WRPI Internship-Kings River Experimental Watersheds

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<u>Executive Summary</u>

The duration of my project was spent working at the Kings River Experimental Watersheds (KREW) in the Sierra National Forest near Shaver Lake, CA. During the internship, I had the opportunity to learn about water quality and monitoring using various instruments such as pH and Electroconductivity devices, using a velocimeter to determine flow rate and discharge of a stream, and using an ISCO device which can automatically be set to collect water samples from a stream. I was also part of a large group of people taking part in the removal of sediment from sediment catchment basins, located along various study stream courses throughout our area of the Sierra National Forest, during the week of Monday 7/22/2019. This was done to determine sediment load during the annual water year of 2018 to 2019, where precipitation runoff would lead to a certain amount, and include various types, of sediment for that water year. In addition, I was assigned the task of designing a tracer test study for 8 sites on some tributaries of the Kings River.

<u>Project Objectives</u>

During the course of my internship project I gained valuable experience with measuring water quality and sampling using various methods and technologies. The experience and research that I have done during this internship has made me more prepared for careers in the USDA which include becoming a hydro-technician. My goals on this project were to learn as much as I can about the tributaries of the Kings River watershed and to get a more in-depth look at what working for the US Forest Service is like on a daily basis. In addition, I designed a tracer test study for the first time which brought both an opportunity as well as a new challenge during the course of the internship.

A tracer test study uses a particular type of tracer salt solution in riparian streams to determine water discharge using the electrical conductivity (EC) of the tracer in the water to calculate discharge. Originally we were to set out conducting tracer tests on 8 sites in the Sierra National Forest sometime in late July, but due to delays in the shipment and arrival of the tracer salts and the approval from the acting head ranger to go ahead and perform the tracer tests, we were only able to do 4 sites in total.

Although we could not get to all 8 sites within our watersheds, the preliminary lab practice of using the tracer, the establishment of a calibration curve for the tracer to water ratio, and the EC measurements from the various sample bottles collected have allowed me to visually see the practicability and efficiency of my tracer test design, which is very important considering that the data that I have collected and the plan that I put together will most likely be used by another colleague or intern at another time.

This project was started unprecedentedly and was the first of its kind being done in this area, so the experiment was more of a practice of discerning which variables to use and seeing how to increase efficiency in design than the actual results themselves or the potential publishing of a scientific paper.

Project Approach

For this project, it was imperative of me to engage and learn how to use unfamiliar measuring equipment that are used in local streams to measure aspects of hydrology such as pH (the measure of acidity/alkalinity in the stream), temperature, electrical conductivity (EC), stream velocity across a width of a stream, and peak/low flows that are measured by ISCO devices remotely (inside sheds next to study reaches). Monitoring these various components of riparian ecology in the upper Sierra Nevadas is important in detecting pollution, abnormalities, and when flooding occurs which can impact structures and lead to montane soil erosion. This is the typical task of a hydro-technician with the US Forest Service.

In addition, occasional conference calls were initiated every few weeks to coordinate various projects as part of KREW and for each of us to update everyone else on our team about our parts of the projects; in my case I was responsible for the tracer test study and design. The tracer test design included the project site names, the type of tracer that would be used which was Potassium Bromide (KBr), the procedure for collecting samples and measuring discharge based on the electrical conductivity of the tracer solution against the background electrical conductivity, and data collection completion.

During the week of July 22, 2019 KREW and volunteers from other US Forest Service units began the annual task of removing sediment from catchment basins located along various study reaches within the Sierra National Forest. These sediment basins are flooded by their corresponding creeks during most of the water year, and then are drained ahead of the removal date to allow workers to dig the sediment load out of the basins to be weighted. This task only lasted a week this year, but in some years depending on the weather patterns due to El Nino/La Nina it can take up to two weeks and require the addition of specialized conveyor belt equipment due to heightened sediment load. This year, the sediment load per site was far lower than it was in precedent years, but still required multiple people to clear them out as much as possible to obtain accurate sediment load counts. The task required physical labor that I do not engage in on a regular basis which was somewhat of a challenge but was very rewarding at the same time to see the results of our labor and be part of a dedicated team of scientists and volunteers.

As for the tracer test study, I could not get as many sites done as I had initially planned, this was due to a delay in the arrival of tracer salts which we were hoping to arrive by mid-July at latest, but ended up arriving July 30, 2019 right before the end of this internship. Not only that but there was a delayed response for approval by the acting head ranger who is responsible for approving projects that use chemicals in the open environment. Most likely this was due to the acting head ranger asking multiple stakeholders and other departments within the national forest for their input and suggestions, and also the occasional rotation of personnel acting as head ranger for the national forest in the first place. We did not want to start until we got approval as this can prevent further complications further along in the project or cause a problem with the other departments various projects without it.

Project Outcome

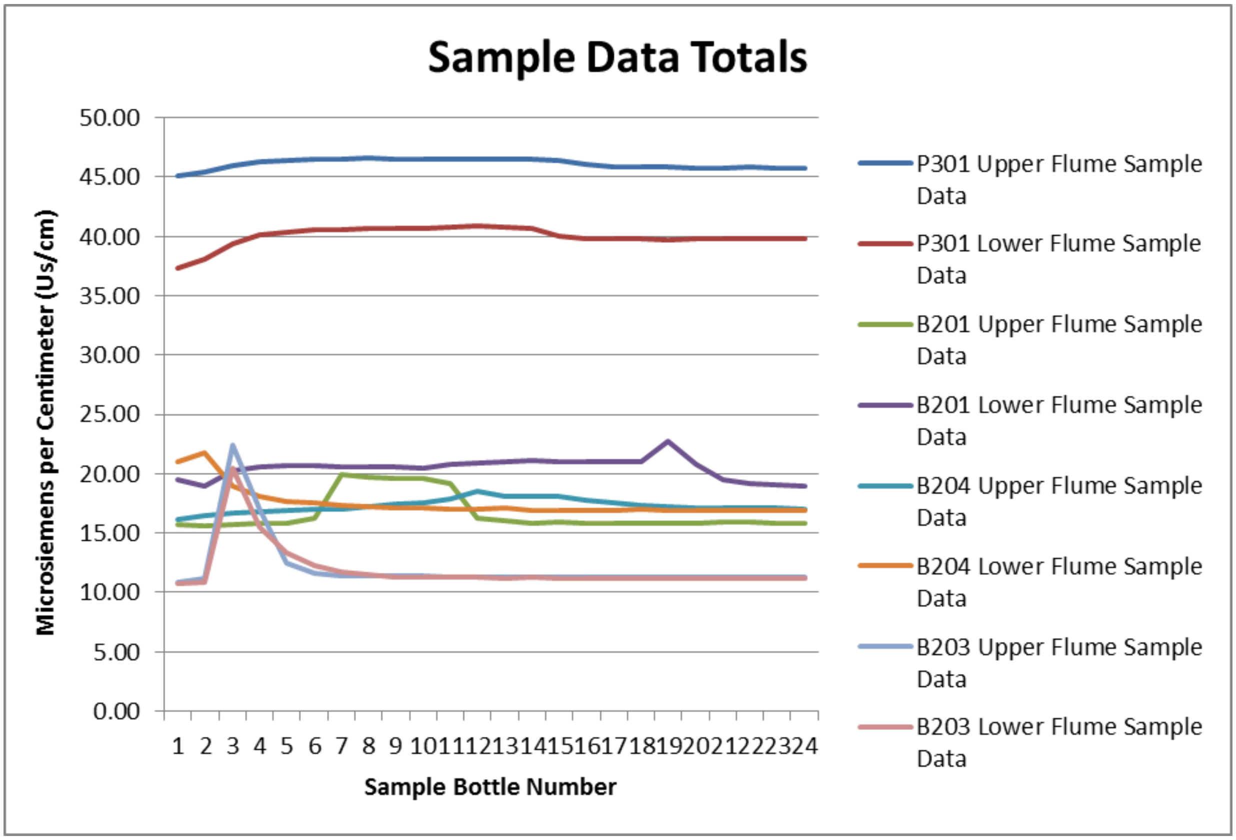


Image 1. The Electrical Conductivity (EC) values of sample bottles collected by an ISCO device at all sites and in two flumes per site. Values are in Microsiemens per Centimeter (Us/cm).

The study plan that I had created to assist in leading the fieldwork and the actual fieldwork done was not entirely carried out step per step as planned. The important part that was completed was seeing how the tracer salt actually behaved out in the field and the corresponding increase/decrease in EC values as time progressed. This is evidenced by the data values shown in the line graph of Image 1 where spikes in EC values within the stream samples were detected nearly within 5 minutes of initial tracer release and the beginning of automatic data collection of 500 ml of sample water per bottle per minute.

In addition to the sample bottle collection, the method of tracer injection release was not consistent. I wanted to see whether using two different methods of tracer release would yield similar results, one method using a water pump to inject tracer water at a specified rate into the stream and another method where the water is simply dumped into the stream all at once. The results did not turn out consistently similar, and in effect the sites where I used the bucket method, where the water was dumped in all at once, produced a sharper spike in EC values within 3 to 5 minutes after release of tracer and then a steep decline versus the gradual rising of EC values at all other sites which then plateaued at a certain value and then gradually lessened in value. Either method could work in future tracer tests, but these appear to be the results of using one method over the other in the field. 2.5 sites were carried out using the pump method (P301, B201, and B204 upper flume) while the remaining 1.5 sites were done using the bucket method (B204 lower flume, and all of B203).

The results of the sediment basins has not been received yet as of this date, but from the experience received out in the field the total weight per site should be far lower than average for all precedent years of sediment basin data. Lastly, the experience with working alongside more experienced hydro-technicians has helped me to be more comfortable with working with lab equipment as it pertains to the study of hydrology and being able to independently monitor sites out in the field.

Starting EC of Stream Water/Tracer Concentration				
Site Name	Flume	EC Starting	Tracer Concentration	EC (Us/cm)
P301	Upper	45.10 Us/cm	5 grams in 5 liters	1075
P301	Lower	38.40	8 grams in 5 liters	1262
B201	Upper	16.02	8 grams in 5 liters	1358
B201	Lower	19.33	10 grams in 5 liters	2420
B204	Upper	17.35	10 grams in 5 liters	2480
B204	Lower	16.47	10 grams in 5 liters	2139
B203	Upper	11.18	10 grams in 5 liters	2410
B203	Lower	13.04	10 grams in 5 liters	2330

Image 2. Experiment sites, flumes, background EC (starting) of stream water, Tracer concentration, and EC value of Tracer concentration in 5 liters of stream water.

Conclusions

For the summer of 2019, my project took place in the Sierra National Forest with the Kings River Experimental Watersheds (KREW). It has been a fulfilling and positive experience for me and has allowed me to practice some of my academic skills in a professional environment. My project involved learning about water quality and monitoring alongside more experienced hydro-technicians. I also participated in clearing out sediment basins to measure sediment load in various streams throughout the water year of 2019. But most importantly, I designed a tracer test that can be carried out on various tributaries in the Kings River watershed which had never been performed in the area before. However; it was unfortunate that I could not get to all of the sites or fully carry out the tracer test steps, yet part of working in a professional environment is understanding that certain aspects of projects will get delayed and that working around them or mitigating them is part of being a professional in the USDA Forest Service and can even lead to new discoveries and ways of completing tasks that were not known before.

For future tracer test studies, perhaps using a dye solution as part of the tracer might assist in identifying areas of discharge leakage that are bypassing normal routes along study reaches, as this was the primary reason for designing the tracer test in the first place. Yet actual discharge missing could not be truly determined by just the tracer salts alone, and I am unsure of whether dye tracers could further assist this aspect of the experiment.

This internship was an excellent experience in that it prepared me to be more independent in leading myself especially with the design of experiments within the USDA and other agencies. This has allowed me to be more effective at learning about an issue, taking measures to solve it, and resolution through field, lab, and experimental work.

Image 3. This is an ISCO model 6712 water sampling device used during the tracer experiments. This device is also used to monitor flows, pH, and temperature of various creeks on site.

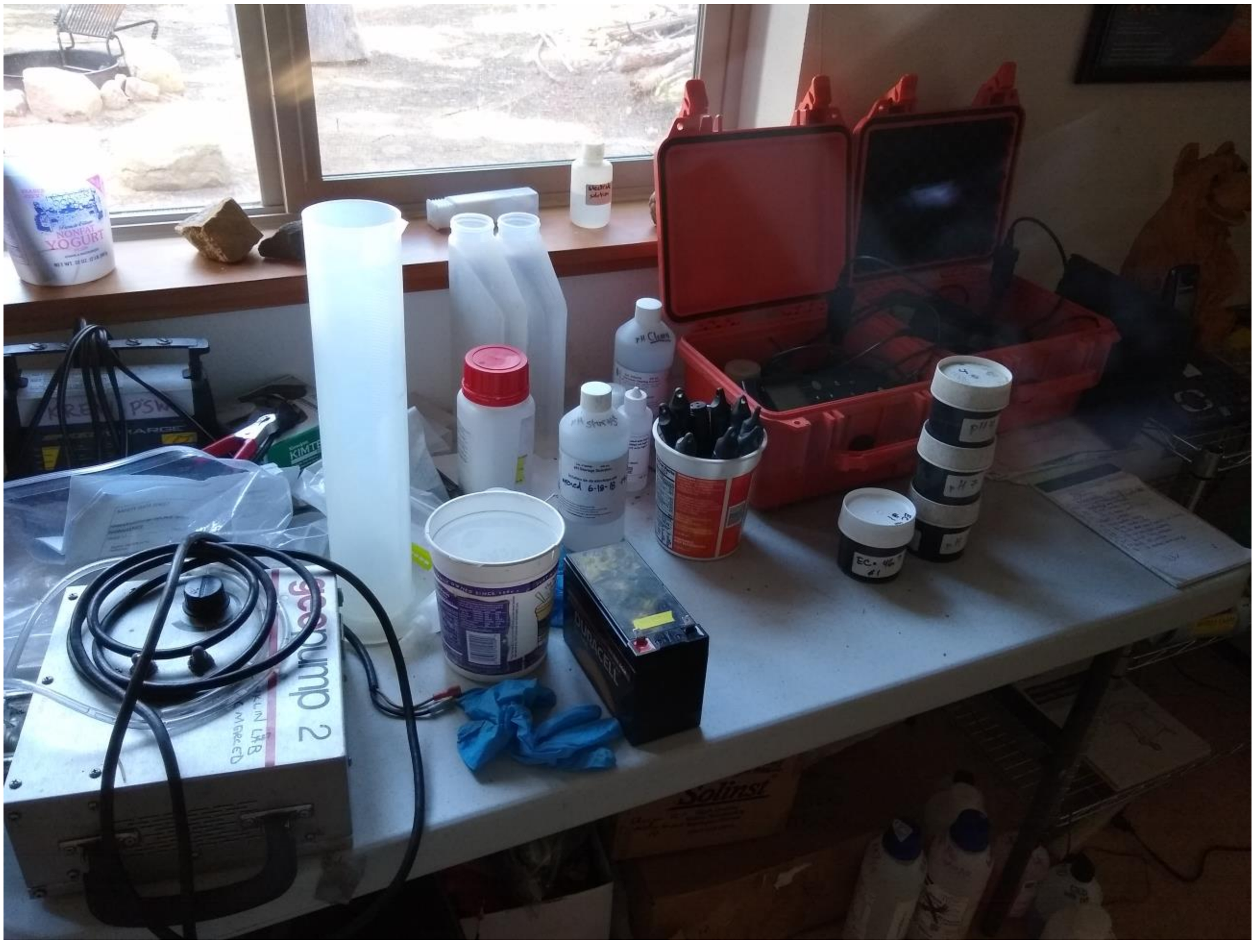


Image 4. These are just some of the various devices and equipment that I learned about and got to use during my internship.

Appendix

The following section shows the study experiment design that I created.

Preliminary Study Experiment Plan

-The reason why we are performing this tracer test is to determine how much water discharge is bypassing the flumes through seepage underneath or just upstream from the flumes which bypass their measurement throats.

-Materials:

- 2 ISCO 6712/6700 Model automatic water samplers
- 2 $110.62 bottles of KBr solution to be divided up between the 8 sites
- 12 V Geotech Geopump II for injecting above tracer solution at a specified rate into each of the 8 sites
- 2 HQ 30d flexi for Electrical Conductivity (EC) measurements
- Large number of 1 liter sampling bottles for the ISCOs

-There will be an estimated 2 to 3 participants in the study: The study lead (intern), and one to two hydro technicians with KREW. Additional volunteers and crew members may be available if applicable.

-There are 8 areas in the Sierra National Forest that will be part of the tracer test experiment. These areas are: T003 (Teakettle); B201, B203, and B204 (Bull); P301, P303, P304 (Providence); and D102 (Duff). Each of these areas except Teakettle has two flumes, an upper and a lower flume that are relatively close (less than 70 feet apart from each other). Teakettle has a large weir dam that will mark the downstream end of the study boundary at that site but also has one flume just upstream from the weir dam.

-Each area will be done at different times and/or days from each other for logistical reasons. For example, all Bull sites could be done in the same day due to proximity to each other, but providence, duff, and teakettle will most likely have to be done on their own days. Total of at least four, can be non-consecutive, days needed.

-The distance between the point of injection and the end of the study reach will be between 50 feet and 100 feet in distance, where the exact distance of each site will be calculated by using this formula: $L = 100 \text{ x } W^2/d$. W=average width of channel, and d= maximum depth of channel. Source: https://www.ethz.ch/content/dam/ethz/special-interest/usys/iac/iac-dam/documents/edu/courses/climatological_and_hydrological_field_work/Discharge.pdf (Institute for Atmospheric and Climate Science, 2019).

-Injection site will be upstream from the upper flume in each area, but downstream from any confluences or steep steps that may impact data analysis. This will be our 0 starting point for the length of creek that the study will take place for each area. Length of each site will vary from each other as noted above.

-Rate of Tracer injection should be .1002 liters per minute for a total of 15 minutes per site. 10 grams of kBr solution should be added to the 1.5 liters of water that will be needed during injection.

-Some helpful things to remember: 1500 grams = 1.5 liter. So 10 grams of tracer per 1500 grams per water is 1:150 of tracer to stream water.

-Velocity and Depth across the width of each stream will be determined with the use of our Acoustic Doppler Velocimeter (ADV).

-A background sample will be taken upstream from the injection site to determine already naturally occurring conductivity, using a 1 liter bottle.

-We will use this formula: $Q1=Q2+Q3$ where Q1 equals upstream discharge, Q2 equals the missing discharge, and Q3 is the discharge through the throat of the flume/weir. Q1 will be determined with the upstream sample, Q3 will be determined at the outlet of the upper flume, and the difference between Q1 and Q3 will be used to determine how much discharge is not bypassing the flumes properly or Q2.

-Samples will not be taken in sediment catchment basins, in steps with various topography that can create error in our results, and upstream from confluences of two or more creeks. Samples will be taken during the injection period of 15 minutes.

-The tracer chemical that we will use will be Potassium Bromide (kBr) the Molar mass of it would be 119.002 grams/mol.

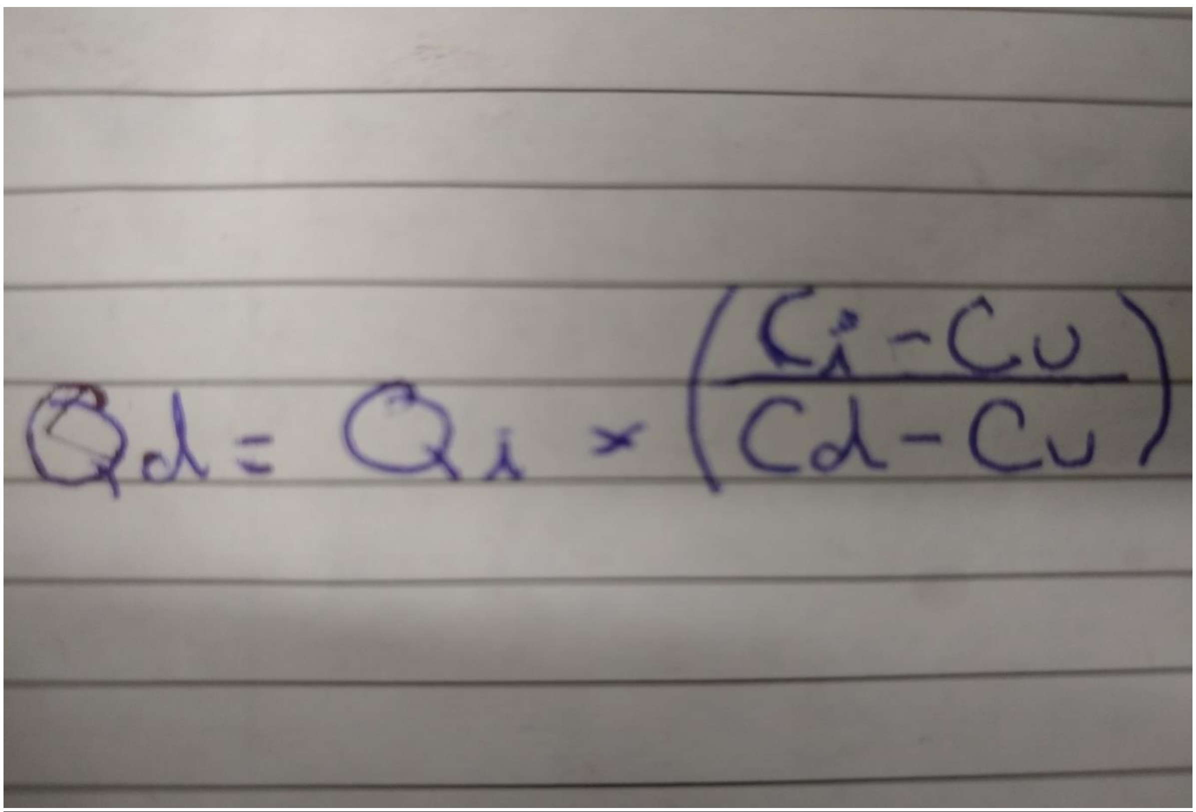
-We can have someone standing at a spot on the shore of the creek performing electroconductivity measurements every 10 seconds as the EC values go up and then 20 to 30 seconds as the EC values start to drop back down. This will take anywhere between 5 to 15 minutes of electroconductivity data collection.

-ISCO 6700/6712 device(s) will be used to take samples just 1 meter upstream from the location where the electroconductivity measurements will be taking place. We will manually trigger the

ISCO device to take samples every minute. The samples will be compared with our electroconductivity measurements.

-Quantity of Discharge. This is one of the formulas I think might be needed near the end of the experiment. Source: https://www.ethz.ch/content/dam/ethz/special-interest/usys/iac/iac-dam/documents/edu/courses/climatological_and_hydrological_field_work/Discharge.pdf (Institute of Atmospheric and Climate Science, 2019).

Quantity of Discharge (Qd) = Injection Rate (Qi) x [Concentration of Injected tracer (Ci) – Concentration of tracer upstream (Cu) / Concentration of tracer downstream (Cd) – Concentration of tracer upstream (Cu)



$$Q_d = Q_i \times \left(\frac{C_i - C_u}{C_d - C_u}\right)$$

<u>Instructions for Tracer Testing on Upper Elevation Watershed Creeks</u>

<u>Preparation for each site</u>

1. Measure the width of the stream using a 50 meter tape at three points: the area where the injection site location has been decided, a point in the section between the upper and lower flumes, and 1 meter downstream from the lower flume. The reason for this is because we need to determine the average width of the stream, and using the above

three points would be a good way to determine the average width or W in the following equation in #3 while leaving out the choke points caused by the flumes.

2. Measure the volumetric discharge by using the average depth and velocity across the width of the creek. Take the measurements of the width of the stream at a point between the injection site and the upper flume using the velocimeter, as this will be the immediate area where the mixing of the tracer will take place and therefore discharge is very crucial. The velocity may come in handy later during the experiment or for other sampling purposes.

3. Determine the exact length of the study by using the above formula: L = 100 x W^2/D. Note: W equals the average width of the three measuring tape sites (above in #1). The length should fall somewhere between 50 and 100 feet (between 15 and 30 meters). (Institute of Atmospheric and Climate Science, 2019).

4. Using a 1 liter bottle, fill the bottle with the creek water at the site and take an EC background measurement of the water, then add 1 gram of tracer to the bottle, stir using a plastic spoon or pole, and then take an EC measurement of the water in the bottle. Repeat with an additional 1 gram five more times to establish a calibration curve between the tracer salt/solution and the background concentration of the water. This will be needed to determine discharge later on. Calibration curve should fall somewhere between a range of 4 to 10 grams with the average being about 7 grams.

Please Note: 1000 grams are in 1 liter of water.

5. Set up the pump adjacent to the injection site, set pump to instantaneously inject at a rate of 0.1002 liters/minute, and add 10 grams of tracer to 1.5 liters of water, attach hose that connects to the pump. Do not start the pump yet.

6. Have an ISCO station set up at the first EC collection spot (upstream of upper flume) and another one at the second EC collection spot (at the outlet of the upper flume). Move both ISCO stations to the lower flume and repeat in the above flume and outlet of flume portions.

7. Have the first upstream technician start the pump and then quickly return to their EC and ISCO station spot to begin data collection. Have the second technician begin data collection as well.

<u>Conducting Data Collection</u>

8. Have a technician stand just upstream from the upper flume and another at the outlet of the upper flume to measure EC every 10 seconds as the EC value goes up and then

every 30 seconds as the EC value goes down. These two EC values will then be shown as curves on a graph.

9. At the same time, have each technician operating an ISCO at the same spot as their EC measurements and have them instruct the ISCO to take samples every minute. Every other EC measurement should line up with about the same amount of EC as the sample that was collected by the adjacent ISCO.

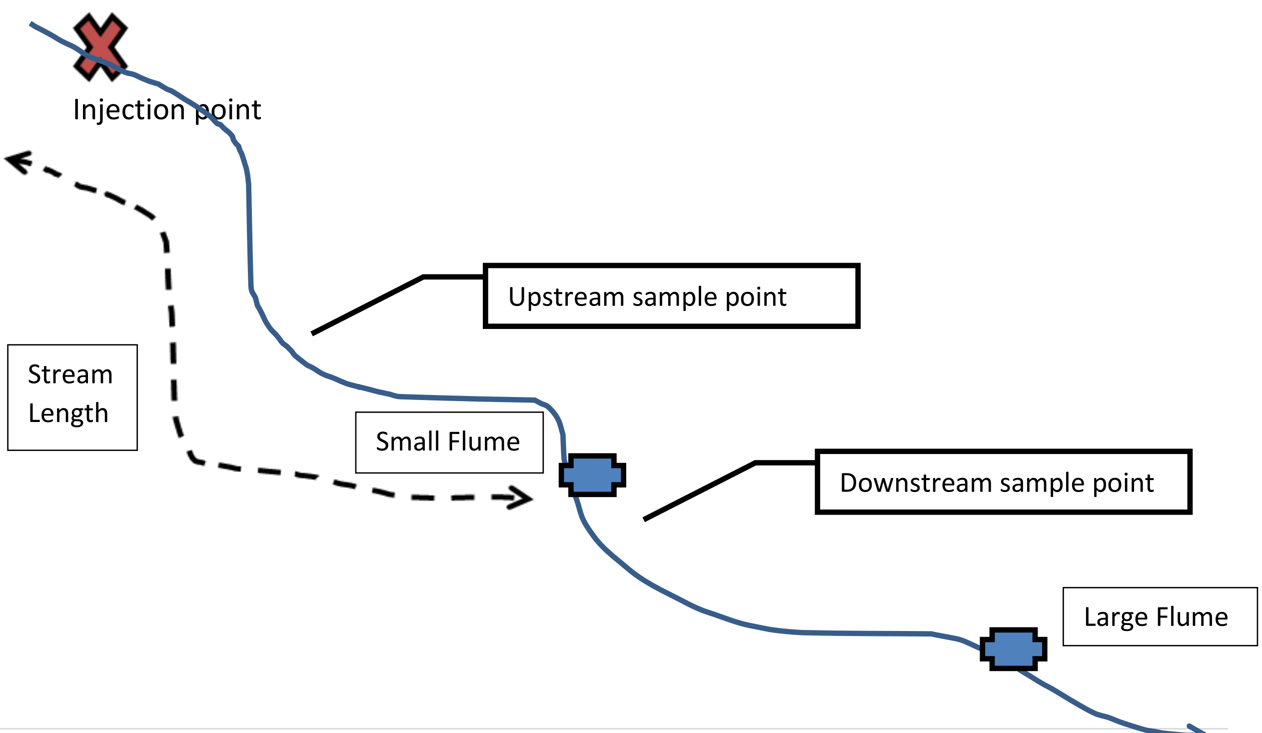
10. After EC values have substantially gone down (after 5 additional EC measurements) at the first (upstream) data collection spot, have the technician finish writing down necessary EC values. Have the second technician do the same at the second spot (downstream) as their EC values substantially go down.

11. After recording EC values, clear up the area of the ISCOs, EC collectors, Velocimeter, and pump. Move onto the next site or cease data collection for the day.

Conducting Data Analysis

12. Next calculations will be performed by the study lead to determine discharge at each site using the Q1=Q2 + Q3 formula to solve this question. In addition, data values will be entered into excel and a graph depicting fluctuation of EC curves will be made. These curves will hopefully demonstrate any water discharge that appears to go missing between flume throats and the downstream EC and ISCO measurements.

Visual Diagram of a typical site



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