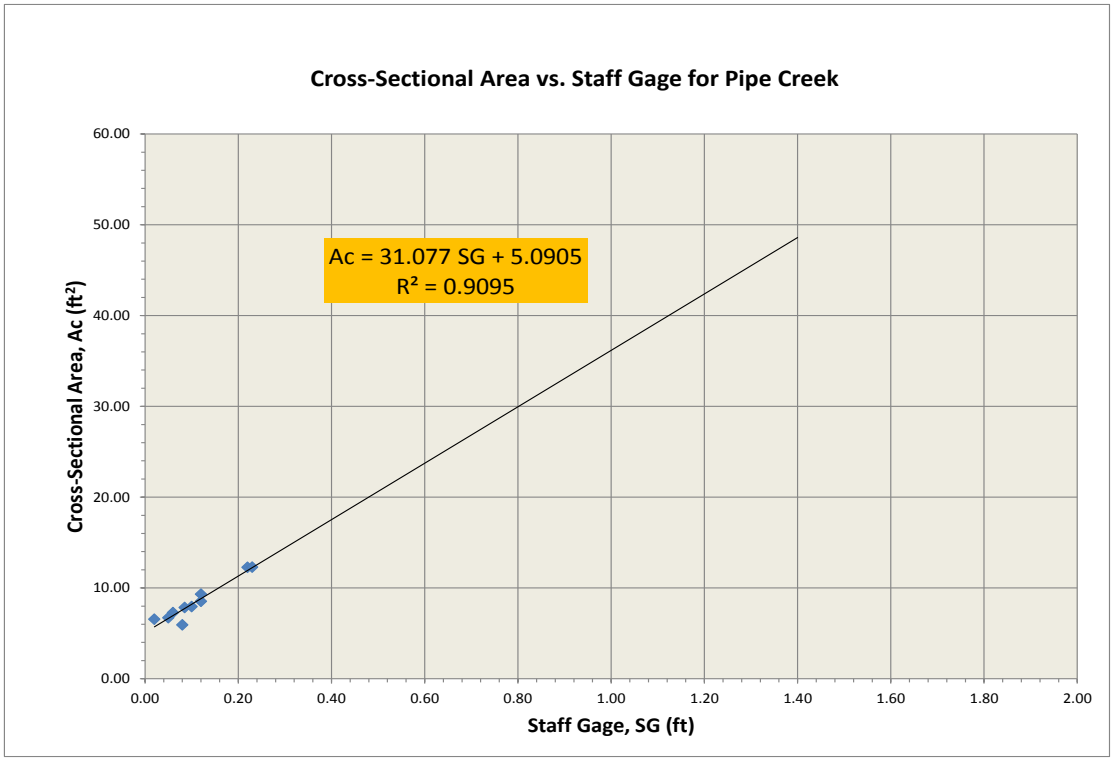


Figure 12: Cross-Sectional Area vs. Staff Gage for Mills Creek

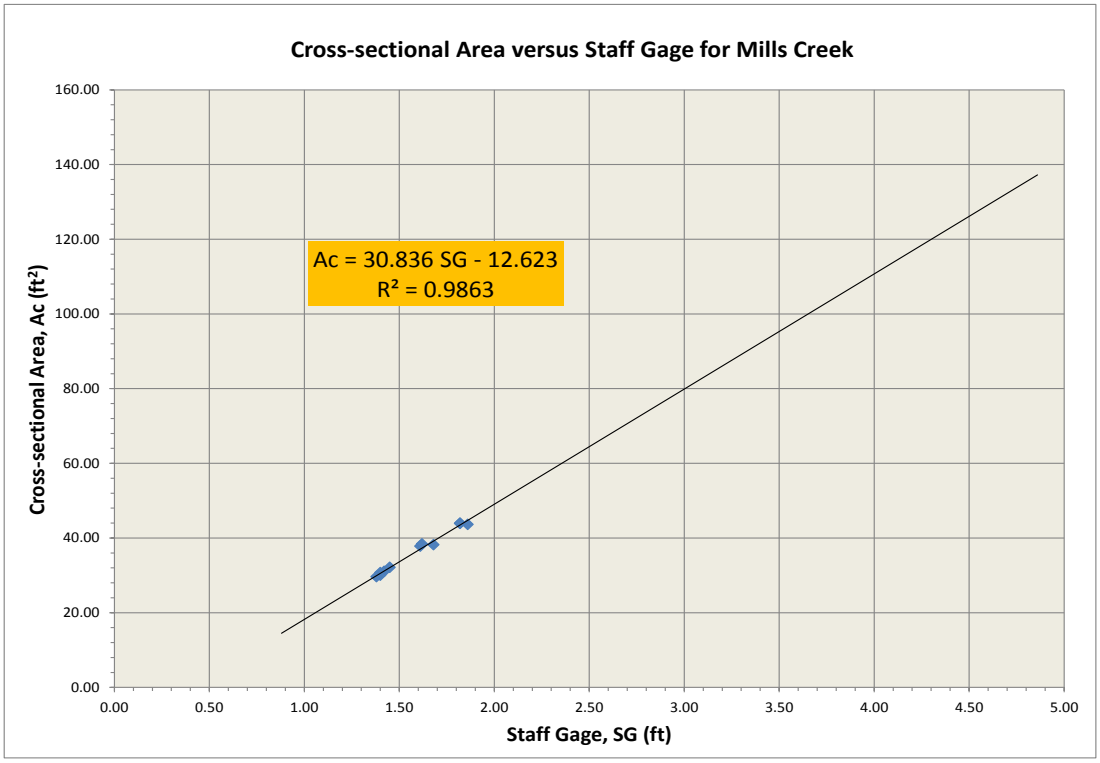


Figure 13: Sawmill Creek Rating Curve

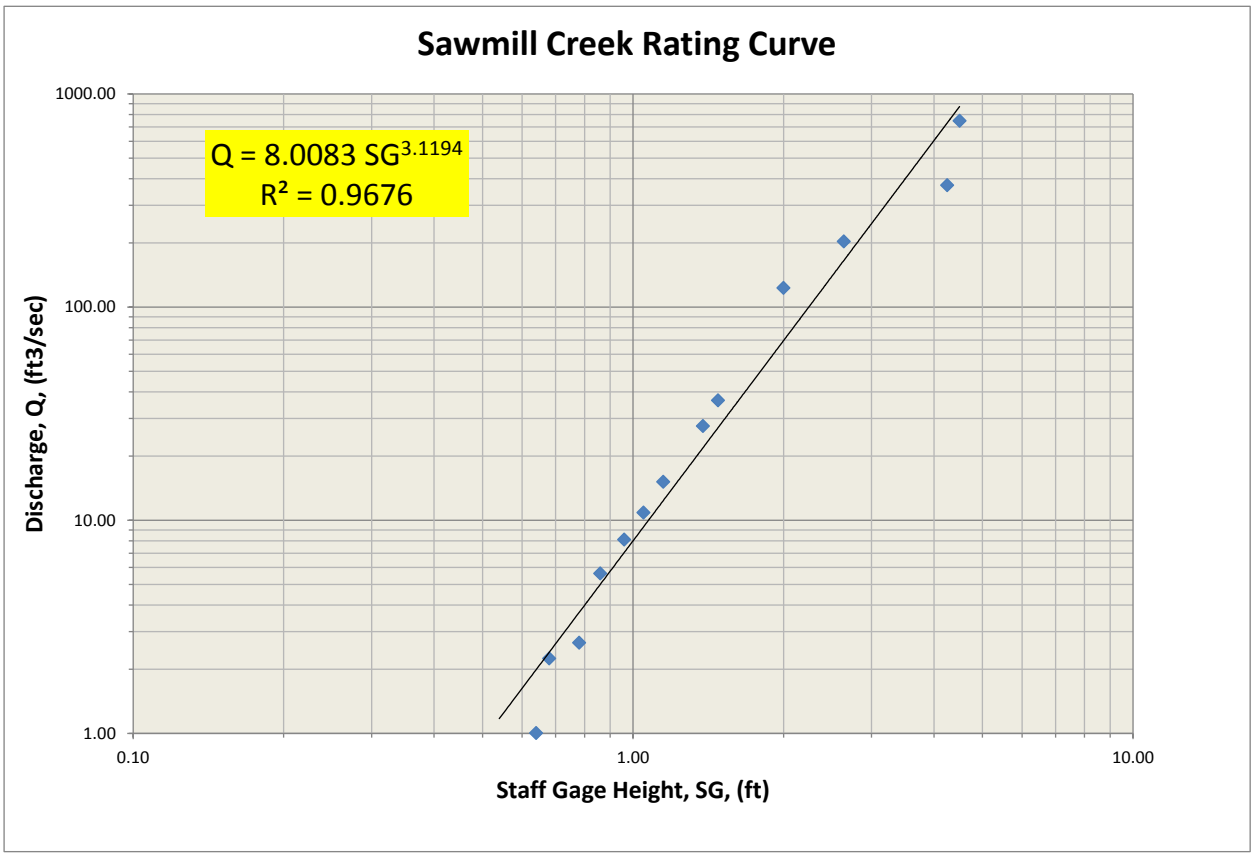


Figure 14: Pipe Creek Rating Curve

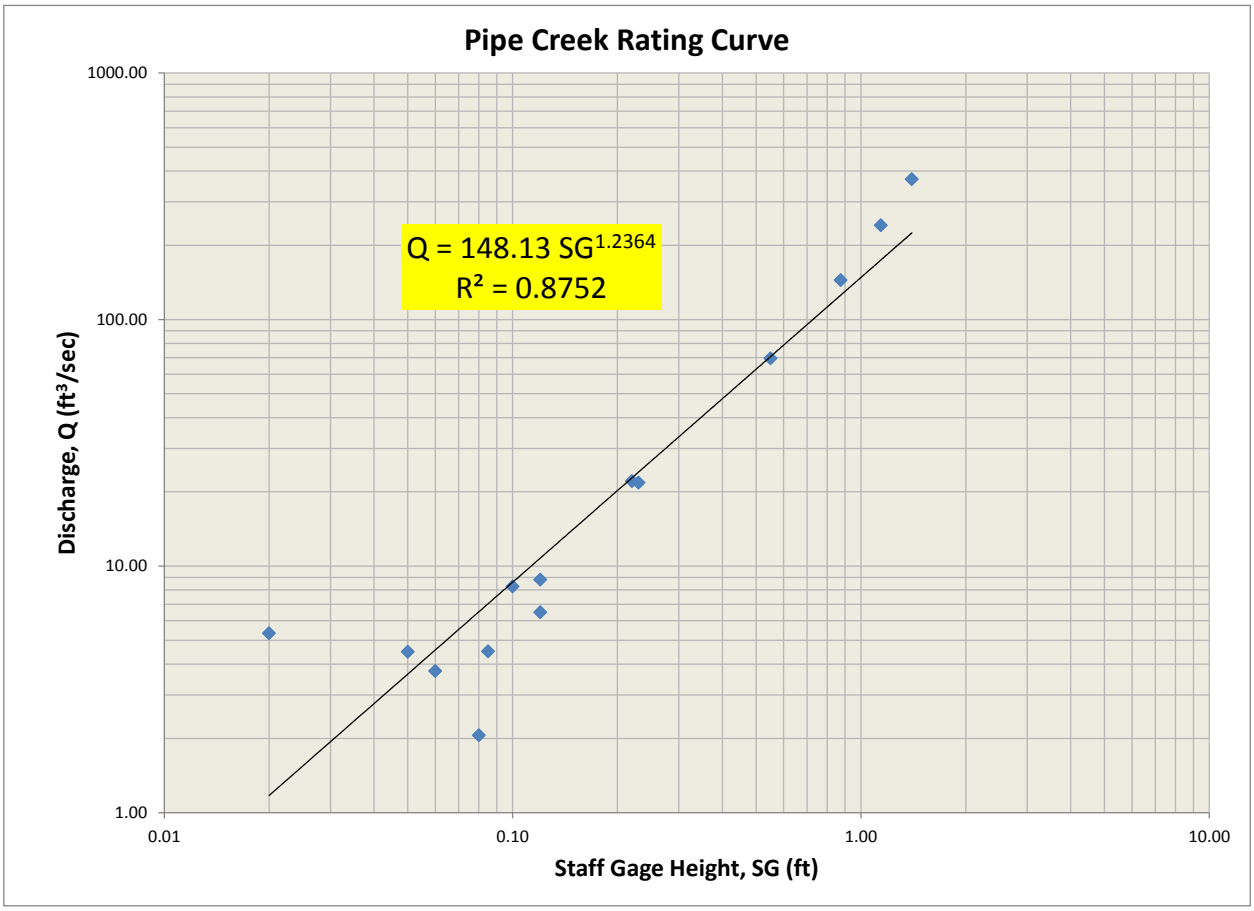
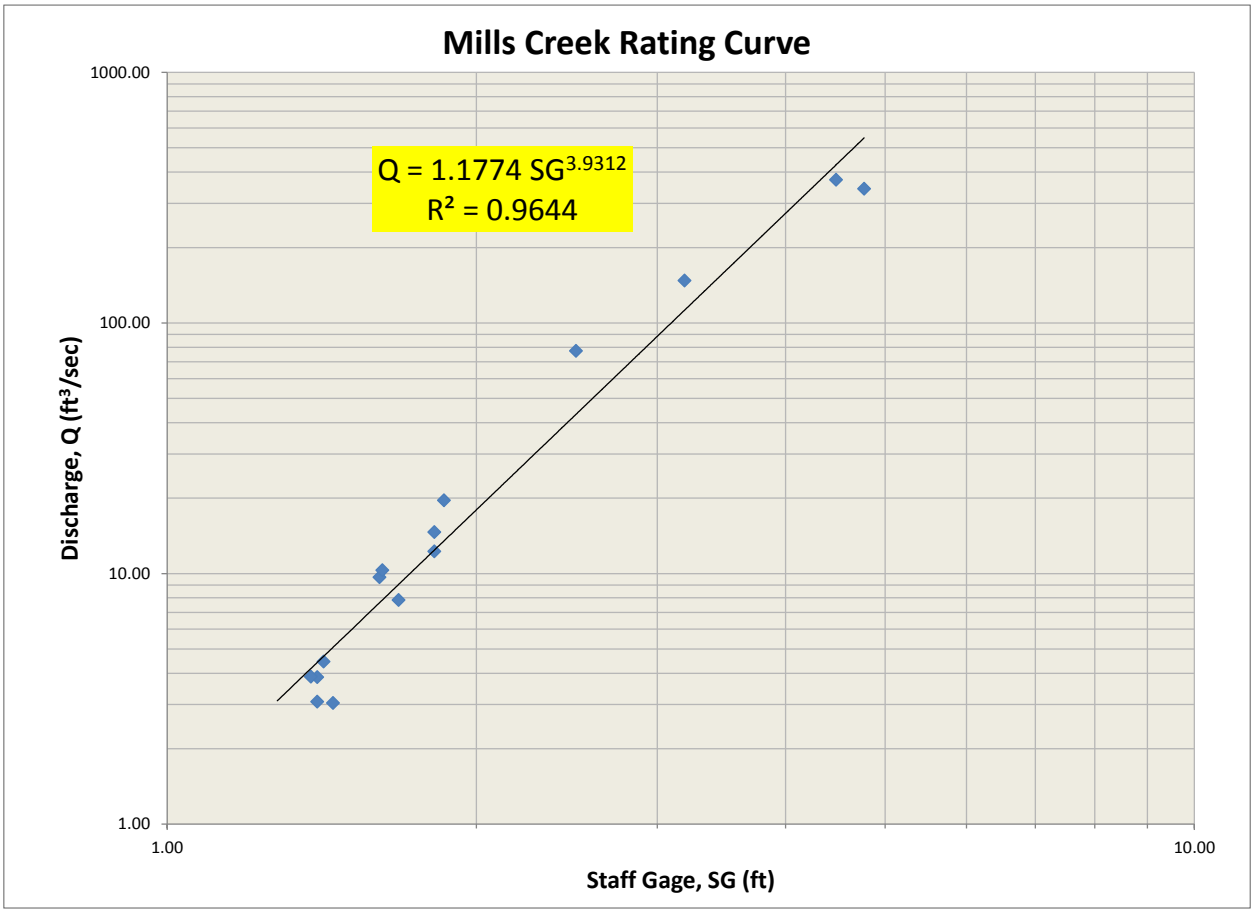


Figure 15: Mills Creek Rating Curve



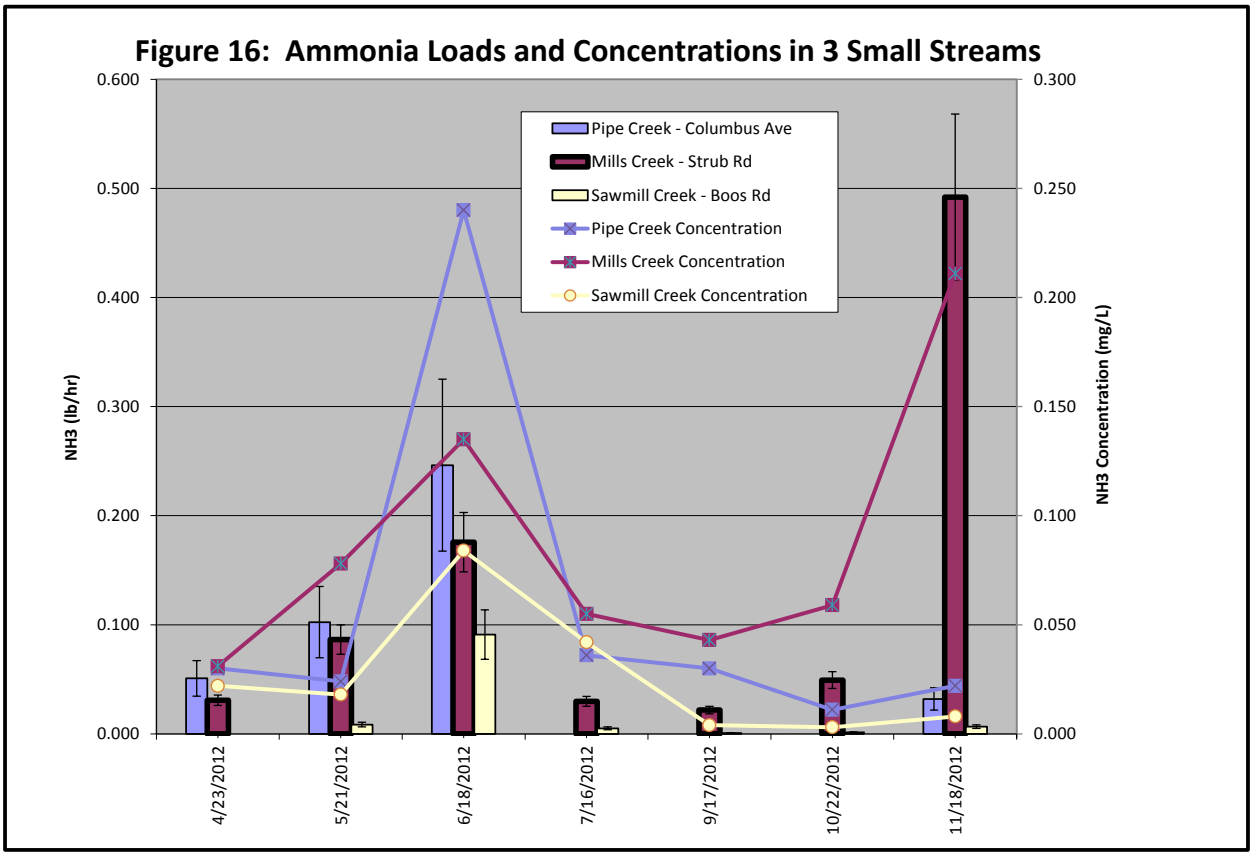


Figure 16: Ammonia Loads and Concentrations in 3 Small Streams
NH3 (lb/hr)
NH3 Concentration (mg/L)
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Pipe Creek - Columbus Ave
Mills Creek - Strub Rd
Sawmill Creek - Boos Rd
Pipe Creek Concentration
Mills Creek Concentration
Sawmill Creek Concentration
4/23/2012
5/21/2012
6/18/2012
7/16/2012
9/17/2012
10/22/2012
11/18/2012

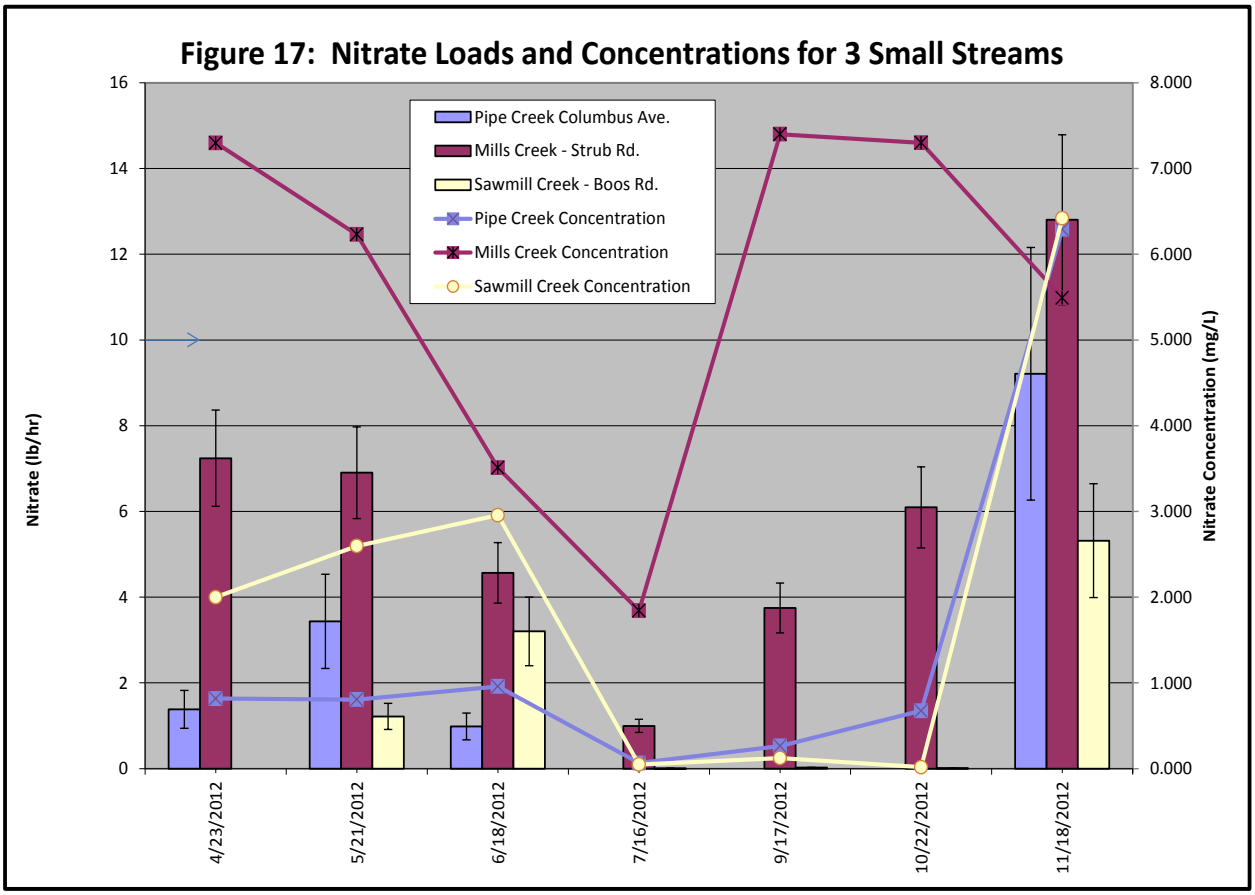
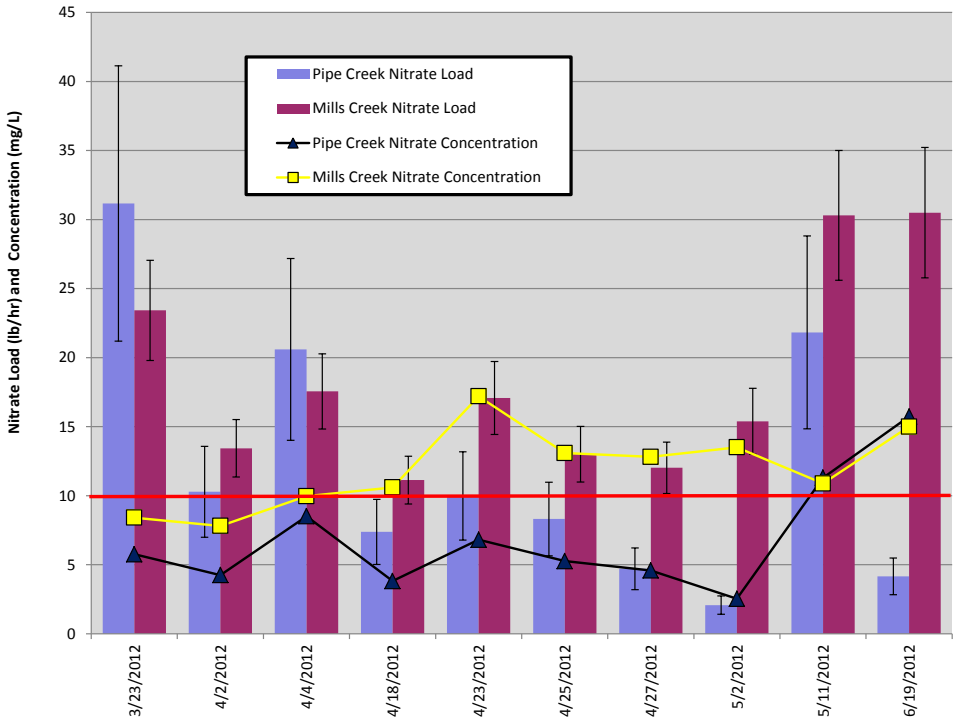


Figure 17: Nitrate Loads and Concentrations for 3 Small Streams
Pipe Creek Columbus Ave.
Mills Creek - Strub Rd.
Sawmill Creek - Boos Rd.
Pipe Creek Concentration
Mills Creek Concentration
Sawmill Creek Concentration
Nitrate (lb/hr)
Nitrate Concentration (mg/L)
0
2
4
6
8
10
12
14
16
0.000
1.000
2.000
3.000
4.000
5.000
6.000
7.000
8.000
4/23/2012
5/21/2012
6/18/2012
7/16/2012
9/17/2012
10/22/2012
11/18/2012

Figure 18: Pipe Creek and Mills Creek Nitrate Loads and Concentrations
***Concentrations measured with YSI Nitrate Electrode**



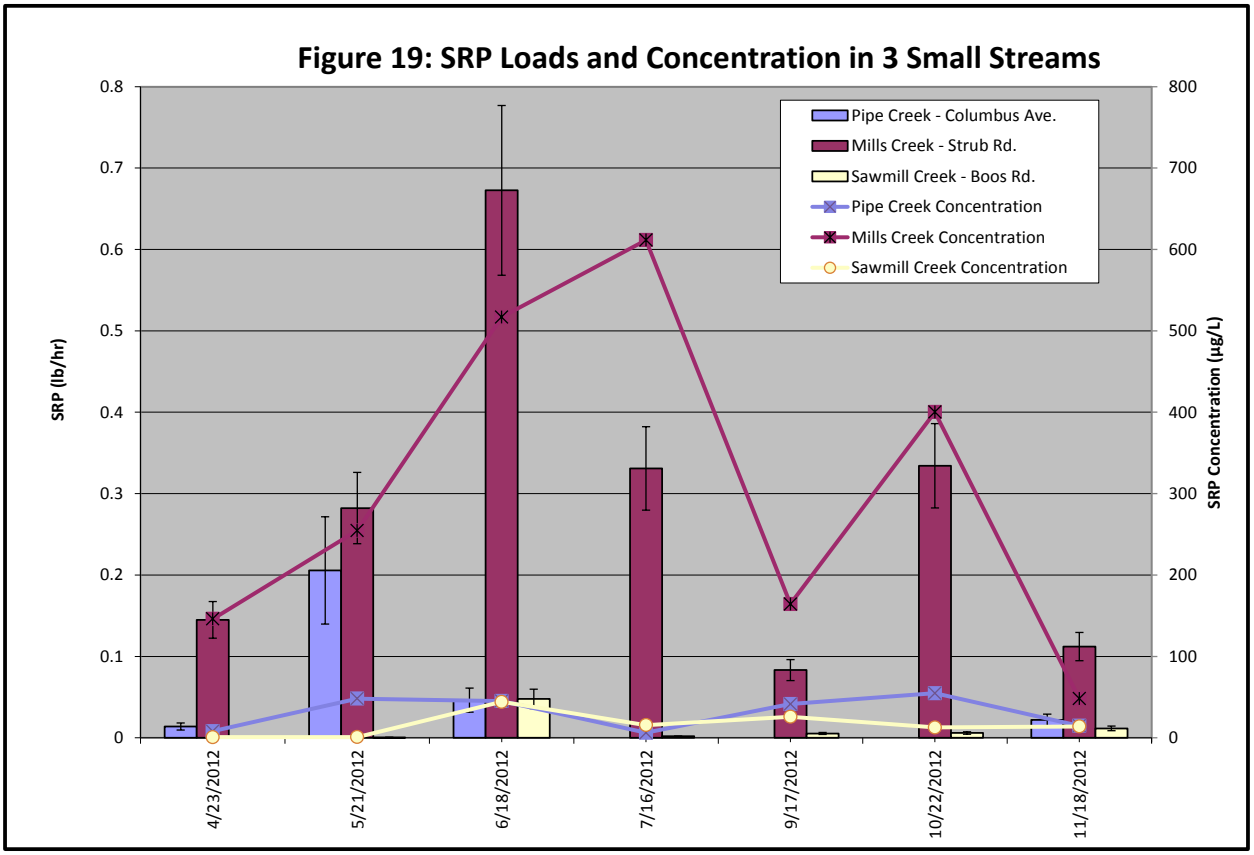


Figure 19: SRP Loads and Concentration in 3 Small Streams
SRP (lb/hr)
SRP Concentration (µg/L)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
800
700
600
500
400
300
200
100
0
Pipe Creek - Columbus Ave.
Mills Creek - Strub Rd.
Sawmill Creek - Boos Rd.
Pipe Creek Concentration
Mills Creek Concentration
Sawmill Creek Concentration
4/23/2012
5/21/2012
6/18/2012
7/16/2012
9/17/2012
10/22/2012
11/18/2012

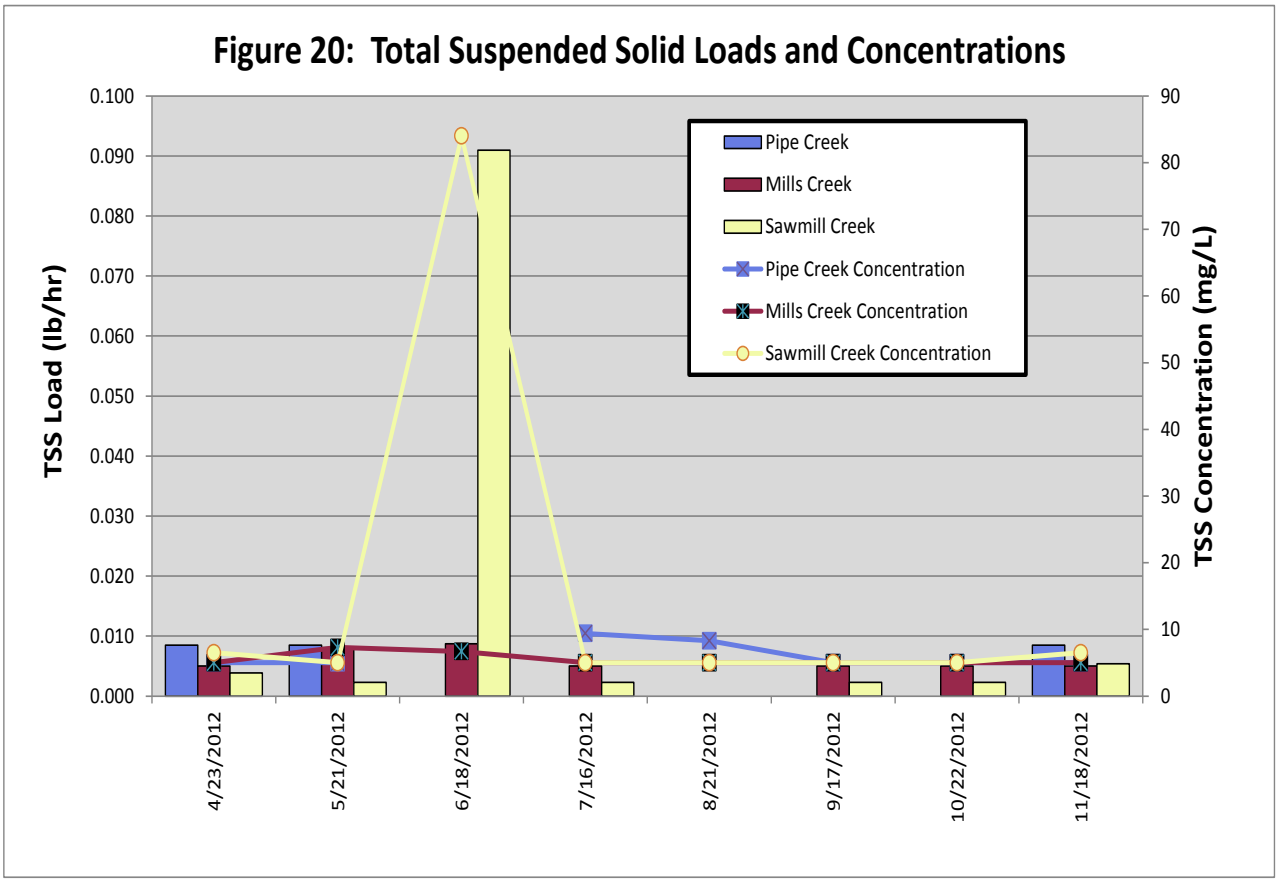


Figure 20: Total Suspended Solid Loads and Concentrations
TSS Load (lb/hr)
TSS Concentration (mg/L)
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
90
80
70
60
50
40
30
20
10
0
Pipe Creek
Mills Creek
Sawmill Creek
Pipe Creek Concentration
Mills Creek Concentration
Sawmill Creek Concentration
4/23/2012
5/21/2012
6/18/2012
7/16/2012
8/21/2012
9/17/2012
10/22/2012
11/18/2012

Table 1: Discharge Data for Sawmill Creek, Pipe Creek and Mills Creek

Rating Curve Data for Sawmill Creek

Date	Staff Gage (ft)	Discharge (ft^3/sec)	Area (ft^2)	Stream Width (ft)	Ave Depth (ft)	Ave. Velocity (ft/sec)	Measurement Method
11/10/2011	0.78	2.66	8.72	17.83	0.44	0.23	0.6
11/13/2011	0.68	2.25	7.14	17.42	0.35	0.23	0.6
11/15/2011	1.48	36.49	23.16	19.84	1.18	1.49	0.6
11/16/2011	1.15	15.14	15.39	18.50	0.81	0.96	0.6
11/29/2011	4.50	747.00		31.00		6.39	stick
3/16/2012	2.00	123.00		20.00		4.23	stick
3/17/2012	1.38	27.62	20.85	20.00	0.93	1.33	0.6
3/21/2012	1.05	10.85	12.18	20.40	0.59	0.79	0.6
3/23/2012	0.96	8.11	10.49	20.30	0.51	0.71	0.6
5/2/2012	0.64	1.00	4.33	19.20	0.22	0.20	0.6
5/11/2012	0.86	5.62	8.57	20.50	0.40	0.61	0.6
10/30/2012	4.25	372.77	81.05			5.11	stick
10/31/2012	2.64	202.98	47.02			4.80	stick

Rating Curve Data for Pipe Creek

Date	Staff Gage (ft)	Discharge (ft^3/sec)	Area (ft^2)	Stream Width (ft)	Ave Depth (ft)	Ave. Velocity (ft/sec)	Measurement Method
3/14/2012	0.55	69.56		25.5		3.38	stick
3/16/2012	1.14	240.97		25.5		6.61	stick
3/17/2012	0.88	144.29		25.5		4.97	stick
3/22/2012	0.22	22.10	12.28	25.5	0.48	1.68	0.6
3/22/2012	0.23	21.80	12.28	25.4	0.48	0.78	0.6
4/2/2012	0.12	8.81	9.32	25.5	0.38	0.87	0.6
4/4/2012	0.12	6.49	8.52	25.2	0.34	0.68	0.6
4/23/2012	0.08	2.06	5.92	25.4	0.25	0.30	0.6
4/25/2012	0.09	4.51	7.83	25.0	0.32	0.51	0.6
4/27/2012	0.06	3.75	7.27	25.4	0.30	0.49	0.6
5/2/2012	0.05	4.49	6.72	25.0	0.26	0.58	0.6
5/11/2012	0.10	8.27	7.94	25.4	0.31	0.93	0.6
10/31/2012	1.40	370.60		25.5		8.47	stick
6/19/2012	0.02	5.34	6.55	24.3	0.29	0.76	0.6

Rating Curve Data for Mills Creek

Date	Staff Gage (ft)	Discharge (ft^3/sec)	Area (ft^2)	Stream Width (ft)	Ave Depth (ft)	Ave. Velocity (ft/sec)	Measurement Method
3/14/2012*	2.50	77.40		33.8		1.330	stick
3/16/2012	4.48	372.35		33.8		3.296	stick
3/17/2012	3.19	147.45		33.8		1.911	stick
3/22/2012	1.86	19.59	43.62	31.7	1.30	0.400	0.6
3/23/2012	1.82	14.63	43.96	34.2	1.23	0.298	0.6
4/2/2012	1.61	9.66	37.81	33.8	1.10	0.231	0.6
4/4/2012	1.62	10.30	38.40	33.6	1.12	0.243	0.6
4/18/2012	1.42	4.45	31.05	33.6	0.91	0.124	0.6
4/23/2012	1.40	3.86	30.71	33.4	0.91	0.103	0.6
4/25/2012	1.40	3.08	30.06	33.6	0.88	0.085	0.6
4/27/2012	1.38	3.87	29.66	33.4	0.88	0.112	0.6
5/2/2012	1.45	3.04	32.12	33.3	0.96	0.081	0.6
5/11/2012	1.82	12.26	43.93	34.2	1.26	0.258	0.6
6/19/2012	1.68	7.84	38.23	33.1	1.14	0.180	0.6
10/31/2012	4.77	342.92				2.834	stick

Table 2: Correlation Equations for Cross-Sectional Area vs. Staff Gage Height and Rating Curves **Ac - Cross-sectional Area (ft^2)** **SG - Staff Gage Height (ft)** **Q - Discharge (cfs)**		
Sawmill Creek	Ac = 21.3756 SG - 8.7769 R^2 = 0.9766	Q = 8.0083 $SG^{3.1194}$ R^2 = 0.9676
Pipe Creek	Ac = 31.077 SG + 5.0905 R^2 = 0.9095	Q = 148.13 $SG^{1.2364}$ R^2 = 0.8752
Mills Creek	Ac = 30.836 SG - 12.623 R^2 = 0.9863	Q = 1.177 $SG^{3.9312}$ R^2 = 0.9644

Table 3: Standard Deviation for Rating Curves

Stream	Discharge (cfs)	Discharge (cfs)	Average (cfs)	STDEV (cfs)	%STDEV	Average %STDEV
	Direct Discharge Meaurement	Rating Curve				
Sawmill Creek	8.11	7.1	7.58	0.75	0.10	
Sawmill Creek	1.00	2.0	1.50	0.70	0.47	
Sawmill Creek	5.62	5.0	5.31	0.44	0.08	
Sawmill Creek	372.80	730.7	551.75	253.07	0.46	
Sawmill Creek	202.98	165.5	184.22	26.53	0.14	25.01%
Pipe Creek	21.84	24.1	22.96	1.58	0.07	
Pipe Creek	8.81	10.8	9.79	1.38	0.14	
Pipe Creek	6.49	10.8	8.63	3.03	0.35	
Pipe Creek		8.6				
Pipe Creek	2.06	6.5	4.29	3.16	0.74	
Pipe Creek	4.51	7.0	5.77	1.78	0.31	
Pipe Creek	3.75	4.6	4.16	0.58	0.14	
Pipe Creek	4.49	3.6	4.07	0.60	0.15	
Pipe Creek	8.27	8.6	8.43	0.23	0.03	
Pipe Creek	5.58	1.2	3.38	3.11	0.92	
Pipe Creek	370.60	224.6	297.58	103.27	0.35	31.87%
Mills Creek	14.63	12.4	13.51	1.58	0.12	
Mills Creek	9.66	7.7	8.66	1.42	0.16	
Mills Creek	10.30	7.8	9.07	1.74	0.19	
Mills Creek	4.45	4.7	4.56	0.16	0.03	
Mills Creek	3.86	4.4	4.14	0.39	0.10	
Mills Creek	3.08	4.4	3.75	0.95	0.25	
Mills Creek	3.87	4.2	4.02	0.21	0.05	
Mills Creek	3.04	5.1	4.06	1.44	0.35	
Mills Creek	12.22	12.4	12.31	0.12	0.01	
Mills Creek	7.84	9.0	8.44	0.85	0.10	
Mills Creek	342.90	547.2	445.06	144.48	0.32	15.43%

Appendix A

Flow Rate and Discharge Data
For
Sawmill Creek

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	0.78
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	17.83
Date:	11/10/2011	**Total Discharge (ft^3/sec):**	2.663
Time:	3:00 PM	**Method:**	0.6
Other:			

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
East	1.50	0.00	0.00			
	1.67	0.60	0.05	0.30	0.015	0.56%
	2.50	0.70	0.16	0.99	0.158	5.95%
	4.50	0.60	0.31	1.05	0.326	12.22%
	6.00	0.70	0.32	1.05	0.336	12.62%
	7.50	0.60	0.38	1.05	0.399	14.98%
	9.50	0.50	0.46	1.00	0.460	17.28%
	11.50	0.45	0.41	0.90	0.369	13.86%
	13.50	0.50	0.37	1.00	0.370	13.90%
	15.50	0.40	0.25	0.90	0.225	8.45%
	18.00	0.25	0.01	0.48	0.005	0.18%
West	19.33	0.00	0.00	0.00	0.000	0.00%
Average		0.44	0.23			
Total				8.72	2.663	

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	0.68
Monitors:	Linda Cornell, Bill Cornell	**Stream Width (ft):**	17.42
Date:	11/13/2011	**Total Discharge (ft^3/sec):**	2.245
Time:	1:00 PM	**Method:**	0.6
Other:	dry, cloudy, windy		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
East	1.50	0.00	0.00			
	2.00	0.58	0.12	0.73	0.087	3.88%
	4.00	0.55	0.39	1.10	0.429	19.11%
	6.00	0.60	0.34	1.20	0.408	18.18%
	8.00	0.50	0.38	1.00	0.380	16.93%
	10.00	0.40	0.39	0.80	0.312	13.90%
	12.00	0.35	0.43	0.70	0.301	13.41%
	14.00	0.38	0.29	0.76	0.220	9.82%
	16.00	0.32	0.14	0.64	0.090	3.99%
	18.00	0.15	0.08	0.22	0.018	0.78%
West	18.92	0.00	0.00	0.00	0.000	0.00%
Average		0.35	0.23			
Total				7.14	2.245	

	Stream:	Sawmill Creek	**Staff Gage Height (ft):**	1.48 (1.46 at 4:15 pm)
	Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	19.84
	Date:	11/15/2011	**Total Discharge (ft^3/sec):**	36.485
	Time:	3:00 pm - 4:15 pm	**Method:**	0.6
	Other	Heavy Rain on 11/14/11 from about 5 - 7:30 pm, at 7:45 am on 11/15/11 SG=1.65-1.7 ft, at bottom edge of pipe.		

Time:	**Bank**	**Horizontal Distance (ft)**	**Depth (ft)**	**velocity (ft/sec)**	**Cross-sectional area (ft^2)**	**Subsection Discharge (ft^3/sec)**	**% discharge**
3:15 PM	**East**	7.83	0.00	0.00			
		8.50	0.45	0.10	0.26	0.026	0.07%
		9.00	1.50	0.57	0.75	0.428	1.17%
		9.50	1.55	0.64	0.78	0.496	1.36%
		10.00	1.55	0.66	0.78	0.512	1.40%
		10.50	1.55	0.92	0.78	0.713	1.95%
		11.00	1.45	1.13	0.73	0.819	2.25%
		11.50	1.40	1.33	0.70	0.931	2.55%
		12.00	1.40	1.50	0.70	1.050	2.88%
		12.50	1.40	1.76	0.70	1.232	3.38%
		13.00	1.45	2.01	0.73	1.457	3.99%
		13.50	1.45	1.79	0.73	1.298	3.56%
		14.00	1.45	2.04	0.80	1.627	4.46%
3:41 PM		14.60	1.35	2.32	0.68	1.566	4.29%
		15.00	1.35	1.97	0.61	1.197	3.28%
		15.50	1.30	2.39	0.65	1.554	4.26%
		16.00	1.35	2.26	0.68	1.526	4.18%
		16.50	1.25	2.26	0.63	1.413	3.87%
		17.00	1.20	2.29	0.60	1.374	3.77%
		17.50	1.20	1.93	0.60	1.158	3.17%
		18.00	1.20	1.96	0.60	1.176	3.22%
		18.50	1.20	2.26	0.60	1.356	3.72%
		19.00	1.20	2.29	0.60	1.374	3.77%
		19.50	1.20	2.24	0.60	1.344	3.68%
		20.00	1.20	2.00	0.60	1.200	3.29%
		20.50	1.20	2.10	0.60	1.260	3.45%
		21.00	1.20	1.94	0.60	1.164	3.19%
		21.50	1.20	1.29	0.60	0.774	2.12%
		22.00	1.20	1.11	0.60	0.666	1.83%
		22.50	1.20	1.88	0.60	1.128	3.09%
		23.00	1.15	1.77	0.58	1.018	2.79%
		23.50	1.10	1.60	0.55	0.880	2.41%
		24.00	1.05	1.56	0.53	0.819	2.24%
		24.50	1.00	1.23	0.50	0.615	1.69%
		25.00	0.95	1.11	0.48	0.527	1.45%
		25.50	0.90	0.80	0.45	0.360	0.99%
		26.00	0.95	0.56	0.52	0.293	0.80%
		26.60	0.80	0.36	0.40	0.144	0.39%
		27.00	0.60	0.04	0.32	0.013	0.04%
4:15 pm	West	27.67	0.00	0.00	0.00	0.000	0.00%
	Average		1.18	1.49			
	Total				23.16	36.485	

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	1.15 (1.14 at 3:15 pm)
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	18.5
Date:	11/16/2011	**Total Discharge (ft^3/sec):**	15.140
Time:	2:36 PM	**Method:**	0.6
Other:	Heavy Rain on 11/14/11 from about 5 - 7:30 pm, at 7:45 am on 11/15/11 SG=1.65-1.7 ft, at bottom edge of pipe.		

Time	Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
2:36 PM	east	8.50	0.00	0.00			
		9.17	1.15	0.54	0.91	0.491	3.24%
		10.08	1.20	0.54	1.10	0.593	3.92%
		11.00	1.10	0.71	1.06	0.750	4.95%
		12.00	1.00	0.84	1.00	0.840	5.55%
		13.00	1.10	1.02	0.83	0.842	5.56%
		13.50	1.00	1.01	0.50	0.505	3.34%
		14.00	1.00	1.22	0.50	0.610	4.03%
		14.50	0.95	1.30	0.48	0.618	4.08%
		15.00	0.95	1.32	0.48	0.627	4.14%
		15.50	0.90	1.23	0.45	0.554	3.66%
		16.00	0.90	1.54	0.45	0.693	4.58%
		16.50	0.85	1.52	0.43	0.646	4.27%
		17.00	0.80	1.49	0.40	0.596	3.94%
		17.50	0.80	1.53	0.40	0.612	4.04%
		18.00	0.80	1.49	0.40	0.596	3.94%
		18.50	0.85	1.41	0.43	0.599	3.96%
		19.00	0.85	1.36	0.64	0.867	5.73%
		20.00	0.85	1.33	0.85	1.131	7.47%
		21.00	0.85	1.04	0.85	0.884	5.84%
		22.00	0.85	1.14	0.85	0.969	6.40%
		23.00	0.85	0.81	0.85	0.689	4.55%
		24.00	0.75	0.52	0.75	0.390	2.58%
		25.00	0.65	0.05	0.81	0.041	0.27%
		26.50	0.00	0.00	0.00	0.000	0.00%
3:15 PM		27.00	0.00	0.00	0.00	0.000	0.00%
	Average		0.81	0.96			
	Total				15.39	15.140	

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	2.06
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	
Date:	11/28/2011	**Total Discharge (ft^3/sec):**	
Time:	1:00 PM		
Other:	Raining, half of pipe showing		

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	4.8 (at 11:05 am)
Monitors:	Linda Cornell, Bruce Mollison		4.4-4.6 (at 3:00 pm)
Date:	11/29/2011	**Stream Width (ft):**	
Time:	1:00 PM	**Total Discharge (ft^3/sec):**	747
Other:	Raining, flooded stream, over bank	**Method:**	stick-foam

at 11:05 am, stream over bank

at 3:00 pm, top of guard rail to surface is 12 ft 1 3/8 inches, depth at bridge 4.19 ft

Time	velocity (ft/sec)
3:00 PM	6.39 ft/sec

(foam took 7.2 sec to move on surface from gage to bridge. Measured from bridge. Distance is about 46 feet.)

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	2.00
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	20
Date:	3/16/2012	**Total Discharge (ft^3/sec):**	123
Time:	11:30 AM	**Method:**	Stick
Other:	Sunny, rain night before		

Timed stick floating down river . Threw in stick from bridge upstream. Timed from gage to bridge, 46 feet.

Depth at bridge: 14'6" from top of guard rail between #6 and #7 I-beams to surface of water.: depth at bridge 1.8 ft deep

Distance was measured in stream from gage to bridge on 3/17/12.

Distance (ft)	Time (sec)	Velocity (ft/sec)
46	10.47	
	9.53	
	11.66	
	11.03	
	11.66	
Average:	10.87	4.23

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	1.38
Monitors:	Linda Cornell, Bill Cornell	**Stream Width (ft):**	20
Date:	3/17/2012	**Total Discharge (ft^3/sec):**	27.6225
Time:	3:00 PM	**Method:**	0.6
Other:			

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
East	27.00	0.00	0.00		0.000	0.00%
	26.00	1.30	0.36	0.98	0.351	1.27%
	25.50	1.15	0.88	0.58	0.506	1.83%
	25.00	1.15	0.92	0.58	0.529	1.92%
	24.50	1.05	1.12	0.53	0.588	2.13%
	24.00	1.00	1.20	0.50	0.600	2.17%
	23.50	0.95	1.26	0.48	0.599	2.17%
	23.00	0.90	1.32	0.68	0.891	3.23%
	22.00	0.90	1.80	0.90	1.620	5.86%
	21.00	1.00	1.73	1.00	1.730	6.26%
	20.00	1.05	2.04	1.05	2.142	7.75%
	19.00	1.00	2.09	1.00	2.090	7.57%
	18.00	1.00	2.11	1.00	2.110	7.64%
	17.00	0.90	2.03	0.90	1.827	6.61%
	16.00	0.90	1.98	0.90	1.782	6.45%
	15.00	0.90	1.89	0.90	1.701	6.16%
	14.00	0.95	1.76	0.95	1.672	6.05%
	13.00	0.90	1.83	0.90	1.647	5.96%
	12.00	0.95	1.62	0.95	1.539	5.57%
	11.00	0.95	1.26	0.95	1.197	4.33%
	10.00	1.00	1.13	1.00	1.130	4.09%
	9.00	0.90	0.92	0.90	0.828	3.00%
	8.00	0.85	0.64	0.85	0.544	1.97%
West	7.00	0.60	0.00	2.40	0.000	0.00%
Average		0.93	1.33			
Total				20.85	27.623	

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	1.05
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	20.4
Date:	3/21/2012	**Total Discharge (ft^3/sec**	10.847
Time:	2:15 pm - 3:00 pm	**Method:**	0.6
Other:	Sunny, sunny 24 hours earlier no rain		

Bank	**Horizontal Distance (ft)**	**Depth (ft)**	**velocity (ft/sec)**	**Cross-sectional area (ft^2)**	**Subsection Discharge (ft^3/sec)**	**% discharge**
east	25.90	0.00	0.00		0.000	0.00%
	25.50	1.00	0.25	0.45	0.113	1.04%
	25.00	0.90	0.34	0.45	0.153	1.41%
	24.50	0.75	0.55	0.38	0.206	1.90%
	24.00	0.70	0.65	0.35	0.228	2.10%
	23.50	0.65	0.68	0.33	0.221	2.04%
	23.00	0.50	0.82	0.38	0.308	2.83%
	22.00	0.50	0.93	0.50	0.465	4.29%
	21.00	0.60	1.13	0.60	0.678	6.25%
	20.00	0.65	1.01	0.65	0.657	6.05%
	19.00	0.65	1.22	0.65	0.793	7.31%
	18.00	0.62	1.26	0.62	0.781	7.20%
	17.00	0.65	1.17	0.65	0.761	7.01%
	16.00	0.60	1.36	0.60	0.816	7.52%
	15.00	0.60	1.16	0.60	0.696	6.42%
	14.00	0.65	1.29	0.65	0.839	7.73%
	13.00	0.62	1.11	0.62	0.688	6.34%
	12.00	0.60	1.05	0.60	0.630	5.81%
	11.00	0.62	0.92	0.62	0.570	5.26%
	10.00	0.65	0.76	0.65	0.494	4.55%
	9.00	0.62	0.63	0.62	0.391	3.60%
	8.00	0.60	0.55	0.60	0.330	3.04%
	7.00	0.50	0.05	0.63	0.031	0.29%
west	5.50	0.00	0.00	0.00	0.000	0.00%
Average		0.59	0.79			
Total				12.18	10.847	

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	0.96
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	20.3
Date:	3/23/2012	**Total Discharge (ft^3/sec):**	8.1104
Time:	2:15 pm - 3:00 pm		
Other:	Sunny-partly cloudy, sunny 24 hours earlier no rain		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
east	25.80	0.00	0.00		0.000	0.00%
	25.00	0.89	0.40	0.58	0.231	2.85%
	24.50	0.75	0.33	0.38	0.124	1.53%
	24.00	0.70	0.57	0.53	0.299	3.69%
	23.00	0.60	0.68	0.60	0.408	5.03%
	22.00	0.45	0.92	0.45	0.414	5.10%
	21.00	0.48	1.03	0.48	0.494	6.10%
	20.00	0.55	0.89	0.55	0.490	6.04%
	19.00	0.55	1.04	0.55	0.572	7.05%
	18.00	0.55	1.08	0.55	0.594	7.32%
	17.00	0.55	1.10	0.55	0.605	7.46%
	16.00	0.50	1.04	0.50	0.520	6.41%
	15.00	0.50	1.00	0.50	0.500	6.16%
	14.00	0.55	1.01	0.55	0.556	6.85%
	13.00	0.48	1.00	0.48	0.480	5.92%
	12.00	0.48	0.96	0.48	0.461	5.68%
	11.00	0.51	0.89	0.51	0.454	5.60%
	10.00	0.55	0.63	0.55	0.347	4.27%
	9.00	0.58	0.53	0.58	0.307	3.79%
	8.00	0.50	0.41	0.50	0.205	2.53%
	7.00	0.50	0.08	0.63	0.050	0.62%
	5.50	0.00	0.00	0.00	0.000	0.00%
Average		0.51	0.71			
Total				10.48	8.110	

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	0.64
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	19.3
Date:	5/2/2012	**Total Discharge (ft^3/sec)**	1.003
Time:	1:10 PM	**Method:**	0.6
Other:	partly cloudy, rainy and partly cloudy in past 24 hours		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
east	25.30	0.00	0.00		0.000	0.00%
	25.00	0.50	0.25	0.33	0.081	8.10%
	24.00	0.48	0.38	0.48	0.182	18.19%
	23.00	0.30	0.14	0.30	0.042	4.19%
	22.00	0.20	0.27	0.20	0.054	5.39%
	21.00	0.20	0.38	0.20	0.076	7.58%
	20.00	0.25	0.37	0.25	0.093	9.23%
	19.00	0.25	0.43	0.31	0.134	13.40%
	17.50	0.20	0.37	0.20	0.074	7.38%
	17.00	0.25	0.37	0.19	0.069	6.92%
	16.00	0.10	0.27	0.10	0.027	2.69%
	15.00	0.20	0.23	0.20	0.046	4.59%
	14.00	0.20	0.16	0.20	0.032	3.19%
	13.00	0.20	0.15	0.20	0.030	2.99%
	12.00	0.20	0.16	0.20	0.032	3.19%
	11.00	0.22	0.09	0.22	0.020	1.97%
	10.00	0.20	0.05	0.20	0.010	1.00%
	9.00	0.25	0.00	0.25	0.000	0.00%
	8.00	0.20	0.00	0.30	0.000	0.00%
west	6.00	0.00	0.00	0.00	0.000	0.00%
Average		0.22	0.20			
Total				4.33	1.003	

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	0.86
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	20.5
Date:	5/11/2012	**Total Discharge (ft^3/sec):**	5.6228
Time:	12:45 PM	**Method:**	0.6
Other:	sunny, partly cloudy in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
East	25.80	0.00	0.00			
	25.00	0.70	0.42	0.63	0.265	4.71%
	24.00	0.60	0.56	0.66	0.370	6.57%
	22.80	0.40	0.70	0.40	0.280	4.98%
	22.00	0.35	0.68	0.32	0.214	3.81%
	21.00	0.40	0.76	0.40	0.304	5.41%
	20.00	0.40	0.90	0.40	0.360	6.40%
	19.00	0.45	0.84	0.45	0.378	6.72%
	18.00	0.45	1.05	0.45	0.473	8.40%
	17.00	0.45	1.02	0.45	0.459	8.16%
	16.00	0.40	1.03	0.40	0.412	7.33%
	15.00	0.40	0.92	0.40	0.368	6.54%
	14.00	0.45	0.87	0.45	0.392	6.96%
	13.00	0.40	0.81	0.40	0.324	5.76%
	12.00	0.42	0.71	0.42	0.298	5.30%
	11.00	0.42	0.61	0.42	0.256	4.56%
	10.00	0.42	0.55	0.42	0.231	4.11%
	9.00	0.50	0.33	0.55	0.182	3.23%
	7.80	0.45	0.13	0.45	0.059	1.04%
	7.00	0.40	0.00	0.50	0.000	0.00%
	5.30	0.00	0.00	0.00	0.000	0.00%
Average		0.40	0.61			
Total				8.57	5.623	

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	4.25
Monitors:	Bruce Mollison	**Stream Width (ft):**	
Date:	10/30/2012	**Total Discharge (ft^3/sec):**	372.77
Time:	2:15 PM	**Method:**	Stick-foam
Other	rain, rain in past 24 hours, over bank, Measured foam from gage to bridge: 9.0 sec to travel 46 ft.		

velocity (ft/sec)	Subsection c area, (ft^2)
5.11	81.05

Stream:	Sawmill Creek	**Staff Gage Height (ft):**	2.64
Monitors:	Bruce Mollison	**Stream Width (ft):**	
Date:	10/31/2012	**Total Discharge (ft^3/sec):**	202.98
Time:	2:06 PM	**Method:**	0.6
Other:	rainy cloudy, rain in past 24 hours, over bank		
	Measured foam from gage to bridge:travel 46 ft.		

	Time (sec):	**velocity (ft/sec)**
	9.99	4.796
	9.57	
	9.57	
	9.77	
	9.01	
	9.64	
Average	9.59	

Appendix B

Flow and Discharge Data
for
Pipe Creek

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.55	up: 0.60 down: 0.50
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.50	
Date:	3/14/2012	**Total Discharge (ft^3/sec):**	69.560	
Time:	3:12 PM	**Method:**	stick	
Other:	Rained day before.			

Timed stick floating down river between gage to just above the small drop.
Distance was measured on the bank paralell to flow.

Distance (ft)	**Time (sec)**	**Velocity ft.sec)**
36	10.33	3.484
	10.40	
	9.64	
	10.96	
Average time	10.33	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	1.14
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.50
Date:	3/16/2012	**Total Discharge (ft3/sec):**	240.970
Time:	10:00 AM	**Method:**	stick
Other:	Sunny, rained night before. Bedrock drop is not visible. Higher flow than 3/14/12. Water is at top of bank on gage side.		

Timed stick floating down river between gage to just above the small drop.
Distance was measured on the bank parallel to flow.

Distance (ft)	**Time (sec)**		**Velocity (ft/sec)**
38.00	5.23		6.61
	5.79		
	6.26	on far side	
	5.72		
Average	5.75		

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.875	Up: 0.9 down: 0.85
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.50	
Date:	3/17/2012	**Total Discharge (ft3/sec):**	144.285	
Time:	Afternoon	**Method:**	stick	
Other:	Sunny, 77oF			

Timed stick floating down river betrween gauge to just above the small drop.
Distance was measured on the bank parallel to flow.

Distance (ft)	**Time (sec)**	**Velocity ft.sec)**
36.00	7.20	4.97
	7.10	
	7.50	
	7.20	
Average	7.25	

Stream:	Pipe Creek	**Staff Gage Height (ft)**	0.22
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.5
Date:	3/22/2012	**Total Discharge (ft^3/s**	22.09755
Time:	3:35 - 4:08 pm	**Method:**	0.6
Other:	Sunny, Sunny 24 hr earlier, put in transect stakes today.		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
South Side	4.4	0	0			0.00%
Gage side	5	0.3		0.24	0	0.00%
	6	0.4	1.77	0.4	0.708	3.20%
	7	0.45	2.03	0.45	0.9135	4.13%
	8	0.55	1.85	0.55	1.0175	4.60%
	9	0.5	1.83	0.5	0.915	4.14%
	10	0.55	2.04	0.55	1.122	5.08%
	11	0.55	2.17	0.55	1.1935	5.40%
	12	0.55	2.08	0.55	1.144	5.18%
	13	0.5	2.23	0.5	1.115	5.05%
	14	0.6	2.08	0.6	1.248	5.65%
	15	0.85	1.92	0.7225	1.3872	6.28%
	15.7	0.95	2.18	0.57	1.2426	5.62%
	16.2	0.6	2.28	0.39	0.8892	4.02%
	17	0.55	1.99	0.495	0.98505	4.46%
	18	0.5	1.94	0.5	0.97	4.39%
	19	0.45	1.77	0.45	0.7965	3.60%
	20	0.5	1.81	0.5	0.905	4.10%
	21	0.5	2.03	0.5	1.015	4.59%
	22	0.5	1.92	0.5	0.96	4.34%
	23	0.55	1.84	0.55	1.012	4.58%
	24	0.45	1.7	0.45	0.765	3.46%
	25	0.45	1.71	0.45	0.7695	3.48%
	26	0.4	1.34	0.4	0.536	2.43%
right facin	27	0.4	1.22	0.4	0.488	2.21%
upstream	28	0.35	0	0.5075	0	0.00%
North side	29.9	0	0	0	0	0.00%
Average		0.47963	1.681923077			
Total				12.275	22.09755	

Stream:	**Pipe Creek**	**Staff Gage Height (ft):**	0.23
Monitors:	**Linda Cornell, Bruce Mollison**	**Stream Width (ft):**	25.4
Date:	**3/23/2012**	**Total Discharge (ft^3/sec):**	21.842625
Time:	**10:29-11:01 am**	**Method:**	0.6
Other	**Partly cloudy.**		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
south side	4.50	0.00	0.00			
left side	5.00	0.30	0.00	0.23	0.000	0.00%
facing upstream	6.00	0.35	1.53	0.35	0.536	2.45%
Gage Side	7.00	0.45	1.88	0.45	0.846	3.87%
	8.00	0.55	2.05	0.55	1.128	5.16%
	9.00	0.55	2.15	0.55	1.183	5.41%
	10.00	0.55	2.28	0.55	1.254	5.74%
	11.00	0.50	2.19	0.50	1.095	5.01%
	12.00	0.50	2.01	0.50	1.005	4.60%
	13.00	0.50	2.19	0.50	1.095	5.01%
	14.00	0.58	2.19	0.58	1.270	5.82%
	15.00	0.80	1.99	0.60	1.194	5.47%
	15.50	0.95	2.06	0.48	0.979	4.48%
	16.00	0.85	2.04	0.43	0.867	3.97%
	16.50	0.55	2.31	0.28	0.635	2.91%
	17.00	0.55	1.99	0.41	0.821	3.76%
	18.00	0.50	1.95	0.50	0.975	4.46%
	19.00	0.50	1.73	0.50	0.865	3.96%
	20.00	0.45	1.71	0.45	0.770	3.52%
	21.00	0.50	1.90	0.50	0.950	4.35%
	22.00	0.48	1.84	0.48	0.883	4.04%
	23.00	0.50	1.72	0.50	0.860	3.94%
	24.00	0.45	1.70	0.45	0.765	3.50%
	25.00	0.42	1.57	0.42	0.659	3.02%
	26.00	0.40	1.57	0.40	0.628	2.88%
	27.00	0.40	1.32	0.40	0.528	2.42%
	28.00	0.38	0.14	0.38	0.053	0.24%
right facing	29.00	0.38	0.00	0.36	0.000	0.00%
upstream	29.90	0.00	0.00	0.00	0.000	0.00%
Average	16.94	0.48	1.59		0.780	
Total				12.28	21.843	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.12
Monitors:	Linda Cornell, Evan Cornell	**Stream Width (ft):**	25.5
Date:	4/2/2012	**Total Discharge (ft^3/sec):**	8.81475
Time:	2:03-2:30 pm	**Method:**	0.6
Other:	Sunny, Sunny 24 hr earlier, lots of algae and silt on creek bed.		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left facing	3.50	0.00	0.00			
upstream	5.00	0.20	0.86	0.25	0.215	2.44%
	6.00	0.35	0.56	0.35	0.196	2.22%
	7.00	0.45	1.02	0.45	0.459	5.21%
	8.00	0.40	0.82	0.40	0.328	3.72%
	9.00	0.45	1.26	0.45	0.567	6.43%
	10.00	0.40	1.16	0.40	0.464	5.26%
	11.00	0.40	1.34	0.40	0.536	6.08%
	12.00	0.40	1.47	0.40	0.588	6.67%
	13.00	0.45	1.42	0.45	0.639	7.25%
	14.00	0.60	0.90	0.48	0.432	4.90%
	14.60	0.80	1.35	0.40	0.540	6.13%
	15.00	0.75	1.46	0.34	0.493	5.59%
	15.50	0.40	1.49	0.20	0.298	3.38%
	16.00	0.40	1.12	0.30	0.336	3.81%
	17.00	0.35	0.78	0.35	0.273	3.10%
	18.00	0.40	1.04	0.40	0.416	4.72%
	19.00	0.35	1.02	0.35	0.357	4.05%
	20.00	0.40	0.96	0.40	0.384	4.36%
	21.00	0.40	0.94	0.40	0.376	4.27%
	22.00	0.40	1.06	0.40	0.424	4.81%
	23.00	0.35	0.64	0.35	0.224	2.54%
	24.00	0.35	0.27	0.35	0.095	1.07%
	25.00	0.30	0.06	0.30	0.018	0.20%
	26.00	0.30	0.18	0.30	0.054	0.61%
right facing	27.00	0.30	0.23	0.45	0.104	1.17%
upstream	29.00	0.00	0.00	0.00	0.000	0.00%
Average		0.38	0.87			
Total				9.32	8.815	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.12
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.2
Date:	4/4/2012	**Total Discharge (ft^3/sec):**	6.494975
Time:	1:45 - 2:20 pm	**Method:**	0.6
Other	Sunny, Sunny 24 hr earlier,algae covered bottom with silt		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left facing	4.20	0.00	0.00			
upstream	5.00	0.10	0.28	0.09	0.025	0.39%
	6.00	0.30	0.72	0.30	0.216	3.33%
	7.00	0.32	0.30	0.32	0.096	1.48%
	8.00	0.35	0.76	0.35	0.266	4.10%
	9.00	0.40	0.77	0.40	0.308	4.74%
	10.00	0.40	1.21	0.40	0.484	7.45%
	11.00	0.40	1.15	0.40	0.460	7.08%
	12.00	0.35	1.00	0.35	0.350	5.39%
	13.00	0.35	1.00	0.35	0.350	5.39%
	14.00	0.45	0.87	0.41	0.352	5.42%
	14.80	0.70	1.29	0.35	0.452	6.95%
	15.00	0.75	1.37	0.41	0.565	8.70%
	15.90	0.40	1.41	0.30	0.423	6.51%
	16.50	0.40	1.19	0.22	0.262	4.03%
	17.00	0.35	0.84	0.26	0.221	3.39%
	18.00	0.35	1.05	0.35	0.368	5.66%
	19.00	0.30	0.84	0.30	0.252	3.88%
	20.00	0.35	0.71	0.35	0.249	3.83%
	21.00	0.35	0.72	0.35	0.252	3.88%
	22.00	0.35	0.25	0.35	0.088	1.35%
	23.00	0.35	0.44	0.35	0.154	2.37%
	24.00	0.35	0.25	0.35	0.088	1.35%
	25.00	0.30	0.17	0.30	0.051	0.79%
	26.00	0.30	0.00	0.30	0.000	0.00%
	27.00	0.25	0.23	0.25	0.058	0.89%
right facing	28.00	0.30	0.30	0.36	0.108	1.66%
upstream	29.40	0.00	0.00	0.00	0.000	0.00%
Average		0.34	0.68			
Total				8.52	6.495	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.1
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	
Date:	4/18/2012	**Total Discharge (ft^3/sec):**	
Time:	2:05 PM		
Other:	Sunny, cloudy 24 hr earlier, large algal bloom, flow in center.		

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.08
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.4
Date:	4/23/2012	**Total Discharge (ft^3/sec):**	2.0606
Time:	2:05 PM	**Method:**	0.6
Other:	Sunny, Sunny 24 hr earlier, large algal bloom, flow in center.		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left facing	4.00	0.00	0.00			
upstream	5.00	0.08	0.00	0.08	0.000	0.00%
	6.00	0.28	0.00	0.28	0.000	0.00%
	7.00	0.25	0.00	0.25	0.000	0.00%
	8.00	0.25	0.00	0.25	0.000	0.00%
	9.00	0.28	0.00	0.28	0.000	0.00%
	10.00	0.25	0.00	0.25	0.000	0.00%
	11.00	0.30	0.00	0.30	0.000	0.00%
	12.00	0.25	0.00	0.25	0.000	0.00%
	13.00	0.25	0.00	0.18	0.000	0.00%
	13.40	0.25	0.18	0.13	0.023	1.09%
	14.00	0.30	0.91	0.17	0.150	7.29%
	14.50	0.50	0.89	0.25	0.223	10.80%
	15.00	0.60	1.17	0.36	0.421	20.44%
	15.70	0.60	1.06	0.30	0.318	15.43%
	16.00	0.30	1.25	0.20	0.244	11.83%
	17.00	0.20	1.04	0.20	0.208	10.09%
	18.00	0.20	0.80	0.20	0.160	7.76%
	19.00	0.20	0.73	0.20	0.146	7.09%
	20.00	0.20	0.68	0.20	0.136	6.60%
	21.00	0.25	0.13	0.25	0.033	1.58%
	22.00	0.25	0.00	0.25	0.000	0.00%
	23.00	0.25	0.00	0.25	0.000	0.00%
	24.00	0.20	0.00	0.20	0.000	0.00%
	25.00	0.20	0.00	0.20	0.000	0.00%
	26.00	0.18	0.00	0.18	0.000	0.00%
	27.00	0.10	0.00	0.10	0.000	0.00%
right facing	28.00	0.15	0.00	0.18	0.000	0.00%
upstream	29.40	0.00	0.00	0.00	0.000	0.00%
Average		0.25	0.30			
Total				5.92	2.061	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.085
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25 (14)
Date:	4/25/2012	**Total Discharge (ft^3/sec):**	4.5093
Time:	2:30-2:58 pm	**Method:**	0.6
Other:	Sunny, Sunny 24 hr earlier,algae mat moved since 4-23-12, mostly on south side		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge	Stream Width (ft)
left facing	4.00	0.00	0.00				
upstream	5.00	0.10	0.00	0.10	0.000	0.00%	25
	6.00	0.25	0.00	0.25	0.000	0.00%	
	7.00	0.30	0.00	0.30	0.000	0.00%	
	8.00	0.35	0.00	0.35	0.000	0.00%	
	9.00	0.35	0.00	0.35	0.000	0.00%	
	10.00	0.35	0.06	0.35	0.021	0.47%	14
	11.00	0.35	0.05	0.35	0.018	0.39%	
	12.00	0.35	0.00	0.35	0.000	0.00%	
	13.00	0.35	0.04	0.35	0.014	0.31%	
	14.00	0.40	1.13	0.40	0.452	10.02%	
	15.00	0.70	1.40	0.53	0.735	16.30%	
	15.50	0.75	1.36	0.38	0.510	11.31%	
	16.00	0.40	1.36	0.30	0.408	9.05%	
	17.00	0.30	1.01	0.30	0.303	6.72%	
	18.00	0.30	0.88	0.30	0.263	5.83%	
	19.00	0.30	1.00	0.30	0.300	6.65%	
	20.00	0.30	1.19	0.30	0.357	7.92%	
	21.00	0.35	1.09	0.35	0.382	8.46%	
	22.00	0.38	0.94	0.38	0.357	7.92%	
	23.00	0.35	0.90	0.35	0.315	6.99%	
	24.00	0.30	0.25	0.30	0.075	1.66%	
	25.00	0.30	0.00	0.30	0.000	0.00%	
	26.00	0.30	0.00	0.30	0.000	0.00%	
right facing	27.00	0.20	0.00	0.30	0.000	0.00%	
upstream	29.00	0.00	0.00	0.00	0.000	0.00%	
Average		0.32	0.49				
Total				7.83	4.509		

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.06
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.4
Date:	4/27/2012	**Total Discharge (ft^3/sec):**	3.75255
Time:	9:30 AM	**Method:**	0.6
Other:	Partly cloudy, partly cloudy in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left facing	4.00	0.00	0.00			
upstream	6.00	0.20	0.00	0.40	0.000	0.00%
	8.00	0.30	0.00	0.60	0.000	0.00%
	10.00	0.30	0.00	0.60	0.000	0.00%
	12.00	0.30	0.00	0.45	0.000	0.00%
	13.00	0.30	0.00	0.23	0.000	0.00%
	13.50	0.35	1.08	0.18	0.189	5.04%
	14.00	0.40	0.86	0.30	0.258	6.88%
	15.00	0.70	1.28	0.53	0.672	17.91%
	15.50	0.70	1.29	0.35	0.452	12.03%
	16.00	0.30	1.17	0.23	0.263	7.02%
	17.00	0.30	0.88	0.30	0.264	7.04%
	18.00	0.30	0.75	0.30	0.225	6.00%
	19.00	0.30	0.83	0.30	0.249	6.64%
	20.00	0.30	0.90	0.30	0.270	7.20%
	21.00	0.30	0.95	0.30	0.285	7.59%
	22.00	0.38	0.86	0.38	0.327	8.71%
	23.00	0.35	0.84	0.35	0.294	7.83%
	24.00	0.25	0.02	0.25	0.005	0.13%
	25.00	0.25	0.00	0.25	0.000	0.00%
	26.00	0.25	0.00	0.25	0.000	0.00%
	27.00	0.20	0.00	0.20	0.000	0.00%
right facing	28.00	0.20	0.00	0.24	0.000	0.00%
upstream	29.40	0.00	0.00	0.00	0.000	0.00%
Average		0.30	0.49			
Total				7.27	3.753	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.05
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25
Date:	5/2/2012	**Total Discharge (ft^3/sec):**	4.4865
Time:	11:05 AM	**Method:**	0.6
Other:	Partly cloudy, rainy and partly cloudy in past 24 hr		

Bank	**Horizontal Distance (ft)**	**Depth (ft)**	**velocity (ft/sec)**	**Cross-sectional area (ft^2)**	**Subsection Discharge (ft^3/sec)**	**% discharge**
left facing	4.00	0.00	0.00			
upstream	5.00	0.18	0.00	0.18	0.000	0.00%
	6.00	0.25	0.08	0.25	0.020	0.45%
	7.00	0.30	0.72	0.30	0.216	4.81%
	8.00	0.30	0.99	0.30	0.297	6.62%
	9.00	0.30	0.83	0.30	0.249	5.55%
	10.00	0.30	0.88	0.30	0.264	5.88%
	11.00	0.30	0.97	0.30	0.291	6.49%
	12.00	0.30	1.04	0.30	0.312	6.95%
	13.00	0.30	0.86	0.30	0.258	5.75%
	14.00	0.45	0.77	0.45	0.347	7.72%
	15.00	0.55	0.76	0.55	0.418	9.32%
	16.00	0.30	0.47	0.30	0.141	3.14%
	17.00	0.28	0.83	0.28	0.232	5.18%
	18.00	0.28	0.68	0.28	0.190	4.24%
	19.00	0.25	0.82	0.25	0.205	4.57%
	20.00	0.28	0.84	0.28	0.235	5.24%
	21.00	0.30	0.84	0.30	0.252	5.62%
	22.00	0.30	0.76	0.30	0.228	5.08%
	23.00	0.30	0.75	0.30	0.225	5.02%
	24.00	0.20	0.53	0.20	0.106	2.36%
	25.00	0.20	0.00	0.20	0.000	0.00%
	26.00	0.20	0.00	0.20	0.000	0.00%
right facing	27.00	0.20	0.00	0.30	0.000	0.00%
upstream	29.00	0.00	0.00	0.00	0.000	0.00%
Average		0.26	0.58			
Total				6.72	4.487	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.10
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.4
Date:	5/11/2012	**Total Discharge (ft^3/sec):**	8.2671
Time:	10:30 AM	**Method:**	0.6
Other:	sunny, partly cloudy in past 24 hr		

Bank	**Horizontal Distance (ft)**	**Depth (ft)**	**velocity (ft/sec)**	**Cross-sectional area (ft^2)**	**Subsection Discharge (ft^3/sec)**	**% discharge**
left facing	4.00	0.00	0.00			
upstream	5.00	0.23	0.00	0.23	0.000	0.00%
	6.00	0.25	1.02	0.25	0.255	3.08%
	7.00	0.32	1.03	0.32	0.330	3.99%
	8.00	0.25	1.27	0.25	0.318	3.84%
	9.00	0.38	1.27	0.38	0.483	5.84%
	10.00	0.38	1.42	0.38	0.540	6.53%
	11.00	0.35	1.25	0.35	0.438	5.29%
	12.00	0.38	1.41	0.38	0.536	6.48%
	13.00	0.32	1.29	0.32	0.413	4.99%
	14.00	0.45	0.98	0.45	0.441	5.33%
	15.00	0.70	1.32	0.70	0.924	11.18%
	16.00	0.38	1.21	0.38	0.460	5.56%
	17.00	0.32	1.06	0.32	0.339	4.10%
	18.00	0.32	1.05	0.32	0.336	4.06%
	19.00	0.30	0.88	0.30	0.264	3.19%
	20.00	0.30	0.93	0.30	0.279	3.37%
	21.00	0.35	1.07	0.35	0.375	4.53%
	22.00	0.40	0.96	0.40	0.384	4.64%
	23.00	0.32	0.91	0.32	0.291	3.52%
	24.00	0.30	1.15	0.30	0.345	4.17%
	25.00	0.30	0.91	0.30	0.273	3.30%
	26.00	0.30	0.82	0.30	0.246	2.98%
right facing	27.00	0.20	0.00	0.34	0.000	0.00%
upstream	29.40	0.00	0.00	0.00	0.000	0.00%
Average		0.31	0.93			
Total				7.94	8.267	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	0.02
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	24.3
Date:	6/19/2012	**Total Discharge (ft^3/sec):**	5.57985
Time:	8:50 AM	**Method:**	0.6
Other:	Sunny, partly cloudy in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left facing	5.00	0.00	0.00			
upstream	6.00	0.23	0.00	0.23	0.000	0.00%
	7.00	0.25	0.45	0.25	0.113	2.02%
	8.00	0.32	1.03	0.32	0.330	5.91%
	9.00	0.25	0.70	0.25	0.175	3.14%
	10.00	0.38	0.74	0.38	0.281	5.04%
	11.00	0.38	0.87	0.57	0.496	8.89%
	13.00	0.25	1.07	0.38	0.401	7.19%
	14.00	0.35	0.92	0.26	0.242	4.33%
	14.50	0.50	0.84	0.25	0.210	3.76%
	15.00	0.65	1.06	0.46	0.482	8.64%
	15.90	0.62	1.02	0.31	0.316	5.67%
	16.00	0.30	1.21	0.17	0.200	3.58%
	17.00	0.25	0.98	0.38	0.368	6.59%
	19.00	0.25	1.10	0.50	0.550	9.86%
	21.00	0.30	1.03	0.45	0.464	8.31%
	22.00	0.25	1.25	0.38	0.469	8.40%
	24.00	0.25	0.97	0.50	0.485	8.69%
right facing	26.00	0.20	0.00	0.53	0.000	0.00%
upstream	29.30	0.00	0.00	0.00	0.000	0.00%
Average		0.30	0.76			
Total				6.55	5.580	

Stream:	Pipe Creek	**Staff Gage Height (ft):**	1.4
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	25.5
Date:	10/31/2012	**Total Discharge (ft^3/sec):**	370.596
Time:	12:00 PM	**Method:**	stick
Other:	rainy, cloudy, Rainy in past 24 hrs		
	Bank full, leaves on gage, rapid flow, stick method, 58.4 ft length		

	Time (sec)	velocity (ft/sec)
	6.98	8.47
	6.91	
	6.77	
	6.91	
Average	6.89	

Appendix C

Flowrate and Discharge Data
For
Mill Creek

Stream:	Mill Creek	**Staff Gage Height (ft):**	2.5
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.8
Date:	3/14/2012	**Total Discharge (ft3/sec)**	77.40
Time:	3:12 PM	**Method:**	stick
Other:	Rained day before.	(Discharge=vel *Ac*.9)	

Timed stick floating down river downstream of bridge to powerpole, 83 ft.
Distance was measured on the bank parallel to flow.

Distance (ft)	**Time (sec)**	**Velocity ft.(sec)**	**Ac (ft^2)**	**Ave depth (ft)**
83	82.49	1.01	64.467	1.84
61	56.29	1.33		
	41.07			
	41.00			
	44.56			
Average Time	45.73			

Stream:	Mill Creek	**Staff Gage Height (ft):**	4.48
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.8
Date:	3/16/2012	**Total Discharge (ft3/sec):**	372.50
Time:	10:00 AM	**Method:**	stick
Other:	Sunny, rained night before. Bedrock drop is not visible.		

Higher flow than 3/14/12. Water is at top of bank on gage side.
Timed stick floating down river downstream of bridge to powerpole, 83 ft.
Distance was measured on the bank parallel to flow.
(Discharge=vel *Ac*.9)

Distance (ft)	**Time (sec)**	**Velocity ft.(sec)**	**Ac (ft^2)**	**Ave depth (ft)**
83	22.28	3.30	3.926	3.53
	30.66			
	25.07			
	26.40			
	21.51			
Average Time	25.18			

Stream:	Mill Creek	**Staff Gage Height (ft):**	3.19
Monitors:	Linda Cornell, Bill Cornell	**Stream Width (ft):**	33.8
Date:	3/17/2012	**Total Discharge (ft3/sec):**	147.45
Time:	afternoon	**Method:**	stick
Other:	Sunny, 77oF		

Timed stick floating down river downstream of bridge to powerpole, 83 ft..
Distance was measured on the bank parallel to flow.
(Discharge=vel *Ac*.9)

Distance (ft)	Time (sec)	Velocity ft.(sec)	Ac (ft^2)	Ave depth (ft)
83.00	36.00	1.91	85.74	2.43
	42.20			
	45.20			
	54.70			
	39.10			
Average Time	43.44			

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.86
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	31.7
Date:	3/22/2012	**Total Discharge (ft^3/sec):**	19.594
Time:	4:40 - 5:15 pm	**Method:**	0.6
Other:	Sunny, sunny in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
right side	36.20	0.00	0.00			
facing upstream	35.00	1.30	0.35	2.08	0.728	3.72%
side with house	33.00	1.80	0.70	3.60	2.520	12.86%
	31.00	1.60	0.70	3.20	2.240	11.43%
	29.00	1.40	0.51	2.80	1.428	7.29%
	27.00	1.25	0.53	2.50	1.325	6.76%
	25.00	1.25	0.42	1.88	0.788	4.02%
	24.00	1.25	0.38	1.25	0.475	2.42%
	23.00	1.20	0.39	1.20	0.468	2.39%
	22.00	1.20	0.41	1.80	0.738	3.77%
	20.00	1.30	0.36	1.95	0.702	3.58%
	19.00	1.55	0.51	2.33	1.186	6.05%
	17.00	1.60	0.46	2.40	1.104	5.63%
	16.00	1.55	0.64	1.55	0.992	5.06%
	15.00	1.55	0.50	1.55	0.775	3.96%
	14.00	1.50	0.50	1.50	0.750	3.83%
	13.00	1.50	0.45	1.50	0.675	3.44%
	12.00	1.50	0.41	2.25	0.923	4.71%
	10.00	1.55	0.35	3.10	1.085	5.54%
	8.00	1.50	0.18	3.00	0.540	2.76%
	6.00	1.25	0.07	2.19	0.153	0.78%
	4.50	0.00	0.00	0.00	0.000	0.00%
Average		1.30	0.40			
Total				43.62	19.594	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.82
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	34.2
Date:	3/23/2012	**Total Discharge (ft3/sec):**	14.6314
Time:	11:31 am -12:03pm	**Method:**	0.6
Other:	Partly cloudy, sunny in past 24 hr		

Bank	**Horizontal Distance (ft)**	**Depth (ft)**	**velocity (ft/sec)**	**Cross-sectional area (ft^2)**	**Subsection Discharge (ft^3/sec)**	**% discharge**
left side	2.70	0.00	0.00			
facing upstream	3.00	0.50	0.00	0.33	0.000	0.00%
east side	4.00	0.98	0.00	1.47	0.000	0.00%
	6.00	1.25	0.00	1.88	0.000	0.00%
	7.00	1.35	0.03	1.35	0.041	0.28%
	8.00	1.45	0.09	2.18	0.196	1.34%
	10.00	1.45	0.39	2.18	0.848	5.80%
	11.00	1.45	0.42	1.45	0.609	4.16%
	12.00	1.42	0.32	1.42	0.454	3.11%
	13.00	1.48	0.36	2.22	0.799	5.46%
	15.00	1.52	0.52	2.28	1.186	8.10%
	16.00	1.55	0.56	1.55	0.868	5.93%
	17.00	1.55	0.52	1.55	0.806	5.51%
	18.00	1.60	0.37	1.60	0.592	4.05%
	19.00	1.20	0.46	1.20	0.552	3.77%
	20.00	1.20	0.23	1.20	0.276	1.89%
	21.00	1.10	0.26	1.10	0.286	1.95%
	22.00	1.12	0.21	1.12	0.235	1.61%
	23.00	1.00	0.21	1.00	0.210	1.44%
	24.00	1.16	0.28	1.16	0.325	2.22%
	25.00	1.12	0.29	1.12	0.325	2.22%
	26.00	1.12	0.28	1.12	0.314	2.14%
	27.00	1.05	0.31	0.95	0.293	2.00%
	27.80	1.30	0.37	1.04	0.385	2.63%
	28.60	1.40	0.40	1.54	0.616	4.21%
	30.00	1.55	0.53	1.86	0.986	6.74%
	31.00	1.60	0.51	1.60	0.816	5.58%
	32.00	1.70	0.60	1.70	1.020	6.97%
	33.00	1.70	0.50	1.70	0.850	5.81%
	34.00	1.45	0.40	1.45	0.578	3.95%
	35.00	1.15	0.10	1.67	0.167	1.14%
	36.90	0.00	0.00	0.00	0.000	0.00%
Average		1.23	0.30			
Total				43.96	14.631	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.61
Monitors:	Linda Cornell, Evan Cornell	**Stream Width (ft):**	33.8
Date:	4/2/2012	**Total Discharge (ft3/sec):**	9.658
Time:	3:03 - 3:35 pm	**Method:**	0.6
Other:	Sunny, clear water		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left side	2.90	0.00	0.00			
facing upstream	4.00	0.65	0.02	0.68	0.014	0.14%
east side	5.00	1.00	0.01	1.00	0.010	0.10%
	6.00	1.05	0.04	1.05	0.042	0.43%
	7.00	1.10	0.04	1.10	0.044	0.46%
	8.00	1.30	0.04	1.30	0.052	0.54%
	9.00	1.30	0.10	1.30	0.130	1.35%
	10.00	1.35	0.17	1.35	0.230	2.38%
	11.00	1.30	0.35	1.30	0.455	4.71%
	12.00	1.33	0.32	1.33	0.426	4.41%
	13.00	1.35	0.32	1.35	0.432	4.47%
	14.00	1.30	0.29	1.30	0.377	3.90%
	15.00	1.31	0.33	1.31	0.432	4.48%
	16.00	1.35	0.45	1.35	0.608	6.29%
	17.00	1.38	0.33	1.38	0.455	4.72%
	18.00	1.40	0.21	1.40	0.294	3.04%
	19.00	0.90	0.33	0.90	0.297	3.08%
	20.00	1.00	0.22	1.00	0.220	2.28%
	21.00	0.90	0.27	0.90	0.243	2.52%
	22.00	0.95	0.22	0.95	0.209	2.16%
	23.00	0.98	0.20	0.98	0.196	2.03%
	24.00	0.98	0.24	0.98	0.235	2.44%
	25.00	0.95	0.23	0.95	0.219	2.26%
	26.00	0.95	0.21	0.95	0.200	2.07%
	27.00	0.95	0.28	0.95	0.266	2.75%
	28.00	1.15	0.38	1.15	0.437	4.52%
	29.00	1.20	0.27	1.20	0.324	3.35%
	30.00	1.30	0.40	1.30	0.520	5.38%
	31.00	1.45	0.39	1.45	0.566	5.86%
	32.00	1.55	0.44	1.55	0.682	7.06%
	33.00	1.50	0.36	1.50	0.540	5.59%
	34.00	1.25	0.35	1.25	0.438	4.53%
	35.00	1.00	0.05	1.35	0.068	0.70%
	36.70	0.00	0.00	0.00	0.000	0.00%
Average		1.10	0.23			
Total				37.81	9.658	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.62
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.6
Date:	4/4/2012	**Total Discharge (ft3/sec):**	10.296
Time:	2:50 PM	**Method:**	0.6
Other:	Sunny, sunny in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left side	3.00	0.00	0.00			
facing upstream	4.00	0.75	0.04	0.75	0.015	0.15%
east side	5.00	1.00	0.02	1.00	0.000	0.00%
	6.00	1.05	0.00	1.05	0.011	0.10%
	7.00	1.20	0.01	1.20	0.036	0.35%
	8.00	1.30	0.03	1.30	0.130	1.26%
	9.00	1.32	0.10	1.32	0.370	3.59%
	10.00	1.32	0.28	1.32	0.462	4.49%
	11.00	1.30	0.35	1.30	0.481	4.67%
	12.00	1.32	0.37	1.32	0.436	4.23%
	13.00	1.35	0.33	1.35	0.459	4.46%
	14.00	1.30	0.34	1.30	0.351	3.41%
	15.00	1.32	0.27	1.32	0.515	5.00%
	16.00	1.35	0.39	1.35	0.527	5.11%
	17.00	1.38	0.39	1.38	0.317	3.08%
	18.00	1.40	0.23	1.68	0.470	4.57%
	19.40	1.10	0.28	1.10	0.308	2.99%
	20.00	1.05	0.28	0.84	0.193	1.88%
	21.00	0.95	0.23	0.95	0.238	2.31%
	22.00	0.95	0.25	0.95	0.257	2.49%
	23.00	1.00	0.27	1.00	0.240	2.33%
	24.00	1.00	0.24	1.00	0.230	2.23%
	25.00	0.95	0.23	0.95	0.257	2.49%
	26.00	0.95	0.27	0.95	0.323	3.14%
	27.00	0.95	0.34	0.95	0.276	2.68%
	28.00	1.10	0.29	1.10	0.275	2.67%
	29.00	1.20	0.25	1.20	0.492	4.78%
	30.00	1.32	0.41	1.32	0.502	4.87%
	31.00	1.45	0.38	1.45	0.653	6.34%
	32.00	1.60	0.45	1.60	0.752	7.30%
	33.00	1.60	0.47	1.60	0.592	5.75%
	34.00	1.20	0.37	1.20	0.132	1.28%
	35.00	1.00	0.11	1.30	0.000	0.00%
	36.60	0.00	0.00	0.00	0.000	0.00%
Average		1.12	0.24			
Total				38.40	10.296	

Stream:	Mill Creek	**Staff Gage Height (ft):**	0.42
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.6
Date:	4/18/2012	**Total Discharge (ft3/sec):**	4.448
Time:	3:14 PM	**Method:**	0.6
Other:	Sunny, sunny in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left side	3.20	0.00	0.00			
facing upst	4.00	0.50	0.00	0.45	0.000	0.00%
east side	5.00	0.80	0.03	0.80	0.024	0.54%
	6.00	0.82	0.03	0.82	0.025	0.55%
	7.00	0.96	0.04	0.96	0.038	0.86%
	8.00	1.10	0.07	1.10	0.077	1.73%
	9.00	1.10	0.13	1.10	0.143	3.22%
	10.00	1.10	0.25	1.10	0.275	6.18%
	11.00	1.10	0.26	1.10	0.286	6.43%
	12.00	1.05	0.16	1.05	0.168	3.78%
	13.00	1.05	0.25	1.05	0.263	5.90%
	14.00	1.10	0.17	1.10	0.187	4.20%
	15.00	1.10	0.25	1.10	0.275	6.18%
	16.00	1.12	0.15	1.12	0.168	3.78%
	17.00	1.16	0.16	1.16	0.186	4.17%
	18.00	1.15	0.07	1.15	0.081	1.81%
	19.00	0.70	0.13	0.70	0.091	2.05%
	20.00	0.82	0.14	0.82	0.115	2.58%
	21.00	0.70	0.15	0.70	0.105	2.36%
	22.00	0.75	0.07	0.75	0.053	1.18%
	23.00	0.80	0.07	0.80	0.056	1.26%
	24.00	0.75	0.03	0.75	0.023	0.51%
	25.00	0.75	0.02	0.75	0.015	0.34%
	26.00	0.72	0.03	0.72	0.022	0.49%
	27.00	0.75	0.15	0.75	0.113	2.53%
	28.00	0.95	0.18	0.95	0.171	3.84%
	29.00	0.98	0.26	0.98	0.255	5.73%
	30.00	1.10	0.20	1.10	0.220	4.95%
	31.00	1.23	0.23	1.23	0.283	6.36%
	32.00	1.40	0.27	1.40	0.378	8.50%
	33.00	1.40	0.12	1.40	0.168	3.78%
	34.00	1.25	0.13	1.25	0.163	3.65%
	35.00	0.60	0.03	0.84	0.025	0.57%
	36.80	0.00	0.00	0.00	0.000	0.00%
Average		0.91	0.12			
Total				31.05	4.448	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.4
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.4
Date:	4/23/2012	**Total Discharge (ft3/sec):**	3.86115
Time:	2:55 PM	**Method:**	0.6
Other:	Sunny, partly cloudy, cloudy in past 24 hr		

Bank	**Horizontal Distance (ft)**	**Depth (ft)**	**velocity (ft/sec)**	**Cross-sectional area (ft^2)**	**Subsection Discharge (ft^3/sec)**	**% discharge**
left side	3.00	0.00	0.00			
facing upstream	4.00	0.40	0.00	0.40	0.000	0.00%
east side	5.00	0.80	0.00	0.80	0.000	0.00%
	6.00	0.85	0.08	0.85	0.068	1.76%
	7.00	1.00	0.09	1.00	0.090	2.33%
	8.00	1.10	0.07	1.10	0.077	1.99%
	9.00	1.10	0.15	1.10	0.165	4.27%
	10.00	1.00	0.17	1.10	0.187	4.84%
	11.20	1.05	0.14	1.05	0.147	3.81%
	12.00	1.05	0.21	0.95	0.198	5.14%
	13.00	1.05	0.24	1.05	0.252	6.53%
	14.00	1.10	0.14	1.10	0.154	3.99%
	15.00	1.10	0.16	1.10	0.176	4.56%
	16.00	1.15	0.16	1.15	0.184	4.77%
	17.00	1.18	0.16	1.18	0.189	4.89%
	18.00	1.20	0.07	1.20	0.084	2.18%
	19.00	0.80	0.05	0.80	0.040	1.04%
	20.00	0.75	0.04	0.75	0.030	0.78%
	21.00	0.70	0.01	0.70	0.007	0.18%
	22.00	0.75	0.00	0.75	0.000	0.00%
	23.00	0.80	0.00	0.80	0.000	0.00%
	24.00	0.75	0.00	0.75	0.000	0.00%
	25.00	0.70	0.01	0.70	0.007	0.18%
	26.00	0.75	0.01	0.75	0.008	0.19%
	27.00	0.80	0.05	0.80	0.040	1.04%
	28.00	0.90	0.12	0.90	0.108	2.80%
	29.00	1.00	0.15	1.00	0.150	3.88%
	30.00	1.15	0.25	1.15	0.288	7.45%
	31.00	1.25	0.27	1.25	0.338	8.74%
	32.00	1.38	0.23	1.38	0.317	8.22%
	33.00	1.40	0.18	1.40	0.252	6.53%
	34.00	1.00	0.18	1.70	0.306	7.93%
	36.40	0.00	0.00	0.00	0.000	0.00%
Average		0.91	0.10			
Total				30.71	3.861	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.4
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.6
Date:	4/25/2012	**Total Discharge (ft^3/sec):**	3.084
Time:	3:20 PM	**Method:**	0.6
Other:	Sunny, sunny in past 24 hr		

Bank	**Horizontal Distance (ft)**	**Depth (ft)**	**velocity (ft/sec)**	**Cross-sectional area (ft^2)**	**Subsection Discharge (ft^3/sec)**	**% discharge**
left side	3.00	0.00	0.00			
facing upstream	4.00	0.40	0.00	0.40	0.000	0.00%
east side	5.00	0.80	0.10	0.80	0.080	2.59%
	6.00	0.80	0.05	0.80	0.040	1.30%
	7.00	0.95	0.02	0.95	0.019	0.62%
	8.00	1.06	0.05	1.06	0.053	1.72%
	9.00	1.05	0.05	1.05	0.053	1.70%
	10.00	1.00	0.18	1.00	0.180	5.84%
	11.00	0.98	0.27	0.98	0.265	8.58%
	12.00	1.00	0.12	1.00	0.120	3.89%
	13.00	1.00	0.30	1.00	0.300	9.73%
	14.00	1.10	0.17	1.10	0.187	6.06%
	15.00	1.10	0.16	1.10	0.176	5.71%
	16.00	1.10	0.16	1.10	0.176	5.71%
	17.00	1.15	0.13	1.15	0.150	4.85%
	18.00	1.15	0.03	1.15	0.035	1.12%
	19.00	0.75	0.09	0.75	0.068	2.19%
	20.00	0.70	0.02	0.70	0.014	0.45%
	21.00	0.70	0.00	0.70	0.000	0.00%
	22.00	0.75	0.00	0.75	0.000	0.00%
	23.00	0.75	0.01	0.75	0.008	0.24%
	24.00	0.70	0.00	0.70	0.000	0.00%
	25.00	0.70	0.00	0.70	0.000	0.00%
	26.00	0.70	0.00	0.70	0.000	0.00%
	27.00	0.70	0.00	0.70	0.000	0.00%
	28.00	0.95	0.06	0.95	0.057	1.85%
	29.00	0.95	0.13	0.95	0.124	4.00%
	30.00	1.15	0.19	1.15	0.219	7.09%
	31.00	1.20	0.18	1.20	0.216	7.00%
	32.00	1.38	0.19	1.38	0.262	8.50%
	33.00	1.30	0.15	1.30	0.195	6.32%
	34.00	1.00	0.08	1.00	0.080	2.59%
	35.00	0.80	0.01	1.04	0.010	0.34%
	36.60	0.00	0.00	0.00	0.000	0.00%
Average		0.88	0.09			
Total				30.06	3.084	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.38
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.4
Date:	4/27/2012	**Total Discharge (ft^3/sec):**	3.8722
Time:	10:15 AM	**Method:**	0.6
Other:	partly cloudy, partly cloudy in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left side	3.00	0.00	0.00			
facing upstream	4.00	0.70	0.00	0.70	0.000	0.00%
east side	5.00	0.80	0.00	0.80	0.000	0.00%
	6.00	0.85	0.03	0.85	0.026	0.66%
	7.00	0.95	0.03	0.95	0.029	0.74%
	8.00	1.05	0.01	1.05	0.011	0.27%
	9.00	1.05	0.09	1.05	0.095	2.44%
	10.00	1.05	0.17	1.05	0.179	4.61%
	11.00	1.10	0.23	1.10	0.253	6.53%
	12.00	1.00	0.23	1.00	0.230	5.94%
	13.00	1.00	0.31	1.00	0.310	8.01%
	14.00	1.05	0.31	1.05	0.326	8.41%
	15.00	1.05	0.21	1.05	0.221	5.69%
	16.00	1.10	0.21	1.10	0.231	5.97%
	17.00	1.15	0.14	1.15	0.161	4.16%
	18.00	1.15	0.05	1.15	0.058	1.48%
	19.00	0.85	0.07	0.85	0.060	1.54%
	20.00	0.70	0.06	0.70	0.042	1.08%
	21.00	0.65	0.06	0.65	0.039	1.01%
	22.00	0.75	0.05	0.75	0.038	0.97%
	23.00	0.75	0.05	0.75	0.038	0.97%
	24.00	0.65	0.05	0.65	0.033	0.84%
	25.00	0.70	0.04	0.70	0.028	0.72%
	26.00	0.70	0.04	0.70	0.028	0.72%
	27.00	0.60	0.07	0.60	0.042	1.08%
	28.00	0.90	0.13	0.90	0.117	3.02%
	29.00	0.95	0.19	0.95	0.181	4.66%
	30.00	1.15	0.27	1.15	0.311	8.02%
	31.00	1.25	0.25	1.25	0.313	8.07%
	32.00	1.35	0.21	1.35	0.284	7.32%
	33.00	1.30	0.13	1.30	0.169	4.36%
	34.00	0.80	0.02	1.36	0.027	0.70%
	36.40	0.00	0.00	0.00	0.000	0.00%
Average		0.88	0.11			
Total				29.66	3.872	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.45
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.3
Date:	5/2/2012	**Total Discharge (ft^3/sec):**	3.039
Time:	11:55 AM	**Method:**	0.6
Other:	partly cloudy, rainy and partly cloudy in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left side	3.00	0.00	0.00			
facing upstream	4.00	0.65	0.02	0.65	0.013	0.43%
east side	5.00	0.90	0.00	0.90	0.000	0.00%
	6.00	1.01	0.00	1.01	0.000	0.00%
	7.00	1.05	0.00	1.05	0.000	0.00%
	8.00	1.10	0.00	1.10	0.000	0.00%
	9.00	1.10	0.00	1.10	0.000	0.00%
	10.00	1.10	0.19	1.10	0.209	6.88%
	11.00	1.12	0.28	1.12	0.314	10.32%
	12.00	1.05	0.25	1.05	0.263	8.64%
	13.00	1.10	0.32	1.10	0.352	11.58%
	14.00	1.12	0.14	1.12	0.157	5.16%
	15.00	1.15	0.08	1.15	0.092	3.03%
	16.00	1.20	0.11	1.20	0.132	4.34%
	17.00	1.20	0.07	1.20	0.084	2.76%
	18.00	1.20	0.03	1.20	0.036	1.18%
	19.00	1.00	0.02	1.00	0.020	0.66%
	20.00	0.80	0.10	0.80	0.080	2.63%
	21.00	0.80	0.00	0.80	0.000	0.00%
	22.00	0.85	0.00	0.85	0.000	0.00%
	23.00	0.80	0.00	0.80	0.000	0.00%
	24.00	0.75	0.00	0.75	0.000	0.00%
	25.00	0.75	0.00	0.75	0.000	0.00%
	26.00	0.75	0.00	0.75	0.000	0.00%
	27.00	0.70	0.00	0.70	0.000	0.00%
	28.00	1.00	0.12	1.00	0.120	3.95%
	29.00	1.00	0.21	1.00	0.210	6.91%
	30.00	1.20	0.14	1.20	0.168	5.53%
	31.00	1.25	0.24	1.25	0.300	9.87%
	32.00	1.45	0.29	1.45	0.421	13.83%
	33.00	1.40	0.05	1.40	0.070	2.30%
	34.00	0.95	0.00	1.57	0.000	0.00%
	36.30	0.00	0.00	0.00	0.000	0.00%
Average		0.95	0.08			
Total				32.12	3.039	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.82
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	34.2
Date:	5/11/2012	**Total Discharge (ft^3/sec):**	12.25565
Time:	11:30 AM	**Method:**	0.6
Other:	sunny, partly cloudy in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left side	2.60	0.00	0.00			
facing upstream	3.00	0.75	0.05	0.53	0.026	0.21%
east side	4.00	1.05	0.04	1.05	0.042	0.34%
	5.00	1.30	0.08	1.30	0.104	0.85%
	6.00	1.30	0.03	1.30	0.039	0.32%
	7.00	1.40	0.02	1.40	0.028	0.23%
	8.00	1.48	0.00	1.48	0.000	0.00%
	9.00	1.48	0.00	1.48	0.000	0.00%
	10.00	1.49	0.12	1.49	0.179	1.46%
	11.00	1.40	0.40	1.40	0.560	4.57%
	12.00	1.42	0.46	1.42	0.653	5.33%
	13.00	1.45	0.52	1.45	0.754	6.15%
	14.00	1.50	0.56	1.50	0.840	6.85%
	15.00	1.50	0.48	1.50	0.720	5.87%
	16.00	1.50	0.51	1.50	0.765	6.24%
	17.00	1.58	0.43	1.58	0.679	5.54%
	18.00	1.58	0.46	1.58	0.727	5.93%
	19.00	1.20	0.54	1.20	0.648	5.29%
	20.00	1.15	0.58	1.15	0.667	5.44%
	21.00	1.10	0.36	1.10	0.396	3.23%
	22.00	1.15	0.41	1.15	0.472	3.85%
	23.00	1.20	0.26	1.20	0.312	2.55%
	24.00	1.10	0.31	1.10	0.341	2.78%
	25.00	1.10	0.17	1.10	0.187	1.53%
	26.00	1.10	0.16	1.10	0.176	1.44%
	27.00	1.05	0.23	1.05	0.242	1.97%
	28.00	1.32	0.18	1.32	0.238	1.94%
	29.00	1.40	0.21	1.40	0.294	2.40%
	30.00	1.56	0.13	1.56	0.203	1.65%
	31.00	1.65	0.29	1.65	0.479	3.90%
	32.00	1.80	0.34	1.80	0.612	4.99%
	33.00	1.62	0.25	1.62	0.405	3.30%
	34.00	1.30	0.19	2.47	0.469	3.83%
	36.80	0.00	0.00	0.00	0.000	0.00%
Average		1.26	0.26			
Total				43.93	12.256	

Stream:	Mill Creek	**Staff Gage Height (ft):**	1.68
Monitors:	Linda Cornell, Bruce Mollison	**Stream Width (ft):**	33.1
Date:	6/19/2012	**Total Discharge (ft^3/sec):**	7.83805
Time:	9:50 AM	**Method:**	0.6
Other:	sunny, rainy and partly cloudy in past 24 hr		

Bank	Horizontal Distance (ft)	Depth (ft)	velocity (ft/sec)	Cross-sectional area (ft^2)	Subsection Discharge (ft^3/sec)	% discharge
left side	0.90	0.00	0.00			
facing upst	2.00	0.70	0.04	0.74	0.029	0.38%
east side	3.00	0.95	0.05	0.95	0.048	0.61%
	4.00	1.10	0.00	1.10	0.000	0.00%
	5.00	1.20	0.00	1.20	0.000	0.00%
	6.00	1.32	0.00	1.32	0.000	0.00%
	7.00	1.35	0.12	1.35	0.162	2.07%
	8.00	1.30	0.26	1.30	0.338	4.31%
	9.00	1.30	0.48	1.95	0.936	11.94%
	11.00	1.30	0.26	2.60	0.676	8.62%
	13.00	1.40	0.12	2.80	0.336	4.29%
	15.00	1.45	0.26	2.18	0.566	7.21%
	16.00	1.42	0.20	1.42	0.284	3.62%
	17.00	1.15	0.25	1.73	0.431	5.50%
	19.00	1.00	0.21	2.00	0.420	5.36%
	21.00	1.05	0.23	2.10	0.483	6.16%
	23.00	0.95	0.38	1.90	0.722	9.21%
	25.00	0.92	0.52	1.38	0.718	9.16%
	26.00	1.18	0.37	1.18	0.437	5.57%
	27.00	1.28	0.52	1.28	0.666	8.49%
	28.00	1.40	0.19	1.40	0.266	3.39%
	29.00	1.52	0.15	1.52	0.228	2.91%
	30.00	1.62	0.03	1.62	0.049	0.62%
	31.00	1.50	0.03	1.50	0.045	0.57%
	32.00	1.15	0.00	1.73	0.000	0.00%
	34.00	0.00	0.00	0.00	0.000	0.00%
Average		1.14	0.18			
Total				38.23	7.838	

Stream:	Mill Creek			**Staff Gage Height (ft):**	2.5
Monitors:	Linda Cornell, Bruce Mollison			**Stream Width (ft):**	33.8
Date:	10/31/2012			**Total Discharge (ft3/sec):**	342.917
Time:	12:45:00 PM			**Method:**	stick
Other:	rainy, cloudy, rainy in past 24 hours			(Discharge=vel *Ac *.9)	
				(Ac from Depth vs Ac correlation)	
	Distance (ft)	**Time(sec)**	**velocity (ft/sec)**	**Cross-sectional Area, Ac, (ft^2)**	
	68	21.72	2.83	134.46	
		22.07			
		26.33			
		23.47			
		26.40			
	Average Time	24.00			