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Suspended Sediment Transport Dynamics and Sediment Yields in Relation to Watershed Characteristics, Upper Green River Basin, Kentucky

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SUSPENDED SEDIMENT TRANSPORT DYNAMICS AND SEDIMENT YIELDS IN RELATION TO WATERSHED CHARACTERISTICS, UPPER GREEN RIVER BASIN, KENTUCKY

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"GOD RICHLY BLESS YOU ALL"

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James Nii Aboh Otoo | May 2010 | 95 Pages

Directed by: Stephen Kenworthy, Ouida Meier, Michael May, and Lee Florea

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Sediment delivery is a major problem in the Green River, Kentucky, home of 71 of the state's 103 known mussel species and 151 fish species. The river also provides water for many of its surrounding counties. This research focuses on how suspended sediment loads, grain size, and sediment concentration during runoff events are related to watershed characteristics.

The research characterized suspended sediment loads, grain size, and sediment concentration during runoff events and how they were related to watershed characteristics such as hydro-climatic regime, watershed size, geology and soils, topography and landuse conditions and land cover conditions. The study focused on Brush Creek and Pitman Creek watersheds in the Upper Green River Basin. This research can help in the planning and development of effective environmental strategies by screening out mitigation measures that would not be effective for implementation to minimize sediment load and suspended sediment concentration in the Green River, thereby improving the water quality of the river. Water quality was monitored using data sondes positioned at selected sites in the two watersheds. Water samples were collected during turbidity thresholds of

100 NTU and analyzed for suspended sediment concentrations. Regression models between 'discharge and stage' and also between 'average turbidity and suspended sediment concentration' were formulated and load estimates were made and compared.

Four sets of samples were collected, two at Brush Creek on 11 April (Brush Creek's event 1) and 3 May (Brush Creek's event 2) and the other two at Pitman Creek on the 12 February (Pitman Creek's event 1) and 3 March (Pitman Creek's event 2) all in the year 2008. The suspended sediment samples collected for all four events were well graded but had relatively more silt than clay and sand. This could be due to the fact that more time and energy was needed to break the bonds in clay minerals or particles and also to the fact that more energy was also needed to transport sand compared to silt. Brush Creek watershed's particles had smaller grain sizes than Pitman Creek watershed's particles. All four events showed clockwise hysteresis indicating that most of the sediments from both watersheds during the events were derived from the bed and banks of the channel or area adjacent to the channel.

The 11 April event (Brush Creek's event 1) produced an estimated load of 1.1×10^5 kg and a sediment yield of 5.3×10^2 kg/km^2. The 3 May event (Brush Creek's event 2) produced an estimated load of 3.8×10^4 kg and a sediment yield of 1.8×10^2 kg/km^2. Brush Creek watershed's estimated load for the period compared was 4.9×10^5 kg and a sediment yield of 2.3×10^3 kg/km^2 (53 kg/km^2/day).

The 12 February event (Pitman Creek's event 1) produced an estimated load of 2.9×10^5 kg and a sediment yield of 8.4×10^2 kg/km^2. The 3 March event (Pitman Creek's event 2) produced an estimated load of 5.7×10^5 kg and a sediment yield of 1.6 x

10^3 kg/km^2. Pitman Creek watershed's estimated load for the period compared was 1.1 x 10^6 kg and a sediment yield of 3.1 x 10^3 kg/km^2 (71 kg/km^2/day).

Pitman Creek watershed's higher number of stream network per unit area, its high elevation and relief, its high percentage of erodible soil per unit area, its lesser area of protection of erodible soil by its vegetation compared to Brush Creek watershed's are responsible for its higher sediment load and yield.

1.0 INTRODUCTION

1.1 ENVIRONMENTAL SIGNIFICANCE OF SUSPENDED SEDIMENTS

Suspended sediment is defined by the United States Environmental Protection Agency (USEPA) as fine material or soil particles that remain suspended by river currents until deposited in areas of weaker current (United States Environmental Protection Agency, 2001). Suspended sediment has several environmental problems associated with it which makes it an important stream parameter to study. Suspended load make up the bulk of sediment transport from rivers to the ocean (Asselman, 1997). Sediment is the greatest water pollutant in terms of volume and mass (Botkin and Keller, 2005). Accumulation of sediments in river channels can reduce the flow capacity of streams, cause siltation of in stream habitat, increase the risk of flooding, and accelerate reservoir filling (Morgan, 2005).

Suspended sediments can pollute water and may serve as a catalyst, carrier and storage agent for pollutants by carrying bacteria, organic matter, pesticides, heavy metals, phosphorous and nitrogen (Botkin and Keller, 2005). Suspended sediment may reduce sunlight penetration into water, thereby reducing the production of microorganisms, which begin the aquatic food chain. Sediments can cover and damage plants and fish eggs at the bottom of rivers (Miller and Gardiner, 2001).

Suspended sediment concentration in rivers is highly variable in time; it is generally high during periods of increased discharge. A major part of the annual load of suspended sediment and its associated contaminants are transported through rivers during flood events, a relatively short period of the year (Steenkamp and Ludikhuize, 1999; McKee et al., 2002). According to Walling and Zhang many evidence suggests that much of the observed suspended sediment load in rivers is derived from erosion of agricultural land (Walling and Zhang, 2004).

1.2 STATEMENT OF RESEARCH

Different river watersheds produce different sediment loads, and the various trunk and tributary streams of the Green River Basin of Kentucky is no exception. Considering two tributary watersheds in the Green River Basin, which one produces more suspended sediments? What factors influence the production of the suspended load? To answer these questions, this research determined suspended sediment load produced by two tributary watersheds in the Upper Green River Basin from 11 February 2008 to 30 September 2008 (study period).

The research characterized suspended sediment loads, grain size, and the temporal co-variation of flow rate and sediment concentration during runoff events and how they are related to watershed characteristics such as hydro-climatic regime, watershed size, geology and soils, topography and land-use conditions. Its primary goal was to determine suspended sediment loads, characterizing their grain size, and discern the sediment concentration during runoff events in the Upper Green River and relate them to watershed characteristics such as hydro-climate regime, geology and soils, topography, landuse and land cover conditions. The focus is on two tributary watersheds in the Upper Green River Basin (Fig. 1) namely:

- Pitman Creek
- Brush Creek

This research can help in the planning and development of effective environmental strategies by screening out mitigation measures that would not be effective for implementation to minimize sediment load and suspended sediment concentration in the Green River, thereby improving the water quality of the river. It will also help determine whether the Conservation Reserve Enhancement Program's "CREP" (an agreement signed between the United States Department of Agriculture and the Commonwealth of Kentucky) main objective of reducing the amount of sediments entering tributaries and trunk system of the Green River as well as the Mammoth Cave System by 10 percent is being attained. This was assessed by monitoring of trends in suspended sediment loads and observation of spatial patterns in the link between loads and landscape characteristics (Nature Conservancy, 2009). Finally, the research will provide some data for any future work that demands an understanding of sediment production and transport in the Upper Green River Basin.

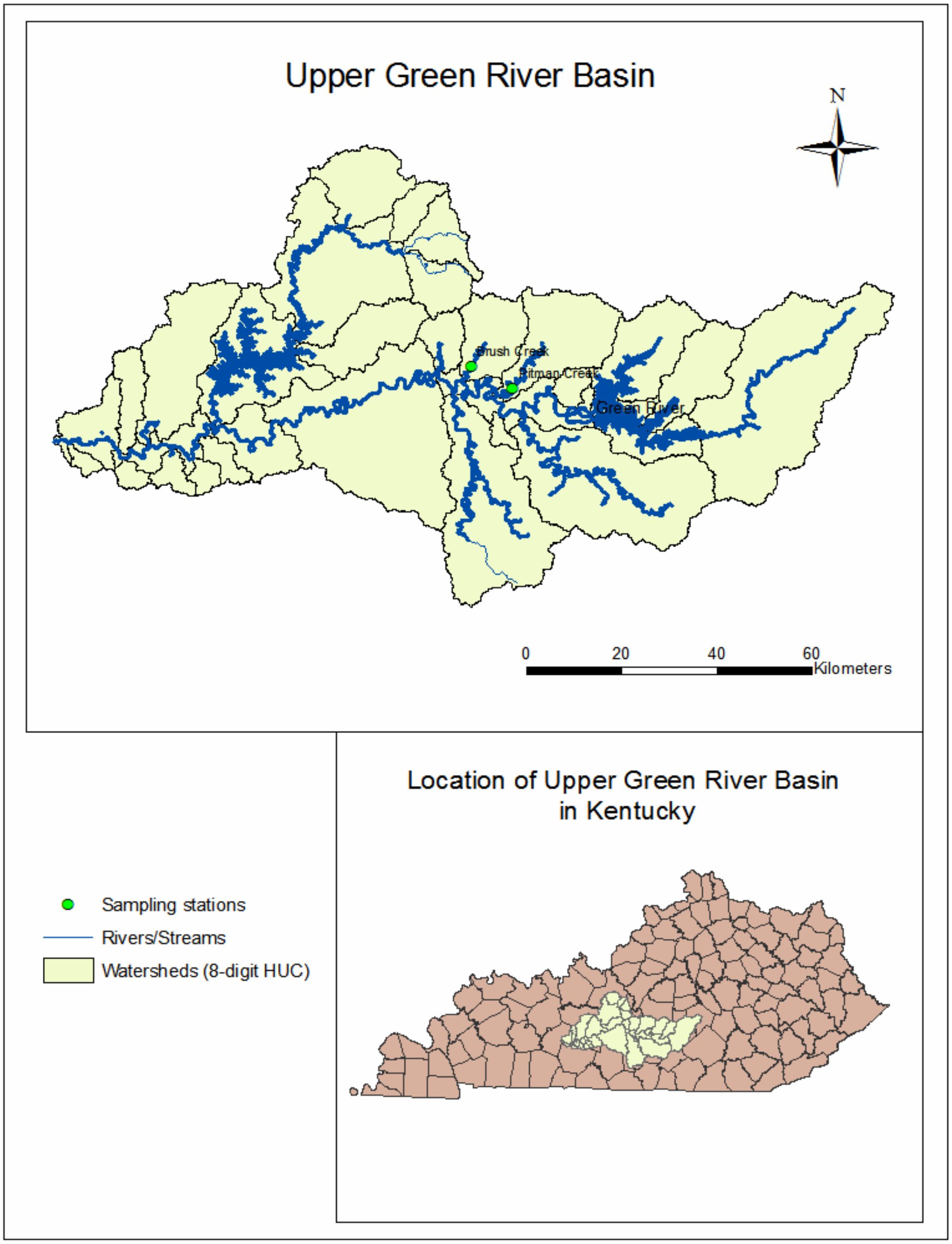

Figure 1: Upper Green River Basin. Data downloaded from the Kentucky Geographical Network.

2.0 PREVIOUS WORK

2.1 FLUVIAL SEDIMENT TRANSPORT

Rivers transport varying quantities of sediment under the influence of various flow regimes. Sediment grain size transported by a river ranges from clay and silt to gravel or even cobbles and boulders. The different sizes from clay to gravel are associated with different environmental and engineering issues, summarized in Table 1.

Table 1: Summary of issues associated with sediment transport in rivers (source: UNEP/WHO, 1996)

Sediment Size	**Environmental Issues**	**Associated Engineering Issues**
Silts and clays	Erosion, especially loss of topsoil in agricultural areas; gullying	
	High sediment loads to reservoirs	Reservoir siltation
	Chemical transport of nutrients, metals and chlorinated organic compounds	Drinking water supply
	Accumulation of contaminants in organisms at the bottom of the food chain (particulate feeders)	
	Silting of fish spawning beds and disturbance of habitats (by erosion or siltation) for benthic organisms	
Sand	River bed and bank erosion	River channel deposition: navigation problems Instability of river cross-sections
	River bed and bank erosion	Sedimentation in reservoirs
	Habitat disturbance	
Gravel	Channel instability when dredged for aggregate	Instability of river channel leads to problems of navigation and flood control
	Habitat disturbance	

In most basins, about 90% of the total sediment load removed from the watershed is by the sum of ordinary discharges. Large floods transport high sediment loads but their occurrence is infrequent, which sometimes makes their contribution to the total amount of sediment transported from a basin minimal (Wolman and Miller, 1960). Under different conditions, rivers maintain or adjust to their channel morphologies, and channels form and reform within a narrow range of flow. They typically have a lower flow limit, which is set by the demands of competence, and an upper flow limit, which is defined by the flow that exceeds stage and is no longer confined to the channel (Wolman and Miller, 1960).

Fluvial sediment transport has been subdivided by source or by mode of transport. (Einstein and others, 1940). By source, the total load is divided between bedload and washload (Fig. 2). Bed load results from the river bed and banks and it is typically sand or gravel-sized. Bed load transport rates are directly related to a river's transport capacity and the range of grain sizes available for transport (Einstein and others, 1940). The washload on the other hand, consists of sediments that have been flushed into the river from upland sources, and is sufficiently fine grained that the river is always capable to retain it in suspension. Thus, the washload is mainly controlled by the supply of sediments to the river. By mode of transport, the sediment load is divided into suspended load and bed load (Fig. 2). The suspended load is dispersed by turbulent flow and is carried for considerable distances without contacting the bed. It is largely derived from the washload and the finer fractions of the bed material. The amount of sand in the suspended load is directly proportional to the turbulence and mainly originates from erosion of the bed and banks of the river (Ongley, 1996). The bed load is typically coarser sediment moving in almost continuous contact with the bed through traction or saltation. Most bedload movement occurs during periods of high discharge when the flow is very turbulent. Sediment yield is the total sediment discharge from a watershed relative to its area at a given time. Sediment discharge and transport from catchment is mostly controlled by hydro-climate regime, geology and soils, topography and landuse and land cover conditions, rainfall intensity and man's impact (Ritter and others, 2002. Milliman and Meade, 1983. Meade and others, 1990. Wang and others, 1998).

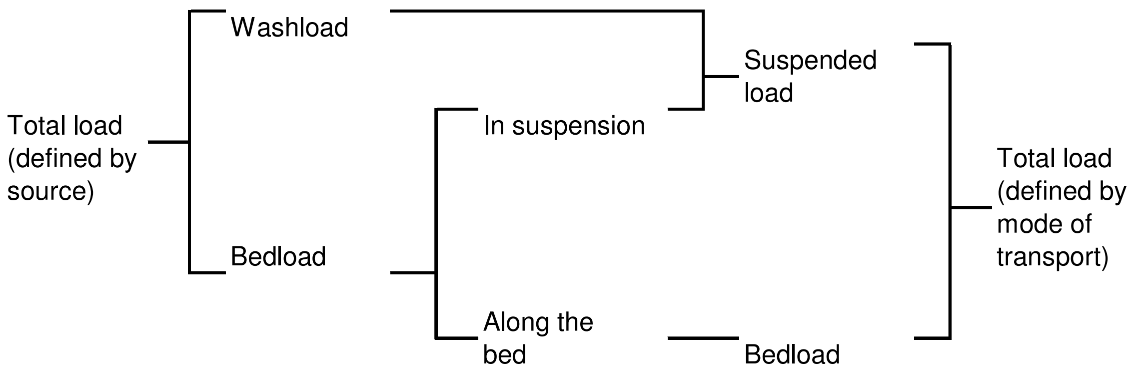

Figure 2: Breakdown of stream sediment load in terms of sediment source and mode of transport. (Source: Hicks and Gomez, 2003)

The water available for stream discharge is determined by evapotranspiration and rainfall patterns. Generally, high discharge is produced by heavy precipitation occurring in a short interval of time (Meyer, 1917). At low temperatures, precipitation may accumulate on the ground as snow, reducing the probabilities of high surface flow (Meyer, 1917). There is a non-linear relationship between changes in precipitation volume and intensity and resulting changes in upland erosion and sediment loadings to streams (Johnson and others, 2005).

The relationship between suspended sediment concentration and discharge varies; there is no general relationship between suspended sediment concentration and discharge. Sutherland and Bryan (1989) had maximum suspended sediment concentration at peak discharges on their work in Kenya. Yair and Lavee (1981) found no correlation between hillslope suspended sediment concentration and run off. Gerson (1977) found no discernible relationship between suspended sediment concentration and discharge. Probst and Suchet (1992) had a rapid decrease in mean suspended sediment concentration with increasing river runoff. Rainstorms cause an increase in discharge with an associated increase in turbulence in a river. The turbulence takes bed sediments into suspension, leading to a relatively high concentration of suspended sediment in the water. When the rainstorm is prolonged, discharge and turbulence may remain high but the quantity of suspended sediments present in the water usually declines progressively, because the quantity of sediment introduced into the river by erosional processes is limited and the amount of sediment available to be taken into suspension diminishes gradually during a storm event. This is known as the hysteresis effect (Ongley, 1996). There are different patterns of hysteresis in the relation between suspended sediment and discharge. These patterns can be related to types and locations of active sediment sources. A clockwise hysteresis occurs when sediment is derived from the bed and banks of the channel or area adjacent to the channel, whereas an anticlockwise hysteresis occurs when the upper part of the slope is the source area (Klein, 1984).

Suspended sediment can be estimated by sediment rating. In sediment rating, suspended sediment concentration is represented as a continuous function of water discharge. There are two main approaches; the first recognizes that there is no unique relationship between suspended sediment concentration and water discharge. The condition of mean concentration as a function of water over the time period of interest is modeled. A relation is estimated by sampling a series of consistent measurement of water discharge and discharge-weighted sediment concentration. The relation is then combined with the water discharge record for the same period in order to determine the sediment yield (Miller, 1951).

A simple equation is mostly represented in the form:

$$\mathbf{C = aQ^b}$$

Where, C is the sediment concentration measured in kg/m^3, Q is the discharge in m^3/s and 'a' and 'b' the sediment rating coefficient and exponents. The rating coefficient 'a' contains information for converting the discharge 'Q' into sediment concentration 'C' and the information about the offset of the rating line in log-log space (Syvitski and others, 1987. Ozgur, 2007).

In the second approach, suspended sediment concentration is modeled with an empirical derived multivariate relation. Thus, suspended sediment concentration is not only related to water discharge but to other controls of processes affecting the sediment supply. Controls or processes normally used include season and hysteresis of sediment delivery during storms.

Suspended sediment grain size data is very important in determining source areas of erosion (Walling and Moorehead, 1987). The relationship between grain size characteristics and discharge varies from place to place. Numerous studies have shown that mean grain size of suspended sediments increases with increased discharge whiles others have shown that mean grain size of suspended sediments decrease with increased discharge (Table 2).

Table 2: Some Relationships between the particle size characteristics of suspended sediments and water discharge (source: Walling & Moorehead, 1987).

River	Response to increasing discharge	Author
Eel River, California, USA	Proportion of sand increases and proportion of clay decreases	Brown & Ritter (1971)
Rio Puerco, New Mexico, USA	Mean particle size increases	Nordin (1963)
Upper Tees, UK	Mean grain size increases during floods	Carling (1983)
Scott Run, Virginia, USA	Proportion of sand increases and proportion of clay decreases	Vice et al (1969)
Rhine, FRG	Portion of coarse particles increases	Horowitz (1985)
River Clyde, Scotland	Mean and median particle size remains relatively constant	Fleming & Poodle (1970)
Niobara River, Nebraska USA	Median particle size decreases at high sediment discharges	Colby & Hembrea (1955)

Generally, suspended sediment yields decrease as the drainage area increases (Trimble, 1977, Walling 1983). This is because there are usually more sediment traps in large basins than smaller basins. In order to develop a relationship between suspended sediment yield and lithology, Probst and Suchet (1992) calculated the rock erodibility coefficient for different rocks (Table 3).

Table 3: Rock erodibility coefficient (KER = rock denudation rate/granite denudation rate) calculated for various lithologies using the data of Chorley and others (1984). (source: Probst and Suchet, 1992).

Lithology	KER
Granites	1
Sandstones, limestones	4
Schists/micaschists	10
Shale, pelites, marly sandstones, marly limestones	27
Marls	50

Rock erodibility coefficient (KER) is defined as a ratio of the denudation rate of a rock to that of granite (Probst and Suchet, 1992). Rocks with KER = 50 are poorly cohesive, those with KER = 1 to 4 are strongly cohesive and those with KER = 10 to 27 are moderately erodible. For each rock group, the suspended sediment yield increases with increasing runoff, but the increase is more rapid for rocks with low cohesion than on sandstone (Probst and Suchet, 1992). That is, for a given runoff intensity, sediment yields are greater on marls than on sandstones or schists.

Most evidence suggests that much of the observed suspended sediment load in rivers is derived from the erosion of soil from agricultural land (Zhang and others, 2003). Erosion of soil is typically by sheetwash or concentrated flow as rills and gullies. Sheetwash typically erodes to a depth of a few soil particles, where as the concentrated flow in rills and gullies erodes more deeply (Fairbridge, 1968). Research also indicates that 15-50% of suspended sediment yield can be attributed to channel erosion during low flows (Leopard and others., 1964., Etchanchu and Probst, 1986., Kattan and others., 1987).

Soil erosion is a major problem and a major control on suspended sediment yield that was recognized from the early 1930s (Trimble and Crosson, 2000). The erodibility of a soil is defined by its resistance to two energy sources: the impact of raindrops on the soil surface and the shearing action of runoff between clods in grooves or rills (United Nations Food and Agriculture, 2007). The erodibility of a soil depends essentially on the amount of organic matter in the soil, the grain size of the soil, especially sand of 100-2000 microns (µm) and silt 2-100 microns (µm) sizes (Wischmeier and others, 1971). The erodibility is also associated with the soil profile and structure of the surface horizon and the permeability (Wischmeier and others, 1971). Soil structure refers to the arrangement of soil particles into compound particles. Principal soil structure forms are prismatic, platy, columnar, blocky or granular. The most erodible soils are those rich in loam and fine sand (Wischmeier and others, 1971). More clayey material is stickier whereas coarser material has heavy particles which can only be moved at higher flow velocities. Soil erodibility is considerably higher in unconsolidated (loose) soil than consolidated (compact) soil. Soil erodibility is decreased by flocculation and accelerated by dispersion. The greater the erodibility of a soil, the higher the sediment that is discharged by flow. The average rate of erosion of any soil can be predicted by the Universal Soil Loss Equation:

$$A = R \times Kf \times LS \times C \times P$$

Where, A represents the potential long-term average annual soil loss in tons per acre per year. R is the rainfall and runoff factor. The greater the intensity and duration of the rain storm, the higher the erosion potential. Kf is the soil erodibility factor, it is the average soil loss in tons/acre per unit area for a particular soil in cultivated, continuous fallow with an arbitrarily selected slope length of 22.13 m (72.6 ft.) and slope steepness of 9%. Kf is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting Kf, but structure, organic matter and permeability also contribute. LS is the slope length-gradient factor. The LS factor represents a ratio of soil loss under given conditions to that at a site with the "standard" slope steepness of 9% and slope length of 22.13 m (72.6 ft). The steeper and longer the slope, the higher is the risk for erosion. C is the crop/vegetation and management factor. It is used to determine the relative effectiveness of soil and crop management systems in terms of preventing soil loss. The C factor is a ratio comparing the soil loss from land under a specific crop and management system to the corresponding loss from continuously fallow and tilled land. P is the support practice factor. It reflects the effects of practices that will reduce the amount and rate of the water runoff and thus reduce the amount of erosion. The P factor represents the ratio of soil loss by a support practice to that of straight-row farming up and down the slope (Wischmeier and Smith, 1978).

The response of fluvial systems to landuse and climate change is reasonably well understood for small catchment areas but less clear for larger drainage basins (Hoffman and others, 2007). The sensitivity of sediment load to land-use change depends on buffering capacity of the river basin and is closely related to the sediment delivery ratio (Walling, 1999; Asselman, and others, 2003). The impact of watershed management on sediment delivery, and thus suspended sediment concentration is higher in regulated and canalized rivers than in natural rivers due to a lack of storage sites in canalized rivers (Verstraeten and others, 2003). Patterns of contemporary land use largely control the production and movement of runoff and sediment. Abandoned farmlands have a high tendency to produce sediments since they do not absorb rain as compared to recently plowed crop lands (Harden, 1993).

Ritter and others, (2002), documented that the sediment yield in a basin is directly proportional to the basin’s elevation and also to the basin’s relief.

2.2 SUSPENDED SEDIMENT ESTIMATION FROM TURBIDITY

Suspended sediment concentration can be estimated from turbidity. Turbidity basically tells the clearness of water, the higher the turbidity, the cloudier the water. Turbidity is caused by suspended solids including clay, silt and algae. High turbidity indicates that a lot of suspended matter exists in the water. Turbidity is a much better predictor in estimating suspended sediment concentration than water discharge (Lewis, 1996). Christensen and others (2002) also purport that turbidity is a better surrogate than stream flow in estimating suspended-sediment loads. It involves the development of regression equations that relate suspended-sediment concentrations to discrete turbidity measurements. Research conducted by the United States Forest Service showed that simple linear regression models between turbidity and suspended sediment concentration determined from sediment samples provide a more accurate daily prediction of sediment loads than other methods, such as the discharge, but the models had to be developed separately for samples taken on the rise and fall of event hydrographs (Lewis 1996).

3.0 STUDY AREA

3.1 GREEN RIVER

The Green River, a tributary of the Ohio River has headwaters in Lincoln County, Kentucky. Its confluence with the Ohio River is near Evansville, Indiana. The portion of the Green River studied in this research is the Upper Green River in south central Kentucky. The Green River provides water for many of its surrounding counties. It is the home to 71 of the state's 103 known mussel species (Nature Conservancy, 2009). It is also home to 151 fish species. It is also lined with numerous tree species and wild flowers. It is about 480km or 300 miles long. Its basin has an area of about 25400 km^2 or 9807 mi^2. The Upper Green river is the area below the Green River Dam and above the lower boundary of Mammoth Cave National Park (Nature Conservancy, 2009).

The initial plan of this research was to study the suspended sediment transport dynamics and sediment yield in four tributaries of the Upper Green River Basin where sampling and monitoring equipment had been installed. The tributaries were Pitman Creek, Brush Creek, Russell Creek and Little Barren River (Fig. 3.1). The study was eventually limited to Pitman Creek and Brush Creek because no sediment samples were collected at the other monitoring sites during the study period.

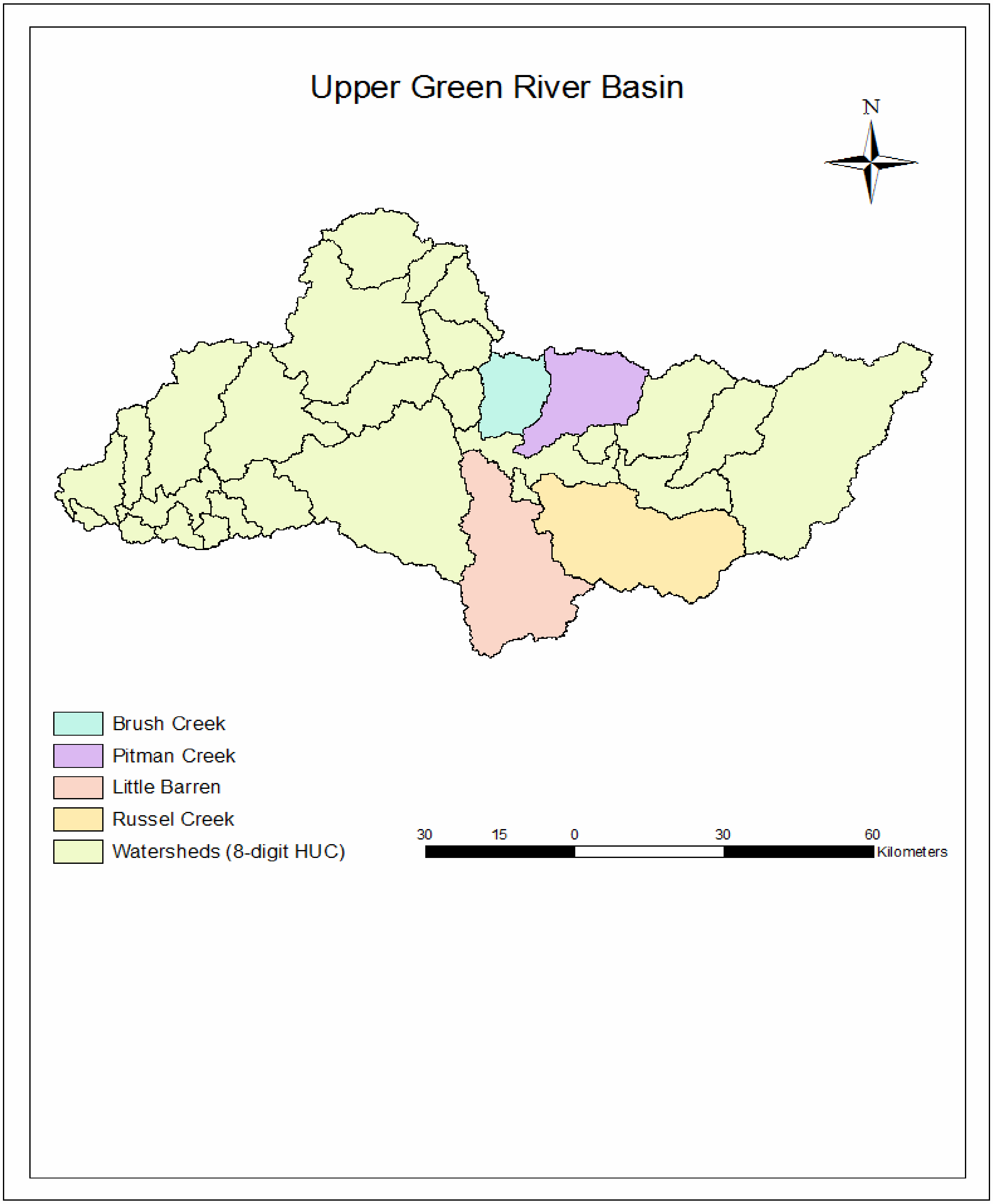

Figure 3.1: Upper Green River Basin showing Brush Creek, Pitman Creek, Little Barren and Russell Creek watersheds.

3.2 Watershed Characteristics

3.2.1 Climate

Climate data obtained from the Midwest Climate Center, indicated that the monthly total precipitation for the study period ranged from 0.01 m (0.39 in) to 0.16 m (6.45 in). Monthly mean temperature ranged from 3.56 ^{o}C (38.4 ^{o}F) to 24.5 ^{o}C (76.1 ^{o}F) Table 4.

Table 4: Study period climate

Study Period (Month)	Total Precipitation		Mean Temperature	
(Feb. 2008 - Sep. 2008)	(in)	(m)	(F)	(C)
February	5.47	0.14	38.4	3.56
March	5.33	0.14	45.9	7.72
April	6.07	0.15	55.5	13.06
May	4.69	0.12	62.3	16.83
June	1.94	0.05	76.1	24.5
July	6.45	0.16	76.1	24.5
August	0.88	0.02	75.1	23.94
September	0.39	0.01	71.4	21.89

3.2.2 Watershed Morphology

The Pitman Creek watershed in map view is funnel shaped and has an area of 350.71km^2 and a perimeter of 108.42 km. Brush Creek watershed in map view is rectangular shaped and has an area of 213.33 km^2 and a perimeter of 75.14 km. Thus the size of Pitman is about one and a half that of Brush (Table 4). The area and perimeter of both watersheds were calculated using the Kentucky HUC (Hydrologic Unit Codes) 11 data. Pitman Creek watershed is identified as an 11-digit HUC number 05110001090 and the Brush Creek watershed is identified as an 11-digit HUC number 05110001100.

Table 5: Watershed Shape, Area and Perimeter

Watershed	Shape	Area (Sq. km)	Perimeter (km)	Area to perimeter ratio (km)
Pitman	Funnel	350.71	108.42	3.23
Brush	Rectangular	213.33	75.14	2.84

There is a slight difference in mean elevation in the two watersheds. Pitman Creek watershed has a mean elevation of 75.73 m and a mean slope of 1.94 degrees whilst Brush Creek watershed has a mean elevation 72.07 m and a mean slope of 3.52 degrees (Table 5, Fig. 3.2 and Fig. 3.3). Elevation in the Pitman Creek watershed is high at the northeastern part of the watershed which happens to be the upstream area, lower elevations occur at the southern to southwestern part of the watershed. Slope is generally high at the western part of the watershed. The eastern part of the watershed is relatively flat. Elevation in the Brush Creek watershed is high at the northwestern to northeastern part of the watershed (upstream area) and low at the southwestern part of the watershed. Brush Creek watershed's slope is high at the northwestern part of the watershed. The eastern to southeastern part of the watershed is relatively flat.

Table 6: Watershed elevation (m) and slope (^{o})

Watershed	Maximum Elevation	Minimum Elevation	Mean Elevation	Maximum slope	Minimum slope	Mean Slope
Pitman	107.77	48.4	75.73	21.44	0	1.94
Brush	99.22	46.45	72.07	57.2	0	3.52

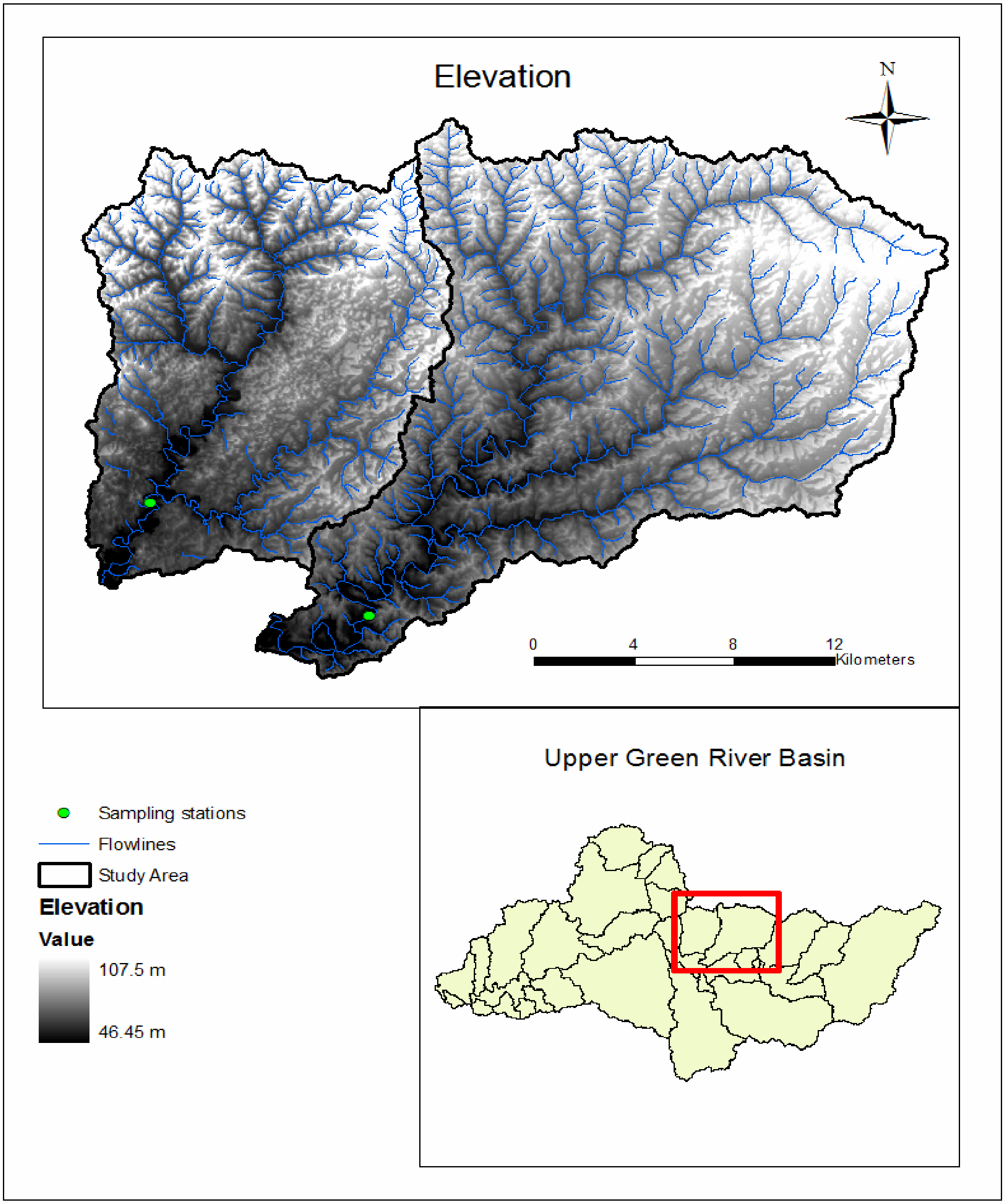

Figure 3.2: Topographic map of study area (Data obtained from the United States Geological Survey).

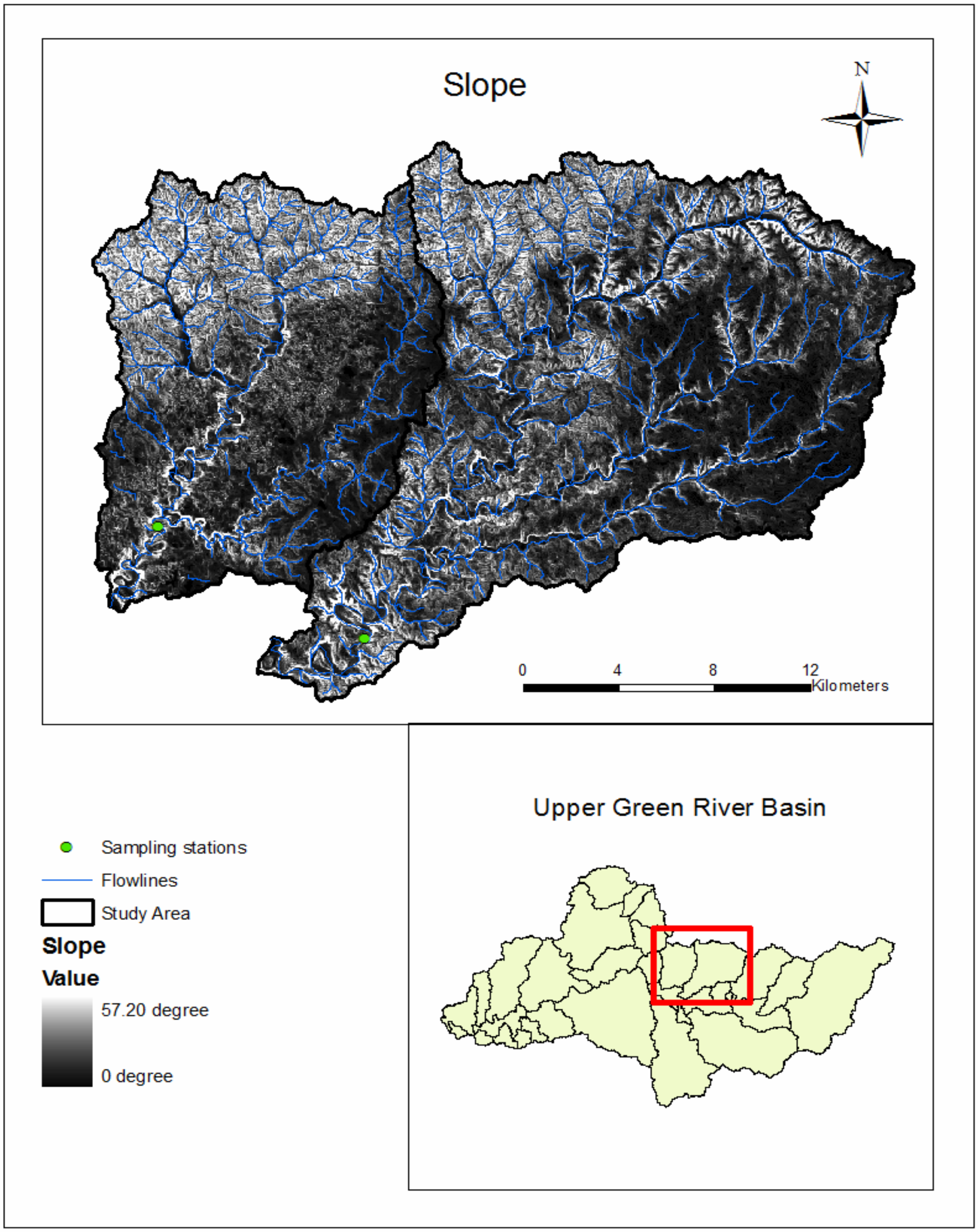

Figure 3.3: Slope map of study area (Data obtained from the United States Geological Survey).

3.2.3 Geology and Soils

The Pitman Creek watershed has 99.95% of its area underlain by sedimentary rocks of Mississippian age, including the Fort Payne, Ste. Genevieve and St. Louis, Salem, Warsaw and Harrodsburg formations and the remaining land area is covered with Quaternary alluvium. The Salem, Warsaw and Harrodsburg units cover about 53% of the surface area with thin outcrop bands of the Fort Payne unit covering about 33.59% (Fig. 3.4, Table 6). The Brush Creek watershed has about 98.39% of its surface geology in the Mississippian, 1.56% in the Pennsylvanian and the remaining is alluvium. The Ste. Genevieve and St. Louis limestones are dominant, and cover about 85.17% of the surface area, it has thin outcrop bands of the Salem, Warsaw and Harrodsburg units around its center and the northwestern portion and a the Pennsylvania Caseyville unit in its northeastern side. The Brush Creek watershed has a fault in the northeastern area (Fig. 3.4, Table 7).

Table 7: Geologic formations, lithology and percentage area in the Pitman watershed

Formation	Period	Primary Lithology	Area (%)
Fort Payne Fm & Muldraugh/Renfro Dolostone members	Mississippian	Limestone, dolomite and shale	33.59
Ste. Genevieve & St. Louis Limestones	Mississippian	Limestone	13.36
Salem, Warsaw & Harrodsburg Limestones	Mississippian	Limestone	53
Alluvium	Alluvium	Gravel, sand, silt and clay	less than 1

Table 8: Geologic formations, lithology and percentage area in the Brush watershed

Formation	Period	Primary Lithology	Area (%)
Ste. Genevieve & St. Louis Limestones	Mississippian	Limestone	85.17
Salem, Warsaw & Harrodsburg Limestones	Mississippian	Limestone, shale and siltstone	13.22
Caseyville Formation	Pennsylvania	Sandstone, shale, limestone and coal	1.56
Alluvium	Alluvium	Gravel, sand, silt and clay	less than 1

The Fort Payne Formation consists of limestone, dolomite and shale. Rocks forming the Fort Payne unit have many small caverns and sinkholes and are overlain by cherty soils. The Ste. Genevieve and St. Louis limestone consist of fine grained, somewhat cherty, argillaceous dolomitic limestone. The Salem and Warsaw consist of argillaceous limestone and limy shale and the base and dolomitic siltstone in the middle and are treated as a single when the Harrodsburg is absent, the Harrodsburg limestone is cherty skeletal and contains numerous fossils. The Caseyville formation consists of pebbly quartzose sandstone, carbonaceous and calcareous shale, limestone and coal and the lithology varies greatly from place to place. The Alluvium consists mostly of recent and some Pleistocene sediment deposits (Kentucky Geological Survey 2008).

The Pitman Creek watershed has mapped soil units including the Caneyville, Dickson, Melvin, Mountview, Newark, Nolin, Otwell, Taft, Elk, Frankstown, Lowell, Morehead, Fredrick, Gamon, Shelocta, Needmore, Nolichucky, Riney and Sensabaugh. Brush Creek watershed has mapped soil units including the Bonnie, Caneyville, Dickson, Melvin, Mountview, Newark, Nolin, Otwell, Taft, Elk, Frankstown, Lowell, Morehead, Fredrick, Nolichucky, Riney and Sensabaugh (Fig. 3.5). The Needmore, Garmon and the Shelocta mapped soil units which are present in the Pitman Creek watershed are missing in the Brush watershed. The Pitman watershed has about 31.69% of its area covered with soil that has an erodibility factor (Kf) of 0.43 and the Brush watershed has about 26.69% of its area covered with soil that has erodibility factor greater than 0.43 (Figure 3.6 and Table 9). It can be seen from Table 8 and Table 9 that the total soil cover for each of the watersheds does not add up to 100%, this is because part of the area is covered by water.

In both Pitman Creek and Brush Creek watersheds the flat areas are covered with soil of high erodibility factor (Kf). The erodibility factor (Kf) of the mapped soil units was obtained from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic (SSURGO) online database.

Table 9: Pitman soil cover and their erodibility factors.

Soil Name	Kf	Area (%)
Caneyville, Dickson, Melvin, Mountview, Newark, Nolin, Otwell, Taft	0.43	31.69
Elk, Frankstown, Lowell, Morehead	0.37	18.77
Fredrick, Gamon, Shelocta, Needmore	0.32	35.16
Nolichucky, Riney	0.28	2.2
Sensabaugh	0.24	Less than 1

Table 10: Brush Soil cover and their erodibility factors

Soil Name	Kf	Area (%)
Bonnie, Caneyville, Dickson, Melvin, Mountview, Newark, Nolin, Otwell, Taf	0.43	26.69
Elk, Frankstown, Lowell, Morehead	0.37	10.35
Fredrick	0.32	29.93
Nolichucky, Riney	0.28	12.11
Sensabaugh	0.24	Less than 1

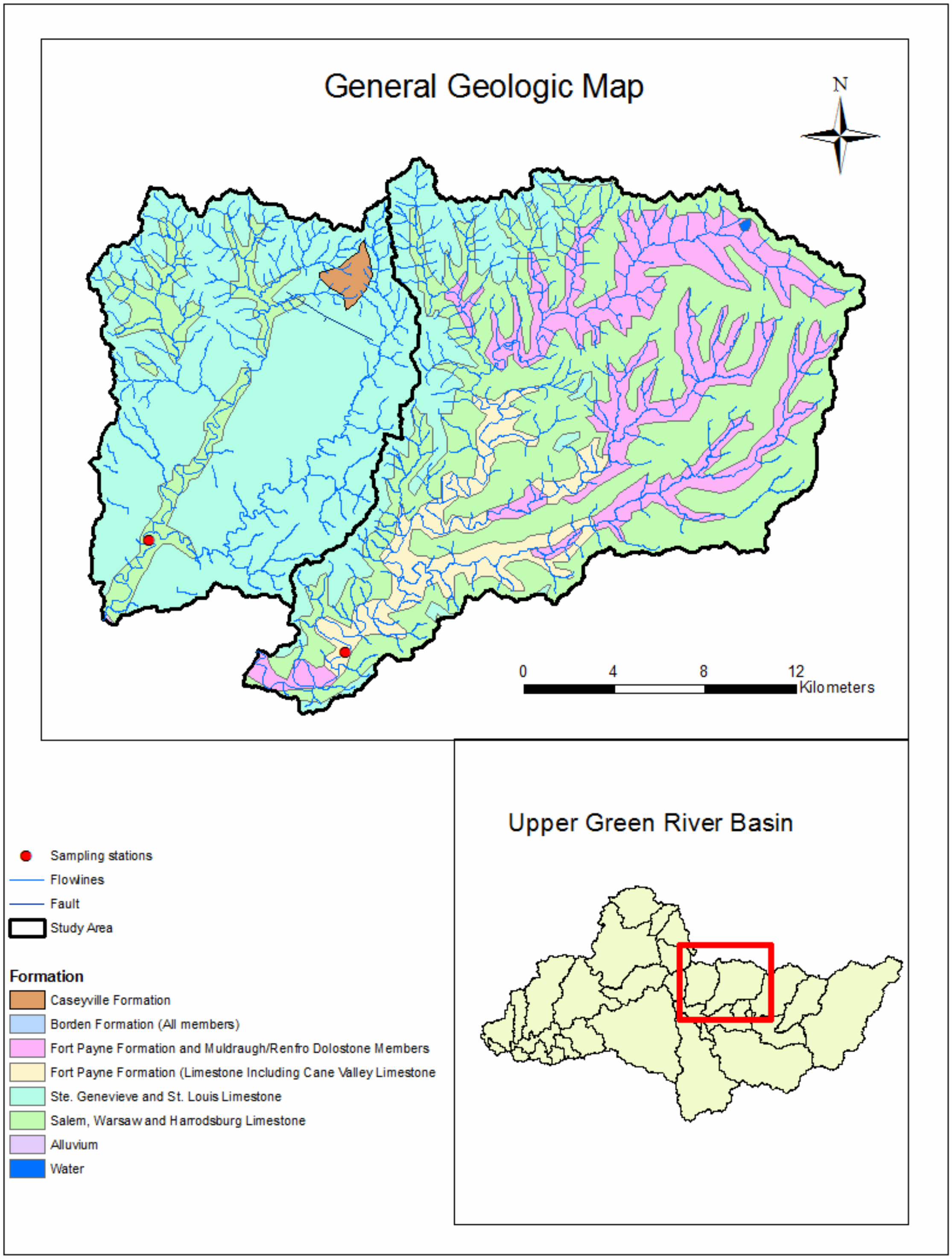

Figure 3.4: Geologic Map of the study area (Data obtained from Kentucky Geological Survey)

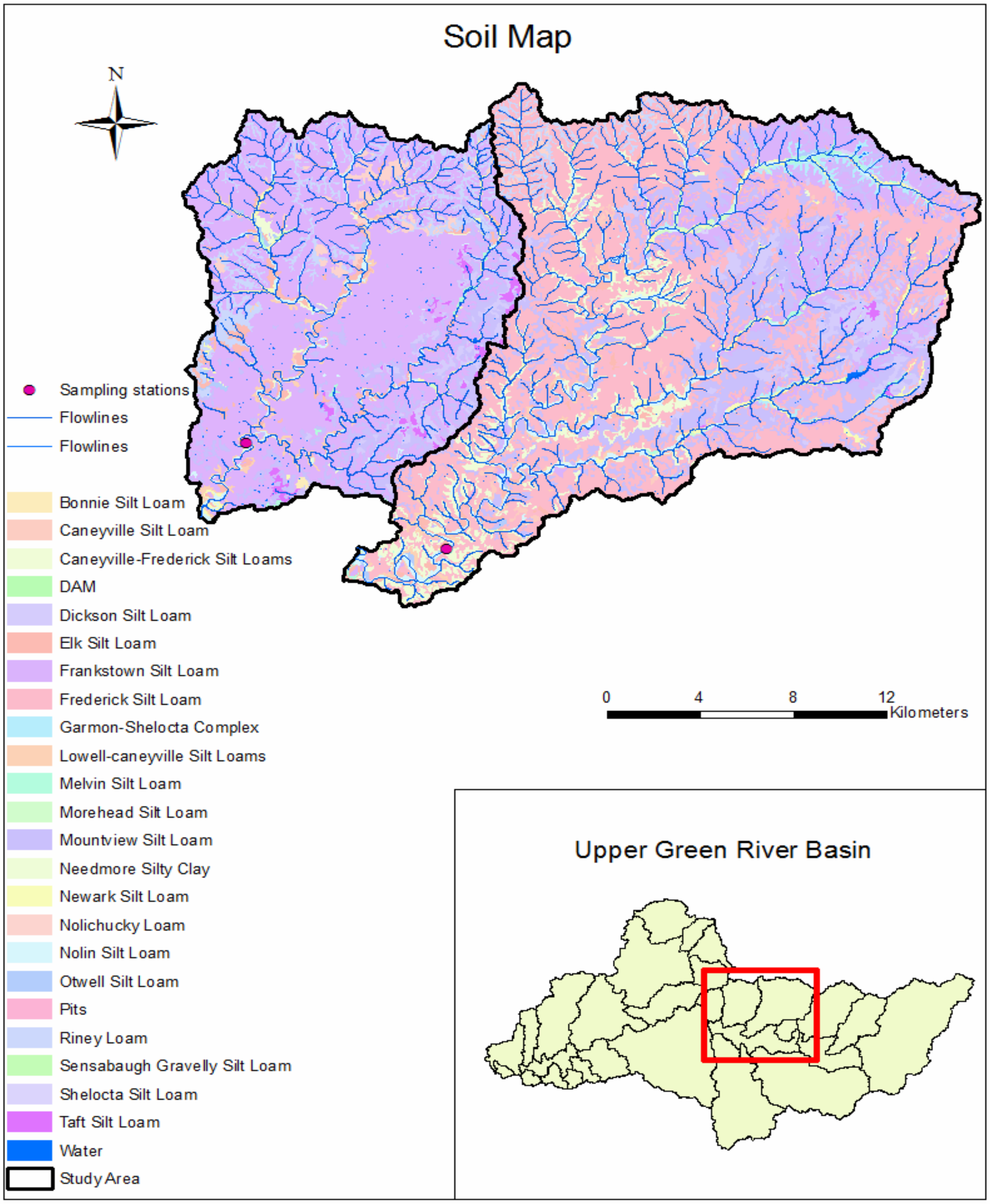

Figure 3.5: Soil map of the study area (Data obtained from United States Department of Agriculture)

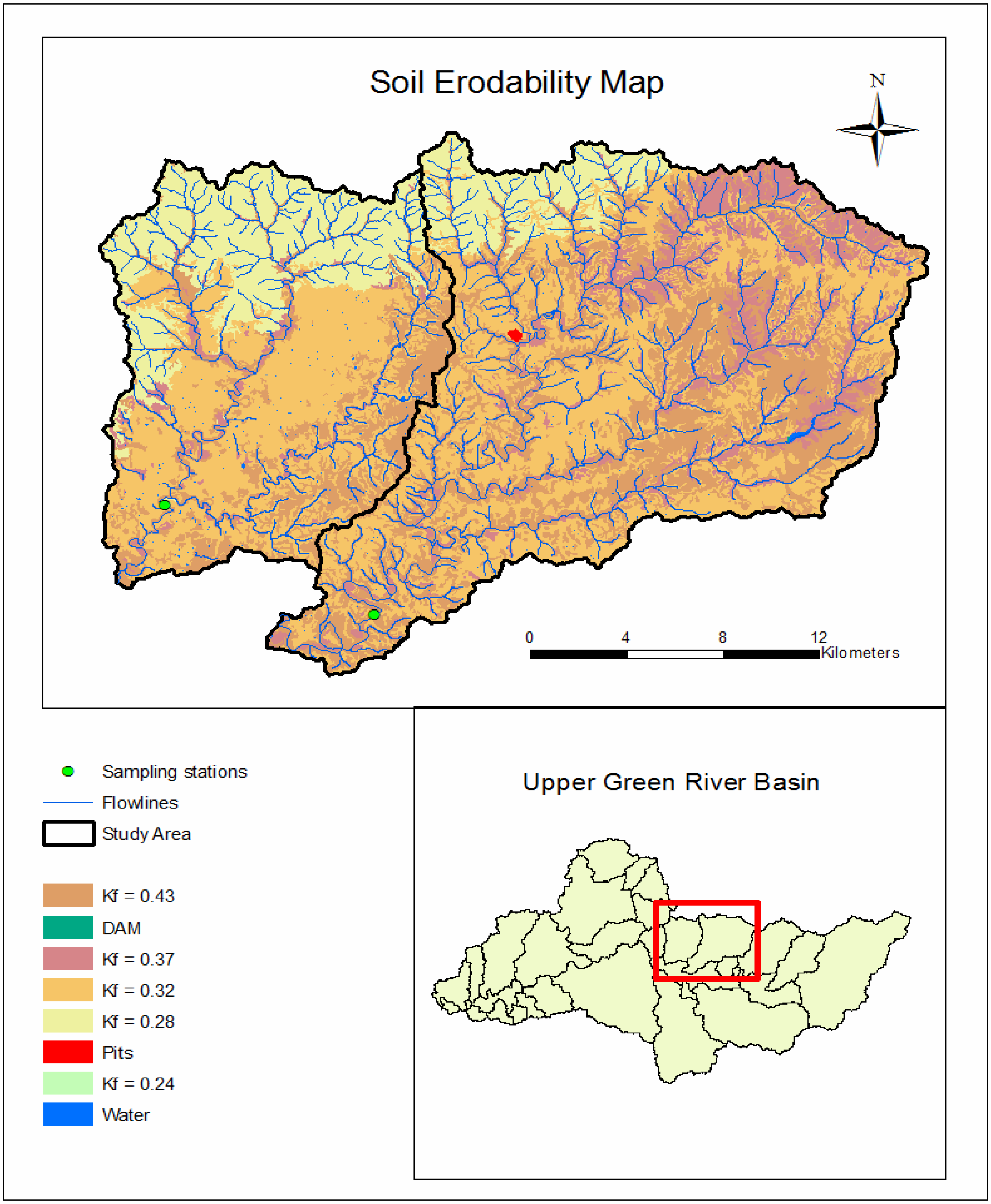

Figure 3.6: Erodibility map of study area (Data obtained from United States Department of Agriculture)

3.2.4 Landuse Patterns

The two watersheds have the same land cover classes but in different percentages. The Pitman watershed is dominated by pasture/hay and deciduous forest covering about 41.31% and 35.24% of its area respectively (Table 10, Fig. 3.7). Brush is dominated by deciduous forest and pasture/hay which covers 49.65% and 33.50% of its area respectively (Table 11, Fig. 3.7).

Table 11: Pitman Creek watershed and Brush Creek watershed Landuse distribution

Landcover	Pitman watershed (%)	Brush watershed (%)
Open water	0.13	0.06
Developed, Open Space	5.98	4.25
Developed, Low Intensity	1.00	0.17
Developed, Medium Intensity	0.47	0.05
Developed, High Intensity	0.36	0.00
Barren Land	0.05	0.00
Deciduous Forest	35.24	49.65
Evergreen Forest	1.09	1.47
Mixed Forest	0.61	0.76
Shrub	0.20	0.05
Grassland/Herbaceous	2.08	2.97
Pasture/Hay	41.31	33.50
Cultivated Crops	11.49	7.00
Woody Wetlands	0.01	0.05
Emergent Herbaceous Wetlands	0.00	0.02

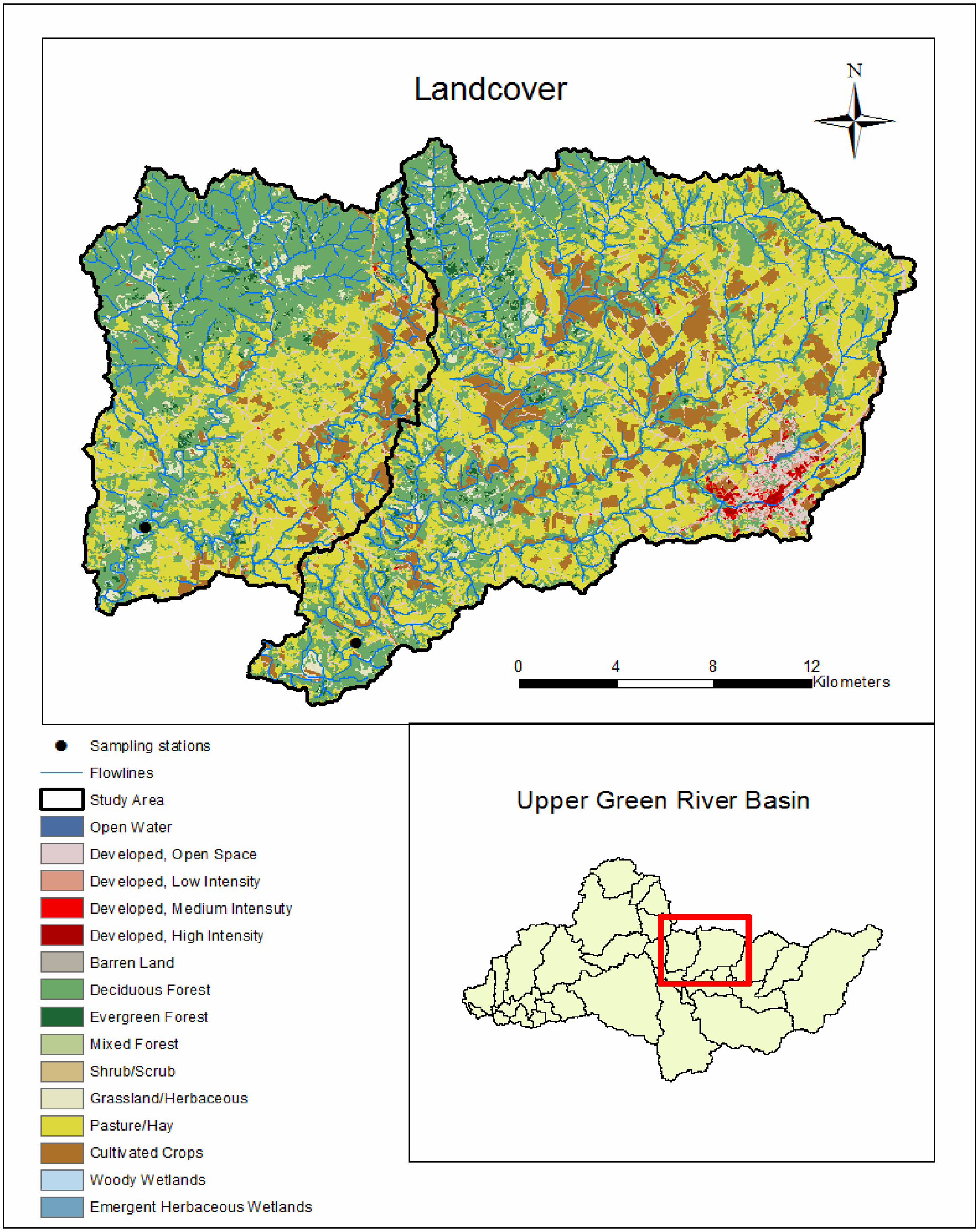

Figure 3.7: Land cover map of study area (Data obtained from Kentucky Division of Geographic Information)

Aggregation of similar landuse types shows the differences in landuse distributions between the two study watersheds (Fig. 3.8).

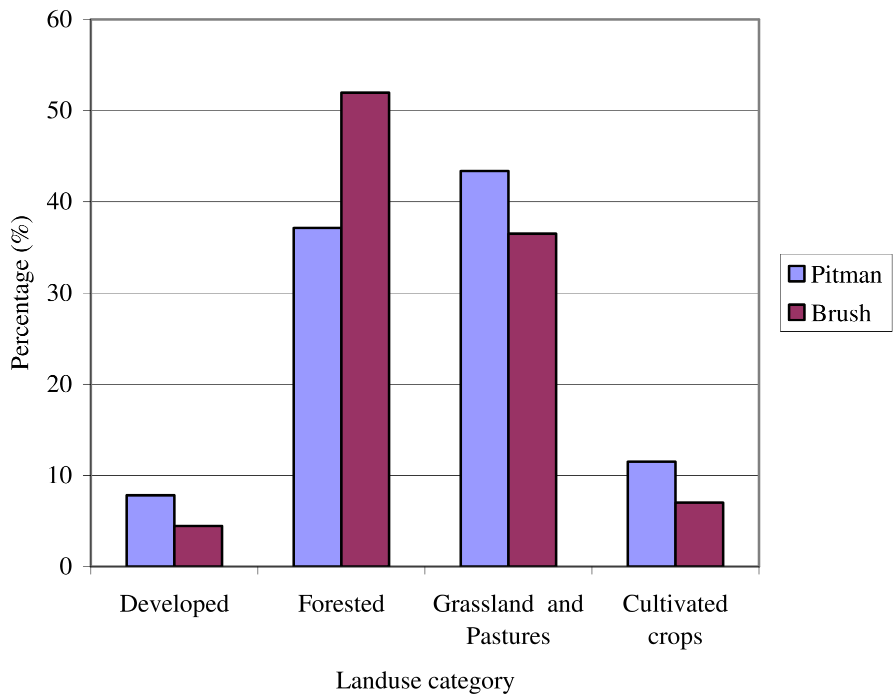

Figure 3.8: Pitman Creek and Brush Creek aggregated land-use distributions

4.0 METHODS

Data were collected in order to relate sediment loads in Pitman Creek and Brush Creek watersheds to their respective watershed characteristics. Water quality was monitored by measuring turbidity and water samples were collected when turbidity exceeded a threshold of 100 NTU at selected sites in the Pitman Creek and Brush Creek watersheds.

4.1 STREAM FLOW AND SEDIMENT MONITORING STATIONS

Field monitoring stations were located on Big Pitman Creek and on Big Brush Creek near their respective junctions with the Green River (Fig. 4.1, Fig. 4.2).

Sampling sites were selected based on several factors which affect the logistics of the data collection.

Channels with characteristic dimensions that do not change over time were preferred over those channels that will degrade, aggrade and change in width with time since they might cause equipment disturbance or loss. A turbulent source could cause equipment disturbance or loss, so areas with high source of turbulence from water were avoided in the site selection process. In terms of water depth, areas which are greatly affected by seasonal variations were avoided and water depth was such that sampling could still be done given changes in flow conditions. Areas with obvious hazards such as debris torrents, extreme flow magnitude, bedload transport, failure of in-channel debris structures, streamside treethrow, and sediment accumulations were avoided. Sites that were accessible at all times were selected to allow safe regular maintenance of the equipment.

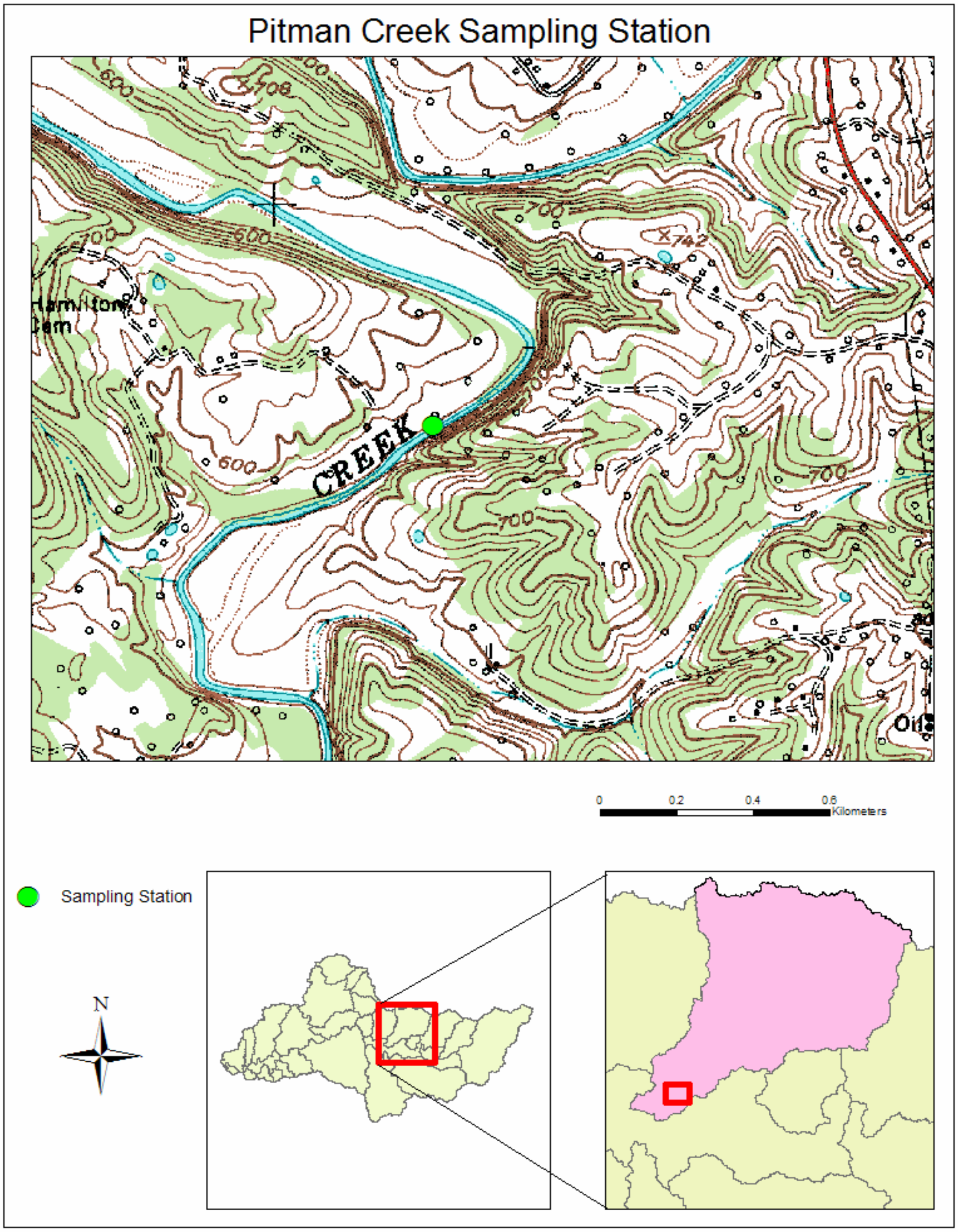

Figure 4.1: Pitman Creek sampling station on a topographic map (Data obtained Kentucky Geological Survey)

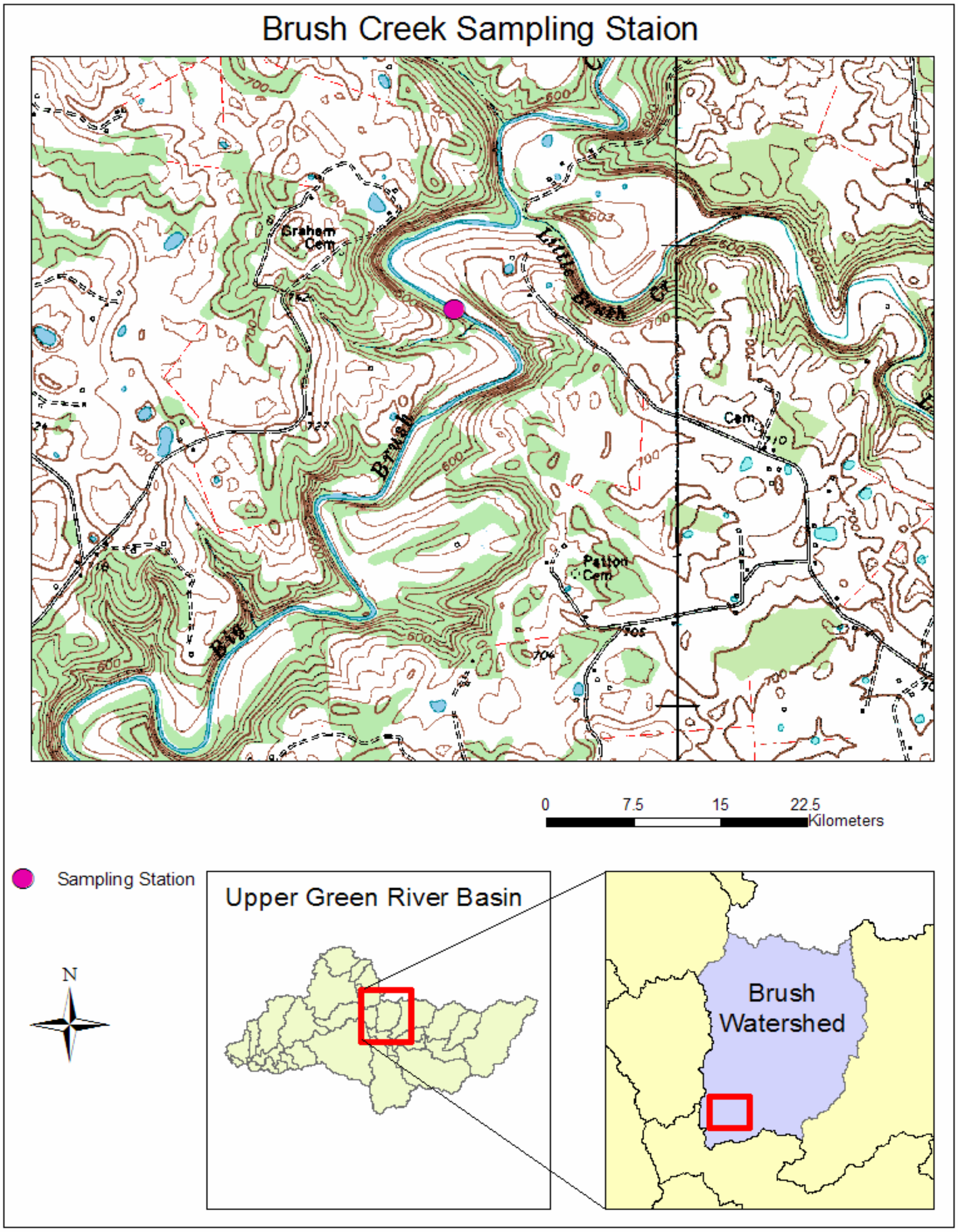

Figure 4.2: Brush Creek sampling station on a topographic map (Data obtained from Kentucky Geological Survey).

4.2 FIELD WORK AND RESEARCH DATA

Field data were collected using standard United States Geological Survey (USGS) methods and protocols for measurements (United States Geological Survey, 2008). Equipment used in the field include Hydrolab MS5 Multiprobe , YSI 600 OMS Data sonde, 3100-iSIC data logger and ISCO portable water sampler.

4.2.1 Hydrolab MS5 Multiprobe:

The Hydrolab MS5 Multiprobe (Fig. 4.3) consist of a calibration cup, storage cup, locking screw, housing, bulkhead connector, bail attachment and four configurable ports that can include sensors. The Hydrolab Multiprobe was installed at the Pitman study site to measure turbidity, depth and temperature (Hach Environmental, 2008. Eco Environmental, 2008).

Figure 4.3: Hydrolab MS5 Multiprobe used in the research

4.2.2 YSI (Yellow Springs Incorporated) 600 Optical Monitoring System (OMS) Data sonde

The YSI 600 OMS (Fig. 4.4) consist of a battery cap, a bail, a bulkhead with probe port plugs, a bulkhead connector with cap, the sonde body, the probes, the probe guard which protects the probes from possible physical damage, and the over the guard bottle which is used for calibration of the sonde. The YSI 600 OMS was installed at Brush Creek to measure the turbidity, conductivity, depth and temperature (YSI Inc. 2008).

Figure 4.4: YSI 600 OMS used in the research

4.2.3 3100-iSIC Data Logger:

The 3100-iSIC dada logger consists of a fiberglass house and an electronic unit (Fig. 4.5). It acquires data by the use of a direct-connect landline phone, radio, cellular or Ethernet telemetry.

Figure 4.5: 3100-iSIC data logger

4.2.4 ISCO (Instrumentation Specialist Company) Portable water Sampler:

The 6712 portable sampler (Fig.4.6) was used in sampling water. It consists of a top cover, a center section, tubs, bottles, plastic retaining rings, bottle carrier and a control panel. It can be programmed to enable or disable a running sampling program when reading received from a connected sonde meets certain conditions.

Figure 4.6: 6712 ISCO portable water sampler used in the research

4.2.5 Stream Flow Measurement:

Flow measurements were made at individual sites with a current meter at times that the river level was considered to be safe. The purpose of the flow measurements was to develop a rating curve for each site to enable us to estimate discharge from stage measurements.

4.2.6 Continuous Monitoring:

Water quality was monitored using Hydrolab and YSI data sondes. The data sondes were installed in PVC pipes at the selected sites. The PVC pipes were positioned to allow the sonde to rest at their bottom. Holes were drilled in the PVC casings to allow passage of water, keeping the sondes protected but also allowing for water quality testing. The sondes were then set up to record turbidity, conductivity, depth and temperature. The sondes were deployed and allowed to run to collect data, with measurements made every minute and an average calculated and stored by the logger every 5 minutes.

4.2.7 Sediment Sampling:

Water samples were collected using ISCO water samplers. The ISCO water samplers were installed and connected to the sonde. A sampling regime was then designed by programming the data logger to allow the ISCO water sampler to collect water samples into 1 liter volume water bottles at hourly intervals when the turbidity recorded by the sonde reached or exceeded 100 NTU. The collected samples were then brought to the laboratory to analyze the sediments.

The fieldwork can be grouped into five major activities which included the installation and maintaining of site/station, checking and maintaining of sonde, installation and maintaining of water sampler, recording of storm event and the sampling of water from storm events (Fig. 4.7). Among the storm events that occurred during the study period, only the February 12 event was recorded by both sondes, this was due to non-operation of the sondes at different times of the study period. Turbidity thresholds (> 100 NTU) set to trigger the autosamplers during the study period also resulted in some storm events with no samples collected (Fig. 4.7).

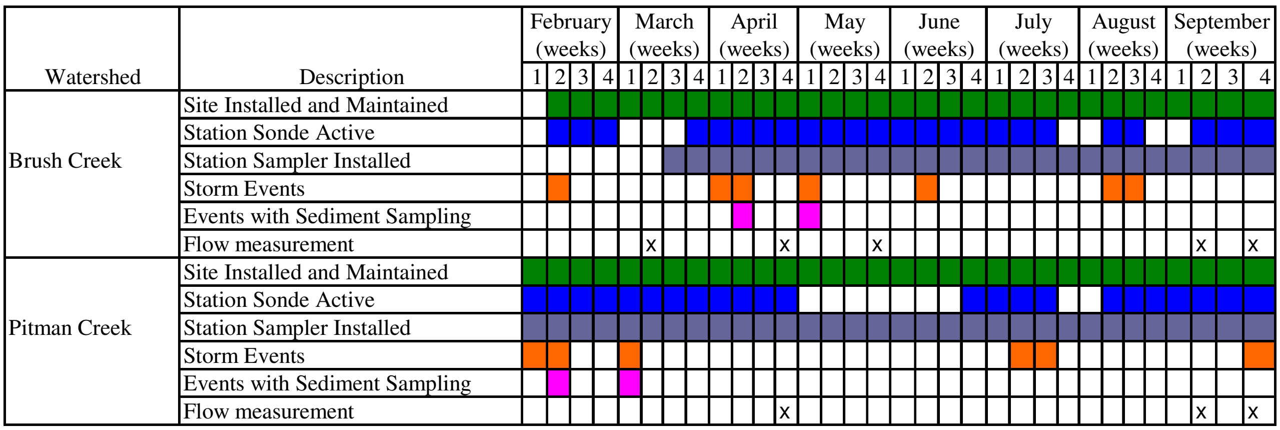

Figure 4.7: Field activities during the study period

Geospatial data which included hydrological, geology, soils, elevation and land cover were also used in the research. The Hydrologic unit polygons and hydrography of the basin were obtained from the USGS National Hydrological Dataset. Geological data were obtained from the Kentucky Geological Survey. Soil data were obtained from the USDA. Elevations were determined from the USGS seamless data and Land cover information was obtained from the Kentucky Land Cover Dataset (Table 12). Data from the Kentucky Office of Geographical Information Systems, USGS remotely sensed data, and available digital products in the department of Geography and Geology at Western Kentucky University were also used in the research.

Table 12: Geospatial data and sources

Data Type	Source	URL
Hydrological	USGS	http://nhdgeo.usgs.gov/viewer.htm
Geology	KGS	http://kgsmap.uky.edu/website/KGSGeology/viewer.asp
Soils	USDA	http://soildatamart.nrcs.usda.gov/
Elevation	USGS	http://seamless.usgs.gov/website/seamless/
Landcover	KLCD	http://kls.ky.gov/klsdata.htm

4.3 LAB ANALYSIS

Laboratory analyses of field samples included suspended sediment concentration and particle size distribution.

4.3.1 Suspended Sediment Concentration

The USGS evaporation method (USGS, 2008) was used in the analysis of suspended sediment concentration. Collected samples in the ISCO bottles were covered and kept for two weeks to allow sediments to settle, the lids were removed gently in order not to stir samples up. Specific conductivity meter was then inserted into the sample to determine the specific conductivity. The conductivity was measured in order to have an idea of the degree of impurities in the water. Care was taken during the insertion of the conductivity meter to avoid the sample being stirred. The ISCO bottle was weighed together with the sample. Water was decanted from the bottle as much as possible. Care was taken when pouring the water to avoid loss of sediments from the bottom of the ISCO bottles. Sediments were swirled back into solution and then poured into a Pyrex evaporative dish. The remaining sediments were washed out from the bottle with deionized (DI) water in order to rinse all out into the evaporation dish. The evaporative dish was weighed together with the sediments sample and the weight was recorded. The Pyrex evaporative dish together with the samples was placed in an oven at a temperature of 100^{o}C to allow the sample to dry. The dried sample was then placed in a desiccator to re-establish room temperature. Sample was then weighed after it re-acclimates in the desiccator. The suspended sediment concentration was then calculated based on specific weight of water and sediment of 1.0 g/cm^3 and 2.65 g/cm^3 respectively (Vanini, 2006). Assumptions were made that all sediment was quartz.

The suspended sediment concentration can be expressed as follows:

In parts per million (ppm);

$$Sediment\ concentraion\ =\ \frac{weight\ of\ sediment\ (mg)}{weight\ of\ sediment\ and\ water\ mixture\ (mg)}\ x\ 10^{6}$$

In milligrams per liter (mg/L);

$$Sediment\ concentraion\ =\ \frac{weight\ of\ sediment\ (mg)}{volume\ of\ sample\ (l)}\ x\ 10^{6}$$

4.3.2 Particle size analysis

Particle size analyses were made using the Malvern Masterizer 2000 (Fig. 4.8). The Malvern Masterizer applies laser diffraction to measure particle size distribution in aqueous suspension. The dried sample was mixed and rubbed loose with the finger. It was re-wetted with 20 to 30 ml D.I. water and placed into a sample jar, thorough saturation was achieved by allowing it to set for few hours. The Malvern was started with a background measurement of 800 ml D.I. water in a 1000 ml beaker for samples with mass greater than or equal to 0.08g, and 600 ml D.I water in a 800 ml beaker for samples with mass less than 0.08g. Samples were rinsed with D.I water when prompted by the equipment until obscuration is within range. Samples which had obscuration below or above range were adjusted by either splitting the sample or by allowing excess water to settle. Measurements of the particles sizes of the sample and their volumes were then estimated by the equipment.

Figure 4.8: Malvern Masterizer 2000

4.4 DATA ANALYSIS

4.4.1 Precipitation

Average precipitation data for the study period collected from 146 stations across the state of Kentucky was interpolated using the ESRI ArcGIS spatial analyst inverse distance weighted method to create a continuous surface precipitation data (Fig. 5.3). The inverse distant method was preferred over other methods because it allocates interpolated values to locations as a result of surroundings measured values and mathematical formulas to create a surface from point data, it also represents small trends well and it leads to results within meaningful values (Earls and Dixon, 2007). Pitman Creek and Brush Creek watershed polygons were then merged and then clipped to the interpolation.

The variations in total precipitation were then estimated using the respective cell values from the interpolation.

Precipitation values recorded on the storm event dates at the Hodgenville, Greensburg and Bradfordsville stations which were the most proximal to the study area were used to estimate the average precipitation for the events. Interpolation of the data from the Hodgenville, Greensburg and Bradfordsville stations did not show any difference in precipitation because of the limited number or points (stations). Mean precipitations on the event dates were estimated from statistical mean, since the three stations formed a triangle around the study area.

4.4.2 Geology

Geology data were downloaded and unzipped from Kentucky Geological Survey (KGS) website and projected to the NAD 1983 State Plane Kentucky FIPS 1600 coordinate system using ESRI ArcGIS. Pitman Creek and Brush Creek watershed polygons were merged and then clipped to the projected geology data choosing different colors to represent different geological formations. The area covered by the different geological formations were determined from the number of polygons (count) by the different formations and divided by the total area covered by all the formations in the watershed to obtain the percentage area.

4.4.3 Soil

Soil data were downloaded and unzipped from United States Department of Agriculture (USDA) website and projected to the NAD 1983 State Plane Kentucky FIPS

1600 coordinate system using ESRI ArcGIS. Pitman Creek and Brush Creek watershed polygons were merged and then clipped to the projected soil data, different soil mapped units were represented with different colors. Soil unit boundaries were removed to give a better representation of the map. Areas covered by the soil units were determined from the number of polygons (count) covered by the soil type. Soil units with the same erodibility factor (Kf) were grouped together and an erodibility map was created based on values of the erodibility factor (Kf). Areas covered by the erodibility factors were determined from the number of polygons (count). The percentage areas were obtained by dividing the polygons (count) by the total area covered by all the soils.

4.4.4 Digital Elevation Model (DEM)

DEM was downloaded and unzipped from United States Geological Survey (USGS) website. The data layer was projected to the NAD 1983 State Plane Kentucky FIPS 1600 coordinate system using ESRI ArcGIS. Pitman Creek and Brush Creek watershed polygons were merged and then clipped to the projected DEM. Slope and elevation were determined using grid cell size, statistical summary of the clipped raster were determined for the elevation and slope of the watersheds using raster tools in ArcGIS.

4.4.5 Vegetation (Land Cover)

The vegetation data was downloaded from the Kentucky Land Cover Dataset website. The vegetation data layer was projected to the NAD 1983 State Plane Kentucky FIPS 1600 coordinate system using ESRI ArcGIS. Pitman Creek and Brush Creek watershed polygons were merged and then clipped to the projected vegetation data. Land covers were grouped into classes. Classes were represented with different colors. Areas (patches) with similar land cover classes were aggregate into categories. Areas covered by a vegetation type were obtained from the number of polygons (counts).

4.4.6 Field Data

Collected field data were sorted and all unreasonable data removed. Unreasonable data are those that are either too high or too low from previous or subsequent recordings, it could also be values recorded from faulty instrument, assuming a reading of 5000 NTU was recorded between a 100 NTU and a 130 NTU; the 5000 NTU can be treated as an unreasonable data. Ratings were developed between suspended sediment concentration and turbidity and also between sonde stream depth and discharge for each watershed by regression with suspended sediment concentration and discharge as the dependent variables respectively. The suspended sediment fluxes for the watersheds were estimated for the sampled events. The incremental loads for these periods were determined by multiplying suspended sediment flux by the time intervals. The sum of the incremental loads represents the total load for the period. To compare the loads, estimates were made for time periods common to both watersheds and with good data. The suspended sediment flux for this time periods were divided by the watershed area and the number of days to obtain the sediment yield. The sediment yield for the two watersheds were then compared and then linked to the hydro-climate regime, geology, soil type, land cover conditions, relief and sizes of the watershed. ESRI ArcGIS 9.3 was used for the spatial analysis and S-Plus 8.0 and Sigma 11.0 were used for the statistical analysis.

5.0 RESULTS

5.1 STUDY PERIOD HYDROLOGY

Daily total precipitation values recorded before, during and after the storm events at three stations most proximal to the study area (Fig.5.1) gave estimates of the average precipitation in the region for the sampling period (Table 13).

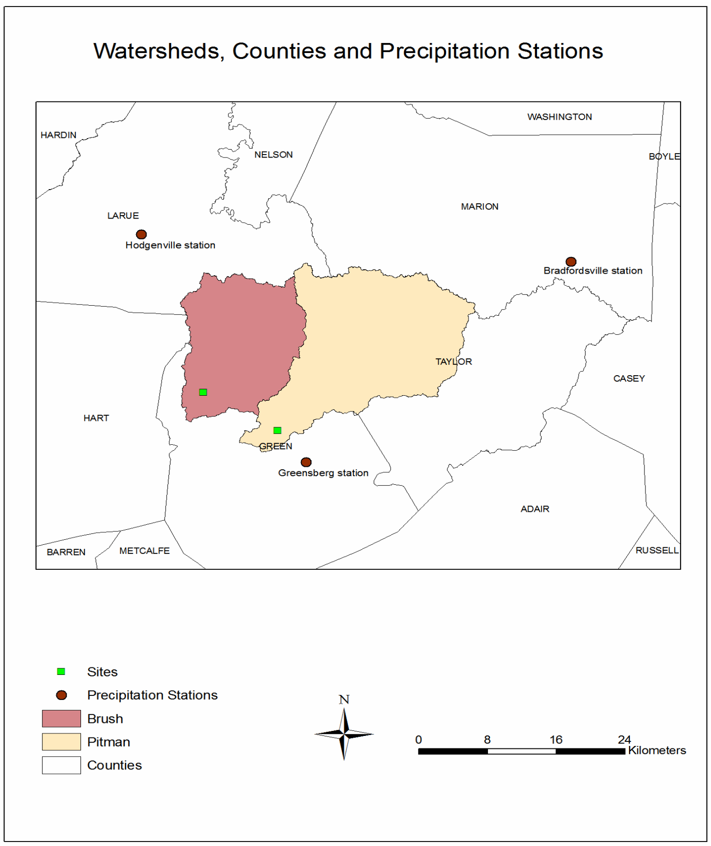

Figure 5.1: Study area watersheds and nearby precipitation stations used to estimate rainfall on the event dates (Data obtained from the Kentucky Geological Survey and the Midwest Regional Climate Center).

Table 13: County, Station and Average Precipitation on the event dates. T in the table represents "Trace" and M represents "Missing"

Storm Event	Storm Event Date	County	Station	Precipitation Recorded (in)			Mean Precipitation (in)	Mean Precipitaion (m)
				Before Storm Event	Storm Event Day	After Storm Event		
Pitman Creek Event 1	2/12/2008	Larue	Hodgenville	0	1.7	0	1.16	0.03
		Green	Greensburg	0.43	1.04	T		
		Marion	Bradfordsville	0	0.74	0.88		
Pitman Creek Event 2	3/3/2008	Larue	Hodgenville	0	2.5	0	1.79	0.04
		Green	Greensburg	T	1.34	0.39		
		Marion	Bradfordsville	0.02	1.52	0.46		
Brush Creek Event 1	4/11/2008	Larue	Hodgenville	0	1.63	0	1.04	0.03
		Green	Greensburg	1.51	0.48	0		
		Marion	Bradfordsville	0.05	1.01	0.31		
Brush Creek Event 2	5/3/2008	Larue	Hodgenville	0	0	0	1.07	0.03
		Green	Greensburg	M	1.52	T		
		Marion	Bradfordsville	0	1.69	0		

Precipitation values for the three stations on the days of the events were approximately the same for all three events except for the 3 March event which had a slightly higher precipitation (Fig. 5.2).

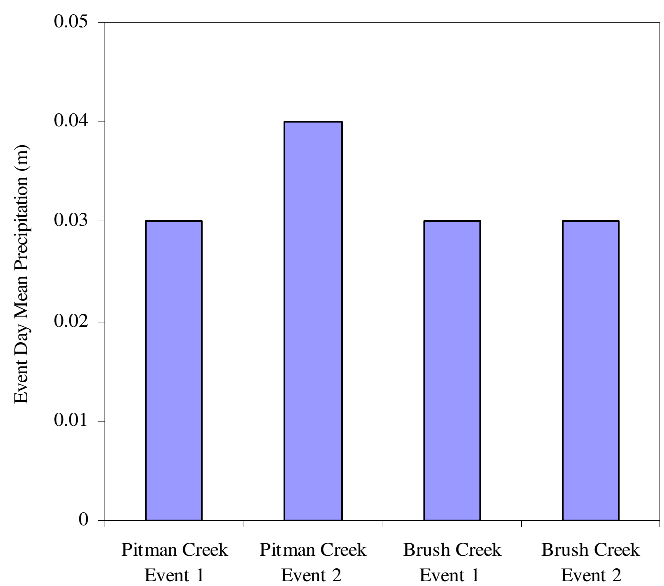

Figure 5.2: Summary of event precipitation for the two study area watersheds

The total precipitation of Pitman watershed for the study period (11 February – 30 September, 2008) based on interpolation from the large set of Kentucky stations ranged between 0.50 m to 0.67 m, a range of about 0.17 m. High precipitation occurred at the southwestern portion of the watershed, which is the area where the stream monitoring station is situated and relatively low precipitation was observed at the northeastern portion. Total precipitation in the Brush watershed ranged from 0.62 m to 0.68 m, a range of 0.6m. High precipitation occurred at the northern tip of the watershed and relatively low precipitation occurred at the southwestern to western portion of the watershed, which is where the stream monitoring station is located (Fig. 5.3).

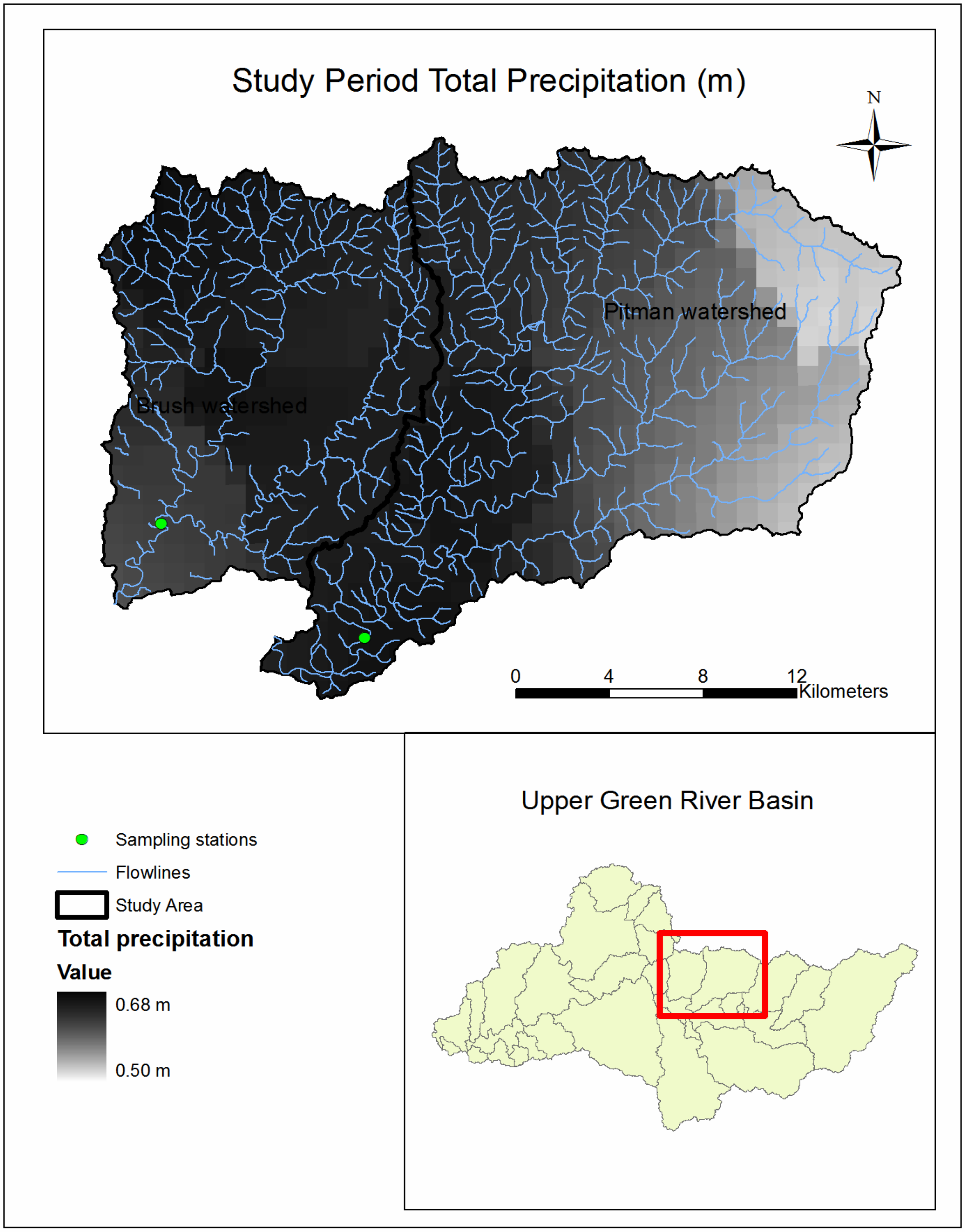

Figure 5.3: Total precipitation for the study period (Data obtained from the Midwest Regional Climate Center)

Thirteen (13) storm events occurred during the study period with seven of them occurring in the Brush Creek watershed and six in the Pitman Creek watershed. Four events, two in the Brush Creek watershed and the other two in the Pitman Creek watershed were sampled (Fig. 4.7). The two Brush Creek watershed sampled events occurred on the 11 April, 2008 and 3 May, 2008, whereas the two Pitman Creek watershed sampled events occurred on the 12 February, 2008 and 3 March, 2008. The 11 April and 3 May runoff events in Brush Creek were caused by mean precipitations of 0.03 m and 0.04 m respectively. The 12 February and 3 March runoff events in Pitman Creek were caused by precipitations of 0.03 m in each case (Table 13).

5.2 DISCHARGE RATING

Based on the recorded stage measurements from the continuous monitoring, ratings between discharge and stream depth recorded by the sonde (sonde stream depth) were developed for the watersheds.

A rating between discharge and sonde stream depth (Table 14) for Brush Creek's watershed was in the form:

Discharge = 10.03 Sonde stream depth – 0.93

A rating between discharge and sonde stream depth (Table 15) for Pitman Creek's watershed was in the form:

Discharge = 6.41 sonde stream depth – 1.83

Table 14: Brush Creek Discharge

Date	Time	Total Discharge (m^3/s)	Sonde Stream Depth (m)
3/13/2008	10:10	5.55	0.66
4/22/2008	13:30	2.74	0.3
5/22/2008	10:30	2.22	0.23
9/10/2008	12:00	0.32	0.13
9/24/2008	14:30	0.18	0.12
10/15/2008	11:30	0.18	0.23

Table 15: Pitman Creek Discharge

Date	Time	Total Discharge, (m^3/s)	Sonde Stream Depth (m)
4/23/2008	13:10	2.47	3.01
9/10/2008	10:30	0.13	1.06
9/24/2008	12:20	0.22	1.10

5.3 SAMPLE TURBIDITY AND SUSPENDED SEDIMENT CONCENTRATION RATING

Based on the continuous turbidity monitoring, ratings between average turbidity and suspended sediment concentration were developed.

Ratings between average turbidity and suspended sediment concentration (Fig. 5.4) for Bruch Creek's watershed was in the form:

SSC = 0.0013 Ave. turbidity + 0.14

Ratings between average turbidity and suspended sediment concentration (Fig. 5.5) for Pitman Creek's watershed was in the form:

SSC = 0.0016 Avg. turbidity – 0.03

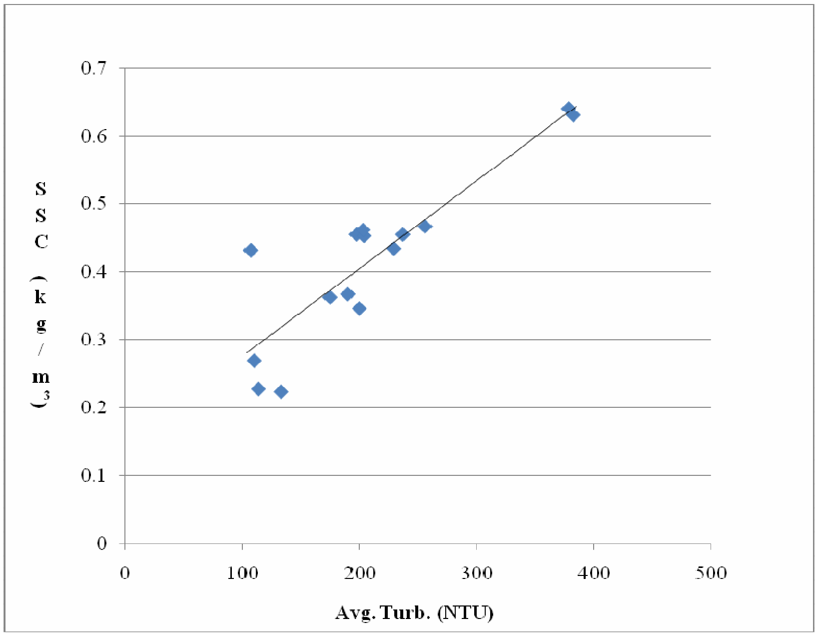

Figure 5.4: Plot of Suspended Sediment Concentration and Average Turbidity for Brush Creek's watershed.

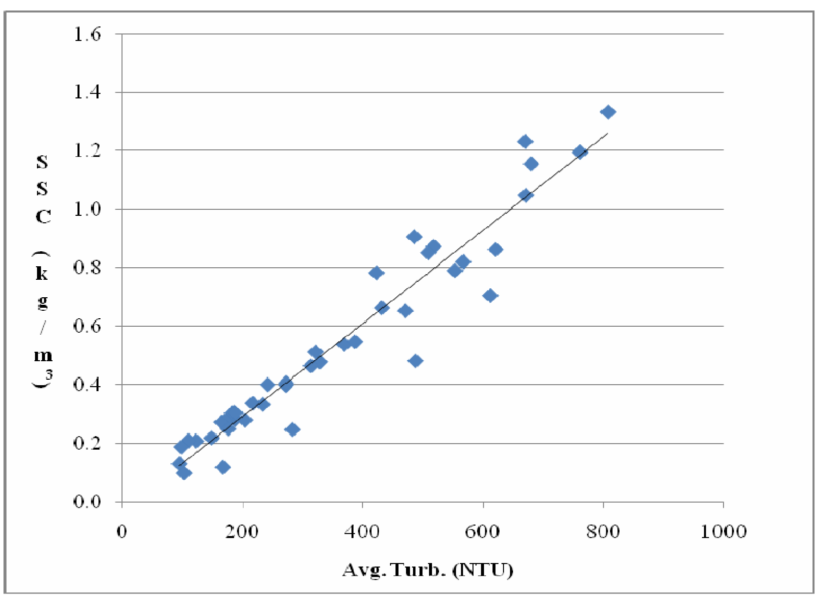

Figure 5.5: Plot of Suspended Sediment Concentration and Average Turbidity for Pitman Creek's watershed.

5.4 BRUSH CREEK WATERSHED'S EVENTS

The first Brush Creek sampled event occurred on 11 April, 2008. Average turbidities ranged between 110.3 NTU and 431.7 NTU with the minimum and maximum occurring at 7:25 GMT and 10:55 GMT. Turbidity rose and dropped twice during the event. Discharge ranged between 5.57 m^3/s and 8.97 m^3/s at 7:30 GMT and 13:30 GMT (Fig. 5.6). Ten (10) water samples with suspended sediment concentration ranging between 0.22 and 0.64 kg/m^3 were collected. The event produced an estimated sediment load of 1.1 $x10^5$ kg and an estimated sediment yield of 5.3 x 10^2 kg/km^2 (Fig. 5.6). The second Brush Creek sampled event occurred on the 3 May, 2008. Average turbidities ranged between 107.5 NTU and 228.4 NTU with minimum and maximum occurring at 8:20 am and 12:00 pm Central time. Turbidity rose and dropped once, discharge ranged between 5.10 m^3/s and 7.95 m^3/s at 8:20 am and 11:40 am central time (Fig.5.7). Five (5) water samples with suspended sediment concentration ranging between 0.36 kg/m^3 and 0.46 kg/m^3 were collected. The event produced an estimated sediment load of 3.8 x 10^4 kg giving an estimated sediment yield of 1.8 x 10^2 kg/km^2 (Fig. 5.7). Brush Creek watershed's estimate for the period common to both watersheds with good data was 4.9 x 10^5 kg giving a sediment yield of 2.3 x 10^3 kg/km^2 or 53 kg/km^2/day (Table 16). A clockwise hysteresis occurred between discharge and suspended sediment concentration for both events (Fig. 5.8). The time series plot for the study period is shown in Figure 5.9.

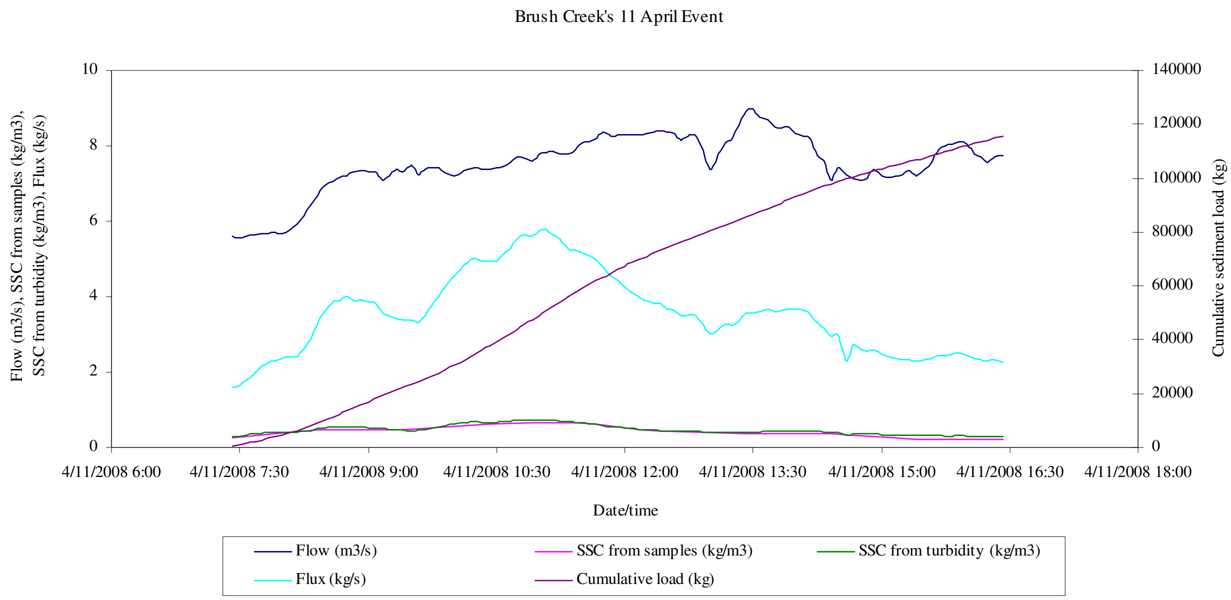

Figure 5.6: Brush Creek's 11 April event

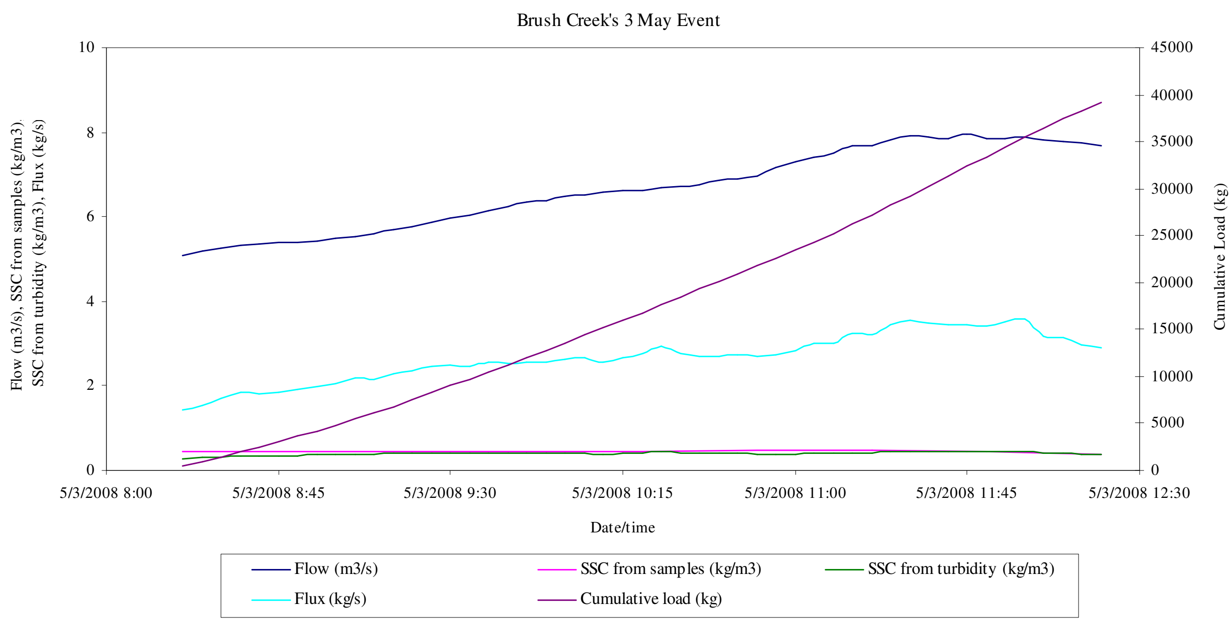

Figure 5.7: Brush Creek's 3 May event

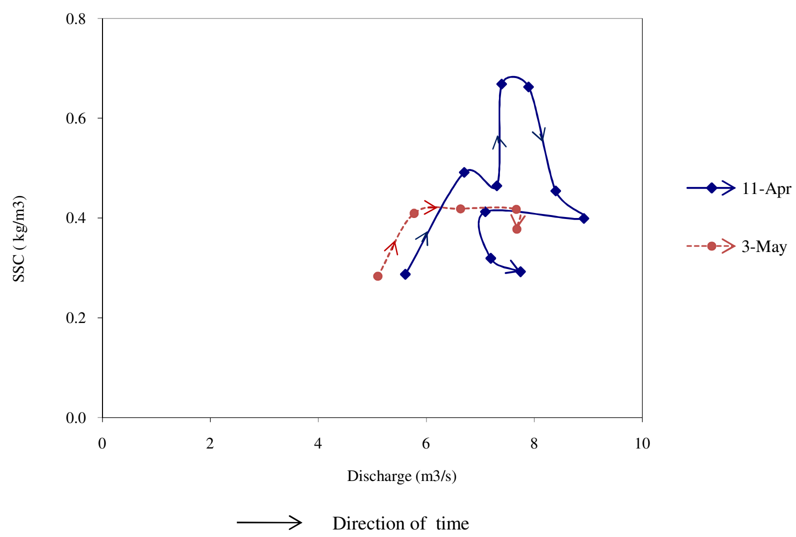

Figure 5.8: SSC and discharge hysteresis for Brush Creek's 11 April and 3 May events

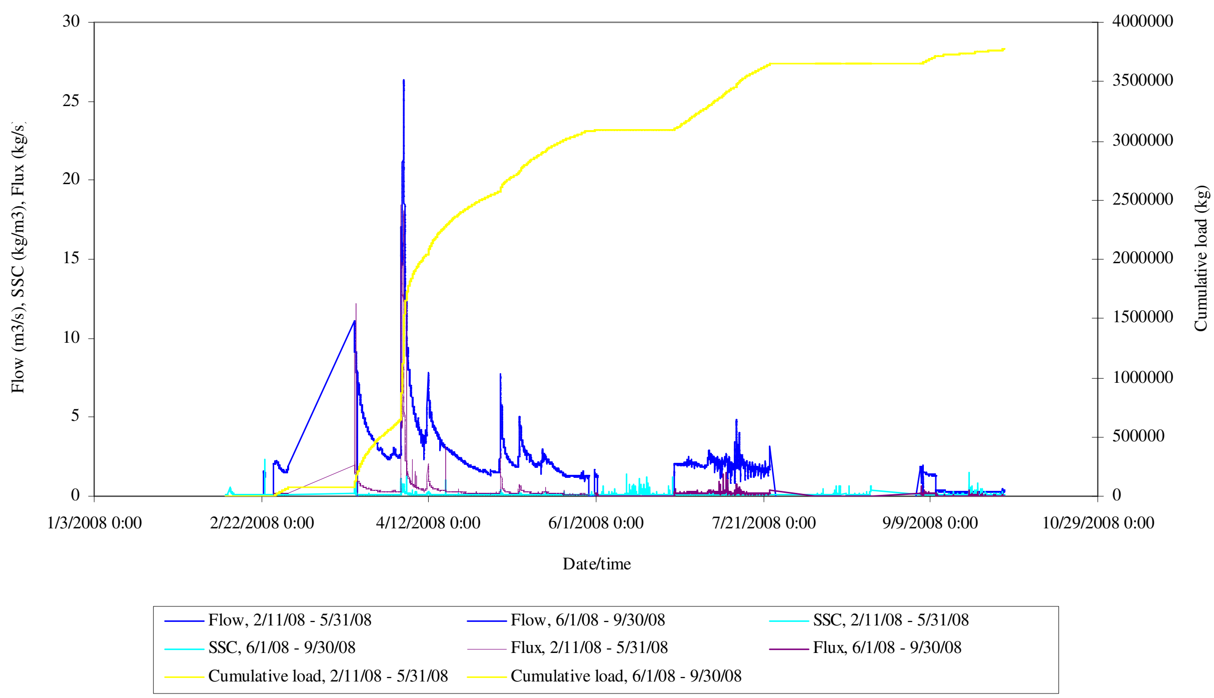

Figure 5.9: Brush Creek's study period

Table 16: Brush Creek's summary of estimates

Watershed	Period	Estimated load (kg)	Estimated sediment yield (kg/km^2)
Brush Creek	11 April event	1.1 x 10^5	5.3 x 10^2
	3 May event	3.8 x 10^4	1.8 x 10 ^{2}
	common to both watersheds and with good data	4.9 x 10^5	2.3 x 10^3

5.4.1 Brush Creek watershed's particle size

The particle sizes for Brush Creek's collected samples ranged from clay to sand were well graded within the range (Fig. 5.10, Fig. 5.11). The samples in both figures (Fig. 5.10, Fig. 5.11) are numbered sequentially in order of collection.

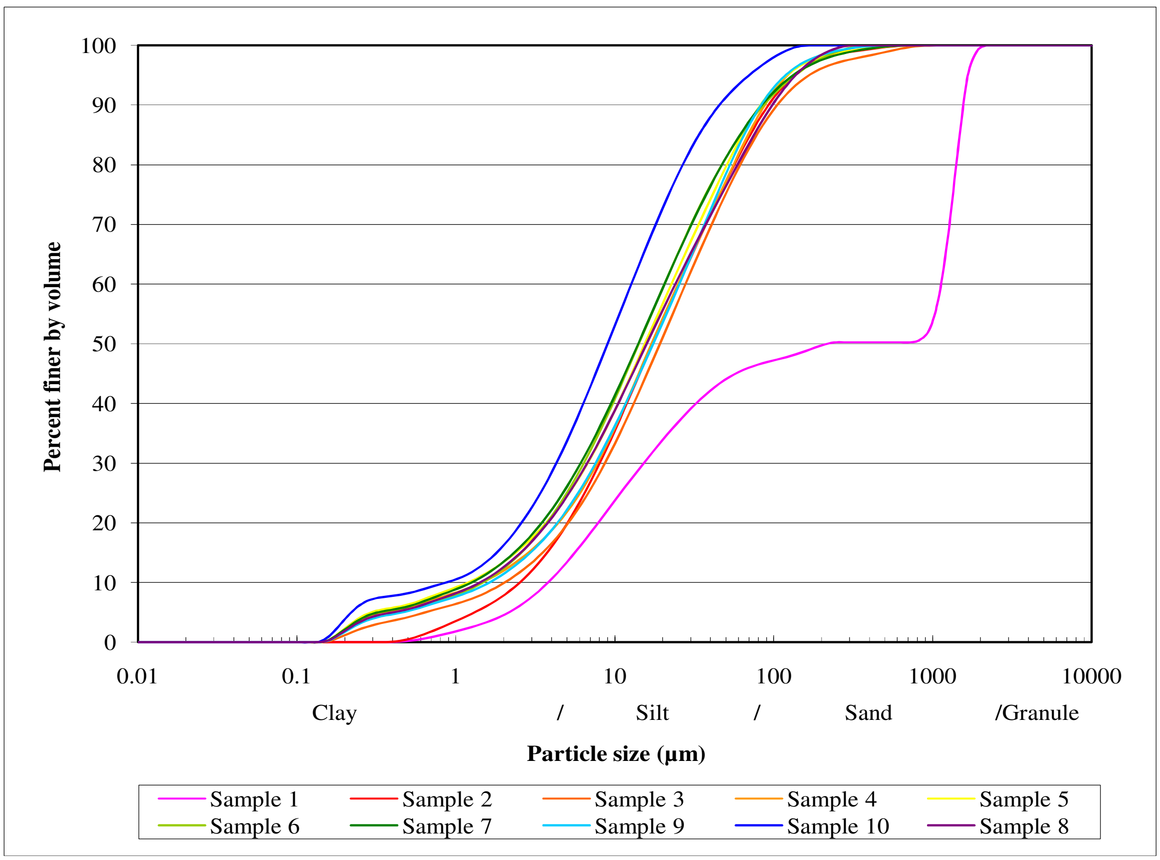

Figure 5.10: Particle size against percent finer by volume for 11 April event

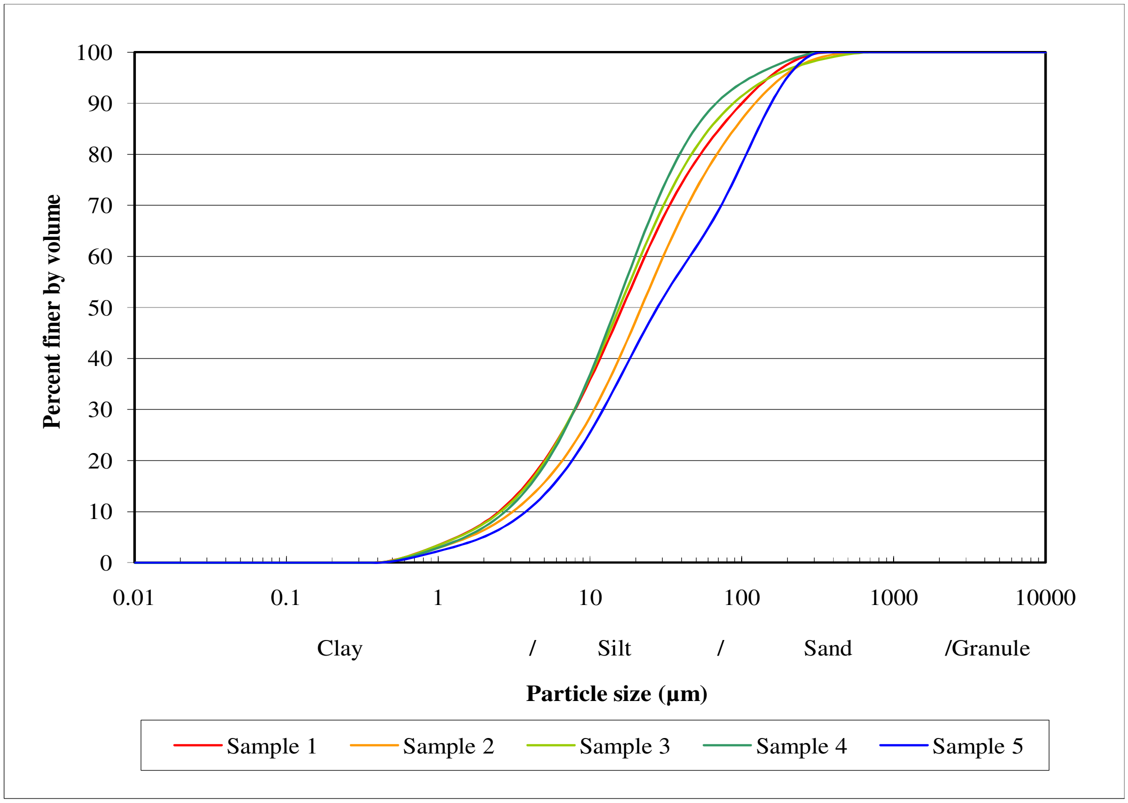

Figure 5.11: Particle size against percent finer by volume for 3 May event

In both events, larger particles were mobilized before smaller particles. In the 3 May event (second event), the final sample shifted to the larger particles of all. Samples of the 11 April event (first event) had 6.53% to 54.74% of the particles sizes greater than 60 µm (Fig. 5.12) whiles those of the 3 May event had 11.60% to 34.36% of the particle sizes greater than 60 µm (Fig. 5.13).

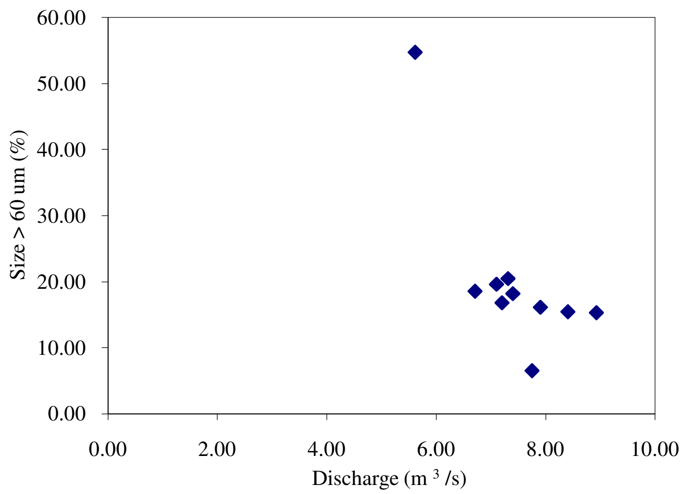

Figure 5.12: Size > 60 µm against discharge for 11 April Event

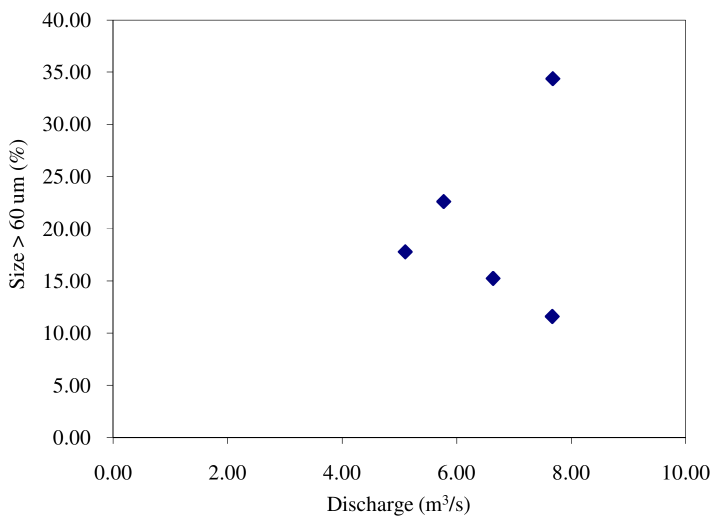

Figure 5.13: Size > 60 µm against discharge for 3 May Event

5.5 PITMAN CREEK WATERSHED'S EVENTS

The first Pitman Creek sampled event occurred on the 12 February, 2008. Average turbidity ranged between 98.1 and 532.0 NTU, with the minimum and maximum values occurring at 18:30 GMT on the 12 February and 5:45 GMT on the 13 February. Turbidity rose and dropped once during the event. Discharge ranged between 8.67 m^3/s and 11.49 m^3/s at 18:30 GMT and 12:45 GMT (Fig. 5.14). Eighteen (18) water samples with suspended sediment concentration ranging between 0.19 and 0.91 kg/m^3 were collected. The event produced an estimated sediment load of 2.9×10^5 kg and an estimated sediment yield of 8.4×10^2 kg/km^2 (Fig. 5.14). The second Pitman Creek sampled event occurred on the 3 March, 2008. Average turbidities of the event ranged between 95.1 and 809 NTU at 0:00 GMT and 9:15 GMT. Turbidity rose and dropped twice during the event, discharge ranged between 7.69 m^3/s and 12.21 m^3/s at 0:00 and 11:25 GMT (Fig. 5.14). Twenty-four (24) water samples with suspended sediment concentration ranging between 0.10 and 1.33 kg/m^3 were collected. The event produced an estimated sediment load of 5.7×10^5 kg and an estimated sediment yield of 1.6×10^3 kg/km^2 (Fig. 5.15). Pitman Creek watershed's estimate for the period common to both watersheds with good data was 1.1×10^6 kg giving a sediment yield of 3.1×10^3 kg/km^2 or 71 $kg/km^2/day$ (Table 17). Both events showed a clockwise hysteresis between discharge and suspended sediment concentration (Fig. 5.16). The time series plot for the study period is shown in Figure 5.17.

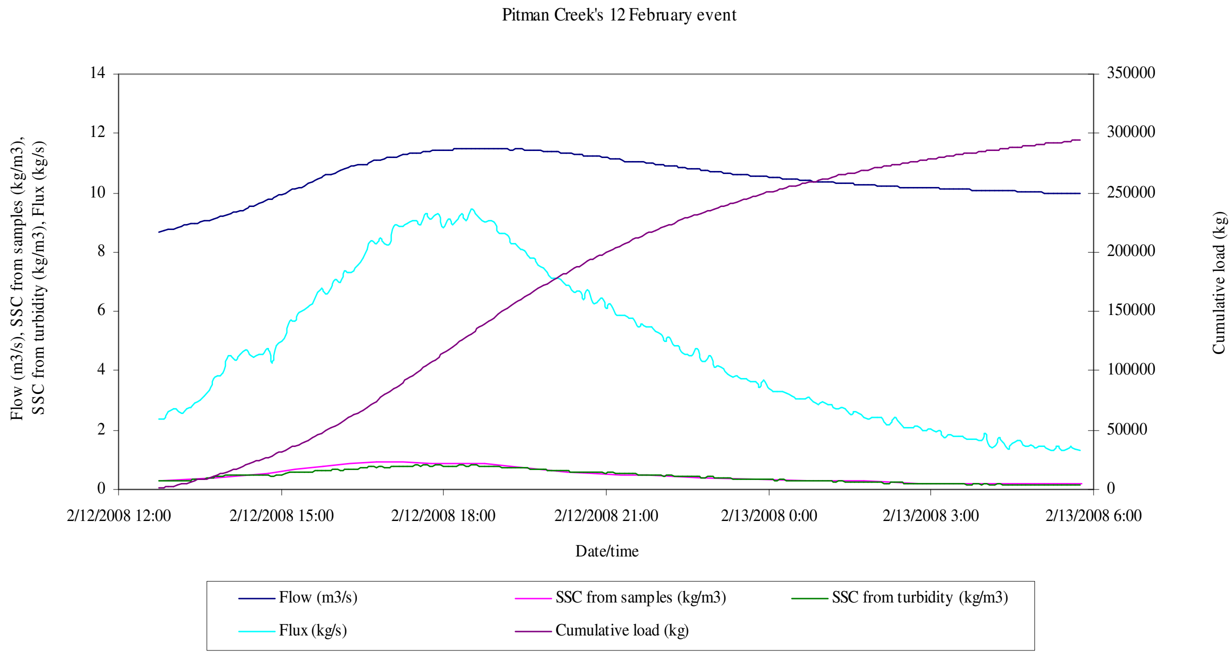

Figure 5.14: Pitman Creek's 12 February event

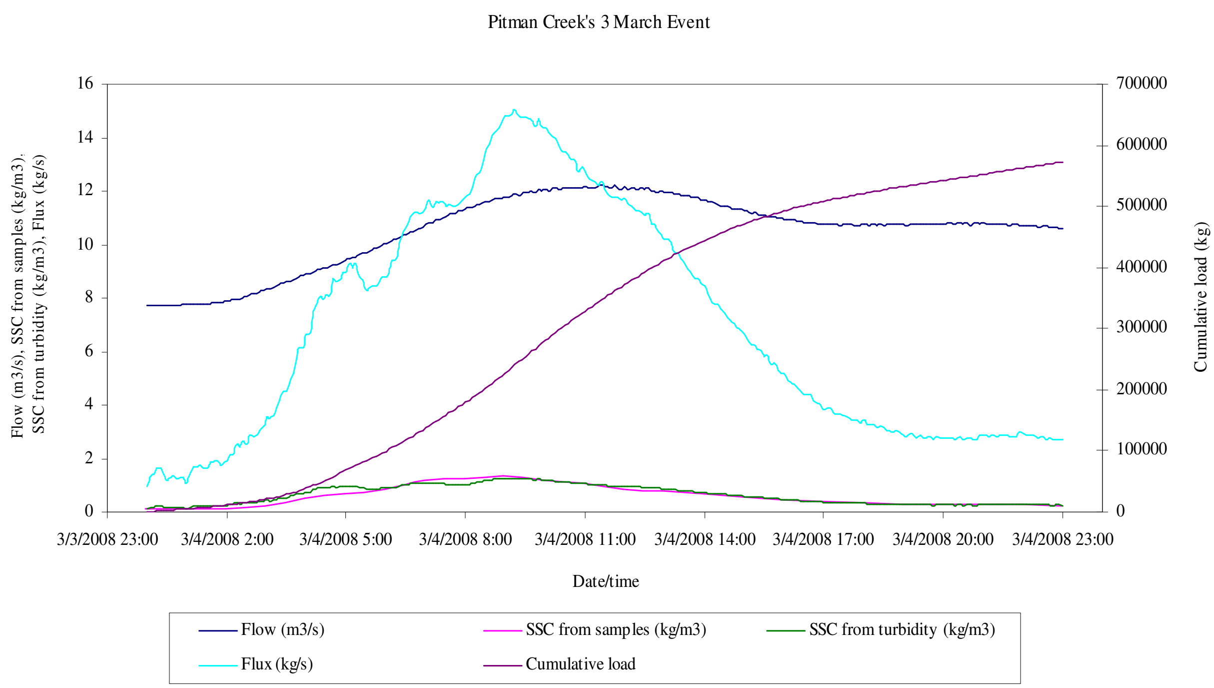

Figure 5.15: Pitman Creek's 3 March event

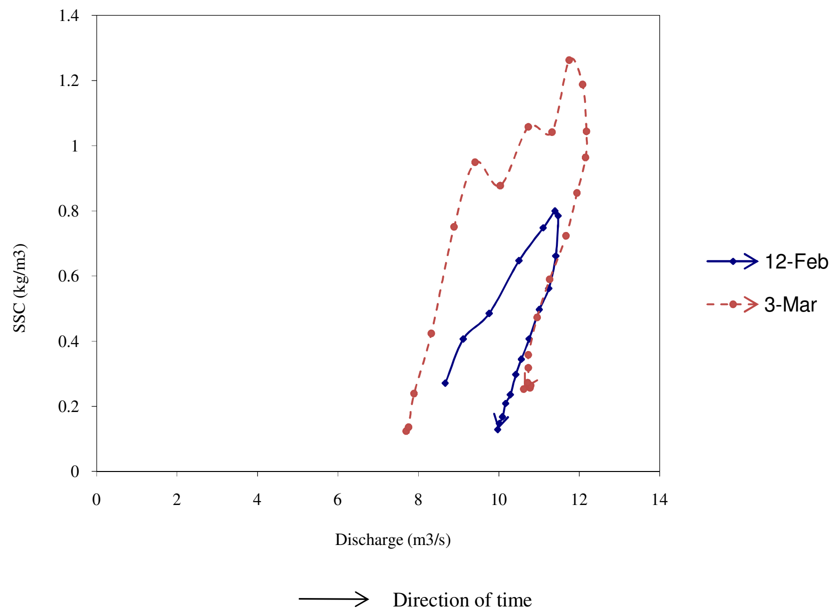

Figure 5.16: SSC and discharge hysteresis for Pitman Creek's 12 February and 3 March events

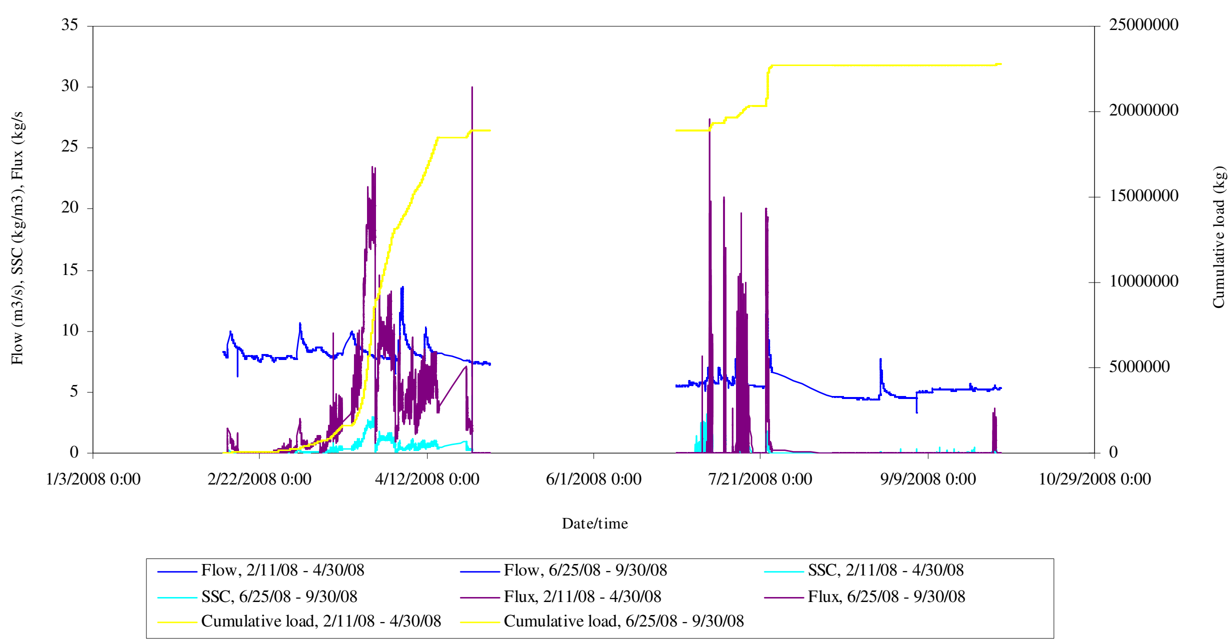

Figure 5.17: Pitman Creek's study period

Table 17: Pitman Creek's summary of estimates

Watershed	Period	Estimated load (kg)	Estimated sediment yield (kg/km^2)
Pitman Creek	12 February event	2.9 x 10^5	8.4 x 10^2
	3 March event	5.7 x 10^5	1.6 x 10^3
	common to both watersheds and with good data	1.1 x 10^6	3.1 x 10^3

5.5.1 Pitman Creek watershed's particle size

The sizes of the particles collected from Pitman Creek's watershed also ranged from clay to sand and were well graded within the range (Fig. 5.18, Fig. 5.19). The samples are numbered sequentially in order of collection.

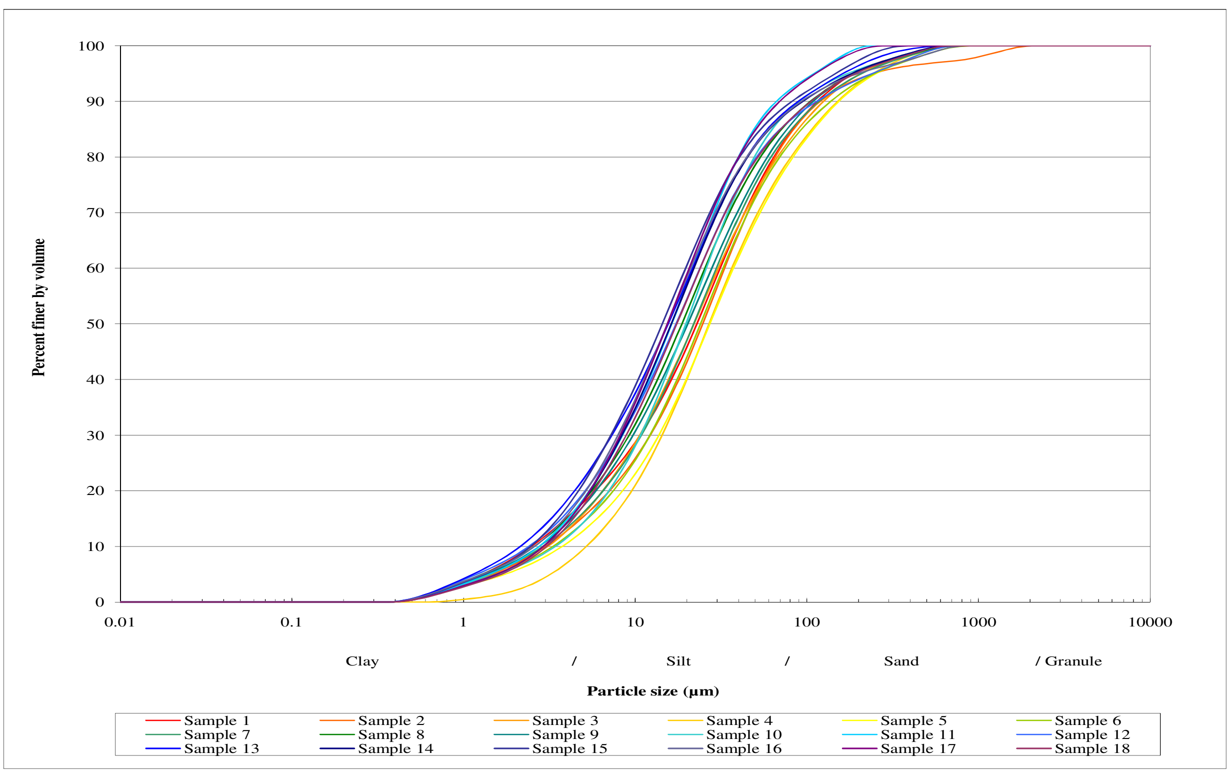

Figure 5.18: Particle size against percent finer by volume for 12 February event

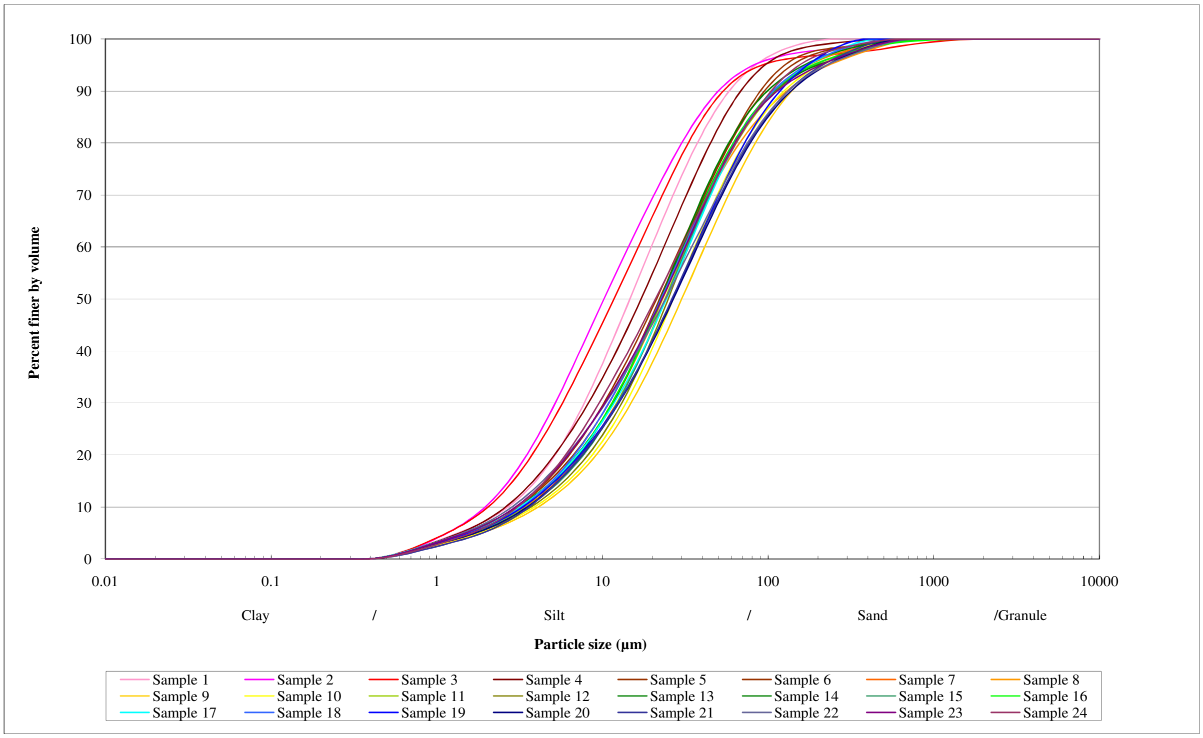

Figure 5.19: Particle size against percent finer by volume for 3 March event

In the 12 February event (first event), the earliest samples were dominated by larger particle sizes while the 3 March event (second event) showed earliest samples being dominated by the smallest particles. The particle sizes greater than 60 µm for the first event ranged from 11.36% to 26.95% (Fig. 5.20) and that of the second event ranged from 7.64 % to 28.71% (Fig. 5.21).

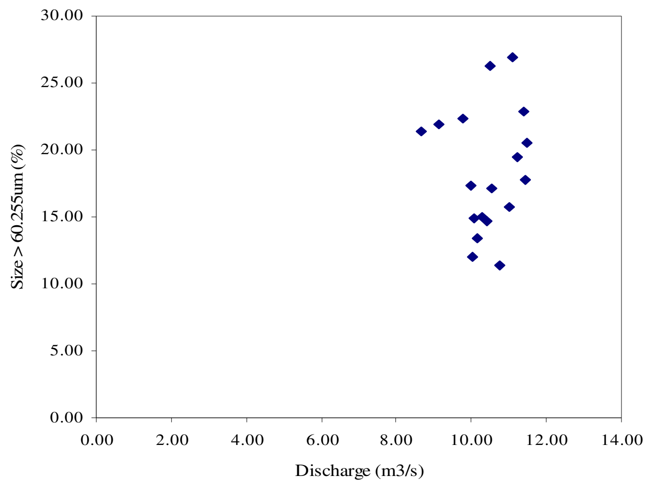

Figure 5.20: Size > 60 µm against discharge for 12 February Event

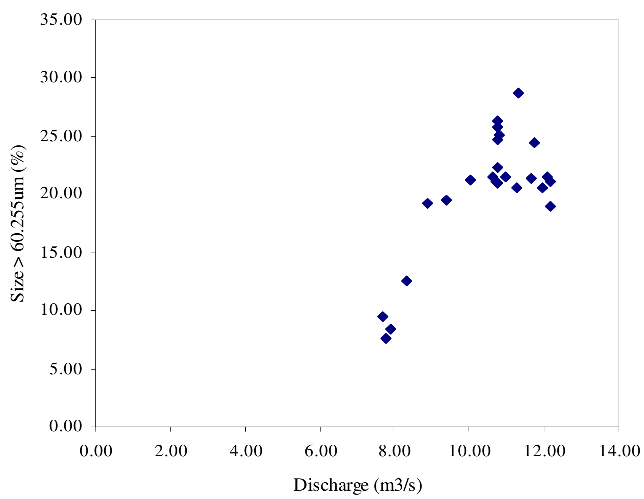

Figure 5.21: Size > 60 µm against discharge for 3 March Event

6.0 DISCUSSIONS, CONCLUSION AND FUTURE RESEARCH

6.1 DISCUSSION AND CONCLUSION

The 11 April (Brush Creek's event 1) and 3 May (Brush Creek's event 2) events showed an increase in average turbidity with an increase in river depth or discharge (Fig. 5.6, Fig. 5.7). Total sediment flux also increased with an increase in river depth and turbidity for both events (Fig. 5.6, Fig. 5.7). The 3 May event produced about one third the total sediment flux of the 11 April event (Table 18), this difference in sediment flux could be due to the difference in the duration of the events and the difference in the peak flow rates. Particles collected from both events were well graded (Fig.5.10, Fig. 5.11) but had more silt relative to sand and clay, this could be due to the fact that more time and energy was needed to break the bonds in clay minerals or particles, more energy was also needed to transport sand compared to silt. The mean diameter of the particles ranged from 1.74 to 10.05 µm. There were no general trends between discharge and particle sizes greater than 60 µm for both events (Fig. 5.12, Fig. 5.13). Both events showed a clockwise hysteresis between suspended sediment concentration and discharge (Fig. 5.8). This clockwise hysteresis indicates that the sediments from Brush Creek's watershed during the events were derived from the bed and banks of the channel or area adjacent to the channel.

The 12 February (Pitman Creek's event 1) and 3 March (Pitman Creek's event 2) events also showed an increase in the average turbidity as river depth or discharge increases (Fig. 5.14, Fig 5.15). The increase in depth and turbidity also caused an increase in the total sediment flux (Fig. 5.14, Fig. 5.15). The longer time duration of the 3

March event and the peak flow rate could be responsible for its sediment flux being about twice that of the 12 February event. The particles from both events were well graded (Fig. 5.18, Fig 5.19). The particles collected from both events had more silt relative to sand and clay. (Fig. 5.18, Fig. 5.19). The mean diameter of the particles ranged from 4.72 to 12.29 µm. The presence of the shale in the Caseyville formation present in Brush Creek's watershed could account for its smaller particles size compared to Pitman Creek's watershed particles. No general trends were observed between discharge and particle sizes greater than 60 µm (Fig. 5.20, Fig. 5.21). The clockwise hysteresis (Fig. 5.16) shown by both events reveals that most of the sediments from Pitman Creek's watershed during the events were also derived from the bed and banks of the channel or area adjacent to the channel.

Both Pitman Creek and Brush Creek watersheds contribute a significant amount of sediment into the Upper Green River. Brush Creek watershed's 11 April storm event (Brush Creek's event 1) produced an estimated load of 1.1×10^5 kg and a sediment yield of 5.3×10^2 kg/km^2, the 3 May event (Brush Creek's event 2) produced an estimated load of 3.8×10^4 kg and a sediment yield of 1.8×10^2 kg/km^2. Brush Creek watershed's estimate for the period common to both watersheds with good data was 4.9×10^5 kg giving a sediment yield of 2.3×10^3 kg/km^2 or 53 kg/km^2/day (Table 18). Pitman Creek watershed's 12 February event (Pitman Creek's event 1) produced an estimated sediment load of 2.9×10^5 kg and a sediment yield of 8.4×10^2 kg/km^2. The 3 March event (Pitman Creek's event 2) produced an estimated sediment load of 5.7×10^5 kg and a sediment yield of 1.6×10^3 kg/km^2. Pitman Creek watershed's estimate for the period common to both watersheds with good data was 1.1×10^6 kg giving a sediment yield of 3.1×10^3

kg/km^2 or 71 kg/km^2/day (Table 18). The Borden and Fort Payne formations could be responsible for Pitman's larger particle sizes whiles the presence of shale in the Caseyville formation could be responsible for the Brush Creek's smaller particle sizes. In both watersheds, no general trend was observed between discharge and the particles sizes greater 60 μm.

Table 18: Summary of estimates for both Brush Creek and Pitman Creek watersheds.

Watershed	Estimated load for Periods (kg)			Estimated yield for periods (kg/km2)		
	Event 1	Event 2	Common and with good data	Event 1	Event 2	Common and with good data
Brush Creek	1.1×10^5	3.8×10^4	4.9×10^5	5.3×10^2	1.8×10^2	2.3×10^3
Pitman Creek	2.9×10^5	5.7×10^5	1.1×10^6	8.4×10^2	1.6×10^3	3.1×10^3

Sediment production is positively influenced by high precipitation, more erodible material (soil or geology) per unit area, high elevation and smaller watershed area. Comparing the loads (Table 18) along with the differences in the factors that influence loads (Table 19).

Table 19: Factors that influence sediment loads

Factors that influence sediment load	Watershed	
	Brush Creek	Pitman Creek
Precipitation:		
Total precipitaion during study period (m)	0.68	0.67
Mean precipitation on sampled events day (m)	0.03	0.035
Watershed area (Km2)	213.33	350.71
Average stream Network (per Km2)	0.32	0.41
Percentage of Erodable soil with erodable factor of (%):		
0.43	26.69	31.69
0.37	10.35	18.77
0.32	29.93	35.16
0.28	12.11	2.2
Mean elevation	72.07	75.73
Relief	52.77	59.37
Protection of soil by vegetation (%):		
Forested	52	38
Grassland and pastures	37	43

Comparing the loads estimated from the periods common to both watersheds and with good data, Pitman Creek's watershed had a higher sediment load and sediment yield compared to Brush Creek's watershed . Factors that could be responsible for Pitman Creek watershed's higher sediment load include:

- Its higher number of stream network per unit area of $0.41/km^2$ compared to that of Brush Creek's watershed of $0.32/km^2$.
- Its high percentage of erodible soil area compared to that of Brush Creek's watershed.
- Its high relief compared to that of Brush Creek's watershed.
- More protection of soil in Brush Creek watershed compared to Pitman Creek watershed.

The existence of more and interconnected stream network in Pitman Creek's watershed would make the transportation of its sediments easier relative to Brush Creek watershed. Pitman Creek watershed had 88% of its area, thus about 308.62 km^2 covered with soil that has erodibility factor (Kf) greater than 0.28 whiles Brush Creek watershed had 79% of its area, thus about 168.53km^2 covered with soil that has erodibility factor greater than 0.28 (Fig 3.6). This larger erodible area would positively influence the production of sediments in Pitman Creek's watershed. Generally, sediment yield increases with an increase in elevation and relief. Pitman Creek watershed's higher relief compared to that of Brush Creek watershed would make the transportation of its sediments easier; this easy transportation of sediment would increase the sediment yield. The protection of soil from erosion by different land categories can be arranged in order of decreasing soil protection ability as forested land, developed land, grassland and pastures, cultivated croplands and barren lands. Considering forested and grassland and pastures landuse categories, since they cover over 75% of the of each watershed's area, Brush Creek watershed has a greater area protected from erosion by vegetation than Pitman Creek watershed, this protection from erosion reduces the amount of eroded and transported sediments, thereby reducing the sediment yield (Table 19).

The higher mean precipitation at Pitman Creek's watershed relative to Brush Creek's watershed could be among the factors responsible for its larger sediment yield but the mean precipitation would not have so great an effect on the sediment yield since both watersheds have limestones and sandstones as the dominant rock types, these sandstones and limestones have a KER of 4 (Table 3), thus making them strongly cohesive, a very high precipitation difference is therefore needed to produce that amount of sediment yield. Generally, smaller watersheds are expected to produce higher loads than bigger watersheds. Pitman Creek watershed's bigger area compared to that of Bruch Creek's watershed, increases Pitman Creek watershed's likelihood of having more sediment traps than Brush Creek's watershed. Thus, Brush Creek's watershed is expected to have a larger sediment yield compared to Pitman Creek watershed. The presence of sediment traps will not have so great an effect on the sediment yield since most of the sediments were derived from the bed and banks of the channel or from area adjacent to the channel as indicated by the hysteresis curves (Fig. 5.16).

6.2 FUTURE RESEARCH

Future research on suspended sediment transport dynamics and sediment yield should be carried out on the other watersheds in the Upper Green River basin, in order to have estimates of the amount of sediment from each of the other watersheds. The physical as well as chemical properties of the suspended sediments should also be investigated.

Appendix

(Sampled Events)

Brush Creek watershed's Event 1

Date/Time (m/d/y)	Avg. Temp (°C)	Avg. Spec. Cond. (µS/cm)	Avg. Depth (m)	Stream Depth (m)	Avg. Turb. (NTU)	Discharge (m^3/s)	SSC (kg/m^3)	SS Flux (kg/s)	Total Flux (kg)
4/11/2008 7:25	15.13	213	0.44	0.65	110.3	5.61	0.26	1.48	444.92
4/11/2008 7:30	15.11	212	0.44	0.65	116.7	5.57	0.27	1.53	457.80
4/11/2008 7:35	15.1	213	0.44	0.65	133.4	5.59	0.30	1.67	501.49
4/11/2008 7:40	15.09	212	0.44	0.65	156.9	5.62	0.33	1.88	563.67
4/11/2008 7:45	15.08	212	0.45	0.66	174.9	5.66	0.36	2.05	613.57
4/11/2008 7:50	15.06	211	0.45	0.66	188	5.67	0.38	2.16	648.11
4/11/2008 7:55	15.04	209	0.45	0.66	193.5	5.70	0.39	2.22	665.67
4/11/2008 8:00	15.02	207	0.45	0.66	201.6	5.68	0.40	2.28	684.05
4/11/2008 8:05	14.99	206	0.46	0.67	203	5.80	0.40	2.34	700.98
4/11/2008 8:10	14.97	205	0.48	0.69	194.8	5.95	0.39	2.32	697.25
4/11/2008 8:15	14.96	202	0.50	0.71	210.6	6.15	0.41	2.55	764.48
4/11/2008 8:20	14.95	200	0.53	0.74	224.7	6.46	0.44	2.81	844.15
4/11/2008 8:25	14.94	196	0.55	0.76	256.3	6.71	0.48	3.24	972.33
4/11/2008 8:30	14.93	193	0.57	0.78	274.3	6.94	0.51	3.54	1061.99
4/11/2008 8:35	14.93	190	0.59	0.80	294.6	7.07	0.54	3.82	1146.53
4/11/2008 8:40	14.92	189	0.60	0.81	293.8	7.18	0.54	3.87	1161.85
4/11/2008 8:45	14.92	189	0.60	0.81	303.4	7.21	0.55	3.99	1197.87
4/11/2008 8:50	14.91	190	0.61	0.82	287.5	7.30	0.53	3.87	1160.64
4/11/2008 8:55	14.9	190	0.61	0.82	288.6	7.34	0.53	3.90	1170.65
4/11/2008 9:00	14.9	189	0.61	0.82	281.4	7.33	0.52	3.82	1145.30
4/11/2008 9:05	14.89	190	0.61	0.82	278.1	7.32	0.52	3.78	1132.86
4/11/2008 9:10	14.89	190	0.59	0.80	265.1	7.09	0.50	3.52	1055.67
4/11/2008 9:15	14.89	191	0.60	0.81	253.6	7.20	0.48	3.45	1034.85
4/11/2008 9:20	14.9	191	0.62	0.83	238.2	7.37	0.46	3.36	1008.29
4/11/2008 9:25	14.9	192	0.61	0.82	237.1	7.31	0.45	3.32	996.44
4/11/2008 9:30	14.9	193	0.63	0.84	226.7	7.48	0.44	3.28	984.68
4/11/2008 9:35	14.9	194	0.61	0.82	230.5	7.25	0.44	3.22	966.70
4/11/2008 9:40	14.9	195	0.62	0.83	244.6	7.37	0.47	3.43	1029.52
4/11/2008 9:45	14.89	195	0.62	0.83	269.2	7.41	0.50	3.72	1117.16
4/11/2008 9:50	14.88	195	0.62	0.83	290.9	7.42	0.54	3.97	1191.14
4/11/2008 9:55	14.88	194	0.61	0.82	327.4	7.29	0.59	4.30	1289.94
4/11/2008 10:00	14.89	193	0.60	0.81	355.2	7.20	0.63	4.55	1364.03
4/11/2008 10:05	14.89	192	0.61	0.82	369.9	7.29	0.65	4.76	1429.37
4/11/2008 10:10	14.89	191	0.62	0.83	378.8	7.40	0.67	4.94	1480.65
4/11/2008 10:15	14.89	191	0.62	0.83	386.8	7.44	0.68	5.05	1515.47
4/11/2008 10:20	14.89	190	0.62	0.83	382.4	7.40	0.67	4.98	1492.64
4/11/2008 10:25	14.9	189	0.62	0.83	382.5	7.40	0.67	4.98	1492.97
4/11/2008 10:30	14.9	188	0.62	0.83	382.6	7.41	0.67	4.98	1495.33

4/11/2008 10:35	14.9	186	0.63	0.84	396.2	7.46	0.69	5.17	1551.11
4/11/2008 10:40	14.89	184	0.64	0.85	404.7	7.55	0.71	5.33	1598.77
4/11/2008 10:45	14.89	183	0.65	0.86	418.7	7.71	0.73	5.60	1681.35
4/11/2008 10:50	14.89	181	0.65	0.86	430.2	7.69	0.74	5.72	1716.78
4/11/2008 10:55	14.89	179	0.64	0.85	431.7	7.62	0.75	5.69	1706.24
4/11/2008 11:00	14.89	176	0.66	0.87	430.3	7.80	0.74	5.81	1741.76
4/11/2008 11:05	14.89	176	0.66	0.87	431.3	7.83	0.75	5.84	1752.01
4/11/2008 11:10	14.89	174	0.67	0.88	419.6	7.85	0.73	5.72	1715.16
4/11/2008 11:15	14.89	173	0.66	0.87	411	7.80	0.72	5.58	1674.00
4/11/2008 11:20	14.89	172	0.66	0.87	391.1	7.78	0.69	5.33	1600.01
4/11/2008 11:25	14.89	172	0.67	0.88	378.6	7.90	0.67	5.27	1580.32
4/11/2008 11:30	14.89	172	0.69	0.90	360.8	8.09	0.64	5.18	1553.62
4/11/2008 11:35	14.88	171	0.69	0.90	352.3	8.13	0.63	5.10	1530.21
4/11/2008 11:40	14.88	171	0.70	0.91	341.3	8.17	0.61	4.99	1497.31
4/11/2008 11:45	14.87	170	0.72	0.93	316.4	8.35	0.57	4.79	1436.79
4/11/2008 11:50	14.87	171	0.71	0.92	299	8.27	0.55	4.53	1358.20
4/11/2008 11:55	14.86	170	0.71	0.92	287.6	8.29	0.53	4.40	1318.95
4/11/2008 12:00	14.86	170	0.71	0.92	272.2	8.28	0.51	4.20	1259.95
4/11/2008 12:05	14.86	171	0.71	0.92	258	8.29	0.49	4.03	1208.48
4/11/2008 12:10	14.85	171	0.71	0.92	248.6	8.30	0.47	3.92	1174.81
4/11/2008 12:15	14.85	171	0.71	0.92	239.4	8.33	0.46	3.82	1144.57
4/11/2008 12:20	14.84	171	0.72	0.93	230.9	8.38	0.45	3.73	1119.39
4/11/2008 12:25	14.83	170	0.72	0.93	229.5	8.40	0.44	3.72	1116.78
4/11/2008 12:30	14.82	170	0.72	0.93	218.8	8.38	0.43	3.58	1073.74
4/11/2008 12:35	14.82	169	0.71	0.92	216.7	8.34	0.42	3.54	1060.72
4/11/2008 12:40	14.82	169	0.70	0.91	210.9	8.16	0.42	3.39	1016.45
4/11/2008 12:45	14.82	170	0.71	0.92	209.8	8.31	0.41	3.44	1031.08
4/11/2008 12:50	14.82	170	0.71	0.92	208.2	8.25	0.41	3.39	1017.67
4/11/2008 12:55	14.84	170	0.67	0.88	199.8	7.91	0.40	3.15	945.69
4/11/2008 13:00	14.87	170	0.62	0.83	197.1	7.38	0.39	2.91	873.16
4/11/2008 13:05	14.9	171	0.65	0.86	193.3	7.66	0.39	2.98	893.30
4/11/2008 13:10	14.93	171	0.69	0.90	192.9	8.09	0.39	3.14	942.15
4/11/2008 13:15	14.95	171	0.70	0.91	187.7	8.18	0.38	3.11	933.51
4/11/2008 13:20	14.96	170	0.74	0.95	186.2	8.55	0.38	3.23	970.09
4/11/2008 13:25	14.98	170	0.77	0.98	190.3	8.93	0.38	3.43	1028.66
4/11/2008 13:30	14.99	168	0.78	0.99	190.5	8.98	0.38	3.45	1035.25
4/11/2008 13:35	14.99	167	0.76	0.97	199.2	8.79	0.40	3.49	1047.66
4/11/2008 13:40	15	167	0.75	0.96	207.1	8.71	0.41	3.56	1069.03
4/11/2008 13:45	15.01	169	0.73	0.94	209.4	8.50	0.41	3.51	1053.19
4/11/2008 13:50	15.01	170	0.73	0.94	212.1	8.46	0.42	3.53	1058.50
4/11/2008 13:55	15.02	170	0.73	0.94	213.6	8.51	0.42	3.57	1070.52
4/11/2008 14:00	15.03	170	0.71	0.92	220	8.32	0.43	3.57	1070.53
4/11/2008 14:05	15.04	169	0.71	0.92	221	8.26	0.43	3.56	1066.50

4/11/2008 14:10	15.05	169	0.70	0.91	214.9	8.17	0.42	3.44	1032.41
4/11/2008 14:15	15.07	169	0.65	0.86	209.4	7.74	0.41	3.20	958.75
4/11/2008 14:20	15.09	168	0.64	0.85	203.6	7.60	0.40	3.07	921.51
4/11/2008 14:25	15.13	168	0.59	0.80	200	7.10	0.40	2.83	849.19
4/11/2008 14:30	15.16	169	0.62	0.83	192.3	7.41	0.39	2.87	860.71
4/11/2008 14:35	15.19	167	0.60	0.81	131.4	7.24	0.30	2.14	642.49
4/11/2008 14:40	15.22	166	0.59	0.80	176.6	7.14	0.36	2.60	778.80
4/11/2008 14:45	15.24	166	0.59	0.80	167.7	7.11	0.35	2.49	747.05
4/11/2008 14:50	15.27	167	0.60	0.81	160.7	7.15	0.34	2.43	728.74
4/11/2008 14:55	15.3	168	0.62	0.83	155	7.38	0.33	2.44	733.33
4/11/2008 15:00	15.33	169	0.60	0.81	150	7.22	0.32	2.34	701.14
4/11/2008 15:05	15.36	169	0.60	0.81	144	7.16	0.31	2.25	675.96
4/11/2008 15:10	15.39	169	0.60	0.81	140.8	7.19	0.31	2.23	668.45
4/11/2008 15:15	15.42	169	0.60	0.81	136	7.24	0.30	2.19	657.47
4/11/2008 15:20	15.45	169	0.62	0.83	132.6	7.35	0.30	2.19	656.25
4/11/2008 15:25	15.48	169	0.60	0.81	133.2	7.20	0.30	2.15	644.76
4/11/2008 15:30	15.51	169	0.62	0.83	130.4	7.38	0.29	2.17	651.63
4/11/2008 15:35	15.53	169	0.64	0.85	127.3	7.57	0.29	2.19	657.90
4/11/2008 15:40	15.56	169	0.67	0.88	126.5	7.91	0.29	2.28	684.70
4/11/2008 15:45	15.58	170	0.68	0.89	123.9	8.01	0.28	2.28	684.01
4/11/2008 15:50	15.59	170	0.69	0.90	126	8.05	0.29	2.32	695.04
4/11/2008 15:55	15.6	170	0.69	0.90	128	8.10	0.29	2.36	706.67
4/11/2008 16:00	15.61	170	0.69	0.90	121.4	8.05	0.28	2.26	678.38
4/11/2008 16:05	15.63	170	0.66	0.87	122.6	7.80	0.28	2.20	661.46
4/11/2008 16:10	15.64	171	0.65	0.86	120.4	7.73	0.28	2.16	647.85
4/11/2008 16:15	15.67	171	0.64	0.85	120.7	7.58	0.28	2.12	636.26
4/11/2008 16:20	15.68	171	0.65	0.86	119.6	7.72	0.28	2.15	644.23
4/11/2008 16:25	15.69	171	0.66	0.87	114	7.75	0.27	2.09	627.20

Brush Creek watershed's Event 2

Date/Time (m/d/y)	Avg. Temp (°C)	Avg. Spec. Cond. (µS/cm)	Avg. Depth (m)	Stream Depth (m)	Avg. Turb. (NTU)	Discharge (m^3/s)	SSC (kg/m^3)	SS Flux (kg/s)	Total Flux (kg)
5/3/2008 8:20	15.38	247	0.39	0.60	107.5	5.10	0.26	1.33	397.94
5/3/2008 8:25	15.36	244	0.40	0.61	116.4	5.19	0.27	1.42	425.78
5/3/2008 8:30	15.33	242	0.41	0.62	135.5	5.25	0.30	1.59	475.87
5/3/2008 8:35	15.31	241	0.41	0.62	153	5.31	0.33	1.74	523.17
5/3/2008 8:40	15.3	240	0.42	0.63	145.8	5.34	0.32	1.70	508.82
5/3/2008 8:45	15.28	239	0.42	0.63	149.4	5.38	0.32	1.74	521.36
5/3/2008 8:50	15.27	236	0.42	0.63	156.6	5.40	0.33	1.80	540.81
5/3/2008 8:55	15.26	233	0.42	0.63	166.9	5.43	0.35	1.90	569.01
5/3/2008 9:00	15.25	225	0.43	0.64	170.9	5.48	0.36	1.95	584.14
5/3/2008 9:05	15.24	221	0.43	0.64	185.6	5.53	0.38	2.09	626.09
5/3/2008 9:10	15.23	217	0.44	0.65	180.1	5.61	0.37	2.07	621.28
5/3/2008 9:15	15.22	214	0.45	0.66	193.7	5.69	0.39	2.22	665.01
5/3/2008 9:20	15.21	211	0.46	0.67	197.6	5.78	0.40	2.28	684.52
5/3/2008 9:25	15.2	209	0.47	0.68	204.5	5.87	0.41	2.38	713.44
5/3/2008 9:30	15.19	208	0.48	0.69	200.8	5.99	0.40	2.39	718.12
5/3/2008 9:35	15.19	207	0.49	0.70	196.5	6.05	0.39	2.38	713.64
5/3/2008 9:40	15.19	205	0.50	0.71	201.3	6.15	0.40	2.46	738.76
5/3/2008 9:45	15.19	204	0.51	0.72	193.3	6.25	0.39	2.43	728.33
5/3/2008 9:50	15.19	203	0.51	0.72	195.5	6.34	0.39	2.48	745.14
5/3/2008 9:55	15.2	202	0.52	0.73	192.3	6.39	0.39	2.47	741.84
5/3/2008 10:00	15.2	202	0.53	0.74	194.6	6.48	0.39	2.53	759.03
5/3/2008 10:05	15.21	201	0.53	0.74	197.6	6.53	0.40	2.58	773.72
5/3/2008 10:10	15.21	201	0.54	0.75	184.4	6.60	0.38	2.48	742.86
5/3/2008 10:15	15.21	202	0.54	0.75	194.3	6.61	0.39	2.58	773.43
5/3/2008 10:20	15.22	202	0.54	0.75	204.1	6.64	0.40	2.69	806.22
5/3/2008 10:25	15.23	202	0.55	0.76	218.4	6.69	0.43	2.85	855.36
5/3/2008 10:30	15.24	203	0.55	0.76	197.5	6.74	0.39	2.66	798.40
5/3/2008 10:35	15.25	204	0.56	0.77	191.3	6.78	0.39	2.61	784.24
5/3/2008 10:40	15.25	206	0.57	0.78	187.9	6.86	0.38	2.61	783.03
5/3/2008 10:45	15.27	209	0.57	0.78	189.1	6.89	0.38	2.63	790.19
5/3/2008 10:50	15.28	213	0.58	0.79	183.2	6.97	0.37	2.60	780.90
5/3/2008 10:55	15.3	217	0.60	0.81	177.1	7.16	0.36	2.61	782.60
5/3/2008 11:00	15.32	221	0.61	0.82	181.7	7.31	0.37	2.71	814.19
5/3/2008 11:05	15.33	224	0.62	0.83	195.8	7.40	0.39	2.90	871.20
5/3/2008 11:10	15.35	228	0.63	0.84	189.9	7.50	0.38	2.88	863.10
5/3/2008 11:15	15.36	230	0.65	0.86	206	7.68	0.41	3.13	939.54
5/3/2008 11:20	15.37	231	0.65	0.86	203.3	7.67	0.40	3.10	928.99
5/3/2008 11:25	15.4	232	0.66	0.87	220	7.81	0.43	3.35	1004.71

5/3/2008 11:30	15.41	230	0.67	0.88	223.7	7.93	0.43	3.44	1033.40
5/3/2008 11:35	15.41	232	0.67	0.88	220.2	7.88	0.43	3.38	1014.45
5/3/2008 11:40	15.43	232	0.67	0.88	220.4	7.85	0.43	3.37	1011.28
5/3/2008 11:45	15.46	231	0.68	0.89	215.2	7.96	0.42	3.36	1006.87
5/3/2008 11:50	15.5	231	0.67	0.88	217	7.86	0.42	3.34	1000.55
5/3/2008 11:55	15.54	231	0.67	0.88	226.6	7.85	0.44	3.44	1033.19
5/3/2008 12:00	15.57	229	0.67	0.88	228.4	7.90	0.44	3.49	1046.20
5/3/2008 12:05	15.6	227	0.66	0.87	194.7	7.81	0.39	3.05	915.77
5/3/2008 12:10	15.63	226	0.66	0.87	192.5	7.80	0.39	3.02	906.87
5/3/2008 12:15	15.67	224	0.65	0.86	178.9	7.74	0.37	2.84	852.49
5/3/2008 12:20	15.72	223	0.65	0.86	175	7.68	0.36	2.77	832.38

Pitman Creek watershed's Event 1

Date/Time (m/d/y)	Avg. Temp (°C)	Avg. Depth (ft)	Avg. Depth (m)	Stream Depth (m)	Avg. Turb. (NTU)	Discharge (m^3/s)	SSC (kg/m^3)	SS Flux (kg/s)	Total Flux (kg)
2/12/2008 12:45	5.41	2.79	0.85	1.64	187.1	8.67	0.27	2.35	705.32
2/12/2008 12:50	5.44	2.81	0.85	1.64	188.3	8.71	0.27	2.38	713.51
2/12/2008 12:55	5.46	2.83	0.86	1.65	206	8.75	0.30	2.64	791.03
2/12/2008 13:00	5.47	2.85	0.87	1.66	209.4	8.79	0.31	2.70	808.89
2/12/2008 13:05	5.48	2.87	0.87	1.66	207.5	8.83	0.30	2.68	804.43
2/12/2008 13:10	5.48	2.89	0.88	1.67	198.1	8.87	0.29	2.56	767.98
2/12/2008 13:15	5.49	2.91	0.88	1.67	207.8	8.90	0.30	2.71	812.82
2/12/2008 13:20	5.49	2.93	0.89	1.68	212.1	8.94	0.31	2.78	834.84
2/12/2008 13:25	5.51	2.94	0.89	1.68	218.9	8.96	0.32	2.89	865.91
2/12/2008 13:30	5.51	2.97	0.90	1.69	227.3	9.02	0.34	3.03	907.93
2/12/2008 13:35	5.53	2.98	0.91	1.70	235	9.04	0.35	3.14	943.31
2/12/2008 13:40	5.54	3	0.91	1.70	248.2	9.08	0.37	3.35	1004.90
2/12/2008 13:45	5.56	3.02	0.92	1.71	271.8	9.12	0.41	3.71	1112.51
2/12/2008 13:50	5.57	3.05	0.93	1.72	279.8	9.18	0.42	3.85	1154.88
2/12/2008 13:55	5.59	3.07	0.93	1.72	285.1	9.22	0.43	3.94	1183.23
2/12/2008 14:00	5.59	3.09	0.94	1.73	314.6	9.26	0.48	4.40	1319.29
2/12/2008 14:05	5.61	3.11	0.95	1.74	320.2	9.29	0.48	4.50	1349.83
2/12/2008 14:10	5.62	3.13	0.95	1.74	311.2	9.33	0.47	4.38	1315.17
2/12/2008 14:15	5.63	3.17	0.96	1.75	320.5	9.41	0.48	4.56	1368.17
2/12/2008 14:20	5.64	3.19	0.97	1.76	329.8	9.45	0.50	4.72	1416.02
2/12/2008 14:25	5.65	3.23	0.98	1.77	316.1	9.53	0.48	4.55	1365.04
2/12/2008 14:30	5.67	3.25	0.99	1.78	308.3	9.57	0.47	4.45	1334.81
2/12/2008 14:35	5.69	3.29	1.00	1.79	313.5	9.64	0.47	4.57	1369.76
2/12/2008 14:40	5.71	3.32	1.01	1.80	311.2	9.70	0.47	4.56	1367.35
2/12/2008 14:45	5.74	3.35	1.02	1.81	320.9	9.76	0.49	4.74	1421.04
2/12/2008 14:50	5.77	3.37	1.02	1.81	289.2	9.80	0.43	4.26	1277.58
2/12/2008 14:55	5.79	3.4	1.03	1.82	325.8	9.86	0.49	4.86	1458.41
2/12/2008 15:00	5.83	3.44	1.05	1.84	332.8	9.94	0.50	5.01	1503.33
2/12/2008 15:05	5.86	3.47	1.05	1.84	341.8	10.00	0.52	5.18	1555.36
2/12/2008 15:10	5.89	3.5	1.06	1.85	369.5	10.05	0.56	5.66	1698.13
2/12/2008 15:15	5.92	3.53	1.07	1.86	369.2	10.11	0.56	5.69	1706.55
2/12/2008 15:20	5.94	3.57	1.09	1.88	384.2	10.19	0.59	5.98	1793.08
2/12/2008 15:25	5.97	3.59	1.09	1.88	387.1	10.23	0.59	6.05	1814.17
2/12/2008 15:30	5.99	3.63	1.10	1.89	390.4	10.31	0.60	6.15	1844.33
2/12/2008 15:35	6.01	3.67	1.12	1.91	393.6	10.39	0.60	6.25	1874.23
2/12/2008 15:40	6.03	3.71	1.13	1.92	413	10.46	0.63	6.62	1985.73
2/12/2008 15:45	6.05	3.73	1.13	1.92	422	10.50	0.65	6.79	2038.49
2/12/2008 15:50	6.06	3.78	1.15	1.94	407	10.60	0.62	6.60	1981.09

2/12/2008 15:55	6.08	3.79	1.15	1.94	416	10.62	0.64	6.77	2030.61
2/12/2008 16:00	6.09	3.82	1.16	1.95	431	10.68	0.66	7.06	2118.67
2/12/2008 16:05	6.11	3.85	1.17	1.96	423	10.74	0.65	6.96	2089.04
2/12/2008 16:10	6.12	3.88	1.18	1.97	443	10.79	0.68	7.35	2204.04
2/12/2008 16:15	6.12	3.91	1.19	1.98	439	10.85	0.67	7.32	2195.14
2/12/2008 16:20	6.12	3.93	1.19	1.98	441	10.89	0.68	7.38	2213.48
2/12/2008 16:25	6.13	3.95	1.20	1.99	450	10.93	0.69	7.56	2268.62
2/12/2008 16:30	6.13	3.96	1.20	1.99	462	10.95	0.71	7.79	2335.74
2/12/2008 16:35	6.12	3.96	1.20	1.99	480	10.95	0.74	8.10	2430.36
2/12/2008 16:40	6.11	4.02	1.22	2.01	492	11.07	0.76	8.40	2520.06
2/12/2008 16:45	6.1	4.04	1.23	2.02	485	11.11	0.75	8.31	2491.61
2/12/2008 16:50	6.09	4.04	1.23	2.02	495	11.11	0.76	8.48	2544.92
2/12/2008 16:55	6.08	4.06	1.23	2.02	482	11.15	0.74	8.28	2484.31
2/12/2008 17:00	6.07	4.08	1.24	2.03	481	11.18	0.74	8.29	2487.63
2/12/2008 17:05	6.07	4.09	1.24	2.03	511	11.20	0.79	8.84	2653.30
2/12/2008 17:10	6.06	4.11	1.25	2.04	511	11.24	0.79	8.88	2662.53
2/12/2008 17:15	6.05	4.13	1.26	2.05	509	11.28	0.79	8.87	2660.93
2/12/2008 17:20	6.04	4.14	1.26	2.05	514	11.30	0.79	8.98	2692.65
2/12/2008 17:25	6.04	4.15	1.26	2.05	517	11.32	0.80	9.05	2713.59
2/12/2008 17:30	6.04	4.15	1.26	2.05	518	11.32	0.80	9.06	2719.03
2/12/2008 17:35	6.03	4.16	1.26	2.05	510	11.34	0.79	8.93	2680.16
2/12/2008 17:40	6.03	4.18	1.27	2.06	528	11.38	0.82	9.29	2787.69
2/12/2008 17:45	6.03	4.19	1.27	2.06	517	11.40	0.80	9.11	2732.28
2/12/2008 17:50	6.04	4.2	1.28	2.07	524	11.42	0.81	9.25	2775.31
2/12/2008 17:55	6.04	4.21	1.28	2.07	522	11.44	0.81	9.23	2769.07
2/12/2008 18:00	6.04	4.2	1.28	2.07	501	11.42	0.77	8.83	2649.26
2/12/2008 18:05	6.05	4.21	1.28	2.07	516	11.44	0.80	9.12	2736.13
2/12/2008 18:10	6.05	4.21	1.28	2.07	506	11.44	0.78	8.94	2681.23
2/12/2008 18:15	6.06	4.23	1.29	2.08	512	11.48	0.79	9.08	2723.42
2/12/2008 18:20	6.06	4.23	1.29	2.08	523	11.48	0.81	9.28	2784.01
2/12/2008 18:25	6.07	4.22	1.28	2.07	511	11.46	0.79	9.04	2713.29
2/12/2008 18:30	6.07	4.24	1.29	2.08	532	11.50	0.82	9.46	2838.41
2/12/2008 18:35	6.08	4.23	1.29	2.08	523	11.48	0.81	9.28	2784.01
2/12/2008 18:40	6.09	4.24	1.29	2.08	516	11.50	0.80	9.17	2750.11
2/12/2008 18:45	6.1	4.23	1.29	2.08	508	11.48	0.78	9.00	2701.38
2/12/2008 18:50	6.11	4.23	1.29	2.08	511	11.48	0.79	9.06	2717.91
2/12/2008 18:55	6.12	4.23	1.29	2.08	508	11.48	0.78	9.00	2701.38
2/12/2008 19:00	6.13	4.24	1.29	2.08	488	11.50	0.75	8.65	2595.61
2/12/2008 19:05	6.14	4.23	1.29	2.08	486	11.48	0.75	8.60	2580.19
2/12/2008 19:10	6.15	4.22	1.28	2.07	485	11.46	0.75	8.57	2570.31
2/12/2008 19:15	6.17	4.2	1.28	2.07	471	11.42	0.73	8.28	2484.83
2/12/2008 19:20	6.18	4.23	1.29	2.08	470	11.48	0.72	8.31	2492.05

2/12/2008 19:25	6.2	4.23	1.29	2.08	457	11.48	0.70	8.07	2420.43
2/12/2008 19:30	6.21	4.21	1.28	2.07	458	11.44	0.70	8.06	2417.70
2/12/2008 19:35	6.23	4.21	1.28	2.07	445	11.44	0.68	7.82	2346.33
2/12/2008 19:40	6.24	4.21	1.28	2.07	445	11.44	0.68	7.82	2346.33
2/12/2008 19:45	6.26	4.2	1.28	2.07	431	11.42	0.66	7.55	2265.60
2/12/2008 19:50	6.28	4.19	1.27	2.06	428	11.40	0.66	7.48	2245.32
2/12/2008 19:55	6.3	4.19	1.27	2.06	420	11.40	0.64	7.34	2201.55
2/12/2008 20:00	6.31	4.18	1.27	2.06	409	11.38	0.63	7.13	2137.71
2/12/2008 20:05	6.33	4.18	1.27	2.06	410	11.38	0.63	7.14	2143.17
2/12/2008 20:10	6.34	4.17	1.27	2.06	407	11.36	0.62	7.08	2123.14
2/12/2008 20:15	6.36	4.17	1.27	2.06	397.3	11.36	0.61	6.90	2070.25
2/12/2008 20:20	6.37	4.16	1.26	2.05	395.4	11.34	0.60	6.85	2056.35
2/12/2008 20:25	6.39	4.13	1.26	2.05	384.7	11.28	0.59	6.63	1987.81
2/12/2008 20:30	6.41	4.14	1.26	2.05	387	11.30	0.59	6.68	2003.72
2/12/2008 20:35	6.42	4.12	1.25	2.04	373.5	11.26	0.57	6.41	1923.83
2/12/2008 20:40	6.44	4.12	1.25	2.04	391.8	11.26	0.60	6.74	2022.76
2/12/2008 20:45	6.45	4.11	1.25	2.04	368.7	11.24	0.56	6.32	1894.60
2/12/2008 20:50	6.47	4.11	1.25	2.04	368.9	11.24	0.56	6.32	1895.68
2/12/2008 20:55	6.48	4.09	1.24	2.03	375.7	11.20	0.57	6.42	1925.67
2/12/2008 21:00	6.49	4.08	1.24	2.03	359.8	11.18	0.55	6.12	1836.97
2/12/2008 21:05	6.51	4.07	1.24	2.03	366.5	11.16	0.56	6.23	1869.67
2/12/2008 21:10	6.53	4.06	1.23	2.02	349.4	11.15	0.53	5.92	1774.93
2/12/2008 21:15	6.54	4.05	1.23	2.02	347.5	11.13	0.53	5.87	1761.68
2/12/2008 21:20	6.56	4.02	1.22	2.01	348.7	11.07	0.53	5.86	1758.79
2/12/2008 21:25	6.57	4.02	1.22	2.01	342.1	11.07	0.52	5.75	1723.73
2/12/2008 21:30	6.59	4.02	1.22	2.01	342.4	11.07	0.52	5.75	1725.33
2/12/2008 21:35	6.61	4.02	1.22	2.01	327.5	11.07	0.50	5.49	1646.17
2/12/2008 21:40	6.63	4	1.22	2.01	333.2	11.03	0.50	5.57	1670.55
2/12/2008 21:45	6.64	3.99	1.21	2.00	328	11.01	0.50	5.47	1640.12
2/12/2008 21:50	6.66	3.98	1.21	2.00	327.8	10.99	0.50	5.45	1636.16
2/12/2008 21:55	6.67	3.96	1.20	1.99	322.9	10.95	0.49	5.35	1604.60
2/12/2008 22:00	6.69	3.95	1.20	1.99	317.2	10.93	0.48	5.24	1571.84
2/12/2008 22:05	6.7	3.94	1.20	1.99	304.7	10.91	0.46	5.01	1503.57
2/12/2008 22:10	6.72	3.94	1.20	1.99	310.5	10.91	0.47	5.11	1533.94
2/12/2008 22:15	6.73	3.93	1.19	1.98	294.3	10.89	0.44	4.82	1446.51
2/12/2008 22:20	6.74	3.91	1.19	1.98	296	10.85	0.45	4.83	1450.19
2/12/2008 22:25	6.75	3.91	1.19	1.98	282.8	10.85	0.42	4.60	1381.42
2/12/2008 22:30	6.77	3.89	1.18	1.97	281.8	10.81	0.42	4.57	1371.27
2/12/2008 22:35	6.78	3.89	1.18	1.97	278.7	10.81	0.42	4.52	1355.18
2/12/2008 22:40	6.79	3.88	1.18	1.97	291.6	10.79	0.44	4.73	1419.58
2/12/2008 22:45	6.8	3.86	1.17	1.96	272	10.76	0.41	4.38	1313.26
2/12/2008 22:50	6.8	3.85	1.17	1.96	267.9	10.74	0.40	4.30	1289.75

2/12/2008 22:55	6.8	3.84	1.17	1.96	279.4	10.72	0.42	4.49	1346.57
2/12/2008 23:00	6.81	3.83	1.16	1.95	259.2	10.70	0.39	4.13	1240.40
2/12/2008 23:05	6.82	3.83	1.16	1.95	261.8	10.70	0.39	4.18	1253.75
2/12/2008 23:10	6.83	3.82	1.16	1.95	255.8	10.68	0.38	4.07	1220.72
2/12/2008 23:15	6.83	3.81	1.16	1.95	245.5	10.66	0.36	3.89	1165.79
2/12/2008 23:20	6.84	3.79	1.15	1.94	240.9	10.62	0.36	3.79	1138.08
2/12/2008 23:25	6.85	3.79	1.15	1.94	244	10.62	0.36	3.85	1153.88
2/12/2008 23:30	6.86	3.78	1.15	1.94	237.9	10.60	0.35	3.74	1120.73
2/12/2008 23:35	6.87	3.78	1.15	1.94	236.4	10.60	0.35	3.71	1113.10
2/12/2008 23:40	6.88	3.76	1.14	1.93	232	10.56	0.34	3.62	1086.70
2/12/2008 23:45	6.88	3.76	1.14	1.93	232.9	10.56	0.34	3.64	1091.26
2/12/2008 23:50	6.89	3.76	1.14	1.93	219.8	10.56	0.32	3.42	1024.86
2/12/2008 23:55	6.9	3.75	1.14	1.93	235.1	10.54	0.35	3.67	1100.38
2/13/2008 0:00	6.9	3.74	1.14	1.93	220.4	10.52	0.32	3.41	1024.11
2/13/2008 0:05	6.91	3.74	1.14	1.93	214.5	10.52	0.32	3.31	994.31
2/13/2008 0:10	6.91	3.73	1.13	1.92	214.1	10.50	0.31	3.30	990.45
2/13/2008 0:15	6.92	3.72	1.13	1.92	214.5	10.48	0.32	3.30	990.62
2/13/2008 0:20	6.93	3.71	1.13	1.92	211.1	10.46	0.31	3.24	971.71
2/13/2008 0:25	6.93	3.71	1.13	1.92	206.3	10.46	0.30	3.16	947.60
2/13/2008 0:30	6.94	3.71	1.13	1.92	199	10.46	0.29	3.04	910.94
2/13/2008 0:35	6.94	3.69	1.12	1.91	199.3	10.42	0.29	3.03	909.04
2/13/2008 0:40	6.95	3.69	1.12	1.91	201.3	10.42	0.29	3.06	919.05
2/13/2008 0:45	6.95	3.69	1.12	1.91	203.7	10.42	0.30	3.10	931.06
2/13/2008 0:50	6.96	3.67	1.12	1.91	195.1	10.39	0.28	2.95	884.71
2/13/2008 0:55	6.96	3.67	1.12	1.91	189.7	10.39	0.28	2.86	857.79
2/13/2008 1:00	6.96	3.65	1.11	1.90	194.8	10.35	0.28	2.93	879.90
2/13/2008 1:05	6.97	3.65	1.11	1.90	189.6	10.35	0.28	2.85	854.07
2/13/2008 1:10	6.97	3.65	1.11	1.90	189.1	10.35	0.27	2.84	851.59
2/13/2008 1:15	6.97	3.64	1.11	1.90	181.3	10.33	0.26	2.70	811.32
2/13/2008 1:20	6.97	3.64	1.11	1.90	184.2	10.33	0.27	2.75	825.70
2/13/2008 1:25	6.97	3.63	1.10	1.89	182	10.31	0.26	2.71	813.25
2/13/2008 1:30	6.97	3.63	1.10	1.89	171.1	10.31	0.25	2.53	759.33
2/13/2008 1:35	6.97	3.62	1.10	1.89	177.3	10.29	0.26	2.63	788.51
2/13/2008 1:40	6.97	3.62	1.10	1.89	173	10.29	0.25	2.56	767.27
2/13/2008 1:45	6.98	3.62	1.10	1.89	165	10.29	0.24	2.43	727.77
2/13/2008 1:50	6.98	3.62	1.10	1.89	162.9	10.29	0.23	2.39	717.40
2/13/2008 1:55	6.97	3.6	1.09	1.88	166	10.25	0.24	2.43	729.93
2/13/2008 2:00	6.98	3.59	1.09	1.88	166.7	10.23	0.24	2.44	731.98
2/13/2008 2:05	6.97	3.59	1.09	1.88	164.6	10.23	0.24	2.41	721.67
2/13/2008 2:10	6.97	3.59	1.09	1.88	151.4	10.23	0.21	2.19	656.85
2/13/2008 2:15	6.97	3.58	1.09	1.88	154.2	10.21	0.22	2.23	669.32
2/13/2008 2:20	6.97	3.58	1.09	1.88	165.9	10.21	0.24	2.42	726.66

2/13/2008 2:25	6.97	3.56	1.08	1.87	155.1	10.17	0.22	2.24	671.16
2/13/2008 2:30	6.96	3.57	1.09	1.88	146.3	10.19	0.21	2.10	629.40
2/13/2008 2:35	6.96	3.57	1.09	1.88	146.6	10.19	0.21	2.10	630.87
2/13/2008 2:40	6.96	3.57	1.09	1.88	145.1	10.19	0.20	2.08	623.54
2/13/2008 2:45	6.96	3.56	1.08	1.87	148.2	10.17	0.21	2.12	637.48
2/13/2008 2:50	6.95	3.56	1.08	1.87	140.4	10.17	0.20	2.00	599.40
2/13/2008 2:55	6.95	3.56	1.08	1.87	140.6	10.17	0.20	2.00	600.37
2/13/2008 3:00	6.94	3.55	1.08	1.87	142.9	10.15	0.20	2.03	610.43
2/13/2008 3:05	6.94	3.55	1.08	1.87	137.9	10.15	0.19	1.95	586.07
2/13/2008 3:10	6.93	3.53	1.07	1.86	139.1	10.11	0.19	1.97	589.64
2/13/2008 3:15	6.93	3.54	1.08	1.87	124.8	10.13	0.17	1.74	521.23
2/13/2008 3:20	6.92	3.54	1.08	1.87	131.8	10.13	0.18	1.85	555.28
2/13/2008 3:25	6.92	3.53	1.07	1.86	128.2	10.11	0.18	1.79	536.73
2/13/2008 3:30	6.91	3.53	1.07	1.86	129	10.11	0.18	1.80	540.62
2/13/2008 3:35	6.9	3.53	1.07	1.86	127.8	10.11	0.18	1.78	534.79
2/13/2008 3:40	6.89	3.53	1.07	1.86	121	10.11	0.17	1.67	501.78
2/13/2008 3:45	6.89	3.52	1.07	1.86	122.5	10.09	0.17	1.69	508.08
2/13/2008 3:50	6.88	3.52	1.07	1.86	123.7	10.09	0.17	1.71	513.90
2/13/2008 3:55	6.87	3.52	1.07	1.86	118.4	10.09	0.16	1.63	488.22
2/13/2008 4:00	6.87	3.51	1.07	1.86	136.2	10.07	0.19	1.91	573.35
2/13/2008 4:05	6.86	3.51	1.07	1.86	107.8	10.07	0.14	1.45	436.02
2/13/2008 4:10	6.85	3.51	1.07	1.86	107.2	10.07	0.14	1.44	433.12
2/13/2008 4:15	6.85	3.5	1.06	1.85	126.5	10.05	0.17	1.75	525.43
2/13/2008 4:20	6.84	3.5	1.06	1.85	117.7	10.05	0.16	1.61	482.96
2/13/2008 4:25	6.83	3.5	1.06	1.85	102.5	10.05	0.14	1.37	409.60
2/13/2008 4:30	6.82	3.5	1.06	1.85	114.7	10.05	0.16	1.56	468.48
2/13/2008 4:35	6.82	3.49	1.06	1.85	121.2	10.03	0.17	1.66	498.88
2/13/2008 4:40	6.81	3.49	1.06	1.85	118	10.03	0.16	1.61	483.47
2/13/2008 4:45	6.8	3.48	1.06	1.85	109.7	10.02	0.15	1.48	442.63
2/13/2008 4:50	6.79	3.48	1.06	1.85	111.4	10.02	0.15	1.50	450.80
2/13/2008 4:55	6.79	3.48	1.06	1.85	106.4	10.02	0.14	1.42	426.76
2/13/2008 5:00	6.78	3.48	1.06	1.85	108.2	10.02	0.14	1.45	435.42
2/13/2008 5:05	6.77	3.47	1.05	1.84	109.8	10.00	0.15	1.47	442.25
2/13/2008 5:10	6.76	3.47	1.05	1.84	102.3	10.00	0.14	1.35	406.26
2/13/2008 5:15	6.75	3.47	1.05	1.84	98.1	10.00	0.13	1.29	386.11
2/13/2008 5:20	6.74	3.46	1.05	1.84	107.4	9.98	0.14	1.43	429.89
2/13/2008 5:25	6.73	3.46	1.05	1.84	99.2	9.98	0.13	1.30	390.62
2/13/2008 5:30	6.72	3.47	1.05	1.84	101.6	10.00	0.13	1.34	402.90
2/13/2008 5:35	6.71	3.46	1.05	1.84	109.5	9.98	0.15	1.47	439.95
2/13/2008 5:40	6.71	3.46	1.05	1.84	101.1	9.98	0.13	1.33	399.72
2/13/2008 5:45	6.69	3.46	1.05	1.84	98.1	9.98	0.13	1.28	385.36

Pitman Creek watershed's Event 2

Date/Time (m/d/y)	Avg. Temp (°C)	Avg. Depth (ft)	Avg. Depth (m)	Stream Depth (m)	Avg. Turb. (NTU)	Discharge (m3/s)	SSC (kg/m3)	SS Flux (kg/s)	Total Flux (kg)
3/4/2008 0:00	11.49	2.29	0.70	1.49	95.1	7.70	0.12	0.95	286.20
3/4/2008 0:05	11.5	2.29	0.70	1.49	127.1	7.70	0.18	1.35	404.41
3/4/2008 0:10	11.51	2.29	0.70	1.49	131.9	7.70	0.18	1.41	422.14
3/4/2008 0:15	11.5	2.29	0.70	1.49	151.7	7.70	0.21	1.65	495.29
3/4/2008 0:20	11.51	2.3	0.70	1.49	148.1	7.72	0.21	1.61	483.21
3/4/2008 0:25	11.51	2.3	0.70	1.49	133.9	7.72	0.19	1.44	430.62
3/4/2008 0:30	11.5	2.3	0.70	1.49	113.2	7.72	0.15	1.18	353.96
3/4/2008 0:35	11.5	2.3	0.70	1.49	122.3	7.72	0.17	1.29	387.66
3/4/2008 0:40	11.5	2.3	0.70	1.49	125.4	7.72	0.17	1.33	399.14
3/4/2008 0:45	11.49	2.31	0.70	1.49	118.9	7.74	0.16	1.25	376.01
3/4/2008 0:50	11.48	2.31	0.70	1.49	120.2	7.74	0.16	1.27	380.84
3/4/2008 0:55	11.47	2.32	0.71	1.50	121.6	7.75	0.17	1.29	387.01
3/4/2008 1:00	11.46	2.32	0.71	1.50	102.5	7.75	0.14	1.05	315.92
3/4/2008 1:05	11.45	2.32	0.71	1.50	136.7	7.75	0.19	1.48	443.22
3/4/2008 1:10	11.43	2.32	0.71	1.50	152.3	7.75	0.22	1.67	501.28
3/4/2008 1:15	11.42	2.33	0.71	1.50	151.6	7.77	0.21	1.67	499.93
3/4/2008 1:20	11.4	2.33	0.71	1.50	159.9	7.77	0.23	1.77	530.90
3/4/2008 1:25	11.39	2.34	0.71	1.50	146.6	7.79	0.21	1.61	482.48
3/4/2008 1:30	11.38	2.34	0.71	1.50	146.7	7.79	0.21	1.61	482.85
3/4/2008 1:35	11.36	2.34	0.71	1.50	164.5	7.79	0.24	1.83	549.44
3/4/2008 1:40	11.35	2.35	0.71	1.50	165.1	7.81	0.24	1.84	553.06
3/4/2008 1:45	11.32	2.36	0.72	1.51	170.3	7.83	0.24	1.91	573.99
3/4/2008 1:50	11.33	2.37	0.72	1.51	158.5	7.85	0.23	1.77	530.95
3/4/2008 1:55	11.31	2.37	0.72	1.51	161.3	7.85	0.23	1.81	541.50
3/4/2008 2:00	11.31	2.39	0.73	1.52	167.2	7.89	0.24	1.89	566.54
3/4/2008 2:05	11.27	2.4	0.73	1.52	188	7.91	0.27	2.16	646.91
3/4/2008 2:10	11.27	2.41	0.73	1.52	187.3	7.93	0.27	2.15	645.84
3/4/2008 2:15	11.23	2.42	0.74	1.53	216.2	7.95	0.32	2.53	757.70
3/4/2008 2:20	11.23	2.43	0.74	1.53	209.7	7.97	0.31	2.45	734.70
3/4/2008 2:25	11.21	2.45	0.74	1.53	225.2	8.01	0.33	2.66	797.87
3/4/2008 2:30	11.23	2.48	0.75	1.54	214.8	8.07	0.32	2.54	763.43
3/4/2008 2:35	11.16	2.5	0.76	1.55	238.2	8.11	0.35	2.86	858.15
3/4/2008 2:40	11.14	2.53	0.77	1.56	234.8	8.16	0.35	2.84	851.02
3/4/2008 2:45	11.15	2.54	0.77	1.56	239.1	8.18	0.35	2.90	869.94
3/4/2008 2:50	11.14	2.56	0.78	1.57	247	8.22	0.37	3.02	905.26
3/4/2008 2:55	11.14	2.58	0.78	1.57	262	8.26	0.39	3.23	969.04
3/4/2008 3:00	11.14	2.61	0.79	1.58	282.6	8.32	0.42	3.53	1058.16
3/4/2008 3:05	11.13	2.63	0.80	1.59	279.4	8.36	0.42	3.50	1050.28

3/4/2008 3:10	11.12	2.65	0.81	1.60	286.2	8.40	0.43	3.61	1082.58
3/4/2008 3:15	11.12	2.68	0.81	1.60	303.9	8.46	0.46	3.87	1161.96
3/4/2008 3:20	11.13	2.71	0.82	1.61	325.1	8.51	0.49	4.19	1256.64
3/4/2008 3:25	11.1	2.73	0.83	1.62	345	8.55	0.52	4.48	1344.10
3/4/2008 3:30	11.09	2.75	0.84	1.63	347.1	8.59	0.53	4.53	1358.88
3/4/2008 3:35	11.09	2.77	0.84	1.63	366.1	8.63	0.56	4.81	1443.77
3/4/2008 3:40	11.06	2.79	0.85	1.64	392.7	8.67	0.60	5.20	1560.99
3/4/2008 3:45	11.05	2.82	0.86	1.65	426	8.73	0.65	5.70	1711.04
3/4/2008 3:50	11.05	2.84	0.86	1.65	454	8.77	0.70	6.12	1836.52
3/4/2008 3:55	11.02	2.87	0.87	1.66	451	8.83	0.69	6.12	1836.05
3/4/2008 4:00	11.01	2.9	0.88	1.67	487	8.88	0.75	6.67	2001.74
3/4/2008 4:05	10.99	2.92	0.89	1.68	487	8.92	0.75	6.70	2010.52
3/4/2008 4:10	10.96	2.95	0.90	1.69	538	8.98	0.83	7.48	2243.58
3/4/2008 4:15	10.95	2.97	0.90	1.69	552	9.02	0.86	7.71	2313.94
3/4/2008 4:20	10.92	2.99	0.91	1.70	574	9.06	0.89	8.07	2419.61
3/4/2008 4:25	10.89	3.01	0.92	1.71	565	9.10	0.88	7.97	2390.71
3/4/2008 4:30	10.86	3.03	0.92	1.71	571	9.14	0.89	8.09	2427.27
3/4/2008 4:35	10.84	3.05	0.93	1.72	572	9.18	0.89	8.14	2442.03
3/4/2008 4:40	10.81	3.07	0.93	1.72	608	9.22	0.94	8.71	2611.65
3/4/2008 4:45	10.78	3.09	0.94	1.73	598	9.26	0.93	8.59	2578.28
3/4/2008 4:50	10.75	3.12	0.95	1.74	601	9.31	0.93	8.69	2607.97
3/4/2008 4:55	10.72	3.14	0.95	1.74	617	9.35	0.96	8.97	2690.71
3/4/2008 5:00	10.69	3.17	0.96	1.75	611	9.41	0.95	8.93	2680.43
3/4/2008 5:05	10.67	3.19	0.97	1.76	633	9.45	0.98	9.30	2791.32
3/4/2008 5:10	10.64	3.22	0.98	1.77	616	9.51	0.96	9.10	2731.00
3/4/2008 5:15	10.63	3.24	0.98	1.77	625	9.55	0.97	9.28	2783.44
3/4/2008 5:20	10.61	3.27	0.99	1.78	591	9.61	0.92	8.81	2643.72
3/4/2008 5:25	10.61	3.3	1.00	1.79	577	9.66	0.90	8.65	2594.87
3/4/2008 5:30	10.6	3.32	1.01	1.80	552	9.70	0.86	8.30	2488.89
3/4/2008 5:35	10.59	3.35	1.02	1.81	554	9.76	0.86	8.38	2513.26
3/4/2008 5:40	10.59	3.38	1.03	1.82	555	9.82	0.86	8.44	2533.03
3/4/2008 5:45	10.58	3.41	1.04	1.83	551	9.88	0.85	8.43	2529.14
3/4/2008 5:50	10.58	3.43	1.04	1.83	561	9.92	0.87	8.62	2586.72
3/4/2008 5:55	10.57	3.47	1.05	1.84	567	10.00	0.88	8.79	2635.84
3/4/2008 6:00	10.55	3.49	1.06	1.85	566	10.03	0.88	8.80	2641.30
3/4/2008 6:05	10.54	3.52	1.07	1.86	573	10.09	0.89	8.97	2690.60
3/4/2008 6:10	10.52	3.55	1.08	1.87	596	10.15	0.93	9.39	2818.26
3/4/2008 6:15	10.5	3.57	1.09	1.88	598	10.19	0.93	9.46	2838.86
3/4/2008 6:20	10.49	3.6	1.09	1.88	629	10.25	0.98	10.03	3007.66
3/4/2008 6:25	10.46	3.63	1.10	1.89	644	10.31	1.00	10.33	3099.03
3/4/2008 6:30	10.45	3.66	1.11	1.90	661	10.37	1.03	10.67	3201.19
3/4/2008 6:35	10.43	3.69	1.12	1.91	669	10.42	1.04	10.86	3259.27
3/4/2008 6:40	10.42	3.73	1.13	1.92	681	10.50	1.06	11.15	3344.14

3/4/2008 6:45	10.41	3.75	1.14	1.93	681	10.54	1.06	11.19	3356.55
3/4/2008 6:50	10.4	3.79	1.15	1.94	673	10.62	1.05	11.14	3340.59
3/4/2008 6:55	10.39	3.81	1.16	1.95	675	10.66	1.05	11.21	3363.09
3/4/2008 7:00	10.38	3.85	1.17	1.96	679	10.74	1.06	11.36	3408.30
3/4/2008 7:05	10.37	3.88	1.18	1.97	692	10.79	1.08	11.65	3494.21
3/4/2008 7:10	10.36	3.9	1.19	1.98	674	10.83	1.05	11.38	3413.23
3/4/2008 7:15	10.35	3.94	1.20	1.99	681	10.91	1.06	11.58	3474.45
3/4/2008 7:20	10.34	3.95	1.20	1.99	679	10.93	1.06	11.57	3470.16
3/4/2008 7:25	10.33	3.99	1.21	2.00	676	11.01	1.05	11.60	3479.06
3/4/2008 7:30	10.32	4.02	1.22	2.01	665	11.07	1.04	11.46	3439.10
3/4/2008 7:35	10.32	4.04	1.23	2.02	664	11.11	1.03	11.49	3445.88
3/4/2008 7:40	10.31	4.06	1.23	2.02	659	11.15	1.03	11.44	3431.22
3/4/2008 7:45	10.31	4.07	1.24	2.03	658	11.16	1.02	11.44	3431.86
3/4/2008 7:50	10.3	4.11	1.25	2.04	658	11.24	1.02	11.52	3455.82
3/4/2008 7:55	10.3	4.13	1.26	2.05	663	11.28	1.03	11.65	3494.88
3/4/2008 8:00	10.29	4.15	1.26	2.05	669	11.32	1.04	11.80	3539.56
3/4/2008 8:05	10.29	4.18	1.27	2.06	669	11.38	1.04	11.86	3557.83
3/4/2008 8:10	10.28	4.19	1.27	2.06	681	11.40	1.06	12.10	3629.58
3/4/2008 8:15	10.28	4.2	1.28	2.07	701	11.42	1.09	12.48	3745.40
3/4/2008 8:20	10.27	4.23	1.29	2.08	707	11.48	1.10	12.66	3797.64
3/4/2008 8:25	10.26	4.26	1.30	2.09	721	11.54	1.13	12.98	3894.50
3/4/2008 8:30	10.23	4.29	1.30	2.09	740	11.59	1.16	13.40	4019.97
3/4/2008 8:35	10.22	4.31	1.31	2.10	755	11.63	1.18	13.72	4117.24
3/4/2008 8:40	10.2	4.32	1.31	2.10	772	11.65	1.21	14.06	4219.22
3/4/2008 8:45	10.17	4.34	1.32	2.11	777	11.69	1.22	14.20	4261.39
3/4/2008 8:50	10.15	4.34	1.32	2.11	785	11.69	1.23	14.35	4306.28
3/4/2008 8:55	10.12	4.35	1.32	2.11	797	11.71	1.25	14.60	4380.91
3/4/2008 9:00	10.1	4.37	1.33	2.12	807	11.75	1.26	14.84	4451.89
3/4/2008 9:05	10.07	4.39	1.33	2.12	804	11.79	1.26	14.83	4449.68
3/4/2008 9:10	10.04	4.42	1.34	2.13	802	11.85	1.26	14.87	4460.38
3/4/2008 9:15	10.02	4.43	1.35	2.14	809	11.87	1.27	15.03	4507.59
3/4/2008 9:20	10.03	4.4	1.34	2.13	802	11.81	1.26	14.82	4445.70
3/4/2008 9:25	10	4.44	1.35	2.14	794	11.89	1.24	14.76	4429.41
3/4/2008 9:30	9.97	4.47	1.36	2.15	790	11.94	1.24	14.76	4428.27
3/4/2008 9:35	9.96	4.47	1.36	2.15	786	11.94	1.23	14.68	4405.33
3/4/2008 9:40	9.94	4.49	1.36	2.15	781	11.98	1.22	14.64	4390.95
3/4/2008 9:45	9.93	4.46	1.36	2.15	774	11.92	1.21	14.43	4329.46
3/4/2008 9:50	9.91	4.53	1.38	2.17	781	12.06	1.22	14.73	4419.51
3/4/2008 9:55	9.9	4.51	1.37	2.16	766	12.02	1.20	14.40	4318.67
3/4/2008 10:00	9.89	4.54	1.38	2.17	760	12.08	1.19	14.35	4304.88
3/4/2008 10:05	9.88	4.5	1.37	2.16	757	12.00	1.18	14.20	4259.81
3/4/2008 10:10	9.87	4.52	1.37	2.16	750	12.04	1.17	14.11	4233.19
3/4/2008 10:15	9.86	4.56	1.39	2.18	737	12.12	1.15	13.95	4184.96

3/4/2008 10:20	9.86	4.54	1.38	2.17	728	12.08	1.14	13.73	4119.31
3/4/2008 10:25	9.85	4.54	1.38	2.17	718	12.08	1.12	13.54	4061.33
3/4/2008 10:30	9.83	4.56	1.39	2.18	711	12.12	1.11	13.45	4033.71
3/4/2008 10:35	9.83	4.56	1.39	2.18	706	12.12	1.10	13.35	4004.62
3/4/2008 10:40	9.82	4.57	1.39	2.18	696	12.14	1.09	13.18	3952.79
3/4/2008 10:45	9.81	4.57	1.39	2.18	694	12.14	1.08	13.14	3941.14
3/4/2008 10:50	9.8	4.55	1.38	2.17	676	12.10	1.05	12.75	3823.94
3/4/2008 10:55	9.79	4.57	1.39	2.18	681	12.14	1.06	12.88	3865.39
3/4/2008 11:00	9.78	4.59	1.40	2.19	670	12.18	1.04	12.71	3813.50
3/4/2008 11:05	9.77	4.56	1.39	2.18	664	12.12	1.03	12.53	3760.28
3/4/2008 11:10	9.76	4.55	1.38	2.17	659	12.10	1.03	12.42	3725.20
3/4/2008 11:15	9.75	4.57	1.39	2.18	653	12.14	1.02	12.34	3702.24
3/4/2008 11:20	9.74	4.58	1.39	2.18	646	12.16	1.01	12.22	3667.33
3/4/2008 11:25	9.72	4.61	1.40	2.19	649	12.22	1.01	12.34	3702.55
3/4/2008 11:30	9.71	4.58	1.39	2.18	636	12.16	0.99	12.03	3608.96
3/4/2008 11:35	9.7	4.59	1.40	2.19	629	12.18	0.98	11.91	3573.83
3/4/2008 11:40	9.69	4.55	1.38	2.17	627	12.10	0.98	11.80	3539.34
3/4/2008 11:45	9.68	4.6	1.40	2.19	620	12.20	0.96	11.76	3526.85
3/4/2008 11:50	9.67	4.55	1.38	2.17	625	12.10	0.97	11.76	3527.72
3/4/2008 11:55	9.66	4.54	1.38	2.17	622	12.08	0.97	11.68	3504.64
3/4/2008 12:00	9.65	4.58	1.39	2.18	620	12.16	0.96	11.72	3515.58
3/4/2008 12:05	9.65	4.54	1.38	2.17	615	12.08	0.96	11.55	3464.05
3/4/2008 12:10	9.65	4.57	1.39	2.18	606	12.14	0.94	11.43	3428.37
3/4/2008 12:15	9.65	4.56	1.39	2.18	602	12.12	0.94	11.33	3399.60
3/4/2008 12:20	9.65	4.54	1.38	2.17	601	12.08	0.93	11.28	3382.87
3/4/2008 12:25	9.64	4.56	1.39	2.18	597	12.12	0.93	11.24	3370.51
3/4/2008 12:30	9.64	4.54	1.38	2.17	592	12.08	0.92	11.10	3330.68
3/4/2008 12:35	9.63	4.55	1.38	2.17	595	12.10	0.92	11.18	3353.48
3/4/2008 12:40	9.63	4.51	1.37	2.16	578	12.02	0.90	10.78	3233.77
3/4/2008 12:45	9.63	4.51	1.37	2.16	577	12.02	0.90	10.76	3228.00
3/4/2008 12:50	9.62	4.48	1.36	2.15	565	11.96	0.88	10.48	3143.39
3/4/2008 12:55	9.61	4.49	1.36	2.15	559	11.98	0.87	10.38	3114.00
3/4/2008 13:00	9.61	4.47	1.36	2.15	552	11.94	0.86	10.21	3063.74
3/4/2008 13:05	9.6	4.48	1.36	2.15	549	11.96	0.85	10.17	3051.51
3/4/2008 13:10	9.6	4.47	1.36	2.15	546	11.94	0.85	10.10	3029.34
3/4/2008 13:15	9.6	4.43	1.35	2.14	532	11.87	0.82	9.77	2929.82
3/4/2008 13:20	9.59	4.44	1.35	2.14	527	11.89	0.82	9.69	2906.11
3/4/2008 13:25	9.6	4.41	1.34	2.13	517	11.83	0.80	9.45	2835.04
3/4/2008 13:30	9.6	4.41	1.34	2.13	511	11.83	0.79	9.34	2800.98
3/4/2008 13:35	9.61	4.41	1.34	2.13	497	11.83	0.77	9.07	2721.50
3/4/2008 13:40	9.61	4.38	1.33	2.12	494	11.77	0.76	8.97	2691.10
3/4/2008 13:45	9.62	4.37	1.33	2.12	483	11.75	0.74	8.75	2624.61

3/4/2008 13:50	9.62	4.38	1.33	2.12	482	11.77	0.74	8.74	2623.31
3/4/2008 13:55	9.63	4.33	1.32	2.11	477	11.67	0.74	8.58	2573.58
3/4/2008 14:00	9.64	4.33	1.32	2.11	470	11.67	0.72	8.45	2534.36
3/4/2008 14:05	9.65	4.29	1.30	2.09	457	11.59	0.70	8.15	2445.09
3/4/2008 14:10	9.65	4.29	1.30	2.09	447	11.59	0.69	7.96	2389.44
3/4/2008 14:15	9.66	4.28	1.30	2.09	438	11.57	0.67	7.78	2335.43
3/4/2008 14:20	9.67	4.23	1.29	2.08	441	11.48	0.68	7.77	2332.29
3/4/2008 14:25	9.67	4.22	1.28	2.07	431	11.46	0.66	7.58	2273.34
3/4/2008 14:30	9.68	4.22	1.28	2.07	423	11.46	0.65	7.43	2229.34
3/4/2008 14:35	9.69	4.2	1.28	2.07	415	11.42	0.64	7.26	2177.91
3/4/2008 14:40	9.7	4.18	1.27	2.06	410	11.38	0.63	7.14	2143.17
3/4/2008 14:45	9.71	4.16	1.26	2.05	407	11.34	0.62	7.06	2119.50
3/4/2008 14:50	9.72	4.16	1.26	2.05	396.9	11.34	0.61	6.88	2064.52
3/4/2008 14:55	9.72	4.14	1.26	2.05	395.1	11.30	0.60	6.83	2047.66
3/4/2008 15:00	9.73	4.12	1.25	2.04	386.4	11.26	0.59	6.65	1993.57
3/4/2008 15:05	9.75	4.12	1.25	2.04	377.8	11.26	0.58	6.49	1947.07
3/4/2008 15:10	9.76	4.07	1.24	2.03	368.8	11.16	0.56	6.27	1882.00
3/4/2008 15:15	9.77	4.09	1.24	2.03	368	11.20	0.56	6.28	1884.26
3/4/2008 15:20	9.78	4.07	1.24	2.03	359	11.16	0.55	6.10	1829.48
3/4/2008 15:25	9.79	4.03	1.23	2.02	357.1	11.09	0.54	6.02	1806.59
3/4/2008 15:30	9.8	4.03	1.23	2.02	345.3	11.09	0.52	5.81	1743.80
3/4/2008 15:35	9.8	4.02	1.22	2.01	347.6	11.07	0.53	5.84	1752.95
3/4/2008 15:40	9.81	4	1.22	2.01	329.7	11.03	0.50	5.51	1652.02
3/4/2008 15:45	9.82	4	1.22	2.01	333.2	11.03	0.50	5.57	1670.55
3/4/2008 15:50	9.83	3.98	1.21	2.00	327.6	10.99	0.50	5.45	1635.10
3/4/2008 15:55	9.84	3.98	1.21	2.00	312.9	10.99	0.47	5.19	1557.56
3/4/2008 16:00	9.85	3.96	1.20	1.99	313.1	10.95	0.47	5.18	1553.09
3/4/2008 16:05	9.86	3.94	1.20	1.99	303.6	10.91	0.46	4.99	1497.80
3/4/2008 16:10	9.87	3.95	1.20	1.99	294.1	10.93	0.44	4.84	1450.63
3/4/2008 16:15	9.88	3.94	1.20	1.99	291.5	10.91	0.44	4.78	1434.43
3/4/2008 16:20	9.89	3.92	1.19	1.98	285.1	10.87	0.43	4.65	1395.91
3/4/2008 16:25	9.9	3.92	1.19	1.98	277.1	10.87	0.42	4.51	1354.16
3/4/2008 16:30	9.91	3.9	1.19	1.98	272.5	10.83	0.41	4.42	1325.38
3/4/2008 16:35	9.92	3.88	1.18	1.97	271.4	10.79	0.41	4.38	1314.91
3/4/2008 16:40	9.92	3.9	1.19	1.98	272.3	10.83	0.41	4.41	1324.34
3/4/2008 16:45	9.93	3.89	1.18	1.97	258.5	10.81	0.39	4.17	1250.33
3/4/2008 16:50	9.94	3.87	1.18	1.97	252.1	10.78	0.38	4.04	1212.72
3/4/2008 16:55	9.94	3.86	1.17	1.96	250.8	10.76	0.37	4.01	1203.81
3/4/2008 17:00	9.95	3.85	1.17	1.96	241.3	10.74	0.36	3.84	1152.68
3/4/2008 17:05	9.95	3.87	1.18	1.97	242.8	10.78	0.36	3.88	1164.62
3/4/2008 17:10	9.96	3.87	1.18	1.97	241.6	10.78	0.36	3.86	1158.41
3/4/2008 17:15	9.96	3.86	1.17	1.96	234.8	10.76	0.35	3.74	1121.21

3/4/2008 17:20	9.97	3.87	1.18	1.97	230.5	10.78	0.34	3.67	1101.00
3/4/2008 17:25	9.98	3.84	1.17	1.96	229.7	10.72	0.34	3.64	1090.91
3/4/2008 17:30	9.98	3.85	1.17	1.96	226.7	10.74	0.33	3.59	1077.44
3/4/2008 17:35	9.98	3.85	1.17	1.96	225.8	10.74	0.33	3.58	1072.80
3/4/2008 17:40	9.99	3.85	1.17	1.96	219.6	10.74	0.32	3.47	1040.85
3/4/2008 17:45	9.99	3.84	1.17	1.96	218.7	10.72	0.32	3.45	1034.33
3/4/2008 17:50	9.99	3.84	1.17	1.96	216.8	10.72	0.32	3.42	1024.56
3/4/2008 17:55	10	3.83	1.16	1.95	213.2	10.70	0.31	3.35	1004.21
3/4/2008 18:00	10	3.85	1.17	1.96	216.5	10.74	0.32	3.42	1024.87
3/4/2008 18:05	10	3.85	1.17	1.96	208.5	10.74	0.31	3.28	983.65
3/4/2008 18:10	10.01	3.84	1.17	1.96	207.8	10.72	0.30	3.26	978.26
3/4/2008 18:15	10.01	3.85	1.17	1.96	207	10.74	0.30	3.25	975.92
3/4/2008 18:20	10.01	3.83	1.16	1.95	203	10.70	0.30	3.17	951.83
3/4/2008 18:25	10.01	3.86	1.17	1.96	204.6	10.76	0.30	3.22	965.30
3/4/2008 18:30	10.02	3.84	1.17	1.96	202.1	10.72	0.30	3.16	948.94
3/4/2008 18:35	10.02	3.85	1.17	1.96	194.5	10.74	0.28	3.04	911.50
3/4/2008 18:40	10.02	3.85	1.17	1.96	195.6	10.74	0.28	3.06	917.17
3/4/2008 18:45	10.02	3.85	1.17	1.96	191.6	10.74	0.28	2.99	896.55
3/4/2008 18:50	10.03	3.86	1.17	1.96	195.2	10.76	0.28	3.06	916.77
3/4/2008 18:55	10.03	3.86	1.17	1.96	192	10.76	0.28	3.00	900.25
3/4/2008 19:00	10.03	3.85	1.17	1.96	185.5	10.74	0.27	2.88	865.12
3/4/2008 19:05	10.03	3.84	1.17	1.96	183.5	10.72	0.27	2.84	853.26
3/4/2008 19:10	10.03	3.85	1.17	1.96	186.6	10.74	0.27	2.90	870.79
3/4/2008 19:15	10.03	3.86	1.17	1.96	183.7	10.76	0.27	2.86	857.40
3/4/2008 19:20	10.03	3.87	1.18	1.97	178.7	10.78	0.26	2.78	833.09
3/4/2008 19:25	10.03	3.87	1.18	1.97	183	10.78	0.26	2.85	855.33
3/4/2008 19:30	10.03	3.87	1.18	1.97	177.8	10.78	0.26	2.76	828.43
3/4/2008 19:35	10.03	3.87	1.18	1.97	178.7	10.78	0.26	2.78	833.09
3/4/2008 19:40	10.03	3.86	1.17	1.96	180.6	10.76	0.26	2.80	841.39
3/4/2008 19:45	10.03	3.87	1.18	1.97	175.9	10.78	0.25	2.73	818.61
3/4/2008 19:50	10.03	3.87	1.18	1.97	180.6	10.78	0.26	2.81	842.92
3/4/2008 19:55	10.02	3.87	1.18	1.97	178.3	10.78	0.26	2.77	831.02
3/4/2008 20:00	10.03	3.87	1.18	1.97	178.4	10.78	0.26	2.77	831.54
3/4/2008 20:05	10.02	3.87	1.18	1.97	177.8	10.78	0.26	2.76	828.43
3/4/2008 20:10	10.02	3.88	1.18	1.97	177.3	10.79	0.26	2.76	827.34
3/4/2008 20:15	10.02	3.87	1.18	1.97	179.1	10.78	0.26	2.78	835.16
3/4/2008 20:20	10.02	3.87	1.18	1.97	175.5	10.78	0.25	2.72	816.54
3/4/2008 20:25	10.02	3.88	1.18	1.97	180.4	10.79	0.26	2.81	843.40
3/4/2008 20:30	10.01	3.87	1.18	1.97	175.3	10.78	0.25	2.72	815.50
3/4/2008 20:35	10.01	3.88	1.18	1.97	176.6	10.79	0.25	2.75	823.71
3/4/2008 20:40	10.01	3.84	1.17	1.96	180	10.72	0.26	2.78	835.26
3/4/2008 20:45	10	3.87	1.18	1.97	173.7	10.78	0.25	2.69	807.23

3/4/2008 20:50	10	3.88	1.18	1.97	175.7	10.79	0.25	2.73	819.05
3/4/2008 20:55	9.99	3.86	1.17	1.96	185.5	10.76	0.27	2.89	866.69
3/4/2008 21:00	9.98	3.88	1.18	1.97	182.4	10.79	0.26	2.85	853.77
3/4/2008 21:05	9.98	3.87	1.18	1.97	183.9	10.78	0.27	2.87	859.98
3/4/2008 21:10	9.97	3.86	1.17	1.96	182.2	10.76	0.26	2.83	849.65
3/4/2008 21:15	9.96	3.86	1.17	1.96	184.1	10.76	0.27	2.86	859.46
3/4/2008 21:20	9.96	3.85	1.17	1.96	182.2	10.74	0.26	2.83	848.11
3/4/2008 21:25	9.95	3.86	1.17	1.96	184.9	10.76	0.27	2.88	863.59
3/4/2008 21:30	9.94	3.86	1.17	1.96	184.5	10.76	0.27	2.87	861.53
3/4/2008 21:35	9.92	3.86	1.17	1.96	185.8	10.76	0.27	2.89	868.24
3/4/2008 21:40	9.91	3.84	1.17	1.96	183.5	10.72	0.27	2.84	853.26
3/4/2008 21:45	9.9	3.85	1.17	1.96	183	10.74	0.26	2.84	852.24
3/4/2008 21:50	9.89	3.85	1.17	1.96	180.6	10.74	0.26	2.80	839.87
3/4/2008 21:55	9.87	3.84	1.17	1.96	190.3	10.72	0.28	2.96	888.24
3/4/2008 22:00	9.86	3.84	1.17	1.96	187.7	10.72	0.27	2.92	874.86
3/4/2008 22:05	9.84	3.83	1.16	1.95	185.2	10.70	0.27	2.87	860.44
3/4/2008 22:10	9.83	3.84	1.17	1.96	185.5	10.72	0.27	2.88	863.55
3/4/2008 22:15	9.81	3.84	1.17	1.96	185.4	10.72	0.27	2.88	863.03
3/4/2008 22:20	9.8	3.83	1.16	1.95	181.9	10.70	0.26	2.81	843.49
3/4/2008 22:25	9.78	3.81	1.16	1.95	179.2	10.66	0.26	2.76	826.61
3/4/2008 22:30	9.76	3.82	1.16	1.95	182.3	10.68	0.26	2.81	844.01
3/4/2008 22:35	9.74	3.82	1.16	1.95	177.3	10.68	0.26	2.73	818.38
3/4/2008 22:40	9.72	3.8	1.16	1.95	181.3	10.64	0.26	2.79	835.82
3/4/2008 22:45	9.71	3.8	1.16	1.95	175.7	10.64	0.25	2.69	807.22
3/4/2008 22:50	9.69	3.8	1.16	1.95	176.9	10.64	0.25	2.71	813.35
3/4/2008 22:55	9.67	3.79	1.15	1.94	178.4	10.62	0.26	2.73	819.51
3/4/2008 23:00	9.65	3.79	1.15	1.94	175.8	10.62	0.25	2.69	806.25

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