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Bacterial and Sediment Transport in an Artificial Sand Bed Stream During Unsteady Flow

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BACTERIAL AND SEDIMENT TRANSPORT IN AN ARTIFICIAL SAND BED STREAM DURING UNSTEADY FLOW

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ABSTRACT

Storms cause a substantial increase in the fecal indicator bacteria (FIB) concentrations in stream water. Causes for this concentration increase include FIB-laden stormwater runoff and the release of bacteria from stream-bottom sediments. Studies were carried out to quantify this second cause of water quality impairment. Coliform bacteria are a group of FIB, indicate the presence of pathogenic microorganisms, and have been shown to be transported in streams far from their source areas, especially during storms. FIB transport is dependent on several factors including water velocity, size and transport rates of bed sediments, and the FIB concentration in bed sediment. The objective of this work is to determine the effect of varying flow rates on the transport of bed-dwelling coliforms in sand bed streams.

Artificial stream experiments were run with field-induced storm hydrographs to determine resuspension rates of coliforms and their association with the movement of bed material. Six artificial storm events were created by varying discharge in a 0.63-m wide stainless steel flume with 2.5 m of the 8-m-long channel bed covered with 0.26 to 0.375-mm sand. Peak flow rates varied from 0.04 to 0.074 m^3/s, peak velocities were 0.3 to 0.65 m/s, and event durations were either 60 min or 90 min. Water samples were collected upstream and downstream of the sand bed at selected intervals throughout each event, and bed sediment samples were collected before and after each event. Average FIB concentrations in water up- and downstream of the sand bed were statistically similar for events with peak velocities less than 0.58 m/s. Peak concentrations of total coliform and suspended sediments occurred in the

downstream samples during the rising limb of hydrographs, due to resuspension of coliforms and sand from the bed. However, after the initial surge, there was no noticeable effect of the water flows on resuspension. To simulate downstream concentrations due to resuspension, we modeled the system using a 1-D advection-dispersion equation with added source/sink terms to account for sediment settling and resuspension. This experiment and its analysis may provide a methodology for determining coliform and suspended sediment inputs into total maximum daily load (TMDL) calculations.

DEDICATION PAGE

This thesis is dedicated to my loving parents, Joe and Debbie McCaskill, for their guidance and encouragement to me and my education.

LIST OF ABBREVIATIONS AND SYMBOLS

ARS	Agricultural Research Service
DS	Downstream
EC	*Escherichia coli*
EPA	Environmental Protection Agency
SS	Suspended Solids
TC	Total Coliform
TMDL	Total Maximum Daily Load
US	Upstream
USDA	United States Department of Agriculture

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1. INTRODUCTION

Under the Clean Water Act section 303d, each state, territory, and authorized tribe is required to measure pollution in water bodies to ensure water quality standards. Any of these bodies of water that do not meet water quality standards are listed as “impaired waters”. Today, the leading cause of impaired waters is pathogens, with about 10,700 reports nationwide (USEPA 2012). Pathogens are microorganisms that are unwanted in surface waters because they cause diseases. Pathogens in water can be harmful to humans by contact through recreational play, consumption of fish, shellfish or wildlife, and public water systems. Although pathogens are heavily tested in medical human body studies, these tiny microorganisms are much less abundant in environmental waters and are rarely tested for because it is extremely difficult and costly. Instead of testing for pathogens themselves, fecal indicator bacteria (FIB) are measured to indicate the presence of pathogens. Examples of FIB, and the ones measured in this study, are total coliform (TC) and *Escherichia coli* (*E. coli* or EC). Though FIB only warns of the possible presence of pathogens, it has been found to be related to human illnesses (Haile et al. 1999, Cabelli et al. 1982).

In order for states to remediate impaired waters, a list of total maximum daily loads (TMDLs) is required for each polluted water body. A TMDL is an estimate of the maximum amount of a pollutant a body of water can handle on a daily basis and still meet water quality standards. The procedure for developing TMDLs is described in detail in the EPA’s “Protocol for

Developing Pathogen TMDLs" (USEPA 2001). It is important to note that one of the beginning steps to developing these daily loads is to determine the source/sources of the pollutant. Many point and nonpoint sources, such as overflows from wastewater treatment plants and stormwater runoff, have been accounted for when developing TMDLs, but the sediment dwelling bacteria in streams have not been considered.

While pathogens are the leading cause of impaired waters, sediment is fifth on the list, with about 6,000 impairments reported (USEPA 2012). Recent studies have found that stream sediment beds are home to many TC and EC bacteria. In fact, Bai and Lung (2005) found the bacterial concentration in the sand bed to be anywhere from 10 to 10,000 times higher than the bacterial concentration in the water column. Cho et al. (2010) found that storms cause a substantial increase in FIB concentrations in stream water. This increase is a result of FIB-laden stormwater runoff and the release of bacteria from stream-bottom sediments, with the latter being the reason for this study. In several studies, such as Cho et al. (2010), bacteria have been shown to be transported in streams far from their sources, especially during storms. Rehmann and Soupir (2009) found a strong relationship between transport of fine sediment and EC. Several studies have also provided models for predicting bacterial concentrations downstream from their source considering mechanisms such as advection, dispersion, settling, growth, and resuspension.

The main objectives for this work are to determine the effect of varying flow rates on the resuspension of bacteria from a sand stream bed, the rates of resuspension of sand and bacteria, and the transport of bed-dwelling coliforms in sand bed streams. Achievement of these objectives will contribute toward refining methodology for determining coliform and suspended sediment TMDLs.

These objectives were accomplished by simulating two, 90 min and four, 60 min storm hydrographs in an 8-m-long artificial stream with 2.5 m of the bed covered with sand. Water samples were collected up and downstream of the sand bed, and sand samples were collected prior to and following each event. All samples were analyzed for TC, EC, and suspended solids (SS). The results were plotted to determine the amount of bacteria and sand that resuspended from the stream bed during each storm event. Steady state analysis compared the ratio of up and downstream bacterial concentrations with a model predicted ratio. Unsteady state conditions were simulated using the advection dispersion equation with added sink and source terms for settling and resuspension. The resulting partial differential equation was discretized and solved using the MacCormack Method (MacCormack 1969) in a Matlab routine. The Matlab model simulated results were compared to the measured downstream TC concentrations, and the model performance was evaluated using the Nash-Sutcliffe model efficiency (NSE) test (Nash and Sutcliff 1970).

2. BACKGROUND

2.1 Impaired Waters

States, territories, and authorized tribes are required to submit a list of impaired waters to the United States Environmental Protection Agency (EPA) on April 1 of every even-numbered year. Impaired waters are bodies of water that do not satisfy the water quality standards set by the state, territory, or authorized tribe. Each area is also required to prioritize these lists by ranking the water bodies based on the severity of the contaminations and their intended uses (USEPA 2001). In submission to the EPA, each impaired water must accompany a total maximum daily load (TMDL), or the loading capacity, accounting for the sum of the total amount of pollution from existing and future point as well as non-point sources plus a margin of safety for uncertainty. A TMDL is based on the sources of a pollutant and the existing water quality conditions of the water body with a purpose of implementing state water quality-based pollution controls (USEPA 2001). The leading cause of impaired waters today is pathogens (USEPA 2012).

2.2 Pathogens and Fecal Indicator Bacteria

Many contagious diseases are spread through contaminated waters. Pathogens are disease-causing microorganisms such as bacteria, protozoa, viruses, helminths, or algae that grow and multiply within a host. Humans can come into contact with waterborne pathogens through recreational play or ingestion of water (USEPA 2001). Due to the high costs and degree of difficulty required to measure specific pathogens in the environment, fecal indicator bacteria (FIB) are measured instead. A major type of FIB is total coliform (TC). TC are fairly harmless microorganisms with large populations living in soils, plants, and the intestines of warm blooded animals (Chapra 1997). *Escherichia coli* (EC) is a genus of the TC group and includes a rare strain called *E. coli* 0157 that has become well known for causing outbreaks of illnesses. The presence of TC does not necessarily prove the presence of pathogens, but rather indicates the possibility of pathogens in light of the associative nature of the two types of organisms (Davis and Masten 2004).

FIB is introduced into surface waters either directly or indirectly through three primary sources including wastewater, stormwater runoff, and animal waste (Surbeck 2009). Although the U.S. National Pollutant Discharge Elimination System (NPDES) requires urban wastewater to be treated to a point where it is not a source of FIB contamination (USEPA 1972), nonpoint sources of water pollution are much harder to quantify, as well as manage, and are potential sources for high FIB concentrations in surface waters. Examples of nonpoint sources are storm and dry weather runoff that pick up pollutants from residential or agricultural areas and deposit them into surface waters. Pets, birds, or other wild animals also play a direct role in FIB concentrations by defecation in or nearby the water bodies (Surbeck 2009).

Although it is difficult to identify and track the sources of FIB, it is just as complicated to determine what happens to the microorganisms once they do reach the water body. The fate of FIB in water depends on factors such as temperature, sunlight, nutrient levels, natural mortality, salinity, and settling (USEPA 2001). Although these microorganisms originate in the relatively high temperatures of fecal wastes (38°C), their survival rate actually decreases as temperature increases above 38°C. Because of ultraviolet rays, bacteria have higher survival rates in the soil or sediment rather than on the surface of the water (USEPA 2001). FIB prefer elevated levels of nutrients and organic matter for food. A base mortality rate for total coliforms can be calculated by the following equation (Mancini 1978, Thomann and Mueller 1987).

$$k_{b1} = (0.8 + 0.006P_s)1.07^{T-20} \tag{1}$$

where P_s is percent sea water and T is temperature (°C). Therefore, TC has a mortality rate of 0.8/d in fresh water at 20°C (Chapra 1997). Free-floating bacteria can settle from the water column at extremely slow rates of ~1.6 m/d (Cizek et al. 2008), but settling rates are greater for those attached to sediment.

2.3 Sand Beds

Soils and sediment are inhabited by a large number of FIB. Pachepsky and Shelton (2011) note that literature has reported EC concentrations in sediment to range anywhere from 1 to 500,000 MPN/g of dry weight. Not only do soils contain natural TC but also TC from other sources that have settled and live in the sediment. As stated in the previous section, these other sources of FIB may include stormwater runoff, wastewater treatment plants, or domestic and wild animal wastes. Bacterial concentrations in bed sediment have been found to be several times higher than concentrations in the water column (Rehmann and Soupir 2009, Cooper and McDowell 1989, Stephenson and Rychert 1982, Bai and Lung 2005). Jamieson et al. (2005) found sediment beds to be a suitable home for bacteria due to their abundant amounts of soluble organic matter and nutrients. It has also been proven that microorganisms attached to sediment particles of any size have a higher survival rate than free-living bacteria in natural waters (Garzio-Hadzick 2010). Bacterial preference on sediment particle size is contradictory from study to study. Rehmann and Soupir (2009) found a strong relation between fine sediments and bacteria. However, Cinotto (2005) found EC survival in larger sediments with diameters between 0.125 and 0.5 mm, possibly due to higher porosity, permeability, and nutrient availability. Garzio (2009) found EC concentrations to steeply decrease with sediment depth, meaning most sediment-borne bacteria live in the top few centimeters.

2.4 Sediment/Bacterial Resuspension and Transport

In streams, storms or high flow events can reintroduce sediment and sediment dwelling bacteria into the water column (Chapra 1997). FIB concentrations have been found to be two to three orders of magnitude higher in streams during storms than during normal flow conditions (Hunter et al. 1992). This increase is either due to stormwater runoff or the release of bacteria from bottom sediments. Lopez-Torres et al. (1987) found that disturbance of the sediment bed can cause increased bacterial concentration in the water column due to bacterial resuspension from the sediment bed. McDonald et al. (1982) proposed a method to isolate the effect of sediment resuspension on water column bacterial concentrations by conducting artificial flow events in a stream after rainless periods so runoff would be negligible. The study resulted in one to two orders of magnitude increases in the water column EC concentrations. Cho et al. (2010) also simulated artificial high-flow events in a small stream and caused a substantial increase in bacterial concentrations in the stream water due to the release of EC from bottom sediments. Furthermore, they reported a high correlation between turbidity and EC, highlighting the importance of fine sediments as a transporting medium for bacteria in their stream. Muirhead et al. (2004) carried out three artificial flood events on three consecutive days and also found EC concentrations to be strongly correlated to turbidity. Both peaked prior to flow peaks due to accelerated flow rates on the rising limb of the storm hydrograph but had differences in the declining limbs because EC settles at a much slower rate than turbidity dominant sediments. Low settling rates of the bacteria during and right after the high flow events (Cho et al. 2010, Muirhead et al. 2004) allow the microorganisms to be transported far from their release site. Although the free swimming bacteria will be transported downstream, Krometis et al. (2007) found significant fractions of FIB attached to sediment, suggesting that much of the bacteria will be removed from the stream flow due to sedimentation.

In the Muirhead et al. (2004) study, both EC and turbidity declined systematically during the flood event most likely due to the “first flush effect”. The first flush effect refers to peak nonpoint source pollutant concentrations that occur during the rising limb of a storm hydrograph, well in advance of the flow peak. This phenomenon may be because the top layer of sediment where most of the bacteria live is flushed out during the initial phase of the event, depleting the FIB source. Long duration storm related concentrations are very dependent on the time of sampling due to a dilution in concentrations after this initial flush (Cooper and McDowell 1989). Also, Pachepsky et al. (2009) found that most storm flow resuspension comes from the top centimeter of sediment making the influence of the first flush significant.

Studies have shown a strong relationship between the transport of fine sediments and bacteria (Rehmann and Soupir 2009, Cho et al. 2010), but larger particles such as sand are harder to transport alone. The Hjulstrom curve (1935, Figure 2-1) is a graph that compares particle size with the velocity of water to determine whether a river will erode, transport, or deposit sediment. This curve shows that, once eroded, fine materials can be transported at much lower velocities than sand. However, a study by Grant et al. (2011) demonstrated entrainment of bacteria from a sand bed by turbulent stream flow when there was no sand transport.

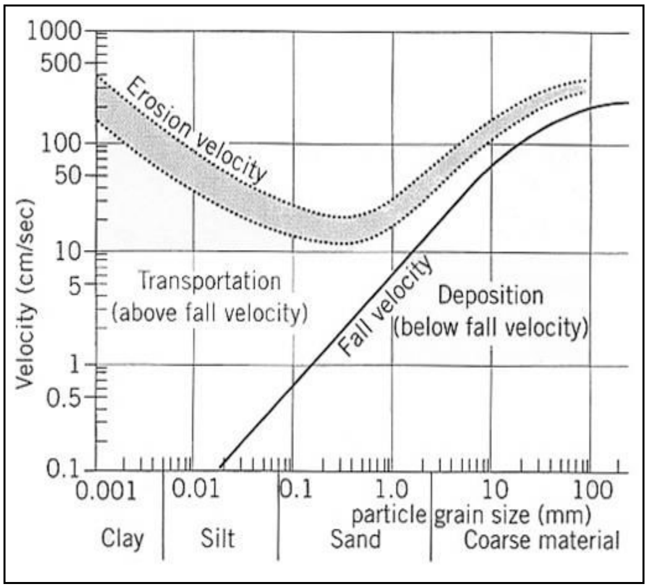


Figure 2-1: Hjulstrom Curve (1935)

2.5   Modeling

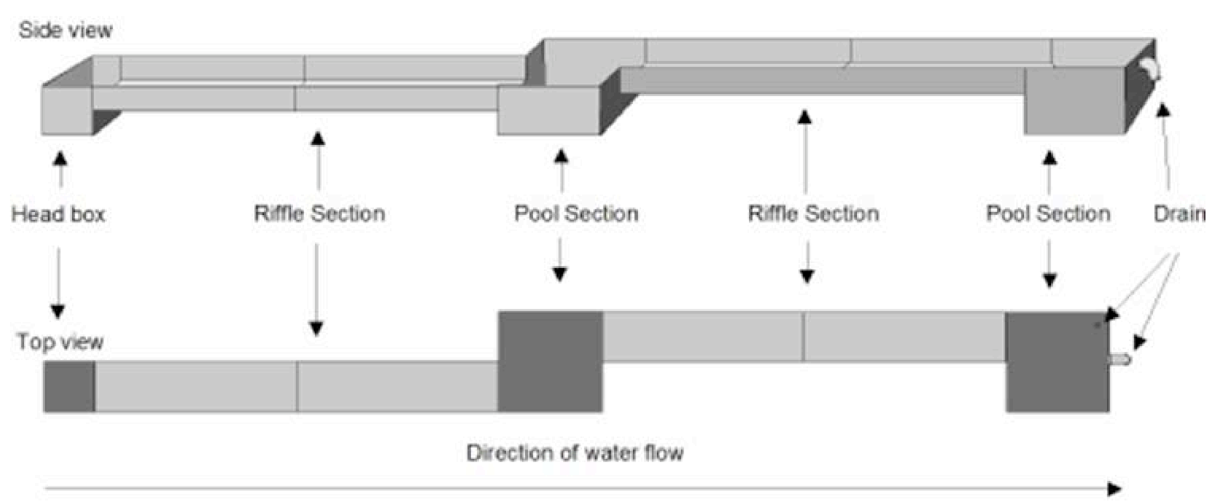
Modeling the fate and transport of FIB in streams is just as if not more difficult than measuring FIB concentrations. Several processes have been considered in describing FIB fate and transport models including: bacteria and sediment influx and outflow, bacterial attachment and detachment to particles, bacterial and sediment resuspension and settling, and bacterial die-off. Both free-floating and attached bacteria can be transported in streams (Pachepskey and Shelton 2011).   Without considering settling and resuspension of bacteria to and from stream bottom sediments, Hellweger and Masopust (2008) captured spatial trends of FIB fate and transport but failed to explain the changes occurring during and after high flow events. McCorquodale et al. (2004) modeled EC fate and transport following storm discharges into Lake

Pontchartrain, LA, USA, and included the settling process by assuming a constant fraction of bacteria attached to the sediment and therefore a constant settling velocity, but the model did not address resuspension. Dortch et al. (2008) also modeled bacterial fate and transport in the same lake without considering resuspension and concluded that other loading sources were not accounted for in the model. Other earlier models did not differentiate between the transport of free-floating and attached bacteria (Pachepsky and Shelton 2011). Bai and Lung (2005) simulated artificial flooding conditions and modeled the transport of fine sediment associated bacteria with sediment transport processes using advection and dispersion. The study found that bacteria are minimal in strong flush situations because it is removed with the fine sediment so quickly.

Resuspension and settling models have better prediction results when stream specific parameters are used because sediment textures are a major factor on bottom shear stresses that control the release of bacteria and entrainment coefficients (Cho et al. 2010). However, most uncertainty in modeling is related to values of critical shear stress at sediment beds when sediment is resuspended and bacteria are carried into the water column (Pachepsky and Shelton 2011). Values of critical shear stress vary widely between studies with 1.7 N/m^2 proposed by Jamieson et al. (2005) and 0.4 N/m^2 by Bai and Lung (2005). The partitioning of bacteria between water and sediment without the presence of sediment resuspension has not been quantified to date (Pachepsky and Shelton 2011).

3. MATERIALS AND METHODS

The study was primarily conducted in an artificial stream at the University of Mississippi Biological Field Station (UMBFS). This metal stream is 0.63 m wide, 0.30 m deep, and 8 m long with two riffle stretch sections divided in the middle by a pool (Figure 3-1). Water for the stream was supplied by gravity from two ponds on site. Inflow into the stream was controlled by opening and closing valves on 2 and 4-in inflow pipes. One outflow pipe with an elbow attached was used to discharge the water from the artificial stream into nearby ponds.



Section	Dimensions L X W X D	# of Sections
Head Box	60 cm X 60 cm X 60	1
Riffle	243 cm X 60 cm X 30	4
Pool	120 cm X 120 cm X 60	2

Figure 3-1: Artificial stream sketch (not to scale)

Modifications to the stream flow were accomplished with pumps. In order to transport sand, a 4-in trash pump and two 2-in trash pumps replaced the outflow pipe to help increase the flow rates and to keep a steady water depth. Roughly 180 kg of sand were placed in the middle of the downstream section of the stream with a length of approximately 2.5 m at a depth of about 8 cm (Figure 3-3). A Marsh-McBirney, Inc. model 2000 Portable Flowmeter was used to record the velocity on site. The flowmeter was positioned over the sand bed using a rod and C-clamp (Figure 3-2). An ISCO Flowmeter 2150 was placed on the bottom downstream of the sand bed (Figure 3-3) and was set to record the water depth and the depth-averaged velocity through the water column and to compute the flow rate at one minute intervals. An Insitu Level Troll was placed on the floor of the stream upstream of the sand bed and was set to measure the water pressure and water temperature. The water pressure was converted to water depth using barometric pressure measured with a Baro Troll placed on site.

Figure 3-2: Marsh-McBirney setup and outflow pump location

Figure 3-3: Artificial stream with ~2.5 m sand bed downstream of the pool. The ISCO flowmeter was placed just downstream of the sand bed.

3.1 Bacterial Analysis

3.1.1 Sand

Samples of the sand bed were collected during background work as well as before and after every stream flow event. Bacteria were extracted from the sand within three hours of collection. This was done following a procedure adapted and modified from Boehm et al. (2009). Ten grams (wet weight) of sand were weighed using sterilized equipment and transfer media (beaker, centrifuge tube, and spatula). In addition, the dry weight of sand was determined by weighing 2 g of wet sand in an aluminum weighing dish (Fisher Scientific, Pittsburgh, PA) and placing the dish with sand in a Thelco oven (Precision Scientific Co., Chicago, IL) for 24 hours at 110^{o}C and re-weighing the remaining sand. The dry weight analysis was done in triplicate for each sand sample. The 10 g of sand were added to a sterile 100-mL plastic container and then suspended in 100 mL of deionized water. The tube was closed and hand shaken for two minutes. The sand was then allowed to settle for 30 seconds (Boehm et al. 2009). Triplicate aliquots of the supernatent was retrieved with a pipet and were each added to a separate dilution vial (Hardy Diagnostics, Santa Maria, CA) filled with 90 mL of deionized water and one packet of Colilert powder (IDEXX Laboratories, Inc., Westbrook, Maine) for quantification of total coliform (TC) and *Escherichia coli* (*E. coli*, EC). The dilution vials were then capped and gently shaken until the Colilert was dissolved. Next, the solutions were poured into Quanti-Trays (IDEXX Laboratories, Inc., Westbrook, Maine) and sealed using a Quanti-Tray Sealer Model 2X (IDEXX Laboratories, Inc., Westbrook, Maine), then incubated at 35°C in a Presision (Precision Scientific, Inc., Winchester, VA) incubator for 24 hours. The Quanti-Tray wells indicating total coliforms and *E. coli* were counted, converted to units of most probable number (MPN) per gram, and recorded. Based on the formula in Jeong et al. (2005), the sand bacteria concentration (C_s) in units of MPN per gram was calculated using Equation (2) as follows:

$$C_s = \frac{C_t * 100mL}{W_s * r} * 100 \quad (2)$$

where C_t (MPN/100mL) is the bacteria concentration calculated from the 10 mL of supernatant, W_s (grams) is the wet weight of sand suspended in the deionized water, and r is the sand's average dry-to-wet weight ratio. A table of calculations for this method is shown in Appendices A-1 and A-2.

3.1.2 Water

Water samples collected during the experiments were also analyzed for bacteria. Bacteria analysis was performed using the same technique as the sand, except the concentrations were determined by converting the Quanti-Tray well counts to MPN per 100 mL using the chart issued by IDEXX Corporation.

3.2 Suspended Solids Analysis

After bacterial analysis, all water samples were taken to the USDA- Agricultural Research Service (ARS) National Sedimentation Laboratory in Oxford, MS to be analyzed for suspended solids (SS). First, about 150 mL of each sample was filtered into a beaker for the dissolved solid analysis. For each sample, two clean evaporating dishes (one for total and one for dissolved) were picked up using crucible tongs and weighed with the dish number and tare weight in g recorded on the data sheet for that sample number. Exactly 100 mL of the sample (either total or dissolved) was poured into the appropriate evaporating dish. The total solids (TS) came directly from the original shaken sample container, and the dissolved solids (DS) came from the filtered beaker. The evaporating dishes were placed into the ovens at a temperature of 105-110°C. After at least 24 hours, the dishes were removed from the oven using crucible tongs and placed on desiccators for cooling. After the dishes cooled for at least one hour, they were weighed and recorded as net weights in g on the data sheets. The net weights were subtracted from the tare weights and converted to mg/L for both the TS and DS. SS concentrations for each location were calculated by subtracting the TS concentrations by the DS concentrations (Appendix C-2). The total SS concentrations were found by subtracting the downstream SS concentrations by the upstream SS concentrations.

3.3 Experiments

Three different types of experiments were conducted: (1) bacterial resuspension laboratory experiment, (2) local stream sand and bacteria characterization, and (3) artificial flow events, with the latter being the focus of the research.

3.3.1 Bacterial Resuspension Lab Experiment

A lab experiment was conducted to evaluate the resuspension of bed dwelling bacteria into the water column and to determine if the play sand in the artificial stream had enough bacteria to affect the downstream water concentrations during the induced storm hydrographs. A 1 L water sample and a 500 mL sample of play sand were collected from the artificial stream, returned to the lab, and analyzed for TC and EC in triplicate. Six 100-mL sterilized bottles were then prepared with approximately 1 cm of sand at the bottom. Three of the bottles were filled with 100 mL of deionized (DI) water and labeled DI1, DI2, and DI3. The other three bottles were filled with 100 mL of stream water and labeled s1, s2, and s3. Each of the three sets was sampled in a different ways. The first set was sampled immediately after mixing for TC and EC, while the water was still cloudy from mixing with the sand. The second set was allowed to settle for one minute and then sampled. The third set was shaken following the same Boehm et al. (2009) sand extraction procedure and then sampled for TC and EC. After 24 hours of incubation the Quanti-Tray wells were counted and quantified for TC and EC. The three sampling times were chosen in order to simulate slight suspension of sand in water, no suspension of sand in water, and complete suspension of sand in water. This simple experiment was used to predict whether there would be significant resuspension of TC and EC in the artificial stream events from the play sand.

3.3.2 Local Stream Sand and Bacteria Characterization

To prepare for the artificial stream events, sand grain size and coliform concentrations in local streams were characterized. Water samples were collected from the ponds at the UMBFS and analyzed for TC and EC to estimate the amount of bacteria in the water being discharged into the artificial stream. In order to compare bacterial concentrations in natural streams to the artificial stream and play sand bacterial concentrations, water and sand samples were collected from several sites in the Oxford, Mississippi area. On May 19, 2011, water and sand samples were collected from Davidson Creek (DAV1), Lake Patsy (PAT), North Mississippi Regional Center (NMRC), Paradise Beach (PAR), and Thompson Creek (TCR). All of the samples were returned to the lab and analyzed for TC and EC. A sieve analysis was later completed for sediment from each of the sites.

3.3.3 Artificial Flow Events

Six simulated high flow events were conducted in the artificial stream between March and July of 2011. The event number and dates are shown in Table 3-1. Each event consisted of a simulated storm hydrograph with a pre-event water sample collected a few minutes prior to each event and sand samples collected prior to and following the events. As shown in Table 3-1, events 1 and 2 were 90-min events with water sample collections at the surface 1 m upstream (US) and 1 m downstream (DS) of the play sand bed at certain time intervals, and events 3-6 were 60-min events with 33 water sample collections also taken at certain time intervals but in three different locations: at the surface 1 m upstream of the DAV1 sand bed (US), at the surface immediately downstream of the DAV1 sand bed (DS), and at mid-water column immediately downstream of the DAV1 sand bed (DSdeep). Temperature and dissolved oxygen (DO) were measured at random intervals throughout each event.

Table 3-1: Artificial Stream Events

Event No.	Date	event time (min)	Sand	Water sample locations	No. of water samples collected	Outflow pumps
1	15-Mar-11	90	play	US, DS	20	4-in trash pump, two 2-in pumps
2	12-Apr-11	90	play	US, DS	26	two 2-in pumps
3	8-Jun-11	60	DAV1	US, DS, DSdeep	33	two 2-in pumps
4	15-Jun-11	60	DAV1	US, DS, DSdeep	33	three 2-in pumps
5	22-Jun-11	60	DAV1	US, DS, DSdeep	33	4-in pump and two 2-in pumps
6	29-Jun-11	60	*DAV1	US, DS, DSdeep	33	4-in pump and two 2-in pumps

* fertilizer

All samples of water and sand were immediately put on ice after collection and taken to the University of Mississippi environmental engineering laboratory for bacterial analysis. Water samples were also filtered and reanalyzed for TC and EC. Although only eight sterile filter kits were available for each event, they were reused to filter every water sample in event 1. Since unsterile filters would skew results, four upstream and four downstream water samples were chosen for event 2 and eight downstream deep samples were chosen to be filtered for events 3-6. Nitrate, nitrite, and phosphate levels were also measured from a beginning and end sample in each event. After bacterial analysis was completed, all water samples were transported to the National Sedimentation Laboratory for Suspended Solids analysis.

Although the six artificial flow events were similar, slight modifications were made to the hydraulic and bed sand conditions during the course of the study to vary the bed sand coliform levels and erosion rates. Different pumps were used for each event as can be seen in Table 3-1. As an attempt to flush out any bacteria living in the pipes of the system, the inflow valves were fully opened for 15 min prior to event 3 and for 60 min prior to events 4-6. Prior to the event 4 flushing, background samples were collected from the two ponds and each of the four inflow pipes to determine which pond and pipe were contributing the most bacteria. Play sand was placed in the stream for events 1 and 2, and natural sediment from Davidson Creek was placed in the stream prior to event 3 and used for the remaining events. Because the amount of bacteria in the sand bed decreased from week to week, about 1500 g of fertilizer was hand mixed into the sand bed following event 5 to enrich bacterial substrate.

Sand bed depths were measured prior to event 3, following event 4, and before and after events 5 and 6. These sand bed depths were used to calculate the total amount of sand transported or the eroded volume of sand during each event. This eroded volume was found by multiplying the pre- and post-event trapezoidal area averages of the sand bed by the width of the stream. The pre event volume was subtracted by the post event volume to find the total amount of sediment that moved during the event. This value was compared to the sediment transport, which was calculated using Equation 3:

$$SS_t = \frac{\sum(Q_i C_{SSi} \Delta t * 1000)}{\rho_{sand}} \qquad (3)$$

where SS_t is the total Suspended Solids transport (m^3), Q_i is the flow rate at every minute (m^3/s), C_{SSi} is the total SS concentration at every minute (mg/L), Δt is the change in time for each interval (s), and ρ_{sand} is the density for average sand deposits (mg/m^3). Equation 4 from Peterson (1986) was used to find the ρ_{sand} for the experiment.

$$\rho_{sand} = W_t = W_i + 0.43K\left[\frac{T}{T-1}(log_e T) - 1\right] \tag{4}$$

where W_t or ρ_{sand} is the density for given average deposits in T years, W_i is the initial unit mass weighted on the basis of particle-size gradation (mg/m^3), K is the Lane and Koelzer factors weighted on the basis of particle-size gradation (mg/m^3), and T is the time after deposition (years).

3.4 Acoustic Monitoring of Bed Movement*

In order to quantify the sediment flowing down the artificial stream in another way, an acoustic backscatter sediment monitoring system was deployed and monitored by personnel from the National Center for Physical Acoustics (NCPA) of the University of Mississippi. The system consisted of a 1 MHz transducer placed in the center of the stream immediately before the downstream pool (Figure 3-4). The transducer sends an acoustic signal upstream aimed at the edge of the sand bed. It then detects the acoustic signal bounced back by particles suspended in the water. The transducer was operated by a custom built signal processing system interfaced with a laptop computer.

* This section is courtesy of and written by Mr. Bradley Goodwiller of NCPA. It is included in this thesis because it is an additional effort to demonstrate sediment movement.

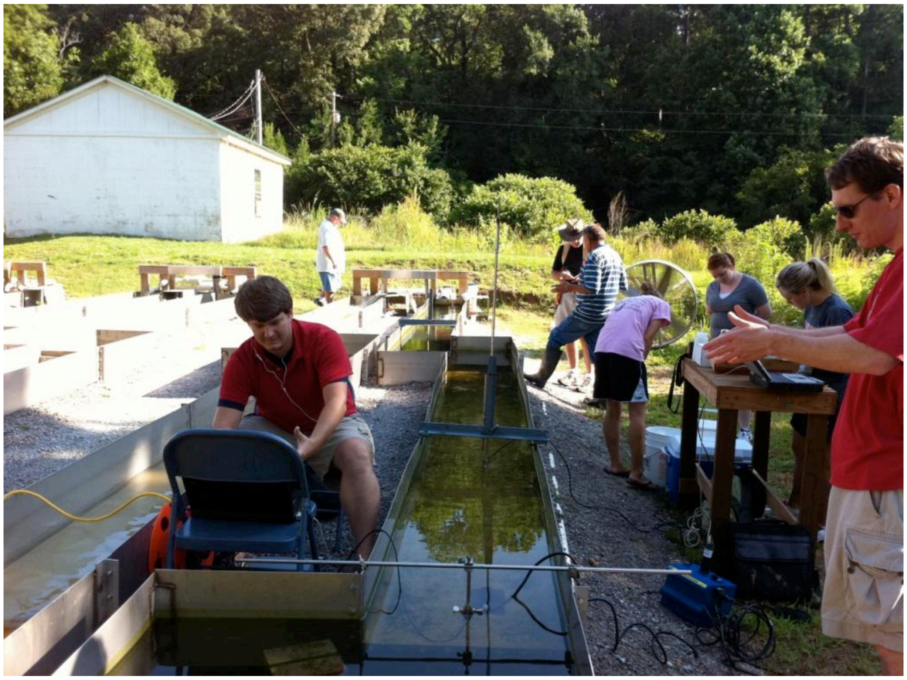


Figure 3-4: Acoustic backscatter sediment monitoring system setup in the artificial stream

This Digital Signal Processing (DSP) system is designed to operate the transducer based on user input and also to quickly process the received backscatter signal. The user input parameters vary based on the experimental situation. For the artificial stream setup, the system was configured to have a spatial resolution of approximately 0.5 cm, a temporal resolution of 0.5 s, and a maximum range of 74 cm. It is important to note that, for technical reasons, the DSP system at the time of these experiments intentionally ignored the first 17 cm of data. For the original intent of the DSP system, this was not a problem. However, the artificial stream was only, on average, 19-20 cm deep. Thus the transducer had to be aimed upstream in order to get a significant number of data points (Figure 3-5).

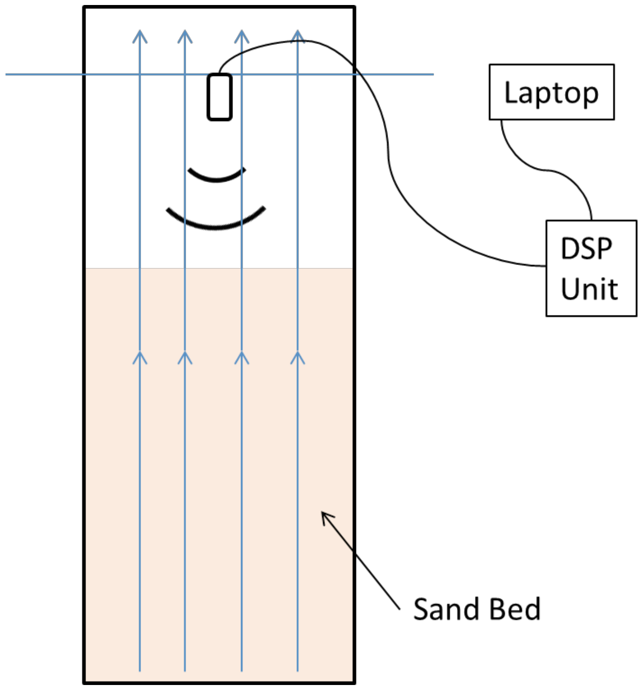


Figure 3-5: Plan view of NCPA experimental setup

3.4.1 Operating Procedures for this Experiment

Every effort was made to place the transducer in the same place for every 'storm event'. It was centered across the stream and aimed upstream such that it received a 'backwall' echo from the edge of the sand bed. Before every simulated storm event, a background data set was taken. This provided confirmation that the transducer was properly placed, as well as providing a comparison for storm event data. The length of the background data sets varied based on available time before the simulation began.

The user interface for the DSP allows for timed data set runs. For the storm events, it was decided to take 15 minute data sets. After the completion of a data set, the data had to be downloaded from the DSP to the laptop computer. This process took on the order of 3 minutes. Thus there is a 3-4 minute gap between data sets.

During each storm event, there were several occurrences that provided anomalous backscatter signals. These included operators taking physical samples (reaching their hands into the water in front of the transducer) as well as repositioning their equipment (which kicked up significant sediment clouds.) The time of these events (relative to the acoustic data set) was noted in order to avoid confusion and prevent invalid sediment calculations.

3.5 Steady State Analysis

Rehmann and Soupir (2009) focus on the importance of the interaction between the sediment and the water column on the bacterial concentrations in streams and quantify this using a one-dimensional steady state model. Data from Jamieson et al. (2005) was used to implement this model, and simulations were compared with the observed concentrations from each of the three storms in the Rehmann and Soupir (2009) study. Water column and sediment concentrations, C_1 and C_2, are derived separately using Equations 5 and 6 with averages of the depth of the water column, H_1, and the depth of the sediment containing microbes, H_2, over the width of the channel. Rehmann and Soupir (2009) use lateral flow in addition to their model. However, because lateral inflow in the artificial stream is not existent, this term was removed from the model, and the C_1 and C_2 equations became

$$\frac{\partial C_1}{\partial t} + U\frac{\partial C_1}{\partial x} = k_{n1}C_1 - \frac{w}{H_1}C_1 + \frac{F_r}{H_1} \tag{5}$$

and,

$$\frac{dC_2}{dt} = k_{n2}C_2 + \frac{w}{H_2}C_1 - \frac{F_r}{H_2} \tag{6}$$

where U is the mean velocity, k_{n1} is the net growth rate of bacteria in the water column, w is the settling velocity, F_r is the resuspension flux, and k_{n2} is the net growth rate of bacteria in the sediment. The resuspension flux, or resuspension rate, can be found using an Equation 7 from Jamieson et al. (2005),

$$F_r = \frac{C_{TCavg} \times Q_{avg}}{SA} \qquad (7)$$

Where C_{TCavg} is the average concentration of total coliform during the resuspension period, Q_{avg} is the average flow during the resuspension period, and *SA* is the surface area of the source cell. This resupsension value along with the sediment concentration can be used to model the resuspension velocity v_r as seen in Equation 8.

$$v_r = \frac{F_r}{C_2} \qquad (8)$$

The net growths in the water column and the sediment have a negative value when they are dominated by decay. Equations 5 and 6 assume the concentrations of bacteria in the water column and sediment are vertically uniform. The resuspension and settling terms have more importance when the bacterial concentrations are non-uniform within the water column because the bacterial concentration at the interface between sediment and water will be higher than the depth-averaged value of Equation 5. The importance of the interaction between the water column and the sediment bed can be determined by the ratio β_2 in Equation 9:

$$\frac{C_2}{C_1} = \frac{f_a w_s}{v_r - k_{n2} H_2} = \beta_2 \qquad (9)$$

where f_a is the fraction of bacteria attached to the sediment, and w_s is the sediment settling velocity. This w_s value depends on the size and properties of the sediment. Settling velocity of bacteria w is assumed to be negligible unless the microbes are attached to the sediment, therefore $w = f_a w_s$.

Another ratio β_1 determines the interaction of the water column for the reach length L by:

$$\frac{C_1}{C_{in}} = \beta_1 = \exp\left[\frac{k_{n1}L}{U}\left(1 + \beta_2 \frac{k_{n2}H_2}{k_{n1}H_1}\right)\right] \tag{10}$$

where C_1 is the concentration in the water column at $x=L$ and C_{in} is the concentration at the beginning of the reach. If there is no interaction between the water column and the sediment (β_2=0), then the ratio β_1 solely depends on the Damköhler number D_a. D_a is the product of the ratio of the advection L/U and growth rate in the water column, $D_a = k_{n1}L/U$. When sediment interaction is included, the sediment interaction parameter (S) is included in the β_1 ratio. S is another ratio that accounts for the amount of microbes gained through growth or lost in decay in the sediment and water column and can be expressed by:

$$S = \beta_2 \frac{k_{n2}H_2}{k_{n1}H_1} \tag{11}$$

Another way of writing Equation 10 is:

$$\frac{C_1}{C_{in}} = \beta_1 = \exp\left[D_a(1 + S)\right] \tag{12}$$

where S is used or omitted depending on whether or not β_2 is 0. β_1 was also calculated using the measured flow averaged upstream (C_{in}) and downstream (C_1) concentrations. The measured β_1 was then compared to the predicted β_1 with and without the sediment interaction factor.

3.6 Unsteady State Model

An unsteady state simulation of the artificial stream experiments was implemented in Matlab, based on the one-dimensional advection dispersion equation:

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} = D\frac{\partial^2 C}{\partial x^2} \tag{13}$$

where C is the TC concentration in the water column (MPN/m^3), t is time (s), u is depth averaged flow velocity (m/s), x is the distance along the sand bed (m), and D is the dispersion coefficient (m^2/s). This well-known equation was slightly modified to include sink and source terms in order to recreate the mechanisms occurring in the artificial stream events (discussed below).

3.6.1 Cho et al. (2010) Source and Sink Terms

Cho et al. (2010) added a resuspension term, a settling term, and a lateral water velocity term to the advection dispersion equation to describe the bacterial transport in their flood events. For the purpose of the artificial stream experiments, the last term was deleted altogether because lateral water velocity is assumed to be negligible in the artificial stream. The modified equation becomes:

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} = \frac{\partial}{\partial x}\left(D\frac{\partial C}{\partial x}\right) + R\frac{C_s}{h} - F\frac{v_s}{h}C \tag{14}$$

where R is the sediment resuspension rate (kg/m^{2}s), C_s is the TC concentration in sediment (MPN/kg), h is the water depth (m), F is the fraction of TC associated with the suspended sediment, and v_s is the sediment settling velocity (m/s). The R can be found using Equation 15.

$$R = \begin{cases} R_e\left(\frac{\tau}{\tau_c} - 1\right), & \tau \geq \tau_c \\ 0, & \tau < \tau_c \end{cases} \quad (15)$$

R_e is the entrainment coefficient (kg/m^{2}s) and ($\tau/\tau_c - 1$) is a term for the relative shear stress on the sediment bed where τ is bottom shear stress and τ_c is the critical bottom shear stress. Bottom shear stress is determined from:

$$\frac{u}{u^*} = \sqrt{\frac{8}{f}} \quad (16)$$

and

$$u^* = \sqrt{\frac{\tau}{\rho}} \quad (17)$$

which becomes:

$$\tau = \frac{\rho f}{8} u^2 = 3.75u^2 \quad (18)$$

where u^* is shear velocity (m/s), f is the friction factor (assumed equal to 0.03 for the artificial stream sand bed), and ρ is the density of water (kg/m^3). The critical shear stress was found using the same τ equation (Equation 18) with the critical velocity for each event. The critical velocity was assumed to be the velocity at which the resuspension of sediment first occurred (Appendix E-2). The dispersion coefficient D is calculated using a longitudinal dispersion coefficient equation from Fischer et al. (1979):

$$D = \frac{0.011 \cdot u^2 \cdot B^2}{h \cdot u^*} \tag{19}$$

where *B* is the stream width (m). However, Fischer notes that this is an approximation with error of about 50%. *F* is found using the measured unfiltered and filtered TC concentrations for each event by

$$F = \frac{C_{unfiltered} - C_{filtered}}{C_{unfiltered}} \tag{20}$$

and an average is taken from each event. Sediment settling velocities, v_s, were found using Stokes Law:

$$v_s = \frac{g(\rho_s - \rho) D_{50}^2}{18\mu} \tag{21}$$

where g is acceleration due to gravity (m/s^2), ρ_s is the sand particle density (kg/m^3), D_{50} is the mean diameter of the sediment (m), and μ is the dynamic viscosity (kg/m·s). Stokes law makes a number of assumptions including: particles are smooth and spherical, particle sizes are identical in diameter and density, settling and resistance are due to fluid viscosity, and terminal velocity is reached as settling begins.

3.6.2 MacCormack Scheme

The advection dispersion partial differential equation was discretized using the MacCormack Method (MacCormack 1969). The MacCormack Method is a numerical finite difference scheme with predictor and corrector steps. Stability terms used in this scheme include:

$$c = u\frac{\Delta t}{\Delta x} = \text{Courant number} \tag{22}$$

$$\propto = D\frac{\Delta t}{\Delta x^2} = \text{diffusion number} \tag{23}$$

where *Δt* is the time interval (s) and *Δx* is the spatial interval (m). Depth-averaged velocity *u* and the dispersion coefficient *D* are functions of time making *c* and *α* also vary with time. Using the Courant and diffusion numbers, the MacCormack scheme can be applied to Equation 14 through three steps shown in Equations 24-26 with *i* and *j* representing space and time, respectively.

Predictor:

$$C_i^* = C_i^j - c\left(C_{i+1}^j - C_i^j\right) + \propto\left(C_{i+1}^j - 2C_i^j + C_{i-1}^j\right) + \left(R_i^j\frac{C_s}{h_i^j} - z\cdot F\frac{v_s}{h_i^j}C_i^j\right)\cdot\Delta t \tag{24}$$

Corrector:

$$C_i^{**} = C_i^* - c_i^{j+1}\left(C_i^* - C_{i-1}^*\right) + \propto\left(C_{i+1}^* - 2C_i^* + C_{i-1}^*\right) + \left(R_i^{j+1}\frac{C_s}{h_i^j} - z\cdot F\frac{v_s}{h_i^j}C_i^*\right)\cdot\Delta t \tag{25}$$

R, *h*, and *C* are now also functions of time and *z* is a settling term adjustment factor. The concentration at the next time step (*Δt*) is:

$$C_i^{j+1} = \frac{1}{2}\left(C_i^j + C_i^{**}\right) \tag{26}$$

The MacCormack method is a good, general numerical approach for water quality calculations. The method solves partial differential equations by using a backward difference in the predictor step and a forward difference for the corrector. It is one of the easier methods to model and is accurate due to its centered-time/centered-space approach. One of the major advantages of the MacCormack method is the ability to specify the boundary conditions in both the predictor and corrector steps. However, the method is not unconditionally stable in that there is a time-step limit beyond which the solution will blow up (Chapra 1997).

3.6.3 "Goodness-of-fit" Test

The standard Nash-Sutcliffe Efficiency *E* (Nash and Sutcliff 1970) was used to calibrate and evaluate the hydraulic model through Equation 27:

$$E = 1.0 - \frac{\sum_{i=1}^{N}(P_i - O_i)^2}{\sum_{i=1}^{N}(O_i - \bar{O}_i)^2} \quad (27)$$

where *E* is the coefficient of efficiency, O_i is the observed data, P_i is the model-simulated data, *N* is the time increments, and $\bar{O}_i$ is the mean of the observed data. The *E* values range from -∞ to 1 with the larger values meaning better agreement. *E* values less than or equal to zero are undesirable because *E* values of zero imply that the model simulated results are no better than the $\bar{O}_i$.

The model was optimized to fit the observed data and output the largest values of *E* using the Matlab nonlinear optimization function $f_{minimax}$, which minimizes the worst-case (largest) value of a set of multivariable functions starting at an initial estimate. This function was used to maximize *E* by adjusting two parameters, R_e and *z*, subject to constraints of 10^{-8} to 10^{-1} and 0.01 to 10, respectively.

4. RESULTS

4.1 Bacterial Resuspension Lab Experiment

Results from the bacterial resuspension lab experiment (Appendix A-1) were analyzed by comparing average TC concentrations from the sampled stream water and sand to the average TC concentrations from each set of DI water and stream water experiment (Table 4-1). The water and sand sample average TC concentrations were 2357 MPN/100mL and 2755 MPN/g, respectively.

Table 4-1: Bacterial resuspension lab experiment results

TC concentrations for water (MPN/100mL) and sand (MPN/g)								
original samples			Set 1		Set 2		Set 3	
DI water	stream water	play sand in stream	DI water	stream water	DI water	stream water	DI water	stream water
0	2357	2755	173	3255	613	2382	816	9208

Set 1, or the set sampled immediately after mixing, resulted in very little increase in TC concentrations in the DI water but close to a 1000 MPN/100mL TC increase in stream water. Set 2, or the set that was allowed to settle for one minute before being sampled, had an average TC increase of 600 MPN/100mL in the DI water, but the stream water from this set had a TC concentration near the original stream water sample collected. Despite the results, it was assumed that the settling time allowed in set 2 would result in lower TC concentrations than set 1 which was only the case in the stream water. The higher TC concentrations from set 3 suggest that if the stream were vigorously stirred, then the coliform concentration would significantly increase, although this degree of mixing is highly unlikely to occur in a natural stream, even during a storm. This laboratory experiment also suggests that the play sand placed in the artificial stream had not accumulated a high enough bacterial concentration to notably affect the downstream water bacterial concentrations. Since higher flow rates are not available in the artificial stream, natural and strongly populated sediments from local streams and creeks were sampled to find a replacement for the play sand.

4.2 Local Stream Sand and Bacteria Characterization

Bacterial concentrations, particle size, and silt and clay percentages from the local streams were measured in order to compare the characteristics of natural streams, the artificial stream, and the UMBFS ponds (Appendices A-1 and C-1, Table 4-2). The dry play sand indicates the sample taken directly from the bag, and the wet play sand is the sample collected a few minutes after the sand was placed in the artificial stream. The TC concentrations in the water from the UMBFS ponds ranged from 2,100 to 12,000 MPN/100mL, which is close to the local stream concentration range of 2,600 to 24,200 MPN/100mL. However, TC concentrations in the play sand were close to zero and much lower than the natural sediment concentrations from local streams which ranged from 80,500 to 320,000 MPN/g. The particle sizes of all the sampled sediments were fairly similar with mean diameters ranging from 0.24 to 0.39 mm (Table 4-3). Although previous studies (e.g. Rehmann and Soupir 2009) found strong relationships between bacteria and fine sediments with *E. coli* concentrations of 1157 to 5495 CFU/g, the sampled stream sediment was mostly sand with very low percentages of fine sediment with clay/silt contents ranging from 0 to 8.5% (Table 4-3). Sediment from Davidson Creek (DAV1) was chosen for the artificial stream events because of its easy access and high bacterial content of 206,000 MPN/g. DAV1 sediment had a mean size diameter of 0.26 mm and clay content of 0.61%.

Table 4-2: TC and EC concentrations in the water and sand samples collected from ponds/play sand and from the local streams

Location	TC in water (MPN/100mL)	TC in sand (MPN/g)	EC in water (MPN/100mL)	EC in sand (MPN/g)
Pond1	12000	NM	50.00	NM
Pond2	2100	NM	10	NM
Dry play sand	NM	<10	NM	<10
Wet play sand	NM	4200	NM	170
DAV1	24200	206000	450	5400
PAT	2600	320000	<10	64000
NMRC	5200	320000	300	4610
PAR	3300	115000	<10	2000
TCR	10500	80500	3700	1200

NM = not measured

Table 4-3: Mean size diameters and silt/clay percentage for sediment from each site

	play sand	DAV1	PAT	NMRC	PAR	TCR
D_{50} (mm)	0.38	0.26	0.33	0.39	0.32	0.24
silt/clay (%)	0.48	0.61	8.47	0.00	1.39	3.62

4.3 Artificial Flow Events

4.3.1 Hydraulic Results

The water velocities and depths measured using the ISCO flowmeter were organized for each event and multiplied by the stream width to calculate flow rates (Table 4-4). Event 3 had the lowest velocity and the greatest depth maxima, while event 6 had the highest velocity and the least depth. Because of a constant width and somewhat steady water depth in the artificial stream, the flow rates depended solely on velocity change which is the main hydraulic parameter used in the study’s analysis. All hydraulic data from the ISCO flowmeter, Insitu level, and Marsh-McBirney portable flowmeter was recorded (Appendices B-1, B-2, and B-3).

Table 4-4: Maximum hydraulic measurements, maximum dissolved oxygen, and water temperature ranges for each event

Event No.	Max velocity (m/s)	Max water depth (m)	Max Flow Rate (m^3/s)	Max DO (mg/L)	Water temperature range (°C)
1	0.52	0.28	0.090	10.2	12.9-13.3
2	0.42	0.27	0.072	8.5	16.8-20.5
3	0.29	0.29	0.053	8.4	21.3-27.3
4	0.58	0.23	0.083	8.9	21.7-29.6
5	0.53	0.23	0.077	7.6	19.6-25.4
6	0.65	0.19	0.079	7.7	19.9-23

4.3.2 Sand Bacterial Concentrations

In four of the six artificial flow events, measured bed sediment bacterial concentrations declined in the sand bed during the event (Table 4-5). Concentrations in events 1 and 3 decreased by a factor of 2 during the event, while concentrations in events 4 and 5 decreased by factors of 4 and 6, respectively. One of the two events that did not decrease was event 6. The addition of fertilizer prior to event 6 triggered blooms of periphyton and bacteria. Bacterial concentrations for the pre- and post-event sand samples were too high to determine using the normal 1:10 dilution analysis, so temporal shifts were indeterminate. The bed sediment TC concentration actually increased by a factor of 3 during event 2, but sediment concentrations for the first two events with play sand were very low. Excluding event 2, the data suggest that much of the bed sediment bacteria were transported downstream during the storm simulations, whether or not significant bed movement occurred.

Table 4-5: Pre and post event TC concentrations in the sand

Total Coliform concentrations in the sand (MPN/g)			
Event	pre event	post event	Decreased by factor:
1	4500	2800	2
2	2100	7300	-3
3	21,000	12,500	2
4	79,000	18,000	4
5	35,000	6000	6
6	>320,000	>320,000	unknown

4.3.3 Mean Water Sample Concentrations (TC/EC/SS)

The water samples collected upstream and downstream of the sand bed during each event were analyzed for TC, EC, and SS (Table 4-6). The TC and EC concentrations (in MPN/100mL) were averaged using a geometric mean, and SS concentrations (in mg/L) were averaged using an arithmetic mean. The averages are also plotted in bar graphs (Figure 4-1, Figure 4-2, and Figure 4-3) with the x-axes indicating the event numbers and the y-axes indicating the concentrations for TC, EC, and SS, respectively.

Table 4-6: Average TC, EC, and SS concentrations for each water sample location and event

Means*	Upstream			Downstream			Downstream Deep		
Event	TC	EC	SS	TC	EC	SS	TC	EC	SS
1	3983.7	39.0	-3.1	3329.8	23.5	-2.1			
2	6132.2	89.3	1.8	6028.6	98.1	3.2			
3	5820.0	70.1	10.0	6009.2	56.0	11.9	5440.7	68.5	18.2
4	5299.4	28.5	9.3	5163.4	29.2	11.7	5259.7	26.4	13.9
5	9485.8	59.6	29.8	8420.7	55.1	30.3	9094.2	47.0	61.4
6	8166.5	34.5	10.1	11067.0	36.7	16.6	11467.5	31.4	23.3
* Geometric means for TC and EC. Arithmetic mean for SS.									

TC concentration averages (Figure 4-1) range from 3,000 to 11,000 MPN/100mL. Events 1 and 2 yield slight decreases from upstream to downstream concentrations, which is most likely because the play sand used in these two events did not contain enough bacteria to resuspend or influence the downstream TC concentrations. Although the procedure for the last four events was the same, the TC concentrations showed wide variation from event to event. Events 3 and 4 yielded very similar concentration averages for all three sample locations. Event 5 yielded a slight decrease from upstream to downstream deep with an even larger decrease in the downstream sample. There was a large jump in TC concentrations from event 4 to event 5 which could have happened for one of the following two reasons. The flow rates from event 4 left a channel on the right side of the sand bed in the artificial stream, which was later smoothed out by hand one day prior to event 5 and could have loosened up the sediment/bacteria in the sand. Also, bacterial populations may have responded positively to weather events (rainfall the week prior to event 5). Event 6 results were close to what was expected for all of the storms events. There was a notable increase in both downstream concentrations with the downstream deep sample averaging slightly higher than the downstream sample. Concentrations are higher for this final event due to the fertilizer mixed in with the sand following the previous week's experiment (event 5), which caused a very large increase in algae and bacteria in the artificial stream sediment.

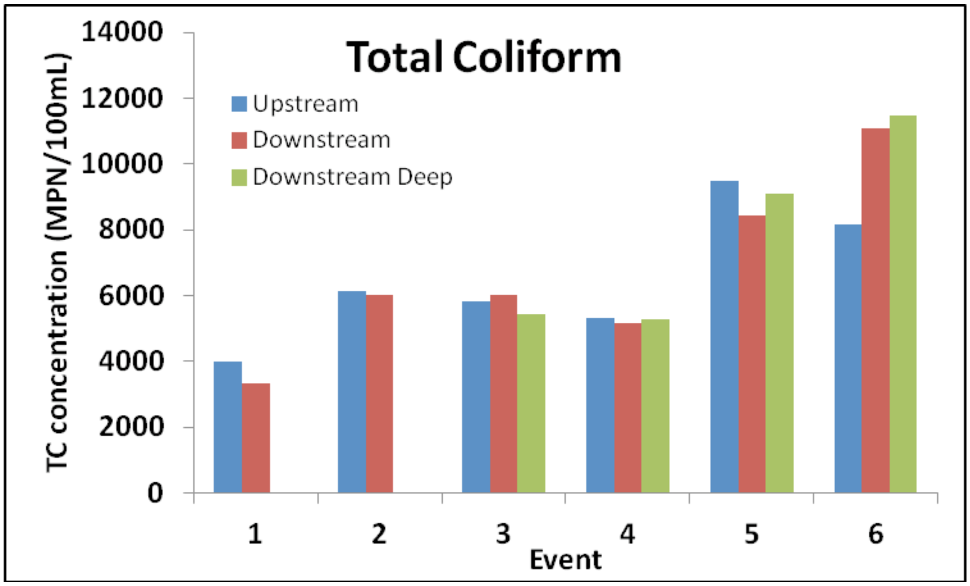


Figure 4-1: Geometric mean TC concentrations for all three water sample locations during each event

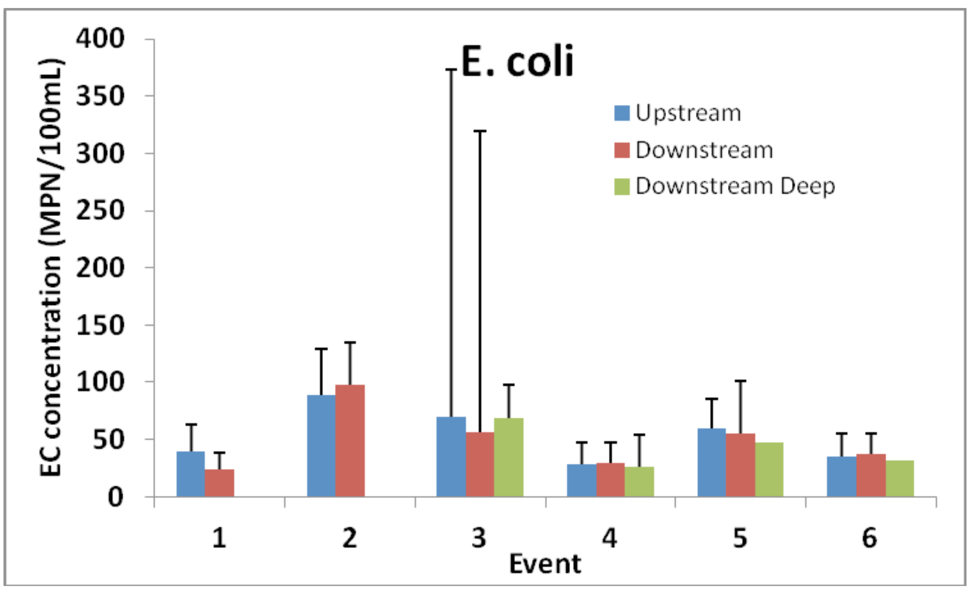


Figure 4-2: Geometric mean EC concentrations for all three water sample locations during each event

EC average concentration means shown in Figure 4-2 reflect noisy and widely variable data. The EC average concentrations are also very low compared to TC concentrations and ranged from 20 to 100 MPN/100mL. With an exception to event 2, there is a decrease in all of the downstream averages. Due to the low and irregular data results from EC analysis, EC was disregarded in most of the analysis for this thesis, but EC data and plots can be found in the water quality data in Appendix A.

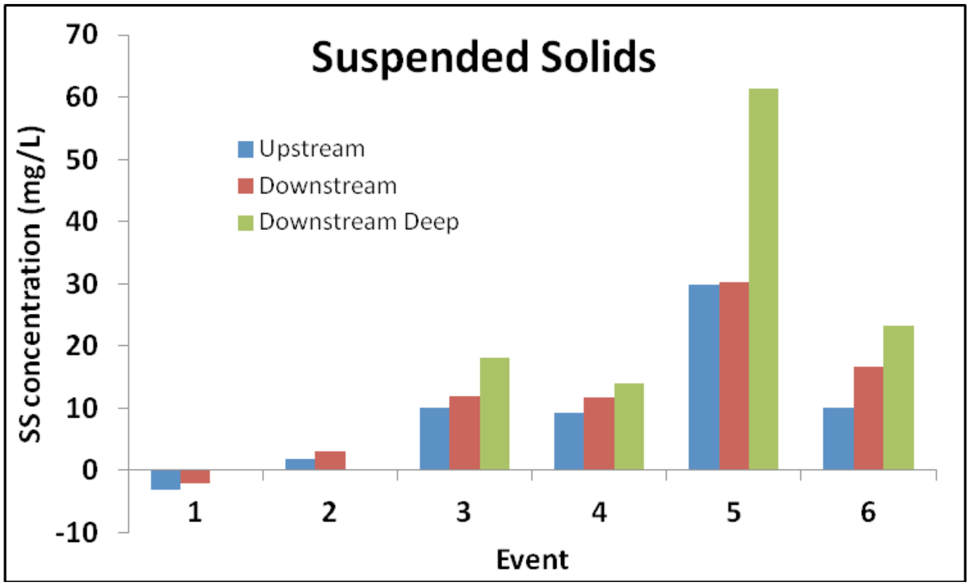


Figure 4-3: Arithmetic means of SS concentrations for all three water sample locations during each event

Average SS concentrations (Figure 4-3) ranged from 0 to 60 mg/L. The SS concentrations for the first two events were extremely low and even resulted in negative values in event 1 due to the laboratory analysis method (SS = TS – DS) and human error. These low values could be due to the large size of the play sand (D_{50} of almost 0.4 mm) used for these two events and the sample location on the surface of the water. Although sediment movement was visible during the events, most sediment transport occurred as the bed load. The last four events all resulted in an increase in the downstream concentrations and even higher downstream deep concentrations. There was a large increase in all of the SS concentrations in event 5 possibly due to the same loosening effect mentioned in the average TC concentration discussion. Event 5 also shows a very large spike in downstream deep SS concentrations because an error in pump operation briefly depressed tail water elevation during the rising limb of the flow hydrograph causing a sudden increase in velocity and a pulse of sediment movement around the 15 min sample time.

T-tests were run to compare each event's upstream sample means with the downstream sample means on a 5% significance level for several measurements including total solids, SS, TC, and EC (Appendix D-1). The null hypothesis for this statistical test was that the means of the two sample locations were similar, which was accepted for all measurements in all events except for TC, SS, and TS in event 6 with the fertilizer (Table 4-7).

Table 4-7: T-test results for upstream and downstream means

Event	**degrees of freedom**	**t_{crit}**	**Total Coliform, t**	***E. coli, t***	**Suspended Solids, t**	**Total Solids, t**
1	18	2.1009	0.5772	1.9012	-0.7614	-0.0476
2	24	2.0639	-0.0445	-0.6635	-0.4276	-1.2119
3	20	2.086	0.5651	0.033	-1.4133	-1.893
4	20	2.086	-0.334	0.5934	-1.4749	-1.835
5	20	2.086	0.2027	0.8987	-0.7892	-0.7961
6	20	2.086	**-2.2669**	0.0855	**-2.2885**	**-2.2015**

Selected water samples from each event were filtered and reanalyzed for TC and EC (Appendix A-3). Geometric means of TC and EC concentrations (MPN/100mL) for downstream or downstream deep (depending on the event) samples and filtered samples were used to determine the fraction of TC attached to the sand (Table 4-8). Two calculations were computed for this fraction: *fa* using the geometric means of the concentrations and *F* using the arithmetic means. Fractions of TC attached to the sand (*fa* and *F*) range from 0.3 to 0.5 for the artificial stream events, which is within the fraction of 0.5 used by Cho et al. (2010) or earlier data from Jamieson et al. (2005).

Table 4-8: Fraction of TC attached to sediment using geometric means *fa* values and average *F* values

Geometric means	Downstream				TC	
	TC	TC filtered	EC	EC filtered	*fa*	*F*
Event 1	3329.8	1880.0	23.5	28.7	0.44	0.39
Event 2	5874.4	3530.9	105.4	90.8	0.40	0.34
	Downstream Deep				*fa*	*F*
Event 3	5630.1	3814.4	53.9	44.4	0.32	0.30
Event 4	5076.6	3199.7	19.1	18.3	0.37	0.34
Event 5	8256.9	4222.7	46.0	63.7	0.49	0.46
Event 6	12516.2	8535.9	33.9	30.2	0.32	0.29

Nutrient (nitrate, nitrite, and phosphate) levels, dissolved oxygen (DO), and temperatures were also recorded for each event. Phosphate and nitrite were undetectable or below 0.3 and 0.08, respectively. Nitrate concentrations were detectable with higher average concentrations in events 1 and 2 than the following 4 events (Appendix A-1). Maximum DO concentrations and temperature ranges for each event are shown in Table 4-4. Water quality conditions were conducive to bacterial growth throughout the study.

4.3.4 Total Coliform Concentration Storm Hydrographs

Figure 4-4 shows time series plots from each event with the upstream TC concentrations graphed on the left and downstream/downstream deep TC concentrations graphed on the right. Bacterial concentrations in the source water (or the upstream location) samples trended downward from ~10^4 to ~10^3 MPN/100mL during the course of each event except for event 5. Background samples of the two ponds and four inflow pipes prior to event 4 showed the major source of TC for the artificial stream (Appendix A-5). Even with the 45 min flushing flows through the pipes prior to the last four events, all events started with high TC concentrations close to ~10^4 MPN/100mL and gradually declined. Downstream concentrations always peaked within the first 20 min of the run with concentrations close to ~10^4 MPN/100mL and declined either gradually or sharply to a level near that of the inflow or upstream concentrations ranging from ~1 to 5000 MPN/100mL.

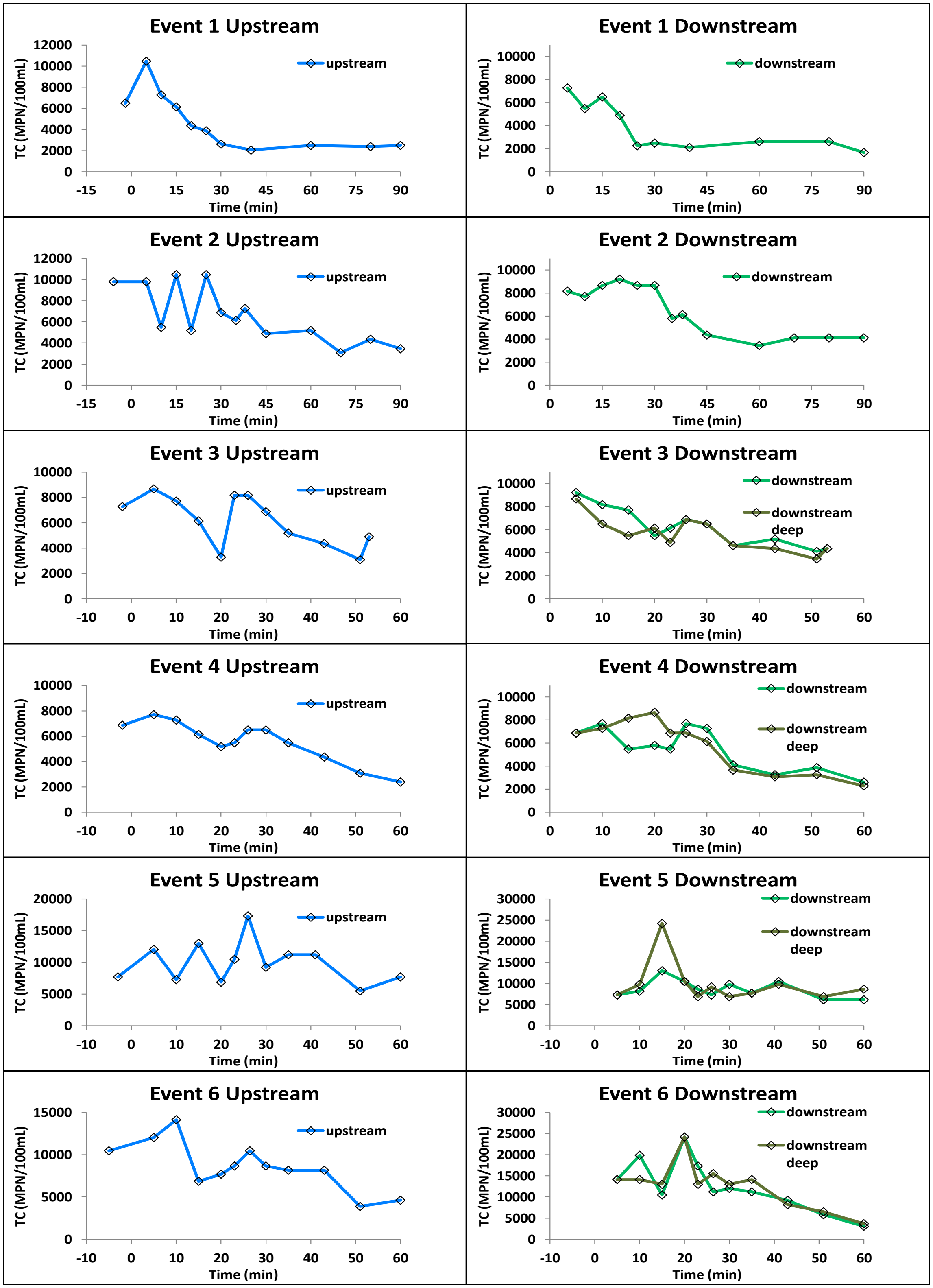


Figure 4-4: Upstream and Downstream TC concentrations for each event

4.3.5 Suspended Solids

Suspended Solids Concentrations

Average SS concentrations at each sample location for all events were previously discussed. However, SS concentration hydrographs from upstream, downstream, and downstream deep sample locations were plotted along with velocity in green to show the storm hydrographs for each event (Figure 4-5). As stated before, the SS concentrations for events 1 and 2 were extremely low and noisy, but the downstream concentration peaks are synchronous with velocity. SS peaks for the downstream deep samples occurred on the rising limb of all four of the final events.

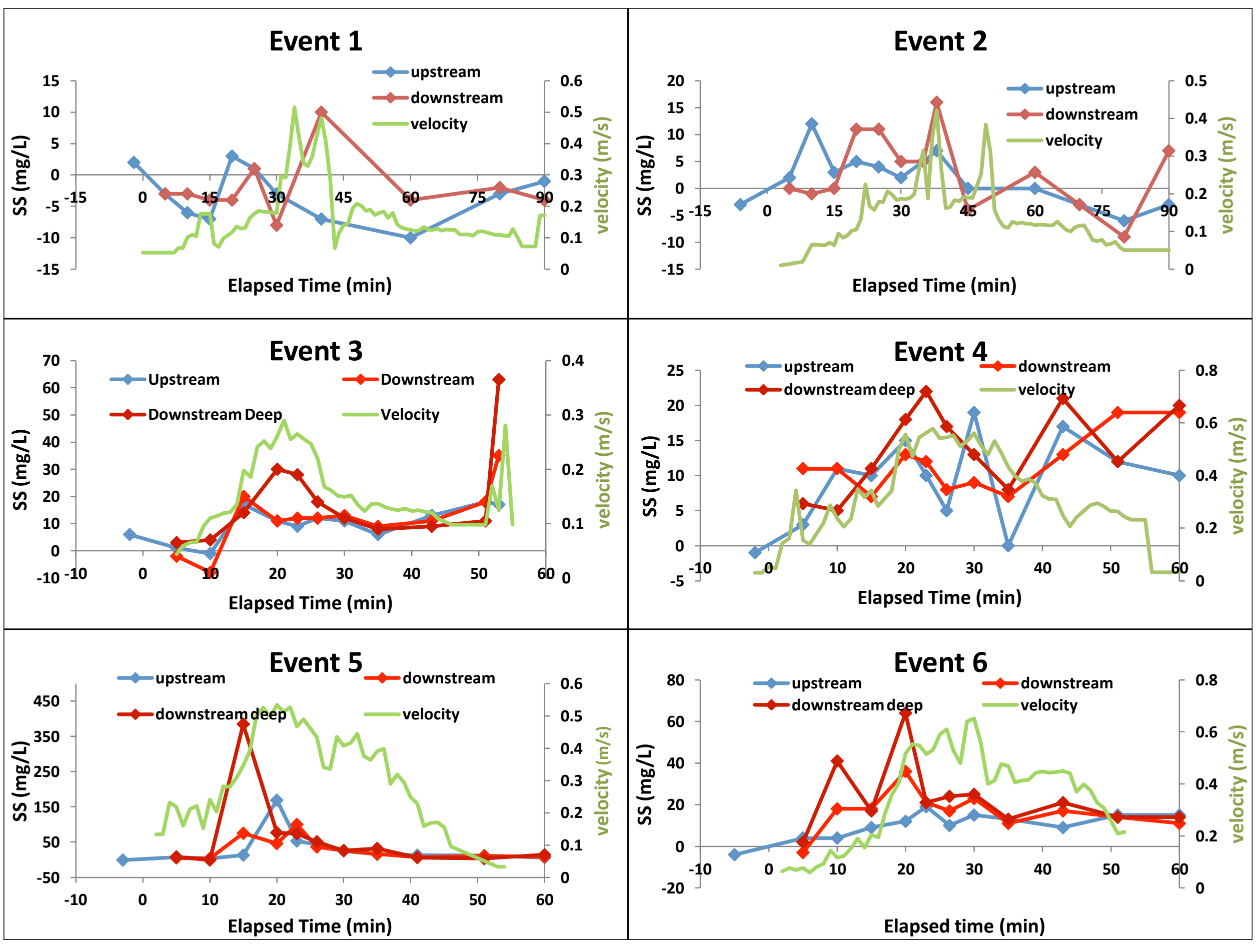


Figure 4-5: SS concentrations at all sample locations for each event

Suspended Solids Transport

The measured sand bed depth eroded volume (V_{eroded}) estimates were calculated from the sand bed profiles measured prior to event 3, following event 4, and prior to and following events 5 and 6 (Figure 4-6). Profiles were not recorded after event 3 or before event 4, so the two profiles prior to event 3 and following event 4 were averaged to come up with an estimation of the sand bed profile between the two events. In Figure 4-6, the purple line on the top graph shows the channel formation that was a result of event 4 and was discussed in a previous section. Profiles were used to calculate a rough total volume of sand that eroded, or the V_{eroded}, from the bed during each event by differencing the integral of bed elevation and multiplying by stream width. All of the calculations for the sand bed depth estimations and calculations/conversions to V_{eroded} from each event can be found in Appendix C-3. Sand depths were not recorded for events 1 or 2, so the first two events were not considered in this comparison. The V_{eroded} estimates were compared to the total SS transport, SS_t, volumes from Equation 3 (Appendix C-4). The V_{eroded} were 6-104 times greater than the SS_t calculations from the SS concentrations (Table 4-9) since most sediment transport occurred as bed load.

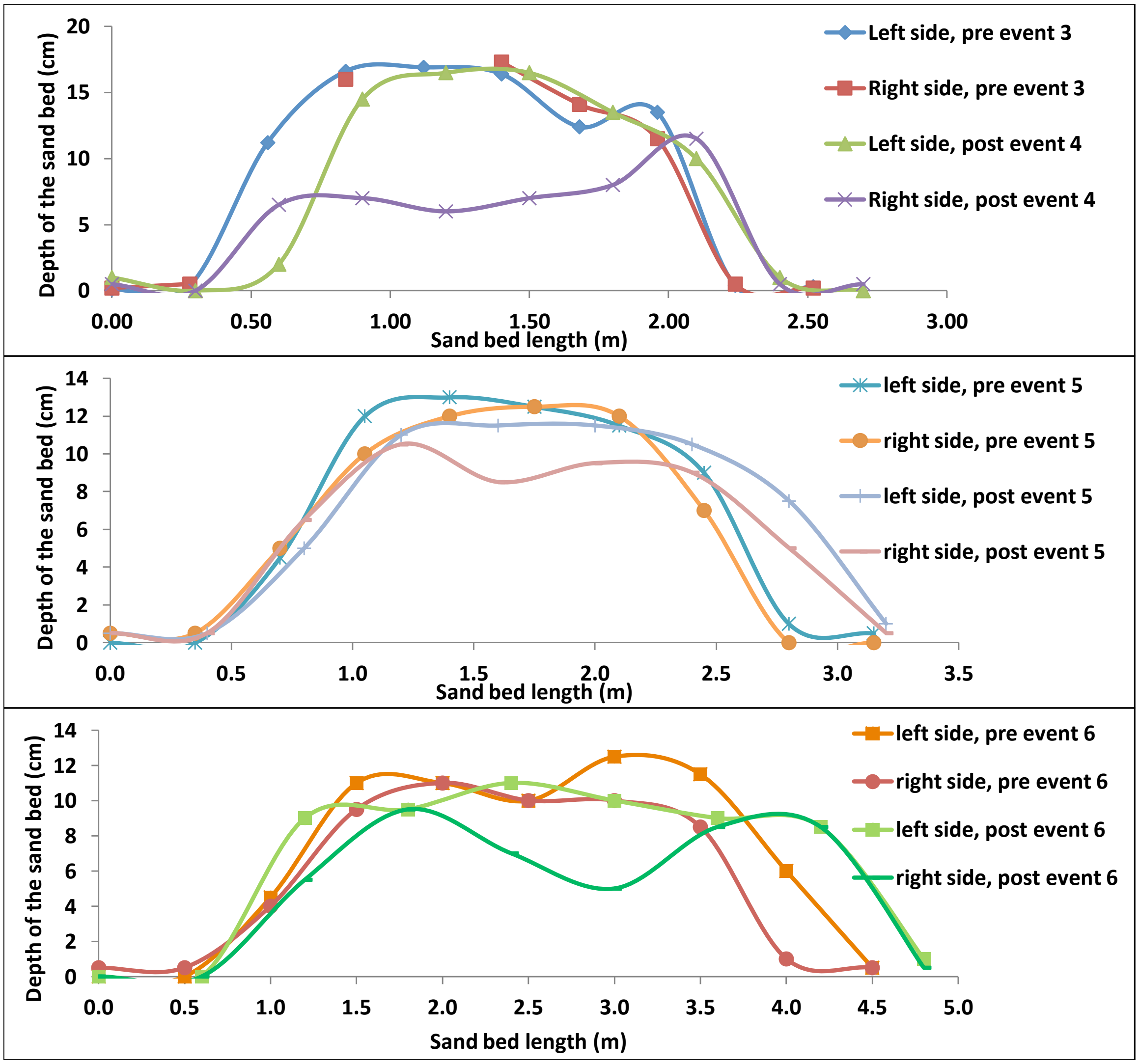


Figure 4-6: Sand bed profile data

Table 4-9: Sediment transport and total volume of sand eroded off the bed during each event

Event	Sediment transport, SS_t (m^3)	Volume eroded from bed during the event, V_{eroded} (m^3)	V_{eroded}/SS_t
3	0.0003	0.006	20
4	0.0003	0.032	104
5	0.0027	0.015	6
6	0.0008	0.069	86

Resuspension of Bacteria and Sand

Resuspended bacterial concentrations were calculated by taking the difference between downstream deep (downstream for the first two events) and upstream concentrations. Time series plots of the resuspended TC concentrations were produced for each event (Figure 4-7). Bacterial entrainment seems to be triggered when velocities first exceed about 20 cm/s, but there are variations from event to event. Resuspended TC always peaked within the first 20 min of the run and declined either gradually or sharply. This consistency of TC peaks for all six events suggests a “first flush” effect. The critical condition for initialization of bacterial entrainment may also be related to the pre-event sediment bacterial concentration. These two assumptions suggest that the top layer of sediment/bacteria on the sand bed, where most of the TC live, is being swept away during the first 20 min of each event.

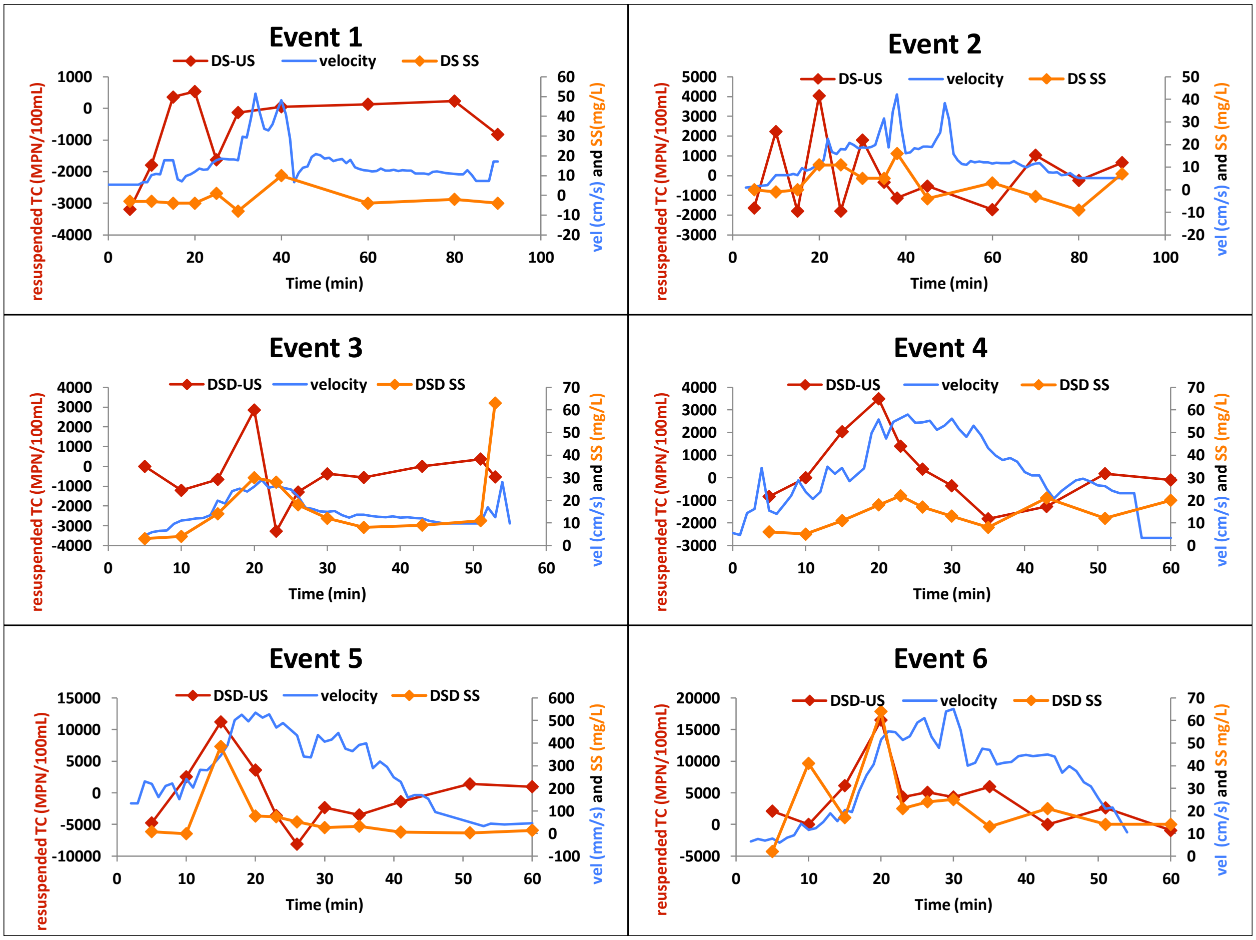


Figure 4-7: Resuspended TC concentrations, velocity, and SS concentrations

4.3.6 Cross Correlations

Cross correlations were performed in Matlab to reveal relationships among experimental parameters in data from the four June 2011 event time series. Cross correlation of velocity with downstream deep TC concentrations (Figure 4-8) for the four events produced similar lags (-8), suggesting that the peak in TC concentrations happened about 10 minutes prior to the peak in velocities. The cross correlation of downstream deep SS concentrations and velocities (Figure 4-9) was more equivocal. Slight “humps” in the cross correlation plots are due to variations in the raw data (Figure 4-7). In event 3 the peaks of SS and velocity occur almost at the same time with a lag of about 1, while event 4 SS concentrations peak slightly later than the velocity with a lag of about 5. However, SS concentrations peak before velocity in events 5 and 6 with a lag of about -5 and -10, respectively.

Resuspended TC concentrations peaked before velocity with lags of roughly -8 for all except event 3 which had a lag of about -2 (Figure 4-10). Resuspended TC is defined here as the difference between upstream and downstream TC concentrations.

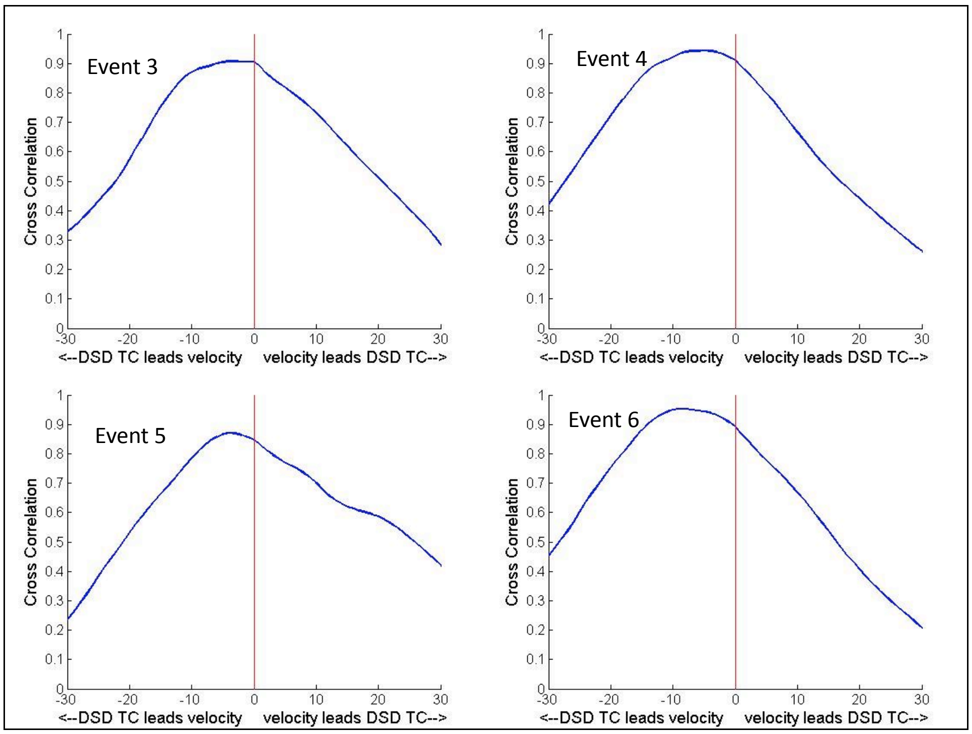


Figure 4-8: Cross Correlation of DSD TC concentrations with velocity for the last 4 events. One lag (on the x-axis) is approximately equal to one minute in the artificial stream study.

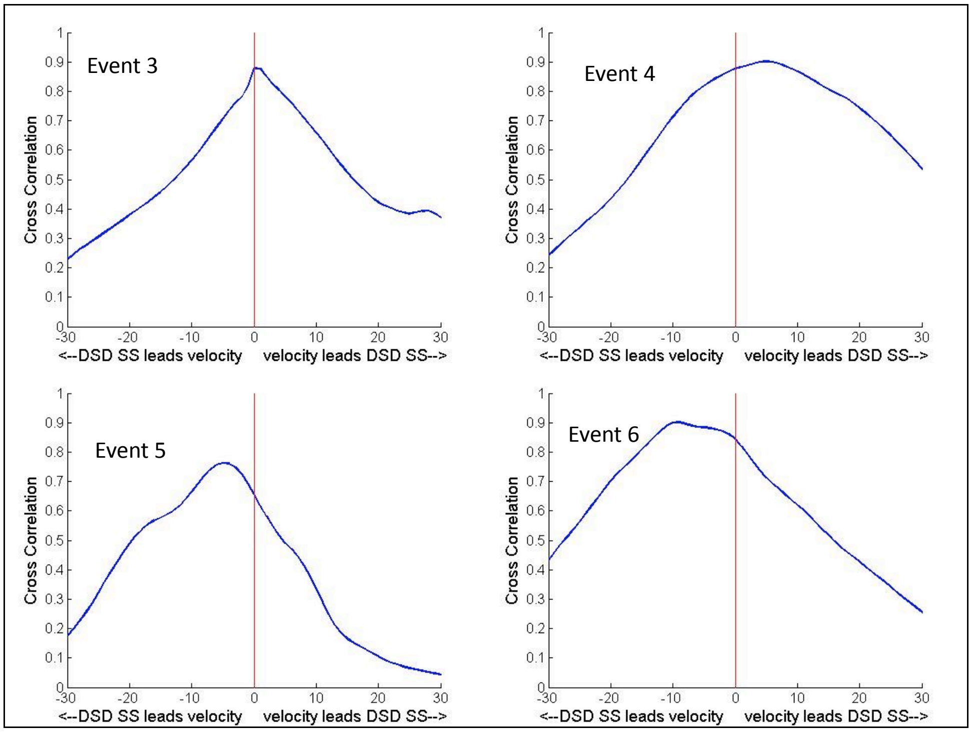


Figure 4-9: Cross Correlation of DSD SS concentrations with velocity for the last 4 events.
One lag (on the x-axis) is approximately equal to one minute in the artificial stream study.

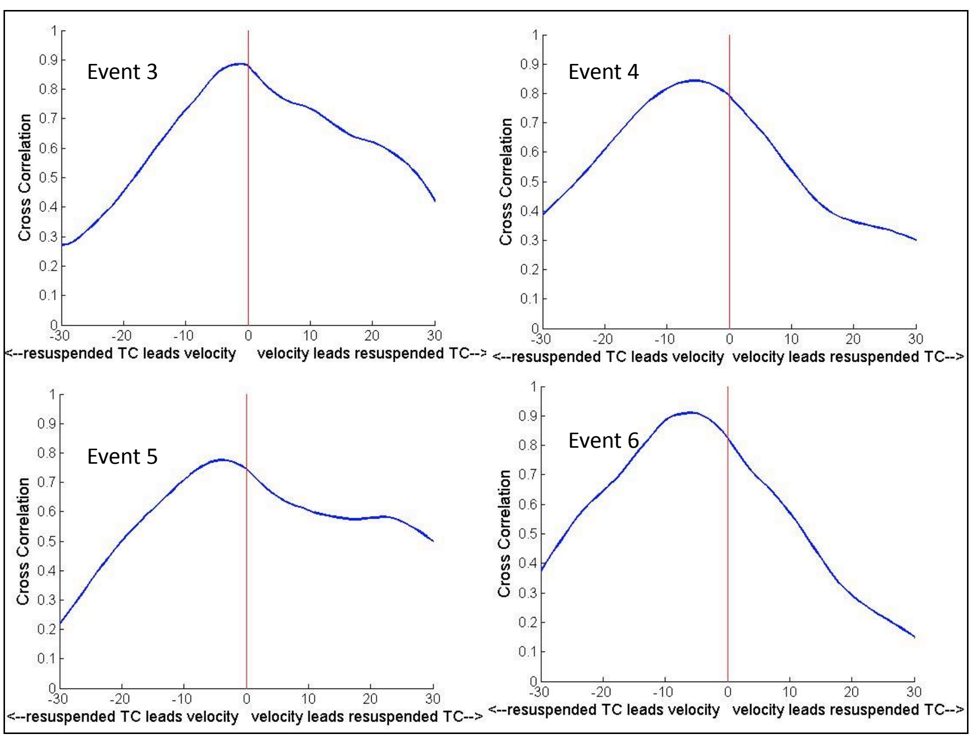


Figure 4-10: Cross Correlation of resuspended TC and velocity
One lag (on the x-axis) is approximately equal to one minute in the artificial stream study.

After analyzing the first three cross correlations with velocity data, the rate of change in velocity was considered as an alternate comparison. The rate of change was found by calculating the temporal gradient of the raw velocity. The velocity gradients peak before the velocity (Figure 4-11).

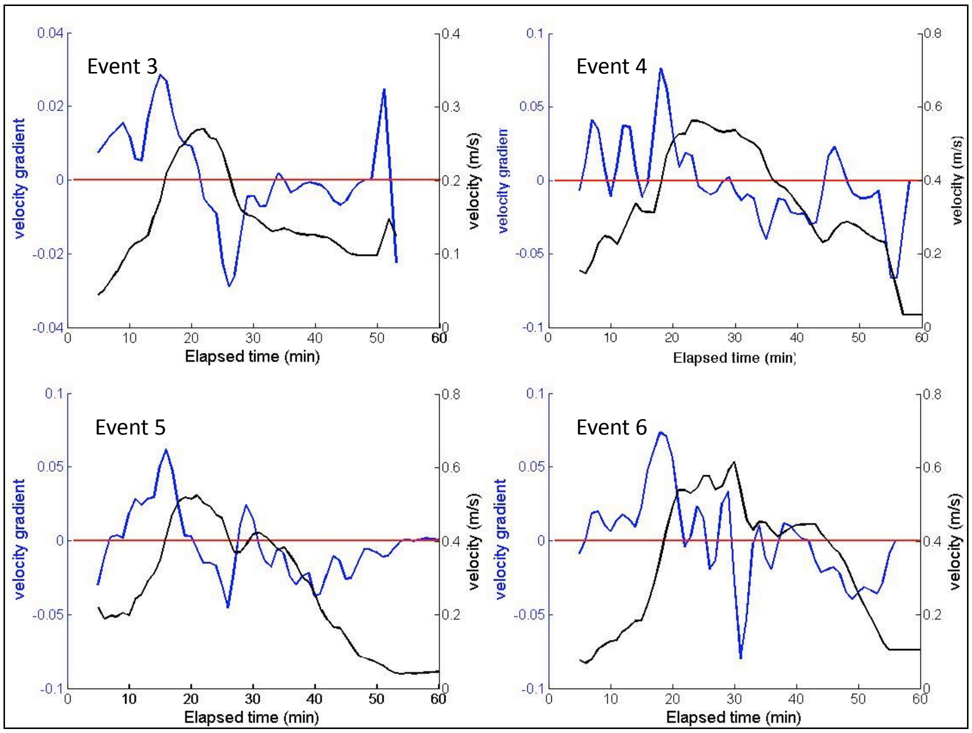


Figure 4-11: Velocity and velocity gradient for event 3-6
The black line represents the raw velocity data with units presented on the right hand y-axis. The blue line represents the velocity gradient with units and values shown on the left hand y-axis.

Similar cross correlations were performed using TC and the velocity gradients instead of the velocity (Figure 4-12 and Figure 4-14). Both of these cross correlations peak near or on the 0 lag, meaning the two parameter patterns are similar. In other words they peak at the same time. Cross correlation of velocity gradients with downstream deep SS concentrations were less consistent (Figure 4-13), reflecting the noisy SS concentration data. These cross correlations prove that the bacteria and SS concentrations in the artificial stream reflect temporal velocity gradients on event rising limbs, displaying a “first flush” effect.

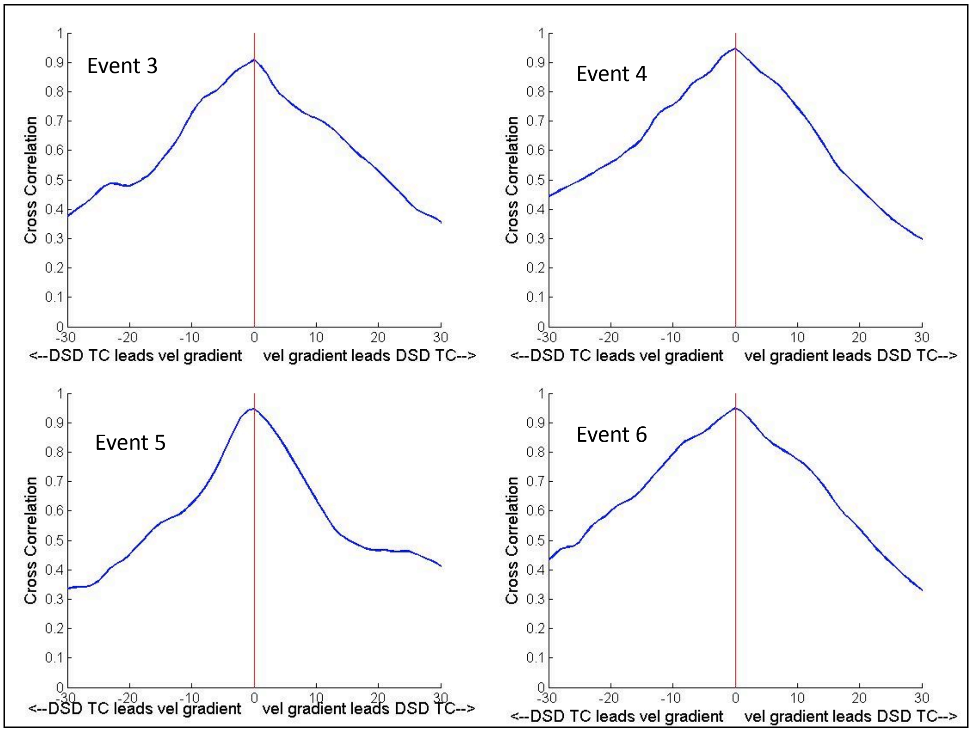


Figure 4-12: Cross Correlation of DSD TC concentrations with the velocity gradient
One lag (on the x-axis) is approximately equal to one minute in the artificial stream study.

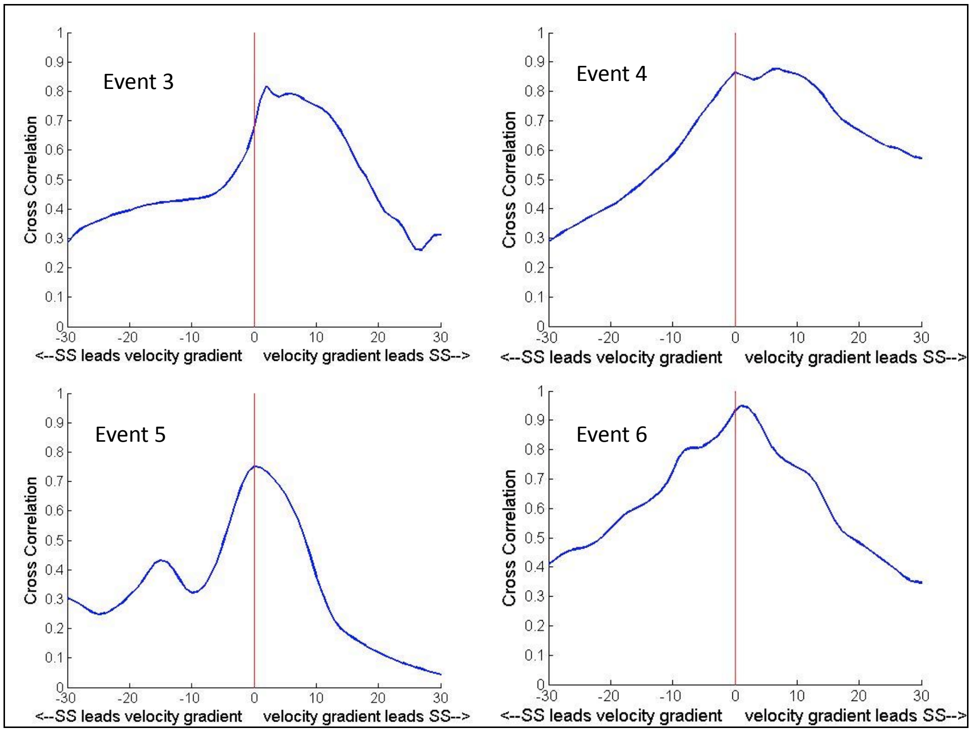


Figure 4-13: Cross Correlation of DSD SS concentration with velocity gradient
One lag (on the x-axis) is approximately equal to one minute in the artificial stream study.

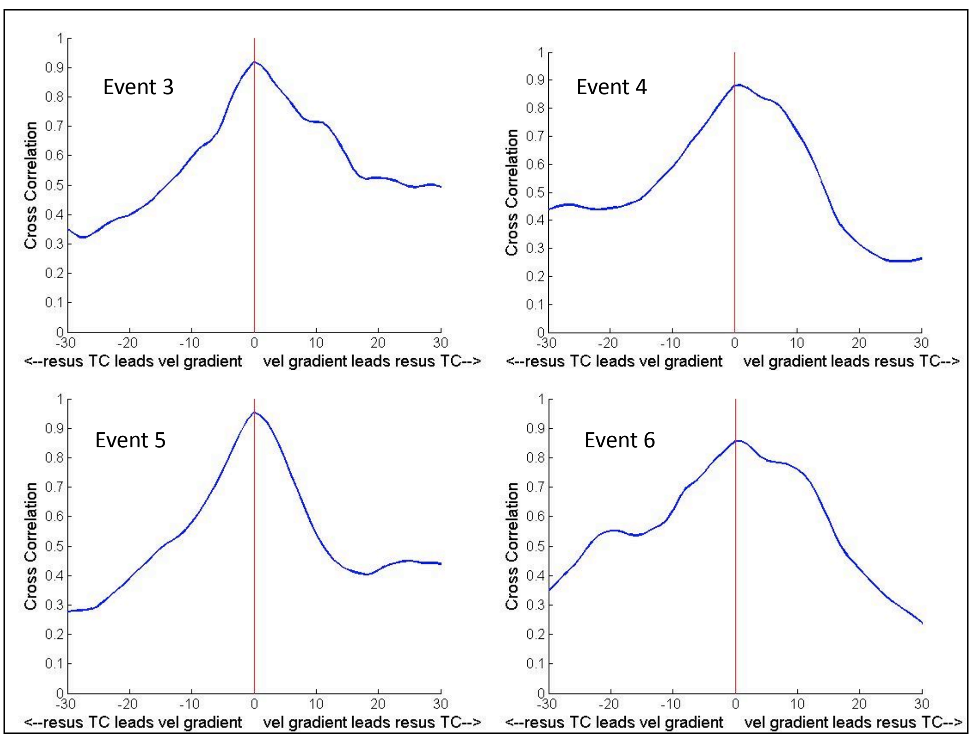


Figure 4-14: Cross Correlation of resuspended TC and velocity gradient
One lag (on the x-axis) is approximately equal to one minute in the artificial stream study.

4.4 Acoustic Monitoring of Bed Movement*

Post processing the storm event data was simply a matter of running a pre-written code that takes the backscattered signal and creates several plots. The 'Total Concentration' plot from the high flow period of event 5 (Figure 4-15) shows sediment concentration at a given depth at a given time using a color scale, with red being the highest concentration. The color scale is simply the amplitude of the received signal (in bytes), and is a very qualitative parameter. The maximum amplitude in this 16 bit system is $(2^{16})/2 = 32768$, which can be converted (via calibration) into voltage and/or concentration. Specific time slices of this plot can be taken, giving the exact concentration in numeric form over the 74 cm range ignoring the first 17 cm. It is easy to see the migration of the bed and the amount of sediment flowing in front of it in Figure 4-15. The water sample collections and the moving of the ISCO are also apparent as these actions kicked up a lot of sediment. Although exact sediment concentrations were not calculated using this data, the use of the acoustic device showed bed movement and particle suspension from the artificial stream storm events in a different way from the grab sample SS concentrations analyzed in the lab.

* This section is courtesy of and written by Mr. Bradley Goodwiller of NCPA. It is included in this thesis because it is an additional effort to demonstrate sediment movement.

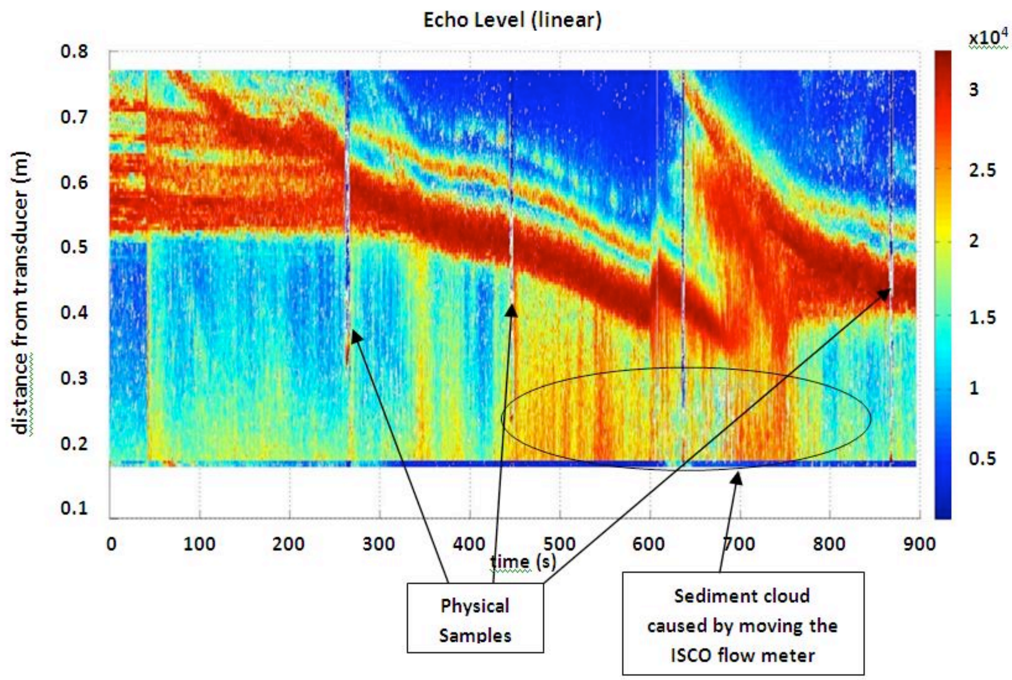


Figure 4-15: Acoustic backscatter sediment monitoring system data for rising limb of event 5

4.5 Steady Flow Analysis

The parameters defined in the steady flow analysis model section above were either measured on site at the artificial streams or calculated/estimated from other sources (Appendix E-1). Table 4-10 shows the calculations for the application of the model to the three storm field measurements of Jamieson et al. (2005), as reported by Rehmann and Soupir (2009), and Table 4-11 shows field measurements and calculations from the artificial stream events. There are a few changes in parameters between the two studies. Total coliform (TC) concentrations measured in MPN/100mL were used for the bacteria model in the artificial stream study rather than *E. coli* (EC) concentrations in CFU/100mL which were used in the Rehmann and Soupir (2009) study. All TC concentrations used were the geometric means for each sample location in each event. A few factors such as the mean velocity, U, and water column depth, H_1, were assumed in different ways than Rehmann and Soupir (2009). The amount of biofilm in the artificial stream varied among events reflecting antecedent conditions and nutrient levels. The biofilms on the sediment appeared to increase critical shear stresses for the sand bed and therefore biased the relationship between sediment resuspension and velocity. The critical or threshold shear stress for bacterial resuspension was quantified for each event by plotting resuspended TC versus time (Figure 4-7). The critical condition for bacterial resuspension was assumed to be along the rising limb of the plot of concentration differences. In Figure 4-7 event 4, this value corresponds to 29.2 cm/s and 12.5 min on the rising limb of the plot. The corresponding measured velocity and depth values were used as critical values. These critical velocity and depth values were multiplied by the constant stream width to compute the discharge. The values needed for the resuspension flux were also found in Figure 4-7 by assuming the period the resuspension period was the time when the plot of concentration differences was above 0 and on the rising limb. During this period, average TC concentrations and flow rates were calculated. These two values along with a surface area of width and length of the sand bed were used to calculate the resuspension fluxes in order to compute the resuspension velocities. Surface light energy was not accounted for in the artificial stream data. Net growth rates in the water column were assumed to be the same as used for the Jamieson et al. (2005) data. The artificial stream D_a values were extremely low compared to the Jamieson et al. (2005) data because of the difference in reach lengths. The Jamieson et al. (2005) data accounts for a 1690 m length, while the artificial stream sand bed is only 2.5 m long. This small reach length and the velocities used result in roughly 7 to 24 second travel times across the sand bed. In this amount of time, the net growth rate of bacteria in the water column only affects about 0.00072 to 0.00247 organisms, and thus growth and decay of bacteria in the water column was not significant in our system.

Table 4-10: Table 1 from Rehmann and Soupir (2009)

		R&S Table 1 data: Storm		
		225 h	**550 h**	**600 h**
measured in Jamieson et al. (2005)	**Discharge (m^3/s)**	0.37	0.33	0.30
	Resuspension Rate (CFU/m^2s)	11000	8200	15000
	Water Temp (°C)	10.6	11.5	14.1
	US Conc. (CFU/100mL)	4.65	3.9	6.8
	DS Conc. (CFU/100mL)	0.95	1.0	3.1
	DSDeep Conc. (MPN/100mL)			
	Conc. In sed (CFU/g)	5495	1157	1387
	SS (mg/L)	28.7	25.2	29.7
Calculated or estimated from other sources	**Water depth (m)**	0.15	0.14	0.13
	Mean Vel (m/s)	0.37	0.35	0.34
	Surface light energy (ly/h)	21.8	17.0	19.1
	k_{n1} (1/d)	-9.50	-8.14	-8.24
	settling vel, *w* (m/s)	0.0085	0.0087	0.0093
	Resuspension vel (m/s)	2.0E-06	7.1E-06	1.1E-05
	Damkohler number, *Da*	-0.51	-0.45	-0.48
	Sed interaction parameter, *S*	7.0	2.6	1.9
Model results	**Measured *C1/Cin***	0.20	0.26	0.45
	Predicted *C1/Cin*	0.02	0.20	0.25
	Predicted *C1/Cin* for *S*=0	0.60	0.64	0.62

The channel width was taken to be 8 m for the Jamieson et al. (2005) data. Sediment settling velocities were computed by Stokes Law using a specific gravity of 2.65 and mean diameters of 0.11 mm for Jamieson et al. (2005) data. All net growth rates in the sediment were assumed to be -0.12 d^{-1} with a H_2 of 2 cm.

Table 4-11: Artificial stream data for Steady State analysis

		Artificial Stream Data					
		1	**2**	**3**	**4**	**5**	**6**
measured in Jamieson et al. (2005)	**Discharge (m^3/s)**	0.028	0.016	0.045	0.038	0.035	0.039
	Resuspension Rate (MPN/m^2s)	51,390	222,103	221,294	490,352	1,710,524	1,294,338
	Water Temp (°C)	7.6-8.2	13.3-25.2	21.3-27.3	21.7-29.6	19.6-25.4	19.9-23
	US Conc. (MPN/100mL)	3008	5974	5815	5555	10536	8296
	DS Conc. (MPN/100mL)	2856	5836	6076	5263	8931	13081
	DSDeep Conc. (MPN/100mL)			5468	5505	10066	13444
	Conc. In sed (MPN/g)	4536	2083	20969	78979	34700	315829
	SS (mg/L)	3.4	5.2	14.9	11.9	42.8	17.7
Calculated or estimated from other sources	**Water depth (m)**	0.25	0.23	0.29	0.21	0.20	0.19
	Mean Vel (m/s)	0.18	0.11	0.25	0.29	0.28	0.32
	Surface light energy (ly/h)						
	k_{n1} (1/d)	-8.89	-8.89	-8.89	-8.89	-8.89	-8.89
	settling vel, *w* (m/s)	0.0184	0.0168	0.0064	0.0073	0.0097	0.0063
	Resuspension vel (m/s)	4.28	40.24	3.98	2.34	18.60	1.55
	Damkohler number, *Da*	-0.0015	-0.0024	-0.0010	-0.0009	-0.0009	-0.0008
	Sed interaction parameter, *S*	0.0	0.0	0.0	0.0	0.0	0.0
Model results	**Measured *C1/Cin***	0.95	0.98	0.94	0.99	0.96	1.62
	Predicted *C1/Cin*	1.00	1.00	1.00	1.00	1.00	1.00
	Predicted *C1/Cin* for *S*=0	0.999	0.998	0.999	0.999	0.999	0.999

The channel width was taken to be 0.63 m for the artificial stream data. Sediment settling velocities were computed by Stokes Law using a specific gravity of 2.65 and mean diameters of 0.375 mm for March and April and 0.257 mm for June events. All net growth rates in the sediment were assumed to be -0.12 d^{-1} with a H_2 of 2 cm.

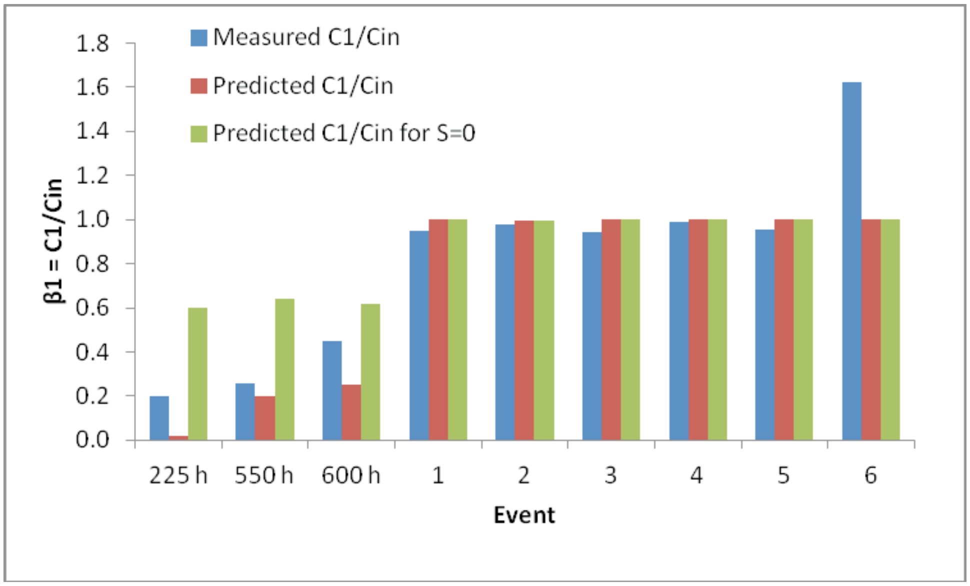


Figure 4-16: Measured and predicted ratios of downstream to upstream bacterial concentrations
The first three events plotted are the storms from the Jamieson et al. (2005) data plotted in Rehmann and Soupir (2009). The next six are artificial stream events. The blue bars are computed from measured values from the field events. The red are the model prediction results including sediment-water interactions, and the green are model predictions ignoring sediment-water interactions. *Cin* is the bacterial concentration at the beginning of the reach, and *C1* is the bacterial concentration at the end of the reach.

Data from Table 4-10 and Table 4-11 is plotted in Figure 4-16 to compare the measured and predicted ratio of the concentration of bacteria at the end of the reach to that from the beginning (*C1*/*Cin*). In the Jamieson et al. (2005) data, the model produced values within a factor of 2 for the last two storms but under predicted the first storm ratio by a factor of 10, although the predicted values without considering the sediment interaction parameter were extremely high compared to the measured values. This confirms that fine sediment interaction with the water column in streams contributes extensively to the concentrations in the water column downstream during and after storms. It also suggests that ignoring sediment interactions when setting water quality standards would require a larger than necessary reduction of upland loads.

Unlike Rehmann and Soupir (2009) results, the predicted and measured values for the artificial stream are fairly similar for each of the six events. The predicted ratios without the sediment interaction parameter are also similar to the first two ratios. Not only does this prediction closely model our field measured data, it also proves that the resuspension of the bacteria has little dependence on the sand resuspension because the predicted value with an S of 0 was statistically similar to the first two ratios.

4.6 Unsteady Flow Model

Concentration hydrographs observed in the artificial stream experiments were simulated by solving Equation 14 (Cho et al. 2010) using the MacCormack Method (MacCormack 1969) in a Matlab routine. Sink (settling) and source (resuspension) terms were adjusted to reflect our system. The last term in the original equation from Cho et al. (2010) was set to zero since it represents lateral inflows. In the artificial stream, storm hydrographs were simulated by the use of pumps and the opening and closing of water supply valves. In contrast, Cho et al. (2010) simulated runoff events by discharging water trucks into a very small stream (~1 m wide) to create a simulated hydrograph with peak flows of 0.025 to 0.06 m^3/s, which are similar to our peak flows of 0.05 to 0.09 m^3/s realized in a 0.6-m-wide artificial stream. It is also important to note that the artificial stream events had almost no sediment finer than sand, but Cho et al. (2010) reported a high correlation between turbidity and TC, highlighting the importance of fine sediments as a transporting medium for bacteria in their stream.

4.6.1 Variables

Variables for the Matlab model are listed in Table 4-12 along with Cho et al. parameters. The artificial stream events were modeled for the entire 90 or 60 min. For the first 5 events, a 2.5 m reach of the sand bed was modeled with a temporal resolution (Δt) of 1 s and spatial resolution (Δx) of 0.5 m. The sand bed for event 6 was 3 m long due erosion and downstream deposition during the previous events. Also, for event 6 the Δt and Δx were set to 0.5 s and 0.75 m, respectively. The change in time and spatial interval for this event was necessary to meet the Courant number (Equation 22) stability criteria for the numerical solution scheme. The *F* values (the same as discussed previously in Table 4-8) were slightly smaller than the 0.50 value from Cho et al. (2010), and the sediment settling velocities (v_s) were greater than reported by Cho et al. (2010). The latter of these differences was most likely due to the difference in sediment size because larger particles settle at faster rates. The critical shear stress τ_c from the artificial stream events is within range of Cho et al. (2010) values. Calculations for the dispersion coefficient *D*, and *F*, v_s, and τ_c are in Appendix D-2.

Table 4-12: Matlab Model variables

Event	**event time duration (s)**	**sand bed, *x* (m)**	**time interval, Δt (s)**	**spatial interval, Δx (m)**	**fraction of TC attached to sediment, *F***	**sediment settling velocity, v_s (m/s)**	**critical shear stress, τ_c (N/m^2)**
1	0-5400	2.5	1	0.5	0.39	3.75E-04	0.0375
2	180-5400	2.5	1	0.5	0.34	3.75E-04	0.0375
3	300-3180	2.5	1	0.5	0.30	2.57E-04	0.0094
4	0-3600	2.5	1	0.5	0.34	2.57E-04	0.0094
5	0-3600	2.5	1	0.5	0.46	2.57E-04	0.1782
6	0-3600	3	0.5	0.75	0.29	2.57E-04	0.0304
Cho et al. (2010)	~7800	140, 350	-	-	0.50	2.66E-07	0.034-0.62

4.6.2 *Model Validation*

The Matlab model was validated by running the code for event 3 with input (TC concentrations, C, at x = 0) for three hypothetical cases: (1) C = 0 for all of time (Figure 4-17), (2) C = 0 with a spike between 7 min and 8 min (Figure 4-18), and (3) C = 0 before 25 min and a constant afterward step function (Figure 4-19). Case 1 (Figure 4-17) with constant input concentrations of 0 shows an output concentration that is very dependent on velocity, which is reasonable because the model is based on shear stress. Case 2 (Figure 4-18) with a short spike of 10^7 MPN/m^3 in input concentrations shows an immediate response spike in the output with about a third of the magnitude that drops back down and continues on to reflect velocity forcing. Case 3 (Figure 4-19) follows velocity until the increase input concentration of $2.5*10^6$ MPN/m^3 at 25 min when the output spikes and continues to follow the velocity pattern but at a constant, higher concentration. These three cases show the output concentrations are properly responding to the input concentrations and confirm the accuracy of the model.

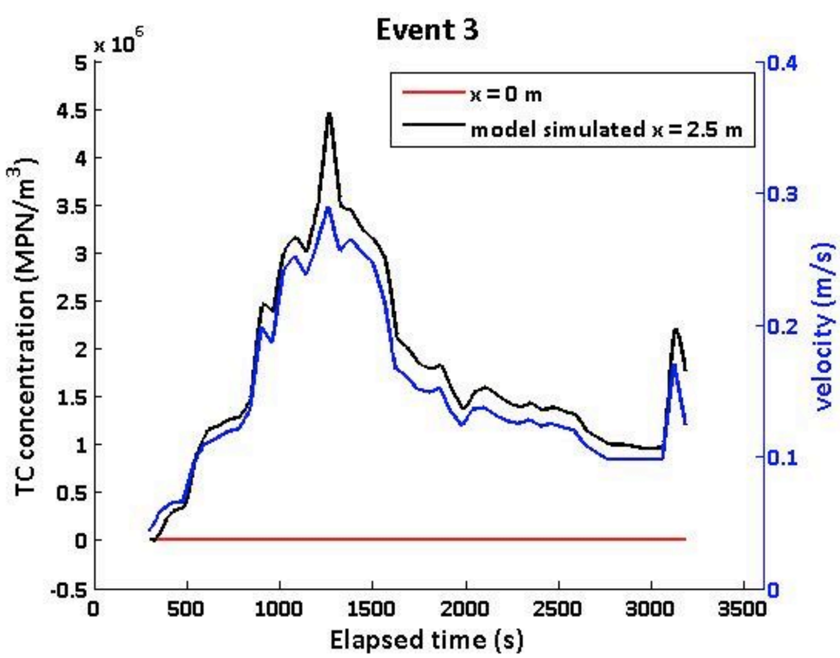


Figure 4-17: Model Validation Case 1: Initial TC concentration = 0 for all of time

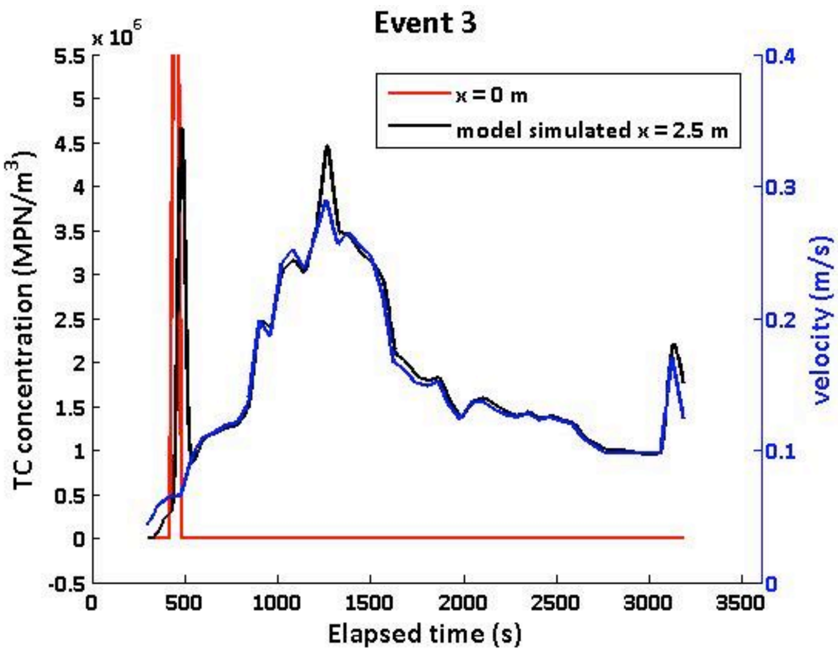


Figure 4-18: Model Validation Case 2: Initial TC concentration = 0 with a spike between 7 min and 8 min

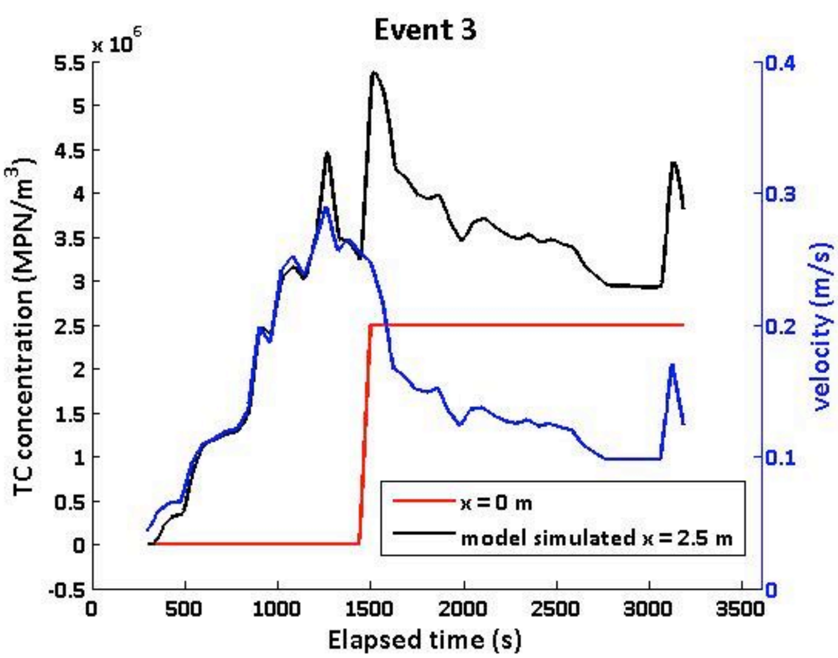


Figure 4-19: Model Validation Case 3: Initial TC concentration = 0 before 25 min and a constant afterward

4.6.3 Reconstitution of Storm Events

Due to differences from the Cho et al. (2010) experiments and the artificial stream events, the Matlab model was modified to better illustrate the mechanisms occurring in the UMBFS artificial stream. An adjustment factor *z* was added to the settling term with constraints from 0.001 to 10. The bacterial entrainment coefficient *Re* was also used in the model sensitivity analysis with constraints of 10^{-8} to 10^{-1}. The Matlab model was run with the *Re* and *z* terms optimized for a best fit for each event.

Plots of the Matlab model outputs were superimposed on experimental data plots from each run. Model outputs represented runs with Re and z coefficients optimized to fit the entire run and those optimized to fit only the first 20 min, or the rising limb, for each run. The resulting values for *Re* and z varied for each set of runs with higher Nash-Sutcliff Efficiencies E for the set optimized for the rising limbs in events 3-6 (Table 4-13). Results for event 2 are very atypical of the others, as were the pre- and post-event sediment TC concentrations as shown in Table 4-5. The Re values for the artificial stream events 3-6 ranged from $6.84*10^{-5}$ to $1.81*10^{-2}$ kg/m^2s (with the exception of all data from event 5), which compared to the $1.6*10^{-5}$ to $3.2*10^{-5}$ kg/m^2s values from the three stream reaches studied by Cho et al. (2010). When all data are considered (Figure 4-20), model best fits for two of the events are essentially the model input (concentration out = concentration in) since the source and sink terms are so low. When only the first 20 min are considered (Figure 4-21), resuspension processes (Re coefficients) are more important. In both sets of output, there is a great deal of variation from event to event, indicating differences in bacterial transport related to source strength (bed sediment TC concentrations) and perhaps flow strength.

Table 4-13: Adjustment terms and Nash-Sutcliff Efficiencies for entire event and rising limb

Model fit for all data				**Model fit for first 20 min of each run**			
Event	Entrainment coefficient (kg/m^{2}s), *Re*	Settling term adjustment factor, *z*	Nash-Sutcliff Efficiency, *E*	Event	Entrainment coefficient (kg/m^{2}s), *Re*	Settling term adjustment factor, *z*	Nash-Sutcliff Efficiency, *E*
1	1.75E-04	0.031	0.87	**1**	1.90E-02	0.032	0.67
2	1.00E-08	0.006	0.50	**2**	1.00E-01	0.005	-12.34
3	1.89E-04	0.140	0.24	**3**	1.50E-03	0.266	0.59
4	4.31E-05	0.059	0.59	**4**	2.08E-04	0.214	0.89
5	1.00E-08	0.003	-0.08	**5**	1.81E-02	0.001	0.40
6	1.37E-04	0.001	0.27	**6**	4.96E-04	0.001	0.90

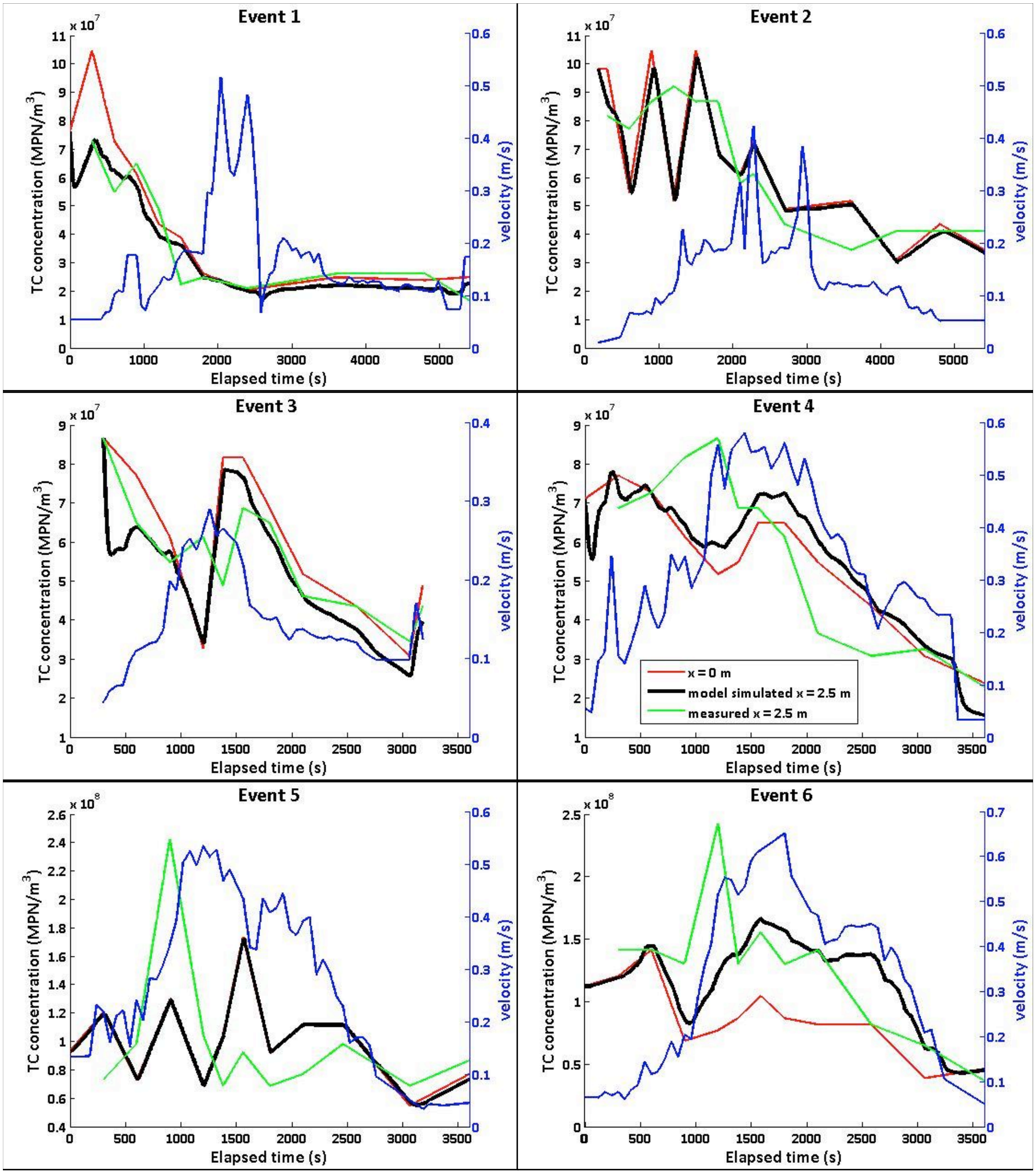


Figure 4-20: Model outputs represent runs with Re and z coefficients optimized to fit the entire run

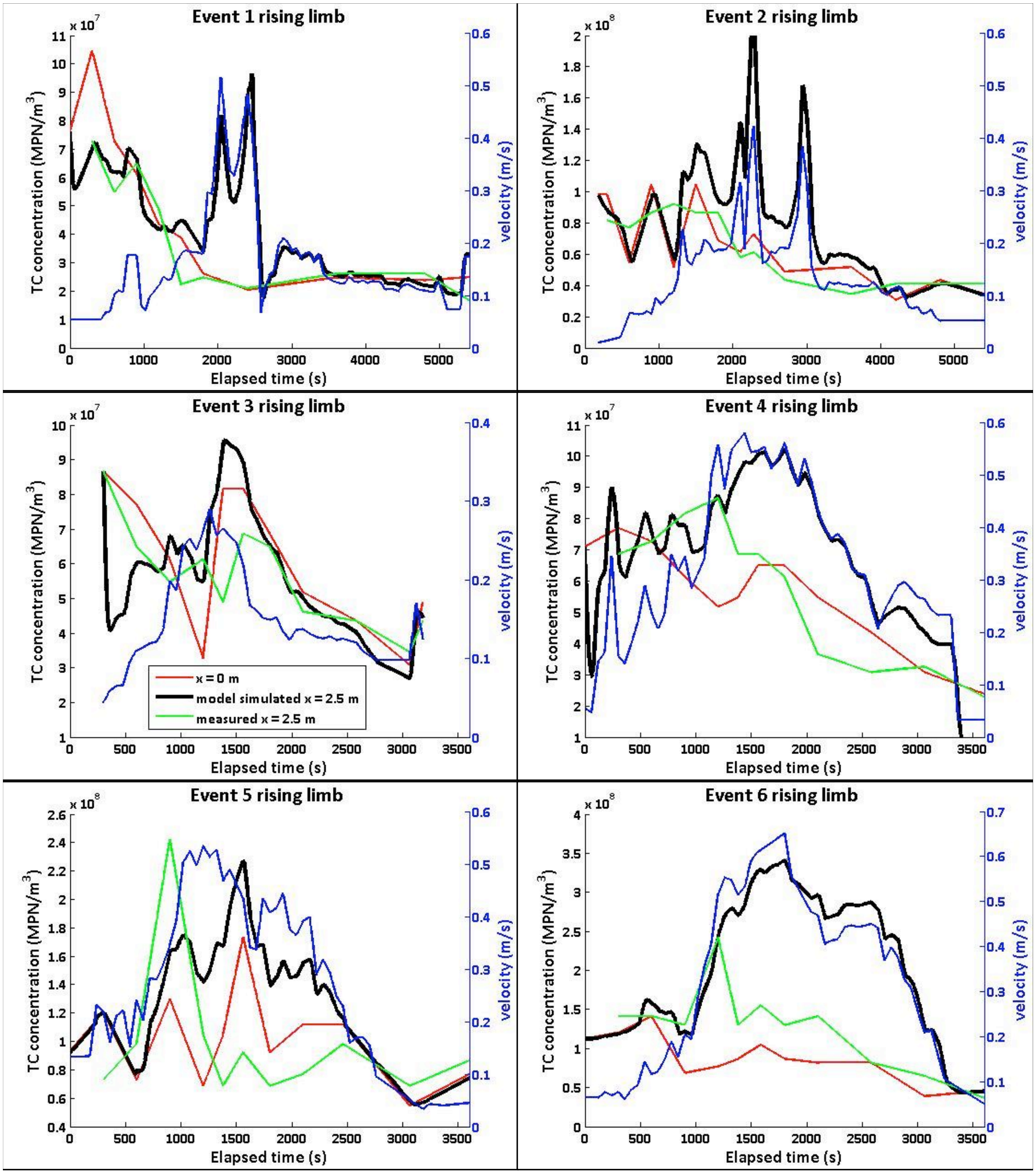


Figure 4-21: Model outputs represent runs with Re and z coefficients optimized to fit the rising limb

In order to examine error variation in the model outputs, modeled TC concentrations versus observed TC concentrations were plotted for both sets of model runs. Model outputs fit for the all data (Figure 4-22) compare nicely to observed data except at high experimental concentrations. Conversely, model outputs fit for the first 20 min (Figure 4-23) compares to the observed data except at high modeled concentrations. Again, observed TC concentrations peaked before the velocities peaked. As shown in the model validation run, the model source term is driven by velocity, causing the modeled concentrations to continue to increase after the observed TC concentrations peak.

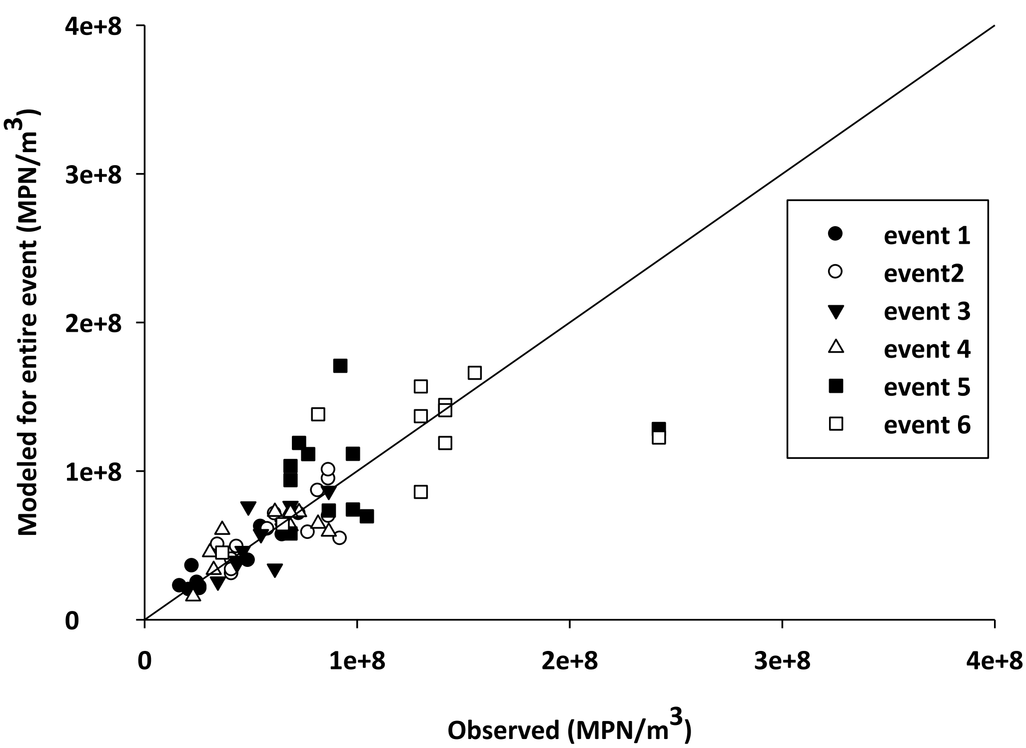


Figure 4-22: Modeled TC for entire events vs. Observed TC

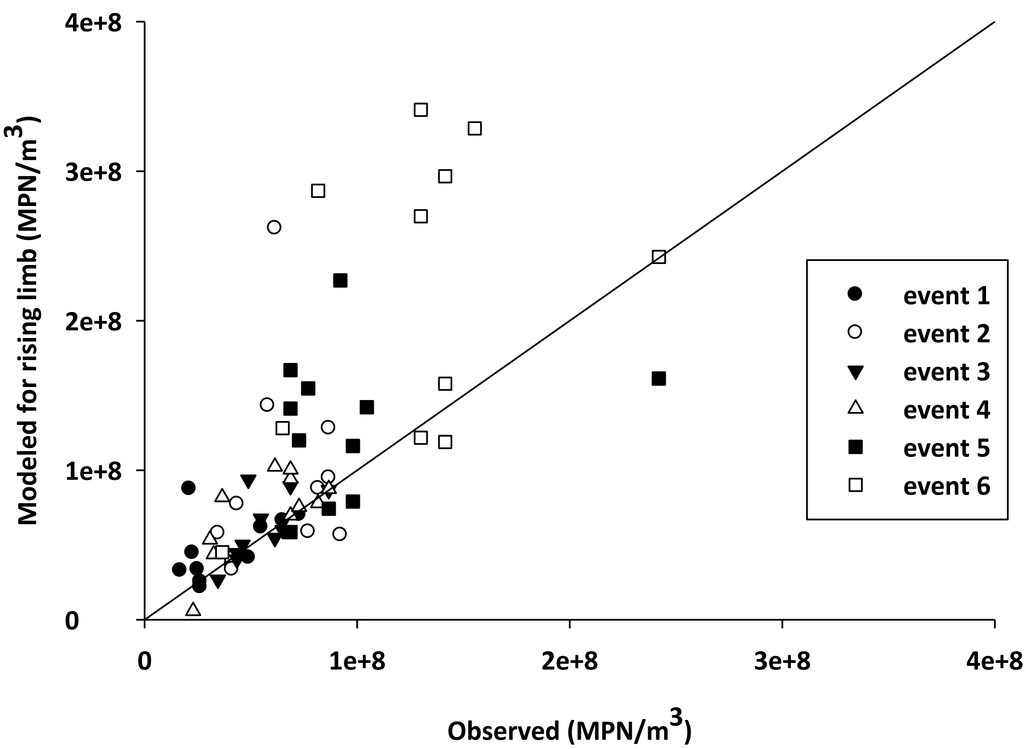


Figure 4-23: Modeled TC for rising limb vs. Observed TC

Through the unsteady state Matlab model, this experiment shows that (1) bacterial transport is weakly coupled to sediment transport in systems/beds with very little fine sediment, and (2) the “first flush” effect is not driven primarily by sediment dynamics.

5. CONCLUSION

High flow storm events can cause a substantial increase in stream TC concentrations due to resuspension of bacteria from sand beds. This study consisted of experimental data from six artificial flow events, as well as steady and unsteady flow simulation of each event. Some major conclusions from this study are as follows:

1. Substantial levels of TC live in streambed sediments that consist mainly of sand and very little fine material.
2. TC entrainment in systems similar to the artificial stream is likely to occur prior to general bed sediment movement.
3. There is a first flush effect in our system, and probably in natural streams, as the upper layer or “skin” of the bed is influenced by flow. This occurred with sharp velocity increases in our system at rates of about 0.2 to 0.3 m/s. Downstream TC increases rapidly as velocity increases past this point, but TC quickly peaks and then declines even as velocity, discharge, and shear stress continue to increase. This most likely reflects the depletion of TC in the bed sediment as the upper, more densely populated sediment layer is flushed out. In other words, C_s in Equations 24 and 25 changes during an event.
4. The first flush effect in our system is not driven primarily by sediment dynamics. Steady state and unsteady state analysis show that TC transport is less coupled

to sediment transport that is dominated by sand with very little fine material. Entrainment of bacteria from the sand bed seems to be occurring during the high flow events even when there is little sand transport, consistent with work by Grant et al. (2011).

5. Our model seems to reproduce the rising limb of the first flush if we adjust it accordingly. The first and second runs are atypical because the bed sediment concentrations were low.
6. The Matlab model source term is velocity dependent and therefore does not contain a representation of processes that would allow the TC to fall prior to the velocity peak, thus creating a first flush effect. This first flush effect means that initially the bacterial concentration in the water is limited by flow conditions while after the “flush” the re-entrainment has largely diminished due to exhausting the bacterial pool available for transport at the surface of the bed (i.e., settling is weak so most of the entrained bacteria leave the system). Thus, there is a transition during the run from transport limitation to supply limitation. Our model best reflects the behavior during transport limitation since it is a shear stress based model. A longer, natural stream reach might respond differently since the TC reservoir would be larger.

In future experiments, variations in TC should be quantified by running 3-5 replicates for a smaller number of samples during selected runs. It may also be beneficial to collect more sand samples during the storm events to better evaluate the sediment TC concentrations throughout the event. This could further explain the amount of bacteria being resuspended and transported during the first flush. The modeling equation (Equation 27) could then be modified to take into account sediment TC concentration as a function of time. There is a calling for a different entrainment model to account for bacterial entrainment independent of sediment.

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LIST OF APPENDICES

APPENDIX A: WATER QUALITY DATA

Appendix A-1: Water Quality Data

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
11/09/2010 Coliform already present?	11/8/06 13:58		stream 1 inflow pipe	water	10
	11/8/06 13:58		stream 2 inflow pipe	water	10
	11/8/06 13:59		stream 3 inflow pipe	water	10
	11/8/06 13:59		stream 4 inflow pipe	water	10
	11/8/06 13:59		stream 5 inflow pipe	water	10
	11/8/06 13:59		stream 6 inflow pipe	water	10
	11/8/06 13:24		Sed Lab pile	sand	10
	11/8/06 13:25		Sed Lab pile	sand	10
2/17/2011 obervations and sampling	2/16/07 9:18		pipe	water	10
	2/16/07 9:19		water bend	water	10
	2/16/07 9:21		end	water	10
	2/16/07 9:23		phyto at bend	algae	10
	2/16/07 9:22		phyto stretch	algae	10
2/24/2011 added 400 lbs of sand and sampled	2/23/07 10:13		mid stretch presand	water	10
	2/23/07 10:21		sand from bag	sand	10
	2/23/07 10:21		sand from bag	sand	10
	2/23/07 10:21		sand from bag	sand	10
	2/23/07 10:32		US sand	water	10
	2/23/07 10:35		above sand	water	10
	2/23/07 10:38		DS sand	water	10
	2/23/07 11:01		sand with algae	sand	10
	2/23/07 11:01		sand with algae	sand	10
	2/23/07 11:01		sand with algae	sand	10
	3/14/07 9:17	1	us presample	water	10
	3/14/07 9:24	2	us	water	10
	3/14/07 9:24	3	ds	water	10
	3/14/07 9:29	4	us	water	10
	3/14/07 9:29	5	ds	water	10
	3/14/07 9:34	6	us	water	10
	3/14/07 9:34	7	ds	water	10
	3/14/07 9:39	8	us	water	10
	3/14/07 9:39	9	ds	water	10
	3/14/07 9:44	10	us	water	10
	3/14/07 9:44	11	ds	water	10
	3/14/07 9:49	12	us	water	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
3/15/2011 90 minute HIGH flow event	3/14/07 9:49	13	ds	water	10
	3/14/07 9:59	14	us	water	10
	3/14/07 9:59	15	ds	water	10
	3/14/07 10:19	16	us	water	10
	3/14/07 10:19	17	ds	water	10
	3/14/07 10:39	18	us	water	10
	3/14/07 10:39	19	ds	water	10
	3/14/07 10:49	20	us	water	10
	3/14/07 10:49	21	ds	water	10
	3/14/07 9:17	1F	us presample	water	10
	3/14/07 9:24	2F	usFiltered	water	10
	3/14/07 9:24	3F	dsFiltered	water	10
	3/14/07 9:29	4F	usFiltered	water	10
	3/14/07 9:29	5F	dsFiltered	water	10
	3/14/07 9:34	6F	usFiltered	water	10
	3/14/07 9:34	7F	dsFiltered	water	10
	3/14/07 9:39	8F	usFiltered	water	10
	3/14/07 9:39	9F	dsFiltered	water	10
	3/14/07 9:44	10F	usFiltered	water	10
	3/14/07 9:44	11F	dsFiltered	water	10
	3/14/07 9:49	12F	usFiltered	water	10
	3/14/07 9:49	13F	dsFiltered	water	10
	3/14/07 9:59	14F	usFiltered	water	10
	3/14/07 9:59	15F	dsFiltered	water	10
	3/14/07 10:19	16F	usFiltered	water	10
	3/14/07 10:19	17F	dsFiltered	water	10
	3/14/07 10:39	18F	usFiltered	water	10
	3/14/07 10:39	19F	dsFiltered	water	10
	3/14/07 10:49	20F	usFiltered	water	10
	3/14/07 10:49	21F	dsFiltered	water	10
	3/14/07 9:55	22a	beg sand bed	sand	10
	3/14/07 9:55	22b	beg sand bed	sand	10
	3/14/07 9:55	22c	beg sand bed	sand	10
	3/14/07 10:51	23a	beg sand bed	sand	10
	3/14/07 10:51	23b	beg sand bed	sand	10
	3/14/07 10:51	23c	beg sand bed	sand	10
	4/11/07 9:03	sand1a	beg sand bed	sand	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
4/12/2011 90 minute MEDIUM flow event	4/11/07 9:03	sand1b	beg sand bed	sand	10
	4/11/07 9:04	sand2a	mid sand bed	sand	10
	4/11/07 9:04	sand2b	mid sand bed	sand	10
	4/11/07 9:05	sand3a	end sand bed	sand	10
	4/11/07 9:05	sand3b	end sand bed	sand	10
	4/11/07 9:10	pond1	pond by road	water	10
	4/11/07 9:13	pond2	pond up on hill	water	10
	4/11/07 9:17	1	us presample	water	10
	4/11/07 9:28	2	us	water	10
	4/11/07 9:28	3	ds	water	10
	4/11/07 9:33	4	us	water	10
	4/11/07 9:33	5	ds	water	10
	4/11/07 9:38	6	us	water	10
	4/11/07 9:38	7	ds	water	10
	4/11/07 9:43	8	us	water	10
	4/11/07 9:43	9	ds	water	10
	4/11/07 9:48	10	us	water	10
	4/11/07 9:48	11	ds	water	10
	4/11/07 9:53	12	us	water	10
	4/11/07 9:53	13	ds	water	10
	4/11/07 9:58	14	us	water	10
	4/11/07 9:58	15	ds	water	10
	4/11/07 10:01	16	us	water	10
	4/11/07 10:01	17	ds	water	10
	4/11/07 10:08	18	us	water	10
	4/11/07 10:08	19	ds	water	10
	4/11/07 10:23	20	us	water	10
	4/11/07 10:23	21	ds	water	10
	4/11/07 10:33	22	us	water	10
	4/11/07 10:33	23	ds	water	10
	4/11/07 10:43	24	us	water	10
	4/11/07 10:43	25	ds	water	10
	4/11/07 10:53	26	us	water	10
	4/11/07 10:53	27	ds	water	10
	4/11/07 10:54	sand4a	mid sand bed	sand	10
	4/11/07 10:54	sand4b	mid sand bed	sand	10
	4/11/07 10:54	sand4c	mid sand bed	sand	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
	4/11/07 9:28	2F	usFiltered	water	10
	4/11/07 9:28	3F	dsFiltered	water	10
	4/11/07 9:58	14F	usFiltered	water	10
	4/11/07 9:58	15F	dsFiltered	water	10
	4/11/07 10:01	16F	usFiltered	water	10
	4/11/07 10:01	17F	dsFiltered	water	10
	4/11/07 10:53	26F	usFiltered	water	10
	4/11/07 10:53	27F	dsFiltered	water	10
5/5/2011 Coliform resuspension lab experiment	5/4/07 9:26	water1	mid stream	water	10
	5/4/07 9:26	water2	mid stream	water	10
	5/4/07 9:26	water3	mid stream	water	10
	5/4/07 9:28	sand1	mid sand bed	sand	10
	5/4/07 9:28	sand2	mid sand bed	sand	10
	5/4/07 9:28	sand3	mid sand bed	sand	10
		DI1	DI water	water	10
		DI2	DI water	water	10
		DI3	DI water	water	10
		stream1	stream water	water	10
		stream2	stream water	water	10
		stream3	stream water	water	10
5/19/2011 Testing for potential natural sediment	5/18/07 8:24	DAV1w	Davidson creek 1	water	10
	5/18/07 8:24	DAV1s	Davidson creek 1	sand	10
	5/18/07 8:58	PATw	Lake Patsy	water	10
	5/18/07 8:58	PATs	Lake Patsy	sand	10
	5/18/07 9:28	NMRCw	N MS Reg Center	water	10
	5/18/07 9:28	NMRCs	N MS Reg Center	sand	10
	5/18/07 10:20	PARw	Paradise Beach	water	10
	5/18/07 10:20	PARs	Paradise Beach	sand	10
	5/18/07 10:38	TCRw	Thompson Creek	water	10
	5/18/07 10:38	TCRs	Thompson Creek	sand	10
	6/7/07 8:52	pre a	mid sand bed	sand	10
	6/7/07 8:52	pre b	mid sand bed	sand	10
	6/7/07 8:52	pre c	mid sand bed	sand	10
	6/7/07 8:52	pre w	us	water	10
	6/7/07 8:59	1	us	water	10
	6/7/07 8:59	2	ds	water	10
	6/7/07 8:59	3	dsd	water	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
6/8/2011 60-min event with TWO 2in pumps	6/7/07 9:04	4	us	water	10
	6/7/07 9:04	5	ds	water	10
	6/7/07 9:04	6	dsd	water	10
	6/7/07 9:09	7	us	water	10
	6/7/07 9:09	8	ds	water	10
	6/7/07 9:09	9	dsd	water	10
	6/7/07 9:14	10	us	water	10
	6/7/07 9:14	11	ds	water	10
	6/7/07 9:14	12	dsd	water	10
	6/7/07 9:17	13	us	water	10
	6/7/07 9:17	14	ds	water	10
	6/7/07 9:17	15	dsd	water	10
	6/7/07 9:20	16	us	water	10
	6/7/07 9:20	17	ds	water	10
	6/7/07 9:20	18	dsd	water	10
	6/7/07 9:24	19	us	water	10
	6/7/07 9:24	20	ds	water	10
	6/7/07 9:24	21	dsd	water	10
	6/7/07 9:29	22	us	water	10
	6/7/07 9:29	23	ds	water	10
	6/7/07 9:29	24	dsd	water	10
	6/7/07 9:37	25	us	water	10
	6/7/07 9:37	26	ds	water	10
	6/7/07 9:37	27	dsd	water	10
	6/7/07 9:45	28	us	water	10
	6/7/07 9:45	29	ds	water	10
	6/7/07 9:45	30	dsd	water	10
	6/7/07 9:47	31	us	water	10
	6/7/07 9:47	32	ds	water	10
	6/7/07 9:47	33	dsd	water	10
	6/7/07 9:49	post a	mid sand bed	sand	10
	6/7/07 9:49	post b	mid sand bed	sand	10
	6/7/07 9:49	post c	mid sand bed	sand	10
	6/7/07 8:59	3F	dsdFiltered	water	10
	6/7/07 9:14	12F	dsdFiltered	water	10
	6/7/07 9:17	15F	dsdFiltered	water	10
	6/7/07 9:20	18F	dsdFiltered	water	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
	6/7/07 9:24	21F	dsdFiltered	water	10
	6/7/07 9:29	24F	dsdFiltered	water	10
	6/7/07 9:37	27F	dsdFiltered	water	10
	6/7/07 9:47	33F	dsdFiltered	water	10
t with THREE 2in pumps	6/14/07 8:33	pond1a	pond by road	water	10
	6/14/07 8:33	pond1b	pond by road	water	10
	6/14/07 8:33	pond1c	pond by road	water	10
	6/14/07 8:35	pond2a	pond up on hill	water	10
	6/14/07 8:35	pond2b	pond up on hill	water	10
	6/14/07 8:35	pond2c	pond up on hill	water	10
	6/14/07 8:28	pipe a	small pipe hill	water	10
	6/14/07 8:28	pipe1b	small pipe hill	water	10
	6/14/07 8:28	pipe1c	small pipe hill	water	10
	6/14/07 8:31	pipe2a	large pipe hill	water	10
	6/14/07 8:31	pipe2b	large pipe hill	water	10
	6/14/07 8:31	pipe2c	large pipe hill	water	10
	6/14/07 8:27	pipe3a	small pipe road	water	10
	6/14/07 8:27	pipe3b	small pipe road	water	10
	6/14/07 8:27	pipe3c	small pipe road	water	10
	6/14/07 8:30	pipe4a	large pipe road	water	10
	6/14/07 8:30	pipe4b	large pipe road	water	10
	6/14/07 8:30	pipe4c	large pipe road	water	10
	6/14/07 9:05	pre a	mid sand bed	sand	100
	6/14/07 9:05	pre b	mid sand bed	sand	100
	6/14/07 9:05	pre c	mid sand bed	sand	100
	6/14/07 10:03	pre w	us	water	10
	6/14/07 10:10	1	us	water	10
	6/14/07 10:10	2	ds	water	10
	6/14/07 10:10	3	dsd	water	10
	6/14/07 10:15	4	us	water	10
	6/14/07 10:15	5	ds	water	10
	6/14/07 10:15	6	dsd	water	10
	6/14/07 10:20	7	us	water	10
	6/14/07 10:20	8	ds	water	10
	6/14/07 10:20	9	dsd	water	10
	6/14/07 10:25	10	us	water	10
	6/14/07 10:25	11	ds	water	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
6/15/2011 60 min event	6/14/07 10:25	12	dsd	water	10
	6/14/07 10:28	13	us	water	10
	6/14/07 10:28	14	ds	water	10
	6/14/07 10:28	15	dsd	water	10
	6/14/07 10:31	16	us	water	10
	6/14/07 10:31	17	ds	water	10
	6/14/07 10:31	18	dsd	water	10
	6/14/07 10:35	19	us	water	10
	6/14/07 10:35	20	ds	water	10
	6/14/07 10:35	21	dsd	water	10
	6/14/07 10:40	22	us	water	10
	6/14/07 10:40	23	ds	water	10
	6/14/07 10:40	24	dsd	water	10
	6/14/07 10:48	25	us	water	10
	6/14/07 10:48	26	ds	water	10
	6/14/07 10:48	27	dsd	water	10
	6/14/07 10:56	28	us	water	10
	6/14/07 10:56	29	ds	water	10
	6/14/07 10:56	30	dsd	water	10
	6/14/07 11:05	31	us	water	10
	6/14/07 11:05	32	ds	water	10
	6/14/07 11:05	33	dsd	water	10
	6/14/07 11:06	post a	mid sand bed	sand	100
	6/14/07 11:06	post b	mid sand bed	sand	100
	6/14/07 11:06	post c	mid sand bed	sand	100
	6/14/07 10:10	3F	dsdFiltered	water	10
	6/14/07 10:25	12F	dsdFiltered	water	10
	6/14/07 10:28	15F	dsdFiltered	water	10
	6/14/07 10:31	18F	dsdFiltered	water	10
	6/14/07 10:35	21F	dsdFiltered	water	10
	6/14/07 10:40	24F	dsdFiltered	water	10
	6/14/07 10:48	27F	dsdFiltered	water	10
	6/14/07 11:05	33F	dsdFiltered	water	10
	6/21/07 9:15	pre a	mid sand bed	sand	10
	6/21/07 9:15	pre b	mid sand bed	sand	10
	6/21/07 9:15	pre c	mid sand bed	sand	10
	6/21/07 9:16	pre w	us	water	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
6/22/2011 60 min event with 4"pump and two 2"pumps	6/21/07 9:24	1	us	water	10
	6/21/07 9:24	2	ds	water	10
	6/21/07 9:24	3	dsd	water	10
	6/21/07 9:29	4	us	water	10
	6/21/07 9:29	5	ds	water	10
	6/21/07 9:29	6	dsd	water	10
	6/21/07 9:34	7	us	water	10
	6/21/07 9:34	8	ds	water	10
	6/21/07 9:34	9	dsd	water	10
	6/21/07 9:39	10	us	water	10
	6/21/07 9:39	11	ds	water	10
	6/21/07 9:39	12	dsd	water	10
	6/21/07 9:42	13	us	water	10
	6/21/07 9:42	14	ds	water	10
	6/21/07 9:42	15	dsd	water	10
	6/21/07 9:45	16	us	water	10
	6/21/07 9:45	17	ds	water	10
	6/21/07 9:45	18	dsd	water	10
	6/21/07 9:49	19	us	water	10
	6/21/07 9:49	20	ds	water	10
	6/21/07 9:49	21	dsd	water	10
	6/21/07 9:54	22	us	water	10
	6/21/07 9:54	23	ds	water	10
	6/21/07 9:54	24	dsd	water	10
	6/21/07 10:00	25	us	water	10
	6/21/07 10:00	26	ds	water	10
	6/21/07 10:00	27	dsd	water	10
	6/21/07 10:10	28	us	water	10
	6/21/07 10:10	29	ds	water	10
	6/21/07 10:10	30	dsd	water	10
	6/21/07 10:19	31	us	water	10
	6/21/07 10:19	32	ds	water	10
	6/21/07 10:19	33	dsd	water	10
	6/21/07 10:21	post a	mid sand bed	sand	10
	6/21/07 10:21	post b	mid sand bed	sand	10
	6/21/07 10:21	post c	mid sand bed	sand	10
	6/21/07 9:24	3F	dsdFiltered	water	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
	6/21/07 9:39	12F	dsdFiltered	water	10
	6/21/07 9:42	15F	dsdFiltered	water	10
	6/21/07 9:45	18F	dsdFiltered	water	10
	6/21/07 9:49	21F	dsdFiltered	water	10
	6/21/07 9:54	24F	dsdFiltered	water	10
	6/21/07 10:00	27F	dsdFiltered	water	10
	6/21/07 10:19	33F	dsdFiltered	water	10
/29/2011 60 min event with fertilizer	6/28/07 8:31	pre a	mid sand bed	sand	10
	6/28/07 8:31	pre b	mid sand bed	sand	10
	6/28/07 8:31	pre c	mid sand bed	sand	10
	6/28/07 8:35	pre w	us	water	10
	6/28/07 8:45	1	us	water	10
	6/28/07 8:45	2	ds	water	10
	6/28/07 8:45	3	dsd	water	10
	6/28/07 8:50	4	us	water	10
	6/28/07 8:50	5	ds	water	10
	6/28/07 8:50	6	dsd	water	10
	6/28/07 8:55	7	us	water	10
	6/28/07 8:55	8	ds	water	10
	6/28/07 8:55	9	dsd	water	10
	6/28/07 9:00	10	us	water	10
	6/28/07 9:00	11	ds	water	10
	6/28/07 9:00	12	dsd	water	10
	6/28/07 9:03	13	us	water	10
	6/28/07 9:03	14	ds	water	10
	6/28/07 9:03	15	dsd	water	10
	6/28/07 9:06	16	us	water	10
	6/28/07 9:06	17	ds	water	10
	6/28/07 9:06	18	dsd	water	10
	6/28/07 9:10	19	us	water	10
	6/28/07 9:10	20	ds	water	10
	6/28/07 9:10	21	dsd	water	10
	6/28/07 9:15	22	us	water	10
	6/28/07 9:15	23	ds	water	10
	6/28/07 9:15	24	dsd	water	10
	6/28/07 9:23	25	us	water	10
	6/28/07 9:23	26	ds	water	10

Event	Date+Time	Sample #	Location	Sample	Dilution factor for bacteria analysis
6	6/28/07 9:23	27	dsd	water	10
	6/28/07 9:31	28	us	water	10
	6/28/07 9:31	29	ds	water	10
	6/28/07 9:31	30	dsd	water	10
	6/28/07 9:40	31	us	water	10
	6/28/07 9:40	32	ds	water	10
	6/28/07 9:40	33	dsd	water	10
	6/28/07 9:42	post a	mid sand bed	sand	10
	6/28/07 9:42	post b	mid sand bed	sand	10
	6/28/07 9:42	post c	mid sand bed	sand	10
	6/28/07 8:45	3F	dsdFiltered	water	10
	6/28/07 8:55	9F	dsdFiltered	water	10
	6/28/07 9:00	12F	dsdFiltered	water	10
	6/28/07 9:03	15F	dsdFiltered	water	10
	6/28/07 9:06	18F	dsdFiltered	water	10
	6/28/07 9:10	21F	dsdFiltered	water	10
	6/28/07 9:15	24F	dsdFiltered	water	10
	6/28/07 9:40	33F	dsdFiltered	water	10

Appendix A-1: Water Quality Data

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
11/09/2010 Coliform already present?	11/8/06 13:58		49	18	3075.9
	11/8/06 13:58		49	17	2909.3
	11/8/06 13:59		49	21	3654
	11/8/06 13:59		49	18	3075.9
	11/8/06 13:59		49	15	2612.5
	11/8/06 13:59		49	24	4351.7
	11/8/06 13:24		43	4	989.5
	11/8/06 13:25		49	21	3654
2/17/2011 obervations and sampling	2/16/07 9:18		49	33	7269.9
	2/16/07 9:19		49	28	5475
	2/16/07 9:21		49	32	6866.7
	2/16/07 9:23		49	41	12033.3
	2/16/07 9:22		49	43	14136.1
2/24/2011 added 400 lbs of sand and sampled	2/23/07 10:13		49	38	9803.9
	2/23/07 10:21		0	0	<10
	2/23/07 10:21		0	0	<10
	2/23/07 10:21		1	0	10
	2/23/07 10:32		49	41	12033.3
	2/23/07 10:35		49	43	14136.1
	2/23/07 10:38		49	47	24195.7
	2/23/07 11:01		30	3	487.4
	2/23/07 11:01		18	4	268.6
	2/23/07 11:01		16	2	213.3
	3/14/07 9:17	1	49	31	6488.2
	3/14/07 9:24	2	49	39	10462.4
	3/14/07 9:24	3	49	33	7269.9
	3/14/07 9:29	4	49	33	7269.9
	3/14/07 9:29	5	49	28	5475
	3/14/07 9:34	6	49	30	6131.4
	3/14/07 9:34	7	49	31	6488.2
	3/14/07 9:39	8	49	24	4351.7
	3/14/07 9:39	9	49	26	4884.4
	3/14/07 9:44	10	49	22	3873.2
	3/14/07 9:44	11	49	12	2246.8
	3/14/07 9:49	12	49	15	2612.5

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
3/15/2011 90 minute HIGH flow event	3/14/07 9:49	13	49	14	2480.9
	3/14/07 9:59	14	49	10	2045.9
	3/14/07 9:59	15	48	14	2098.2
	3/14/07 10:19	16	49	14	2480.9
	3/14/07 10:19	17	49	15	2612.5
	3/14/07 10:39	18	48	17	2382.2
	3/14/07 10:39	19	49	15	2612.5
	3/14/07 10:49	20	48	18	2489
	3/14/07 10:49	21	47	11	1664
	3/14/07 9:17	1F	49	23	4105.8
	3/14/07 9:24	2F	49	19	3255.4
	3/14/07 9:24	3F	49	20	3448
	3/14/07 9:29	4F	48	13	2014.2
	3/14/07 9:29	5F	46	14	1669.5
	3/14/07 9:34	6F	49	25	4611.1
	3/14/07 9:34	7F	49	23	4105.8
	3/14/07 9:39	8F	49	19	3255.4
	3/14/07 9:39	9F	48	15	2187.2
	3/14/07 9:44	10F	47	10	1607.1
	3/14/07 9:44	11F	41	11	1071.2
	3/14/07 9:49	12F	40	12	1039.4
	3/14/07 9:49	13F	42	11	1137
	3/14/07 9:59	14F	49	16	2755.1
	3/14/07 9:59	15F	49	13	2359.3
	3/14/07 10:19	16F	49	11	2142.6
	3/14/07 10:19	17F	49	11	2142.6
	3/14/07 10:39	18F	49	13	2359.3
	3/14/07 10:39	19F	49	12	2246.8
	3/14/07 10:49	20F	44	12	1334.4
	3/14/07 10:49	21F	38	5	771.2
	3/14/07 9:55	22a	26	0	354.6
	3/14/07 9:55	22b	27	2	404.4
	3/14/07 9:55	22c	20	3	288.2
	3/14/07 10:51	23a	20	2	275.1
	3/14/07 10:51	23b	12	5	192.6
	3/14/07 10:51	23c	14	2	184.9
	4/11/07 9:03	sand1a	11	0	122.3

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
4/12/2011 90 minute MEDIUM flow event	4/11/07 9:03	sand1b	12	1	146.4
	4/11/07 9:04	sand2a	15	0	174.9
	4/11/07 9:04	sand2b	16	1	201.1
	4/11/07 9:05	sand3a	12	0	135
	4/11/07 9:05	sand3b	15	1	186.9
	4/11/07 9:10	pond1	49	31	6488.2
	4/11/07 9:13	pond2	43	9	1144.6
	4/11/07 9:17	1	49	38	9803.9
	4/11/07 9:28	2	49	38	9803.9
	4/11/07 9:28	3	49	35	8164.1
	4/11/07 9:33	4	49	28	5475
	4/11/07 9:33	5	49	34	7701
	4/11/07 9:38	6	49	39	10462.4
	4/11/07 9:38	7	49	36	8664.4
	4/11/07 9:43	8	49	27	5172.1
	4/11/07 9:43	9	49	37	9208.4
	4/11/07 9:48	10	49	39	10462.4
	4/11/07 9:48	11	49	36	8664.4
	4/11/07 9:53	12	49	32	6866.7
	4/11/07 9:53	13	49	36	8664.4
	4/11/07 9:58	14	49	30	6131.4
	4/11/07 9:58	15	49	29	5794.3
	4/11/07 10:01	16	49	33	7269.9
	4/11/07 10:01	17	49	30	6131.4
	4/11/07 10:08	18	49	26	4884.4
	4/11/07 10:08	19	49	24	4351.7
	4/11/07 10:23	20	49	27	5172.1
	4/11/07 10:23	21	49	20	3448
	4/11/07 10:33	22	49	18	3075.9
	4/11/07 10:33	23	49	23	4105.8
	4/11/07 10:43	24	49	24	4351.7
	4/11/07 10:43	25	49	23	4105.8
	4/11/07 10:53	26	49	20	3448
	4/11/07 10:53	27	49	23	4105.8
	4/11/07 10:54	sand4a	38	3	727.3
	4/11/07 10:54	sand4b	30	3	487.4
	4/11/07 10:54	sand4c	29	3	463.8

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
	4/11/07 9:28	2F	49	37	9208.4
	4/11/07 9:28	3F	49	38	9803.9
	4/11/07 9:58	14F	48	21	2851
	4/11/07 9:58	15F	48	23	3130.1
	4/11/07 10:01	16F	49	19	3255.4
	4/11/07 10:01	17F	48	20	2723
	4/11/07 10:53	26F	49	20	3448
	4/11/07 10:53	27F	48	11	1860
5/5/2011 Coliform resuspension lab experiment	5/4/07 9:26	water1	49	16	2755.1
	5/4/07 9:26	water2	49	13	2359.3
	5/4/07 9:26	water3	49	9	1955.9
	5/4/07 9:28	sand1	15	1	186.9
	5/4/07 9:28	sand2	14	2	184.9
	5/4/07 9:28	sand3	22	1	295.4
		DI1	14	1	173.1
		DI2	34	4	612.7
		DI3	38	7	816.2
		stream1	49	19	3255.4
		stream2	48	17	2382.2
		stream3	49	37	9208.4
5/19/2011 Testing for potential natural sediment	5/18/07 8:24	DAV1w	49	47	24195.7
	5/18/07 8:24	DAV1s	49	44	15531.2
	5/18/07 8:58	PATw	49	15	2612.5
	5/18/07 8:58	PATs	49	48	>24196
	5/18/07 9:28	NMRCw	49	27	5172.1
	5/18/07 9:28	NMRCs	49	47	24195.7
	5/18/07 10:20	PARw	49	19	3255.4
	5/18/07 10:20	PARs	49	37	9208.4
	5/18/07 10:38	TCRw	49	39	10462.4
	5/18/07 10:38	TCRs	49	31	6488.2
	6/7/07 8:52	pre a	46	11	1515.2
	6/7/07 8:52	pre b	47	11	1664
	6/7/07 8:52	pre c	47	11	1664
	6/7/07 8:52	pre w	49	33	7269.9
	6/7/07 8:59	1	49	36	8664.4
	6/7/07 8:59	2	49	37	9208.4
	6/7/07 8:59	3	49	36	8664.4

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
6/8/2011 60-min event with TWO 2in pumps	6/7/07 9:04	4	49	34	7701
	6/7/07 9:04	5	49	35	8164.1
	6/7/07 9:04	6	49	31	6488.2
	6/7/07 9:09	7	49	30	6131.4
	6/7/07 9:09	8	49	34	7701
	6/7/07 9:09	9	49	28	5475
	6/7/07 9:14	10	48	24	3281.5
	6/7/07 9:14	11	49	28	5475
	6/7/07 9:14	12	49	30	6131.4
	6/7/07 9:17	13	49	35	8164.1
	6/7/07 9:17	14	49	30	6131.4
	6/7/07 9:17	15	49	26	4884.4
	6/7/07 9:20	16	49	35	8164.1
	6/7/07 9:20	17	49	32	6866.7
	6/7/07 9:20	18	49	32	6866.7
	6/7/07 9:24	19	49	32	6866.7
	6/7/07 9:24	20	49	31	6488.2
	6/7/07 9:24	21	49	31	6488.2
	6/7/07 9:29	22	49	27	5172.1
	6/7/07 9:29	23	49	25	4611.1
	6/7/07 9:29	24	49	25	4611.1
	6/7/07 9:37	25	49	24	4351.7
	6/7/07 9:37	26	49	27	5172.1
	6/7/07 9:37	27	49	24	4351.7
	6/7/07 9:45	28	49	18	3075.9
	6/7/07 9:45	29	49	23	4105.8
	6/7/07 9:45	30	49	20	3448
	6/7/07 9:47	31	49	26	4884.4
	6/7/07 9:47	32	49	24	4351.7
	6/7/07 9:47	33	49	24	4351.7
	6/7/07 9:49	post a	41	9	1014.4
	6/7/07 9:49	post b	42	7	1016.8
	6/7/07 9:49	post c	41	6	932.6
	6/7/07 8:59	3F	49	26	4884.4
	6/7/07 9:14	12F	48	20	2723
	6/7/07 9:17	15F	49	18	3075.9
	6/7/07 9:20	18F	49	29	5794.3

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
	6/7/07 9:24	21F	49	21	3654
	6/7/07 9:29	24F	49	20	3448
	6/7/07 9:37	27F	49	24	4351.7
	6/7/07 9:47	33F	49	20	3448
t with THREE 2in pumps	6/14/07 8:33	pond1a	49	43	14136.1
	6/14/07 8:33	pond1b	49	45	17328.9
	6/14/07 8:33	pond1c	49	40	11198.7
	6/14/07 8:35	pond2a	49	14	2480.9
	6/14/07 8:35	pond2b	49	14	2480.9
	6/14/07 8:35	pond2c	49	11	2142.6
	6/14/07 8:28	pipe a	24	2	345.1
	6/14/07 8:28	pipe1b	21	5	331.9
	6/14/07 8:28	pipe1c	17	1	215.7
	6/14/07 8:31	pipe2a	49	36	8664.4
	6/14/07 8:31	pipe2b	49	31	6488.2
	6/14/07 8:31	pipe2c	49	22	3873.2
	6/14/07 8:27	pipe3a	49	36	8664.4
	6/14/07 8:27	pipe3b	49	44	15531.2
	6/14/07 8:27	pipe3c	49	34	7701
	6/14/07 8:30	pipe4a	49	37	9208.4
	6/14/07 8:30	pipe4b	49	44	15531.2
	6/14/07 8:30	pipe4c	49	38	9803.9
	6/14/07 9:05	pre a	34	7	6695
	6/14/07 9:05	pre b	25	7	4371
	6/14/07 9:05	pre c	36	5	6968
	6/14/07 10:03	pre w	49	32	6866.7
	6/14/07 10:10	1	49	34	7701
	6/14/07 10:10	2	49	32	6866.7
	6/14/07 10:10	3	49	32	6866.7
	6/14/07 10:15	4	49	33	7269.9
	6/14/07 10:15	5	49	34	7701
	6/14/07 10:15	6	49	33	7269.9
	6/14/07 10:20	7	49	30	6131.4
	6/14/07 10:20	8	49	28	5475
	6/14/07 10:20	9	49	35	8164.1
	6/14/07 10:25	10	49	27	5172.1
	6/14/07 10:25	11	49	29	5794.3

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
6/15/2011 60 min event	6/14/07 10:25	12	49	36	8664.4
	6/14/07 10:28	13	49	28	5475
	6/14/07 10:28	14	49	28	5475
	6/14/07 10:28	15	49	32	6866.7
	6/14/07 10:31	16	49	31	6488.2
	6/14/07 10:31	17	49	34	7701
	6/14/07 10:31	18	49	32	6866.7
	6/14/07 10:35	19	49	31	6488.2
	6/14/07 10:35	20	49	33	7269.9
	6/14/07 10:35	21	49	30	6131.4
	6/14/07 10:40	22	49	28	5475
	6/14/07 10:40	23	49	23	4105.8
	6/14/07 10:40	24	49	21	3654
	6/14/07 10:48	25	49	24	4351.7
	6/14/07 10:48	26	49	19	3255.4
	6/14/07 10:48	27	49	18	3075.9
	6/14/07 10:56	28	49	18	3075.9
	6/14/07 10:56	29	49	22	3873.2
	6/14/07 10:56	30	49	19	3255.4
	6/14/07 11:05	31	48	17	2382.2
	6/14/07 11:05	32	49	15	2612.5
	6/14/07 11:05	33	48	16	2281.8
	6/14/07 11:06	post a	8	0	860
	6/14/07 11:06	post b	16	0	1890
	6/14/07 11:06	post c	12	2	1579
	6/14/07 10:10	3F	49	24	4351.7
	6/14/07 10:25	12F	49	21	3654
	6/14/07 10:28	15F	49	26	4884.4
	6/14/07 10:31	18F	49	30	6131.4
	6/14/07 10:35	21F	49	24	4351.7
	6/14/07 10:40	24F	49	22	3873.2
	6/14/07 10:48	27F	44	7	1152.8
	6/14/07 11:05	33F	44	8	1187.4
	6/21/07 9:15	pre a	49	14	2480.9
	6/21/07 9:15	pre b	48	22	2986.6
	6/21/07 9:15	pre c	49	14	2480.9
	6/21/07 9:16	pre w	49	34	7701

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
6/22/2011 60 min event with 4"pump and two 2"pumps	6/21/07 9:24	1	49	41	12033.3
	6/21/07 9:24	2	49	33	7269.9
	6/21/07 9:24	3	49	33	7269.9
	6/21/07 9:29	4	49	33	7269.9
	6/21/07 9:29	5	49	35	8164.1
	6/21/07 9:29	6	49	38	9803.9
	6/21/07 9:34	7	49	42	12996.5
	6/21/07 9:34	8	49	42	12996.5
	6/21/07 9:34	9	49	47	24195.7
	6/21/07 9:39	10	49	32	6866.7
	6/21/07 9:39	11	49	39	10462.4
	6/21/07 9:39	12	49	39	10462.4
	6/21/07 9:42	13	49	39	10462.4
	6/21/07 9:42	14	49	36	8664.4
	6/21/07 9:42	15	49	32	6866.7
	6/21/07 9:45	16	49	45	17328.9
	6/21/07 9:45	17	49	33	7269.9
	6/21/07 9:45	18	49	37	9208.4
	6/21/07 9:49	19	49	37	9208.4
	6/21/07 9:49	20	49	38	9803.9
	6/21/07 9:49	21	49	32	6866.7
	6/21/07 9:54	22	49	40	11198.7
	6/21/07 9:54	23	49	34	7701
	6/21/07 9:54	24	49	34	7701
	6/21/07 10:00	25	49	40	11198.7
	6/21/07 10:00	26	49	39	10462.4
	6/21/07 10:00	27	49	38	9803.9
	6/21/07 10:10	28	49	28	5475
	6/21/07 10:10	29	49	30	6131.4
	6/21/07 10:10	30	49	32	6866.7
	6/21/07 10:19	31	49	34	7701
	6/21/07 10:19	32	49	30	6131.4
	6/21/07 10:19	33	49	36	8664.4
	6/21/07 10:21	post a	37	2	670.1
	6/21/07 10:21	post b	24	1	331
	6/21/07 10:21	post c	25	4	393.1
	6/21/07 9:24	3F	49	18	3075.9

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
	6/21/07 9:39	12F	49	23	4105.8
	6/21/07 9:42	15F	49	26	4884.4
	6/21/07 9:45	18F	49	19	3255.4
	6/21/07 9:49	21F	49	32	6866.7
	6/21/07 9:54	24F	49	25	4611.1
	6/21/07 10:00	27F	49	26	4884.4
	6/21/07 10:19	33F	49	19	3255.4
5/29/2011 60 min event with fertilizer	6/28/07 8:31	pre a	49	48	>24196
	6/28/07 8:31	pre b	49	47	24195.7
	6/28/07 8:31	pre c	49	48	>24196
	6/28/07 8:35	pre w	49	39	10462.4
	6/28/07 8:45	1	49	41	12033.3
	6/28/07 8:45	2	49	43	14136.1
	6/28/07 8:45	3	49	43	14136.1
	6/28/07 8:50	4	49	43	14136.1
	6/28/07 8:50	5	49	46	19862.9
	6/28/07 8:50	6	49	43	14136.1
	6/28/07 8:55	7	49	32	6866.7
	6/28/07 8:55	8	49	39	10462.4
	6/28/07 8:55	9	49	42	12996.5
	6/28/07 9:00	10	49	34	7701
	6/28/07 9:00	11	49	48	>24196
	6/28/07 9:00	12	49	48	>24196
	6/28/07 9:03	13	49	36	8664.4
	6/28/07 9:03	14	49	45	17328.9
	6/28/07 9:03	15	49	42	12996.5
	6/28/07 9:06	16	49	39	10462.4
	6/28/07 9:06	17	49	40	11198.7
	6/28/07 9:06	18	49	44	15531.2
	6/28/07 9:10	19	49	36	8664.4
	6/28/07 9:10	20	49	41	12033.3
	6/28/07 9:10	21	49	42	12996.5
	6/28/07 9:15	22	49	35	8164.1
	6/28/07 9:15	23	49	40	11198.7
	6/28/07 9:15	24	49	43	14136.1
	6/28/07 9:23	25	49	35	8164.1
	6/28/07 9:23	26	49	37	9208.4

Event	Date+Time	Sample #	Total Coliform large wells	Total Coliform small wells	Total Coliform (MPN/100 mL)
6	6/28/07 9:23	27	49	35	8164.1
	6/28/07 9:31	28	49	22	3873.2
	6/28/07 9:31	29	49	29	5794.3
	6/28/07 9:31	30	49	31	6488.2
	6/28/07 9:40	31	49	25	4611.1
	6/28/07 9:40	32	49	18	3075.9
	6/28/07 9:40	33	49	21	3654
	6/28/07 9:42	post a	49	48	>24196
	6/28/07 9:42	post b	49	48	>24196
	6/28/07 9:42	post c	49	48	>24196
	6/28/07 8:45	3F	49	43	14136.1
	6/28/07 8:55	9F	49	33	7269.9
	6/28/07 9:00	12F	49	46	19862.9
	6/28/07 9:03	15F	49	43	14136.1
	6/28/07 9:06	18F	49	41	12033.3
	6/28/07 9:10	21F	49	36	8664.4
	6/28/07 9:15	24F	49	26	4884.4
	6/28/07 9:40	33F	47	15	1917.9

Appendix A-1: Water Quality Data

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
11/09/2010 Coliform already present?	11/8/06 13:58		3075.9	3.49	7	1
	11/8/06 13:58		2909.3	3.46	6	0
	11/8/06 13:59		3654.0	3.56	6	1
	11/8/06 13:59		3075.9	3.49	5	2
	11/8/06 13:59		2612.5	3.42	4	1
	11/8/06 13:59		4351.7	3.64	5	1
	11/8/06 13:24		9897.0	4.00	1	0
	11/8/06 13:25		36547.3	4.56	11	0
2/17/2011 obervations and sampling	2/16/07 9:18		7269.9	3.86	32	5
	2/16/07 9:19		5475.0	3.74	12	0
	2/16/07 9:21		6866.7	3.84	14	0
	2/16/07 9:23		12033.3	4.08	6	0
	2/16/07 9:22		14136.1	4.15	12	3
2/24/2011 added 400 lbs of sand and sampled	2/23/07 10:13		9803.9	3.99	36	4
	2/23/07 10:21		<100.6	<2.00	0	0
	2/23/07 10:21		<100.6	<2.00	0	0
	2/23/07 10:21		100.6	2.00	0	0
	2/23/07 10:32		12033.3	4.08	29	7
	2/23/07 10:35		14136.1	4.15	35	5
	2/23/07 10:38		24195.7	4.38	30	5
	2/23/07 11:01		6325.0	3.80	1	0
	2/23/07 11:01		3485.6	3.54	2	0
	2/23/07 11:01		2768.0	3.44	0	0
	3/14/07 9:17	1	6488.2	3.81	0	0
	3/14/07 9:24	2	10462.4	4.02	7	1
	3/14/07 9:24	3	7269.9	3.86	1	0
	3/14/07 9:29	4	7269.9	3.86	4	0
	3/14/07 9:29	5	5475.0	3.74	4	0
	3/14/07 9:34	6	6131.4	3.79	6	0
	3/14/07 9:34	7	6488.2	3.81	4	0
	3/14/07 9:39	8	4351.7	3.64	7	0
	3/14/07 9:39	9	4884.4	3.69	3	0
	3/14/07 9:44	10	3873.2	3.59	2	0
	3/14/07 9:44	11	2246.8	3.35	1	0
	3/14/07 9:49	12	2612.5	3.42	3	0

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
3/15/2011 90 minute HIGH flow event	3/14/07 9:49	13	**2480.9**	**3.39**	5	0
	3/14/07 9:59	14	**2045.9**	**3.31**	3	0
	3/14/07 9:59	15	**2098.2**	**3.32**	3	0
	3/14/07 10:19	16	**2480.9**	**3.39**	2	0
	3/14/07 10:19	17	**2612.5**	**3.42**	1	0
	3/14/07 10:39	18	**2382.2**	**3.38**	6	0
	3/14/07 10:39	19	**2612.5**	**3.42**	2	0
	3/14/07 10:49	20	**2489.0**	**3.40**	2	0
	3/14/07 10:49	21	**1664.0**	**3.22**	3	0
	3/14/07 9:17	1F	**4105.8**	**3.61**	7	1
	3/14/07 9:24	2F	**3255.4**	**3.51**	6	2
	3/14/07 9:24	3F	**3448.0**	**3.54**	5	1
	3/14/07 9:29	4F	**2014.2**	**3.30**	7	0
	3/14/07 9:29	5F	**1669.5**	**3.22**	7	0
	3/14/07 9:34	6F	**4611.1**	**3.66**	3	0
	3/14/07 9:34	7F	**4105.8**	**3.61**	0	0
	3/14/07 9:39	8F	**3255.4**	**3.51**	6	0
	3/14/07 9:39	9F	**2187.2**	**3.34**	5	0
	3/14/07 9:44	10F	**1607.1**	**3.21**	2	0
	3/14/07 9:44	11F	**1071.2**	**3.03**	0	0
	3/14/07 9:49	12F	**1039.4**	**3.02**	1	0
	3/14/07 9:49	13F	**1137.0**	**3.06**	3	0
	3/14/07 9:59	14F	**2755.1**	**3.44**	2	0
	3/14/07 9:59	15F	**2359.3**	**3.37**	3	0
	3/14/07 10:19	16F	**2142.6**	**3.33**	2	0
	3/14/07 10:19	17F	**2142.6**	**3.33**	1	0
	3/14/07 10:39	18F	**2359.3**	**3.37**	3	0
	3/14/07 10:39	19F	**2246.8**	**3.35**	1	0
	3/14/07 10:49	20F	**1334.4**	**3.13**	3	0
	3/14/07 10:49	21F	**771.2**	**2.89**	2	0
	3/14/07 9:55	22a	**4607.7**	**3.66**	2	0
	3/14/07 9:55	22b	**5254.8**	**3.72**	1	0
	3/14/07 9:55	22c	**3744.9**	**3.57**	0	0
	3/14/07 10:51	23a	**3525.8**	**3.55**	1	0
	3/14/07 10:51	23b	**2468.5**	**3.39**	1	0
	3/14/07 10:51	23c	**2369.8**	**3.37**	0	1
	4/11/07 9:03	sand1a	**1580.8**	**3.20**	0	0

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
4/12/2011 90 minute MEDIUM flow event	4/11/07 9:03	sand1b	**1892.3**	**3.28**	0	0
	4/11/07 9:04	sand2a	**2266.0**	**3.36**	0	0
	4/11/07 9:04	sand2b	**2605.4**	**3.42**	0	0
	4/11/07 9:05	sand3a	**1741.5**	**3.24**	0	0
	4/11/07 9:05	sand3b	**2411.0**	**3.38**	0	0
	4/11/07 9:10	pond1	**6488.2**	**3.81**	9	2
	4/11/07 9:13	pond2	**1144.6**	**3.06**	0	0
	4/11/07 9:17	1	**9803.9**	**3.99**	12	1
	4/11/07 9:28	2	**9803.9**	**3.99**	12	0
	4/11/07 9:28	3	**8164.1**	**3.91**	14	2
	4/11/07 9:33	4	**5475.0**	**3.74**	11	2
	4/11/07 9:33	5	**7701.0**	**3.89**	13	0
	4/11/07 9:38	6	**10462.4**	**4.02**	12	0
	4/11/07 9:38	7	**8664.4**	**3.94**	11	0
	4/11/07 9:43	8	**5172.1**	**3.71**	10	0
	4/11/07 9:43	9	**9208.4**	**3.96**	10	1
	4/11/07 9:48	10	**10462.4**	**4.02**	3	1
	4/11/07 9:48	11	**8664.4**	**3.94**	8	1
	4/11/07 9:53	12	**6866.7**	**3.84**	6	0
	4/11/07 9:53	13	**8664.4**	**3.94**	6	2
	4/11/07 9:58	14	**6131.4**	**3.79**	7	0
	4/11/07 9:58	15	**5794.3**	**3.76**	9	0
	4/11/07 10:01	16	**7269.9**	**3.86**	7	0
	4/11/07 10:01	17	**6131.4**	**3.79**	5	1
	4/11/07 10:08	18	**4884.4**	**3.69**	6	1
	4/11/07 10:08	19	**4351.7**	**3.64**	10	1
	4/11/07 10:23	20	**5172.1**	**3.71**	6	0
	4/11/07 10:23	21	**3448.0**	**3.54**	6	1
	4/11/07 10:33	22	**3075.9**	**3.49**	4	0
	4/11/07 10:33	23	**4105.8**	**3.61**	6	0
	4/11/07 10:43	24	**4351.7**	**3.64**	9	3
	4/11/07 10:43	25	**4105.8**	**3.61**	5	1
	4/11/07 10:53	26	**3448.0**	**3.54**	11	1
	4/11/07 10:53	27	**4105.8**	**3.61**	9	1
	4/11/07 10:54	sand4a	**9453.7**	**3.98**	0	0
	4/11/07 10:54	sand4b	**6335.4**	**3.80**	0	0
	4/11/07 10:54	sand4c	**6028.6**	**3.78**	0	0

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
	4/11/07 9:28	2F	**9208.4**	**3.96**	14	1
	4/11/07 9:28	3F	**9803.9**	**3.99**	11	3
	4/11/07 9:58	14F	**2851.0**	**3.45**	6	1
	4/11/07 9:58	15F	**3130.1**	**3.50**	5	0
	4/11/07 10:01	16F	**3255.4**	**3.51**	6	0
	4/11/07 10:01	17F	**2723.0**	**3.44**	8	0
	4/11/07 10:53	26F	**3448.0**	**3.54**	8	1
	4/11/07 10:53	27F	**1860.0**	**3.27**	8	1
5/5/2011 Coliform resuspension lab experiment	5/4/07 9:26	water1	**2755.1**	**3.44**	0	0
	5/4/07 9:26	water2	**2359.3**	**3.37**	0	0
	5/4/07 9:26	water3	**1955.9**	**3.29**	0	0
	5/4/07 9:28	sand1	**2315.3**	**3.36**	0	0
	5/4/07 9:28	sand2	**2290.5**	**3.36**	0	0
	5/4/07 9:28	sand3	**3659.3**	**3.56**	0	0
		DI1	**173.1**	**2.24**	0	0
		DI2	**612.7**	**2.79**	0	0
		DI3	**816.2**	**2.91**	0	0
		stream1	**3255.4**	**3.51**	0	0
		stream2	**2382.2**	**3.38**	0	0
		stream3	**9208.4**	**3.96**	0	0
5/19/2011 Testing for potential natural sediment	5/18/07 8:24	DAV1w	**24195.7**	**4.38**	27	5
	5/18/07 8:24	DAV1s	**206049.2**	**5.31**	27	2
	5/18/07 8:58	PATw	**2612.5**	**3.42**	0	0
	5/18/07 8:58	PATs	**>317585.6**	**>5.50**	49	26
	5/18/07 9:28	NMRCw	**5172.1**	**3.71**	21	2
	5/18/07 9:28	NMRCs	**323184.2**	**5.51**	24	2
	5/18/07 10:20	PARw	**3255.4**	**3.51**	0	0
	5/18/07 10:20	PARs	**115307.0**	**5.06**	13	1
	5/18/07 10:38	TCRw	**10462.4**	**4.02**	49	21
	5/18/07 10:38	TCRs	**80551.6**	**4.91**	8	1
	6/7/07 8:52	pre a	**19680.6**	**4.29**	4	2
	6/7/07 8:52	pre b	**21613.3**	**4.33**	4	1
	6/7/07 8:52	pre c	**21613.3**	**4.33**	8	0
	6/7/07 8:52	pre w	**7269.9**	**3.86**	40	2
	6/7/07 8:59	1	**8664.4**	**3.94**	37	11
	6/7/07 8:59	2	**9208.4**	**3.96**	41	3
	6/7/07 8:59	3	**8664.4**	**3.94**	33	7

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
6/8/2011 60-min event with TWO 2in pumps	6/7/07 9:04	4	**7701.0**	**3.89**	21	0
	6/7/07 9:04	5	**8164.1**	**3.91**	27	3
	6/7/07 9:04	6	**6488.2**	**3.81**	27	6
	6/7/07 9:09	7	**6131.4**	**3.79**	8	2
	6/7/07 9:09	8	**7701.0**	**3.89**	6	0
	6/7/07 9:09	9	**5475.0**	**3.74**	10	1
	6/7/07 9:14	10	**3281.5**	**3.52**	4	1
	6/7/07 9:14	11	**5475.0**	**3.74**	2	1
	6/7/07 9:14	12	**6131.4**	**3.79**	2	0
	6/7/07 9:17	13	**8164.1**	**3.91**	8	0
	6/7/07 9:17	14	**6131.4**	**3.79**	0	2
	6/7/07 9:17	15	**4884.4**	**3.69**	4	3
	6/7/07 9:20	16	**8164.1**	**3.91**	0	2
	6/7/07 9:20	17	**6866.7**	**3.84**	5	0
	6/7/07 9:20	18	**6866.7**	**3.84**	7	0
	6/7/07 9:24	19	**6866.7**	**3.84**	4	1
	6/7/07 9:24	20	**6488.2**	**3.81**	0	0
	6/7/07 9:24	21	**6488.2**	**3.81**	3	0
	6/7/07 9:29	22	**5172.1**	**3.71**	5	0
	6/7/07 9:29	23	**4611.1**	**3.66**	2	0
	6/7/07 9:29	24	**4611.1**	**3.66**	3	0
	6/7/07 9:37	25	**4351.7**	**3.64**	3	0
	6/7/07 9:37	26	**5172.1**	**3.71**	4	1
	6/7/07 9:37	27	**4351.7**	**3.64**	2	0
	6/7/07 9:45	28	**3075.9**	**3.49**	1	0
	6/7/07 9:45	29	**4105.8**	**3.61**	2	0
	6/7/07 9:45	30	**3448.0**	**3.54**	3	0
	6/7/07 9:47	31	**4884.4**	**3.69**	1	0
	6/7/07 9:47	32	**4351.7**	**3.64**	2	0
	6/7/07 9:47	33	**4351.7**	**3.64**	0	0
	6/7/07 9:49	post a	**12862.3**	**4.11**	6	0
	6/7/07 9:49	post b	**12892.8**	**4.11**	8	0
	6/7/07 9:49	post c	**11825.1**	**4.07**	2	0
	6/7/07 8:59	3F	**4884.4**	**3.69**	40	4
	6/7/07 9:14	12F	**2723.0**	**3.44**	7	0
	6/7/07 9:17	15F	**3075.9**	**3.49**	6	0
	6/7/07 9:20	18F	**5794.3**	**3.76**	1	0

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
	6/7/07 9:24	21F	**3654.0**	**3.56**	2	1
	6/7/07 9:29	24F	**3448.0**	**3.54**	4	0
	6/7/07 9:37	27F	**4351.7**	**3.64**	3	0
	6/7/07 9:47	33F	**3448.0**	**3.54**	1	0
t with THREE 2in pumps	6/14/07 8:33	pond1a	**14136.1**	**4.15**	1	0
	6/14/07 8:33	pond1b	**17328.9**	**4.24**	5	0
	6/14/07 8:33	pond1c	**11198.7**	**4.05**	2	0
	6/14/07 8:35	pond2a	**2480.9**	**3.39**	0	0
	6/14/07 8:35	pond2b	**2480.9**	**3.39**	0	0
	6/14/07 8:35	pond2c	**2142.6**	**3.33**	0	0
	6/14/07 8:28	pipe a	**345.1**	**2.54**	0	0
	6/14/07 8:28	pipe1b	**331.9**	**2.52**	0	0
	6/14/07 8:28	pipe1c	**215.7**	**2.33**	0	0
	6/14/07 8:31	pipe2a	**8664.4**	**3.94**	0	0
	6/14/07 8:31	pipe2b	**6488.2**	**3.81**	0	0
	6/14/07 8:31	pipe2c	**3873.2**	**3.59**	0	0
	6/14/07 8:27	pipe3a	**8664.4**	**3.94**	2	0
	6/14/07 8:27	pipe3b	**15531.2**	**4.19**	1	1
	6/14/07 8:27	pipe3c	**7701.0**	**3.89**	0	0
	6/14/07 8:30	pipe4a	**9208.4**	**3.96**	1	0
	6/14/07 8:30	pipe4b	**15531.2**	**4.19**	1	0
	6/14/07 8:30	pipe4c	**9803.9**	**3.99**	2	0
	6/14/07 9:05	pre a	**87961.1**	**4.94**	0	0
	6/14/07 9:05	pre b	**57427.6**	**4.76**	1	0
	6/14/07 9:05	pre c	**91547.9**	**4.96**	0	0
	6/14/07 10:03	pre w	**6866.7**	**3.84**	2	0
	6/14/07 10:10	1	**7701.0**	**3.89**	3	1
	6/14/07 10:10	2	**6866.7**	**3.84**	6	0
	6/14/07 10:10	3	**6866.7**	**3.84**	0	0
	6/14/07 10:15	4	**7269.9**	**3.86**	5	1
	6/14/07 10:15	5	**7701.0**	**3.89**	4	0
	6/14/07 10:15	6	**7269.9**	**3.86**	7	1
	6/14/07 10:20	7	**6131.4**	**3.79**	3	0
	6/14/07 10:20	8	**5475.0**	**3.74**	3	0
	6/14/07 10:20	9	**8164.1**	**3.91**	4	0
	6/14/07 10:25	10	**5172.1**	**3.71**	4	0
	6/14/07 10:25	11	**5794.3**	**3.76**	3	2

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
6/15/2011 60 min event	6/14/07 10:25	12	**8664.4**	**3.94**	4	0
	6/14/07 10:28	13	**5475.0**	**3.74**	2	0
	6/14/07 10:28	14	**5475.0**	**3.74**	3	0
	6/14/07 10:28	15	**6866.7**	**3.84**	1	0
	6/14/07 10:31	16	**6488.2**	**3.81**	5	0
	6/14/07 10:31	17	**7701.0**	**3.89**	4	0
	6/14/07 10:31	18	**6866.7**	**3.84**	3	0
	6/14/07 10:35	19	**6488.2**	**3.81**	4	1
	6/14/07 10:35	20	**7269.9**	**3.86**	0	1
	6/14/07 10:35	21	**6131.4**	**3.79**	1	0
	6/14/07 10:40	22	**5475.0**	**3.74**	1	0
	6/14/07 10:40	23	**4105.8**	**3.61**	3	0
	6/14/07 10:40	24	**3654.0**	**3.56**	2	0
	6/14/07 10:48	25	**4351.7**	**3.64**	1	0
	6/14/07 10:48	26	**3255.4**	**3.51**	0	0
	6/14/07 10:48	27	**3075.9**	**3.49**	0	0
	6/14/07 10:56	28	**3075.9**	**3.49**	0	0
	6/14/07 10:56	29	**3873.2**	**3.59**	0	0
	6/14/07 10:56	30	**3255.4**	**3.51**	0	0
	6/14/07 11:05	31	**2382.2**	**3.38**	0	0
	6/14/07 11:05	32	**2612.5**	**3.42**	1	0
	6/14/07 11:05	33	**2281.8**	**3.36**	0	0
	6/14/07 11:06	post a	**10530.1**	**4.02**	0	0
	6/14/07 11:06	post b	**23141.8**	**4.36**	0	0
	6/14/07 11:06	post c	**19333.8**	**4.29**	0	0
	6/14/07 10:10	3F	**4351.7**	**3.64**	3	0
	6/14/07 10:25	12F	**3654.0**	**3.56**	1	0
	6/14/07 10:28	15F	**4884.4**	**3.69**	3	0
	6/14/07 10:31	18F	**6131.4**	**3.79**	2	2
	6/14/07 10:35	21F	**4351.7**	**3.64**	1	0
	6/14/07 10:40	24F	**3873.2**	**3.59**	1	0
	6/14/07 10:48	27F	**1152.8**	**3.06**	0	0
	6/14/07 11:05	33F	**1187.4**	**3.07**	0	0
	6/21/07 9:15	pre a	**32492.07039**	**4.51**	0	0
	6/21/07 9:15	pre b	**39115.16685**	**4.59**	0	0
	6/21/07 9:15	pre c	**32492.07039**	**4.51**	1	0
	6/21/07 9:16	pre w	**7701**	**3.89**	7	0

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
6/22/2011 60 min event with 4"pump and two 2"pumps	6/21/07 9:24	1	**12033.3**	**4.08**	7	0
	6/21/07 9:24	2	**7269.9**	**3.86**	2	1
	6/21/07 9:24	3	**7269.9**	**3.86**	3	0
	6/21/07 9:29	4	**7269.9**	**3.86**	2	0
	6/21/07 9:29	5	**8164.1**	**3.91**	3	2
	6/21/07 9:29	6	**9803.9**	**3.99**	5	1
	6/21/07 9:34	7	**12996.5**	**4.11**	5	1
	6/21/07 9:34	8	**12996.5**	**4.11**	13	1
	6/21/07 9:34	9	**24195.7**	**4.38**	9	0
	6/21/07 9:39	10	**6866.7**	**3.84**	6	0
	6/21/07 9:39	11	**10462.4**	**4.02**	10	0
	6/21/07 9:39	12	**10462.4**	**4.02**	3	0
	6/21/07 9:42	13	**10462.4**	**4.02**	7	0
	6/21/07 9:42	14	**8664.4**	**3.94**	8	1
	6/21/07 9:42	15	**6866.7**	**3.84**	2	0
	6/21/07 9:45	16	**17328.9**	**4.24**	7	0
	6/21/07 9:45	17	**7269.9**	**3.86**	2	0
	6/21/07 9:45	18	**9208.4**	**3.96**	8	0
	6/21/07 9:49	19	**9208.4**	**3.96**	7	2
	6/21/07 9:49	20	**9803.9**	**3.99**	3	0
	6/21/07 9:49	21	**6866.7**	**3.84**	8	0
	6/21/07 9:54	22	**11198.7**	**4.05**	10	0
	6/21/07 9:54	23	**7701**	**3.89**	9	1
	6/21/07 9:54	24	**7701**	**3.89**	6	0
	6/21/07 10:00	25	**11198.7**	**4.05**	5	2
	6/21/07 10:00	26	**10462.4**	**4.02**	7	1
	6/21/07 10:00	27	**9803.9**	**3.99**	6	1
	6/21/07 10:10	28	**5475**	**3.74**	1	1
	6/21/07 10:10	29	**6131.4**	**3.79**	3	0
	6/21/07 10:10	30	**6866.7**	**3.84**	2	0
	6/21/07 10:19	31	**7701**	**3.89**	5	0
	6/21/07 10:19	32	**6131.4**	**3.79**	2	1
	6/21/07 10:19	33	**8664.4**	**3.94**	3	0
	6/21/07 10:21	post a	**8622.454934**	**3.94**	0	0
	6/21/07 10:21	post b	**4259.114435**	**3.63**	0	0
	6/21/07 10:21	post c	**5058.18092**	**3.70**	0	0
	6/21/07 9:24	3F	**3075.9**	**3.49**	12	0

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
	6/21/07 9:39	12F	**4105.8**	**3.61**	4	1
	6/21/07 9:42	15F	**4884.4**	**3.69**	10	1
	6/21/07 9:45	18F	**3255.4**	**3.51**	5	0
	6/21/07 9:49	21F	**6866.7**	**3.84**	5	0
	6/21/07 9:54	24F	**4611.1**	**3.66**	5	0
	6/21/07 10:00	27F	**4884.4**	**3.69**	7	0
	6/21/07 10:19	33F	**3255.4**	**3.51**	2	1
/29/2011 60 min event with fertilizer	6/28/07 8:31	pre a	**>315830.2**	**>5.50**	4	3
	6/28/07 8:31	pre b	**315826.3**	**5.50**	5	0
	6/28/07 8:31	pre c	**>315830.2**	**>5.50**	8	0
	6/28/07 8:35	pre w	**10462.4**	**4.02**	2	1
	6/28/07 8:45	1	**12033.3**	**4.08**	2	0
	6/28/07 8:45	2	**14136.1**	**4.15**	3	1
	6/28/07 8:45	3	**14136.1**	**4.15**	7	0
	6/28/07 8:50	4	**14136.1**	**4.15**	2	0
	6/28/07 8:50	5	**19862.9**	**4.30**	4	1
	6/28/07 8:50	6	**14136.1**	**4.15**	3	1
	6/28/07 8:55	7	**6866.7**	**3.84**	2	1
	6/28/07 8:55	8	**10462.4**	**4.02**	5	0
	6/28/07 8:55	9	**12996.5**	**4.11**	2	0
	6/28/07 9:00	10	**7701**	**3.89**	3	0
	6/28/07 9:00	11	**>24196**	**>4.38**	6	0
	6/28/07 9:00	12	**>24196**	**>4.38**	3	0
	6/28/07 9:03	13	**8664.4**	**3.94**	4	0
	6/28/07 9:03	14	**17328.9**	**4.24**	4	0
	6/28/07 9:03	15	**12996.5**	**4.11**	2	0
	6/28/07 9:06	16	**10462.4**	**4.02**	8	0
	6/28/07 9:06	17	**11198.7**	**4.05**	1	1
	6/28/07 9:06	18	**15531.2**	**4.19**	7	2
	6/28/07 9:10	19	**8664.4**	**3.94**	5	0
	6/28/07 9:10	20	**12033.3**	**4.08**	3	1
	6/28/07 9:10	21	**12996.5**	**4.11**	6	0
	6/28/07 9:15	22	**8164.1**	**3.91**	2	0
	6/28/07 9:15	23	**11198.7**	**4.05**	6	1
	6/28/07 9:15	24	**14136.1**	**4.15**	3	0
	6/28/07 9:23	25	**8164.1**	**3.91**	5	0
	6/28/07 9:23	26	**9208.4**	**3.96**	3	0

Event	Date+Time	Sample #	TC (MPN/100mL) for water or (MPN/g) for sand	Log TC	E. coli large wells	E. coli small wells
	6/28/07 9:23	27	**8164.1**	**3.91**	2	0
	6/28/07 9:31	28	**3873.2**	**3.59**	6	0
	6/28/07 9:31	29	**5794.3**	**3.76**	3	0
	6/28/07 9:31	30	**6488.2**	**3.81**	2	0
	6/28/07 9:40	31	**4611.1**	**3.66**	2	0
	6/28/07 9:40	32	**3075.9**	**3.49**	0	0
	6/28/07 9:40	33	**3654**	**3.56**	0	0
	6/28/07 9:42	post a	**>315271.6**	**>5.50**	6	2
	6/28/07 9:42	post b	**>315271.6**	**>5.50**	8	2
	6/28/07 9:42	post c	**>315271.61**	**>5.50**	8	0
	6/28/07 8:45	3F	**14136.1**	**4.15**	2	1
	6/28/07 8:55	9F	**7269.9**	**3.86**	3	0
	6/28/07 9:00	12F	**19862.9**	**4.30**	1	0
	6/28/07 9:03	15F	**14136.1**	**4.15**	6	0
	6/28/07 9:06	18F	**12033.3**	**4.08**	3	0
	6/28/07 9:10	21F	**8664.4**	**3.94**	5	1
	6/28/07 9:15	24F	**4884.4**	**3.69**	3	0
	6/28/07 9:40	33F	**1917.9**	**3.28**	2	0

Appendix A-1: Water Quality Data

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
11/09/2010 Coliform already present?	11/8/06 13:58		85.2	**85.2**	**1.93**			
	11/8/06 13:58		63.2	**63.2**	**1.80**			
	11/8/06 13:59		73.8	**73.8**	**1.87**			
	11/8/06 13:59		73.1	**73.1**	**1.86**			
	11/8/06 13:59		51.6	**51.6**	**1.71**			
	11/8/06 13:59		62.6	**62.6**	**1.80**			
	11/8/06 13:24		10	**100.0**	**2.00**			
	11/8/06 13:25		122.3	**1223.2**	**3.09**			
2/17/2011 obervations and sampling	2/16/07 9:18		573.1	**573.1**	**2.76**			
	2/16/07 9:19		135	**135.0**	**2.13**	0.474		
	2/16/07 9:21		161.3	**161.3**	**2.21**			
	2/16/07 9:23		63.2	**63.2**	**1.80**	0.556		
	2/16/07 9:22		169.4	**169.4**	**2.23**			
2/24/2011 added 400 lbs of sand and sampled	2/23/07 10:13		676.6	**676.6**	**2.83**			8
	2/23/07 10:21		<10	**<100.6**	**<2.00**			
	2/23/07 10:21		<10	**<100.6**	**<2.00**			
	2/23/07 10:21		<10	**<100.6**	**<2.00**			
	2/23/07 10:32		528.4	**528.4**	**2.72**		8.70	10
	2/23/07 10:35		663.1	**663.1**	**2.82**		8.92	21
	2/23/07 10:38		520.4	**520.4**	**2.72**		8.92	27
	2/23/07 11:01		10	**129.8**	**2.11**			
	2/23/07 11:01		20.2	**262.1**	**2.42**			
	2/23/07 11:01		<10	**<129.8**	**<2.11**			
	3/14/07 9:17	1	<10	**<10**	**<1**	0.438	6.92	30
	3/14/07 9:24	2	85.2	**85.2**	**1.93**			26
	3/14/07 9:24	3	10	**10.0**	**1.00**			22
	3/14/07 9:29	4	41.3	**41.3**	**1.62**			17
	3/14/07 9:29	5	41.3	**41.3**	**1.62**			20
	3/14/07 9:34	6	63.2	**63.2**	**1.80**			19
	3/14/07 9:34	7	41.3	**41.3**	**1.62**			20
	3/14/07 9:39	8	74.5	**74.5**	**1.87**		8.79	20
	3/14/07 9:39	9	30.6	**30.6**	**1.49**			17
	3/14/07 9:44	10	20.2	**20.2**	**1.31**			15
	3/14/07 9:44	11	10	**10.0**	**1.00**			15
	3/14/07 9:49	12	30.6	**30.6**	**1.49**		9.30	14

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
3/15/2011 90 minute HIGH flow event	3/14/07 9:49	13	52.1	**52.1**	**1.72**			11
	3/14/07 9:59	14	30.6	**30.6**	**1.49**		9.85	10
	3/14/07 9:59	15	30.6	**30.6**	**1.49**			24
	3/14/07 10:19	16	20.2	**20.2**	**1.31**		9.94	14
	3/14/07 10:19	17	10	**10.0**	**1.00**			10
	3/14/07 10:39	18	63.2	**63.2**	**1.80**		10.13	14
	3/14/07 10:39	19	20.2	**20.2**	**1.31**			13
	3/14/07 10:49	20	20.2	**20.2**	**1.31**	0.301	10.18	14
	3/14/07 10:49	21	30.6	**30.6**	**1.49**			12
	3/14/07 9:17	1F	85.2	**85.2**	**1.93**			
	3/14/07 9:24	2F	84.4	**84.4**	**1.93**			
	3/14/07 9:24	3F	62.6	**62.6**	**1.80**			
	3/14/07 9:29	4F	74.5	**74.5**	**1.87**			
	3/14/07 9:29	5F	74.5	**74.5**	**1.87**			
	3/14/07 9:34	6F	30.6	**30.6**	**1.49**			
	3/14/07 9:34	7F	<10	**10.0**	**<1**			
	3/14/07 9:39	8F	63.2	**63.2**	**1.80**			
	3/14/07 9:39	9F	52.1	**52.1**	**1.72**			
	3/14/07 9:44	10F	20.2	**20.2**	**1.31**			
	3/14/07 9:44	11F	<10	**10.0**	**<1**			
	3/14/07 9:49	12F	10	**10.0**	**1.00**			
	3/14/07 9:49	13F	30.6	**30.6**	**1.49**			
	3/14/07 9:59	14F	20.2	**20.2**	**1.31**			
	3/14/07 9:59	15F	30.6	**30.6**	**1.49**			
	3/14/07 10:19	16F	20.2	**20.2**	**1.31**			
	3/14/07 10:19	17F	10	**10.0**	**1.00**			
	3/14/07 10:39	18F	30.6	**30.6**	**1.49**			
	3/14/07 10:39	19F	10	**10.0**	**1.00**			
	3/14/07 10:49	20F	30.6	**30.6**	**1.49**			
	3/14/07 10:49	21F	20.2	**20.2**	**1.31**			
	3/14/07 9:55	22a	20.2	**262.5**	**2.42**			
	3/14/07 9:55	22b	10	**129.9**	**2.11**			
	3/14/07 9:55	22c	<10	**<129.9**	**<2.11**			
	3/14/07 10:51	23a	10	**128.2**	**2.11**			
	3/14/07 10:51	23b	10	**128.2**	**2.11**			
	3/14/07 10:51	23c	9.9	**126.9**	**2.10**			
	4/11/07 9:03	sand1a	<10	**<129.3**	**<2.11**			

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
4/12/2011 90 minute MEDIUM flow event	4/11/07 9:03	sand1b	<10	<129.3	<2.11			
	4/11/07 9:04	sand2a	<10	<129.6	<2.11			
	4/11/07 9:04	sand2b	<10	<129.6	<2.11			
	4/11/07 9:05	sand3a	<10	<129.0	<2.11			
	4/11/07 9:05	sand3b	<10	<129.0	<2.11			
	4/11/07 9:10	pond1	119.9	119.9	2.08			
	4/11/07 9:13	pond2	<10	10.0	<1			
	4/11/07 9:17	1	146.4	146.4	2.17	0.469		40
	4/11/07 9:28	2	135	135.0	2.13		6.30	42
	4/11/07 9:28	3	184.9	184.9	2.27			38
	4/11/07 9:33	4	144.9	144.9	2.16			46
	4/11/07 9:33	5	148	148.0	2.17			44
	4/11/07 9:38	6	135	135.0	2.13			44
	4/11/07 9:38	7	122.3	122.3	2.09			40
	4/11/07 9:43	8	110	110.0	2.04			38
	4/11/07 9:43	9	121.1	121.1	2.08			43
	4/11/07 9:48	10	40.9	40.9	1.61			46
	4/11/07 9:48	11	96.9	96.9	1.99			47
	4/11/07 9:53	12	63.2	63.2	1.80			42
	4/11/07 9:53	13	84.4	84.4	1.93			47
	4/11/07 9:58	14	74.5	74.5	1.87			41
	4/11/07 9:58	15	97.9	97.9	1.99			44
	4/11/07 10:01	16	74.5	74.5	1.87			42
	4/11/07 10:01	17	62.6	62.6	1.80			54
	4/11/07 10:08	18	73.8	73.8	1.87			40
	4/11/07 10:08	19	121.1	121.1	2.08		8.52	39
	4/11/07 10:23	20	63.2	63.2	1.80			39
	4/11/07 10:23	21	73.8	73.8	1.87			42
	4/11/07 10:33	22	41.3	41.3	1.62			40
	4/11/07 10:33	23	63.2	63.2	1.80			41
	4/11/07 10:43	24	131	131.0	2.12			39
	4/11/07 10:43	25	62.6	62.6	1.80			36
	4/11/07 10:53	26	133.6	133.6	2.13	0.472	8.16	40
	4/11/07 10:53	27	108.9	108.9	2.04			48
	4/11/07 10:54	sand4a	<10	<130.0	<2.11			
	4/11/07 10:54	sand4b	<10	<130.0	<2.11			
	4/11/07 10:54	sand4c	<10	<130.0	<2.11			

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
	4/11/07 9:28	2F	173.1	**173.1**	**2.24**			
	4/11/07 9:28	3F	156.3	**156.3**	**2.19**			
	4/11/07 9:58	14F	73.8	**73.8**	**1.87**			
	4/11/07 9:58	15F	52.1	**52.1**	**1.72**			
	4/11/07 10:01	16F	63.2	**63.2**	**1.80**			
	4/11/07 10:01	17F	86	**86.0**	**1.93**			
	4/11/07 10:53	26F	96.9	**96.9**	**1.99**			
	4/11/07 10:53	27F	96.9	**96.9**	**1.99**			
5/5/2011 Coliform resuspension lab experiment	5/4/07 9:26	water1	<10	**<10**	**<1**			
	5/4/07 9:26	water2	<10	**<10**	**<1**			
	5/4/07 9:26	water3	<10	**<10**	**<1**			
	5/4/07 9:28	sand1	10	**123.9**	**2.09**			
	5/4/07 9:28	sand2	10	**123.9**	**2.09**			
	5/4/07 9:28	sand3	10	**123.9**	**2.09**			
		DI1	<10	**<10**	**<1**			
		DI2	<10	**<10**	**<1**			
		DI3	<10	**<10**	**<1**			
		stream1	<10	**<10**	**<1**			
		stream2	<10	**<10**	**<1**			
		stream3	<10	**<10**	**<1**			
5/19/2011 Testing for potential natural sediment	5/18/07 8:24	DAV1w	450	**450.0**	**2.65**			
	5/18/07 8:24	DAV1s	404.4	**5365.1**	**3.73**			
	5/18/07 8:58	PATw	<10	**<10**	**<1**			
	5/18/07 8:58	PATs	4884.4	**64110.4**	**4.81**			
	5/18/07 9:28	NMRCw	291.7	**291.7**	**2.46**			
	5/18/07 9:28	NMRCs	345.1	**4609.5**	**3.66**			
	5/18/07 10:20	PARw	<10	**<10**	**<1**			
	5/18/07 10:20	PARs	159.6	**1998.5**	**3.30**			
	5/18/07 10:38	TCRw	3654	**3654.0**	**3.56**			
	5/18/07 10:38	TCRs	96.9	**1203.0**	**3.08**			
	6/7/07 8:52	pre a	62	**805.3**	**2.91**			
	6/7/07 8:52	pre b	51.6	**670.2**	**2.83**			
	6/7/07 8:52	pre c	86	**1117.0**	**3.05**			
	6/7/07 8:52	pre w	785	**785.0**	**2.89**			32
	6/7/07 8:59	1	864.7	**864.7**	**2.94**	0.325		26
	6/7/07 8:59	2	854.7	**854.7**	**2.93**			24
	6/7/07 8:59	3	638.2	**638.2**	**2.80**			30

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
6/8/2011 60-min event with TWO 2in pumps	6/7/07 9:04	4	265.3	**265.3**	**2.42**		6.64	26
	6/7/07 9:04	5	419.5	**419.5**	**2.62**			20
	6/7/07 9:04	6	465.4	**465.4**	**2.67**			30
	6/7/07 9:09	7	107.8	**107.8**	**2.03**			37
	6/7/07 9:09	8	63.2	**63.2**	**1.80**			44
	6/7/07 9:09	9	121.1	**121.1**	**2.08**			43
	6/7/07 9:14	10	51.6	**51.6**	**1.71**			35
	6/7/07 9:14	11	30.4	**30.4**	**1.48**			36
	6/7/07 9:14	12	20.2	**20.2**	**1.31**			48
	6/7/07 9:17	13	86	**86.0**	**1.93**		7.74	35
	6/7/07 9:17	14	19.9	**19.9**	**1.30**			33
	6/7/07 9:17	15	72.4	**72.4**	**1.86**			48
	6/7/07 9:20	16	19.9	**19.9**	**1.30**			33
	6/7/07 9:20	17	52.1	**52.1**	**1.72**			32
	6/7/07 9:20	18	74.5	**74.5**	**1.87**			37
	6/7/07 9:24	19	51.6	**51.6**	**1.71**			36
	6/7/07 9:24	20	<10	**<10**	**<1**			35
	6/7/07 9:24	21	30.6	**30.6**	**1.49**			34
	6/7/07 9:29	22	52.1	**52.1**	**1.72**			30
	6/7/07 9:29	23	20.2	**20.2**	**1.31**			33
	6/7/07 9:29	24	30.6	**30.6**	**1.49**			33
	6/7/07 9:37	25	30.6	**30.6**	**1.49**		8.41	34
	6/7/07 9:37	26	51.6	**51.6**	**1.71**			34
	6/7/07 9:37	27	20.2	**20.2**	**1.31**			37
	6/7/07 9:45	28	10	**10.0**	**1.00**			39
	6/7/07 9:45	29	20.2	**20.2**	**1.31**			38
	6/7/07 9:45	30	30.6	**30.6**	**1.49**	0.335		36
	6/7/07 9:47	31	10	**10.0**	**1.00**			37
	6/7/07 9:47	32	20.2	**20.2**	**1.31**			55
	6/7/07 9:47	33	<10	**<10**	**<1**			70
	6/7/07 9:49	post a	63.2	**801.4**	**2.90**			
	6/7/07 9:49	post b	86	**1090.5**	**3.04**			
	6/7/07 9:49	post c	20.2	**256.1**	**2.41**			
	6/7/07 8:59	3F	832.9	**832.9**	**2.92**			
	6/7/07 9:14	12F	74.5	**74.5**	**1.87**			
	6/7/07 9:17	15F	63.2	**63.2**	**1.80**			
	6/7/07 9:20	18F	10	**10.0**	**1.00**			

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
	6/7/07 9:24	21F	30.4	**30.4**	**1.48**			
	6/7/07 9:29	24F	41.3	**41.3**	**1.62**			
	6/7/07 9:37	27F	30.6	**30.6**	**1.49**			
	6/7/07 9:47	33F	10	**10.0**	**1.00**			
t with THREE 2in pumps	6/14/07 8:33	pond1a	10	**10.0**	**1.00**			
	6/14/07 8:33	pond1b	52.1	**52.1**	**1.72**			
	6/14/07 8:33	pond1c	20.2	**20.2**	**1.31**			
	6/14/07 8:35	pond2a	<10	**<10**	**<1**			
	6/14/07 8:35	pond2b	<10	**<10**	**<1**			
	6/14/07 8:35	pond2c	<10	**<10**	**<1**			
	6/14/07 8:28	pipe a	<10	**<10**	**<1**			
	6/14/07 8:28	pipe1b	<10	**<10**	**<1**			
	6/14/07 8:28	pipe1c	<10	**<10**	**<1**			
	6/14/07 8:31	pipe2a	<10	**<10**	**<1**			
	6/14/07 8:31	pipe2b	<10	**<10**	**<1**			
	6/14/07 8:31	pipe2c	<10	**<10**	**<1**			
	6/14/07 8:27	pipe3a	20.2	**20.2**	**1.31**			
	6/14/07 8:27	pipe3b	20.1	**20.1**	**1.30**			
	6/14/07 8:27	pipe3c	<10	**<10**	**<1**			
	6/14/07 8:30	pipe4a	10	**10.0**	**1.00**			
	6/14/07 8:30	pipe4b	10	**10.0**	**1.00**			
	6/14/07 8:30	pipe4c	20.2	**20.2**	**1.31**			
	6/14/07 9:05	pre a	<10	**<131.4**	**<2.12**			
	6/14/07 9:05	pre b	100	**1313.8**	**3.12**			
	6/14/07 9:05	pre c	<10	**<131.4**	**<2.12**			
	6/14/07 10:03	pre w	20.2	**20.2**	**1.31**			24
	6/14/07 10:10	1	40.9	**40.9**	**1.61**		8.37	30
	6/14/07 10:10	2	63.2	**63.2**	**1.80**			35
	6/14/07 10:10	3	<10	**<10**	**<1**			36
	6/14/07 10:15	4	62.6	**62.6**	**1.80**			34
	6/14/07 10:15	5	41.3	**41.3**	**1.62**			36
	6/14/07 10:15	6	85.2	**85.2**	**1.93**			32
	6/14/07 10:20	7	30.6	**30.6**	**1.49**			35
	6/14/07 10:20	8	30.6	**30.6**	**1.49**			32
	6/14/07 10:20	9	41.3	**41.3**	**1.62**			39
	6/14/07 10:25	10	41.3	**41.3**	**1.62**			43
	6/14/07 10:25	11	51.2	**51.2**	**1.71**			41

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
6/15/2011 60 min event	6/14/07 10:25	12	41.3	**41.3**	**1.62**			48
	6/14/07 10:28	13	20.2	**20.2**	**1.31**			39
	6/14/07 10:28	14	30.6	**30.6**	**1.49**			42
	6/14/07 10:28	15	10	**10.0**	**1.00**			50
	6/14/07 10:31	16	52.1	**52.1**	**1.72**			33
	6/14/07 10:31	17	41.3	**41.3**	**1.62**			38
	6/14/07 10:31	18	30.6	**30.6**	**1.49**			43
	6/14/07 10:35	19	51.6	**51.6**	**1.71**		8.86	46
	6/14/07 10:35	20	9.9	**9.9**	**1.00**			39
	6/14/07 10:35	21	10	**10.0**	**1.00**			39
	6/14/07 10:40	22	10	**10.0**	**1.00**			31
	6/14/07 10:40	23	30.6	**30.6**	**1.49**			32
	6/14/07 10:40	24	20.2	**20.2**	**1.31**			37
	6/14/07 10:48	25	10	**10.0**	**1.00**			41
	6/14/07 10:48	26	<10	**<10**	**<1**			37
	6/14/07 10:48	27	<10	**<10**	**<1**			43
	6/14/07 10:56	28	<10	**<10**	**<1**			34
	6/14/07 10:56	29	<10	**<10**	**<1**			39
	6/14/07 10:56	30	<10	**<10**	**<1**			38
	6/14/07 11:05	31	<10	**<10**	**<1**		8.67	33
	6/14/07 11:05	32	<10	**<10**	**<1**			42
	6/14/07 11:05	33	<10	**<10**	**<1**			39
	6/14/07 11:06	post a	<10	**<122.4**	**<2.09**			
	6/14/07 11:06	post b	<10	**<122.4**	**<2.09**			
	6/14/07 11:06	post c	<10	**<122.4**	**<2.09**			
	6/14/07 10:10	3F	30.6	**30.6**	**1.49**			
	6/14/07 10:25	12F	10	**10.0**	**1.00**			
	6/14/07 10:28	15F	30.6	**30.6**	**1.49**			
	6/14/07 10:31	18F	40.5	**40.5**	**1.61**			
	6/14/07 10:35	21F	10	**10.0**	**1.00**			
	6/14/07 10:40	24F	10	**10.0**	**1.00**			
	6/14/07 10:48	27F	<10	**<10**	**<1**			
	6/14/07 11:05	33F	<10	**<10**	**<1**			
	6/21/07 9:15	pre a	<10	**<131.0**	**<2.12**			
	6/21/07 9:15	pre b	<10	**<131.0**	**<2.12**			
	6/21/07 9:15	pre c	10	**131**	**2.12**			
	6/21/07 9:16	pre w	74.5	**74.5**	**1.87**			28

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
6/22/2011 60 min event with 4"pump and two 2"pumps	6/21/07 9:24	1	74.5	**74.5**	**1.87**	0.279		33
	6/21/07 9:24	2	30.4	**30.4**	**1.48**			30
	6/21/07 9:24	3	30.6	**30.6**	**1.49**			33
	6/21/07 9:29	4	20.2	**20.2**	**1.31**		7.31	26
	6/21/07 9:29	5	51.2	**51.2**	**1.71**			27
	6/21/07 9:29	6	62.6	**62.6**	**1.80**			29
	6/21/07 9:34	7	62.6	**62.6**	**1.80**			42
	6/21/07 9:34	8	159.6	**159.6**	**2.20**			102
	6/21/07 9:34	9	97.9	**97.9**	**1.99**			413
	6/21/07 9:39	10	63.2	**63.2**	**1.80**			196
	6/21/07 9:39	11	110	**110**	**2.04**			72
	6/21/07 9:39	12	30.6	**30.6**	**1.49**			103
	6/21/07 9:42	13	74.5	**74.5**	**1.87**			80
	6/21/07 9:42	14	96.9	**96.9**	**1.99**			128
	6/21/07 9:42	15	20.2	**20.2**	**1.31**			101
	6/21/07 9:45	16	74.5	**74.5**	**1.87**			71
	6/21/07 9:45	17	20.2	**20.2**	**1.31**			63
	6/21/07 9:45	18	86	**86**	**1.93**			77
	6/21/07 9:49	19	96	**96**	**1.98**			52
	6/21/07 9:49	20	30.6	**30.6**	**1.49**			54
	6/21/07 9:49	21	86	**86**	**1.93**			56
	6/21/07 9:54	22	110	**110**	**2.04**		6.99	43
	6/21/07 9:54	23	108.9	**108.9**	**2.04**			42
	6/21/07 9:54	24	63.2	**63.2**	**1.80**			60
	6/21/07 10:00	25	73.1	**73.1**	**1.86**			40
	6/21/07 10:00	26	85.2	**85.2**	**1.93**			32
	6/21/07 10:00	27	73.8	**73.8**	**1.87**			30
	6/21/07 10:10	28	20.1	**20.1**	**1.30**			33
	6/21/07 10:10	29	30.6	**30.6**	**1.49**			30
	6/21/07 10:10	30	20.2	**20.2**	**1.31**			26
	6/21/07 10:19	31	52.1	**52.1**	**1.72**	0.318	7.63	29
	6/21/07 10:19	32	30.4	**30.4**	**1.48**			29
	6/21/07 10:19	33	30.6	**30.6**	**1.49**			38
	6/21/07 10:21	post a	<10	**<128.7**	**<2.11**			
	6/21/07 10:21	post b	<10	**<128.7**	**<2.11**			
	6/21/07 10:21	post c	<10	**<128.7**	**<2.11**			
	6/21/07 9:24	3F	135	**135**	**2.13**			

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
	6/21/07 9:39	12F	51.6	**51.6**	**1.71**			
	6/21/07 9:42	15F	121.1	**121.1**	**2.08**			
	6/21/07 9:45	18F	52.1	**52.1**	**1.72**			
	6/21/07 9:49	21F	52.1	**52.1**	**1.72**			
	6/21/07 9:54	24F	52.1	**52.1**	**1.72**			
	6/21/07 10:00	27F	74.5	**74.5**	**1.87**			
	6/21/07 10:19	33F	30.4	**30.4**	**1.48**			
5/29/2011 60 min event with fertilizer	6/28/07 8:31	pre a	72.4	**945.0**	**2.98**			
	6/28/07 8:31	pre b	52.1	**680.1**	**2.83**			
	6/28/07 8:31	pre c	86	**1122.6**	**3.05**			
	6/28/07 8:35	pre w	30.4	**30.4**	**1.48**			31
	6/28/07 8:45	1	20.2	**20.2**	**1.31**	0.314	7.72	35
	6/28/07 8:45	2	40.9	**40.9**	**1.61**			31
	6/28/07 8:45	3	74.5	**74.5**	**1.87**			34
	6/28/07 8:50	4	20.2	**20.2**	**1.31**			35
	6/28/07 8:50	5	51.6	**51.6**	**1.71**			50
	6/28/07 8:50	6	40.9	**40.9**	**1.61**			76
	6/28/07 8:55	7	30.4	**30.4**	**1.48**			38
	6/28/07 8:55	8	52.1	**52.1**	**1.72**			44
	6/28/07 8:55	9	20.2	**20.2**	**1.31**			45
	6/28/07 9:00	10	30.6	**30.6**	**1.49**			42
	6/28/07 9:00	11	63.2	**63.2**	**1.80**			66
	6/28/07 9:00	12	30.6	**30.6**	**1.49**			93
	6/28/07 9:03	13	41.3	**41.3**	**1.62**			48
	6/28/07 9:03	14	41.3	**41.3**	**1.62**			50
	6/28/07 9:03	15	20.2	**20.2**	**1.31**			49
	6/28/07 9:06	16	86	**86**	**1.93**			37
	6/28/07 9:06	17	20.1	**20.1**	**1.30**			46
	6/28/07 9:06	18	96	**96**	**1.98**			55
	6/28/07 9:10	19	52.1	**52.1**	**1.72**			46
	6/28/07 9:10	20	40.9	**40.9**	**1.61**			52
	6/28/07 9:10	21	63.2	**63.2**	**1.80**			53
	6/28/07 9:15	22	20.2	**20.2**	**1.31**		6.60	41
	6/28/07 9:15	23	73.8	**73.8**	**1.87**			40
	6/28/07 9:15	24	30.6	**30.6**	**1.49**			43
	6/28/07 9:23	25	52.1	**52.1**	**1.72**			39
	6/28/07 9:23	26	30.6	**30.6**	**1.49**			45

Event	Date+Time	Sample #	E. coli (MPN/100mL)	EC (MPN/100 mL) or (MPN/g) for sand	Log EC	Nitrate (mg/L)	DO	Total Solids (mg/L)
6	6/28/07 9:23	27	20.2	**20.2**	**1.31**			50
	6/28/07 9:31	28	63.2	**63.2**	**1.80**			41
	6/28/07 9:31	29	30.6	**30.6**	**1.49**			40
	6/28/07 9:31	30	20.2	**20.2**	**1.31**			38
	6/28/07 9:40	31	20.2	**20.2**	**1.31**	0.296	7.70	41
	6/28/07 9:40	32	<10	**<10**	**<1**			37
	6/28/07 9:40	33	<10	**<10**	**<1**			39
	6/28/07 9:42	post a	84.4	**1099.7**	**3.04**			
	6/28/07 9:42	post b	107.8	**1404.6**	**3.15**			
	6/28/07 9:42	post c	86	**1120.6**	**3.05**			
	6/28/07 8:45	3F	30.4	**30.4**	**1.48**			
	6/28/07 8:55	9F	30.6	**30.6**	**1.49**			
	6/28/07 9:00	12F	10	**10**	**1.00**			
	6/28/07 9:03	15F	63.2	**63.2**	**1.80**			
	6/28/07 9:06	18F	30.6	**30.6**	**1.49**			
	6/28/07 9:10	21F	62.6	**62.6**	**1.80**			
	6/28/07 9:15	24F	30.6	**30.6**	**1.49**			
	6/28/07 9:40	33F	20.2	**20.2**	**1.31**			

Appendix A-1: Water Quality Data

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
11/09/2010 Coliform already present?	11/8/06 13:58					
	11/8/06 13:58					
	11/8/06 13:59					
	11/8/06 13:59					
	11/8/06 13:59					
	11/8/06 13:59					
	11/8/06 13:24				10	0.9998
	11/8/06 13:25				10	0.9998
2/17/2011 obervations and sampling	2/16/07 9:18					
	2/16/07 9:19					
	2/16/07 9:21					
	2/16/07 9:23					
	2/16/07 9:22					
2/24/2011 added 400 lbs of sand and sampled	2/23/07 10:13					
	2/23/07 10:21				10.03	0.9916
	2/23/07 10:21				10.03	0.9916
	2/23/07 10:21				10.03	0.9916
	2/23/07 10:32					
	2/23/07 10:35					
	2/23/07 10:38					
	2/23/07 11:01				10.08	0.7644
	2/23/07 11:01				10.08	0.7644
	2/23/07 11:01				10.08	0.7644
	3/14/07 9:17	1	28	2		
	3/14/07 9:24	2	29	-3		
	3/14/07 9:24	3	25	-3		
	3/14/07 9:29	4	23	-6		
	3/14/07 9:29	5	23	-3		
	3/14/07 9:34	6	26	-7		
	3/14/07 9:34	7	24	-4		
	3/14/07 9:39	8	17	3		
	3/14/07 9:39	9	21	-4		
	3/14/07 9:44	10	14	1		
	3/14/07 9:44	11	14	1		
	3/14/07 9:49	12	17	-3		

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
3/15/2011 90 minute HIGH flow event	3/14/07 9:49	13	19	-8		
	3/14/07 9:59	14	17	-7		
	3/14/07 9:59	15	14	10		
	3/14/07 10:19	16	24	-10		
	3/14/07 10:19	17	14	-4		
	3/14/07 10:39	18	17	-3		
	3/14/07 10:39	19	15	-2		
	3/14/07 10:49	20	15	-1		
	3/14/07 10:49	21	16	-4		
	3/14/07 9:17	1F				
	3/14/07 9:24	2F				
	3/14/07 9:24	3F				
	3/14/07 9:29	4F				
	3/14/07 9:29	5F				
	3/14/07 9:34	6F				
	3/14/07 9:34	7F				
	3/14/07 9:39	8F				
	3/14/07 9:39	9F				
	3/14/07 9:44	10F				
	3/14/07 9:44	11F				
	3/14/07 9:49	12F				
	3/14/07 9:49	13F				
	3/14/07 9:59	14F				
	3/14/07 9:59	15F				
	3/14/07 10:19	16F				
	3/14/07 10:19	17F				
	3/14/07 10:39	18F				
	3/14/07 10:39	19F				
	3/14/07 10:49	20F				
	3/14/07 10:49	21F				
	3/14/07 9:55	22a			9.966	0.7722
	3/14/07 9:55	22b			9.966	0.7722
	3/14/07 9:55	22c			9.966	0.7722
	3/14/07 10:51	23a			10.15	0.7691
	3/14/07 10:51	23b			10.15	0.7691
	3/14/07 10:51	23c			10.15	0.7691
	4/11/07 9:03	sand1a			9.996	0.7740

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
4/12/2011 90 minute MEDIUM flow event	4/11/07 9:03	sand1b			9.996	0.7740
	4/11/07 9:04	sand2a			10.02	0.7702
	4/11/07 9:04	sand2b			10.02	0.7702
	4/11/07 9:05	sand3a			9.982	0.7766
	4/11/07 9:05	sand3b			9.982	0.7766
	4/11/07 9:10	pond1				
	4/11/07 9:13	pond2				
	4/11/07 9:17	1	43	-3		
	4/11/07 9:28	2	40	2		
	4/11/07 9:28	3	38	0		
	4/11/07 9:33	4	34	12		
	4/11/07 9:33	5	45	-1		
	4/11/07 9:38	6	41	3		
	4/11/07 9:38	7	40	0		
	4/11/07 9:43	8	33	5		
	4/11/07 9:43	9	32	11		
	4/11/07 9:48	10	42	4		
	4/11/07 9:48	11	36	11		
	4/11/07 9:53	12	40	2		
	4/11/07 9:53	13	42	5		
	4/11/07 9:58	14	36	5		
	4/11/07 9:58	15	39	5		
	4/11/07 10:01	16	35	7		
	4/11/07 10:01	17	38	16		
	4/11/07 10:08	18	40	0		
	4/11/07 10:08	19	43	-4		
	4/11/07 10:23	20	39	0		
	4/11/07 10:23	21	39	3		
	4/11/07 10:33	22	43	-3		
	4/11/07 10:33	23	44	-3		
	4/11/07 10:43	24	45	-6		
	4/11/07 10:43	25	45	-9		
	4/11/07 10:53	26	43	-3		
	4/11/07 10:53	27	41	7		
	4/11/07 10:54	sand4a			10.07	0.7641
	4/11/07 10:54	sand4b			10.07	0.7641
	4/11/07 10:54	sand4c			10.07	0.7641

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
	4/11/07 9:28	2F				
	4/11/07 9:28	3F				
	4/11/07 9:58	14F				
	4/11/07 9:58	15F				
	4/11/07 10:01	16F				
	4/11/07 10:01	17F				
	4/11/07 10:53	26F				
	4/11/07 10:53	27F				
5/5/2011 Coliform resuspension lab experiment	5/4/07 9:26	water1				
	5/4/07 9:26	water2				
	5/4/07 9:26	water3				
	5/4/07 9:28	sand1			10.18	0.7927
	5/4/07 9:28	sand2			10.18	0.7927
	5/4/07 9:28	sand3			10.18	0.7927
		DI1				
		DI2				
		DI3				
		stream1				
		stream2				
		stream3				
5/19/2011 Testing for potential natural sediment	5/18/07 8:24	DAV1w			10.09	0.7470
	5/18/07 8:24	DAV1s			10.09	0.7470
	5/18/07 8:58	PATw			10.27	0.7418
	5/18/07 8:58	PATs			10.27	0.7418
	5/18/07 9:28	NMRCw			10.06	0.7442
	5/18/07 9:28	NMRCs			10.06	0.7442
	5/18/07 10:20	PARw			10.13	0.7884
	5/18/07 10:20	PARs			10.13	0.7884
	5/18/07 10:38	TCRw			10.21	0.7889
	5/18/07 10:38	TCRs			10.21	0.7889
	6/7/07 8:52	pre a			10.01	0.7691
	6/7/07 8:52	pre b			10.01	0.7691
	6/7/07 8:52	pre c			10.01	0.7691
	6/7/07 8:52	pre w	26	6	10.01	0.7691
	6/7/07 8:59	1	25	1		
	6/7/07 8:59	2	26	-2		
	6/7/07 8:59	3	27	3		

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
6/8/2011 60-min event with TWO 2in pumps	6/7/07 9:04	4	27	-1		
	6/7/07 9:04	5	28	-8		
	6/7/07 9:04	6	26	4		
	6/7/07 9:09	7	20	17		
	6/7/07 9:09	8	24	20		
	6/7/07 9:09	9	29	14		
	6/7/07 9:14	10	24	11		
	6/7/07 9:14	11	25	11		
	6/7/07 9:14	12	18	30		
	6/7/07 9:17	13	26	9		
	6/7/07 9:17	14	21	12		
	6/7/07 9:17	15	20	28		
	6/7/07 9:20	16	21	12		
	6/7/07 9:20	17	20	12		
	6/7/07 9:20	18	19	18		
	6/7/07 9:24	19	25	11		
	6/7/07 9:24	20	22	13		
	6/7/07 9:24	21	22	12		
	6/7/07 9:29	22	24	6		
	6/7/07 9:29	23	24	9		
	6/7/07 9:29	24	25	8		
	6/7/07 9:37	25	21	13		
	6/7/07 9:37	26	23	11		
	6/7/07 9:37	27	28	9		
	6/7/07 9:45	28	21	18		
	6/7/07 9:45	29	20	18		
	6/7/07 9:45	30	25	11		
	6/7/07 9:47	31	20	17		
	6/7/07 9:47	32	20	35		
	6/7/07 9:47	33	7	63		
	6/7/07 9:49	post a			10.06	0.7841
	6/7/07 9:49	post b			10.06	0.7841
	6/7/07 9:49	post c			10.06	0.7841
	6/7/07 8:59	3F				
	6/7/07 9:14	12F				
	6/7/07 9:17	15F				
	6/7/07 9:20	18F				

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
	6/7/07 9:24	21F				
	6/7/07 9:29	24F				
	6/7/07 9:37	27F				
	6/7/07 9:47	33F				
t with THREE 2in pumps	6/14/07 8:33	pond1a				
	6/14/07 8:33	pond1b				
	6/14/07 8:33	pond1c				
	6/14/07 8:35	pond2a				
	6/14/07 8:35	pond2b				
	6/14/07 8:35	pond2c				
	6/14/07 8:28	pipe a				
	6/14/07 8:28	pipe1b				
	6/14/07 8:28	pipe1c				
	6/14/07 8:31	pipe2a				
	6/14/07 8:31	pipe2b				
	6/14/07 8:31	pipe2c				
	6/14/07 8:27	pipe3a				
	6/14/07 8:27	pipe3b				
	6/14/07 8:27	pipe3c				
	6/14/07 8:30	pipe4a				
	6/14/07 8:30	pipe4b				
	6/14/07 8:30	pipe4c				
	6/14/07 9:05	pre a			10.13	0.7515
	6/14/07 9:05	pre b			10.13	0.7515
	6/14/07 9:05	pre c			10.13	0.7515
	6/14/07 10:03	pre w	25	-1		
	6/14/07 10:10	1	27	3		
	6/14/07 10:10	2	24	11		
	6/14/07 10:10	3	30	6		
	6/14/07 10:15	4	23	11		
	6/14/07 10:15	5	25	11		
	6/14/07 10:15	6	27	5		
	6/14/07 10:20	7	25	10		
	6/14/07 10:20	8	25	7		
	6/14/07 10:20	9	28	11		
	6/14/07 10:25	10	28	15		
	6/14/07 10:25	11	28	13		

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
6/15/2011 60 min event	6/14/07 10:25	12	30	18		
	6/14/07 10:28	13	29	10		
	6/14/07 10:28	14	30	12		
	6/14/07 10:28	15	28	22		
	6/14/07 10:31	16	28	5		
	6/14/07 10:31	17	30	8		
	6/14/07 10:31	18	26	17		
	6/14/07 10:35	19	27	19		
	6/14/07 10:35	20	30	9		
	6/14/07 10:35	21	26	13		
	6/14/07 10:40	22	31	0		
	6/14/07 10:40	23	25	7		
	6/14/07 10:40	24	29	8		
	6/14/07 10:48	25	24	17		
	6/14/07 10:48	26	24	13		
	6/14/07 10:48	27	22	21		
	6/14/07 10:56	28	22	12		
	6/14/07 10:56	29	20	19		
	6/14/07 10:56	30	26	12		
	6/14/07 11:05	31	23	10		
	6/14/07 11:05	32	23	19		
	6/14/07 11:05	33	19	20		
	6/14/07 11:06	post a			10.17	0.8027
	6/14/07 11:06	post b			10.17	0.8027
	6/14/07 11:06	post c			10.17	0.8027
	6/14/07 10:10	3F				
	6/14/07 10:25	12F				
	6/14/07 10:28	15F				
	6/14/07 10:31	18F				
	6/14/07 10:35	21F				
	6/14/07 10:40	24F				
	6/14/07 10:48	27F				
	6/14/07 11:05	33F				
	6/21/07 9:15	pre a			10.09	0.7570
	6/21/07 9:15	pre b			10.09	0.7570
	6/21/07 9:15	pre c			10.09	0.7570
	6/21/07 9:16	pre w	29	-1		

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
6/22/2011 60 min event with 4"pump and two 2"pumps	6/21/07 9:24	1	26	7		
	6/21/07 9:24	2	25	5		
	6/21/07 9:24	3	25	8		
	6/21/07 9:29	4	23	3		
	6/21/07 9:29	5	24	3		
	6/21/07 9:29	6	30	-1		
	6/21/07 9:34	7	29	13		
	6/21/07 9:34	8	27	75		
	6/21/07 9:34	9	28	385		
	6/21/07 9:39	10	27	169		
	6/21/07 9:39	11	26	46		
	6/21/07 9:39	12	26	77		
	6/21/07 9:42	13	27	53		
	6/21/07 9:42	14	28	100		
	6/21/07 9:42	15	27	74		
	6/21/07 9:45	16	28	43		
	6/21/07 9:45	17	27	36		
	6/21/07 9:45	18	26	51		
	6/21/07 9:49	19	27	25		
	6/21/07 9:49	20	28	26		
	6/21/07 9:49	21	30	26		
	6/21/07 9:54	22	28	15		
	6/21/07 9:54	23	26	16		
	6/21/07 9:54	24	28	32		
	6/21/07 10:00	25	27	13		
	6/21/07 10:00	26	25	7		
	6/21/07 10:00	27	24	6		
	6/21/07 10:10	28	21	12		
	6/21/07 10:10	29	19	11		
	6/21/07 10:10	30	23	3		
	6/21/07 10:19	31	23	6		
	6/21/07 10:19	32	21	8		
	6/21/07 10:19	33	24	14		
	6/21/07 10:21	post a			10.12	0.7681
	6/21/07 10:21	post b			10.12	0.7681
	6/21/07 10:21	post c			10.12	0.7681
	6/21/07 9:24	3F				

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
	6/21/07 9:39	12F				
	6/21/07 9:42	15F				
	6/21/07 9:45	18F				
	6/21/07 9:49	21F				
	6/21/07 9:54	24F				
	6/21/07 10:00	27F				
	6/21/07 10:19	33F				
/29/2011 60 min event with fertilizer	6/28/07 8:31	pre a			10.03	0.7641
	6/28/07 8:31	pre b			10.03	0.7641
	6/28/07 8:31	pre c			10.03	0.7641
	6/28/07 8:35	pre w	35	-4		
	6/28/07 8:45	1	31	4		
	6/28/07 8:45	2	34	-3		
	6/28/07 8:45	3	32	2		
	6/28/07 8:50	4	31	4		
	6/28/07 8:50	5	32	18		
	6/28/07 8:50	6	35	41		
	6/28/07 8:55	7	29	9		
	6/28/07 8:55	8	26	18		
	6/28/07 8:55	9	28	17		
	6/28/07 9:00	10	30	12		
	6/28/07 9:00	11	30	36		
	6/28/07 9:00	12	29	64		
	6/28/07 9:03	13	29	19		
	6/28/07 9:03	14	29	21		
	6/28/07 9:03	15	28	21		
	6/28/07 9:06	16	27	10		
	6/28/07 9:06	17	29	17		
	6/28/07 9:06	18	31	24		
	6/28/07 9:10	19	31	15		
	6/28/07 9:10	20	29	23		
	6/28/07 9:10	21	28	25		
	6/28/07 9:15	22	28	13		
	6/28/07 9:15	23	29	11		
	6/28/07 9:15	24	30	13		
	6/28/07 9:23	25	30	9		
	6/28/07 9:23	26	28	17		

Event	Date+Time	Sample #	Dissolved Solids (mg/L)	Suspended Solids (mg/L)	sand, Ws (g)	sand, r
	6/28/07 9:23	27	29	21		
	6/28/07 9:31	28	26	15		
	6/28/07 9:31	29	26	14		
	6/28/07 9:31	30	24	14		
	6/28/07 9:40	31	26	15		
	6/28/07 9:40	32	26	11		
	6/28/07 9:40	33	25	14		
	6/28/07 9:42	post a			10.1	0.7599
	6/28/07 9:42	post b			10.1	0.7599
	6/28/07 9:42	post c			10.1	0.7599
	6/28/07 8:45	3F				
	6/28/07 8:55	9F				
	6/28/07 9:00	12F				
	6/28/07 9:03	15F				
	6/28/07 9:06	18F				
	6/28/07 9:10	21F				
	6/28/07 9:15	24F				
	6/28/07 9:40	33F				

Appendix A-1: Water Quality Data

Event	Date+Time	Sample #	Notes
11/09/2010 Coliform already present?	11/8/06 13:58		
	11/8/06 13:58		
	11/8/06 13:59		
	11/8/06 13:59		
	11/8/06 13:59		
	11/8/06 13:59		
	11/8/06 13:24		
	11/8/06 13:25		
2/17/2011 obervations and sampling	2/16/07 9:18		
	2/16/07 9:19		
	2/16/07 9:21		
	2/16/07 9:23		
	2/16/07 9:22		
2/24/2011 added 400 lbs of sand and sampled	2/23/07 10:13		400 lb of sand placed in artificial stream between 10:15 and 10:23 roughly 2 meters long in center of stretch. Sand depths = 3" at 12in and 36in from beginning, 3.75" at 60in, and 2" at end of 2 m. Water temp was 15.9°C at beginning of stream and 16.5°C above sand bed. Air temp=21.3°C
	2/23/07 10:21		
	2/23/07 10:21		
	2/23/07 10:21		
	2/23/07 10:32		
	2/23/07 10:35		
	2/23/07 10:38		
	2/23/07 11:01		
	2/23/07 11:01		
	2/23/07 11:01		
	3/14/07 9:17	1	7.6°C outside temp
	3/14/07 9:24	2	
	3/14/07 9:24	3	
	3/14/07 9:29	4	
	3/14/07 9:29	5	
	3/14/07 9:34	6	
	3/14/07 9:34	7	
	3/14/07 9:39	8	
	3/14/07 9:39	9	
	3/14/07 9:44	10	
	3/14/07 9:44	11	
	3/14/07 9:49	12	

Event	Date+Time	Sample #	Notes
3/15/2011 90 minute HIGH flow event	3/14/07 9:49	13	
	3/14/07 9:59	14	
	3/14/07 9:59	15	
	3/14/07 10:19	16	
	3/14/07 10:19	17	8.2°C outside temp
	3/14/07 10:39	18	
	3/14/07 10:39	19	
	3/14/07 10:49	20	
	3/14/07 10:49	21	
	3/14/07 9:17	1F	
	3/14/07 9:24	2F	
	3/14/07 9:24	3F	
	3/14/07 9:29	4F	
	3/14/07 9:29	5F	
	3/14/07 9:34	6F	
	3/14/07 9:34	7F	
	3/14/07 9:39	8F	
	3/14/07 9:39	9F	
	3/14/07 9:44	10F	
	3/14/07 9:44	11F	
	3/14/07 9:49	12F	
	3/14/07 9:49	13F	
	3/14/07 9:59	14F	
	3/14/07 9:59	15F	
	3/14/07 10:19	16F	
	3/14/07 10:19	17F	
	3/14/07 10:39	18F	
	3/14/07 10:39	19F	
	3/14/07 10:49	20F	
	3/14/07 10:49	21F	
	3/14/07 9:55	22a	
	3/14/07 9:55	22b	
	3/14/07 9:55	22c	
	3/14/07 10:51	23a	
	3/14/07 10:51	23b	
	3/14/07 10:51	23c	
	4/11/07 9:03	sand1a	

Event	Date+Time	Sample #	Notes
4/12/2011 90 minute MEDIUM flow event	4/11/07 9:03	sand1b	
	4/11/07 9:04	sand2a	
	4/11/07 9:04	sand2b	
	4/11/07 9:05	sand3a	
	4/11/07 9:05	sand3b	
	4/11/07 9:10	pond1	
	4/11/07 9:13	pond2	
	4/11/07 9:17	1	
	4/11/07 9:28	2	
	4/11/07 9:28	3	
	4/11/07 9:33	4	
	4/11/07 9:33	5	
	4/11/07 9:38	6	
	4/11/07 9:38	7	
	4/11/07 9:43	8	
	4/11/07 9:43	9	
	4/11/07 9:48	10	
	4/11/07 9:48	11	
	4/11/07 9:53	12	
	4/11/07 9:53	13	
	4/11/07 9:58	14	
	4/11/07 9:58	15	
	4/11/07 10:01	16	
	4/11/07 10:01	17	
	4/11/07 10:08	18	
	4/11/07 10:08	19	
	4/11/07 10:23	20	
	4/11/07 10:23	21	
	4/11/07 10:33	22	
	4/11/07 10:33	23	
	4/11/07 10:43	24	
	4/11/07 10:43	25	
	4/11/07 10:53	26	
	4/11/07 10:53	27	
	4/11/07 10:54	sand4a	
	4/11/07 10:54	sand4b	
	4/11/07 10:54	sand4c	

Event	Date+Time	Sample #	Notes
	4/11/07 9:28	2F	
	4/11/07 9:28	3F	
	4/11/07 9:58	14F	
	4/11/07 9:58	15F	
	4/11/07 10:01	16F	
	4/11/07 10:01	17F	
	4/11/07 10:53	26F	
	4/11/07 10:53	27F	
5/5/2011 Coliform resuspension lab experiment	5/4/07 9:26	water1	outside temp = 17.0°C , water temp = 12.7°C, very low water, depth about 3/8 normal
	5/4/07 9:26	water2	
	5/4/07 9:26	water3	
	5/4/07 9:28	sand1	
	5/4/07 9:28	sand2	
	5/4/07 9:28	sand3	
		DI1	
		DI2	
		DI3	
		stream1	
		stream2	
		stream3	
5/19/2011 Testing for potential natural sediment	5/18/07 8:24	DAV1w	
	5/18/07 8:24	DAV1s	
	5/18/07 8:58	PATw	
	5/18/07 8:58	PATs	
	5/18/07 9:28	NMRCw	
	5/18/07 9:28	NMRCs	
	5/18/07 10:20	PARw	
	5/18/07 10:20	PARs	
	5/18/07 10:38	TCRw	
	5/18/07 10:38	TCRs	
	6/7/07 8:52	pre a	
	6/7/07 8:52	pre b	
	6/7/07 8:52	pre c	
	6/7/07 8:52	pre w	
	6/7/07 8:59	1	
	6/7/07 8:59	2	
	6/7/07 8:59	3	

Event	Date+Time	Sample #	Notes
6/8/2011 60-min event with TWO 2in pumps	6/7/07 9:04	4	
	6/7/07 9:04	5	
	6/7/07 9:04	6	
	6/7/07 9:09	7	
	6/7/07 9:09	8	
	6/7/07 9:09	9	
	6/7/07 9:14	10	
	6/7/07 9:14	11	
	6/7/07 9:14	12	
	6/7/07 9:17	13	
	6/7/07 9:17	14	
	6/7/07 9:17	15	
	6/7/07 9:20	16	
	6/7/07 9:20	17	
	6/7/07 9:20	18	
	6/7/07 9:24	19	
	6/7/07 9:24	20	
	6/7/07 9:24	21	
	6/7/07 9:29	22	
	6/7/07 9:29	23	
	6/7/07 9:29	24	
	6/7/07 9:37	25	
	6/7/07 9:37	26	
	6/7/07 9:37	27	
	6/7/07 9:45	28	
	6/7/07 9:45	29	
	6/7/07 9:45	30	
	6/7/07 9:47	31	
	6/7/07 9:47	32	
	6/7/07 9:47	33	
	6/7/07 9:49	post a	
	6/7/07 9:49	post b	
	6/7/07 9:49	post c	
	6/7/07 8:59	3F	
	6/7/07 9:14	12F	
	6/7/07 9:17	15F	
	6/7/07 9:20	18F	

Event	Date+Time	Sample #	Notes
	6/7/07 9:24	21F	
	6/7/07 9:29	24F	
	6/7/07 9:37	27F	
	6/7/07 9:47	33F	
t with THREE 2in pumps	6/14/07 8:33	pond1a	
	6/14/07 8:33	pond1b	
	6/14/07 8:33	pond1c	
	6/14/07 8:35	pond2a	
	6/14/07 8:35	pond2b	
	6/14/07 8:35	pond2c	
	6/14/07 8:28	pipe a	
	6/14/07 8:28	pipe1b	
	6/14/07 8:28	pipe1c	
	6/14/07 8:31	pipe2a	
	6/14/07 8:31	pipe2b	
	6/14/07 8:31	pipe2c	
	6/14/07 8:27	pipe3a	
	6/14/07 8:27	pipe3b	
	6/14/07 8:27	pipe3c	
	6/14/07 8:30	pipe4a	
	6/14/07 8:30	pipe4b	
	6/14/07 8:30	pipe4c	
	6/14/07 9:05	pre a	30.6°C outside
	6/14/07 9:05	pre b	
	6/14/07 9:05	pre c	
	6/14/07 10:03	pre w	33.2°C outside
	6/14/07 10:10	1	
	6/14/07 10:10	2	
	6/14/07 10:10	3	
	6/14/07 10:15	4	34.8°C outside
	6/14/07 10:15	5	
	6/14/07 10:15	6	
	6/14/07 10:20	7	
	6/14/07 10:20	8	
	6/14/07 10:20	9	
	6/14/07 10:25	10	
	6/14/07 10:25	11	

Event	Date+Time	Sample #	Notes
6/15/2011 60 min event	6/14/07 10:25	12	
	6/14/07 10:28	13	34.7°C outside
	6/14/07 10:28	14	
	6/14/07 10:28	15	35.7°C outside
	6/14/07 10:31	16	
	6/14/07 10:31	17	
	6/14/07 10:31	18	
	6/14/07 10:35	19	
	6/14/07 10:35	20	
	6/14/07 10:35	21	
	6/14/07 10:40	22	
	6/14/07 10:40	23	
	6/14/07 10:40	24	
	6/14/07 10:48	25	
	6/14/07 10:48	26	
	6/14/07 10:48	27	
	6/14/07 10:56	28	
	6/14/07 10:56	29	
	6/14/07 10:56	30	
	6/14/07 11:05	31	
	6/14/07 11:05	32	
	6/14/07 11:05	33	34.8°C outside
	6/14/07 11:06	post a	
	6/14/07 11:06	post b	
	6/14/07 11:06	post c	
	6/14/07 10:10	3F	
	6/14/07 10:25	12F	
	6/14/07 10:28	15F	
	6/14/07 10:31	18F	
	6/14/07 10:35	21F	
	6/14/07 10:40	24F	
	6/14/07 10:48	27F	
	6/14/07 11:05	33F	
	6/21/07 9:15	pre a	28.7°C outside
	6/21/07 9:15	pre b	
	6/21/07 9:15	pre c	
	6/21/07 9:16	pre w	

Event	Date+Time	Sample #	Notes
6/22/2011 60 min event with 4"pump and two 2"pumps	6/21/07 9:24	1	
	6/21/07 9:24	2	
	6/21/07 9:24	3	
	6/21/07 9:29	4	
	6/21/07 9:29	5	
	6/21/07 9:29	6	32.6°C outside
	6/21/07 9:34	7	21.6°C water temp
	6/21/07 9:34	8	
	6/21/07 9:34	9	
	6/21/07 9:39	10	
	6/21/07 9:39	11	
	6/21/07 9:39	12	
	6/21/07 9:42	13	
	6/21/07 9:42	14	
	6/21/07 9:42	15	
	6/21/07 9:45	16	
	6/21/07 9:45	17	
	6/21/07 9:45	18	
	6/21/07 9:49	19	
	6/21/07 9:49	20	
	6/21/07 9:49	21	
	6/21/07 9:54	22	
	6/21/07 9:54	23	
	6/21/07 9:54	24	
	6/21/07 10:00	25	
	6/21/07 10:00	26	
	6/21/07 10:00	27	
	6/21/07 10:10	28	
	6/21/07 10:10	29	
	6/21/07 10:10	30	33.7°C outside
	6/21/07 10:19	31	
	6/21/07 10:19	32	
	6/21/07 10:19	33	
	6/21/07 10:21	post a	
	6/21/07 10:21	post b	
	6/21/07 10:21	post c	
	6/21/07 9:24	3F	

Event	Date+Time	Sample #	Notes
	6/21/07 9:39	12F	
	6/21/07 9:42	15F	
	6/21/07 9:45	18F	
	6/21/07 9:49	21F	
	6/21/07 9:54	24F	
	6/21/07 10:00	27F	
	6/21/07 10:19	33F	
/29/2011 60 min event with fertilizer	6/28/07 8:31	pre a	
	6/28/07 8:31	pre b	
	6/28/07 8:31	pre c	
	6/28/07 8:35	pre w	
	6/28/07 8:45	1	
	6/28/07 8:45	2	
	6/28/07 8:45	3	
	6/28/07 8:50	4	
	6/28/07 8:50	5	
	6/28/07 8:50	6	
	6/28/07 8:55	7	
	6/28/07 8:55	8	
	6/28/07 8:55	9	
	6/28/07 9:00	10	
	6/28/07 9:00	11	
	6/28/07 9:00	12	
	6/28/07 9:03	13	
	6/28/07 9:03	14	
	6/28/07 9:03	15	
	6/28/07 9:06	16	
	6/28/07 9:06	17	
	6/28/07 9:06	18	
	6/28/07 9:10	19	
	6/28/07 9:10	20	
	6/28/07 9:10	21	
	6/28/07 9:15	22	
	6/28/07 9:15	23	
	6/28/07 9:15	24	
	6/28/07 9:23	25	
	6/28/07 9:23	26	

Event	Date+Time	Sample #	Notes
	6/28/07 9:23	27	
	6/28/07 9:31	28	
	6/28/07 9:31	29	
	6/28/07 9:31	30	
	6/28/07 9:40	31	
	6/28/07 9:40	32	
	6/28/07 9:40	33	
	6/28/07 9:42	post a	
	6/28/07 9:42	post b	
	6/28/07 9:42	post c	
	6/28/07 8:45	3F	
	6/28/07 8:55	9F	
	6/28/07 9:00	12F	
	6/28/07 9:03	15F	
	6/28/07 9:06	18F	
	6/28/07 9:10	21F	
	6/28/07 9:15	24F	
	6/28/07 9:40	33F	

Appendix A-2: Sand Bacterial Conversion Calculations

Date+Time	Location	Sample #	Ws= amount added for sand extraction procedure	dish	total pre oven	total post oven	Ws pre oven
11/9/2010 13:24	Sed Lab pile		10				
11/9/2010 13:25	Sed Lab pile		10				
2/24/2011 10:21	sand from bag	19	10.029				
	1			2.36	13.82	13.74	11.46
	2			2.38	20.29	20.13	17.91
	3			2.27	19.63	19.48	17.36
2/24/2011 11:01	sand w/algae	11	10.0807				
	1			2.23	12.87	10.31	10.64
	2			2.29	17.92	14.20	15.63
	3			2.33	25.18	19.88	22.85
3/15/2011 9:55	beg sand bed	22	9.966				
	1			2.23	4.91	4.30	2.68
	2			2.29	4.38	3.90	2.09
	3			2.33	4.46	3.98	2.13
3/15/2011 10:51	beg sand bed	23	10.145				
	1			2.36	5.36	4.66	3.00
	2			2.38	4.85	4.29	2.47
	3			2.27	4.23	3.77	1.96
4/12/2011 9:03	beg sand bed	sand 1	9.996				
	1			2.36	4.88	4.31	2.52
	2			2.38	4.91	4.34	2.53
	3			2.27	4.55	4.04	2.28
4/12/2011 9:04	mid sand bed	sand 2	10.021				
	1			2.23	4.46	3.95	2.23
	2			2.30	4.39	3.91	2.09
	3			2.33	4.76	4.20	2.42
4/12/2011 9:05	end sand bed	sand 3	9.982				
	1			2.38	5.20	4.60	2.83
	2			2.34	4.33	3.87	1.99
	3			2.35	4.42	3.95	2.07
4/12/2011 10:54	mid sand bed	sand 4	10.068				
	1			2.39	4.43	3.92	2.04
	2			2.30	4.48	3.98	2.18
	3			2.36	4.30	3.85	1.94

Date+Time	Location	Sample #	Ws= amount added for sand extraction procedure	dish	total pre oven	total post oven	Ws pre oven
5/5/2011 9:28	mid sand bed	and 1,2,3	10.1842				
	1			2.36	4.60	4.11	2.24
	2			2.38	4.90	4.37	2.52
	3			2.27	4.86	4.36	2.59
5/19/2011 8:24	DAV site 1	DAV1 s	10.09				
	1			2.36	4.97	4.31	2.61
	2			2.38	6.40	5.37	4.02
	3			2.27	4.84	4.21	2.57
5/19/2011 8:58	PAT	PAT s	10.27				
	1			2.23	4.71	4.18	2.48
	2			2.29	4.53	3.95	2.24
	3			2.33	4.67	3.95	2.34
5/19/2011 9:28	NMRC	NMRC s	10.06				
	1			2.38	5.43	4.63	3.05
	2			2.34	5.08	4.37	2.74
	3			2.35	4.53	4.00	2.19
5/19/2011 10:20	PAR	PAR s	10.13				
	1			2.39	4.72	4.20	2.34
	2			2.30	5.38	4.76	3.08
	3			2.36	4.53	4.06	2.17
5/19/2011 10:38	TCR	TCR s	10.21				
	1			2.37	4.49	4.01	2.12
	2			2.27	5.41	4.76	3.14
	3			2.27	4.72	4.22	2.45
6/8/2011 8:52	mid sand bed	presand	10.01				
	1			2.36	5.26	4.60	2.90
	2			2.38	5.46	4.74	3.08
	3			2.27	4.49	3.97	2.22
6/8/2011 9:49	mid sand bed	postsand	10.058				
	1			2.38	5.01	4.45	2.63
	2			2.34	4.48	4.02	2.14
	3			2.35	4.80	4.26	2.46
6/15/2011 9:05	mid sand bed	presand	10.128				
	1			2.36	4.56	3.99	2.19
	2			2.38	5.11	4.43	2.73

Date+Time	Location	Sample #	Ws= amount added for sand extraction procedure	dish	total pre oven	total post oven	Ws pre oven
	3			2.27	4.46	3.93	2.19
6/15/2011 11:06	mid sand bed	postsand	10.174				
	1			2.38	5.34	4.78	2.97
	2			2.34	4.73	4.24	2.39
	3			2.35	4.81	4.32	2.46
6/22/2011 9:15	mid sand bed	presand	10.0863				
	1			2.36	4.68	4.12	2.32
	2			2.38	5.37	4.63	2.98
	3			2.27	4.70	4.12	2.43
6/22/2011 10:21	mid sand bed	postsand	10.1174				
	1			2.38	4.97	4.37	2.60
	2			2.34	4.63	4.10	2.30
	3			2.35	4.78	4.22	2.43
6/29/2011 8:31	mid sand bed	presand	10.0265				
	1			2.36	4.55	4.03	2.18
	2			2.38	4.58	4.07	2.20
	3			2.27	4.50	3.97	2.23
6/29/2011 9:42	mid sand bed	postsand	10.0991				
	1			2.38	4.88	4.28	2.50
	2			2.34	4.64	4.10	2.30
	3			2.35	4.49	3.96	2.15

Appendix A-2: Sand Bacterial Conversior

Date+Time	Location	Sample #	Ws post oven	r=post oven tot-dish/pre oven tot-dish
11/9/2010 13:24	Sed Lab pile			
11/9/2010 13:25	Sed Lab pile			
2/24/2011 10:21	sand from bag	19		
	1		11.38	0.993
	2		17.75	0.991
	3		17.21	0.991
2/24/2011 11:01	sand w/algae	11		
	1		8.08	0.760
	2		11.91	0.762
	3		17.55	0.768
3/15/2011 9:55	beg sand bed	22		
	1		2.07	0.772
	2		1.61	0.772
	3		1.65	0.773
3/15/2011 10:51	beg sand bed	23		
	1		2.30	0.769
	2		1.91	0.774
	3		1.50	0.763
4/12/2011 9:03	beg sand bed	sand 1		
	1		1.95	0.774
	2		1.96	0.773
	3		1.77	0.775
4/12/2011 9:04	mid sand bed	sand 2		
	1		1.71	0.769
	2		1.62	0.773
	3		1.86	0.769
4/12/2011 9:05	end sand bed	sand 3		
	1		2.22	0.785
	2		1.53	0.768
	3		1.60	0.773
4/12/2011 10:54	mid sand bed	sand 4		
	1		1.53	0.750
	2		1.68	0.773
	3		1.49	0.769

Date+Time	Location	Sample #	Ws post oven	r=post oven tot-dish/pre oven tot-dish
5/5/2011 9:28	mid sand bed	sand 1,2,3		
	1		1.75	0.779
	2		1.99	0.790
	3		2.09	0.807
5/19/2011 8:24	DAV site 1	DAV1 s		
	1		1.95	0.747
	2		2.99	0.742
	3		1.94	0.754
5/19/2011 8:58	PAT	PAT s		
	1		1.95	0.788
	2		1.66	0.740
	3		1.62	0.694
5/19/2011 9:28	NMRC	NMRC s		
	1		2.25	0.739
	2		2.03	0.741
	3		1.65	0.757
5/19/2011 10:20	PAR	PAR s		
	1		1.82	0.778
	2		2.46	0.799
	3		1.70	0.784
5/19/2011 10:38	TCR	TCR s		
	1		1.65	0.775
	2		2.49	0.793
	3		1.95	0.795
6/8/2011 8:52	mid sand bed	presand		
	1		2.24	0.772
	2		2.36	0.768
	3		1.70	0.767
6/8/2011 9:49	mid sand bed	postsand		
	1		2.07	0.787
	2		1.68	0.783
	3		1.92	0.782
6/15/2011 9:05	mid sand bed	presand		
	1		1.63	0.743
	2		2.05	0.753

Date+Time	Location	Sample #	Ws post oven	r=post oven tot-dish/pre oven tot-dish
	3		1.66	0.758
6/15/2011 11:06	mid sand bed	postsand		
	1		2.40	0.810
	2		1.90	0.794
	3		1.98	0.802
6/22/2011 9:15	mid sand bed	presand		
	1		1.76	0.760
	2		2.24	0.752
	3		1.85	0.760
6/22/2011 10:21	mid sand bed	postsand		
	1		1.99	0.767
	2		1.76	0.768
	3		1.87	0.769
6/29/2011 8:31	mid sand bed	presand		
	1		1.67	0.765
	2		1.68	0.767
	3		1.70	0.761
6/29/2011 9:42	mid sand bed	postsand		
	1		1.91	0.763
	2		1.76	0.763
	3		1.62	0.753

Appendix A-3: Filtered and Unfiltered TC/EC

EVENT 1	UPSTREAM					DOWNSTREAM				
Elapsed Time (min)	**Sample #**	**TC**	**Filtered TC**	**EC**	**Filtered EC**	**Sample #**	**TC**	**Filtered TC**	**EC**	**Filtered EC**
-2	1	6488	4106	<10	85					
5	2	10462	3255	85	84	3	7270	3448	10	63
10	4	7270	2014	41	75	5	5475	1670	41	75
15	6	6131	4611	63	31	7	6488	4106	41	<10
20	8	4352	3255	75	63	9	4884	2187	31	52
25	10	3873	1607	20	20	11	2247	1071	10	<10
30	12	2613	1039	31	10	13	2481	1137	52	31
40	14	2046	2755	31	20	15	2098	2359	31	31
60	16	2481	2143	20	20	17	2613	2143	10	10
80	18	2382	2359	63	31	19	2613	2247	20	10
90	20	2489	1334	20	31	21	1664	771	31	20
Geometric Mean		3984	2358	39	34		3330	1880	24	29

*ALL TC and EC in units of MPN/100mL

`

EVENT 2	UPSTREAM					DOWNSTREAM				
Elapsed Time (min)	**Sample #**	**TC**	**Filtered TC**	**EC**	**Filtered EC**	**Sample #**	**TC**	**Filtered TC**	**EC**	**Filtered EC**
-6	1	9804		146						
5	2	9804	9208	135	173	3	8164	9804	185	156
10	4	5475		145		5	7701		148	
15	6	10462		135		7	8664		122	
20	8	5172		110		9	9208		121	
25	10	10462		41		11	8664		97	
30	12	6867		63		13	8664		84	
35	14	6131	2851	75	74	15	5794	3130	98	52
38	16	7270	3255	75	63	17	6131	2723	63	86
45	18	4884		74		19	4352		121	
60	20	5172		63		21	3448		74	
70	22	3076		41		23	4106		63	
80	24	4352		131		25	4106		63	
90	26	3448	3448	134	97	27	4106	1860	109	97
Geometric Mean		6230	4143	100	94		5874	3531	105	91

*ALL TC and EC in units of MPN/100mL

EVENT 3	UPSTREAM			DOWNSTREAM			DOWNSTREAM deep				
Elapsed Time (min)	**Sample #**	**TC**	**EC**	**Sample #**	**TC**	**EC**	**Sample #**	**TC**	**Filtered TC**	**EC**	**Filtered EC**
-2	pre	7270	785								
5	1	8664	865	2	9208	855	3	8664	4884	638	833
10	4	7701	265	5	8164	420	6	6488		465	
15	7	6131	108	8	7701	63	9	5475		121	
20	10	3282	52	11	5475	30	12	6131	2723	20	75
23	13	8164	86	14	6131	20	15	4884	3076	72	63
26	16	8164	20	17	6867	52	18	6867	5794	75	10
30	19	6867	52	20	6488	<10	21	6488	3654	31	30

35	22	5172	52	23	4611	20	24	4611	3448	31	41
43	25	4352	31	26	5172	52	27	4352	4352	20	31
51	28	3076	10	29	4106	20	30	3448		31	
53	31	4884	10	32	4352	20	33	4352	3448	10	10
Geometric Mean								5630	3814	44	44

*ALL TC and EC in units of MPN/100mL

EVENT 4	UPSTREAM			DOWNSTREAM			DOWNSTREAM deep				
Elapsed Time (min)	**Sample #**	**TC**	**EC**	**Sampl e #**	**TC**	**EC**	**Sampl e #**	**TC**	**Filtered TC**	**EC**	**Filtered EC**
-2	pre	6867	20								
5	1	7701	41	2	6867	63	3	6867	4352	<10	31
10	4	7270	63	5	7701	41	6	7270		85	
15	7	6131	31	8	5475	31	9	8164		41	
20	10	5172	41	11	5794	51	12	8664	3654	41	10
23	13	5475	20	14	5475	31	15	6867	4884	10	31
26	16	6488	52	17	7701	41	18	6867	6131	31	41
30	19	6488	52	20	7270	10	21	6131	4352	10	10
35	22	5475	10	23	4106	31	24	3654	3873	20	10
43	25	4352	10	26	3255	<10	27	3076	1153	<10	<10
51	28	3076	<10	29	3873	<10	30	3255		<10	
60	31	2382	<10	32	2613	10	33	2282	1187	<10	<10
Geometric Mean								5077	3200	15	18

*ALL TC and EC in units of MPN/100mL

EVENT 5	UPSTREAM			DOWNSTREAM			DOWNSTREAM deep				
Elapsed Time (min)	**Sample #**	**TC**	**EC**	**Sampl e #**	**TC**	**EC**	**Sampl e #**	**TC**	**Filtered TC**	**EC**	**Filtered EC**
-3	pre	pre	75								
5	1	12033	75	2	7270	30	3	7270	3076	31	135
10	4	7270	20	5	8164	51	6	9804		63	
15	7	12997	63	8	12997	160	9	24196		98	
20	10	6867	63	11	10462	110	12	10462	4106	31	52
23	13	10462	75	14	8664	97	15	6867	4884	20	121
26	16	17329	75	17	7270	20	18	9208	3255	86	52
30	19	9208	96	20	9804	31	21	6867	6867	86	52
35	22	11199	110	23	7701	109	24	7701	4611	63	52
41	25	11199	73	26	10462	85	27	9804	4884	74	75
51	28	5475	20	29	6131	31	30	6867		20	
60	31	7701	52	32	6131	30	33	8664	3255	31	30
Geometric Mean								8257	4223	46	64

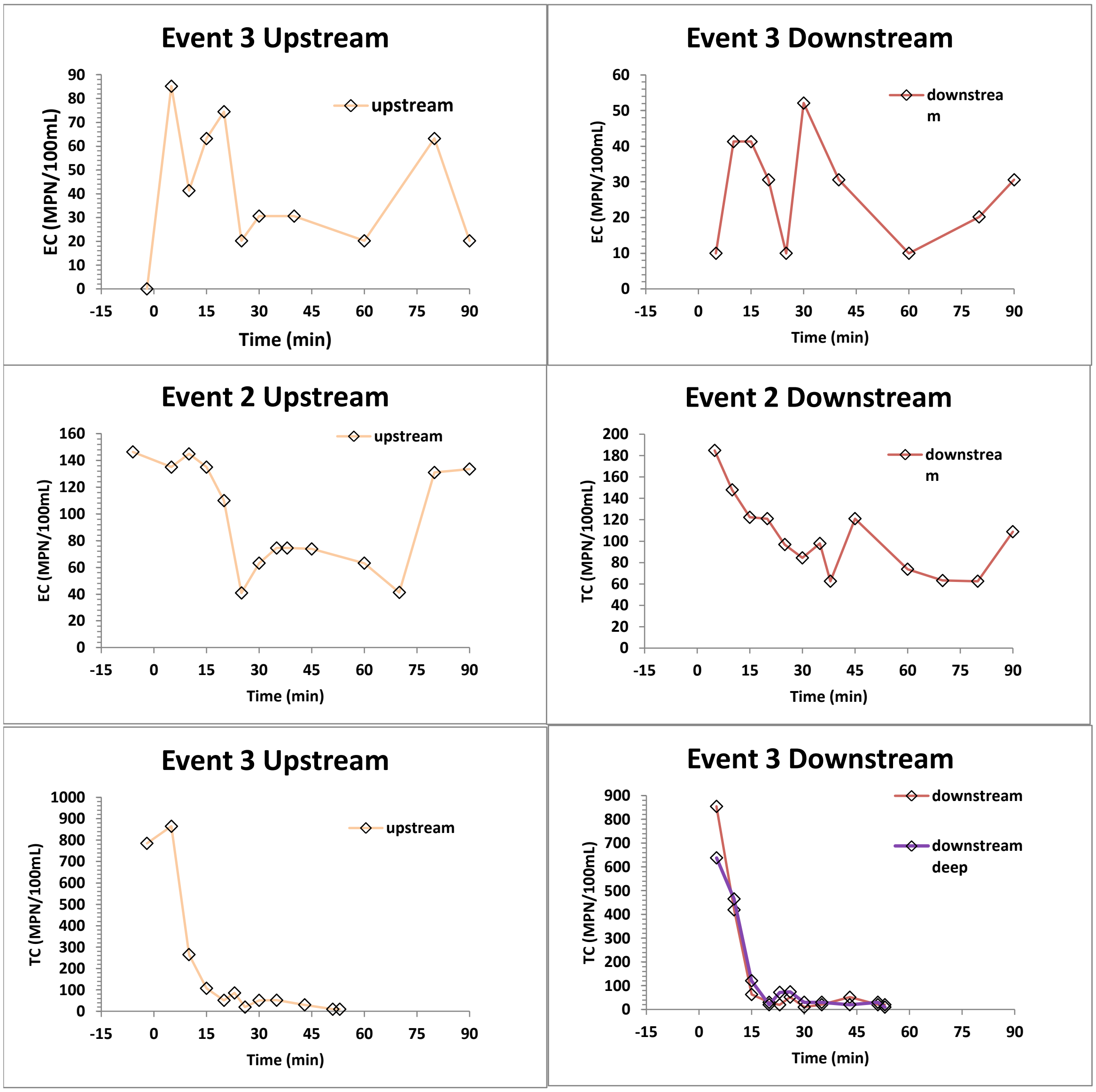
*ALL TC and EC in units of MPN/100mL

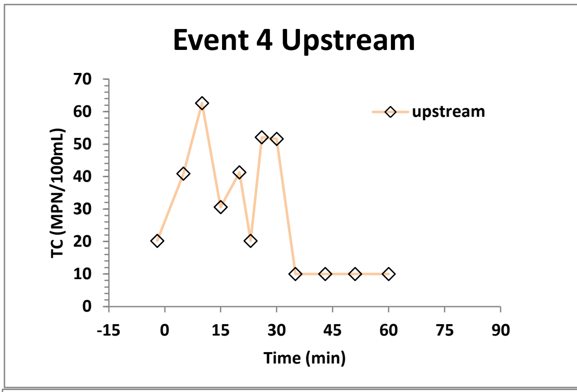
EVENT 6	UPSTREAM			DOWNSTREAM			DOWNSTREAM deep				
Elapsed Time (min)	**Sample #**	**TC**	**EC**	**Sampl e #**	**TC**	**EC**	**Sampl e #**	**TC**	**Filtered TC**	**EC**	**Filtered EC**
-5	pre	10462	30								
5	1	12033	20	2	14136	41	3	14136	14136	75	30
10	4	14136	20	5	19863	52	6	14136		41	

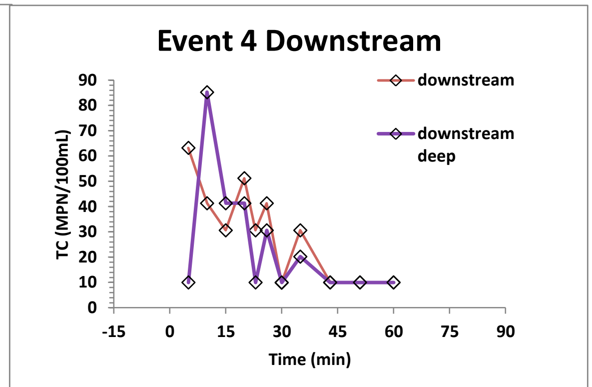
15	7	6867	30	8	10462	52	9	12997	7270	20	31
20	10	7701	31	11	>24192	63	12	>24192	19863	31	10
23	13	8664	41	14	17329	41	15	12997	14136	20	63
26.4	16	10462	86	17	11199	20	18	15531	12033	96	31
30	19	8664	52	20	12033	41	21	12997	8664	63	63
35	22	8164	20	23	11199	74	24	14136	4884	31	31
43	25	8164	52	26	9208	31	27	8164		20	
51	28	3873	63	29	5794	31	30	6488		20	
60	31	4611	20	32	3076	<10	33	3654	1918	<10	20
Geometric Mean								**12516**	**8536**	**34**	30

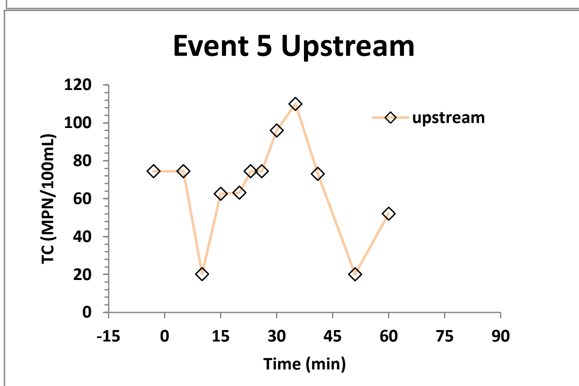
*ALL TC and EC in units of MPN/100mL

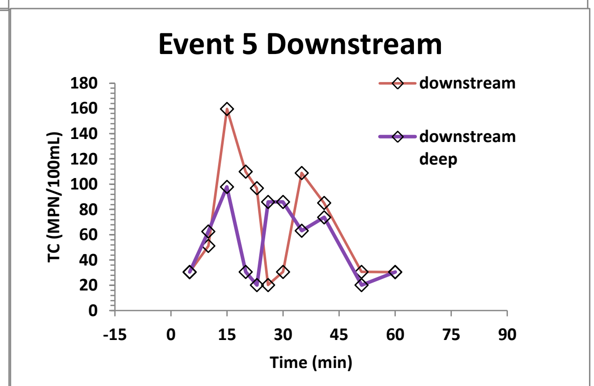
Appendix A-4: E. coli plots

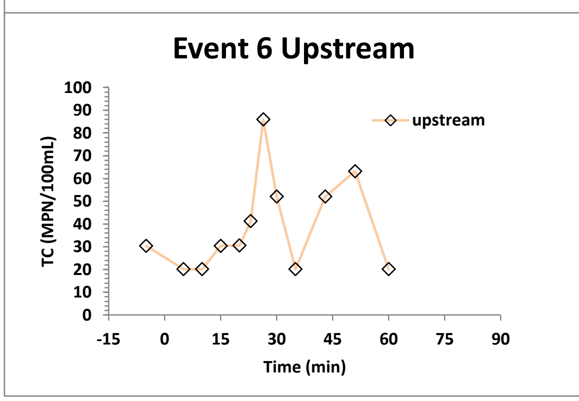


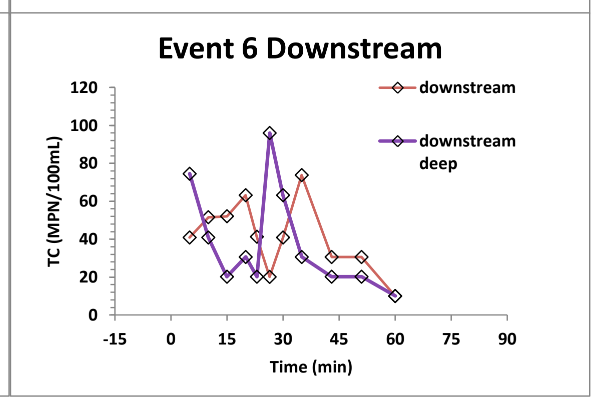

Event 4 Upstream
upstream
TC (MPN/100mL)
0
10
20
30
40
50
60
70
-15
0
15
30
45
60
75
90
Time (min)

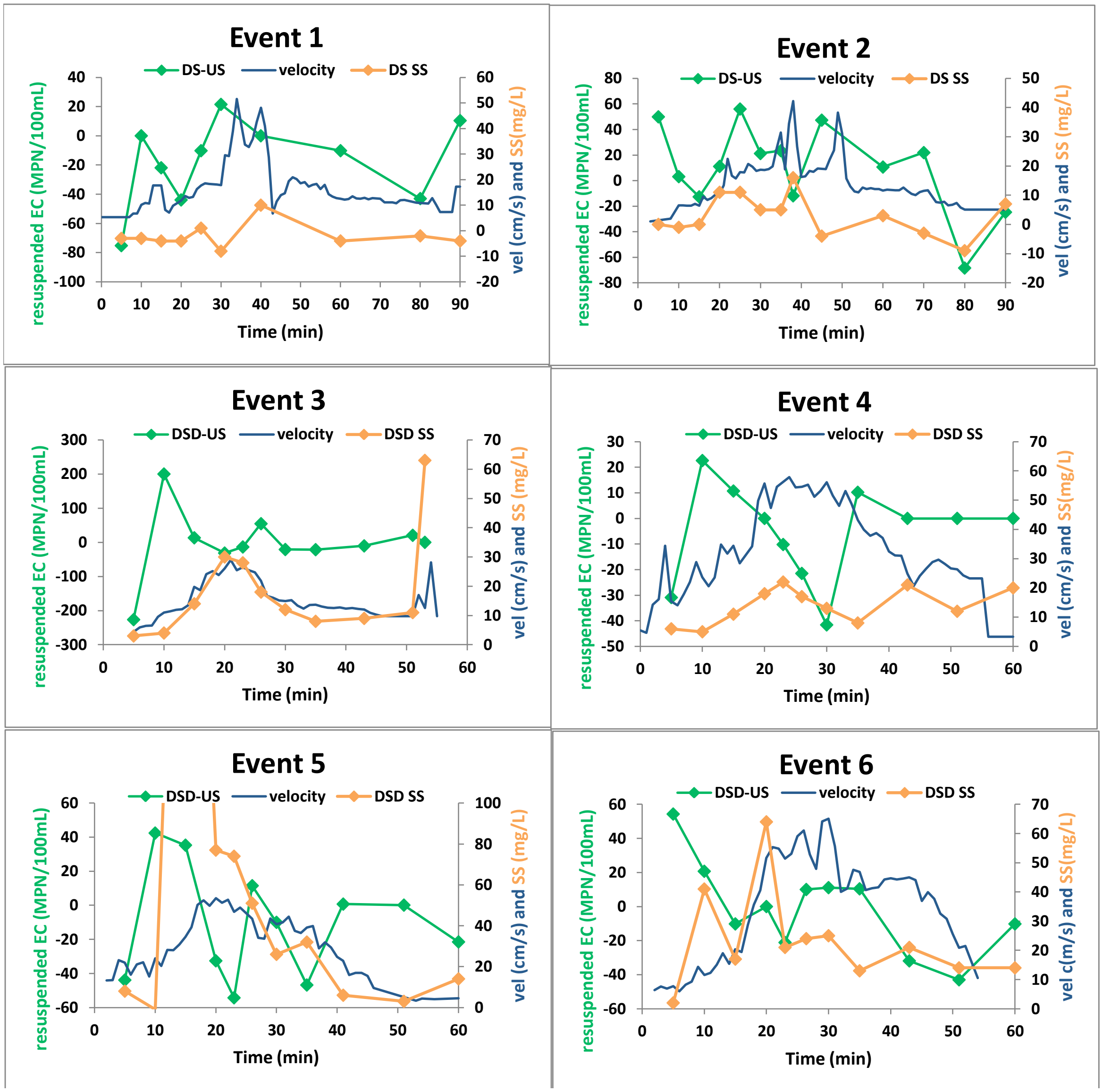

Event 4 Downstream
downstream
downstream deep
TC (MPN/100mL)
0
10
20
30
40
50
60
70
80
90
-15
0
15
30
45
60
75
90
Time (min)


Event 5 Upstream
upstream
TC (MPN/100mL)
0
20
40
60
80
100
120
-15
0
15
30
45
60
75
90
Time (min)


Event 5 Downstream
downstream
downstream deep
TC (MPN/100mL)
0
20
40
60
80
100
120
140
160
180
-15
0
15
30
45
60
75
90
Time (min)


Event 6 Upstream
upstream
TC (MPN/100mL)
0
10
20
30
40
50
60
70
80
90
100
-15
0
15
30
45
60
75
90
Time (min)


Event 6 Downstream
downstream
downstream deep
TC (MPN/100mL)
0
20
40
60
80
100
120
-15
0
15
30
45
60
75
90
Time (min)


Event 1
DS-US
velocity
DS SS
resuspended EC (MPN/100mL)
vel (cm/s) and SS(mg/L)
Time (min)
Event 2
DS-US
velocity
DS SS
resuspended EC (MPN/100mL)
vel (cm/s) and SS (mg/L)
Time (min)
Event 3
DSD-US
velocity
DSD SS
resuspended EC (MPN/100mL)
vel (cm/s) and SS (mg/L)
Time (min)
Event 4
DSD-US
velocity
DSD SS
resuspended EC (MPN/100mL)
vel (cm/s) and SS(mg/L)
Time (min)
Event 5
DSD-US
velocity
DSD SS
resuspended EC (MPN/100mL)
vel (cm/s) and SS (mg/L)
Time (min)
Event 6
DSD-US
velocity
DSD SS
resuspended EC (MPN/100mL)
vel c(m/s) and SS(mg/L)
Time (min)

Appendix A-5: Artificial Stream Water Bacterial Source

Event 4: 6/15/2011

time	location	sample	sample #	TC	Log TC	avg TC	EC	Log EC	avg EC
8:33	pond by the road	water	pond 1a	14136	4.15		10	**1.0**	
8:33	pond by the road	water	pond 1b	17329	4.24	**4.15**	52.1	**1.7**	**1.34**
8:33	pond by the road	water	pond 1c	11199	4.05		20.2	**1.3**	
8:35	pond up on the hill	water	pond 2a	2480.9	3.39		<10	**<1.0**	
8:35	pond up on the hill	water	pond 2b	2480.9	3.39	**3.37**	<10	**<1.0**	**<1.0**
8:35	pond up on the hill	water	pond 2c	2142.6	3.33		<10	**<1.0**	
8:28	small pipe hill	water	pipe 1a	345.1	2.54		<10	**<1.0**	
8:28	small pipe hill	water	pipe 1b	331.9	2.52	**2.46**	<10	**<1.0**	**<1.0**
8:28	small pipe hill	water	pipe 1c	215.7	2.33		<10	**<1.0**	
8:31	large pipe hill	water	pipe 2a	8664.4	3.94		<10	**<1.0**	
8:31	large pipe hill	water	pipe 2b	6488.2	3.81	**3.78**	<10	**<1.0**	**<1.0**
8:31	large pipe hill	water	pipe 2c	3873.2	3.59		<10	**<1.0**	
8:27	small pipe road	water	pipe 3a	8664.4	3.94		20.2	**1.3**	
8:27	small pipe road	water	pipe 3b	15531	4.19	**4.01**	20.1	**1.3**	**1.30**
8:27	small pipe road	water	pipe 3c	7701	3.89		<10	**<1.0**	
8:30	large pipe road	water	pipe 4a	9208.4	3.96		10	**1.0**	
8:30	large pipe road	water	pipe 4b	15531	4.19	**4.05**	10	**1.0**	**1.10**
8:30	large pipe road	water	pipe 4c	9803.9	3.99		20.2	**1.3**	

Relative Percent difference (RPD):

$$RPD = \frac{|X_1 - X_2|}{(X_1 + X_2)/2} \times 100$$

X1 = logs of TC/EC in pond
X2 = log of TC/EC out of pipe

	Pond by the road			**Pond up on the hill**		
	pond	**small pipe**	**large pipe**	**pond**	**small pipe**	**large pipe**
Average Total Coliform (MPN/100mL)	4.15	4.01	4.05	3.37	2.46	3.78
TC Relative % Difference		**3.5**	**2.4**		**31.1**	**11.4**
Average E. coli (MPN/100mL)	1.34	1.30	1.10	<1.0	<1.0	<1.0
EC Relative % Difference		**2.8**	**19.6**		**0.0**	**0.0**

APPENDIX B: HYDRAULIC DATA

Appendix B-1: ISCO Flowmeter Data

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m^3/s)	Calculated Flow rate (m^3/s)	Flow rate (gpm)
1	3/15/2011 9:16	-3	0.19	0.053	0.006	0.0064	101.1
1	3/15/2011 9:17	-2	0.19	0.053	0.006	0.0063	100.0
1	3/15/2011 9:18	-1	0.19	0.053	0.006	0.0063	99.5
1	3/15/2011 9:19	0	0.19	0.053	0.006	0.0062	98.4
1	3/15/2011 9:20	1	0.19	0.053	0.006	0.0062	98.4
1	3/15/2011 9:21	2	0.19	0.053	0.006	0.0062	98.4
1	3/15/2011 9:22	3	0.19	0.053	0.006	0.0062	98.4
1	3/15/2011 9:23	4	0.19	0.053	0.006	0.0062	98.4
1	3/15/2011 9:24	5	0.19	0.053	0.006	0.0063	99.5
1	3/15/2011 9:25	6	0.19	0.053	0.006	0.0064	101.1
1	3/15/2011 9:26	7	0.19	0.053	0.006	0.0065	102.7
1	3/15/2011 9:27	8	0.2	0.067	0.008	0.0084	132.5
1	3/15/2011 9:28	9	0.2	0.067	0.008	0.0084	133.8
1	3/15/2011 9:29	10	0.21	0.102	0.013	0.0133	210.9
1	3/15/2011 9:30	11	0.22	0.109	0.015	0.0152	240.6
1	3/15/2011 9:31	12	0.23	0.106	0.015	0.0152	241.4
1	3/15/2011 9:32	13	0.24	0.177	0.018	0.0263	417.2
1	3/15/2011 9:33	14	0.24	0.177	0.02	0.0270	427.8
1	3/15/2011 9:34	15	0.25	0.177	0.021	0.0280	443.7
1	3/15/2011 9:35	16	0.27	0.081	0.018	0.0137	216.8
1	3/15/2011 9:36	17	0.27	0.071	0.012	0.0122	193.6
1	3/15/2011 9:37	18	0.27	0.098	0.017	0.0167	264.2
1	3/15/2011 9:38	19	0.27	0.107	0.018	0.0179	283.2
1	3/15/2011 9:39	20	0.27	0.118	0.02	0.0199	315.8
1	3/15/2011 9:40	21	0.27	0.136	0.023	0.0227	359.9
1	3/15/2011 9:41	22	0.27	0.129	0.022	0.0217	344.0
1	3/15/2011 9:42	23	0.27	0.132	0.023	0.0228	361.2
1	3/15/2011 9:43	24	0.28	0.163	0.029	0.0285	452.5
1	3/15/2011 9:44	25	0.27	0.177	0.03	0.0302	479.0
1	3/15/2011 9:45	26	0.27	0.186	0.032	0.0318	503.4
1	3/15/2011 9:46	27	0.27	0.183	0.032	0.0316	500.8
1	3/15/2011 9:47	28	0.28	0.182	0.031	0.0315	499.8
1	3/15/2011 9:48	29	0.28	0.181	0.031	0.0315	498.9
1	3/15/2011 9:49	30	0.28	0.178	0.031	0.0312	494.2
1	3/15/2011 9:50	31	0.27	0.296	0.049	0.0494	783.4
1	3/15/2011 9:51	32	0.24	0.292	0.045	0.0447	708.6
1	3/15/2011 9:52	33	0.22	0.389	0.053	0.0532	843.0
1	3/15/2011 9:53	34	0.18	0.515	0.059	0.0590	936.1
1	3/15/2011 9:54	35	0.19	0.420	0.049	0.0492	780.2
1	3/15/2011 9:55	36	0.2	0.337	0.042	0.0425	673.1
1	3/15/2011 9:56	37	0.2	0.328	0.042	0.0417	661.7
1	3/15/2011 9:57	38	0.19	0.359	0.044	0.0437	692.0
1	3/15/2011 9:58	39	0.18	0.426	0.048	0.0483	765.8
1	3/15/2011 9:59	40	0.17	0.481	0.05	0.0500	792.6
1	3/15/2011 10:00	41	0.15	0.410	0.039	0.0382	606.0
1	3/15/2011 10:01	42	0.14	0.287	0.024	0.0255	404.1
1	3/15/2011 10:02	43	0.19	0.067	0.008	0.0081	127.8
1	3/15/2011 10:03	44	0.22	0.115	0.016	0.0159	252.7
1	3/15/2011 10:04	45	0.24	0.140	0.021	0.0212	335.6
1	3/15/2011 10:05	46	0.25	0.146	0.023	0.0233	368.9
1	3/15/2011 10:06	47	0.24	0.194	0.029	0.0292	463.0

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m^3/s)	Calculated Flow rate (m^3/s)	Flow rate (gpm)
1	3/15/2011 10:07	48	0.21	0.209	0.028	0.0282	446.7
1	3/15/2011 10:08	49	0.21	0.202	0.027	0.0267	423.6
1	3/15/2011 10:09	50	0.21	0.186	0.024	0.0243	384.5
1	3/15/2011 10:10	51	0.21	0.190	0.025	0.0254	402.3
1	3/15/2011 10:11	52	0.22	0.173	0.024	0.0237	374.9
1	3/15/2011 10:12	53	0.22	0.180	0.025	0.0251	397.3
1	3/15/2011 10:13	54	0.22	0.183	0.026	0.0257	407.5
1	3/15/2011 10:14	55	0.23	0.163	0.023	0.0231	366.3
1	3/15/2011 10:15	56	0.22	0.180	0.025	0.0253	400.9
1	3/15/2011 10:16	57	0.23	0.143	0.021	0.0205	325.6
1	3/15/2011 10:17	58	0.24	0.133	0.02	0.0200	317.4
1	3/15/2011 10:18	59	0.25	0.128	0.02	0.0200	317.0
1	3/15/2011 10:19	60	0.25	0.125	0.02	0.0198	314.6
1	3/15/2011 10:20	61	0.25	0.122	0.019	0.0190	300.9
1	3/15/2011 10:21	62	0.24	0.124	0.019	0.0188	298.4
1	3/15/2011 10:22	63	0.24	0.135	0.02	0.0202	319.5
1	3/15/2011 10:23	64	0.24	0.126	0.019	0.0187	295.7
1	3/15/2011 10:24	65	0.24	0.125	0.019	0.0185	293.4
1	3/15/2011 10:25	66	0.23	0.129	0.019	0.0190	301.5
1	3/15/2011 10:26	67	0.23	0.123	0.018	0.0181	287.4
1	3/15/2011 10:27	68	0.24	0.127	0.019	0.0188	298.1
1	3/15/2011 10:28	69	0.23	0.126	0.019	0.0186	294.4
1	3/15/2011 10:29	70	0.23	0.125	0.018	0.0184	292.1
1	3/15/2011 10:30	71	0.23	0.111	0.016	0.0162	256.1
1	3/15/2011 10:31	72	0.24	0.111	0.016	0.0164	260.5
1	3/15/2011 10:32	73	0.24	0.111	0.017	0.0165	261.6
1	3/15/2011 10:33	74	0.24	0.107	0.016	0.0160	254.3
1	3/15/2011 10:34	75	0.24	0.119	0.018	0.0180	285.2
1	3/15/2011 10:35	76	0.24	0.121	0.018	0.0183	290.0
1	3/15/2011 10:36	77	0.24	0.117	0.018	0.0178	281.6
1	3/15/2011 10:37	78	0.24	0.113	0.017	0.0171	270.8
1	3/15/2011 10:38	79	0.24	0.110	0.017	0.0167	264.7
1	3/15/2011 10:39	80	0.24	0.109	0.016	0.0165	261.3
1	3/15/2011 10:40	81	0.23	0.107	0.016	0.0158	250.0
1	3/15/2011 10:41	82	0.23	0.106	0.015	0.0151	239.2
1	3/15/2011 10:42	83	0.22	0.128	0.018	0.0177	281.2
1	3/15/2011 10:43	84	0.21	0.102	0.014	0.0136	216.0
1	3/15/2011 10:44	85	0.2	0.073	0.009	0.0093	148.0
1	3/15/2011 10:45	86	0.2	0.073	0.012	0.0091	143.6
1	3/15/2011 10:46	87	0.19	0.073	0.023	0.0089	141.4
1	3/15/2011 10:47	88	0.2	0.073	0.024	0.0093	148.0
1	3/15/2011 10:48	89	0.21	0.172	0.024	0.0228	360.7
1	3/15/2011 10:49	90	0.21	0.172	0.018	0.0231	365.9
2	4/12/2011 9:21	-2	0.22	0.115	0.025	0.0159	251.5
2	4/12/2011 9:22	-1	0.22	0.115	0.025	0.0159	252.7
2	4/12/2011 9:23	0	0.22	0.115	0.025	0.0159	252.7
2	4/12/2011 9:24	1	0.22	0.115	0.025	0.0159	252.7
2	4/12/2011 9:25	2	0.22	0.115	0.025	0.0161	255.0
2	4/12/2011 9:26	3	0.22	0.115	0.026	0.0162	257.3
2	4/12/2011 9:27	4	0.23	0.115	0.026	0.0163	258.4
2	4/12/2011 9:28	5	0.23	0.115	0.026	0.0163	258.4
2	4/12/2011 9:29	6	0.23	0.115	0.026	0.0164	260.7
2	4/12/2011 9:30	7	0.23	0.115	0.027	0.0170	268.7

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m³/s)	Calculated Flow rate (m³/s)	Flow rate (gpm)
2	4/12/2011 9:31	8	0.24	0.115	0.027	0.0173	274.5
2	4/12/2011 9:32	9	0.24	0.115	0.028	0.0176	279.1
2	4/12/2011 9:33	10	0.25	0.065	0.024	0.0101	159.7
2	4/12/2011 9:34	11	0.25	0.065	0.01	0.0102	161.0
2	4/12/2011 9:35	12	0.25	0.064	0.01	0.0099	157.2
2	4/12/2011 9:36	13	0.23	0.064	0.01	0.0094	149.6
2	4/12/2011 9:37	14	0.22	0.070	0.01	0.0099	156.6
2	4/12/2011 9:38	15	0.22	0.064	0.009	0.0087	138.1
2	4/12/2011 9:39	16	0.23	0.095	0.014	0.0136	215.4
2	4/12/2011 9:40	17	0.24	0.084	0.013	0.0127	201.3
2	4/12/2011 9:41	18	0.24	0.090	0.014	0.0137	217.5
2	4/12/2011 9:42	19	0.24	0.102	0.015	0.0155	245.5
2	4/12/2011 9:43	20	0.23	0.106	0.016	0.0156	246.7
2	4/12/2011 9:44	21	0.24	0.133	0.02	0.0199	314.8
2	4/12/2011 9:45	22	0.22	0.225	0.031	0.0312	494.3
2	4/12/2011 9:46	23	0.22	0.167	0.023	0.0226	358.6
2	4/12/2011 9:47	24	0.22	0.157	0.022	0.0218	344.9
2	4/12/2011 9:48	25	0.22	0.179	0.025	0.0250	396.9
2	4/12/2011 9:49	26	0.22	0.178	0.024	0.0244	387.5
2	4/12/2011 9:50	27	0.24	0.207	0.031	0.0306	485.8
2	4/12/2011 9:51	28	0.26	0.198	0.032	0.0324	514.1
2	4/12/2011 9:52	29	0.27	0.183	0.031	0.0311	493.4
2	4/12/2011 9:53	30	0.27	0.187	0.032	0.0317	502.4
2	4/12/2011 9:54	31	0.27	0.186	0.031	0.0314	497.8
2	4/12/2011 9:55	32	0.26	0.189	0.031	0.0312	494.5
2	4/12/2011 9:56	33	0.23	0.199	0.028	0.0288	457.1
2	4/12/2011 9:57	34	0.2	0.263	0.032	0.0323	512.2
2	4/12/2011 9:58	35	0.17	0.315	0.033	0.0333	528.5
2	4/12/2011 9:59	36	0.17	0.188	0.02	0.0201	319.2
2	4/12/2011 10:00	37	0.16	0.345	0.034	0.0339	537.5
2	4/12/2011 10:01	38	0.15	0.422	0.04	0.0396	627.9
2	4/12/2011 10:02	39	0.19	0.267	0.032	0.0320	506.6
2	4/12/2011 10:03	40	0.25	0.162	0.025	0.0250	396.4
2	4/12/2011 10:04	41	0.26	0.165	0.027	0.0267	423.5
2	4/12/2011 10:05	42	0.26	0.183	0.03	0.0297	471.5
2	4/12/2011 10:06	43	0.26	0.180	0.029	0.0289	458.4
2	4/12/2011 10:07	44	0.25	0.191	0.03	0.0301	476.9
2	4/12/2011 10:08	45	0.25	0.190	0.03	0.0298	472.5
2	4/12/2011 10:09	46	0.23	0.189	0.028	0.0276	437.9
2	4/12/2011 10:10	47	0.21	0.222	0.029	0.0294	465.6
2	4/12/2011 10:11	48	0.19	0.254	0.031	0.0309	489.6
2	4/12/2011 10:12	49	0.16	0.383	0.038	0.0379	600.5
2	4/12/2011 10:13	50	0.15	0.312	0.029	0.0291	461.1
2	4/12/2011 10:14	51	0.17	0.157	0.016	0.0164	260.3
2	4/12/2011 10:15	52	0.19	0.130	0.016	0.0159	251.9
2	4/12/2011 10:16	53	0.22	0.113	0.016	0.0157	249.4
2	4/12/2011 10:17	54	0.23	0.110	0.016	0.0160	253.8
2	4/12/2011 10:18	55	0.23	0.126	0.019	0.0186	294.4
2	4/12/2011 10:19	56	0.23	0.121	0.017	0.0172	271.9
2	4/12/2011 10:20	57	0.22	0.124	0.017	0.0171	271.2
2	4/12/2011 10:21	58	0.22	0.121	0.017	0.0165	262.2
2	4/12/2011 10:22	59	0.22	0.121	0.016	0.0164	259.8
2	4/12/2011 10:23	60	0.21	0.116	0.016	0.0156	247.9

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m³/s)	Calculated Flow rate (m³/s)	Flow rate (gpm)
2	4/12/2011 10:24	61	0.22	0.119	0.016	0.0161	255.5
2	4/12/2011 10:25	62	0.22	0.118	0.016	0.0160	253.4
2	4/12/2011 10:26	63	0.21	0.117	0.016	0.0158	250.0
2	4/12/2011 10:27	64	0.21	0.117	0.016	0.0156	247.7
2	4/12/2011 10:28	65	0.21	0.126	0.017	0.0168	266.8
2	4/12/2011 10:29	66	0.21	0.115	0.015	0.0154	243.5
2	4/12/2011 10:30	67	0.21	0.105	0.014	0.0140	222.3
2	4/12/2011 10:31	68	0.22	0.100	0.014	0.0137	216.7
2	4/12/2011 10:32	69	0.22	0.111	0.015	0.0152	241.7
2	4/12/2011 10:33	70	0.22	0.115	0.016	0.0156	248.1
2	4/12/2011 10:34	71	0.22	0.117	0.016	0.0158	251.2
2	4/12/2011 10:35	72	0.21	0.097	0.013	0.0126	199.6
2	4/12/2011 10:36	73	0.2	0.077	0.01	0.0098	155.3
2	4/12/2011 10:37	74	0.21	0.075	0.01	0.0098	155.8
2	4/12/2011 10:38	75	0.22	0.078	0.011	0.0107	169.8
2	4/12/2011 10:39	76	0.22	0.065	0.009	0.0088	139.6
2	4/12/2011 10:40	77	0.21	0.067	0.009	0.0087	138.5
2	4/12/2011 10:41	78	0.2	0.073	0.009	0.0092	146.5
2	4/12/2011 10:42	79	0.2	0.058	0.007	0.0074	117.0
2	4/12/2011 10:43	80	0.21	0.051	0.007	0.0067	105.9
2	4/12/2011 10:44	81	0.22	0.051	0.007	0.0071	113.1
2	4/12/2011 10:45	82	0.23	0.051	0.008	0.0075	119.2
2	4/12/2011 10:46	83	0.25	0.051	0.008	0.0079	124.8
2	4/12/2011 10:47	84	0.25	0.051	0.008	0.0081	127.8
2	4/12/2011 10:48	85	0.26	0.051	0.008	0.0082	129.9
2	4/12/2011 10:49	86	0.25	0.051	0.008	0.0081	128.3
2	4/12/2011 10:50	87	0.25	0.051	0.008	0.0081	128.3
2	4/12/2011 10:51	88	0.25	0.051	0.008	0.0081	127.8
2	4/12/2011 10:52	89	0.24	0.051	0.008	0.0078	123.8
2	4/12/2011 10:53	90	0.24	0.051	0.008	0.0076	121.2
3	6/8/2011 8:52	-2	0.21	0.124	0.016	0.0164	260.1
3	6/8/2011 8:53	-1	0.21	0.124	0.017	0.0165	261.3
3	6/8/2011 8:54	0	0.21	0.124	0.017	0.0166	262.5
3	6/8/2011 8:55	1	0.21	0.124	0.017	0.0167	265.0
3	6/8/2011 8:56	2	0.22	0.124	0.017	0.0172	272.4
3	6/8/2011 8:57	3	0.23	0.124	0.018	0.0177	279.9
3	6/8/2011 8:58	4	0.23	0.124	0.018	0.0183	289.8
3	6/8/2011 8:59	5	0.24	0.044	0.007	0.0067	105.9
3	6/8/2011 9:00	6	0.25	0.059	0.009	0.0092	146.1
3	6/8/2011 9:01	7	0.26	0.065	0.01	0.0104	165.5
3	6/8/2011 9:02	8	0.26	0.066	0.011	0.0109	173.4
3	6/8/2011 9:03	9	0.26	0.096	0.015	0.0159	252.1
3	6/8/2011 9:04	10	0.26	0.110	0.018	0.0182	288.9
3	6/8/2011 9:05	11	0.27	0.114	0.019	0.0194	307.4
3	6/8/2011 9:06	12	0.28	0.119	0.021	0.0206	326.8
3	6/8/2011 9:07	13	0.28	0.121	0.021	0.0211	334.7
3	6/8/2011 9:08	14	0.28	0.135	0.024	0.0238	377.5
3	6/8/2011 9:09	15	0.28	0.198	0.034	0.0346	547.7
3	6/8/2011 9:10	16	0.27	0.186	0.031	0.0314	497.8
3	6/8/2011 9:11	17	0.29	0.241	0.044	0.0436	690.8
3	6/8/2011 9:12	18	0.29	0.252	0.046	0.0459	727.3
3	6/8/2011 9:13	19	0.29	0.238	0.043	0.0429	679.8
3	6/8/2011 9:14	20	0.27	0.261	0.044	0.0444	703.8

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m³/s)	Calculated Flow rate (m³/s)	Flow rate (gpm)
3	6/8/2011 9:15	21	0.23	0.290	0.042	0.0422	669.0
3	6/8/2011 9:16	22	0.26	0.255	0.042	0.0424	672.3
3	6/8/2011 9:17	23	0.28	0.265	0.047	0.0469	743.7
3	6/8/2011 9:18	24	0.29	0.255	0.046	0.0459	728.3
3	6/8/2011 9:19	25	0.29	0.247	0.044	0.0443	703.0
3	6/8/2011 9:20	26	0.26	0.219	0.036	0.0361	573.0
3	6/8/2011 9:21	27	0.26	0.167	0.028	0.0278	440.3
3	6/8/2011 9:22	28	0.26	0.161	0.027	0.0267	422.9
3	6/8/2011 9:23	29	0.26	0.151	0.025	0.0251	398.1
3	6/8/2011 9:24	30	0.27	0.149	0.025	0.0251	397.3
3	6/8/2011 9:25	31	0.27	0.152	0.026	0.0257	406.8
3	6/8/2011 9:26	32	0.27	0.134	0.023	0.0225	357.3
3	6/8/2011 9:27	33	0.27	0.123	0.021	0.0210	332.9
3	6/8/2011 9:28	34	0.27	0.136	0.023	0.0232	368.1
3	6/8/2011 9:29	35	0.27	0.137	0.023	0.0230	363.9
3	6/8/2011 9:30	36	0.26	0.131	0.022	0.0218	345.4
3	6/8/2011 9:31	37	0.27	0.127	0.021	0.0213	337.4
3	6/8/2011 9:32	38	0.27	0.125	0.021	0.0212	335.8
3	6/8/2011 9:33	39	0.27	0.128	0.022	0.0217	343.9
3	6/8/2011 9:34	40	0.27	0.123	0.021	0.0208	330.4
3	6/8/2011 9:35	41	0.27	0.125	0.021	0.0211	334.6
3	6/8/2011 9:36	42	0.27	0.122	0.021	0.0206	326.5
3	6/8/2011 9:37	43	0.27	0.120	0.02	0.0202	320.0
3	6/8/2011 9:38	44	0.27	0.109	0.018	0.0182	288.5
3	6/8/2011 9:39	45	0.25	0.103	0.016	0.0164	260.2
3	6/8/2011 9:40	46	0.25	0.098	0.015	0.0151	239.8
3	6/8/2011 9:41	47	0.24	0.098	0.012	0.0151	238.8
3	6/8/2011 9:42	48	0.25	0.098	0.01	0.0154	244.7
3	6/8/2011 9:43	49	0.26	0.098	0.011	0.0159	252.5
3	6/8/2011 9:44	50	0.26	0.098	0.011	0.0159	252.5
3	6/8/2011 9:45	51	0.25	0.098	0.01	0.0157	248.6
3	6/8/2011 9:46	52	0.25	0.170	0.015	0.0266	421.0
3	6/8/2011 9:47	53	0.22	0.125	0.018	0.0173	274.6
3	6/8/2011 9:48	54	0.19	0.281	0.037	0.0328	519.2
3	6/8/2011 9:49	55	0.22	0.098	0.014	0.0138	218.3
3	6/8/2011 9:50	56	0.21	0.098	0.009	0.0131	207.5
3	6/8/2011 9:51	57	0.2	0.098	0.009	0.0126	199.7
3	6/8/2011 9:52	58	0.2	0.098	0.009	0.0126	199.7
3	6/8/2011 9:53	59	0.21	0.098	0.009	0.0127	201.6
3	6/8/2011 9:54	60	0.21	0.098	0.009	0.0127	200.6
4	6/15/2011 10:03	-2	0.18	0.031	0.004	0.0036	57.0
4	6/15/2011 10:04	-1	0.18	0.031	0.004	0.0036	57.0
4	6/15/2011 10:05	0	0.19	0.055	0.007	0.0066	104.4
4	6/15/2011 10:06	1	0.21	0.046	0.006	0.0060	95.6
4	6/15/2011 10:07	2	0.2	0.143	0.018	0.0183	289.9
4	6/15/2011 10:08	3	0.2	0.161	0.02	0.0198	313.5
4	6/15/2011 10:09	4	0.19	0.344	0.041	0.0407	645.9
4	6/15/2011 10:10	5	0.18	0.154	0.018	0.0179	283.0
4	6/15/2011 10:11	6	0.19	0.140	0.017	0.0170	269.8
4	6/15/2011 10:12	7	0.21	0.179	0.023	0.0233	370.0
4	6/15/2011 10:13	8	0.21	0.220	0.029	0.0290	459.2
4	6/15/2011 10:14	9	0.18	0.288	0.033	0.0328	520.6
4	6/15/2011 10:15	10	0.19	0.237	0.029	0.0288	456.8

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m^3/s)	Calculated Flow rate (m^3/s)	Flow rate (gpm)
4	6/15/2011 10:16	11	0.2	0.206	0.026	0.0257	407.3
4	6/15/2011 10:17	12	0.21	0.236	0.03	0.0305	483.2
4	6/15/2011 10:18	13	0.21	0.348	0.045	0.0449	712.5
4	6/15/2011 10:19	14	0.18	0.317	0.036	0.0359	569.8
4	6/15/2011 10:20	15	0.2	0.344	0.04	0.0425	673.3
4	6/15/2011 10:21	16	0.21	0.284	0.037	0.0367	581.4
4	6/15/2011 10:22	17	0.23				
4	6/15/2011 10:23	18	0.22	0.342	0.047	0.0470	744.6
4	6/15/2011 10:24	19	0.21	0.498	0.066	0.0659	1044.4
4	6/15/2011 10:25	20	0.21	0.557	0.074	0.0744	1179.3
4	6/15/2011 10:26	21	0.21	0.473	0.062	0.0620	982.5
4	6/15/2011 10:27	22	0.21	0.546	0.07	0.0705	1117.8
4	6/15/2011 10:28	23	0.19	0.081	0.01	0.0098	155.3
4	6/15/2011 10:29	24	0.2	0.579	0.072	0.0719	1139.1
4	6/15/2011 10:30	25	0.2	0.543	0.069	0.0694	1100.8
4	6/15/2011 10:31	26	0.2	0.545	0.069	0.0694	1099.4
4	6/15/2011 10:32	27	0.2	0.553	0.07	0.0697	1104.5
4	6/15/2011 10:33	28	0.2	0.511	0.065	0.0654	1036.0
4	6/15/2011 10:34	29	0.2	0.531	0.068	0.0682	1081.8
4	6/15/2011 10:35	30	0.2	0.561	0.07	0.0700	1109.3
4	6/15/2011 10:36	31	0.2	0.516	0.065	0.0647	1025.5
4	6/15/2011 10:37	32	0.2	0.480	0.061	0.0608	963.5
4	6/15/2011 10:38	33	0.2	0.531	0.065	0.0652	1034.1
4	6/15/2011 10:39	34	0.19	0.488	0.057	0.0575	911.4
4	6/15/2011 10:40	35	0.19	0.432	0.053	0.0525	832.7
4	6/15/2011 10:41	36	0.2	0.399	0.05	0.0495	785.0
4	6/15/2011 10:42	37	0.2	0.378	0.048	0.0476	755.0
4	6/15/2011 10:43	38	0.19	0.387	0.047	0.0468	742.1
4	6/15/2011 10:44	39	0.18	0.371	0.043	0.0428	678.0
4	6/15/2011 10:45	40	0.19	0.324	0.039	0.0388	614.8
4	6/15/2011 10:46	41	0.19	0.311	0.037	0.0376	596.3
4	6/15/2011 10:47	42	0.19	0.310	0.037	0.0367	582.0
4	6/15/2011 10:48	43	0.19	0.249	0.03	0.0298	472.5
4	6/15/2011 10:49	44	0.21	0.207	0.027	0.0269	425.9
4	6/15/2011 10:50	45	0.21	0.241	0.031	0.0316	500.6
4	6/15/2011 10:51	46	0.2	0.265	0.034	0.0336	531.9
4	6/15/2011 10:52	47	0.2	0.288	0.036	0.0356	563.7
4	6/15/2011 10:53	48	0.19	0.296	0.036	0.0360	570.5
4	6/15/2011 10:54	49	0.19	0.282	0.034	0.0341	540.7
4	6/15/2011 10:55	50	0.19	0.266	0.032	0.0320	507.4
4	6/15/2011 10:56	51	0.2	0.263	0.033	0.0326	517.4
4	6/15/2011 10:57	52	0.2	0.243	0.031	0.0305	482.9
4	6/15/2011 10:58	53	0.18	0.232	0.027	0.0267	424.0
4	6/15/2011 10:59	54	0.17	0.232	0.024	0.0248	393.9
4	6/15/2011 11:00	55	0.16	0.232	0.023	0.0232	368.4
4	6/15/2011 11:01	56	0.17	0.033	0.004	0.0035	55.7
4	6/15/2011 11:02	57	0.17	0.033	0.004	0.0035	56.0
4	6/15/2011 11:03	58	0.17	0.033	0.004	0.0035	56.0
4	6/15/2011 11:04	59	0.17	0.033	0.004	0.0036	56.7
4	6/15/2011 11:05	60	0.17	0.033	0.004	0.0036	57.3
5	6/22/2011 9:16	-3	0.19		-0.008		
5	6/22/2011 9:17	-2	0.19		-0.009		
5	6/22/2011 9:18	-1	0.19		-0.009		

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m^3/s)	Calculated Flow rate (m^3/s)	Flow rate (gpm)
5	6/22/2011 9:19	0	0.19		-0.009		
5	6/22/2011 9:20	1	0.22		-0.01		
5	6/22/2011 9:21	2	0.23	0.133	0.019	0.0193	305.5
5	6/22/2011 9:22	3	0.23	0.134	0.019	0.0192	303.8
5	6/22/2011 9:23	4	0.22	0.231	0.032	0.0323	512.1
5	6/22/2011 9:24	5	0.2	0.219	0.028	0.0280	444.0
5	6/22/2011 9:25	6	0.21	0.160	0.021	0.0208	329.2
5	6/22/2011 9:26	7	0.21	0.211	0.028	0.0279	442.5
5	6/22/2011 9:27	8	0.2	0.221	0.028	0.0281	445.8
5	6/22/2011 9:28	9	0.2	0.152	0.019	0.0192	305.1
5	6/22/2011 9:29	10	0.2	0.241	0.03	0.0302	479.0
5	6/22/2011 9:30	11	0.2	0.203	0.025	0.0255	403.4
5	6/22/2011 9:31	12	0.2	0.282	0.036	0.0355	563.3
5	6/22/2011 9:32	13	0.2	0.280	0.035	0.0351	556.5
5	6/22/2011 9:33	14	0.21	0.309	0.04	0.0403	638.8
5	6/22/2011 9:34	15	0.2	0.346	0.044	0.0440	698.0
5	6/22/2011 9:35	16	0.19	0.392	0.046	0.0464	736.0
5	6/22/2011 9:36	17	0.19	0.502	0.061	0.0614	972.6
5	6/22/2011 9:37	18	0.19	0.525	0.064	0.0635	1006.7
5	6/22/2011 9:38	19	0.2	0.497	0.062	0.0620	982.8
5	6/22/2011 9:39	20	0.2	0.534	0.068	0.0676	1071.9
5	6/22/2011 9:40	21	0.2	0.513	0.064	0.0637	1009.3
5	6/22/2011 9:41	22	0.19	0.527	0.063	0.0631	1000.0
5	6/22/2011 9:42	23	0.19	0.468	0.056	0.0566	897.4
5	6/22/2011 9:43	24	0.19	0.489	0.058	0.0582	923.0
5	6/22/2011 9:44	25	0.19	0.489	0.058	0.0570	903.5
5	6/22/2011 9:45	26	0.19	0.434	0.052	0.0522	827.8
5	6/22/2011 9:46	27	0.2	0.341	0.042	0.0423	670.9
5	6/22/2011 9:47	28	0.19	0.336	0.041	0.0411	651.0
5	6/22/2011 9:48	29	0.2	0.435	0.054	0.0537	851.5
5	6/22/2011 9:49	30	0.2	0.407	0.052	0.0518	821.1
5	6/22/2011 9:50	31	0.2	0.416	0.053	0.0522	826.7
5	6/22/2011 9:51	32	0.19	0.445	0.054	0.0541	857.7
5	6/22/2011 9:52	33	0.2	0.375	0.047	0.0465	737.8
5	6/22/2011 9:53	34	0.2	0.364	0.046	0.0456	723.4
5	6/22/2011 9:54	35	0.2	0.391	0.049	0.0495	784.9
5	6/22/2011 9:55	36	0.2	0.399	0.05	0.0495	785.0
5	6/22/2011 9:56	37	0.2	0.289	0.036	0.0360	571.5
5	6/22/2011 9:57	38	0.2	0.319	0.039	0.0392	621.2
5	6/22/2011 9:58	39	0.19	0.294	0.036	0.0356	563.7
5	6/22/2011 9:59	40	0.2	0.248	0.031	0.0314	497.8
5	6/22/2011 10:00	41	0.19	0.229	0.027	0.0274	434.5
5	6/22/2011 10:01	42	0.19	0.159	0.019	0.0194	308.1
5	6/22/2011 10:02	43	0.2	0.169	0.022	0.0215	340.9
5	6/22/2011 10:03	44	0.19	0.170	0.021	0.0206	326.0
5	6/22/2011 10:04	45	0.18	0.154	0.018	0.0178	281.4
5	6/22/2011 10:05	46	0.18	0.095	0.012	0.0110	174.6
5	6/22/2011 10:06	47	0.19	0.095	0.006	0.0114	181.2
5	6/22/2011 10:07	48	0.2	0.095	0.006	0.0119	188.8
5	6/22/2011 10:08	49	0.19	0.095	0.006	0.0116	184.1
5	6/22/2011 10:09	50	0.2	0.095	0.006	0.0121	192.6
5	6/22/2011 10:10	51	0.2	0.095	0.004	0.0120	189.7
5	6/22/2011 10:11	52	0.21	0.095	0.004	0.0123	195.4

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m^3/s)	Calculated Flow rate (m^3/s)	Flow rate (gpm)
5	6/22/2011 10:12	53	0.22	0.033	0.004	0.0045	71.2
5	6/22/2011 10:13	54	0.22	0.043	0.006	0.0060	95.8
5	6/22/2011 10:14	55	0.23	0.043	0.006	0.0061	97.1
5	6/22/2011 10:15	56	0.22	0.040	0.006	0.0055	87.1
5	6/22/2011 10:16	57	0.2	0.040	0.004	0.0051	81.1
5	6/22/2011 10:17	58	0.2	0.040	0.004	0.0050	79.5
5	6/22/2011 10:18	59	0.19	0.040	0.004	0.0049	77.5
5	6/22/2011 10:19	60	0.19	0.040	0.004	0.0049	77.5
6	6/29/2011 8:40	0	0.18				
6	6/29/2011 8:41	1	0.18				
6	6/29/2011 8:42	2	0.18	0.064	0.007	0.0073	115.0
6	6/29/2011 8:43	3	0.18	0.076	0.008	0.0085	134.3
6	6/29/2011 8:44	4		0.069			
6	6/29/2011 8:45	5	0.18	0.077	0.009	0.0086	136.1
6	6/29/2011 8:46	6	0.18	0.060	0.007	0.0067	106.7
6	6/29/2011 8:47	7	0.18	0.082	0.009	0.0094	148.2
6	6/29/2011 8:48	8	0.19	0.093	0.011	0.0111	175.5
6	6/29/2011 8:49	9	0.19	0.144	0.017	0.0169	267.5
6	6/29/2011 8:50	10	0.18	0.116	0.013	0.0133	210.8
6	6/29/2011 8:51	11	0.18	0.123	0.014	0.0142	224.8
6	6/29/2011 8:52	12	0.19	0.151	0.018	0.0176	279.0
6	6/29/2011 8:53	13	0.18	0.190	0.022	0.0215	341.5
6	6/29/2011 8:54	14	0.19	0.154	0.018	0.0179	284.5
6	6/29/2011 8:55	15	0.18	0.204	0.024	0.0235	372.8
6	6/29/2011 8:56	16		0.194	0.022		
6	6/29/2011 8:57	17	0.19	0.287	0.035	0.0347	550.3
6	6/29/2011 8:58	18	0.19	0.357	0.042	0.0423	670.3
6	6/29/2011 8:59	19	0.18	0.405	0.046	0.0462	732.1
6	6/29/2011 9:00	20		0.516	0.059		
6	6/29/2011 9:01	21	0.16	0.553	0.056	0.0564	894.7
6	6/29/2011 9:02	22	0.16	0.548	0.054	0.0535	848.3
6	6/29/2011 9:03	23	0.16	0.514	0.05	0.0505	800.8
6	6/29/2011 9:04	24	0.15	0.531	0.051	0.0512	811.4
6	6/29/2011 9:05	25	0.15	0.591	0.056	0.0566	897.1
6	6/29/2011 9:06	26	0.15	0.610	0.058	0.0580	919.9
6	6/29/2011 9:07	27	0.15	0.529	0.051	0.0507	803.0
6	6/29/2011 9:08	28	0.14	0.479	0.043	0.0432	684.1
6	6/29/2011 9:09	29	0.1	0.641	0.038	0.0384	608.1
6	6/29/2011 9:10	30	0.09	0.651		0.0381	604.6
6	6/29/2011 9:11	31	0.12	0.557	0.041	0.0407	645.3
6	6/29/2011 9:12	32	0.13	0.400	0.032	0.0318	503.3
6	6/29/2011 9:13	33		0.412	0.033		
6	6/29/2011 9:14	34	0.12	0.476	0.036	0.0363	575.2
6	6/29/2011 9:15	35	0.12	0.469	0.034	0.0340	538.6
6	6/29/2011 9:16	36	0.11	0.406	0.029	0.0292	462.2
6	6/29/2011 9:17	37	0.12	0.413	0.03	0.0299	474.3
6	6/29/2011 9:18	38	0.11	0.416		0.0299	473.6
6	6/29/2011 9:19	39	0.12	0.443	0.032	0.0321	508.8
6	6/29/2011 9:20	40	0.12	0.447	0.033	0.0327	517.8
6	6/29/2011 9:21	41		0.443	0.032		
6	6/29/2011 9:22	42		0.446	0.033		
6	6/29/2011 9:23	43		0.450			
6	6/29/2011 9:24	44	0.12	0.441	0.032	0.0320	506.5

Event	Date+Time (CST)	Event Elapsed time (min)	Level (m)	Velocity (m/s)	Flow rate (m³/s)	Calculated Flow rate (m³/s)	Flow rate (gpm)
6	6/29/2011 9:25	45	0.11	0.369	0.026	0.0260	412.7
6	6/29/2011 9:26	46	0.12	0.399	0.029	0.0289	458.2
6	6/29/2011 9:27	47	0.11	0.376	0.025	0.0253	401.8
6	6/29/2011 9:28	48	0.12	0.326	0.024	0.0242	384.2
6	6/29/2011 9:29	49	0.11	0.308	0.022	0.0215	341.4
6	6/29/2011 9:30	50	0.11	0.256	0.017	0.0169	268.4
6	6/29/2011 9:31	51	0.11	0.209	0.014	0.0144	227.5
6	6/29/2011 9:32	52	0.11	0.215	0.015	0.0153	242.6
6	6/29/2011 9:33	53	0.11		0.014		
6	6/29/2011 9:34	54	0.1	0.105	0.007	0.0068	108.0
6	6/29/2011 9:35	55	0.11				
6	6/29/2011 9:36	56	0.11				
6	6/29/2011 9:37	57	0.11				
6	6/29/2011 9:38	58	0.12		0.008		
6	6/29/2011 9:39	59	0.11				
6	6/29/2011 9:40	60	0.11		0.007		

Appendix B-2: Insitu Level Troll

Date and Time (CT)	Pressure (PSI)	Tempera ture (C)	Depth (m)	BaroCalc Pressure (PSI)	BaroCalc Depth (m)	elapsed time (min)
EVENT 1						
3/15/2011 8:00	0.242	11.40	0.170	14.64	10.30	
3/15/2011 8:43	0.196	12.26	0.138	14.65	10.31	
3/15/2011 9:00	0.159	12.50	0.112	14.65	10.31	
3/15/2011 9:05	0.193	12.53	0.136	14.66	10.31	
3/15/2011 9:19			0.136			0
3/15/2011 9:31	0.281	12.85	0.197	14.66	10.31	12
3/15/2011 9:35	0.324	12.82	0.228	14.66	10.32	16
3/15/2011 9:36	0.346	12.84	0.243	14.66	10.32	17
3/15/2011 9:51	0.335	13.15	0.236	14.66	10.32	32
3/15/2011 9:53	0.284	13.17	0.200	14.66	10.32	34
3/15/2011 9:54	0.254	13.18	0.179	14.66	10.32	35
3/15/2011 10:00	0.229	13.22	0.161	14.66	10.32	41
3/15/2011 10:02	0.198	13.22	0.140	14.66	10.32	43
3/15/2011 10:03	0.243	13.21	0.171	14.66	10.32	44
3/15/2011 10:04	0.282	13.20	0.198	14.66	10.32	45
3/15/2011 10:05	0.308	13.20	0.217	14.66	10.32	46
3/15/2011 10:06	0.329	13.20	0.231	14.66	10.32	47
3/15/2011 10:07	0.300	13.20	0.211	14.66	10.32	48
3/15/2011 10:08	0.274	13.20	0.193	14.66	10.32	49
3/15/2011 10:18	0.308	13.21	0.217	14.66	10.32	59
3/15/2011 10:45	0.249	13.30	0.175	14.66	10.32	86
3/15/2011 10:49			0.175			90
EVENT 2						
4/12/2011 7:05	0.267	14.37	0.188	14.58	10.26	
4/12/2011 8:05	0.280	15.23	0.197	14.59	10.27	
4/12/2011 8:28	0.302	16.04	0.213	14.59	10.27	
4/12/2011 9:05	0.277	16.82	0.195	14.59	10.27	
4/12/2011 9:35	0.303	17.78	0.214	14.59	10.27	12
4/12/2011 9:36	0.283	17.72	0.199	14.59	10.27	13
4/12/2011 9:39	0.298	17.64	0.210	14.60	10.27	16
4/12/2011 9:45	0.275	17.82	0.194	14.60	10.27	22
4/12/2011 9:50	0.320	18.63	0.225	14.60	10.27	27
4/12/2011 9:51	0.347	18.70	0.244	14.60	10.27	28
4/12/2011 9:55	0.297	18.91	0.209	14.60	10.27	32
4/12/2011 9:56	0.249	18.88	0.175	14.60	10.27	33
4/12/2011 9:57	0.214	18.84	0.150	14.60	10.27	34

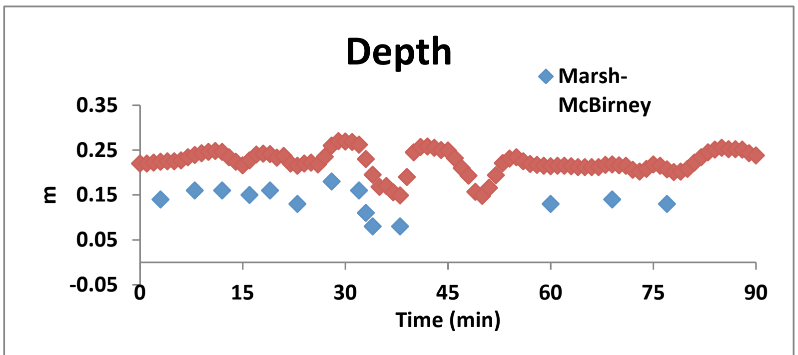
Date and Time (CT)	Pressure (PSI)	Temperature (C)	Depth (m)	BaroCalc Pressure (PSI)	BaroCalc Depth (m)	elapsed time (min)
4/12/2011 10:01	0.224	19.13	0.158	14.60	10.27	37
4/12/2011 10:02	0.292	19.09	0.206	14.60	10.27	38
4/12/2011 10:03	0.325	19.06	0.229	14.60	10.27	39
4/12/2011 10:05	0.330	18.98	0.232	14.60	10.28	41
4/12/2011 10:09	0.283	18.69	0.199	14.60	10.28	45
4/12/2011 10:10	0.253	18.67	0.178	14.60	10.27	46
4/12/2011 10:11	0.219	18.73	0.154	14.60	10.27	47
4/12/2011 10:12	0.187	18.81	0.132	14.60	10.27	48
4/12/2011 10:14	0.222	19.06	0.156	14.60	10.28	49
4/12/2011 10:15	0.262	19.21	0.184	14.60	10.28	50
4/12/2011 10:16	0.289	19.37	0.203	14.60	10.28	51
4/12/2011 10:19	0.280	19.73	0.197	14.60	10.28	54
4/12/2011 10:43	0.276	20.56	0.195	14.60	10.28	58
4/12/2011 10:44	0.299	20.52	0.210	14.60	10.28	59
4/12/2011 10:58	-0.006	19.47	-0.004	14.60	10.28	73
EVENT 5						
6/21/2011 19:16	0.285	21.41	0.201	14.50	10.21	
6/21/2011 20:16	0.284	21.11	0.200	14.51	10.21	
6/21/2011 21:16	0.283	20.84	0.199	14.51	10.21	
6/21/2011 22:16	0.287	20.53	0.202	14.51	10.21	
6/21/2011 23:16	0.285	20.24	0.200	14.51	10.21	
6/22/2011 0:16	0.284	20.10	0.200	14.51	10.21	
6/22/2011 1:16	0.287	19.93	0.202	14.52	10.22	
6/22/2011 2:16	0.285	19.81	0.201	14.51	10.21	
6/22/2011 3:16	0.286	19.71	0.202	14.51	10.21	
6/22/2011 4:16	0.286	19.62	0.201	14.52	10.22	
6/22/2011 5:16	0.286	19.51	0.201	14.53	10.22	
6/22/2011 6:16	0.285	19.44	0.201	14.53	10.23	
6/22/2011 7:16	0.287	19.51	0.202	14.53	10.23	
6/22/2011 8:16	0.283	19.65	0.199	14.53	10.23	
6/22/2011 8:28	0.265	19.82	0.187	14.53	10.23	
6/22/2011 9:16	0.220	20.31	0.155	14.53	10.23	-3
6/22/2011 9:20	0.272	20.31	0.192	14.53	10.23	1
6/22/2011 9:23	0.254	20.59	0.179	14.53	10.23	4
6/22/2011 9:32	0.261	23.53	0.183	14.53	10.22	13
6/22/2011 9:34	0.247	23.00	0.174	14.53	10.22	15
6/22/2011 10:01	0.241	22.00	0.169	14.53	10.23	42
6/22/2011 10:03	0.215	22.15	0.151	14.53	10.22	44
6/22/2011 10:08	0.240	23.30	0.169	14.53	10.23	49

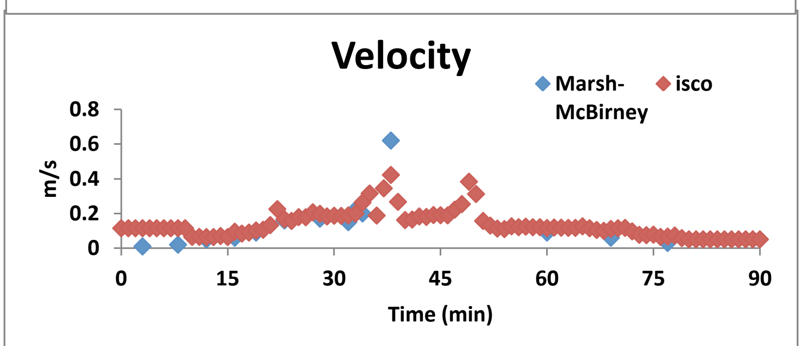
Date and Time (CT)	Pressure (PSI)	Temperature (C)	Depth (m)	BaroCalc Pressure (PSI)	BaroCalc Depth (m)	elapsed time (min)
6/22/2011 10:11	0.251	24.27	0.177	14.53	10.23	52
6/22/2011 10:16	0.254	25.39	0.179	14.53	10.23	57
EVENT 6						
6/29/2011 6:16	0.262	19.12	0.184	14.60	10.28	
6/29/2011 7:16	0.262	19.26	0.184	14.60	10.28	
6/29/2011 8:16	0.262	19.94	0.185	14.61	10.28	
6/29/2011 8:56	0.262	21.02	0.185	14.60	10.28	16
6/29/2011 9:11	0.263	22.56	0.185	14.61	10.28	31
6/29/2011 9:16	0.249	22.62	0.176	14.61	10.28	36
6/29/2011 9:26	0.239	22.94	0.168	14.61	10.28	46
6/29/2011 9:27	0.260	23.01	0.183	14.61	10.28	47

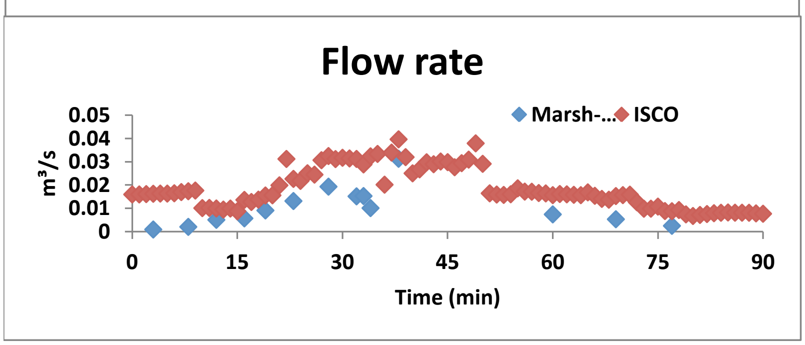
Appendix B-3: Marsh-McBirney Portable Flowmeter

EVENT 2

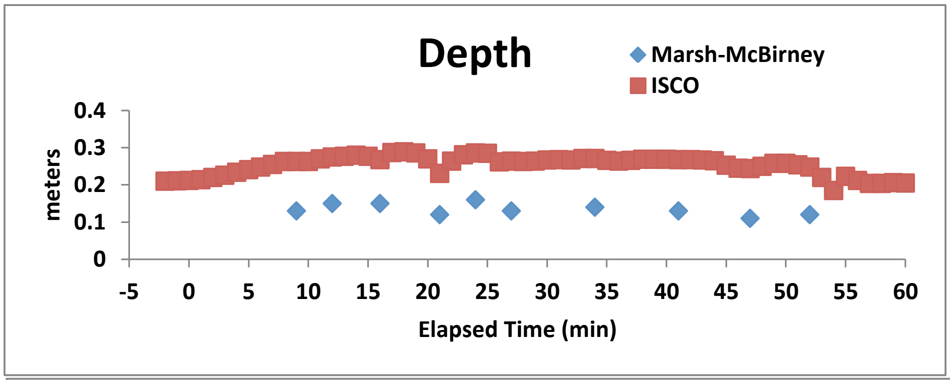
elapsed time (min)	depth (cm)	depth (m)	velocity (m/s)	calculated Flow rate (m³/s)
3	14	0.14	0.01	0.000882
8	16	0.16	0.02	0.002016
12	16	0.16	0.05	0.00504
16	15	0.15	0.06	0.00567
19	16	0.16	0.09	0.009072
23	13	0.13	0.16	0.013104
28	18	0.18	0.17	0.019278
32	16	0.16	0.15	0.01512
33	11	0.11	0.22	0.015246
34	8	0.08	0.2	0.01008
38	8	0.08	0.62	0.031248
60	13	0.13	0.09	0.007371
69	14	0.14	0.06	0.005292
77	13	0.13	0.03	0.002457

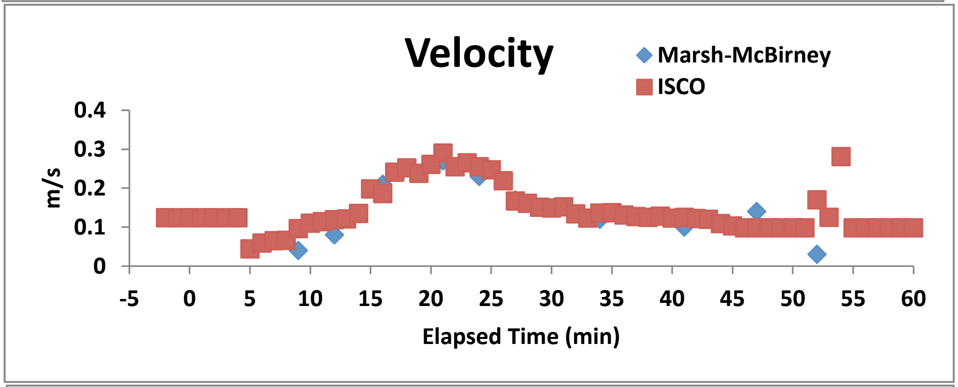


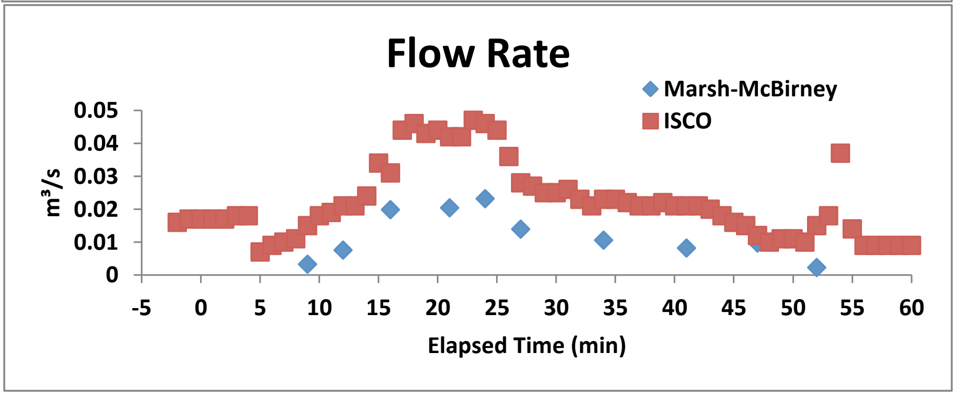




EVENT 3						
time	elapsed time	depth (cm)	depth (m)	velocity (cm/s)	velocity (m/s)	calculated flow rate (m^3/s)
9:03	9	13	0.13	4	0.04	0.003276
9:06	12	15	0.15	8	0.08	0.00756
9:10	16	15	0.15	21	0.21	0.019845
9:15	21	12	0.12	27	0.27	0.020412
9:18	24	16	0.16	23	0.23	0.023184
9:21	27	13	0.13	17	0.17	0.013923
9:28	34	14	0.14	12	0.12	0.010584
9:35	41	13	0.13	10	0.1	0.00819
9:41	47	11	0.11	14	0.14	0.009702
9:46	52	12	0.12	3	0.03	0.002268
		13.4				







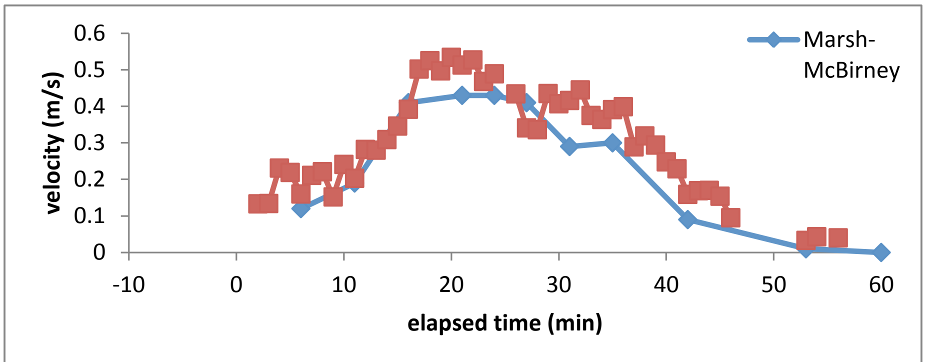
EVENT 4

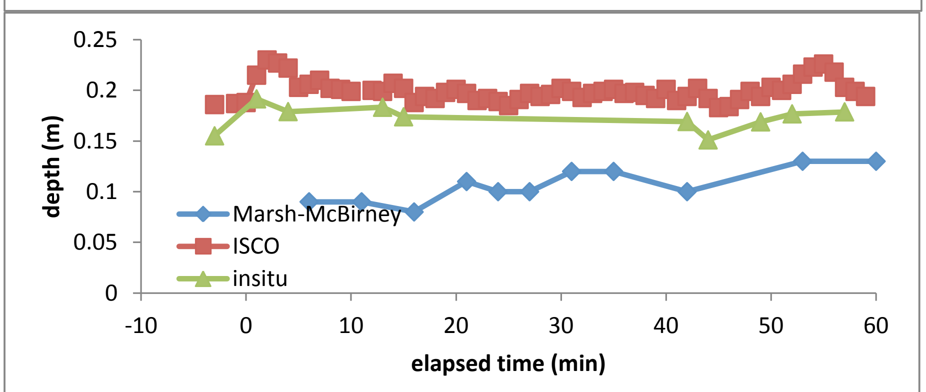
time	elapsed time	depth (cm)	depth (m)	velocity (cm/s)	velocity (m/s)	calculated flow rate (m^3/s)
10:11	6	8	0.08	3	0.03	0.001512
10:15	10	9	0.09	11	0.11	0.006237
10:20	15	10	0.1	14	0.14	0.00882
10:25	20	11	0.11	29	0.29	0.020097
10:28	23	11	0.11	34	0.34	0.023562
10:31	26	11	0.11	21	0.21	0.014553
10:35	30	10	0.1	34	0.34	0.02142
10:40	35	10	0.1	21	0.21	0.01323
10:48	43	10	0.1	10	0.1	0.0063
10:56	51	10	0.1	13	0.13	0.00819
11:05	60	8	0.08	1	0.01	0.000504

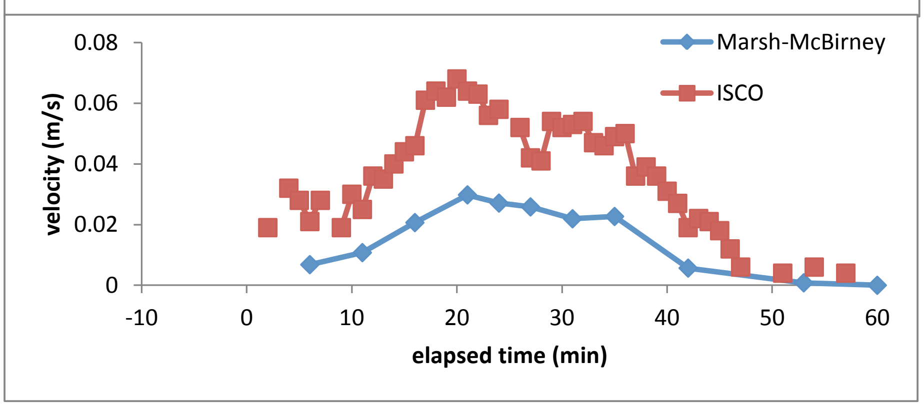
EVENT 6

time	elapsed time	depth (cm)	depth (m)	velocity (cm/s)	velocity (m/s)	calculated flow rate (m^3/s)
8:45	5	10	0.1	4	0.04	0.00252
8:50	10	11	0.11	3	0.03	0.002079
8:56	16	10	0.1	9	0.09	0.00567
9:01	21	9	0.09	46	0.46	0.026082
9:04	24	8	0.08	39	0.39	0.019656
9:07	27	8	0.08	41	0.41	0.020664
9:11	31	10	0.1	26	0.26	0.01638
9:16	36	11	0.11	30	0.3	0.02079
9:24	44	11	0.11	32	0.32	0.022176
9:31	51	11	0.11	14	0.14	0.009702
9:41	61	11	0.11	0	0	0

EVENT 5						
time	elapsed time	depth (cm)	depth (m)	velocity (cm/s)	velocity (m/s)	calculated flow rate (m^3/s)
9:25	6	9	0.09	12	0.12	0.006804
9:30	11	9	0.09	19	0.19	0.010773
9:35	16	8	0.08	41	0.41	0.020664
9:40	21	11	0.11	43	0.43	0.029799
9:43	24	10	0.1	43	0.43	0.02709
9:46	27	10	0.1	41	0.41	0.02583
9:50	31	12	0.12	29	0.29	0.021924
9:54	35	12	0.12	30	0.3	0.02268
10:01	42	10	0.1	9	0.09	0.00567
10:12	53	13	0.13	1	0.01	0.000819
10:19	60	13	0.13	0	0	0







APPENDIX C: SEDIMENT

Appendix C-1: Sieve Analysis

DAVIDSON CREEK

Sample ID:	DAV1; 8:24; 05/19/2011	Begin Date:	6/29/2011	End Date:	6/29/2011	
Drying method description:	Oven @ 50o C	Personnel:	AS			
Initial Sediment Weight (g):	20.0370					
Dish Number:	9052	Square Bottle Number:	NA	10 ml Dispersant Added (check):		
Dish Tare (g):	48.5078	Square Bottle Tare (g):		Dispersant Weight (~0.028g/25ml):		0.0000
Sand + Dish (g):	68.5448	Final Sample + Bottle Weight (g):		Water Volume (ml):	-0.0741	
Sand Weight (g):	20.0370	Silt and Clay in Bottle (g):	0.0741			

Sieve (mm)	Weight (g	% by Mass	% retaine	% finer
1.41	0.1080	0.537722744	0.53772	99.4623
0.5	0.9813	4.885808601	5.42353	94.5765
0.354	2.0937	10.42435287	15.8479	84.1521
0.25	6.1573	30.65666901	46.5046	53.4954
0.178	6.7728	33.72119076	80.2257	19.7743
0.125	3.0861	15.36542741	95.5912	4.40883
0.088	0.6444	3.208412374	98.7996	1.20042
0.063	0.1193	0.593984476	99.3936	0.60643
Pan	0.1218	0.606431761	100	0
TOTAL:	20.0847	100		

Coarse Pippette Dish Number:	NA
Coarse Pippette Dish Tare (g):	
Final Coarse Pippette Weight (g):	
Coarse Sediment Weight (g):	0.0000
Fine Pippette Dish Number:	NA
Fine Pippette Dish Tare (g):	
Final Fine Pippette Weight (g):	
Fine Sediment Weight (g):	0.0000
Residue Dish Number:	NA
Residue Dish Tare (g):	
Final Residue Weight (g):	
Residue Weight (g):	0.0000

Check: Light yellow squares must not exceed initial sample weight.

Course Sediment Settling Time : 1 min 50 sec
Course Sediment Pulloff Depth : 8 cm

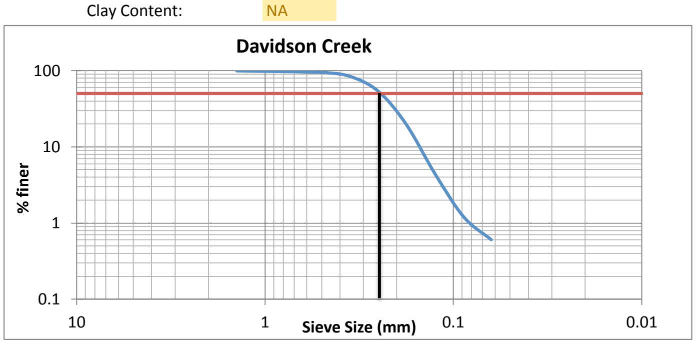
Enter Final Sample Total: #VALUE!

Fine Sediment Settling Time : 3 hrs 9 min 26 sec
Fine Sediment Pulloff Depth : 5 cm

Analysis Acceptance Initials:

Pulloff Ratio:	NA
Sand Content:	100.24
Coarse Silt Content:	NA
Fine Silt Content:	NA
Clay Content:	NA

Error: -0.24



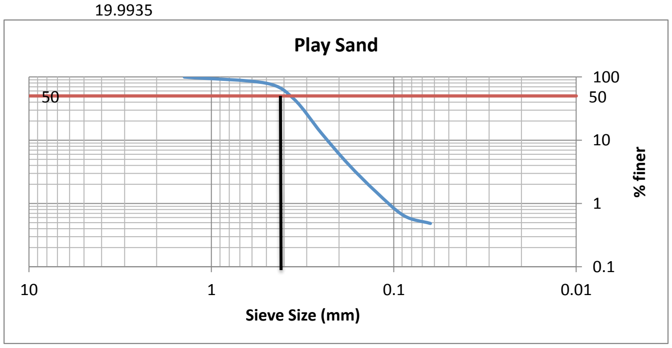
x	Y
0.01	50
10	50

d50= 0.257 mm

PLAYSAND

Sieve	mass retained (g)	% mass retained on each sieve	% retained	% finer
1.41	0.0252	0.126040963	0.12604	99.874
0.5	4.0088	20.05051642	20.1766	79.8234
0.354	6.9276	34.64926101	54.8258	45.1742
0.25	6.4283	32.15194938	86.9778	13.0222
0.178	1.764	8.822867432	95.8006	4.19936
0.125	0.5364	2.682871933	98.4835	1.51649
0.088	0.1753	0.876784955	99.3603	0.63971
0.063	0.0316	0.158051367	99.5183	0.48166
pan	0.0963	0.481656538	100	0
	19.9935			

x	Y
0.01	50
10	50



d50= 0.375 mm

LAKE PATSY

Sample ID: PAT; 8:58; 05/19/2011 Begin Date: 6/29/2011 End Date: 6/29/2011

Drying method description: Oven @ 50o C Personnel: AS

Initial Sediment Weight (g): 20.0269

Dish Number: X221 Square Bottle Number: NA 10 ml Dispersant Added (check):

Dish Tare (g): 48.4264 Square Bottle Tare (g): Dispersant Weight (~0.028g/25ml): 0.0000

Sand + Dish (g): 68.4533 Final Sample + Bottle Weight (g): Water Volume (ml): -1.7466

Sand Weight (g): 20.0269 Silt and Clay in Bottle (g): 1.7466

Sieve (mm)	Weight (g)	% by Mass	% retained	% finer
1.41	1.2817	1052.298851	1052.299	-952.299
0.5	4.1673	3421.428571	4473.727	-4373.73
0.354	3.1172	2559.277504	7033.005	-6933
0.25	4.4000	3612.479475	10645.48	-10545.5
0.178	3.1930	2621.510673	13267	-13167
0.125	1.4778	1213.300493	14480.3	-14380.3
0.088	0.4019	329.9671593	14810.26	-14710.3
0.063	0.2414	198.1937603	15008.46	-14908.5
Pan	1.6919	1389.08046	16397.54	-16297.5
TOTAL:	19.9722	16397.53695		

Coarse Pippette Dish Number:	NA
Coarse Pippette Dish Tare (g):	
Final Coarse Pippette Weight (g):	
Coarse Sediment Weight (g):	0.0000
Fine Pippette Dish Number:	NA
Fine Pippette Dish Tare (g):	
Final Fine Pippette Weight (g):	
Fine Sediment Weight (g):	0.0000
Residue Dish Number:	NA
Residue Dish Tare (g):	
Final Residue Weight (g):	
Residue Weight (g):	0.0000

Course Sediment Settling Time : 1 min 50 sec

Course Sediment Pulloff Depth : 8 cm

Check: Light yellow squares must not exceed initial sample weight.

Enter Final Sample Total: #VALUE!

Fine Sediment Settling Time : 3 hrs 9 min 26 sec

Fine Sediment Pulloff Depth : 5 cm

Analysis Acceptance Initials:

Pulloff Ratio: NA

Sand Content: 99.73

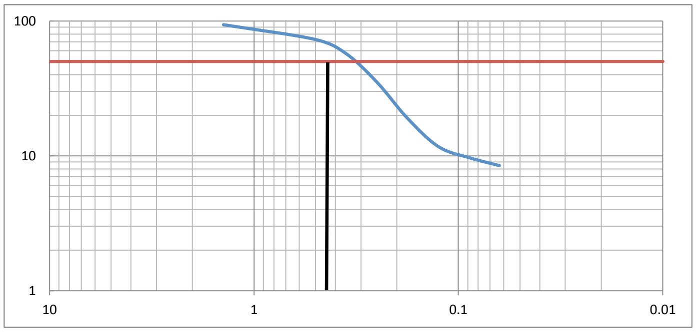
Coarse Silt Content: NA

Fine Silt Content: NA

Clay Content: NA

Error: 0.27

d_{50}= 0.325 mm



x	Y
0.01	50
10	50

NORTH MISSISSIPPI REGIONAL CENTER

Sample ID:	NMRC; 9:28; 05/19/2011		Begin Date:	6/29/2011	End Date:	6/29/2011	
Drying method description:	Oven @ 50o C		Personnel:	AS			
Initial Sediment Weight (g):		19.6411					
Dish Number:	505	Square Bottle Number:		NA	10 ml Dispersant Added (check):		
Dish Tare (g):	47.7866	Square Bottle Tare (g):			Dispersant Weight (~0.028g/25ml):		0.0000
Sand + Dish (g):	67.4277	Final Sample + Bottle Weight (g):			Water Volume (ml):	-0.0515	
Sand Weight (g):	19.6411	Silt and Clay in Bottle (g):		0.0515			

Sieve (mm)	Weight (g)	% by Mass	% retained	% finer
1.41	0.0161	13.2183908	13.21839	86.78161
0.5	4.0286	3307.553366	3320.772	-3220.77
0.354	9.0150	7401.477833	10722.25	-10622.2
0.25	5.8485	4801.724138	15523.97	-15424
0.178	0.6332	519.8686371	16043.84	-15943.8
0.125	0.0481	39.4909688	16083.33	-15983.3
0.088	0.0001	0.082101806	16083.42	-15983.4
0.063	0.0000	0	16083.42	-15983.4
Pan	0.0000	0	16083.42	-15983.4
TOTAL:	19.5896	16083.41544		

Coarse Pippette Dish Number:	NA
Coarse Pippette Dish Tare (g):	
Final Coarse Pippette Weight (g):	
Coarse Sediment Weight (g):	0.0000
Fine Pippette Dish Number:	NA
Fine Pippette Dish Tare (g):	
Final Fine Pippette Weight (g):	
Fine Sediment Weight (g):	0.0000
Residue Dish Number:	NA
Residue Dish Tare (g):	
Final Residue Weight (g):	
Residue Weight (g):	0.0000

Course Sediment Settling Time : 1 min 50 sec

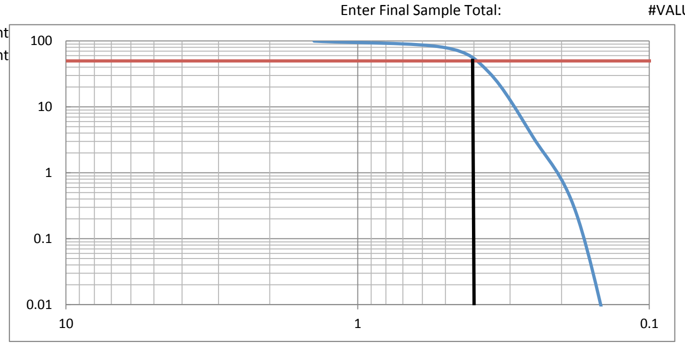
Check: Light yellow squares must not exceed initial sample weight.

Course Sediment Pulloff Depth : 8 cm

Enter Final Sample Total: #VALUE!

Fine Sediment

Fine Sediment



x	Y
0.01	50
10	50

d_{50}= 0.39 mm

PARADISE BEACH

Sample ID:	PAR; 10:20; 05/19/2011	Begin Date:	6/29/2011		End Date:	6/29/2011
Drying method description:	Oven @ 50o C	Personnel:	AS			
Initial Sediment Weight (g):	20.0149					
Dish Number:	583	Square Bottle Number:	NA	10 ml Dispersant Added (check):		
Dish Tare (g):	60.4912	Square Bottle Tare (g):		Dispersant Weight (~0.028g/25ml):		0.0000
Sand + Dish (g):	80.5061	Final Sample + Bottle Weight (g):		Water Volume (ml):	-0.3295	
Sand Weight (g):	20.0149	Silt and Clay in Bottle (g):	0.3295			

Sieve (mm)	Weight (g)	% by Mass	% retained	% finer
1.41	0.1071	87.93103448	87.93103	12.06897
0.5	3.1554	2590.640394	2678.571	-2578.57
0.354	4.6070	3782.430213	6461.002	-6361
0.25	6.3372	5202.955665	11663.96	-11564
0.178	3.3880	2781.609195	14445.57	-14345.6
0.125	1.4611	1199.589491	15645.16	-15545.2
0.088	0.4599	377.5862069	16022.74	-15922.7
0.063	0.1697	139.3267652	16162.07	-16062.1
Pan	0.2770	227.4220033	16389.49	-16289.5
TOTAL:	19.9624	16389.49097		

Coarse Pippette Dish Number:	NA
Coarse Pippette Dish Tare (g):	
Final Coarse Pippette Weight (g):	
Coarse Sediment Weight (g):	0.0000
Fine Pippette Dish Number:	NA
Fine Pippette Dish Tare (g):	
Final Fine Pippette Weight (g):	
Fine Sediment Weight (g):	0.0000
Residue Dish Number:	NA
Residue Dish Tare (g):	
Final Residue Weight (g):	
Residue Weight (g):	0.0000

Course Sediment Settling Time : 1 min 50 sec
Course Sediment Pulloff Depth : 8 cm

Check: Light yellow squares must not exceed initial sample weight.

Enter Final Sample Total: #VALUE!

Fine Sediment Settling Time : 3 hrs 9 min 26 sec
Fine Sediment Pulloff Depth : 5 cm

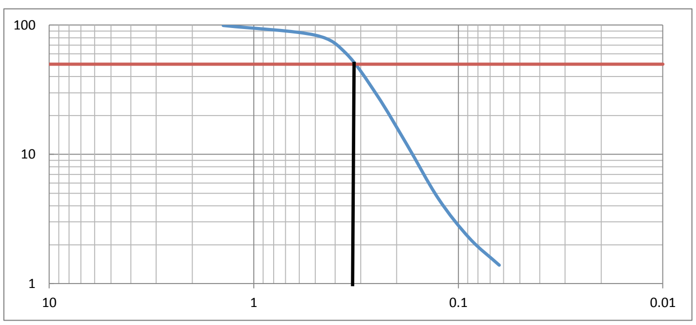
Analysis Acceptance Initials:

Pulloff Ratio:	NA
Sand Content:	99.74
Coarse Silt Content:	NA
Fine Silt Content:	NA
Clay Content:	NA

Error: 0.26

d_{50}= 0.32 mm

x	Y
0.01	50
10	50



THOMPSON CREEK

Sample ID:	TCR; 10:38; 05/19/2011	Begin Date:	6/29/2011	End Date:	6/29/2011	
Drying method description:	Oven @ 50o C	Personnel:	AS			
Initial Sediment Weight (g):	20.0372					
Dish Number:	531	Square Bottle Number:	NA	10 ml Dispersant Added (check):		
Dish Tare (g):	46.8433	Square Bottle Tare (g):		Dispersant Weight (~0.028g/25ml):	0.0000	
Sand + Dish (g):	66.8805	Final Sample + Bottle Weight (g):		Water Volume (ml):	-0.8254	
Sand Weight (g):	20.0372	Silt and Clay in Bottle (g):	0.8254			

Sieve (mm)	Weight (g)	% by Mass	% retained	% finer
1.41	0.0152	12.47947455	12.47947	87.52053
0.5	0.3442	282.5944171	295.0739	-195.074
0.354	2.0492	1682.430213	1977.504	-1877.5
0.25	6.3062	5177.504105	7155.008	-7055.01
0.178	5.8270	4784.07225	11939.08	-11839.1
0.125	3.5154	2886.206897	14825.29	-14725.3
0.088	0.9376	769.7865353	15595.07	-15495.1
0.063	0.2170	178.1609195	15773.23	-15673.2
Pan	0.7208	591.7898194	16365.02	-16265
TOTAL:	19.9326	16365.02463		

Coarse Pippette Dish Number:	NA
Coarse Pippette Dish Tare (g):	
Final Coarse Pippette Weight (g):	
Coarse Sediment Weight (g):	0.0000
Fine Pippette Dish Number:	NA
Fine Pippette Dish Tare (g):	
Final Fine Pippette Weight (g):	
Fine Sediment Weight (g):	0.0000
Residue Dish Number:	NA
Residue Dish Tare (g):	
Final Residue Weight (g):	
Residue Weight (g):	0.0000

Check: Light yellow squares must not exceed initial sample weight.

Course Sediment Settling Time : 1 min 50 sec

Course Sediment Pulloff Depth : 8 cm

Enter Final Sample Total: #VALUE!

Fine Sediment Settling Time : 3 hrs 9 min 26 sec

Fine Sediment Pulloff Depth : 5 cm

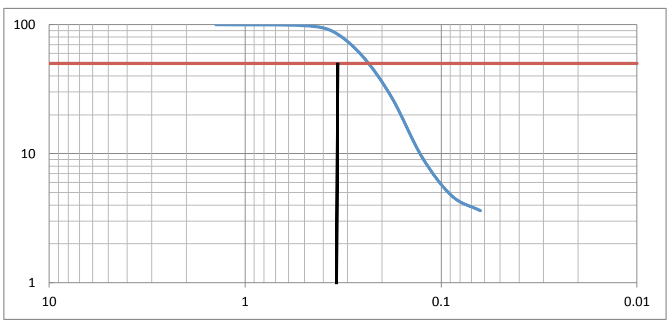
Analysis Acceptance Initials:

Pulloff Ratio:	NA
Sand Content:	99.48
Coarse Silt Content:	NA
Fine Silt Content:	NA
Clay Content:	NA

Error: 0.52

d_{50}= 0.24 mm

x	Y
0.01	50
10	50



Appendix C-2: Suspended Solids Data

Event 1	Date sampled		3/15/2011		
DISSOLVED SOLIDS					
Sample #	**Dish #**	**Net Wt. (g)**	**Tare Wt. (g)**	**Solids (mg/L)**	
1	136	46.4948	46.4920	28	
2	118	47.1336	47.1307	29	
3	710	36.6176	36.6151	25	
4	C-11	41.3837	41.3814	23	
5	521	34.9496	34.9473	23	
6	371	35.4347	35.4321	26	
7	C-9	39.3412	39.3388	24	
8	148	43.5986	43.5969	17	
9	228	41.3868	41.3847	21	
10	211	40.9166	40.9152	14	
11	119	47.4562	47.4548	14	
12	73	49.2502	49.2485	17	
13	B3	34.6508	34.6489	19	
14	197	40.2176	40.2159	17	
15	51	47.7835	47.7821	14	
16	690	38.2563	38.2539	24	
17	151	44.9716	44.9702	14	
18	688	34.9655	34.9638	17	
19	T-92	43.8145	43.8130	15	
20	195	49.2884	49.2869	15	
21	JG	40.1948	40.1932	16	
TOTAL SOLIDS					
Sample #	**Dish #**	**Net Wt. (g)**	**Tare Wt. (g)**	**Solids (mg/L)**	**SS = Total Solids - Dissolved Solids**
1	C-8	39.8861	39.8831	30	**2**
2	81	36.3723	36.3697	26	**-3**
3	202	40.4422	40.4400	22	**-3**
4	181	48.8554	48.8537	17	**-6**
5	825	43.4034	43.4014	20	**-3**
6	180	47.6599	47.6580	19	**-7**
7	137	44.1393	44.1373	20	**-4**
8	5	36.1209	36.1189	20	**3**
9	C-62	40.3445	40.3428	17	**-4**
10	C-12	42.2389	42.2374	15	**1**
11	138	43.8335	43.8320	15	**1**
12	A6	40.5253	40.5239	14	**-3**

13	C-10	43.1056	43.1045	11	**-8**
14	67	39.9143	39.9133	10	**-7**
15	R21	43.426	43.4236	24	**10**
16	810	34.9548	34.9534	14	**-10**
17	935	42.4251	42.4241	10	**-4**
18	142	43.5288	43.5274	14	**-3**
19	609	36.9748	36.9735	13	**-2**
20	412	36.931	36.9296	14	**-1**
21	501	33.8889	33.8877	12	**-4**

Event 2	Date sampled			4/12/2011
DISSOLVED SOLIDS				
Sample #	**Dish #**	**Net Wt. (g)**	**Tare Wt. (g)**	**Solids (mg/L)**
1	C-12	42.2415	42.2372	43
2	108	37.6618	37.6578	40
3	C-62	40.3460	40.3422	38
4	138	43.8353	43.8319	34
5	181	48.8556	48.8511	45
6	JG	40.1974	40.1933	41
7	142	43.5294	43.5254	40
8	A1	38.8262	38.8229	33
9	148	43.5996	43.5964	32
10	688	34.9677	34.9635	42
11	5	36.1227	36.1191	36
12	725	37.1624	37.1584	40
13	T92	43.8152	43.8110	42
14	412	36.9305	36.9269	36
15	86	43.0644	43.0605	39
16	119	47.4573	47.4538	35
17	825	43.4031	43.3993	38
18	136	46.4965	46.4925	40
19	72	43.1051	43.1008	43
20	A6	40.5270	40.5231	39
21	195	49.2903	49.2864	39
22	67	39.9164	39.9121	43
23	151	44.9752	44.9708	44
24	246	42.3063	42.3018	45
25	C-10	43.1080	43.1035	45
26	T-102	43.9772	43.9729	43
27	371	35.4341	35.4300	41
TOTAL SOLIDS				

Site #	Dish #	Net Wt. (g)	Tare Wt. (g)	Solids (mg/L)	SS = Total Solids - Dissolved Solids
1	137	44.1393	44.1353	40	**-3**
2	C-8	39.8879	39.8837	42	**2**
3	690	38.2568	38.2530	38	**0**
4	169/10	53.9487	53.9441	46	**12**
5	521	34.9505	34.9461	44	**-1**
6	710	36.6199	36.6155	44	**3**
7	211	40.9189	40.9149	40	**0**
8	180	47.6615	47.6577	38	**5**
9	51	47.7833	47.779	43	**11**
10	73	49.2534	49.2488	46	**4**
11	81	36.3708	36.3661	47	**11**
12	120	41.1682	41.164	42	**2**
13	C-44	40.6494	40.6447	47	**5**
14	R21	43.4258	43.4217	41	**5**
15	207	39.315	39.3106	44	**5**
16	B5	37.5213	37.5171	42	**7**
17	M	38.1709	38.1655	54	**16**
18	150	42.3777	42.3737	40	**0**
19	228	41.3885	41.3846	39	**-4**
20	935	42.4246	42.4207	39	**0**
21	810	34.9552	34.951	42	**3**
22	501	33.891	33.887	40	**-3**
23	525	36.716	36.7119	41	**-3**
24	C-9	39.3419	39.338	39	**-6**
25	118	47.1359	47.1323	36	**-9**
26	131	45.617	45.613	40	**-3**
27	154	43.6701	43.6653	48	**7**

Event 3	Date sampled		6/8/2011	
DISSOLVED SOLIDS				
Sample #	**Dish #**	**Net Wt. (g)**	**Tare Wt. (g)**	**Solids (mg/L)**
pre	120	41.1626	41.16	26
1	690	38.2489	38.2464	25
2	C-63	39.3812	39.3786	26
3	JG	40.1929	40.1902	27
4	RCL-7	44.3191	44.3164	27
5	195	49.2873	49.2845	28
6	R21	43.4203	43.4177	26
7	C-44	40.6444	40.6424	20

8	525	36.7126	36.7102	24
9	136	46.4924	46.4895	29
10	426	34.4776	34.4752	24
11	412	36.9263	36.9238	25
12	51	47.7776	47.7758	18
13	890	34.8360	34.8334	26
14	237	38.2571	38.2550	21
15	T-102	43.9723	43.9703	20
16	B6	38.8972	38.8951	21
17	86	43.0592	43.0572	20
18	173	53.1259	53.1240	19
19	501	33.8870	33.8845	25
20	T-92	43.8106	43.8084	22
21	825	43.4004	43.3982	22
22	181	48.8516	48.8492	24
23	244	42.4817	42.4793	24
24	202	40.4374	40.4349	25
25	C-61	42.2173	42.2152	21
26	831	38.2781	38.2758	23
27	J18	45.9510	45.9482	28
28	154	43.6639	43.6618	21
29	137	44.1333	44.1313	20
30	108	37.6557	37.6532	25
31	688	34.9617	34.9597	20
32	C-8	39.8846	39.8826	20
33	193	55.9656	55.9649	7

TOTAL SOLIDS

Site #	Dish #	Net Wt. (g)	Tare Wt. (g)	Solids (mg/L)	SS = Total Solids - Dissolved Solids
pre	246	42.3022	42.2990	32	**6**
1	A1	38.8236	38.8210	26	**1**
2	C-62	40.3375	40.3351	24	**-2**
3	C-22	40.6239	40.6209	30	**3**
4	609	36.9712	36.9686	26	**-1**
5	B3	34.6479	34.6459	20	**-8**
6	109	42.5483	42.5453	30	**4**
7	72	43.1015	43.0978	37	**17**
8	142	43.5289	43.5245	44	**20**
9	140	45.9144	45.9101	43	**14**
10	73	49.2484	49.2449	35	**11**
11	A3	35.3423	35.3387	36	**11**
12	735	43.7987	43.7939	48	**30**

13	211	40.9148	40.9113	35	**9**
14	119	47.4546	47.4513	33	**12**
15	197	40.2147	40.2099	48	**28**
16	67	39.9144	39.9111	33	**12**
17	C-51	39.5613	39.5581	32	**12**
18	228	41.3853	41.3816	37	**18**
19	148	43.5969	43.5933	36	**11**
20	150	42.3743	42.3708	35	**13**
21	132	44.202	44.1986	34	**12**
22	C-9	39.3393	39.3363	30	**6**
23	10/169	53.9446	53.9413	33	**9**
24	C-31	40.1852	40.1819	33	**8**
25	225	41.3682	41.3648	34	**13**
26	5	36.1195	36.1161	34	**11**
27	118	47.1313	47.1276	37	**9**
28	231	43.2312	43.2273	39	**18**
29	151	44.9727	44.9689	38	**18**
30	C-7	40.7077	40.7041	36	**11**
31	521	34.9466	34.9429	37	**17**
32	371	35.4326	35.4271	55	**35**
33	81	36.3713	36.3643	70	**63**

Event 4 Date sampled 6/15/2011

DISSOLVED SOLIDS

Sample #	Dish #	Net Wt. (g)	Tare Wt. (g)	Solids (mg/L)
pre	211	40.9165	40.914	25
1	501	33.8863	33.8836	27
2	JG	40.1925	40.1901	24
3	C-61	42.2195	42.2165	30
4	371	35.4287	35.4264	23
5	137	44.1337	44.1312	25
6	412	36.9267	36.9240	27
7	RCL-7	44.3173	44.3148	25
8	136	46.4890	46.4865	25
9	84	38.3206	38.3178	28
10	C-51	39.5595	39.5567	28
11	67	39.9138	39.9110	28
12	831	38.2798	38.2768	30
13	228	41.3803	41.3774	29
14	R21	43.4212	43.4182	30

15	C-44	40.6450	40.6422	28
16	73	49.2448	49.2420	28
17	B6	38.8963	38.8933	30
18	72	43.1010	43.0984	26
19	525	36.7146	36.7119	27
20	609	36.9706	36.9676	30
21	193	55.9683	55.9657	26
22	150	42.3736	42.3705	31
23	T-102	43.9686	43.9661	25
24	521	34.9431	34.9402	29
25	173	53.1231	53.1207	24
26	225	41.3663	41.3639	24
27	10/169	53.9438	53.9416	22
28	120	41.1603	41.1581	22
29	426	34.4771	34.4751	20
30	C-9	39.3353	39.3327	26
31	890	34.8328	34.8305	23
32	825	43.4001	43.3978	23
33	197	40.2115	40.2096	19

TOTAL SOLIDS

Sample #	Dish #	Net Wt. (g)	Tare Wt. (g)	Solids (mg/L)	SS = Total Solids - Dissolved Solids
pre	148	43.5953	43.5929	24	**-1**
1	237	38.2576	38.2546	30	**3**
2	51	47.7791	47.7756	35	**11**
3	119	47.4532	47.4496	36	**6**
4	C-31	40.185	40.1816	34	**11**
5	151	44.9706	44.9670	36	**11**
6	C-62	40.3383	40.3351	32	**5**
7	231	43.2300	43.2265	35	**10**
8	244	42.4823	42.4791	32	**7**
9	140	45.9137	45.9098	39	**11**
10	118	47.1313	47.127	43	**15**
11	132	44.2022	44.1981	41	**13**
12	688	34.964	34.9592	48	**18**
13	690	38.2502	38.2463	39	**10**
14	109	42.5492	42.545	42	**12**
15	5	36.1199	36.1149	50	**22**
16	246	42.3025	42.2992	33	**5**
17	195	49.2882	49.2844	38	**8**
18	86	43.0611	43.0568	43	**17**
19	C-7	40.7077	40.7031	46	**19**

20	A1	38.8244	38.8205	39	**9**
21	B3	34.65	34.6461	39	**13**
22	108	37.656	37.6529	31	**0**
23	154	43.6647	43.6615	32	**7**
24	C-8	39.8853	39.8816	37	**8**
25	A3	35.3421	35.338	41	**17**
26	202	40.4383	40.4346	37	**13**
27	J18	45.9515	45.9472	43	**21**
28	C-63	39.382	39.3786	34	**12**
29	181	48.8528	48.8489	39	**19**
30	142	43.5278	43.524	38	**12**
31	C-22	40.6243	40.621	33	**10**
32	81	36.3662	36.362	42	**19**
33	C-11	41.381	41.3771	39	**20**

Event 5 Date sampled 6/22/2011

DISSOLVED SOLIDS

Sample #	Dish #	Net Wt. (g)	Tare Wt. (g)	Solids (mg/L)
pre	81	36.365	36.3621	29
1	C-7	40.7065	40.7039	26
2	C-31	40.1845	40.1820	25
3	231	43.2298	43.2273	25
4	195	49.2871	49.2848	23
5	A1	38.8233	38.8209	24
6	51	47.7783	47.7753	30
7	RCL-7	44.3179	44.3150	29
8	154	43.6649	43.6622	27
9	501	33.8872	33.8844	28
10	C-61	42.2164	42.2137	27
11	150	42.3737	42.3711	26
12	890	34.8335	34.8309	26
13	A3	35.3412	35.3385	27
14	C-44	40.6434	40.6406	28
15	137	44.1339	44.1312	27
16	142	43.5268	43.5240	28
17	181	48.8517	48.8490	27
18	109	42.5481	42.5455	26
19	72	43.1003	43.0976	27
20	136	46.4903	46.4875	28
21	73	49.2460	49.2430	30

22	371	35.4285	35.4257	28	
23	67	39.9142	39.9116	26	
24	690	38.2491	38.2463	28	
25	228	41.3815	41.3788	27	
26	108	37.6555	37.6530	25	
27	688	34.9621	34.9597	24	
28	C-62	40.3373	40.3352	21	
29	525	36.7104	36.7085	19	
30	197	40.2119	40.2096	23	
31	86	43.0591	43.0568	23	
32	36	38.8962	38.8941	21	
33	246	42.3021	42.2997	24	

TOTAL SOLIDS

Site #	Dish #	Net Wt. (g)	Tare Wt. (g)	Solids (mg/L)	SS = Total Solids - Dissolved Solids
pre	119	47.4527	47.4499	28	**-1**
1	C-9	39.3360	39.3327	33	**7**
2	5	36.118	36.1150	30	**5**
3	140	45.9134	45.9101	33	**8**
4	151	44.9707	44.9681	26	**3**
5	J18	45.9505	45.9478	27	**3**
6	521	34.9443	34.9414	29	**-1**
7	C-11	41.3816	41.3774	42	**13**
8	211	40.9211	40.9109	102	**75**
9	10/169	53.9815	53.9402	413	**385**
10	C-22	40.6399	40.6203	196	**169**
11	173	53.1284	53.1212	72	**46**
12	244	42.4897	42.4794	103	**77**
13	609	36.9761	36.9681	80	**53**
14	831	38.2863	38.2735	128	**100**
15	B3	34.6564	34.6463	101	**74**
16	412	36.9314	36.9243	71	**43**
17	T-102	43.973	43.9667	63	**36**
18	825	43.4061	43.3984	77	**51**
19	JG	40.1957	40.1905	52	**25**
20	426	34.4785	34.4731	54	**26**
21	148	43.5988	43.5932	56	**26**
22	C-51	39.5607	39.5564	43	**15**
23	118	47.1319	47.1277	42	**16**
24	132	44.2046	44.1986	60	**32**
25	225	41.3665	41.3625	40	**13**
26	128	47.1959	47.1927	32	**7**

27	C-63	39.3812	39.3782	30	**6**
28	120	41.1621	41.1588	33	**12**
29	C-8	39.8851	39.8821	30	**11**
30	202	40.4372	40.4346	26	**3**
31	R21	43.421	43.4181	29	**6**
32	237	38.2578	38.2549	29	**8**
33	193	55.9681	55.9643	38	**14**

Event 6 Date sampled 6/29/2011

DISSOLVED SOLIDS

Sample #	Dish #	Net Wt. (g)	Tare Wt. (g)	Solids (mg/L)
pre	246	36.9697	36.9662	35
1	225	40.3381	40.3350	31
2	525	44.3177	44.3143	34
3	154	40.1851	40.1819	32
4	690	38.2585	38.2554	31
5	C-22	45.9503	45.9471	32
6	173	39.3391	39.3356	35
7	831	36.1174	36.1145	29
8	C-63	53.9425	53.9399	26
9	119	39.9129	39.9101	28
10	371	48.8529	48.8499	30
11	197	47.1944	47.1914	30
12	202	34.8328	34.8299	29
13	A3	42.3724	42.3695	29
14	37	40.6406	40.6377	29
15	140	41.3809	41.3781	28
16	C-11	43.9682	43.9655	27
17	426	46.4899	46.4870	29
18	109	44.2011	44.1980	31
19	B6	34.6488	34.6457	31
20	81	42.4810	42.4781	29
21	521	34.9637	34.9609	28
22	86	43.4013	43.3985	28
23	193	39.8841	39.8812	29
24	A1	43.0994	43.0964	30
25	C-61	40.1904	40.1874	30
26	151	40.7056	40.7028	28
27	148	39.5579	39.5550	29
28	73	36.9255	36.9229	26

29	R21	40.9129	40.9103	26	
30	120	47.1305	47.1281	24	
31	51	49.2870	49.2844	26	
32	231	43.5253	43.5227	26	
33	501	37.6543	37.6518	25	

TOTAL SOLIDS

Site #	Dish #	Net Wt. (g)	Tare Wt. (g)	Solids (mg/L)	SS = Total Solids - Dissolved Solids
pre	609	42.3026	42.2995	31	**-4**
1	C-62	41.3664	41.3629	35	**4**
2	RCL-7	36.7101	36.7070	31	**-3**
3	C-31	43.6649	43.6615	34	**2**
4	237	38.2489	38.2454	35	**4**
5	J18	40.6240	40.6190	50	**18**
6	C-9	53.1266	53.119	76	**41**
7	5	38.2745	38.2707	38	**9**
8	10/169	39.3801	39.3757	44	**18**
9	67	47.4507	47.4462	45	**17**
10	181	35.4269	35.4227	42	**12**
11	128	40.2178	40.2112	66	**36**
12	890	40.4428	40.4335	93	**64**
13	150	35.3437	35.3389	48	**19**
14	C-44	44.1361	44.1311	50	**21**
15	228	45.9145	45.9096	49	**21**
16	T-102	41.3808	41.3771	37	**10**
17	136	34.477	34.4724	46	**17**
18	132	42.551	42.5455	55	**24**
19	B3	38.8984	38.8938	46	**15**
20	244	36.3676	36.3624	52	**23**
21	688	34.9453	34.94	53	**25**
22	825	43.0608	43.0567	41	**13**
23	C-8	55.9674	55.9634	40	**11**
24	72	38.8249	38.8206	43	**13**
25	JG	42.2163	42.2124	39	**9**
26	C-7	44.9718	44.9673	45	**17**
27	C-51	43.5978	43.5928	50	**21**
28	412	49.2472	49.2431	41	**15**
29	211	43.4205	43.4165	40	**14**
30	118	41.1606	41.1568	38	**14**
31	195	47.7795	47.7754	41	**15**
32	142	43.231	43.2273	37	**11**
33	108	33.8882	33.8843	39	**14**

Appendix C-3: Sand depth profiles and eroded Volume

NOTES:

***distance from top of artificial stream wall to bed in cm**

***measurements from upstream sampling point downstream at ~ 30 cm intervals**

prior to 6/8/11 experiment			**following 6/15/11 experiment**			**prior to 6/22/11 experiment**		
station	Left side	Right side	station	Left side	Right side	station	Left side	Right side
1	30.4	30.3	1	29.5	30.0	1	30.5	30.0
2	30.1	30	2	30.5	30.5	2	30.5	30.0
3	19.3		3	28.5	24.0	3	26.0	25.5
4	13.9	14.5	4	16.0	23.5	4	18.5	20.5
5	13.6		5	14.0	24.5	5	17.5	18.5
6	14.1	13.2	6	14.0	23.5	6	18.0	18.0
7	18.1	16.4	7	17.0	22.5	7	19.0	18.5
8	17	19	8	20.5	19.0	8	21.5	23.5
9	30.1	30	9	29.5	30.0	9	29.5	30.5
10	30.2	30.3	10	30.5	30.0	10	30.0	30.5
horizontal distance, m	height of bed above bottom of stream, cm		horizontal distance, m	height of bed above bottom of stream, cm		horizontal distance, m	height of bed above bottom of stream, cm	
0.00	0.1	0.2	0.00	1.0	0.5	0.00	0.0	0.5
0.28	0.4	0.5	0.30	0.0	0.0	0.35	0.0	0.5
0.56	11.2		0.60	2.0	6.5	0.70	4.5	5.0
0.84	16.6	16	0.90	14.5	7.0	1.05	12.0	10.0
1.12	16.9		1.20	16.5	6.0	1.40	13.0	12.0
1.40	16.4	17.3	1.50	16.5	7.0	1.75	12.5	12.5
1.68	12.4	14.1	1.80	13.5	8.0	2.10	11.5	12.0
1.96	13.5	11.5	2.10	10.0	11.5	2.45	9.0	7.0
2.24	0.4	0.5	2.40	1.0	0.5	2.80	1.0	0.0
2.52	0.3	0.2	2.70	0.0	0.5	3.15	0.5	0.0

following 6/22/11 experiment			**prior to 6/29/11 experiment**			**following 6/29/11 experiment**		
station	Left side	Right side	station	Left side	Right side	station	Left side	Right side
1	30.0	30.0	1	30.5	30.0	1	30.5	30.5
2	30.0	30.0	2	30.5	30.0	2	30.5	30.5
3	25.5	24.0	3	26.0	26.5	3	21.5	25.0
4	19.5	20.0	4	19.5	21.0	4	21.0	21.0
5	19.0	22.0	5	19.5	19.5	5	19.5	23.5
6	19.0	21.0	6	20.5	20.5	6	20.5	25.5
7	20.0	21.5	7	18.0	20.5	7	21.5	22.0
8	23.0	25.5	8	19.0	22.0	8	22.0	22.0

9	29.5	30.0	9	24.5	29.5	9	29.5	30.0
10	30.0	30.0	10	30.0	30.0			
horizontal distance, m	height of bed above bottom of stream, cm		horizontal distance, m	height of bed above bottom of stream, cm		horizontal distance, m	height of bed above bottom of stream, cm	
0.00	0.5	0.5	0.00	0.0	0.5	0.00	0.0	0.0
0.40	0.5	0.5	0.50	0.0	0.5	0.60	0.0	0.0
0.80	5.0	6.5	1.00	4.5	4.0	1.20	9.0	5.5
1.20	11.0	10.5	1.50	11.0	9.5	1.80	9.5	9.5
1.60	11.5	8.5	2.00	11.0	11.0	2.40	11.0	7.0
2.00	11.5	9.5	2.50	10.0	10.0	3.00	10.0	5.0
2.40	10.5	9.0	3.00	12.5	10.0	3.60	9.0	8.5
2.80	7.5	5.0	3.50	11.5	8.5	4.20	8.5	8.5
3.20	1.0	0.5	4.00	6.0	1.0	4.80	1.0	0.5
3.60	0.5	0.5	4.50	0.5	0.5			

Trapezoidal Integration

inputs:
a = value of lower integration limit
b = value of upper integration limit
n = number of steps
f(x) = the function to be integrated

prior to event 3

a	b	n		h
0.00	2.52	9		0.28

x	f(x) left	f(x) right	Trapezoidal Area left	Trapezoidal Area right		
0.00	0.001	0.002				
0.28	0.004	0.005	0.0007	0.00098		
0.56	0.112	0.0825	0.01624	0.01225		
0.84	0.166	0.16	0.03892	0.03395		
1.12	0.169	0.1665	0.0469	0.04571		
1.40	0.164	0.173	0.04662	0.04753		
1.68	0.124	0.141	0.04032	0.04396		
1.96	0.135	0.115	0.03626	0.03584		
2.24	0.004	0.005	0.01946	0.0168		
2.52	0.003	0.002	0.00098	0.00098		
		sum=	**0.2464**	**0.238**	**average area=**	**0.2422 m²**
					volume =	**0.15259 m³**

following event 3

a	b	n		h
0.00	2.61	9		0.29

x	f(x) left	f(x) right	Trapezoidal Area left	Trapezoidal Area right		
0.00	0.0055	0.006				
0.29	0.002	0.0025	0.0010875	0.0012325		
0.58	0.066	0.05125	0.00986	0.0077938		
0.87	0.1555	0.1525	0.0321175	0.0295438		
1.16	0.167	0.16575	0.0467625	0.0461463		
1.45	0.1645	0.169	0.0480675	0.0485388		
1.74	0.1295	0.138	0.04263	0.044515		
2.03	0.1175	0.1075	0.035815	0.0355975		
2.32	0.007	0.0075	0.0180525	0.016675		
2.61	0.0015	0.001	0.0012325	0.0012325		
		sum=	**0.235625**	**0.231275**	**average area=**	**0.23345 m²**
					volume =	**0.14707 m³**

volume of sand eroded off the bed during the event = 0.00551 m³

Trapezoidal Integration

inputs:
a = value of lower integration limit
b = value of upper integration limit
n = number of steps
f(x) = the function to be integrated

prior to event 4

a	b	n	h
0.00	2.61	9	0.29

x	f(x) left	f(x) right	Trapezoidal Area left	Trapezoidal Area right
0.00	0.0055	0.006		
0.29	0.002	0.0025	0.0010875	0.0012325
0.58	0.066	0.05125	0.00986	0.00779375
0.87	0.1555	0.1525	0.0321175	0.02954375
1.16	0.167	0.16575	0.0467625	0.04614625
1.45	0.1645	0.169	0.0480675	0.04853875
1.74	0.1295	0.138	0.04263	0.044515
2.03	0.1175	0.1075	0.035815	0.0355975
2.32	0.007	0.0075	0.0180525	0.016675
2.61	0.0015	0.001	0.0012325	0.0012325
		sum=	**0.235625**	**0.231275**

average area = 0.23345 m²

volume = 0.14707 m³

following event 4

a	b	n	h
0.00	2.70	9	0.3

x	f(x) left	f(x) right	Trapezoidal Area left	Trapezoidal Area right
0.00	0.01	0.005		
0.30	0	0	0.0015	0.00075
0.60	0.02	0.065	0.003	0.00975
0.90	0.145	0.07	0.02475	0.02025
1.20	0.165	0.06	0.0465	0.0195
1.50	0.165	0.07	0.0495	0.0195
1.80	0.135	0.08	0.045	0.0225
2.10	0.1	0.115	0.03525	0.02925
2.40	0.01	0.005	0.0165	0.018
2.70	0	0.005	0.0015	0.0015
		sum=	**0.2235**	**0.141**

average area = 0.18225 m²

volume = 0.11482 m³

volume of sand eroded off the bed during the event = 0.03226 m³

Trapezoidal Integration		inputs:	a = value of lower integration limit
			b = value of upper integration limit
			n = number of steps
			f(x) = the function to be integrated

prior to event 5

a	b	n		h
0.00	3.15	9		0.35

x	f(x) left	f(x) right	Trapezoidal Area left	Trapezoidal Area right		
0.00	0	0.005				
0.35	0	0.005	0	0.00175		
0.70	0.045	0.05	0.007875	0.009625		
1.05	0.12	0.1	0.028875	0.02625		
1.40	0.13	0.12	0.04375	0.0385		
1.75	0.125	0.125	0.044625	0.042875		
2.10	0.115	0.12	0.042	0.042875		
2.45	0.09	0.07	0.035875	0.03325		
2.80	0.01	0	0.0175	0.01225		
3.15	0.005	0	0.002625	0		
		sum=	**0.223125**	**0.207375**	**average area =**	**0.21525 m^2**
					volume =	**0.135608 m^3**

following event 5

a	b	n		h
0.00	3.60	9		0.4

x	f(x) left	f(x) right	Trapezoidal Area left	Trapezoidal Area right		
0.00	0.005	0.005				
0.40	0.005	0.005	0.00175	0.00175		
0.80	0.05	0.065	0.009625	0.01225		
1.20	0.11	0.105	0.028	0.02975		
1.60	0.115	0.085	0.039375	0.03325		
2.00	0.115	0.095	0.04025	0.0315		
2.40	0.105	0.09	0.0385	0.032375		
2.80	0.075	0.05	0.0315	0.0245		
3.20	0.01	0.005	0.014875	0.009625		
3.60	0.005	0.005	0.002625	0.00175		
		sum=	**0.2065**	**0.17675**	**average area =**	**0.191625 m^2**
					volume =	**0.120724 m^3**

volume of sand eroded off the bed during the event = 0.014884 m^3

Trapezoidal Integration

inputs:
a = value of lower integration limit
b = value of upper integration limit
n = number of steps
f(x) = the function to be integrated

prior to event 6

a	b	n		h
0.00	4.50	9		0.5

x	f(x) left	f(x) right	Trapezoidal Area left	Trapezoidal Area right
0	0	0.005		
0.5	0	0.005	0	0.0025
1	0.045	0.04	0.01125	0.01125
1.5	0.11	0.095	0.03875	0.03375
2	0.11	0.11	0.055	0.05125
2.5	0.1	0.1	0.0525	0.0525
3	0.125	0.1	0.05625	0.05
3.5	0.115	0.085	0.06	0.04625
4	0.06	0.01	0.04375	0.02375
4.5	0.005	0.005	0.01625	0.00375
		sum =	**0.33375**	**0.275**

average area = 0.304375 m²
Volume = 0.191756 m³

following event 6

a	b	n		h
0.00	4.80	8		0.4

interpolated in matlab

x	f(x) left	f(x) right	Trapezoidal Area left	Trapezoidal Area right
0	0	0		
0.4	0	0	0	0
0.8	0.03	0.0183	0.006	0.00366
1.2	0.09	0.055	0.024	0.01466
1.6	0.0933	0.0817	0.03666	0.02734
2	0.1	0.0867	0.03866	0.03368
2.4	0.11	0.07	0.042	0.03134
2.8	0.1033	0.0567	0.04266	0.02534
3.2	0.0967	0.0617	0.04	0.02368
3.6	0.09	0.085	0.03734	0.02934
4	0.0867	0.085	0.03534	0.034
4.4	0.06	0.0583	0.02934	0.02866
4.8	0.01	0.005	0.014	0.01266
			0.22998	**0.1597**

average area = 0.19484 m²
Volume = 0.122749 m³

volume of sand eroded off the bed during the event = 0.069007 m³

Appendix C-4: Suspended Solids Transport

Event3	dsd-us
t	C_{SS} (mg/L)
5	2
10	5
15	-3
20	19
23	19
26	6
30	1
35	2
43	-4
51	-7
53	46

Δt =	60	s
Wt =	1.55	Mg/m³
	1.6E+09	mg/m³

t	vel (m/s)	d (m)	Q (m^3/s)	interpolated in Matlab C_{SS} (mg/L)	QiCiΔt (mg)
5	0.044	0.241	0.00668	2	801.6624
6	0.059	0.248	0.00922	2.6	1438.03296
7	0.065	0.255	0.01044	3.2	2004.912
8	0.066	0.263	0.01094	3.8	2493.30312
9	0.096	0.263	0.01591	4.4	4199.24736
10	0.11	0.263	0.01823	5	5467.77
11	0.114	0.27	0.01939	3.4	3955.8456
12	0.119	0.275	0.02062	1.8	2226.609
13	0.121	0.277	0.02112	0.2	253.38852
14	0.135	0.28	0.02381	-1.4	-2000.376
15	0.198	0.277	0.03455	-3	-6219.5364
16	0.186	0.268	0.0314	1.4	2637.95616
17	0.241	0.287	0.04358	5.8	15164.1731
18	0.252	0.289	0.04588	10.2	28079.5637
19	0.238	0.286	0.04288	14.6	37565.3678
20	0.261	0.27	0.0444	19	50611.554
21	0.29	0.231	0.0422	19	48112.218
22	0.255	0.264	0.04241	19	48349.224
23	0.265	0.281	0.04691	19	53480.763
24	0.255	0.286	0.04595	14.6667	40432.4839
25	0.247	0.285	0.04435	10.3333	27496.1983
26	0.219	0.262	0.03615	6	13013.3304
27	0.167	0.264	0.02778	4.75	7916.0004
28	0.161	0.263	0.02668	3.5	5601.9789
29	0.151	0.264	0.02511	2.25	3390.4332
30	0.149	0.267	0.02506	1	1503.7974
31	0.152	0.268	0.02566	1.2	1847.78496
32	0.134	0.267	0.02254	1.4	1893.37176
33	0.123	0.271	0.021	1.6	2015.97984
34	0.136	0.271	0.02322	1.8	2507.68224
35	0.137	0.266	0.02296	2	2755.0152
36	0.131	0.264	0.02179	1.25	1634.094
37	0.127	0.266	0.02128	0.5	638.4798
38	0.125	0.269	0.02118	-0.25	-317.75625
39	0.128	0.269	0.02169	-1	-1301.5296
40	0.123	0.269	0.02084	-1.75	-2188.70505
41	0.125	0.268	0.02111	-2.5	-3165.75
42	0.122	0.268	0.0206	-3.25	-4016.7036
43	0.12	0.267	0.02019	-4	-4844.448
44	0.109	0.265	0.0182	-4.375	-4776.85688
45	0.103	0.253	0.01642	-4.75	-4678.89345
46	0.098	0.245	0.01513	-5.125	-4651.33725
47	0.098	0.244	0.01506	-5.5	-4971.3048
48	0.098	0.25	0.01544	-5.875	-5440.8375
49	0.098	0.258	0.01593	-6.25	-5973.345
50	0.098	0.258	0.01593	-6.625	-6331.7457
51	0.098	0.254	0.01568	-7	-6586.4232
52	0.17	0.248	0.02656	19.5	31076.136
53	0.125	0.22	0.01733	46	47817
				∑=	430915.808 mg
				∑/Wt =	0.00027801 m³

volume of sand eroded off the bed during the event = 0.0055125 m³

19.8284092

Event4	dsd-us
t	C_{SS} (mg/L)
5	3
10	-6
15	1
20	3
23	12
26	12
30	-6
35	8
43	4
51	0
60	10

Δt =	60	s
Wt =	1.55	Mg/m³
	1.6E+09	mg/m³

interpolated in Matlab				interpolated in Matlab	
time	vel	depth	Q (m³/s)	C_{SS} (mg/L)	QiCiΔt (mg)
5	0.154	0.184	0.01785	3	3213.3024
6	0.14	0.193	0.01702	1.2	1225.6272
7	0.179	0.207	0.02334	-0.6	-840.36204
8	0.22	0.209	0.02897	-2.4	-4171.3056
9	0.288	0.181	0.03284	-4.2	-8275.8413
10	0.237	0.193	0.02882	-6	-10374.059
11	0.206	0.198	0.0257	-4.6	-7092.2174
12	0.236	0.205	0.03048	-3.2	-5852.0448
13	0.348	0.205	0.04494	-1.8	-4853.9736
14	0.317	0.18	0.03595	-0.4	-862.7472
15	0.344	0.196	0.04248	1	2548.6272
16	0.284	0.205	0.03668	1.4	3081.0024
17	0.313	0.228	0.04496	1.8	4855.6066
18	0.342	0.218	0.04697	2.2	6200.077
19	0.498	0.21	0.06589	2.6	10278.122
20	0.557	0.212	0.07439	3	13390.726
21	0.473	0.208	0.06198	6	22313.491
22	0.546	0.205	0.07052	9	38078.586
23	0.5625	0.192	0.06804	12	48988.8
24	0.579	0.197	0.07186	12	51738.977
25	0.543	0.203	0.06944	12	49999.874
26	0.545	0.202	0.06936	12	49936.824
27	0.553	0.2	0.06968	7.5	31355.1
28	0.511	0.203	0.06535	3	11763.322
29	0.531	0.204	0.06824	-1.5	-6141.9708
30	0.561	0.198	0.06998	-6	-25192.49
31	0.516	0.199	0.06469	-3.2	-12420.657
32	0.48	0.201	0.06078	-0.4	-1458.7776
33	0.531	0.195	0.06523	2.4	9393.6024
34	0.488	0.187	0.05749	5.2	17937.279
35	0.432	0.193	0.05253	8	25212.902
36	0.399	0.197	0.04952	7.5	22283.951
37	0.378	0.2	0.04763	7	20003.76
38	0.387	0.192	0.04681	6.5	18256.493
39	0.371	0.183	0.04277	6	15398.132
40	0.324	0.19	0.03878	5.5	12798.324
41	0.311	0.192	0.03762	5	11285.568
42	0.31	0.188	0.03672	4.5	9913.428
43	0.249	0.19	0.02981	4	7153.272
44	0.207	0.206	0.02686	3.5	5641.5366
45	0.241	0.208	0.03158	3	5684.5152
46	0.265	0.201	0.03356	2.5	5033.5425
47	0.288	0.196	0.03556	2	4267.4688
48	0.296	0.193	0.03599	1.5	3239.1576
49	0.282	0.192	0.03411	1	2046.6432
50	0.266	0.191	0.03201	0.5	960.2334
51	0.263	0.197	0.03264	0	0
52	0.243	0.199	0.03046	1.1111	2030.9737
53	0.232	0.183	0.02675	2.2222	3566.2683
54	0.232	0.17	0.02485	3.3333	4969.3903
55	0.232	0.159	0.02324	4.4444	6197.122
56	0.033	0.169	0.00351	5.5556	1171.1794
57	0.033	0.17	0.00353	6.6667	1413.7271
58	0.033	0.17	0.00353	7.7778	1649.3447
59	0.033	0.172	0.00358	8.8889	1907.1384
60	0.033	0.174	0.00362	10	2170.476
				∑=	483017.05
				∑/Wt =	0.0003116 m³

volume of sand eroded off the bed during the event = 0.03226 m³

103.509

Event5	dsd-us
t	C_{SS} (mg/L)
5	1
10	-4
15	372
20	-92
23	21
26	8
30	1
35	17
41	-7
51	-9
60	8

Δt =	60	s
Wt =	1.55	Mg/m³
	1.6E+09	mg/m³

interpolated in Matlab				interpolated in Matlab	
time	vel	depth	Q (m^3/s)	C_{SS} (mg/L)	QiCiΔt (mg)
5	0.219	0.203	0.02801	1.0	1680.4746
6	0.16	0.206	0.02076	0.0	0
7	0.211	0.21	0.02792	-1.0	-1674.918
8	0.221	0.202	0.02812	-2.0	-3374.9352
9	0.152	0.201	0.01925	-3.0	-3464.5968
10	0.241	0.199	0.03021	-4.0	-7251.4008
11	0.203	0.1995	0.02551	71.2	108996.043
12	0.282	0.2	0.03553	146.4	312113.088
13	0.28	0.199	0.0351	221.6	466737.466
14	0.309	0.207	0.0403	296.8	717603.456
15	0.346	0.202	0.04403	372.0	982793.347
16	0.392	0.188	0.04643	279.2	777769.897
17	0.502	0.194	0.06135	186.4	686188.057
18	0.525	0.192	0.0635	93.6	356638.464
19	0.497	0.198	0.062	0.8	2975.79744
20	0.534	0.201	0.06762	-92.0	-373264.718
21	0.513	0.197	0.06367	-54.3	-207558.954
22	0.527	0.19	0.06308	-16.7	-63082.0262
23	0.468	0.192	0.05661	21.0	71327.6928
24	0.489	0.189	0.05823	16.7	58225.3465
25	0.4615	0.185	0.05379	12.3	39802.8829
26	0.434	0.191	0.05222	8.0	25067.1456
27	0.341	0.197	0.04232	6.3	15870.5663
28	0.336	0.194	0.04107	4.5	11087.7984
29	0.435	0.196	0.05371	2.8	8862.777
30	0.407	0.202	0.05179	1.0	3107.6892
31	0.416	0.199	0.05215	4.2	13142.7878
32	0.445	0.193	0.05411	7.4	24023.7522
33	0.375	0.197	0.04654	10.6	29600.235
34	0.364	0.199	0.04563	13.8	37785.515
35	0.391	0.201	0.04951	17.0	50502.5766
36	0.399	0.197	0.04952	13.0	38625.5142
37	0.289	0.198	0.03605	9.0	19466.9244
38	0.319	0.195	0.03919	5.0	11756.745
39	0.294	0.192	0.03556	1.0	2133.7344
40	0.248	0.201	0.0314	-3.0	-5652.7632
41	0.229	0.19	0.02741	-7.0	-11512.746
42	0.159	0.194	0.01943	-7.2	-8395.04736
43	0.169	0.202	0.02151	-7.4	-9549.08136
44	0.17	0.192	0.02056	-7.6	-9376.8192
45	0.154	0.183	0.01775	-7.8	-8309.18088
46	0.095	0.184	0.01101	-8.0	-5285.952
47	0.089	0.191	0.01071	-8.2	-5269.01004
48	0.083	0.199	0.01041	-8.4	-5244.47784
49	0.077	0.194	0.00941	-8.6	-4856.04504
50	0.071	0.203	0.00908	-8.8	-4794.34032
51	0.065	0.2	0.00819	-9.0	-4422.6
52	0.049	0.206	0.00636	-7.1	-2713.26296
53	0.033	0.216	0.00449	-5.2	-1407.06121
54	0.043	0.223	0.00604	-3.3	-1208.20192
55	0.0415	0.226	0.00591	-1.4	-512.077643
56	0.04	0.218	0.00549	0.4	146.48135
57	0.0412	0.203	0.00527	2.3	737.658982
58	0.0425	0.199	0.00533	4.2	1349.8099
59	0.0438	0.194	0.00535	6.1	1962.84963
60	0.045	0.194	0.0055	8.0	2639.952

∑ = 4132542.31 mg

∑/Wt = 0.00266616 m³

volume of sand eroded off the bed during the event = 0.01488375 m³

5.58247461

Event6	dsd-us
t	C_{SS} (mg/L)
5	-2
10	37
15	8
20	52
23	2
26.4	14
30	10
35	0
43	12
51	-1
60	-1

Δt =	60	s
Wt =	1.55	Mg/m³
	1.6E+09	mg/m³

interpolated in Matlab				interpolated in Matlab	
time	vel	depth	Q (m^3/s)	C_{SS} (mg/L)	QiCiΔt (mg)
5	0.077	0.177	0.00859	-2	-1030.3524
6	0.06	0.178	0.00673	5.8	2341.4832
7	0.082	0.181	0.00935	13.6	7629.97536
8	0.093	0.189	0.01107	21.4	14218.38684
9	0.144	0.186	0.01687	29.2	29563.10784
10	0.116	0.182	0.0133	37	29527.2432
11	0.123	0.183	0.01418	31.2	26546.21424
12	0.151	0.185	0.0176	25.4	26820.9522
13	0.19	0.18	0.02155	19.6	25338.096
14	0.154	0.185	0.01795	13.8	14861.5236
15	0.204	0.183	0.02352	8	11289.1968
16	0.194	0.1875	0.02292	16.8	23099.58
17	0.287	0.192	0.03472	25.6	53323.03872
18	0.357	0.188	0.04228	34.4	87272.27712
19	0.405	0.181	0.04618	43.2	119704.1328
20	0.516	0.1715	0.05575	52	173943.8064
21	0.553	0.162	0.05644	35.3333	119650.9487
22	0.548	0.155	0.05351	18.6667	59933.77102
23	0.514	0.156	0.05052	2	6061.9104
24	0.531	0.153	0.05118	5.5294	16980.70667
25	0.591	0.152	0.05659	9.0588	30760.5106
26	0.61	0.151	0.05803	12.5882	43829.06606
27	0.529	0.152	0.05066	13.3333	40525.53069
28	0.479	0.143	0.04315	12.2222	31645.55646
29	0.641	0.095	0.03836	11.1111	25575.87442
30	0.651	0.093	0.03814	10	22885.254
31	0.557	0.116	0.04071	8	19538.6688
32	0.4	0.126	0.03175	6	11430.72
33	0.412	0.1235	0.03206	4	7693.3584
34	0.476	0.121	0.03629	2	4354.2576
35	0.469	0.115	0.03398	0	0
36	0.406	0.114	0.02916	1.5	2624.3028
37	0.413	0.115	0.02992	3	5385.933
38	0.416	0.114	0.02988	4.5	8066.8224
39	0.443	0.115	0.0321	6	11554.326
40	0.447	0.116	0.03267	7.5	14700.042
41	0.443	0.1157	0.03229	9	17436.98502
42	0.446	0.1153	0.0324	10.5	20410.10622
43	0.45	0.115	0.0326	12	23473.8
44	0.441	0.115	0.03195	10.375	19889.15513
45	0.369	0.112	0.02604	8.75	13669.236
46	0.399	0.115	0.02891	7.125	12357.97763
47	0.376	0.107	0.02535	5.5	8364.2328
48	0.326	0.118	0.02423	3.875	5634.6003
49	0.308	0.111	0.02154	2.25	2907.6894
50	0.256	0.105	0.01693	0.625	635.04
51	0.209	0.109	0.01435	-1	-861.1218
52	0.215	0.113	0.01531	-1	-918.351
53	0.16	0.106	0.01068	-1	-641.088
54	0.105	0.103	0.00681	-1	-408.807
55	0.105	0.112	0.00741	-1	-444.528
56	0.105	0.109	0.00721	-1	-432.621
57	0.105	0.112	0.00741	-1	-444.528
58	0.105	0.115	0.00761	-1	-456.435
59	0.105	0.114	0.00754	-1	-452.466
60	0.105	0.112	0.00741	-1	-444.528
				∑ =	1246920.571 mg
				∑/Wt =	0.000804465 m³

volume of sand eroded off the bed during the event = 0.06900705 m³

85.78006492

APPENDIX D: STATISTICS

Appendix D-1: T-test Matlab code and Results

MATLAB FUNCTION

```
function TTEST2(x,y)
%Two-tail t-test)
%x,y are (1,n) row vectors of values, not necessarily the same length
[dfx] = length(x);
[dfy] = length(y);
df = dfx + dfy -2;
sp = ((dfx-1)*var(x)+(dfy-1)*var(y))/df; %Pooled estimate
t = (mean(x)-mean(y))/(sqrt(sp)*sqrt(1/dfx+1/dfy));
tcrit = tinv(1-0.025,df);
disp(sprintf('%3d Degrees of Freedom',df))
disp(sprintf('t value = %8.4f with a critical t value = %8.4f%',t,tcrit))
if (t > tcrit || t < -tcrit)
   disp('Null hypothesis rejected')
else
   disp('Null hypothesis not rejected')
end
```

RESULTS

Total Coliform

```
%% For all TC concentrations
% x = US
% y = DS or DSD for June events
>> x=Mar(:,1);
>> y=Mar(:,2);
>> TTEST2(x,y)
 18 Degrees of Freedom
t value =   0.5772 with a critical t value =   2.1009
Null hypothesis not rejected
>> x=Apr(:,1);
>> y=Apr(:,2);
>> TTEST2(x,y)
 24 Degrees of Freedom
t value =  -0.0445 with a critical t value =   2.0639
Null hypothesis not rejected
>> x=Jun8(:,1);
>> y=Jun8(:,3);
>> TTEST2(x,y)
 20 Degrees of Freedom
t value =   0.5651 with a critical t value =   2.0860
```

Null hypothesis not rejected
>> x=Jun15(:,1);
>> y=Jun15(:,3);
>> TTEST2(x,y)
 20 Degrees of Freedom
t value = -0.3340 with a critical t value =   2.0860
Null hypothesis not rejected
>> x=Jun22(:,1);
>> y=Jun22(:,3);
>> TTEST2(x,y)
 20 Degrees of Freedom
t value =   0.2027 with a critical t value =   2.0860
Null hypothesis not rejected
>> x=Jun29(:,1);
>> y=Jun29(:,3);
>> TTEST2(x,y)
20 Degrees of Freedom
t value = -2.2669 with a critical t value =   2.0860
Null hypothesis rejected

Suspended Solids

%ttest for all **Suspended solids** data
%Up and Downstream for March and April events
%Up and Downstream deep for June events
>> x=Mar(:,1);
y=Mar(:,2);
TTEST2(x,y)
x=Apr(:,1);
y=Apr(:,2);
TTEST2(x,y)
x=Jun8(:,1);
y=Jun8(:,3);
TTEST2(x,y)
x=Jun15(:,1);
y=Jun15(:,3);
TTEST2(x,y)
x=Jun22(:,1);
y=Jun22(:,3);
TTEST2(x,y)
x=Jun29(:,1);
y=Jun29(:,3);
TTEST2(x,y)
 18 Degrees of Freedom

t value = -0.7614 with a critical t value =   2.1009
Null hypothesis not rejected
 24 Degrees of Freedom
t value = -0.4276 with a critical t value =   2.0639
Null hypothesis not rejected
 20 Degrees of Freedom
t value = -1.4133 with a critical t value =   2.0860
Null hypothesis not rejected
 20 Degrees of Freedom
t value = -1.4749 with a critical t value =   2.0860
Null hypothesis not rejected
 20 Degrees of Freedom
t value = -0.7892 with a critical t value =   2.0860
Null hypothesis not rejected
20 Degrees of Freedom
t value = -2.2885 with a critical t value =   2.0860
Null hypothesis rejected

Total Solids

%**Total Solids** ttest
%%Upstream / Downstream for March and April events
%%Upstream / Downstream Deep for June events
>> x=Mar(:,1);
y=Mar(:,2);
TTEST2(x,y)
x=Apr(:,1);
y=Apr(:,2);
TTEST2(x,y)
x=Jun8(:,1);
y=Jun8(:,3);
TTEST2(x,y)
x=Jun15(:,1);
y=Jun15(:,3);
TTEST2(x,y)
x=Jun22(:,1);
y=Jun22(:,3);
TTEST2(x,y)
x=Jun29(:,1);
y=Jun29(:,3);
TTEST2(x,y)
 18 Degrees of Freedom
t value = -0.0476 with a critical t value =   2.1009
Null hypothesis not rejected

24 Degrees of Freedom
t value = -1.2119 with a critical t value =   2.0639
Null hypothesis not rejected
 20 Degrees of Freedom
t value = -1.8930 with a critical t value =   2.0860
Null hypothesis not rejected
 20 Degrees of Freedom
t value = -1.8350 with a critical t value =   2.0860
Null hypothesis not rejected
 20 Degrees of Freedom
t value = -0.7961 with a critical t value =   2.0860
Null hypothesis not rejected
 20 Degrees of Freedom
t value = -2.2015 with a critical t value =   2.0860
Null hypothesis rejected
>>

E. coli

>> % TTest for **EC** data
%% Upstream and Downstream for March and April events
%% Up and Downstream Deep for June events
>> x=Mar(:,1);
y=Mar(:,2);
TTEST2(x,y)
x=Apr(:,1);
y=Apr(:,2);
TTEST2(x,y)
x=Jun8(:,1);
y=Jun8(:,3);
TTEST2(x,y)
x=Jun15(:,1);
y=Jun15(:,3);
TTEST2(x,y)
x=Jun22(:,1);
y=Jun22(:,3);
TTEST2(x,y)
x=Jun29(:,1);
y=Jun29(:,3);
TTEST2(x,y)
 18 Degrees of Freedom
t value =   1.9012 with a critical t value =   2.1009
Null hypothesis not rejected
 24 Degrees of Freedom

```
t value =  -0.6635 with a critical t value =   2.0639
Null hypothesis not rejected
 20 Degrees of Freedom
t value =   0.0330 with a critical t value =   2.0860
Null hypothesis not rejected
 20 Degrees of Freedom
t value =   0.5934 with a critical t value =   2.0860
Null hypothesis not rejected
 20 Degrees of Freedom
t value =   0.8987 with a critical t value =   2.0860
Null hypothesis not rejected
 20 Degrees of Freedom
t value =   0.0855 with a critical t value =   2.0860
Null hypothesis not rejected
>>
```

Appendix D-2: Cross-Correlation Matlab code and Results

<u>Three point average function</u>

```
function v = Avg3pt(x)
% 3 point moving average
n = length(x);
v = [x(1),(x(1)+x(2))/2];
for j = 3:length(x)-2
   v = [v,(x(j-1)+x(j)+x(j+1))/3];
end;
v = [v, (x(n-1)+x(n))/2 , x(n)];
```

<u>Cross-Correlation function</u>

```
function c = cross_corr(y1,y2)
%Crosscorrelation
%Wrapper for the MATLAB xcorr function
%Inputs are column vectors of the series to compare
c = xcorr(y1,y2,'coeff');
```

<u>Cross-Correlation code</u>

```
%%Alex McCaskill
%Cross-correlation for June events
%made for June 15th (event 4)

%%DATA sets:
%tv = ["elapsed time(min)"  "vel(m/s)"]
%TCSS = ["elapsed time(min)" "USTC(MPN/100mL)" "DSTC(MPN/100mL)"
         %"DSDTC(MPN/100mL)" "SS(mg/L)"]

%%Variables:
%t = time (5min to 60 min), (5 to 53 for event3)
%v = vel(m/s) for t
%US = upstream TC concentrations for t
%DS = downstream TC concentrations for t
%DSD = downstream deep TC concentrations for t
%SS = suspended solids concentrations for t (mg/L)

t = 5:1:60;
% t = 5:1:53;  %%event3
vel = interp1(datatv(:,1),datatv(:,2),t);
US = interp1(dataTCSS(:,1),dataTCSS(:,2),t);
DS = interp1(dataTCSS(:,1),dataTCSS(:,3),t);
DSD = interp1(dataTCSS(:,1),dataTCSS(:,4),t);
SS = interp1(dataTCSS(:,1),dataTCSS(:,5),t);
```

```
%Avg3pt function for velocity
v = Avg3pt(vel);
%DSD and velocity)

figure
[AX,H1,H2] = plotyy(t,DSD,t,v);
xlabel 'Elapsed time (min)'
set(get(AX(1),'Ylabel'),'String','Downstream Deep TC concentration (MPN/100mL)');
set(get(AX(2),'Ylabel'),'String','velocity (m/s)');
% axis(AX(1),[0 60 0 9000])
% axis(AX(2),[0 60 0 0.6])
% set(AX(1),'Ytick',0:1000:9000)
% set(AX(2),'Ytick',0:0.1:0.6)
axis(AX(1),[0 60 0 25000])
axis(AX(2),[0 60 0 0.7])
set(AX(1),'Ytick',0:5000:25000)
set(AX(2),'Ytick',0:0.1:0.7)
set(get(AX(1),'Xlabel'),'FontSize',14)
set(get(AX(1),'Ylabel'),'FontSize',14)
set(get(AX(2),'Ylabel'),'FontSize',14)
set(AX(2),'FontSize',12)
set(AX(1),'FontSize',12)
set(H1,'LineWidth',2)
set(H2,'LineWidth',2)
set(AX(1),'YColor','g') %axis font color
set(H1,'Color','g') %line color
set(AX(2),'YColor','b') %axis font color
set(H2,'Color','b') %line color

y1 = DSD;
y2 = v;
c = xcorr(y1,y2,'coeff');
x = linspace(-(length(c)-1)/2,(length(c)-1)/2,length(c));
x = x';
figure
plot(x,c,'b',[0,0],[-.2,1],'r')
axis([-30 30 -.2 1])
xlabel('<--DSD leads velocity     velocity leads DSD-->')

%SS and velocity
figure
[AX,H1,H2] = plotyy(t,SS,t,v);
xlabel 'Elapsed time (min)'
```

```
set(get(AX(1),'Ylabel'),'String','Downstream Deep Suspended Solids (mg/L)');
set(get(AX(2),'Ylabel'),'String','velocity (m/s)');
% axis(AX(1),[0 60 0 30])  %event3
% axis(AX(2),[0 60 0 0.6])
% set(AX(1),'Ytick',0:5:30)
% set(AX(2),'Ytick',0:0.1:0.6)
axis(AX(1),[0 60 0 70]) %event 6
axis(AX(2),[0 60 0 0.7])
set(AX(1),'Ytick',0:5:70)
set(AX(2),'Ytick',0:0.1:0.7)
% axis(AX(1),[0 60 0 400])  $event 5
% axis(AX(2),[0 60 0 0.6])
% set(AX(1),'Ytick',0:50:400)
% set(AX(2),'Ytick',0:0.1:0.6)
set(get(AX(1),'Xlabel'),'FontSize',14)
set(get(AX(1),'Ylabel'),'FontSize',14)
set(get(AX(2),'Ylabel'),'FontSize',14)
set(AX(2),'FontSize',12)
set(AX(1),'FontSize',12)
set(H1,'LineWidth',2)
set(H2,'LineWidth',2)
set(AX(1),'YColor','r') %axis font color
set(H1,'Color','y') %line color
set(AX(2),'YColor','b') %axis font color
set(H2,'Color','b') %line color

y1 = SS;
y2 = v;
c = xcorr(y1,y2,'coeff');
x = linspace(-(length(c)-1)/2,(length(c)-1)/2,length(c));
x = x';
figure
plot(x,c,'b',[0,0],[-.2,1],'r')
axis([-30 30 -.2 1])
xlabel('<--SS leads velocity     velocity leads SS-->')

%DSD and SS
figure
[AX,H1,H2] = plotyy(t,DSD,t,SS);
xlabel 'Elapsed time (min)'
set(get(AX(1),'Ylabel'),'String','Downstream Deep TC concentration (MPN/100mL)');
set(get(AX(2),'Ylabel'),'String','Downstream Deep Suspended Solids (mg/L)');
axis(AX(1),[0 60 0 9000])
axis(AX(2),[0 60 0 30])
```

```
set(AX(1),'Ytick',0:1000:9000)
set(AX(2),'Ytick',0:5:30)
% axis(AX(1),[0 60 0 25000])
% axis(AX(2),[0 60 0 400])  %event 5
% set(AX(1),'Ytick',0:5000:25000)
% set(AX(2),'Ytick',0:50:400)
axis(AX(1),[0 60 0 25000])
axis(AX(2),[0 60 0 70])  %event 6
set(AX(1),'Ytick',0:5000:25000)
set(AX(2),'Ytick',0:10:70)
set(get(AX(1),'Xlabel'),'FontSize',14)
set(get(AX(1),'Ylabel'),'FontSize',14)
set(get(AX(2),'Ylabel'),'FontSize',14)
set(AX(2),'FontSize',12)
set(AX(1),'FontSize',12)
set(H1,'LineWidth',2)
set(H2,'LineWidth',2)
set(AX(1),'YColor','g') %axis font color
set(H1,'Color','g') %line color
set(AX(2),'YColor','r') %axis font color
set(H2,'Color','r') %line color

y1 = DSD;
y2 = SS;
c = xcorr(y1,y2,'coeff');
x = linspace(-(length(c)-1)/2,(length(c)-1)/2,length(c));
x = x';
figure
plot(x,c,'b',[0,0],[-.2,1],'r')
axis([-30 30 -.2 1])
xlabel('<--DSD leads SS     SS leads DSD-->')

%US and DSD
figure
[AX,H1,H2] = plotyy(t,US,t,DSD);
xlabel 'Elapsed time (min)'
set(get(AX(1),'Ylabel'),'String','Upstream TC concentration (MPN/100mL)');
set(get(AX(2),'Ylabel'),'String','Downstream Deep TC concentration (MPN/100mL)');
% axis(AX(1),[0 60 0 9000])
% axis(AX(2),[0 60 0 9000])
% set(AX(1),'Ytick',0:1000:9000)
% set(AX(2),'Ytick',0:1000:9000)
axis(AX(1),[0 60 0 26000])
axis(AX(2),[0 60 0 26000])
```

```
set(AX(1),'Ytick',0:5000:25000)
set(AX(2),'Ytick',0:5000:25000)

y1 = US;
y2 = DSD;
c = xcorr(y1,y2,'coeff');
x = linspace(-(length(c)-1)/2,(length(c)-1)/2,length(c));
x = x';
figure
plot(x,c,'b',[0,0],[-.2,1],'r')
axis([-30 30 -.2 1])
xlabel('<--US leads DSD     DSD leads US-->')


%DSD and velocity gradient)
newGv = Gv+abs(min(Gv))
figure
[AX,H1,H2] = plotyy(t,DSD,t,Gv);
xlabel 'Elapsed time (min)'
set(get(AX(1),'Ylabel'),'String','Downstream Deep TC concentration (MPN/100mL)');
set(get(AX(2),'Ylabel'),'String','velocity gradient');
% axis(AX(1),[0 60 0 9000])
% axis(AX(2),[0 60 0 0.08])
% set(AX(1),'Ytick',0:1000:9000)
% set(AX(2),'Ytick',0:0.02:0.08)
axis(AX(1),[0 60 6000 26000])
axis(AX(2),[0 60 -.08 0.08])
set(AX(1),'Ytick',6000:4000:26000)
set(AX(2),'Ytick',-.08:0.02:0.08)
set(get(AX(1),'Xlabel'),'FontSize',14)
set(get(AX(1),'Ylabel'),'FontSize',14)
set(get(AX(2),'Ylabel'),'FontSize',14)
set(AX(2),'FontSize',12)
set(AX(1),'FontSize',12)
set(H1,'LineWidth',2)
set(H2,'LineWidth',2)
set(AX(1),'YColor','g') %axis font color
set(H1,'Color','g') %line color
set(AX(2),'YColor','b') %axis font color
set(H2,'Color','b') %line color

y1 = DSD;
y2 = newGv;
c = xcorr(y1,y2,'coeff');
```

```
x = linspace(-(length(c)-1)/2,(length(c)-1)/2,length(c));
x = x';
figure
plot(x,c,'b',[0,0],[-.2,1],'r')
axis([-30 30 -.2 1])
xlabel('<--DSD leads velocity gradient     velocity gradient leads DSD-->')


%SS and velocity gradient
figure
[AX,H1,H2] = plotyy(t,SS,t,Gv);
xlabel 'Elapsed time (min)'
set(get(AX(1),'Ylabel'),'String','Downstream Deep Suspended Solids (mg/L)');
set(get(AX(2),'Ylabel'),'String','velocity gradient');
% axis(AX(1),[0 60 0 30])   %event 3
% axis(AX(2),[0 60 0 0.08])
% set(AX(1),'Ytick',0:5:30)
% set(AX(2),'Ytick',0:0.02:0.08)
% axis(AX(1),[0 60 0 400])  %event 5
% axis(AX(2),[0 60 0 0.14])
% set(AX(1),'Ytick',0:50:400)
% set(AX(2),'Ytick',0:0.02:0.14)
axis(AX(1),[0 60 0 70]) %event 6
axis(AX(2),[0 60 0 0.16])
set(AX(1),'Ytick',0:10:70)
set(AX(2),'Ytick',0:0.02:0.16)
set(get(AX(1),'Xlabel'),'FontSize',14)
set(get(AX(1),'Ylabel'),'FontSize',14)
set(get(AX(2),'Ylabel'),'FontSize',14)
set(AX(2),'FontSize',12)
set(AX(1),'FontSize',12)
set(H1,'LineWidth',2)
set(H2,'LineWidth',2)
set(AX(1),'YColor','y') %axis font color
set(H1,'Color','y') %line color
set(AX(2),'YColor','b') %axis font color
set(H2,'Color','b') %line color


y1 = SS;
y2 = newGv;
c = xcorr(y1,y2,'coeff');
x = linspace(-(length(c)-1)/2,(length(c)-1)/2,length(c));
x = x';
```

```
figure
plot(x,c,'b',[0,0],[-.2,1],'r')
axis([-30 30 -.2 1])
xlabel('<--SS leads velocity gradient     velocity gradient leads SS-->')


%resuspended TC and vel gradient
newsusTC = susTC+abs(min(susTC));
%new figure
figure
[AX,H1,H2] = plotyy(t,newsusTC,t,newGv);
xlabel 'Elapsed time (min)'
set(get(AX(1),'Ylabel'),'String','resuspended TC concentration (MPN/100mL)');
set(get(AX(2),'Ylabel'),'String','velocity gradient');
% axis(AX(1),[0 60 0 9000])
% axis(AX(2),[0 60 0 0.08])
% set(AX(1),'Ytick',0:1000:9000)
% set(AX(2),'Ytick',0:0.02:0.08)
axis(AX(1),[0 60 0 25000])
axis(AX(2),[0 60 0 0.14])
set(AX(1),'Ytick',0:5000:25000)
set(AX(2),'Ytick',0:0.02:0.14)
set(get(AX(1),'Xlabel'),'FontSize',14)
set(get(AX(1),'Ylabel'),'FontSize',14)
set(get(AX(2),'Ylabel'),'FontSize',14)
set(AX(2),'FontSize',12)
set(AX(1),'FontSize',12)
set(H1,'LineWidth',2)
set(H2,'LineWidth',2)
set(AX(1),'YColor','g') %axis font color
set(H1,'Color','g') %line color
set(AX(2),'YColor','b') %axis font color
set(H2,'Color','b') %line color

%original susTC and vel grad data
figure
[AX,H1,H2] = plotyy(t,susTC,t,Gv);
xlabel 'Elapsed time (min)'
set(get(AX(1),'Ylabel'),'String','resuspended TC concentration (MPN/100mL)');
set(get(AX(2),'Ylabel'),'String','velocity gradient');
% axis(AX(1),[0 60 -2000 4000])
% axis(AX(2),[0 60 -.08 0.08])
% set(AX(1),'Ytick',-2000:1000:4000)
% set(AX(2),'Ytick',-.08:0.02:0.08)   %event 4
```

```
% axis(AX(1),[0 60 -10000 15000])
% axis(AX(2),[0 60 -.06 0.08])
% set(AX(1),'Ytick',-10000:2000:15000)
% set(AX(2),'Ytick',-.06:0.02:0.08)
axis(AX(1),[0 60 -2000 18000])  %event 6
axis(AX(2),[0 60 -.08 0.08])
set(AX(1),'Ytick',-2000:2000:18000)
set(AX(2),'Ytick',-.08:0.02:0.08)
set(get(AX(1),'Xlabel'),'FontSize',14)
set(get(AX(1),'Ylabel'),'FontSize',14)
set(get(AX(2),'Ylabel'),'FontSize',14)
set(AX(2),'FontSize',12)
set(AX(1),'FontSize',12)
set(H1,'LineWidth',2)
set(H2,'LineWidth',2)
set(AX(1),'YColor','g') %axis font color
set(H1,'Color','g') %line color
set(AX(2),'YColor','b') %axis font color
set(H2,'Color','b') %line color

y1 = newsusTC;
y2 = newGv;
c = xcorr(y1,y2,'coeff');
x = linspace(-(length(c)-1)/2,(length(c)-1)/2,length(c));
x = x';
figure
plot(x,c,'b',[0,0],[-.2,1],'r')
axis([-30 30 -.2 1])
xlabel('<--resuspended TC leads velocity gradient     velocity gradient leads resuspended TC-->')

y1 = newsusTC;
y2 = v;
c = xcorr(y1,y2,'coeff');
x = linspace(-(length(c)-1)/2,(length(c)-1)/2,length(c));
x = x';
figure
plot(x,c,'b',[0,0],[-.2,1],'r')
axis([-30 30 -.2 1])
xlabel('<--resuspended TC leads velocity     velocity leads resuspended TC-->')
```

APPENDIX E: MODELING

Appendix E-1: Steady Flow Analysis Data

Rehmann's equation 1 and 2:

w =	0.63	m		
L =	2.5	m		
H2 =	0.02	m		
kn2 =	-0.12	1/d	=	-1.4E-06 1/s
Kn2*H2 =	-2.8E-08	m/s		
SA =	1.6	m^2		

		15-Mar	12-Apr	8-Jun	15-Jun	22-Jun	29-Jun
	travel time (sec)	14.12	23.58	10.14	8.56	8.90	7.76
	timecrit (min)	15	20	17.5	12.5	12.5	17.5
U	**vcrit (m/s)**	0.177	0.106	0.247	0.292	0.281	0.322
H1	**depthcrit (m)**	0.251	0.233	0.288	0.205	0.200	0.190
	Qcrit (m^3/s)	0.028	0.016	0.045	0.038	0.035	0.039
avg of values along rising limb of US-DS plot	v_{avg} (m/s)	0.109	0.118	0.144	0.413	0.374	0.415
	d_{avg} (m)	0.266	0.234	0.270	0.203	0.198	0.147
	Qavg (m^3/s)	0.018	0.017	0.024	0.053	0.047	0.039
	C_{avg} (MPN/100mL)	445	2015	1425	1459	5776	5291
conversion	C_{avg} (MPN/m^3)	4.4E+06	2.0E+07	1.4E+07	1.5E+07	5.8E+07	5.3E+07
Jamieson et al. 2005 eq. 4: Fr = [Cavg*Qavg]/SA	Fr (MPN/m^2s)	51390	222103	221294	490352	1710524	1294338
$v_r = F_r/C_2$	v_r (m/s)	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
from Cho: τc=3.75v_c^2	**τc (N/m²)**	0.117	0.042	0.228	0.320	0.296	0.389
across the reach (all pos us, ds, and dsd samples)	**avg SS (mg/L)**	3.40	5.22	14.90	11.94	42.75	17.72
upstream	**Cin, avg TC (MPN/100mL)**	3008	5974	5815	5555	10536	8296
downstream	**C1 for Mar&Apr, avg TC (MPN/100mL)**	2856	5836	6076	5263	8931	13081
downstream Deep	**C1 for June, avg TC (MPN/100mL)**			5468	5505	10066	13444
pre event	**C2, SAND avg TC (MPN/g)**	0	0	0	0	0	0
	sand density (g/m³)	2.65	2.65	2.65	2.65	2.65	2.65
C2*sand density	**C2 (MPN/m³)**	0	0	0	0	0	0
	fa	0.44	0.40	0.32	0.37	0.49	0.32
	ws (m/s)	0.0422	0.0422	0.0198	0.0198	0.0198	0.0198
$w = w_s*f_a$	**w (m/s)**	0.0184	0.0168	0.0064	0.0073	0.0097	0.0063
from table 2	**kn1 (per hour)**	-0.3704	-0.3704	-0.3704	-0.3704	-0.3704	-0.3704
	kn1 (per sec)	-1.0E-04	-1.0E-04	-1.0E-04	-1.0E-04	-1.0E-04	-1.0E-04
	Kn1*7sec	-7.2E-04	-7.2E-04	-7.2E-04	-7.2E-04	-7.2E-04	-7.2E-04
	kn1*24sec	-0.00247	-0.00247	-0.00247	-0.00247	-0.00247	-0.00247
table 1	**kn2 (per day)**	-0.12	-0.12	-0.12	-0.12	-0.12	-0.12
	kn2 (per sec)	-1.4E-06	-1.4E-06	-1.4E-06	-1.4E-06	-1.4E-06	-1.4E-06
eq. 1	**∂C1/∂t + U(∂C1/∂x)**	204533	952809	768246	2391774	8573619	6811872
eq 2	**dC2/dt**	-2.6E+06	-1.1E+07	-1.1E+07	-2.5E+07	-8.6E+07	-6.5E+07
eq. 3: C2/C1 = w/(vr-kn2H2) = β2	**C2/C1 = β2 =**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
eq. 5 λL	λL =	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!

originally were geometric mean, but modified on **2/7/12** for flow averaged concentrations

		15-Mar	12-Apr	8-Jun	15-Jun	22-Jun	29-Jun
eq. 4: C1/Cin = β1 = e^(λL) (from eq. 5)	**C1/Cin = β1 =**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	Da =	-0.0015	-0.0024	-0.0010	-0.0009	-0.0009	-0.0008
	kn1*H1 =	-2.6E-05	-2.4E-05	-3.0E-05	-2.1E-05	-2.1E-05	-2.0E-05
	(kn2*H2)/(kn1*H1	0.0011	0.0012	0.0009	0.0013	0.0014	0.0014
eq. 7	**S =**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	(1+S) =	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
	Da(1+S) =	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
eq. 8: C1/Cin = β1 = exp[Da(1+S)]	**C1/Cin =** β1 =	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
eq. 8 w/ S=0	**C1/Cin for S=0**	0.9985	0.9976	0.9990	0.9991	0.9991	0.9992

Appendix E-2: Unsteady Flow Analysis Variables

Fischer et al 1979 Longitudinal Dispersion Coefficient Equation:

$$D = E_x = \frac{0.011 \cdot \overline{u}^2 \cdot B^2}{d \cdot u^*} \pm 50\%$$

$$u^* = \sqrt{\frac{0.003u^2}{\rho}}$$

corrected: $3.75u^2$ √

modified from Cho's paper. Email on

-> note in "Crit. Shear stress" tab

u = Mean Velocity [m/sec]
B = Width, [m]
d = Depth (hydraulic radius), [m]
u* = Shear Velocity, [m/sec]
S = Channel Slope [m/m]

Re = 3.2E-05 (Cho table 4)

B= 0.63 m
ρ= 1000 kg/m³

NOTE: from Cho et al. 2010: D = 0.56 m²/s

Event	elapsed time	u (m/s)	d (m)	u* (m/s)	Ex or D (m²/s)	(-50%) Ex or D (m²/s)	(+50%) Ex or D (m²/s)	τ (N/m²)	τc(N/m²)	R = 0 IF τ < τc	OR R = Re(τ /τc -1)	D (m²/min)
	2	0.064	0.18	0.00392	**0.025**	0.013	0.038	0.01536	0.030375	0		1.52096
	3	0.076	0.177	0.00465	**0.031**	0.015	0.046	0.02166	0.030375	0		1.83675
	4	0.069	0.177	0.00423	**0.028**	0.014	0.042	0.01785375	0.030375	0		1.66757
	5	0.077	0.177	0.00472	**0.031**	0.016	0.047	0.02223375	0.030375	0		1.86092
	6	0.06	0.178	0.00367	**0.024**	0.012	0.036	0.0135	0.030375	0		1.44192
	7	0.082	0.181	0.00502	**0.032**	0.016	0.048	0.025215	0.030375	0		1.93796
	8	0.093	0.189	0.0057	**0.035**	0.018	0.053	0.03243375	0.030375		2.16889E-06	2.1049
	9	0.144	0.186	0.00882	**0.055**	0.028	0.083	0.07776	0.030375		0.00004992	3.31176
	10	0.116	0.182	0.0071	**0.045**	0.023	0.068	0.05046	0.030375		2.11595E-05	2.72644
	11	0.123	0.183	0.00753	**0.048**	0.024	0.072	0.05673375	0.030375		2.77689E-05	2.87517
	12	0.151	0.185	0.00925	**0.058**	0.029	0.087	0.08550375	0.030375		5.8078E-05	3.49152
	13	0.19	0.18	0.01164	**0.075**	0.038	0.113	0.135375	0.030375		0.000110617	4.51534
	14	0.154	0.185	0.00943	**0.059**	0.030	0.089	0.088935	0.030375		6.16928E-05	3.56089
	15	0.204	0.183	0.01249	**0.079**	0.040	0.119	0.15606	0.030375		0.000132409	4.76857
	16	0.194	0.1875	0.01188	**0.074**	0.037	0.111	0.141135	0.030375		0.000116685	4.42598
	17	0.287	0.192	0.01758	**0.107**	0.053	0.160	0.30888375	0.030375		0.000293408	6.39426
	18	0.357	0.188	0.02186	**0.135**	0.068	0.203	0.47793375	0.030375		0.000471502	8.12306
	19	0.405	0.181	0.0248	**0.160**	0.080	0.239	0.61509375	0.030375		0.000616	9.57163
	20	0.516	0.1715	0.0316	**0.215**	0.107	0.322	0.99846	0.030375		0.001019876	12.8705
	21	0.553	0.162	0.03386	**0.243**	0.122	0.365	1.14678375	0.030375		0.001176134	14.6022
	22	0.548	0.155	0.03356	**0.252**	0.126	0.378	1.12614	0.030375		0.001154386	15.1237
	23	0.514	0.156	0.03148	**0.235**	0.117	0.352	0.990735	0.030375		0.001011737	14.0944
	24	0.531	0.153	0.03252	**0.247**	0.124	0.371	1.05735375	0.030375		0.00108192	14.8461
	25	0.591	0.152	0.03619	**0.277**	0.139	0.416	1.30980375	0.030375		0.001347876	16.6323
	26	0.61	0.151	0.03735	**0.288**	0.144	0.432	1.395375	0.030375		0.001438025	17.2807
	27	0.529	0.152	0.03239	**0.248**	0.124	0.372	1.04940375	0.030375		0.001073545	14.8875
6	28	0.479	0.143	0.02933	**0.239**	0.119	0.358	0.86040375	0.030375		0.000874434	14.3288
	29	0.641	0.095	0.03925	**0.481**	0.241	0.722	1.54080375	0.030375		0.001591234	28.8632
	30	0.651	0.093	0.03987	**0.499**	0.250	0.749	1.58925375	0.030375		0.001642276	29.9438
	31	0.557	0.116	0.03411	**0.342**	0.171	0.514	1.16343375	0.030375		0.001193675	20.5403
	32	0.4	0.126	0.02449	**0.226**	0.113	0.339	0.6	0.030375		0.000600099	13.58
	33	0.412	0.1235	0.02523	**0.238**	0.119	0.357	0.63654	0.030375		0.000638594	14.2705
	34	0.476	0.121	0.02915	**0.280**	0.140	0.421	0.84966	0.030375		0.000863115	16.8279
	35	0.469	0.115	0.02872	**0.291**	0.145	0.436	0.82485375	0.030375		0.000836982	17.4455
	36	0.406	0.114	0.02486	**0.254**	0.127	0.381	0.618135	0.030375		0.000619204	15.2346
	37	0.413	0.115	0.02529	**0.256**	0.128	0.384	0.63963375	0.030375		0.000641853	15.3625
	38	0.416	0.114	0.02547	**0.260**	0.130	0.390	0.64896	0.030375		0.000651678	15.6098
	39	0.443	0.115	0.02713	**0.275**	0.137	0.412	0.73593375	0.030375		0.000743305	16.4784
	40	0.447	0.116	0.02737	**0.275**	0.137	0.412	0.74928375	0.030375		0.000757369	16.4839
	41	0.443	0.11575	0.02713	**0.273**	0.136	0.409	0.73593375	0.030375		0.000743305	16.3716
	42	0.446	0.1155	0.02731	**0.275**	0.138	0.413	0.745935	0.030375		0.000753841	16.5182
	43	0.45	0.11525	0.02756	**0.278**	0.139	0.418	0.759375	0.030375		0.000768	16.7025
	44	0.441	0.115	0.02701	**0.273**	0.137	0.410	0.72930375	0.030375		0.00073632	16.404
	45	0.369	0.112	0.0226	**0.235**	0.117	0.352	0.51060375	0.030375		0.00050592	14.0935
	46	0.399	0.115	0.02443	**0.247**	0.124	0.371	0.59700375	0.030375		0.000596942	14.8417
	47	0.376	0.107	0.02303	**0.251**	0.125	0.376	0.53016	0.030375		0.000526522	15.0319
	48	0.326	0.118	0.01996	**0.197**	0.098	0.295	0.398535	0.030375		0.000387856	11.818
	49	0.308	0.111	0.01886	**0.198**	0.099	0.297	0.35574	0.030375		0.000342771	11.8696
	50	0.256	0.105	0.01568	**0.174**	0.087	0.261	0.24576	0.030375		0.000226908	10.4294
	51	0.209	0.109	0.0128	**0.137**	0.068	0.205	0.16380375	0.030375		0.000140567	8.20218
	52	0.215	0.113	0.01317	**0.136**	0.068	0.203	0.17334375	0.030375		0.000150617	8.13897
	54	0.105	0.103	0.00643	**0.073**	0.036	0.109	0.04134375	0.030375		1.15556E-05	4.36075
	60	0.05	0.112	0.00306	**0.032**	0.016	0.048	0.009375	0.030375			
	mean	0.337	0.144	0.02061	**0.166**	0.083	0.249	0.42493051	0.030375		0.000415663	9.97712
	2	0.133	0.23	0.00814	**0.041**	0.021	0.062	0.06633375	0.178215	0		2.47362
	3	0.134	0.227	0.00821	**0.042**	0.021	0.063	0.067335	0.178215	0		2.52516
	4	0.231	0.222	0.01415	**0.074**	0.037	0.111	0.20010375	0.178215		3.93031E-06	4.45111
	5	0.219	0.203	0.01341	**0.077**	0.038	0.115	0.17985375	0.178215		2.94251E-07	4.61485
	6	0.16	0.206	0.0098	**0.055**	0.028	0.083	0.096	0.178215	0		3.32248

Event	elapsed time	u (m/s)	d (m)	u* (m/s)	Ex or D (m^2/s)	(-50%) Ex or D (m^2/s)	(+50%) Ex or D (m^2/s)	τ (N/m^2)	τc(N/m^2)	**R** = 0 IF $\tau < \tau c$	OR **R** = Re($\tau/\tau c$ -1)	D (m^2/min)
	7	0.211	0.21	0.01292	**0.072**	0.036	0.107	0.16695375	0.178215	0		4.29806
	8	0.221	0.202	0.01353	**0.078**	0.039	0.117	0.18315375	0.178215		8.86794E-07	4.68005
	9	0.152	0.201	0.00931	**0.054**	0.027	0.081	0.08664	0.178215	0		3.23487
	10	0.241	0.199	0.01476	**0.086**	0.043	0.130	0.21780375	0.178215		7.10849E-06	5.18052
	11	0.203	0.199	0.01243	**0.073**	0.036	0.109	0.15453375	0.178215	0		4.36367
	12	0.282	0.2	0.01727	**0.101**	0.050	0.151	0.298215	0.178215		2.1547E-05	6.03154
	13	0.28	0.199	0.01715	**0.100**	0.050	0.150	0.294	0.178215		2.07902E-05	6.01886
	14	0.309	0.207	0.01892	**0.106**	0.053	0.160	0.35805375	0.178215		3.22916E-05	6.38554
	15	0.346	0.202	0.02119	**0.122**	0.061	0.183	0.448935	0.178215		4.861E-05	7.32713
	16	0.392	0.188	0.024	**0.149**	0.074	0.223	0.57624	0.178215		7.14687E-05	8.91944
	17	0.502	0.194	0.03074	**0.184**	0.092	0.277	0.945015	0.178215		0.000137685	11.0691
	18	0.525	0.192	0.03215	**0.195**	0.097	0.292	1.03359375	0.178215		0.00015359	11.6968
	19	0.497	0.198	0.03043	**0.179**	0.089	0.268	0.92628375	0.178215		0.000134322	10.7374
	20	0.534	0.201	0.0327	**0.189**	0.095	0.284	1.069335	0.178215		0.000160008	11.3646
	21	0.513	0.197	0.03141	**0.186**	0.093	0.278	0.98688375	0.178215		0.000145203	11.1394
	22	0.527	0.19	0.03227	**0.198**	0.099	0.297	1.04148375	0.178215		0.000155007	11.865
	23	0.468	0.192	0.02866	**0.174**	0.087	0.261	0.82134	0.178215		0.000115478	10.4269
	24	0.489	0.189	0.02995	**0.184**	0.092	0.277	0.89670375	0.178215		0.000129011	11.0677
	26	0.434	0.191	0.02658	**0.162**	0.081	0.243	0.706335	0.178215		9.48284E-05	9.71999
5	27	0.341	0.197	0.02088	**0.123**	0.062	0.185	0.43605375	0.178215		4.62971E-05	7.40453
	28	0.336	0.194	0.02058	**0.123**	0.062	0.185	0.42336	0.178215		4.40178E-05	7.40878
	29	0.435	0.196	0.02664	**0.158**	0.079	0.237	0.70959375	0.178215		9.54135E-05	9.49385
	30	0.407	0.202	0.02492	**0.144**	0.072	0.215	0.62118375	0.178215		7.95388E-05	8.61891
	31	0.416	0.199	0.02547	**0.149**	0.075	0.224	0.64896	0.178215		8.45262E-05	8.94231
	32	0.445	0.193	0.02725	**0.164**	0.082	0.247	0.74259375	0.178215		0.000101339	9.86307
	33	0.375	0.197	0.02296	**0.136**	0.068	0.204	0.52734375	0.178215		6.2689E-05	8.14281
	34	0.364	0.199	0.02229	**0.130**	0.065	0.196	0.49686	0.178215		5.72154E-05	7.82452
	35	0.391	0.201	0.02394	**0.139**	0.069	0.208	0.57330375	0.178215		7.09415E-05	8.32128
	36	0.399	0.197	0.02443	**0.144**	0.072	0.217	0.59700375	0.178215		7.5197E-05	8.66395
	37	0.289	0.198	0.0177	**0.104**	0.052	0.156	0.31320375	0.178215		2.42384E-05	6.2437
	38	0.319	0.195	0.01953	**0.117**	0.058	0.175	0.38160375	0.178215		3.65202E-05	6.99786
	39	0.294	0.192	0.018	**0.109**	0.055	0.164	0.324135	0.178215		2.62012E-05	6.55021
	40	0.248	0.201	0.01519	**0.088**	0.044	0.132	0.23064	0.178215		9.41335E-06	5.27795
	41	0.229	0.19	0.01402	**0.086**	0.043	0.129	0.19665375	0.178215		3.31083E-06	5.15574
	42	0.159	0.194	0.00974	**0.058**	0.029	0.088	0.09480375	0.178215	0		3.50594
	43	0.169	0.202	0.01035	**0.060**	0.030	0.089	0.10710375	0.178215	0		3.57886
	44	0.17	0.192	0.01041	**0.063**	0.032	0.095	0.108375	0.178215	0		3.78754
	45	0.154	0.183	0.00943	**0.060**	0.030	0.090	0.088935	0.178215	0		3.59981
	46	0.095	0.184	0.00582	**0.037**	0.018	0.055	0.03384375	0.178215	0		2.20859
	53	0.033	0.216	0.00202	**0.011**	0.005	0.016	0.00408375	0.178215	0		0.65354
	54	0.043	0.223	0.00263	**0.014**	0.007	0.021	0.00693375	0.178215	0		0.82485
	56	0.04	0.218	0.00245	**0.013**	0.007	0.020	0.006	0.178215	0		0.7849
	60	0.045	0.194	0.00276	**0.017**	0.008	0.025	0.00759375	0.178215	0		0.99225
	mean	0.296	0.200	0.01811	**0.105**	0.053	0.158	0.328143882	0.178215		2.6921E-05	6.32961
	0	0.055	0.19	0.00337	**0.021**	0.010	0.031	0.01134375	0.009375		6.72E-06	1.23828
	1	0.046	0.208	0.00282	**0.016**	0.008	0.024	0.007935	0.009375	0		0.94603
	2	0.143	0.203	0.00876	**0.050**	0.025	0.075	0.07668375	0.009375		0.000229747	3.01335
	3	0.161	0.195	0.00986	**0.059**	0.029	0.088	0.09720375	0.009375		0.000299789	3.53184
	4	0.344	0.188	0.02107	**0.130**	0.065	0.196	0.44376	0.009375		0.001482701	7.82726
	5	0.154	0.184	0.00943	**0.060**	0.030	0.090	0.088935	0.009375		0.000271565	3.58024
	6	0.14	0.193	0.00857	**0.052**	0.026	0.078	0.0735	0.009375		0.00021888	3.10299
	7	0.179	0.207	0.01096	**0.062**	0.031	0.092	0.12015375	0.009375		0.000378125	3.69907
	8	0.22	0.209	0.01347	**0.075**	0.038	0.113	0.1815	0.009375		0.00058752	4.50283
	9	0.288	0.181	0.01764	**0.113**	0.057	0.170	0.31104	0.009375		0.001029683	6.80649
	10	0.237	0.193	0.01451	**0.088**	0.044	0.131	0.21063375	0.009375		0.000686963	5.25292
	11	0.206	0.198	0.01261	**0.074**	0.037	0.111	0.159135	0.009375		0.000511181	4.45053
	12	0.236	0.205	0.01445	**0.082**	0.041	0.123	0.20886	0.009375		0.000680909	4.92456
	13	0.348	0.205	0.02131	**0.121**	0.061	0.182	0.45414	0.009375		0.001518131	7.26164
	14	0.317	0.18	0.01941	**0.126**	0.063	0.188	0.37683375	0.009375		0.001254259	7.53349
	15	0.344	0.196	0.02107	**0.125**	0.063	0.188	0.44376	0.009375		0.001482701	7.50778
	16	0.284	0.205	0.01739	**0.099**	0.049	0.148	0.30246	0.009375		0.001000397	5.92617
	17	0.313	0.2165	0.01917	**0.103**	0.052	0.155	0.36738375	0.009375		0.001222003	6.18438
	18	0.342	0.228	0.02094	**0.107**	0.053	0.160	0.438615	0.009375		0.001465139	6.41654
	19	0.498	0.218	0.0305	**0.163**	0.081	0.244	0.930015	0.009375		0.003142451	9.77197
	20	0.557	0.21	0.03411	**0.189**	0.095	0.284	1.16343375	0.009375		0.003939187	11.3461
	21	0.473	0.212	0.02897	**0.159**	0.080	0.239	0.83898375	0.009375		0.002831731	9.54409
	22	0.546	0.208	0.03344	**0.187**	0.094	0.281	1.117935	0.009375		0.003783885	11.2289
	23	0.5625	0.2065	0.03445	**0.194**	0.097	0.291	1.186523438	0.009375		0.004018	11.6523
	24	0.579	0.205	0.03546	**0.201**	0.101	0.302	1.25715375	0.009375		0.004259085	12.0819
	25	0.543	0.192	0.03325	**0.202**	0.101	0.302	1.10568375	0.009375		0.003742067	12.0978
	26	0.545	0.197	0.03337	**0.197**	0.099	0.296	1.11384375	0.009375		0.00376992	11.8342

Event	elapsed time	u (m/s)	d (m)	u* (m/s)	Ex or D (m^2/s)	(-50%) Ex or D (m^2/s)	(+50%) Ex or D (m^2/s)	τ (N/m^2)	τc(N/m^2)	**R** = 0 IF τ < τc	OR **R** = Re(τ /τc -1)	D (m^2/min)
	27	0.553	0.203	0.03386	**0.194**	0.097	0.291	1.14678375	0.009375		0.003882355	11.653
	28	0.511	0.202	0.03129	**0.180**	0.090	0.271	0.97920375	0.009375		0.003310349	10.8213
	29	0.531	0.2	0.03252	**0.189**	0.095	0.284	1.05735375	0.009375		0.003577101	11.3573
	30	0.561	0.203	0.03435	**0.197**	0.099	0.296	1.18020375	0.009375		0.003996429	11.8216
4	31	0.516	0.204	0.0316	**0.180**	0.090	0.271	0.99846	0.009375		0.003376077	10.82
	32	0.48	0.198	0.02939	**0.173**	0.086	0.259	0.864	0.009375		0.00291712	10.3702
	33	0.531	0.199	0.03252	**0.190**	0.095	0.285	1.05735375	0.009375		0.003577101	11.4143
	34	0.488	0.201	0.02988	**0.173**	0.087	0.260	0.89304	0.009375		0.003016243	10.3856
	35	0.432	0.195	0.02645	**0.158**	0.079	0.237	0.69984	0.009375		0.002356787	9.47673
	36	0.399	0.187	0.02443	**0.152**	0.076	0.228	0.59700375	0.009375		0.002005773	9.12727
	37	0.378	0.193	0.02315	**0.140**	0.070	0.209	0.535815	0.009375		0.001796915	8.37807
	38	0.387	0.197	0.0237	**0.140**	0.070	0.210	0.56163375	0.009375		0.001885043	8.40338
	39	0.371	0.2	0.02272	**0.132**	0.066	0.198	0.51615375	0.009375		0.001729805	7.93512
	40	0.324	0.192	0.01984	**0.120**	0.060	0.180	0.39366	0.009375		0.001311693	7.2186
	41	0.311	0.183	0.01904	**0.121**	0.061	0.182	0.36270375	0.009375		0.001206029	7.26974
	42	0.31	0.19	0.01898	**0.116**	0.058	0.174	0.360375	0.009375		0.00119808	6.97939
	43	0.249	0.192	0.01525	**0.092**	0.046	0.139	0.23250375	0.009375		0.000761613	5.54763
	44	0.207	0.188	0.01268	**0.079**	0.039	0.118	0.16068375	0.009375		0.000516467	4.71001
	45	0.241	0.19	0.01476	**0.090**	0.045	0.136	0.21780375	0.009375		0.000711437	5.42591
	46	0.265	0.206	0.01623	**0.092**	0.046	0.138	0.26334375	0.009375		0.00086688	5.50285
	47	0.288	0.208	0.01764	**0.099**	0.049	0.148	0.31104	0.009375		0.001029683	5.92296
	48	0.296	0.201	0.01813	**0.105**	0.052	0.157	0.32856	0.009375		0.001089485	6.29949
	49	0.282	0.196	0.01727	**0.103**	0.051	0.154	0.298215	0.009375		0.000985907	6.15464
	50	0.266	0.193	0.01629	**0.098**	0.049	0.147	0.265335	0.009375		0.000873677	5.89568
	51	0.263	0.192	0.01611	**0.098**	0.049	0.146	0.25938375	0.009375		0.000853363	5.85955
	52	0.243	0.191	0.01488	**0.091**	0.045	0.136	0.22143375	0.009375		0.000723827	5.4423
	53	0.232	0.197	0.01421	**0.084**	0.042	0.126	0.20184	0.009375		0.000656947	5.03769
	54	0.232	0.199	0.01421	**0.083**	0.042	0.125	0.20184	0.009375		0.000656947	4.98706
	55	0.232	0.183	0.01421	**0.090**	0.045	0.136	0.20184	0.009375		0.000656947	5.42308
	56	0.033	0.17	0.00202	**0.014**	0.007	0.021	0.00408375	0.009375	0		0.83038
	57	0.033	0.159	0.00202	**0.015**	0.007	0.022	0.00408375	0.009375	0		0.88782
	58	0.033	0.169	0.00202	**0.014**	0.007	0.021	0.00408375	0.009375	0		0.83529
	59	0.033	0.17	0.00202	**0.014**	0.007	0.021	0.00408375	0.009375	0		0.83038
	60	0.033	0.17	0.00202	**0.014**	0.007	0.021	0.00408375	0.009375	0		0.83038
	mean	0.31483	0.19597	0.01928	**0.115**	0.057	0.172	0.371687201	0.009375		0.001236692	6.87225
	5	0.044	0.241	0.00269	**0.013**	0.007	0.020	0.00726	0.009375	0		0.78099
	6	0.059	0.248	0.00361	**0.017**	0.008	0.025	0.01305375	0.009375		1.25568E-05	1.01768
	7	0.065	0.255	0.00398	**0.018**	0.009	0.027	0.01584375	0.009375		0.00002208	1.09039
	8	0.066	0.263	0.00404	**0.018**	0.009	0.027	0.016335	0.009375		2.37568E-05	1.07349
	9	0.096	0.263	0.00588	**0.026**	0.013	0.039	0.03456	0.009375		8.59648E-05	1.56144
	10	0.11	0.263	0.00674	**0.030**	0.015	0.045	0.045375	0.009375		0.00012288	1.78915
	11	0.114	0.27	0.00698	**0.030**	0.015	0.045	0.048735	0.009375		0.000134349	1.80614
	12	0.119	0.275	0.00729	**0.031**	0.015	0.046	0.05310375	0.009375		0.000149261	1.85107
	13	0.121	0.277	0.00741	**0.031**	0.016	0.047	0.05490375	0.009375		0.000155405	1.86859
	14	0.135	0.28	0.00827	**0.034**	0.017	0.052	0.06834375	0.009375		0.00020128	2.06246
	15	0.198	0.277	0.01212	**0.051**	0.025	0.076	0.147015	0.009375		0.000469811	3.0577
	16	0.186	0.268	0.01139	**0.049**	0.025	0.074	0.129735	0.009375		0.000410829	2.96885
	17	0.241	0.287	0.01476	**0.060**	0.030	0.090	0.21780375	0.009375		0.000711437	3.59207
	18	0.252	0.289	0.01543	**0.062**	0.031	0.093	0.23814	0.009375		0.000780851	3.73003
	19	0.238	0.286	0.01457	**0.059**	0.030	0.089	0.212415	0.009375		0.000693043	3.55976
	20	0.261	0.27	0.01598	**0.069**	0.034	0.103	0.25545375	0.009375		0.000839949	4.1351
	21	0.29	0.231	0.01776	**0.090**	0.045	0.134	0.315375	0.009375		0.00104448	5.37026
	22	0.255	0.264	0.01562	**0.069**	0.034	0.103	0.24384375	0.009375		0.00080032	4.13186
	23	0.265	0.281	0.01623	**0.067**	0.034	0.101	0.26334375	0.009375		0.00086688	4.03412
	24	0.255	0.286	0.01562	**0.064**	0.032	0.095	0.24384375	0.009375		0.00080032	3.81403
	25	0.247	0.285	0.01513	**0.062**	0.031	0.093	0.22878375	0.009375		0.000748915	3.70733
	26	0.219	0.262	0.01341	**0.060**	0.030	0.089	0.17985375	0.009375		0.000581901	3.57563
	27	0.167	0.264	0.01023	**0.045**	0.023	0.068	0.10458375	0.009375		0.000324979	2.70596
	28	0.161	0.263	0.00986	**0.044**	0.022	0.065	0.09720375	0.009375		0.000299789	2.61866
	29	0.151	0.264	0.00925	**0.041**	0.020	0.061	0.08550375	0.009375		0.000259853	2.44671
3	30	0.149	0.267	0.00912	**0.040**	0.020	0.060	0.08325375	0.009375		0.000252173	2.38718
	31	0.152	0.268	0.00931	**0.040**	0.020	0.061	0.08664	0.009375		0.000263731	2.42615
	32	0.134	0.267	0.00821	**0.036**	0.018	0.054	0.067335	0.009375		0.000197837	2.14686
	33	0.123	0.271	0.00753	**0.032**	0.016	0.049	0.05673375	0.009375		0.000161651	1.94153
	34	0.136	0.271	0.00833	**0.036**	0.018	0.054	0.06936	0.009375		0.000204749	2.14674
	35	0.137	0.266	0.00839	**0.037**	0.018	0.055	0.07038375	0.009375		0.000208243	2.20317
	36	0.131	0.264	0.00802	**0.035**	0.018	0.053	0.06435375	0.009375		0.000187661	2.12264
	37	0.127	0.266	0.00778	**0.034**	0.017	0.051	0.06048375	0.009375		0.000174451	2.04236
	38	0.125	0.269	0.00765	**0.033**	0.017	0.050	0.05859375	0.009375		0.000168	1.98777
	39	0.128	0.269	0.00784	**0.034**	0.017	0.051	0.06144	0.009375		0.000177715	2.03548
	40	0.123	0.269	0.00753	**0.033**	0.016	0.049	0.05673375	0.009375		0.000161651	1.95597

Event	elapsed time	u (m/s)	d (m)	u* (m/s)	Ex or D (m²/s)	(-50%) Ex or D (m²/s)	(+50%) Ex or D (m²/s)	τ (N/m²)	τc(N/m²)	**R** = 0 IF τ < τc	OR **R** = Re(τ /τc -1)	D (m²/min)
	41	0.125	0.268	0.00765	**0.033**	0.017	0.050	0.05859375	0.009375		0.000168	1.99519
	42	0.122	0.268	0.00747	**0.032**	0.016	0.049	0.055815	0.009375		0.000158515	1.94731
	43	0.12	0.267	0.00735	**0.032**	0.016	0.048	0.054	0.009375		0.00015232	1.92256
	44	0.109	0.265	0.00667	**0.029**	0.015	0.044	0.04455375	0.009375		0.000120077	1.7595
	45	0.103	0.253	0.00631	**0.029**	0.015	0.044	0.03978375	0.009375		0.000103795	1.74151
	46	0.098	0.245	0.006	**0.029**	0.014	0.043	0.036015	0.009375		9.09312E-05	1.71108
	47	0.098	0.244	0.006	**0.029**	0.014	0.043	0.036015	0.009375		9.09312E-05	1.71809
	48	0.098	0.25	0.006	**0.028**	0.014	0.042	0.036015	0.009375		9.09312E-05	1.67685
	49	0.098	0.258	0.006	**0.027**	0.014	0.041	0.036015	0.009375		9.09312E-05	1.62486
	50	0.098	0.258	0.006	**0.027**	0.014	0.041	0.036015	0.009375		9.09312E-05	1.62486
	51	0.098	0.254	0.006	**0.028**	0.014	0.041	0.036015	0.009375		9.09312E-05	1.65045
	52	0.17	0.248	0.01041	**0.049**	0.024	0.073	0.108375	0.009375		0.00033792	2.93229
	53	0.125	0.22	0.00765	**0.041**	0.020	0.061	0.05859375	0.009375		0.000168	2.43051
	54	0.281	0.185	0.01721	**0.108**	0.054	0.162	0.29610375	0.009375		0.000978701	6.49747
	55	0.098	0.223	0.006	**0.031**	0.016	0.047	0.036015	0.009375		9.09312E-05	1.87988
	mean	0.14943	0.26206	0.00915	**0.041**	0.020	0.061	0.083736507	0.009375		0.000253821	2.43923
	3	0.01	0.224	0.00061	**0.003**	0.002	0.005	0.000375	0.0375	0		0.19097
	8	0.02	0.239	0.00122	**0.006**	0.003	0.009	0.0015	0.0375	0		0.35797
	10	0.065	0.246	0.00398	**0.019**	0.009	0.028	0.01584375	0.0375	0		1.13028
	11	0.065	0.248	0.00398	**0.019**	0.009	0.028	0.01584375	0.0375	0		1.12117
	12	0.064	0.246	0.00392	**0.019**	0.009	0.028	0.01536	0.0375	0		1.1129
	13	0.064	0.234	0.00392	**0.019**	0.010	0.029	0.01536	0.0375	0		1.16997
	14	0.07	0.224	0.00429	**0.022**	0.011	0.033	0.018375	0.0375	0		1.33678
	15	0.064	0.216	0.00392	**0.021**	0.011	0.032	0.01536	0.0375	0		1.26746
	16	0.095	0.227	0.00582	**0.030**	0.015	0.045	0.03384375	0.0375	0		1.79022
	17	0.084	0.24	0.00514	**0.025**	0.012	0.037	0.02646	0.0375	0		1.49719
	18	0.09	0.242	0.00551	**0.027**	0.013	0.040	0.030375	0.0375	0		1.59088
	19	0.102	0.241	0.00625	**0.030**	0.015	0.045	0.039015	0.0375		1.2928E-06	1.81047
	20	0.106	0.233	0.00649	**0.032**	0.016	0.049	0.042135	0.0375		3.9552E-06	1.94607
	21	0.133	0.237	0.00814	**0.040**	0.020	0.060	0.06633375	0.0375		2.46048E-05	2.40056
	22	0.225	0.22	0.01378	**0.073**	0.036	0.109	0.18984375	0.0375		0.00013	4.37491
	23	0.167	0.215	0.01023	**0.055**	0.028	0.083	0.10458375	0.0375		5.72448E-05	3.32267
	24	0.157	0.22	0.00961	**0.051**	0.025	0.076	0.09243375	0.0375		4.68768E-05	3.05272
	25	0.179	0.222	0.01096	**0.057**	0.029	0.086	0.12015375	0.0375		7.05312E-05	3.44913
	26	0.178	0.218	0.0109	**0.058**	0.029	0.087	0.118815	0.0375		6.93888E-05	3.49279
	27	0.207	0.235	0.01268	**0.063**	0.031	0.094	0.16068375	0.0375		0.000105117	3.76801
	28	0.198	0.26	0.01212	**0.054**	0.027	0.081	0.147015	0.0375		9.34528E-05	3.25763
	29	0.183	0.27	0.01121	**0.048**	0.024	0.072	0.12558375	0.0375		7.51648E-05	2.89932
	30	0.187	0.269	0.01145	**0.050**	0.025	0.074	0.13113375	0.0375		7.99008E-05	2.97371
	31	0.186	0.268	0.01139	**0.049**	0.025	0.074	0.129735	0.0375		7.87072E-05	2.96885
	32	0.189	0.262	0.01157	**0.051**	0.026	0.077	0.13395375	0.0375		8.23072E-05	3.08582
	33	0.199	0.23	0.01219	**0.062**	0.031	0.093	0.14850375	0.0375		9.47232E-05	3.70113
	34	0.263	0.195	0.01611	**0.096**	0.048	0.144	0.25938375	0.0375		0.000189341	5.7694
	35	0.315	0.168	0.01929	**0.134**	0.067	0.201	0.37209375	0.0375		0.00028552	8.02067
	36	0.188	0.17	0.01151	**0.079**	0.039	0.118	0.13254	0.0375		8.11008E-05	4.73062
	37	0.345	0.156	0.02113	**0.158**	0.079	0.237	0.44634375	0.0375		0.00034888	9.46028
	38	0.422	0.149	0.02584	**0.202**	0.101	0.303	0.667815	0.0375		0.000537869	12.1153
	39	0.267	0.19	0.01635	**0.100**	0.050	0.150	0.26733375	0.0375		0.000196125	6.01128
	40	0.162	0.245	0.00992	**0.047**	0.024	0.071	0.098415	0.0375		5.19808E-05	2.82851
	41	0.165	0.257	0.0101	**0.046**	0.023	0.069	0.10209375	0.0375		0.00005512	2.74638
	42	0.183	0.258	0.01121	**0.051**	0.025	0.076	0.12558375	0.0375		7.51648E-05	3.03418
	43	0.18	0.255	0.01102	**0.050**	0.025	0.075	0.1215	0.0375		0.00007168	3.01955
	44	0.191	0.25	0.0117	**0.054**	0.027	0.082	0.13680375	0.0375		8.47392E-05	3.26816
	45	0.19	0.249	0.01164	**0.054**	0.027	0.082	0.135375	0.0375		0.00008352	3.2641
	46	0.189	0.232	0.01157	**0.058**	0.029	0.087	0.13395375	0.0375		8.23072E-05	3.48484
	47	0.222	0.21	0.01359	**0.075**	0.038	0.113	0.184815	0.0375		0.000125709	4.52213
	48	0.254	0.193	0.01555	**0.094**	0.047	0.141	0.241935	0.0375		0.000174451	5.62971
2	49	0.383	0.157	0.02345	**0.174**	0.087	0.261	0.55008375	0.0375		0.000437405	10.4354
	50	0.312	0.148	0.01911	**0.150**	0.075	0.225	0.36504	0.0375		0.000279501	9.01783
	51	0.157	0.166	0.00961	**0.067**	0.034	0.101	0.09243375	0.0375		4.68768E-05	4.04577
	52	0.13	0.194	0.00796	**0.048**	0.024	0.072	0.063375	0.0375		0.00002208	2.86649
	53	0.113	0.221	0.00692	**0.036**	0.018	0.055	0.04788375	0.0375		8.8608E-06	2.18724
	54	0.11	0.231	0.00674	**0.034**	0.017	0.051	0.045375	0.0375		6.72E-06	2.037
	55	0.126	0.234	0.00772	**0.038**	0.019	0.058	0.059535	0.0375		1.88032E-05	2.30337
	56	0.121	0.225	0.00741	**0.038**	0.019	0.058	0.05490375	0.0375		1.48512E-05	2.30045
	57	0.124	0.219	0.00759	**0.040**	0.020	0.061	0.05766	0.0375		1.72032E-05	2.42207
	58	0.121	0.217	0.00741	**0.040**	0.020	0.060	0.05490375	0.0375		1.48512E-05	2.38526
	59	0.121	0.215	0.00741	**0.040**	0.020	0.060	0.05490375	0.0375		1.48512E-05	2.40744
	60	0.116	0.214	0.0071	**0.039**	0.019	0.058	0.05046	0.0375		1.10592E-05	2.31875
	61	0.119	0.215	0.00729	**0.039**	0.020	0.059	0.05310375	0.0375		1.33152E-05	2.36765
	62	0.118	0.215	0.00723	**0.039**	0.020	0.059	0.052215	0.0375		1.25568E-05	2.34776

Event	elapsed time	u (m/s)	d (m)	u* (m/s)	Ex or D (m²/s)	(-50%) Ex or D (m²/s)	(+50%) Ex or D (m²/s)	τ (N/m²)	τc(N/m²)	**R** = 0 IF τ < τc	OR **R** = Re(τ /τc -1)	D (m²/min)
	63	0.117	0.214	0.00716	**0.039**	0.019	0.058	0.05133375	0.0375		1.18048E-05	2.33874
	64	0.117	0.212	0.00716	**0.039**	0.020	0.059	0.05133375	0.0375		1.18048E-05	2.3608
	65	0.126	0.212	0.00772	**0.042**	0.021	0.064	0.059535	0.0375		1.88032E-05	2.5424
	66	0.115	0.212	0.00704	**0.039**	0.019	0.058	0.04959375	0.0375		0.00001032	2.32045
	67	0.105	0.212	0.00643	**0.035**	0.018	0.053	0.04134375	0.0375		3.28E-06	2.11867
	68	0.1	0.217	0.00612	**0.033**	0.016	0.049	0.0375	0.0375		0	1.97129
	69	0.111	0.218	0.0068	**0.036**	0.018	0.054	0.04620375	0.0375		7.4272E-06	2.17809
	70	0.115	0.216	0.00704	**0.038**	0.019	0.057	0.04959375	0.0375		0.00001032	2.27747
	71	0.117	0.215	0.00716	**0.039**	0.019	0.058	0.05133375	0.0375		1.18048E-05	2.32786
	72	0.097	0.206	0.00594	**0.034**	0.017	0.050	0.03528375	0.0375	0		2.01425
	73	0.077	0.202	0.00472	**0.027**	0.014	0.041	0.02223375	0.0375	0		1.6306
	74	0.075	0.208	0.00459	**0.026**	0.013	0.039	0.02109375	0.0375	0		1.54244
	75	0.078	0.218	0.00478	**0.026**	0.013	0.038	0.022815	0.0375	0		1.53055
	76	0.065	0.215	0.00398	**0.022**	0.011	0.032	0.01584375	0.0375	0		1.29326
	77	0.067	0.207	0.0041	**0.023**	0.012	0.035	0.01683375	0.0375	0		1.38457
	78	0.073	0.201	0.00447	**0.026**	0.013	0.039	0.01998375	0.0375	0		1.55359
	79	0.058	0.202	0.00355	**0.020**	0.010	0.031	0.012615	0.0375	0		1.22825
	80	0.051	0.208	0.00312	**0.017**	0.009	0.026	0.00975375	0.0375	0		1.04886
	81	0.051	0.222	0.00312	**0.016**	0.008	0.025	0.00975375	0.0375	0		0.98271
	82	0.051	0.234	0.00312	**0.016**	0.008	0.023	0.00975375	0.0375	0		0.93232
	83	0.051	0.245	0.00312	**0.015**	0.007	0.022	0.00975375	0.0375	0		0.89046
	84	0.051	0.251	0.00312	**0.014**	0.007	0.022	0.00975375	0.0375	0		0.86917
	85	0.051	0.255	0.00312	**0.014**	0.007	0.021	0.00975375	0.0375	0		0.85554
	86	0.051	0.252	0.00312	**0.014**	0.007	0.022	0.00975375	0.0375	0		0.86572
	87	0.051	0.252	0.00312	**0.014**	0.007	0.022	0.00975375	0.0375	0		0.86572
	88	0.051	0.251	0.00312	**0.014**	0.007	0.022	0.00975375	0.0375	0		0.86917
	89	0.051	0.243	0.00312	**0.015**	0.007	0.022	0.00975375	0.0375	0		0.89779
	90	0.051	0.238	0.00312	**0.015**	0.008	0.023	0.00975375	0.0375	0		0.91665
	mean	0.13455	0.22255	0.00824	**0.043**	0.022	0.065	0.06789314	0.0375		2.59355E-05	2.58625
	0	0.053	0.186	0.00325	**0.020**	0.010	0.030	0.01053375	0.0375	0		1.21891
	1	0.053	0.186	0.00325	**0.020**	0.010	0.030	0.01053375	0.0375	0		1.21891
	2	0.053	0.186	0.00325	**0.020**	0.010	0.030	0.01053375	0.0375	0		1.21891
	3	0.053	0.186	0.00325	**0.020**	0.010	0.030	0.01053375	0.0375	0		1.21891
	4	0.053	0.186	0.00325	**0.020**	0.010	0.030	0.01053375	0.0375	0		1.21891
	5	0.053	0.188	0.00325	**0.020**	0.010	0.030	0.01053375	0.0375	0		1.20594
	6	0.053	0.191	0.00325	**0.020**	0.010	0.030	0.01053375	0.0375	0		1.187
	7	0.053	0.194	0.00325	**0.019**	0.010	0.029	0.01053375	0.0375	0		1.16865
	8	0.067	0.198	0.0041	**0.024**	0.012	0.036	0.01683375	0.0375	0		1.4475
	9	0.067	0.2	0.0041	**0.024**	0.012	0.036	0.01683375	0.0375	0		1.43303
	10	0.102	0.207	0.00625	**0.035**	0.018	0.053	0.039015	0.0375		1.2928E-06	2.10785
	11	0.109	0.221	0.00667	**0.035**	0.018	0.053	0.04455375	0.0375		6.0192E-06	2.10981
	12	0.106	0.228	0.00649	**0.033**	0.017	0.050	0.042135	0.0375		3.9552E-06	1.98875
	13	0.177	0.236	0.01084	**0.053**	0.027	0.080	0.11748375	0.0375		6.82528E-05	3.20827
	14	0.177	0.242	0.01084	**0.052**	0.026	0.078	0.11748375	0.0375		6.82528E-05	3.12872
	15	0.177	0.251	0.01084	**0.050**	0.025	0.075	0.11748375	0.0375		6.82528E-05	3.01654
	16	0.081	0.268	0.00496	**0.022**	0.011	0.032	0.02460375	0.0375	0		1.29288
	17	0.071	0.273	0.00435	**0.019**	0.009	0.028	0.01890375	0.0375	0		1.11251
	18	0.098	0.27	0.006	**0.026**	0.013	0.039	0.036015	0.0375	0		1.55264
	19	0.107	0.265	0.00655	**0.029**	0.014	0.043	0.04293375	0.0375		4.6368E-06	1.72722
	20	0.118	0.268	0.00723	**0.031**	0.016	0.047	0.052215	0.0375		1.25568E-05	1.88346
	21	0.136	0.265	0.00833	**0.037**	0.018	0.055	0.06936	0.0375		2.71872E-05	2.19534
	22	0.129	0.267	0.0079	**0.034**	0.017	0.052	0.06240375	0.0375		2.12512E-05	2.06675
	23	0.132	0.274	0.00808	**0.034**	0.017	0.052	0.06534	0.0375		2.37568E-05	2.06079
	24	0.163	0.278	0.00998	**0.042**	0.021	0.063	0.09963375	0.0375		5.30208E-05	2.50814
	25	0.177	0.271	0.01084	**0.047**	0.023	0.070	0.11748375	0.0375		6.82528E-05	2.79392
	26	0.186	0.271	0.01139	**0.049**	0.024	0.073	0.129735	0.0375		7.87072E-05	2.93598
	27	0.183	0.274	0.01121	**0.048**	0.024	0.071	0.12558375	0.0375		7.51648E-05	2.857
	28	0.182	0.275	0.01115	**0.047**	0.024	0.071	0.124215	0.0375		7.39968E-05	2.83105
	29	0.181	0.276	0.01108	**0.047**	0.023	0.070	0.12285375	0.0375		7.28352E-05	2.8053
	30	0.178	0.278	0.0109	**0.046**	0.023	0.068	0.118815	0.0375		6.93888E-05	2.73895
	31	0.296	0.265	0.01813	**0.080**	0.040	0.119	0.32856	0.0375		0.000248371	4.7781
	32	0.292	0.243	0.01788	**0.086**	0.043	0.129	0.31974	0.0375		0.000240845	5.14027
	33	0.389	0.217	0.02382	**0.128**	0.064	0.192	0.56745375	0.0375		0.000452227	7.6683
	34	0.515	0.182	0.03154	**0.202**	0.101	0.303	0.99459375	0.0375		0.00081672	12.1045
	35	0.42	0.186	0.02572	**0.161**	0.080	0.241	0.6615	0.0375		0.00053248	9.6593
	36	0.337	0.2	0.02064	**0.120**	0.060	0.180	0.42588375	0.0375		0.000331421	7.20791
	37	0.328	0.202	0.02009	**0.116**	0.058	0.174	0.40344	0.0375		0.000312269	6.94595
	38	0.359	0.193	0.02198	**0.133**	0.066	0.199	0.48330375	0.0375		0.000380419	7.95695
	39	0.426	0.18	0.02609	**0.169**	0.084	0.253	0.680535	0.0375		0.000548723	10.1239
	40	0.481	0.165	0.02946	**0.208**	0.104	0.312	0.86760375	0.0375		0.000708355	12.4701
	41	0.41	0.148	0.02511	**0.198**	0.099	0.296	0.630375	0.0375		0.00050592	11.8504

Event	elapsed time	u (m/s)	d (m)	u* (m/s)	Ex or D (m^2/s)	(-50%) Ex or D (m^2/s)	(+50%) Ex or D (m^2/s)	τ (N/m^2)	τc(N/m^2)	**R** = 0 IF τ < τc	OR **R** = Re(τ /τc -1)	D (m^2/min)
	42	0.287	0.141	0.01758	**0.145**	0.073	0.218	0.30888375	0.0375		0.000231581	8.70707
	43	0.067	0.191	0.0041	**0.025**	0.013	0.038	0.01683375	0.0375	0		1.50055
	44	0.115	0.22	0.00704	**0.037**	0.019	0.056	0.04959375	0.0375		0.00001032	2.23607
	45	0.14	0.24	0.00857	**0.042**	0.021	0.062	0.0735	0.0375		0.00003072	2.49532
1	46	0.146	0.253	0.00894	**0.041**	0.021	0.062	0.079935	0.0375		3.62112E-05	2.46855
	47	0.194	0.239	0.01188	**0.058**	0.029	0.087	0.141135	0.0375		8.84352E-05	3.47227
	48	0.209	0.214	0.0128	**0.070**	0.035	0.104	0.16380375	0.0375		0.000107779	4.17774
	49	0.202	0.21	0.01237	**0.069**	0.034	0.103	0.153015	0.0375		9.85728E-05	4.11473
	50	0.186	0.207	0.01139	**0.064**	0.032	0.096	0.129735	0.0375		7.87072E-05	3.84372
	51	0.19	0.212	0.01164	**0.064**	0.032	0.096	0.135375	0.0375		0.00008352	3.83378
	52	0.173	0.217	0.01059	**0.057**	0.028	0.085	0.11223375	0.0375		6.37728E-05	3.41033
	53	0.18	0.221	0.01102	**0.058**	0.029	0.087	0.1215	0.0375		0.00007168	3.48409
	54	0.183	0.223	0.01121	**0.059**	0.029	0.088	0.12558375	0.0375		7.51648E-05	3.51039
	55	0.163	0.225	0.00998	**0.052**	0.026	0.077	0.09963375	0.0375		5.30208E-05	3.09895
	56	0.18	0.223	0.01102	**0.058**	0.029	0.086	0.1215	0.0375		0.00007168	3.45284
	57	0.143	0.228	0.00876	**0.045**	0.022	0.067	0.07668375	0.0375		3.34368E-05	2.68294
	58	0.133	0.239	0.00814	**0.040**	0.020	0.060	0.06633375	0.0375		2.46048E-05	2.38047
	59	0.128	0.248	0.00784	**0.037**	0.018	0.055	0.06144	0.0375		2.04288E-05	2.20784
	60	0.125	0.252	0.00765	**0.035**	0.018	0.053	0.05859375	0.0375		0.000018	2.12187
	61	0.122	0.247	0.00747	**0.035**	0.018	0.053	0.055815	0.0375		1.56288E-05	2.11287
	62	0.124	0.241	0.00759	**0.037**	0.018	0.055	0.05766	0.0375		1.72032E-05	2.20097
	63	0.135	0.237	0.00827	**0.041**	0.020	0.061	0.06834375	0.0375		0.00002632	2.43666
	64	0.126	0.235	0.00772	**0.038**	0.019	0.057	0.059535	0.0375		1.88032E-05	2.29357
	65	0.125	0.235	0.00765	**0.038**	0.019	0.057	0.05859375	0.0375		0.000018	2.27537
	66	0.129	0.234	0.0079	**0.039**	0.020	0.059	0.06240375	0.0375		2.12512E-05	2.35821
	67	0.123	0.234	0.00753	**0.037**	0.019	0.056	0.05673375	0.0375		1.64128E-05	2.24853
	68	0.127	0.235	0.00778	**0.039**	0.019	0.058	0.06048375	0.0375		1.96128E-05	2.31177
	69	0.126	0.234	0.00772	**0.038**	0.019	0.058	0.059535	0.0375		1.88032E-05	2.30337
	70	0.125	0.234	0.00765	**0.038**	0.019	0.057	0.05859375	0.0375		0.000018	2.28509
	71	0.111	0.231	0.0068	**0.034**	0.017	0.051	0.04620375	0.0375		7.4272E-06	2.05551
	72	0.111	0.235	0.0068	**0.034**	0.017	0.051	0.04620375	0.0375		7.4272E-06	2.02053
	73	0.111	0.236	0.0068	**0.034**	0.017	0.050	0.04620375	0.0375		7.4272E-06	2.01196
	74	0.107	0.238	0.00655	**0.032**	0.016	0.048	0.04293375	0.0375		4.6368E-06	1.92316
	75	0.119	0.24	0.00729	**0.035**	0.018	0.053	0.05310375	0.0375		1.33152E-05	2.12102
	76	0.121	0.24	0.00741	**0.036**	0.018	0.054	0.05490375	0.0375		1.48512E-05	2.15667
	77	0.117	0.241	0.00716	**0.035**	0.017	0.052	0.05133375	0.0375		1.18048E-05	2.07672
	78	0.113	0.24	0.00692	**0.034**	0.017	0.050	0.04788375	0.0375		8.8608E-06	2.01408
	79	0.11	0.241	0.00674	**0.033**	0.016	0.049	0.045375	0.0375		6.72E-06	1.95247
	80	0.109	0.24	0.00667	**0.032**	0.016	0.049	0.04455375	0.0375		6.0192E-06	1.94278
	81	0.107	0.234	0.00655	**0.033**	0.016	0.049	0.04293375	0.0375		4.6368E-06	1.95604
	82	0.106	0.226	0.00649	**0.033**	0.017	0.050	0.042135	0.0375		3.9552E-06	2.00635
	83	0.128	0.22	0.00784	**0.041**	0.021	0.062	0.06144	0.0375		2.04288E-05	2.48884
	84	0.102	0.212	0.00625	**0.034**	0.017	0.051	0.039015	0.0375		1.2928E-06	2.05813
	85	0.073	0.203	0.00447	**0.026**	0.013	0.038	0.01998375	0.0375	0		1.53828
	86	0.073	0.197	0.00447	**0.026**	0.013	0.040	0.01998375	0.0375	0		1.58513
	87	0.073	0.194	0.00447	**0.027**	0.013	0.040	0.01998375	0.0375	0		1.60965
	88	0.073	0.203	0.00447	**0.026**	0.013	0.038	0.01998375	0.0375	0		1.53828
	89	0.172	0.21	0.01053	**0.058**	0.029	0.088	0.11094	0.0375		6.26688E-05	3.50363
	90	0.172	0.213	0.01053	**0.058**	0.029	0.086	0.11094	0.0375		6.26688E-05	3.45429
	mean	0.158	0.226	0.00969	**0.050**	0.025	0.075	0.093836504	0.0375		4.80738E-05	2.98876

F= Fraction of bacteria associated with SS

$$F = \frac{unfiltered - filtered}{unfiltered}$$

(NOTE: all Downstream Deep samples for June events)

Cho et al. 2010: F= 0.50

		Total Coliform			*E. coli*				
event	elapsed time (min)	unfiltered	filtered	F	unfiltered	filtered	F		
3	5	8664.4	4884.4	**0.44**	638.2	832.9	**0.31**		
	20	6131.4	2723	**0.56**	20.2	74.5	**2.69**		
	23	4884.4	3075.9	**0.37**	72.4	63.2	**-0.13**	avg TC F =	0.302
	26	6866.7	5794.3	**0.16**	74.5	10	**-0.87**		
	30	6488.2	3654	**0.44**	30.6	30.4	**-0.01**		
	35	4611.1	3448	**0.25**	30.6	41.3	**0.35**		
	43	4351.7	4351.7	**0.00**	20.2	30.6	**0.51**		
	53	4351.7	3448	**0.21**	10	10	**0.00**		
4	5	6866.7	4351.7	**0.37**	10	30.6	**2.06**		
	20	8664.4	3654	**0.58**	41.3	10	**-0.76**		
	23	6866.7	4884.4	**0.29**	10	30.6	**2.06**		
	26	6866.7	6131.4	**0.11**	30.6	40.5	**0.32**	avg TC F =	0.342
	30	6131.4	4351.7	**0.29**	10	10	**0.00**		
	35	3654	3873.2	**0.00**	20.2	10	**-0.50**		
	43	3075.9	1152.8	**0.63**	10	10	**0.00**		
	60	2281.8	1187.4	**0.48**	10	10	**0.00**		
5	5	7269.9	3075.9	**0.58**	30.6	135	**3.41**		
	20	10462.4	4105.8	**0.61**	30.6	51.6	**0.69**		
	23	6866.7	4884.4	**0.29**	20.2	121.1	**5.00**		
	26	9208.4	3255.4	**0.65**	86	52.1	**-0.39**	avg TC F =	0.456
	30	6866.7	6866.7	**0.00**	86	52.1	**-0.39**		
	35	7701	4611.1	**0.40**	63.2	52.1	**-0.18**		
	41	9803.9	4884.4	**0.50**	73.8	74.5	**0.01**		
	60	8664.4	3255.4	**0.62**	30.6	30.4	**-0.01**		
6	5	14136.1	14136.1	**0.00**	74.5	30.4	**-0.59**		
	15	12996.5	7269.9	**0.44**	20.2	30.6	**0.51**		
	20	24192	19862.9	**0.18**	30.6	10	**-0.67**		
	23	12996.5	14136.1	**0.00**	20.2	63.2	**2.13**	avg TC F =	0.288
	26.4167	15531.2	12033.3	**0.23**	96	30.6	**-0.68**		
	30	12996.5	8664.4	**0.33**	63.2	62.6	**-0.01**		
	35	14136.1	4884.4	**0.65**	30.6	30.6	**0.00**		
	60	3654	1917.9	**0.48**	10	20.2	**1.02**		
1	5	7269.9	3448	**0.53**	10	62.6	**5.26**		
	10	5475	1669.5	**0.70**	41.3	74.5	**0.80**		
	15	6488.2	4105.8	**0.37**	41.3	10	**-0.76**		
	20	4884.4	2187.2	**0.55**	30.6	52.1	**0.70**		
	25	2246.8	1071.2	**0.52**	10	10	**0.00**	avg TC F =	0.394
	30	2480.9	1137	**0.54**	52.1	30.6	**-0.41**		
	40	2098.2	2359.3	**-0.12**	30.6	30.6	**0.00**		
	60	2612.5	2142.6	**0.18**	10	10	**0.00**		
	80	2612.5	2246.8	**0.14**	20.2	10	**-0.50**		
	90	1664	771.2	**0.54**	30.6	20.2	**-0.34**		
2	5	8164.1	9803.9	**-0.20**	184.9	156.3	**-0.15**		
	35	5794.3	3130.1	**0.46**	97.9	52.1	**-0.47**		
	38	6131.4	2723	**0.56**	62.6	86	**0.37**	avg TC F =	0.340
	90	4105.8	1860	**0.55**	108.9	96.9	**-0.11**		

Sediment Settling Velocities:

Stokes Law:

$$V_s = \frac{g(\rho_s - \rho)\, D_{50}^2}{18\mu}$$

g =	9.81	m/s	Sediment D50:						
ρs =	2650	kg/m³	play sand	=	0.375	mm	=	0.00038	m
ρ =	1000	kg/m³	DAV1	=	0.257	mm	=	0.00026	m
μ =	0.001	kg/m*s							

	vs	
playsand =	**0.12646**	**m/s**
DAV1 =	**0.05939**	**m/s**

Cho et al. 2010: vs = 2.66*10^-7 m/s

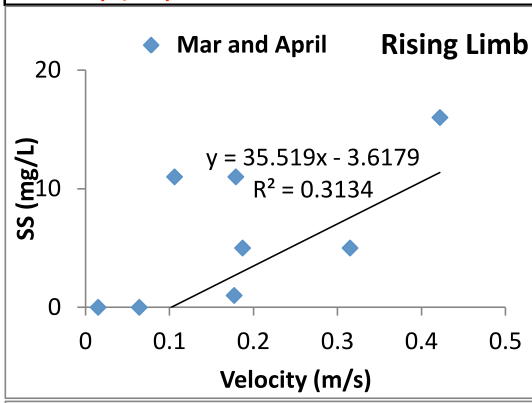
Critical Velocities u_{crit} and Criticial Shear Stress τ_{crit}:

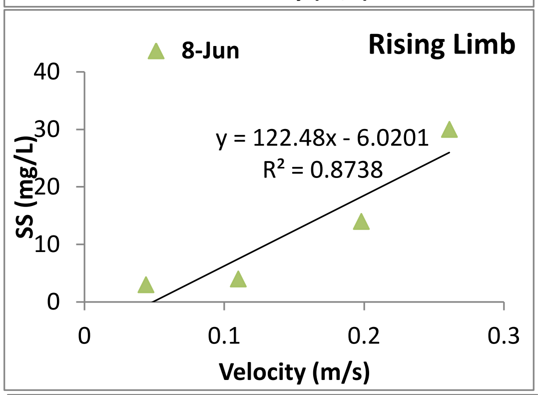
Cho et al. 2010:	Non-reach specific	Reach 12	Reach 23	Reach34
τc (N/m^2) =	0.12	0.034	0.187	0.62

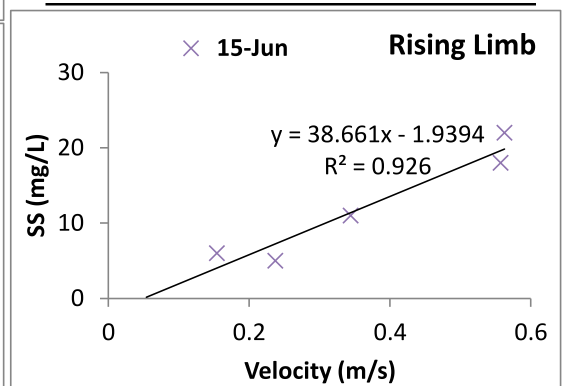
$$\tau_{crit} = 3.75\, u_{crit}^2$$

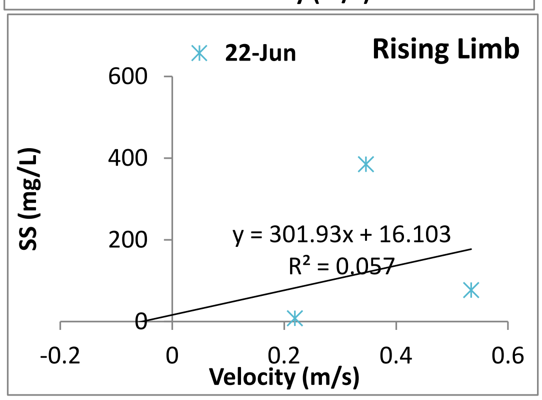
V crit is equal to the x-intercept for each date

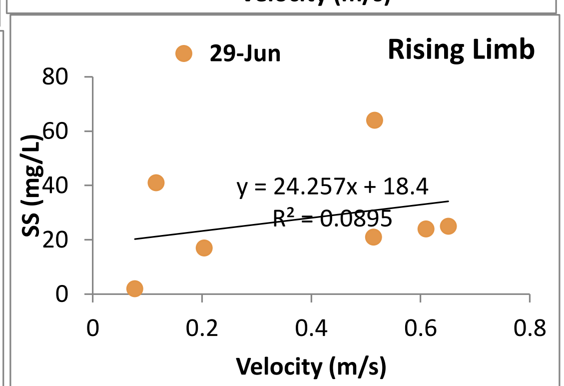
event #	date	v_{crit} (m/s)	τ_{crit} (N/m^2)
1&2	Mar Apr	0.1	0.0375
3	8-Jun	0.05	0.00938
4	15-Jun	0.05	0.00938
5	22-Jun	0.218	0.17822
6	29-Jun	0.09	0.03038











Appendix E-3: Matlab Model Codes

MacCormack Method- AdvectionDispersion with constant u and D coefficients

```
%function MacCormack(WQ,vD)
%%MacCormack Scheme steady state (constant u and D)
%McCaskill 11/14/11
%u = mean velocity (m/s)
%D = mean Diffusion Coefficient
%dt = delta time
%dx = delta x
%C0 = upstream TC concentrations at x=0 at different t (MPN/100mL)
clear all
load June15.mat WQ textdataWQ textdatavD vD
u = mean(vD(:,2));    %average velocity (m/s)
D = mean(vD(:,3)); %average Diffusion Coefficient (m^2/s)
%D = 0.05
p = 0;      %start of sand bed
q = 2.5;    %end of sand bed
time = 0;      %start clock (s)
runtime = 3600;   %required run time (s)
dt = 1;    %sec
dx = 0.5;  %meter
x = p:dx:q;
t = time:dt:runtime;
ni = (q+dx)/dx;
nj = (runtime+dt)/dt;

c = (u*dt)/(dx);      %courant number
a = (D*dt)/(dx*dx); %(alpha) = diffusion number
C = zeros(((q+dx)/dx),((runtime+dt)/dt));  %intializing size of TC concentration array
C(1,1:end) = interp1((WQ(:,1))*60,WQ(:,2),t); %intializing first row of C matrix for US
concentrations
C(:,1) = C(1,1);    %Concentrations are assumed to be equal for all x at t=0
Cstar = zeros(((q+dx)/dx),((runtime+dt)/dt));
Cstar(:,1) = C(1,1);
Cstarstar = zeros(((q+dx)/dx),((runtime+dt)/dt));

for j = 1
   for i = 2:ni
      if i == ni
         Cstarstar(i,j) = Cstar(i,j)-c*(Cstar(i,j)-Cstar(i-1,j))+a*(Cstar(i,j)-(2*Cstar(i,j))+Cstar(i-1,j));
         C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      else
```

```
            Cstarstar(i,j) = Cstar(i,j)-c*(Cstar(i,j)-Cstar(i-1,j))+a*(Cstar(i+1,j)-2*Cstar(i,j)+Cstar(i-1,j));
            C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
        end
    end
end
%a=.1  %NUMERICAL!!
for j = 2:nj-1
    j;
    for i=1:ni
        if i==1
        Cstar(i,j) = C(i,j)-c*(C(i+1,j)-C(i,j))+a*(C(i+1,j)-(2*C(i,j))+C(i,j));
        elseif i==ni
        Cstar(i,j) = C(i,j)-c*(C(i,j)-C(i,j))+a*(C(i,j)-(2*C(i,j))+C(i-1,j));
        else
        Cstar(i,j) = C(i,j)-c*(C(i+1,j)-C(i,j))+a*(C(i+1,j)-(2*C(i,j))+C(i-1,j));
       end
    end
    for i=2:ni
        if i==ni
        Cstarstar(i,j) = Cstar(i,j)-c*(Cstar(i,j)-Cstar(i-1,j))+a*(Cstar(i,j)-(2*Cstar(i,j))+Cstar(i-1,j));
        C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
        else
        Cstarstar(i,j) = Cstar(i,j)-c*(Cstar(i,j)-Cstar(i-1,j))+a*(Cstar(i+1,j)-2*Cstar(i,j)+Cstar(i-1,j));
        C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
       end
    end
  end
    plot(t,C(1,1:end),'r','LineWidth',2)
    hold on
    plot(t,C(end,1:end),'g','LineWidth',2)
    ylabel('TC concentrations (MPN/100mL)','FontSize',14)
    xlabel ('Elapsed time (s)','FontSize',14)
    legend('TC at x = 0 m','TC at x = 2.5 m')
figure;
    plot(x,C(:,1),'r','LineWidth',2)
    hold on
    plot(x,C(:,45),'g','LineWidth',2)
    ylabel('TC concentrations (MPN/100mL)','FontSize',14)
    xlabel ('Position (m)','FontSize',14)
    legend('TC at t = 0 sec','TC at t ')
```

<u>**MacCormack Method- AdvectionDispersion with vel and D as functions of time**</u>

```
%function MacCormack(WQ,vD)
%%MacCormack Scheme unsteady
```

```
%McCaskill 12/20/11 modified

%u = velocity as function of t (m/s)
%D = Diffusion Coefficient as function of t (m^2/s)
%dt = delta time
%dx = delta x
%C0 = upstream TC concentrations at x=0 at different t (MPN/100mL)
clear all
load June15.mat WQ textdataWQ textdatavD vD
p = 0;      %start of sand bed
q = 2.5;    %end of sand bed
time = 0;      %start clock (s)
runtime = 3600;   %required run time (s)
dt = 1;    %sec
deltax = 0.5;
dx = deltax;  %meter
x = p:dx:q;
t = time:dt:runtime;
ni = (q+dx)/dx;
nj = (runtime+dt)/dt;

u = zeros(ni,nj);
u(1,1:end) = interp1(60*vD(:,1),vD(:,2),t);  %interpolating velocity with t
D = zeros(((q+dx)/dx),((runtime+dt)/dt));
D(1,1:end) = interp1(60*vD(:,1),vD(:,3),t); %interpolating Diffusion Coefficient with t
c = zeros(((q+dx)/dx),((runtime+dt)/dt));   %initializing courant number
a = zeros(((q+dx)/dx),((runtime+dt)/dt));   %initializing diffusion number

for j = 1:nj
u(:,j) = u(1,j);          %assume u and D do not change along x, only with t
D(:,j) = D(1,j);
c(:,j) = (u(:,j)*dt)/(dx);      %courant number wrt t
a(:,j) = (D(:,j)*dt)/(dx*dx);   %(alpha) = diffusion number wrt t
j = j+1;
end

C = zeros(((q+dx)/dx),((runtime+dt)/dt));  %intializing size of TC concentration array
C(1,1:end) = interp1((WQ(:,1))*60,WQ(:,2),t); %intializing first row of C matrix for US
concentrations
C(:,1) = C(1,1);            %Concentrations are assumed to be equal for all x at t=0
Cstar = zeros(((q+dx)/dx),((runtime+dt)/dt));
Cstar(:,1) = C(1,1);
Cstarstar = zeros(((q+dx)/dx),((runtime+dt)/dt));
```

```
for j = 1
   for i = 2:ni
      if i == ni
         Cstarstar(i,j) = Cstar(i,j)-c(i,j)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i,j)-(2*Cstar(i,j))+Cstar(i-
1,j));
         C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      else
         Cstarstar(i,j) = Cstar(i,j)-c(i,j)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i+1,j)-2*Cstar(i,j)+Cstar(i-
1,j));
         C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      end
   end
end
for j = 2:nj-1
   j;
   for i=1:ni
      if i==1
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i+1,j)-C(i,j))+a(i,j)*(C(i+1,j)-(2*C(i,j))+C(i,j));
      elseif i==ni
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i,j)-C(i,j))+a(i,j)*(C(i,j)-(2*C(i,j))+C(i-1,j));
      else
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i+1,j)-C(i,j))+a(i,j)*(C(i+1,j)-(2*C(i,j))+C(i-1,j));
     end
   end

   for i=2:ni
      if i==ni
      Cstarstar(i,j) = Cstar(i,j)-c(i,j)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i,j)-(2*Cstar(i,j))+Cstar(i-
1,j));
      C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      else
      Cstarstar(i,j) = Cstar(i,j)-c(i,j)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i+1,j)-2*Cstar(i,j)+Cstar(i-
1,j));
      C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
     end
   end
end
figure
plot(t,C(1,1:end),'r','LineWidth',2)
hold on
% plot(t,C(2,1:end),'y','LineWidth',2)
% plot(t,C(3,1:end),'g','LineWidth',2)
% plot(t,C(4,1:end),'c','LineWidth',2)
% plot(t,C(5,1:end),'b','LineWidth',2)
```

```
plot(t,C(end,1:end),'y','LineWidth',2)
ylabel('TC concentrations (MPN/100mL)','FontSize',14)
xlabel ('Elapsed time (s)','FontSize',14)
legend('x = 0 m','x = 2.5 m')
figure;
   plot(x,C(:,1),'r','LineWidth',2)
   hold on
   plot(x,C(:,45),'g','LineWidth',2)
   ylabel('TC concentrations (MPN/100mL)','FontSize',14)
   xlabel ('Position (m)','FontSize',14)
   legend('TC at t = 0 sec','TC at t ')
```

MacCormack Method UNSTEADY with added sink and source terms "unsteadyMACandCHO.m"

```
% function[E]=unsteadyMACandCHO(event,Re)
%%MacCormack Scheme unsteady with added source adn sink terms
%McCaskill 12/28/11 modified from unsteady.m

%u = velocity as function of t (m/s)
%D = Diffusion Coefficient as function of t (m^2/s)
%dt = delta time
%dx = delta x
%C0 = upstream TC concentrations at x=0 at different t (MPN/100mL converted to MPN/m^3
by multiplying by 10000)

%%NEW VARIABLES for Cho. et al 2010 eq. 3 source (R*Cs/h) and sink (f*C*vs/h) terms
%R = sediment resuspension rate (kg/(m^2 * s))
%Cs = TC concentration in sediment (MPN/kg)
%h = water depth (m) changes with time
%f = fraction of TC associated with sediment (averaged for each event)
%vs = sediment settling velocity (m/s) Stokes Law
%C = TC concentration in water column (MPN/m^3)  possibly the C from
   %previous time step
%T = shear stress (tau) in N/m^2
%Tc = critical shear stess in N/m^2
%Re = entrainment coefficient (kg/(m^2 * s))

load June8.mat%%CHANGES depending on event!
%% variables in .mat files!
% WQ :  'elapsed time'          ,'US TC','DS TC','DSD TC'
% vD:  'time (min)',     'vel (m/s)',       'D (m sqrd/s)', 'vel squared'
% th:  'time (min), 'depth,h (m)'
```

```
% p = 0;     %start of sand bed
% q = 2.5;   %end of sand bed: 2.5, but 3 for event6
% time = 0*60;     %start clock (s)...CHANGES!! 3 = 5min, 4and6 = 0min
% runtime = 60*60;  %required run time (s)..CHANGES! 3=53min, 4,5and6=60min,
% dt = 1;   %sec
% deltax = 0.5;     %0.5, but 0.75 for event6
% Tc = 0.009375;  %different for each event: 3&4 = 0.009375, 5 = 0.178215, 6 = 0.030375
% f = 0.30;      %different for each event: 3 = 0.30, 4 = 0.34, 5 = 0.46, 6 = 0.29
% Cs = 78979*1000;   %Bacterial concentration in sand converted to MPN/kg
%   %different for each event: 3 = 20969, 4 = 78979, 5 = 34700, 6 = 315829

dx = deltax;  %meter
x = p:dx:q;
t = time:dt:runtime;
ni = (q+dx)/dx;
nj = ((runtime+dt)/dt)-time;

%change depending on event or sand
vs = 0.059394563;  %DAV1 sand
% vs = 0.126457031;  %play sand

%%Re and z optimal values! (from optimization results in Appendix E-4)
% Re =   0.00017541;  %event 1
% % z = 0.0305;
% Re =   0.019;  %event 1 rising limb
% z = 0.0318;
% Re =   1*10^-8;  %event 2
% z = 0.0057;
% Re =   0.1;  %event 2 rising limb
% z = 0.005;
Re =   0.00018904;  %event 3
z = 0.1401;
% Re =   0.0015;  %event 3 rising limb
% z = 0.266;
% Re =   4.3055*10^-5;  %event 4
% z = 0.0589;
% Re =   0.00020783;  %event 4 rising limb
% z = 0.2143;
% Re =   1*10^-8;  %event 5
% z = 0.0025;
% Re =   0.0181;  %event 5 rising limb
% z = 0.001;
% Re =   0.0001366;  %event 6
% z = 0.001;
```

```
% Re =   0.00049588;   %event 6 rising limb
% z = 0.001;

u = zeros(ni,nj);
u(1,1:end) = interp1(60*vD(:,1),vD(:,2),t);  %interpolating velocity with t
us = zeros(ni,nj);
us(1,1:end) = interp1(60*vD(:,1),vD(:,4),t); %interpolating velocity squared with t
D = zeros(ni,nj);
D(1,1:end) = interp1(60*vD(:,1),vD(:,3),t); %interpolating Diffusion Coefficient with t
h = zeros(ni,nj);
h(1,1:end) = interp1(60*th(:,1),th(:,2),t); %interpolating depth with t
T = zeros (ni,nj);
T(1,1:end) = 3.75*us(1,1:end);   %%3.75 could change.. depends on chosen f
R = zeros(ni,nj);
c = zeros(ni,nj);   %initializing courant number
a = zeros(ni,nj);   %initializing diffusion number

%R calculation
for j = 1:nj
   if(T(1,j)>=Tc)
      R(1,j) = Re*((T(1,j)/Tc)-1);
   else
      R(1,j) = 0;
   end
   j = j+1;
end
for j = 1:nj
   u(:,j) = u(1,j);     %assume u,D,h,T,and R do not change along x, only with t
   D(:,j) = D(1,j);
   h(:,j) = h(1,j);
   T(:,j) = T(1,j);
   R(:,j) = R(1,j);
   c(:,j) = (u(:,j)*dt)/(dx);      %courant number wrt t
   a(:,j) = (D(:,j)*dt)/(dx*dx);   %(alpha) = diffusion number wrt t
   j = j+1;
end
C = zeros(ni,nj);  %intializing size of TC concentration array
C(1,1:end) = interp1((WQ(:,1))*60,WQ(:,2)*10000,t); %intializing first row of C matrix for US
concentrations
% C(1,1:end) = interp1((tC(:,1))*60,tC(:,2)*10000,t); %initializing for model validation
C(:,1) = C(1,1);            %Concentrations are assumed to be equal for all x at t=0
Cstar = zeros(ni,nj);
Cstar(:,1) = C(1,1);
Cstarstar = zeros(ni,nj);
```

```
for j = 1
   for i = 2:ni
      if i == ni
         Cstarstar(i,j) = Cstar(i,j)-c(i,j+1)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i,j)-
(2*Cstar(i,j))+Cstar(i-1,j))+(R(i,j+1)*(Cs/h(i,j))-z*f*(vs/h(i,j))*Cstar(i,j))*dt;
         C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      else
         Cstarstar(i,j) = Cstar(i,j)-c(i,j+1)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i+1,j)-
2*Cstar(i,j)+Cstar(i-1,j))+(R(i,j+1)*(Cs/h(i,j))-z*f*(vs/h(i,j))*Cstar(i,j))*dt;
         C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      end
   end
end
for j = 2:nj-1
   j;
   for i=1:ni
      if i==1
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i+1,j)-C(i,j))+a(i,j)*(C(i+1,j)-(2*C(i,j))+C(i,j))+(R(i,j)*(Cs/h(i,j))-
z*f*(vs/h(i,j))*C(i,j))*dt;
      elseif i==ni
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i,j)-C(i,j))+a(i,j)*(C(i,j)-(2*C(i,j))+C(i-1,j))+(R(i,j)*(Cs/h(i,j))-
z*f*(vs/h(i,j))*C(i,j))*dt;
      else
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i+1,j)-C(i,j))+a(i,j)*(C(i+1,j)-(2*C(i,j))+C(i-1,j))+(R(i,j)*(Cs/h(i,j))-
z*f*(vs/h(i,j))*C(i,j))*dt;
     end
   end
   for i=2:ni
      if i==ni
      Cstarstar(i,j) = Cstar(i,j)-c(i,j+1)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i,j)-(2*Cstar(i,j))+Cstar(i-
1,j))+(R(i,j+1)*(Cs/h(i,j))-z*f*(vs/h(i,j))*Cstar(i,j))*dt;
      C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      else
      Cstarstar(i,j) = Cstar(i,j)-c(i,j+1)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i+1,j)-2*Cstar(i,j)+Cstar(i-
1,j))+(R(i,j+1)*(Cs/h(i,j))-z*f*(vs/h(i,j))*Cstar(i,j))*dt;
      C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
     end
   end
end

% %VALIDATING MODEL
% figure
% [AX,H1,H2] = plotyy(t,C(1,1:end),t,u(end,1:end));
% box off
```

```
% xlabel 'Elapsed time (s)'
% set(get(AX(1),'Ylabel'),'String','TC concentration (MPN/m^3)');
% set(get(AX(2),'Ylabel'),'String','velocity (m/s)');
% axis(AX(1),[0 3600 -0.5*10^6 5.5*10^6])
% axis(AX(2),[0 3600 0 0.4])
% set(AX(1),'Ytick',-0.5*10^6:0.5*10^6:5.5*10^6)
% set(AX(2),'Ytick',0:0.1:0.4)
% %EVENT 3
% % axis(AX(1),[0 3600 1*10^7 9*10^7])
% % axis(AX(2),[0 3600 0 0.6])
% % set(AX(1),'Ytick',1*10^7:1*10^7:9*10^7)
% % set(AX(2),'Ytick',0:0.1:0.6)
% set(get(AX(1),'Xlabel'),'FontSize',14)
% set(get(AX(1),'Ylabel'),'FontSize',14)
% set(get(AX(2),'Ylabel'),'FontSize',14)
% set(AX(2),'FontSize',12)
% set(AX(1),'FontSize',12)
% set(H1,'LineWidth',2)
% set(H2,'LineWidth',2)
% set(AX(1),'YColor','k') %axis font color
% set(H1,'Color','r') %line color
% set(AX(2),'YColor','b') %axis font color
% set(H2,'Color','b') %line color
% hold on
% plot(t,C(end,1:end),'k','LineWidth',2)
% title('Event 3','FontSize',16)
% legend('x = 0 m','model simulated x = 2.5 m')
```

CHECKING MODEL VARIABLES

```
figure
plot(t,C(1,1:end),'r','LineWidth',2)
hold on
plot(t,C(end,1:end),'b','LineWidth',2)
hold on
ylabel('C (MPN/m^3)','FontSize',14)
figure
plot(t,R(end,1:end))
hold on
ylabel('R','FontSize',14)
figure
plot(t,T(end,1:end))
hold on
ylabel('T','FontSize',14)
figure
```

```
plot(t,a(end,1:end))
hold on
ylabel('a','FontSize',14)
figure
plot(t,c(end,1:end))
hold on
ylabel('c','FontSize',14)
figure
plot(t,h(end,1:end))
hold on
ylabel('h','FontSize',14)
figure
plot(t,D(end,1:end))
hold on
ylabel('D','FontSize',14)
figure
plot(t,u(end,1:end))
hold on
ylabel('u','FontSize',14)
figure
plot(t,Cstar(1,1:end),'r','LineWidth',2)
hold on
plot(t,Cstar(end,1:end),'b','LineWidth',2)
hold on
ylabel('Cstar','FontSize',14)
figure
plot(t,Cstarstar(2,1:end),'r','LineWidth',2)
hold on
plot(t,Cstarstar(end,1:end),'b','LineWidth',2)
hold on
ylabel('Cstarstar','FontSize',14)
```

PLOTTING OBSERVED WITH MODEL OUTPUTS

```
figure
[AX,H1,H2] = plotyy(t,C(1,1:end),t,u(end,1:end));
box off
xlabel 'Elapsed time (s)'
set(get(AX(1),'Ylabel'),'String','TC concentration (MPN/m^3)');
set(get(AX(2),'Ylabel'),'String','velocity (m/s)');
%EVENT 1 and 2
% axis(AX(1),[0 5400 0 11*10^7])
% axis(AX(2),[0 5400 0 0.6])
% set(AX(1),'Ytick',0:1*10^7:11*10^7)
% set(AX(2),'Ytick',0:0.1:0.6)
```

```
% %EVENT 4
% axis(AX(1),[0 3600 1*10^7 9*10^7])
% axis(AX(2),[0 3600 0 0.6])
% set(AX(1),'Ytick',1*10^7:1*10^7:9*10^7)
% set(AX(2),'Ytick',0:0.1:0.6)
%EVENT 3
axis(AX(1),[0 3600 1*10^7 9*10^7])
axis(AX(2),[0 3600 0 0.4])
set(AX(1),'Ytick',1*10^7:1*10^7:9*10^7)
set(AX(2),'Ytick',0:0.1:0.4)
%EVENT 5
% axis(AX(1),[0 3600 0.4*10^8 2.6*10^8])
% axis(AX(2),[0 3600 0 0.6])
% set(AX(1),'Ytick',0.4*10^8:0.2*10^8:2.6*10^8)
% set(AX(2),'Ytick',0:0.1:0.6)
%EVENT 6
% axis(AX(1),[0 3600 0 2.5*10^8])
% axis(AX(2),[0 3600 0 0.7])
% set(AX(1),'Ytick',0:0.5*10^8:2.5*10^8)
% set(AX(2),'Ytick',0:0.1:0.7)
set(get(AX(1),'Xlabel'),'FontSize',14)
set(get(AX(1),'Ylabel'),'FontSize',14)
set(get(AX(2),'Ylabel'),'FontSize',14)
set(AX(2),'FontSize',12)
set(AX(1),'FontSize',12)
set(H1,'LineWidth',2)
set(H2,'LineWidth',2)
set(AX(1),'YColor','k') %axis font color
set(H1,'Color','r') %line color
set(AX(2),'YColor','b') %axis font color
set(H2,'Color','b') %line color
hold on
plot(t,C(end,1:end),'k','LineWidth',3)
ts = 60*WQ(2:end,1);    %times sampled
O = 10000*WQ(2:end,4); %observed dsd concentrations
   dsdC = interp1(ts,O,t);         %interpolating dsdC for t
   plot(t,dsdC,'g','LineWidth',2)
title('Event ','FontSize',16)
legend('x = 0 m','model simulated x = 2.5 m', 'measured x = 2.5 m')
M = interp1(t,C(end,1:end),ts);
```

Appendix E-4: Matlab Optimization and Fit Functions

Optimization function $f_{minimax}$

```
input = fminimax(@Fit,[0.00000001,1],[],[],[],[],[0.00000001,0.001],[0.1,10])
```

Fit function for entire event

```
function [e]=Fit(input)
Re = input(1)
z = input(2)
unsteadyMACandCHO
C;
%initializing measured downstream deep Concentrations
ts = 60*WQ(2:end,1)     %times sampled
O = 10000*WQ(2:end,4) %observed dsd concentrations

%interpolated model final results for same time intervals as measured
P = interp1(t,C(end,1:end),ts)   %model simulated C at 2.5m
% figure
% plot(ts,O,'g')
% hold
% plot(ts,P,'b')
% hold off

%Coefficient of Efficiency:
Obar = mean(O)         %Nash
top = (P-O).^2         %Nash
bottom = (O-Obar).^2   %Nash
% Obar = 10000*WQ(2,4)  %Garrick  %baseline observed upstream conc(preevent sample)
% top = abs(O-P)        %Garrick
% bottom = abs(O-Obar)  %Garrick
term = ((sum(top))/(sum(bottom)))
e = -1+term
E = -e
end
```

Fit function for rising limb

```
function [e]=Fit(input)
Re = input(1)
z = input(2)
unsteadyMACandCHO
C;
%initializing measured downstream deep Concentrations
```

```
ts = 60*WQ(2:5,1)     %times sampled
O = 10000*WQ(2:5,4) %observed dsd concentrations

%interpolated model final results for same time intervals as measured
P = interp1(t,C(end,1:end),ts)   %model simulated C at 2.5m
% figure
% plot(ts,O,'g')
% hold
% plot(ts,P,'b')
% hold off

%Coefficient of Efficiency:
Obar = mean(O)        %Nash
top = (P-O).^2        %Nash
bottom = (O-Obar).^2    %Nash
% Obar = 10000*WQ(2,4)  %Garrick  %baseline observed upstream conc(preevent sample)
% top = abs(O-P)       %Garrick
% bottom = abs(O-Obar)  %Garrick
term = ((sum(top))/(sum(bottom)))
e = -1+term
E = -e
end
```

"unsteadyMACandCHO.m" for fit function

```
% function[E]=unsteadyMACandCHO(event,Re)
%%MacCormack Scheme unsteady with added source adn sink terms
%McCaskill 12/28/11 modified from unsteady.m

%u = velocity as function of t (m/s)
%D = Diffusion Coefficient as function of t (m^2/s)
%dt = delta time
%dx = delta x
%C0 = upstream TC concentrations at x=0 at different t (MPN/100mL converted to MPN/m^3
by multiplying by 10000)
%%NEW VARIABLES for Cho. et al 2010 eq. 3 source (R*Cs/h) and sink (f*C*vs/h) terms
%R = sediment resuspension rate (kg/(m^2 * s))
%Cs = TC concentration in sediment (MPN/kg)
%h = water depth (m) changes with time
%f = fraction of TC associated with sediment (averaged for each event)
%vs = sediment settling velocity (m/s) Stokes Law
%C = TC concentration in water column (MPN/m^3)  possibly the C from
   %previous time step
%T = shear stress (tau) in N/m^2
%Tc = critical shear stess in N/m^2
```

```
%Re = entrainment coefficient (kg/(m^2 * s))

load June8.mat%%CHANGES depending on event!
%% variables in .mat files!
% p = 0;     %start of sand bed
% q = 2.5;    %end of sand bed: 2.5, but 3 for event6
% time = 0*60;     %start clock (s)...CHANGES!! 3 = 5min, 4and6 = 0min
% runtime = 60*60;   %required run time (s)..CHANGES! 3=53min, 4,5and6=60min,
% dt = 1;    %sec
% deltax = 0.5;     %0.5, but 0.75 for event6
% Tc = 0.009375;   %different for each event: 3&4 = 0.009375, 5 = 0.178215, 6 = 0.030375
% f = 0.30;      %different for each event: 3 = 0.30, 4 = 0.34, 5 = 0.46, 6 = 0.29
% Cs = 78979*1000;    %Bacterial concentration in sand converted to MPN/kg
%    %different for each event: 3 = 20969, 4 = 78979, 5 = 34700, 6 = 315829
dx = deltax;  %meter
x = p:dx:q;
t = time:dt:runtime;
ni = (q+dx)/dx;
nj = ((runtime+dt)/dt)-time;

%change depending on event or sand
vs = 0.059394563;   %DAV1 sand
% vs = 0.126457031;   %play sand

%%Re and z optimal values!
% Re =   0.00017541;   %event 1
% % z = 0.0305;
% Re =   0.019;   %event 1 rising limb
% z = 0.0318;
% Re =   1*10^-8;   %event 2
% z = 0.0057;
% Re =   0.1;   %event 2 rising limb
% z = 0.005;
% Re =   0.00018904;   %event 3
% z = 0.1401;
% Re =   0.0015;   %event 3 rising limb
% z = 0.266;
% Re =   4.3055*10^-5;   %event 4
% z = 0.0589;
% Re =   0.00020783;   %event 4 rising limb
% z = 0.2143;
% Re =   1*10^-8;   %event 5
% z = 0.0025;
% Re =   0.0181;   %event 5 rising limb
```

```
% z = 0.001;
% Re =   0.0001366;   %event 6
% z = 0.001;
% Re =   0.00049588;   %event 6 rising limb
% z = 0.001;

u = zeros(ni,nj);
u(1,1:end) = interp1(60*vD(:,1),vD(:,2),t);  %interpolating velocity with t
us = zeros(ni,nj);
us(1,1:end) = interp1(60*vD(:,1),vD(:,4),t); %interpolating velocity squared with t
D = zeros(ni,nj);
D(1,1:end) = interp1(60*vD(:,1),vD(:,3),t); %interpolating Diffusion Coefficient with t
h = zeros(ni,nj);
h(1,1:end) = interp1(60*th(:,1),th(:,2),t); %interpolating depth with t
T = zeros (ni,nj);
T(1,1:end) = 3.75*us(1,1:end);   %%3.75 could change.. depends on chosen f
R = zeros(ni,nj);
c = zeros(ni,nj);   %initializing courant number
a = zeros(ni,nj);   %initializing diffusion number

%R calculation
for j = 1:nj
   if(T(1,j)>=Tc)
      R(1,j) = Re*((T(1,j)/Tc)-1);
   else
      R(1,j) = 0;
   end
   j = j+1;
end

for j = 1:nj
   u(:,j) = u(1,j);     %assume u,D,h,T,and R do not change along x, only with t
   D(:,j) = D(1,j);
   h(:,j) = h(1,j);
   T(:,j) = T(1,j);
   R(:,j) = R(1,j);
   c(:,j) = (u(:,j)*dt)/(dx);      %courant number wrt t
   a(:,j) = (D(:,j)*dt)/(dx*dx);   %(alpha) = diffusion number wrt t
   j = j+1;
end

C = zeros(ni,nj);  %intializing size of TC concentration array
C(1,1:end) = interp1((WQ(:,1))*60,WQ(:,2)*10000,t); %intializing first row of C matrix for US
concentrations
```

```
% C(1,1:end) = interp1((tC(:,1))*60,tC(:,2)*10000,t); %initializing for model validation
C(:,1) = C(1,1);           %Concentrations are assumed to be equal for all x at t=0
Cstar = zeros(ni,nj);
Cstar(:,1) = C(1,1);
Cstarstar = zeros(ni,nj);
for j = 1
   for i = 2:ni
      if i == ni
         Cstarstar(i,j) = Cstar(i,j)-c(i,j+1)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i,j)-
(2*Cstar(i,j))+Cstar(i-1,j))+(R(i,j+1)*(Cs/h(i,j))-z*f*(vs/h(i,j))*Cstar(i,j))*dt;
         C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      else
         Cstarstar(i,j) = Cstar(i,j)-c(i,j+1)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i+1,j)-
2*Cstar(i,j)+Cstar(i-1,j))+(R(i,j+1)*(Cs/h(i,j))-z*f*(vs/h(i,j))*Cstar(i,j))*dt;
         C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      end
   end
end
for j = 2:nj-1
   j;
   for i=1:ni
      if i==1
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i+1,j)-C(i,j))+a(i,j)*(C(i+1,j)-(2*C(i,j))+C(i,j))+(R(i,j)*(Cs/h(i,j))-
z*f*(vs/h(i,j))*C(i,j))*dt;
      elseif i==ni
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i,j)-C(i,j))+a(i,j)*(C(i,j)-(2*C(i,j))+C(i-1,j))+(R(i,j)*(Cs/h(i,j))-
z*f*(vs/h(i,j))*C(i,j))*dt;
      else
      Cstar(i,j) = C(i,j)-c(i,j)*(C(i+1,j)-C(i,j))+a(i,j)*(C(i+1,j)-(2*C(i,j))+C(i-1,j))+(R(i,j)*(Cs/h(i,j))-
z*f*(vs/h(i,j))*C(i,j))*dt;
     end
   end
   for i=2:ni
      if i==ni
      Cstarstar(i,j) = Cstar(i,j)-c(i,j+1)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i,j)-(2*Cstar(i,j))+Cstar(i-
1,j))+(R(i,j+1)*(Cs/h(i,j))-z*f*(vs/h(i,j))*Cstar(i,j))*dt;
      C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
      else
      Cstarstar(i,j) = Cstar(i,j)-c(i,j+1)*(Cstar(i,j)-Cstar(i-1,j))+a(i,j)*(Cstar(i+1,j)-2*Cstar(i,j)+Cstar(i-
1,j))+(R(i,j+1)*(Cs/h(i,j))-z*f*(vs/h(i,j))*Cstar(i,j))*dt;
      C(i,j+1) = 0.5*(C(i,j)+Cstarstar(i,j));
     end
   end
end
```

Appendix E-5: Model Output TC

Event	observed/ measured TC	modeled TC entire run	modeled TC rising limb
1	72699000	71280721	70295453
	54750000	62449643	61996017
	64882000	56951099	66474605
	48844000	39723286	41702247
	22468000	36104578	44802587
	24809000	24849013	33759479
	20982000	20029253	87556871
	26125000	22039426	25539978
	26125000	20746642	22047468
	16640000	22606877	33021465

All for downstream sample location in MPN/m^3

Event	observed/ measured TC	modeled TC entire run	modeled TC rising limb
2	81641000	86666863	87987555
	77010000	58559899	58906243
	86644000	94584232	95053944
	92084000	54491705	56789957
	86644000	100598514	128144497
	86644000	69417684	95037341
	57943000	60818594	143261193
	61314000	71178323	261928229
	43517000	48951850	77432721
	34480000	50440417	58011951
	41058000	30750315	36997470
	41058000	40376666	40638008
	41058000	33517755	33719919

Event	observed/ measured TC	modeled TC entire run	modeled TC rising limb
3	86644000	86644000	86644000
	64882000	63719237	59887519
	54750000	57521231	67616348
	61314000	34328004	54710339
	48844000	76177260	93707323
	68667000	76479127	89275004
	64882000	61404440	65261534
	46111000	46171831	50098224
	43517000	37587485	40256758
	34480000	25633287	26850943
	43517000	39580101	44477888

Event	observed/ measured TC	modeled TC entire run	modeled TC rising limb
4	68667000	73584412	69603582
	72699000	72340849	75320122
	81641000	64543656	77832755
	86644000	59185564	87361182
	68667000	62824664	94128448
	68667000	71896421	100372717
	61314000	72533355	102359891
	36540000	60388283	81941527
	30759000	45364605	53568847
	32554000	33464911	43705582
	22818000	15597069	5772559.5

Event	observed/ measured TC	modeled TC entire run	modeled TC rising limb
5	72699000	118891813	119907812
	98039000	74106062	78998610
	241957000	128289967	161340273
	104624000	69511053	142073471
	68667000	103377157	166886159
	92084000	170779170	226925038
	68667000	93929424	141253326
	77010000	111328748	154689112
	98039000	111566637	116118024
	68667000	58054940	58584158
	86644000	73396483	74226339

Event	observed/ measured TC	modeled TC entire run	modeled TC rising limb
6	141361000	118811852	118811852
	141361000	144404016	157740162
	129965000	85865985	121626488
	241920000	122466978	242573379
	129965000	136833932	269792043
	155312000	165967686	328566152
	129965000	156911699	340918199
	141361000	140837984	296464352
	81641000	138089993	286762113
	64882000	64123168	128109215
	36540000	45087122	45087160

VITA

EDUCATION

Bachelor of Science in Civil Engineering – Magna Cum Laude May 2010
The University of Mississippi, University, MS

ACADEMIC HONORS

- Chi Epsilon – Editor, Civil Engineering honor society
- Phi Kappa Phi – Honor society for top 10% of their class for all disciplines
- Tau Beta Pi - National Engineering Honor Society
- Awarded Who's Who – University of Mississippi (2009-2010)
- Lambda Sigma – National Sophomore Honor Society

EXPERIENCE

Engineering Technician June 2010-May 2012
USDA ARS National Sedimentation Laboratory**,** Oxford, MS

Graduate Assistant August 2010-May 2012
The University of Mississippi, University, MS

ACTIVITIES and SERVICE

- Captain of The University of Mississippi Dance Team–The Ole Miss Rebelettes (2006-2010)
- Member of Delta Delta Delta Sorority (2006-2010)