Lake Decatur Watershed

Monitoring Summary – Year 1

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Contents

Cover page: Monitoring station installation at IL Route 32 Bridge, Upper Sangamon (photo credit: Miles Corcoran)

1. Introduction

Lake Decatur watershed water quality and streamflow monitoring was launched in the fall of 2020 with a primary objective to estimate sediment and nutrient yields entering the lake to support planning and operations. The monitoring enables the city to track changes over time, evaluate trends, and monitor progress towards improving the lake and watershed.

The monitoring program is being executed in partnership with the City of Decatur, University of Illinois (UIUC), the Illinois State Water Survey (ISWS) and the National Great Rivers Research and Education Center (NGRREC). The program is built upon other complimentary past and current activities in the watershed and lake.

Three categories of monitoring are differentiated:

1. Watershed and lake monitoring

Four permanent stations have been established/re-established for sediment and nutrient monitoring. The locations on the Upper Sangamon River, Long Creek and Friends Creek capture nearly 80% of the lake watershed. The in-lake station in upper Lake Decatur is managed by NGRREC and provides important lake health parameters and has data going back to 2015, its location in the lake does not support estimates of sediment and nutrient yields.

The City invested in the development of a sediment bedload monitoring program on the Upper Sangamon River at the USGS station at Monticello. The research is being led by Professor Bruce Rhoades at UIUC, and it is anticipated that the station will be up and running in the spring of 2022. Estimating the bedload proportion of sediment yield is a **significant data gap** in estimating total sediment delivery to the lake.

The City has re-established lake monitoring under the Volunteer Lake Monitoring Program (VLMP) and monitors nutrients, sediment, water clarity, dissolved oxygen and other lake health parameters.

2. Best Management Practice monitoring

Monitoring is undertaken at smaller watershed areas where high impact projects are anticipated to occur to reduce sediment and nutrient loading. So far two sites have been identified and monitoring has commenced, one site is the DeWitt Well Field and the other at a highly eroding ravine located between Lake Decatur and the airport.

3. Lake sediment monitoring

Lake bathymetry and sediment accumulation monitoring was initiated in October 2021 to track the loss of lake storage and capacity. Lake-wide mapping will be completed first and serve as a baseline condition from which all future measurements will be based. Bathymetry cross sections will be performed every 2-3 years to track sediment accumulation rates in areas throughout the lake. Dredged in-lake sediment traps at Sand Creek (Basin 1), Big Creek (Basin 1), and the upper lake (Basin 6) will receive priority.

This summary report presents provisional results from the watershed monitoring at three stream monitoring stations (Upper Sangamon River, Long Creek and Friends Creek) from November 2020 through November 2021. Bi-weekly monitoring was performed at these stations to document river stage, and collect waters samples for nutrient and sediment analysis. A continuous, real-time monitoring station was recently installed at the Upper Sangamon River station in partnership with NGGREC which monitors flow, nitrate, turbidity and other water quality parameters at 2 hour intervals. Continous flow monitoring sensors are being considerd for the Long Creek and Friends Creek stations.

2. Stream monitoring and data

Table 1 outlines the stream monitoring stations and the data collected. Flow data is utilized from the two USGS stations listed in Table 1 to support flow estimates at the ungauged stations. Table 2 further details the monitoring parameters and temporal resolution for each of the three stream stations and the Upper Lake Decatur in-lake station managed by NGRREC.

Table 1 – Watershed

Station ID	Name	Drainage Area	Data Monitored				
			Stage	Flow	Nutrients	Sediment	Other
101	Long Creek at South Twin Bridge Rd.	66.4 mi^2	X	X	X	X	X
102	Friends Creek at IL Route 48	26.0 mi^2	X	X	X	X	X
113	Upper Sangamon River at Route 32 (Cisco Bridge)	627.2 mi^2	X		X	X	X
05572000*	USGS – Sangamon River at Monticello	550 mi^2	X	X	X	X	X
05578100*	USGS – Salt Creek near Farmer City	111 mi^2	X	X	X	X	X

**only flow data is used from these USGS stations in this summary report*

Table 2 – Water Quality Monitoring Parameters and Temporal Resolution

Parameter		Station			
		101 – Long Creek	**102 – Friends Creek**	**113 – Sangamon River[1]**	**SRLK_UpperDecatur**
Nitrate-N	laboratory	Bi-weekly & storm-events			--
	sensor	--	--	Continuous (2 hr.)	Continuous (2 hr.)
Total Phosphorus	laboratory	Bi-weekly & storm-events			--
Suspended Sediment Concentration (SSC)	laboratory	Bi-weekly & storm-events			--
Specific Conductance / Conductivity	In-situ	Bi-weekly & storm-events			Continuous (2 hr.)
	sensor	--	--	Continuous (2 hr.)	Continuous (2 hr.)
Temperature	In-situ	Bi-weekly & storm-events			
	sensor	--	--	Continuous (2 hr.)	Continuous (2 hr.)
Turbidity	In-situ / laboratory	Bi-weekly & storm-events			--
	sensor	--	--	Continuous (2 hr.)	Continuous (2 hr.)
pH	In-situ	Bi-weekly & storm-events			--
Dissolved Oxygen	Sensor	--	--	--	Continuous (2 hr.)
Blue-green Algae	Sensor	--	--	--	Continuous (2 hr.)
Dissolved Organic Matter	Sensor	--	--	--	Continuous (2 hr.)
1 – Continuous monitoring at station 113 planned to commence in 2021 in conjunction with USDA grant program					

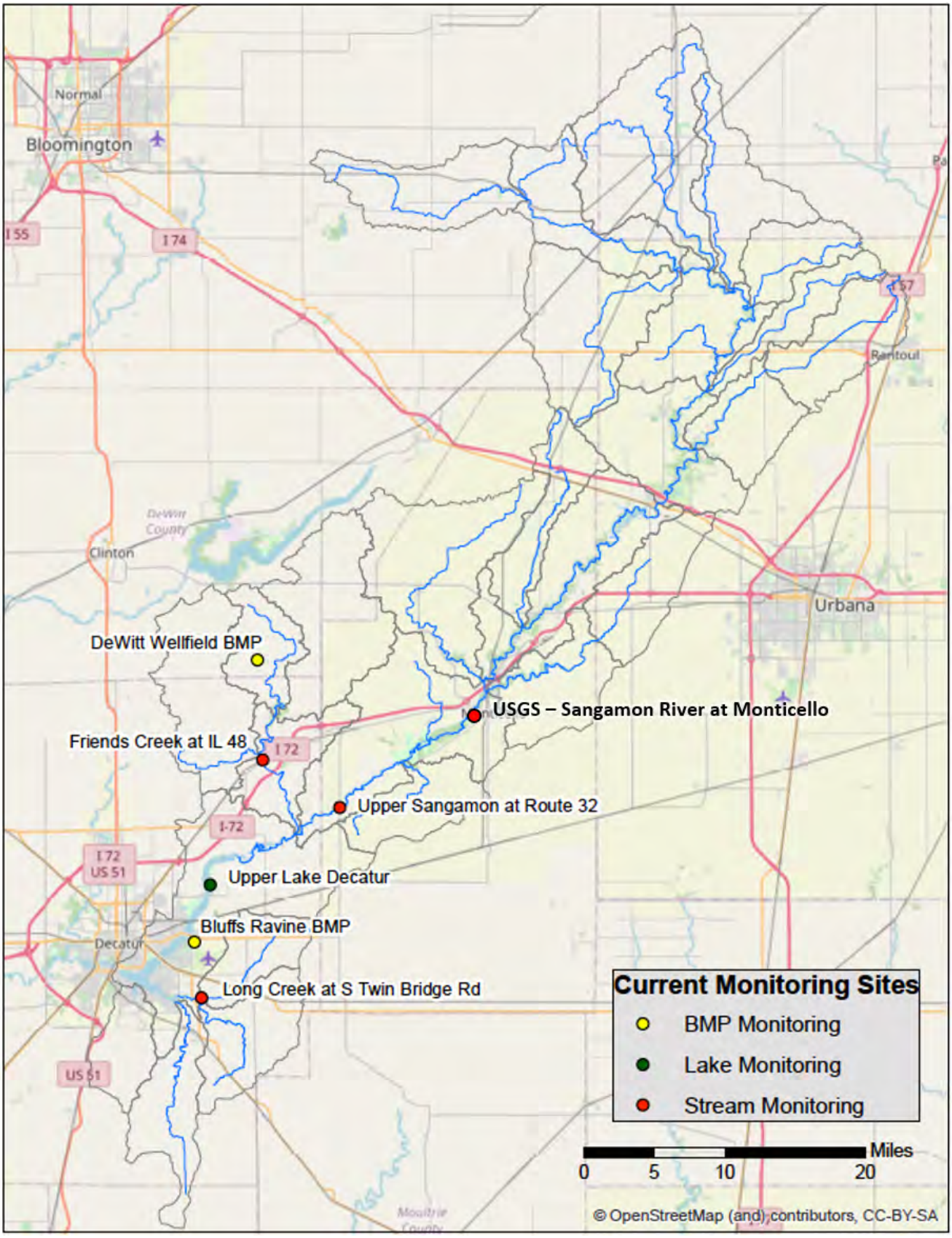


Figure 1 – Current watershed monitoring stations

3. Flow Data

The USGS station located on the Upper Sangamon River at Monticello provides historical daily flow and annual statistics dating back to 1909. Figure 2 presents average annual streamflow over the last 30 years, and statistics are presented in Table 3.

Based on data from the USGS station at Monticello, the 2020-2021 year of monitoring reported an average flow of 464 cfs, which is below the 30-year average of 509 cfs. The first year of monitoring data captures a below average water year resulting also in below average sediment and nutrient yields.

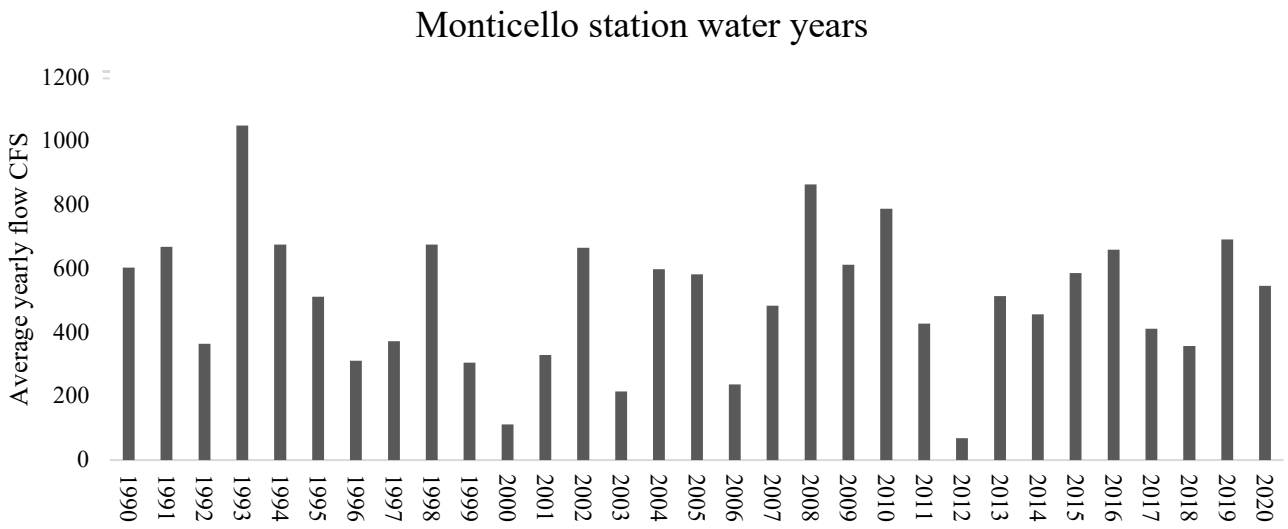


Figure 2 – Average Water Year average flow from 1990 to 2020.

Table 3 – Summary Statistics of Upper Sangamon River Flow at Monticello USGS station, 1990 – 2020

1990-2020 Flow Statistics (cfs)							
25% percentile:	362	Average:	509	Median:	516	75% percentile:	665

The City's new Upper Sangamon station at the Route 32 bridge (station 113) is located downstream from the Monticello USGS station, is closer to the lake and captures 15% more watershed area. Flow was estimated for station 113 using a watershed area correction method applied to flows recorded at the upstream USGS gage (Equation 1). At station 113, river stage height is monitored bi-weekly, and direct flow measurements at station 113 have recently commenced. Future analysis and estimates of sediment and nutrient yield at station 113 will benefit from direct measurements.

$$Flow\ at\ 113 = \frac{Flow\ at\ Monticello}{Monticello\ drainage\ area} \times 113\ drainage\ area, \quad \boldsymbol{Eq.1}$$

Flow and stage height data was measured at Friends Creek (station 102) and Long Creek (station 101). Flow measurements were measured manually on several occasions to support establishing a rating curve,

a relationship between river height and flows. For this report, the rating curves were provided by the ISWS based on historical monitoring. These rating curves were applied to derive flows when direct flow measurement was not made (Figure 3).

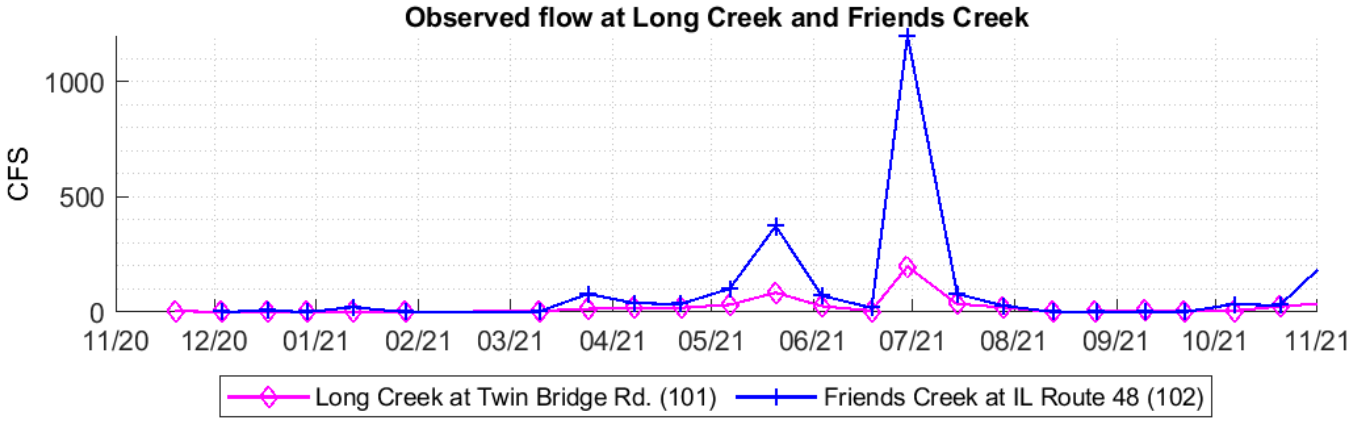
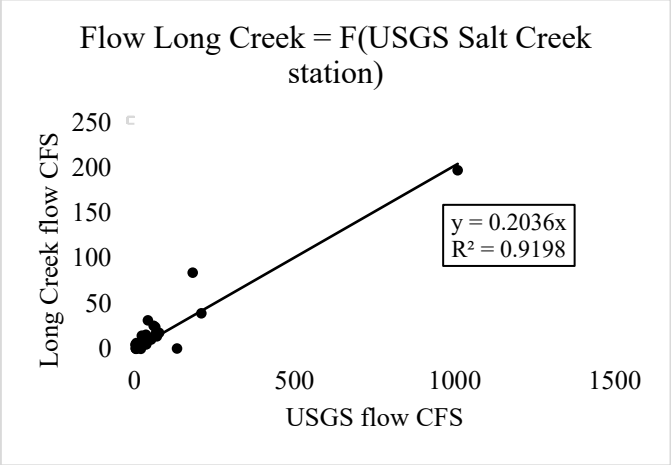


Figure 3 – Combination of measured flow and estimated flow using the rating curve at Long Creek and Friends Creek

Daily flows for Long Creek and Friends Creek were established using the nearby USGS station on Salt Creek near Farmer City (USGS 05578100). This station has a smaller watershed area (111.63 mi^2) than the Monticello station and better correlates with Friends Creek and Long Creek flows (Figure 4). Figure 5 presents the interpolated annual flows at Long Creek and Friends Creek in logarithmic and linear scales.



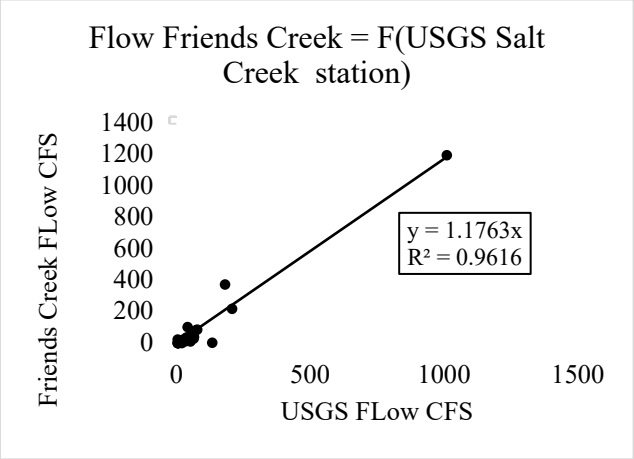


Figure 4 – Flow Relationship Between Long and Friends Creek with Salt Creek

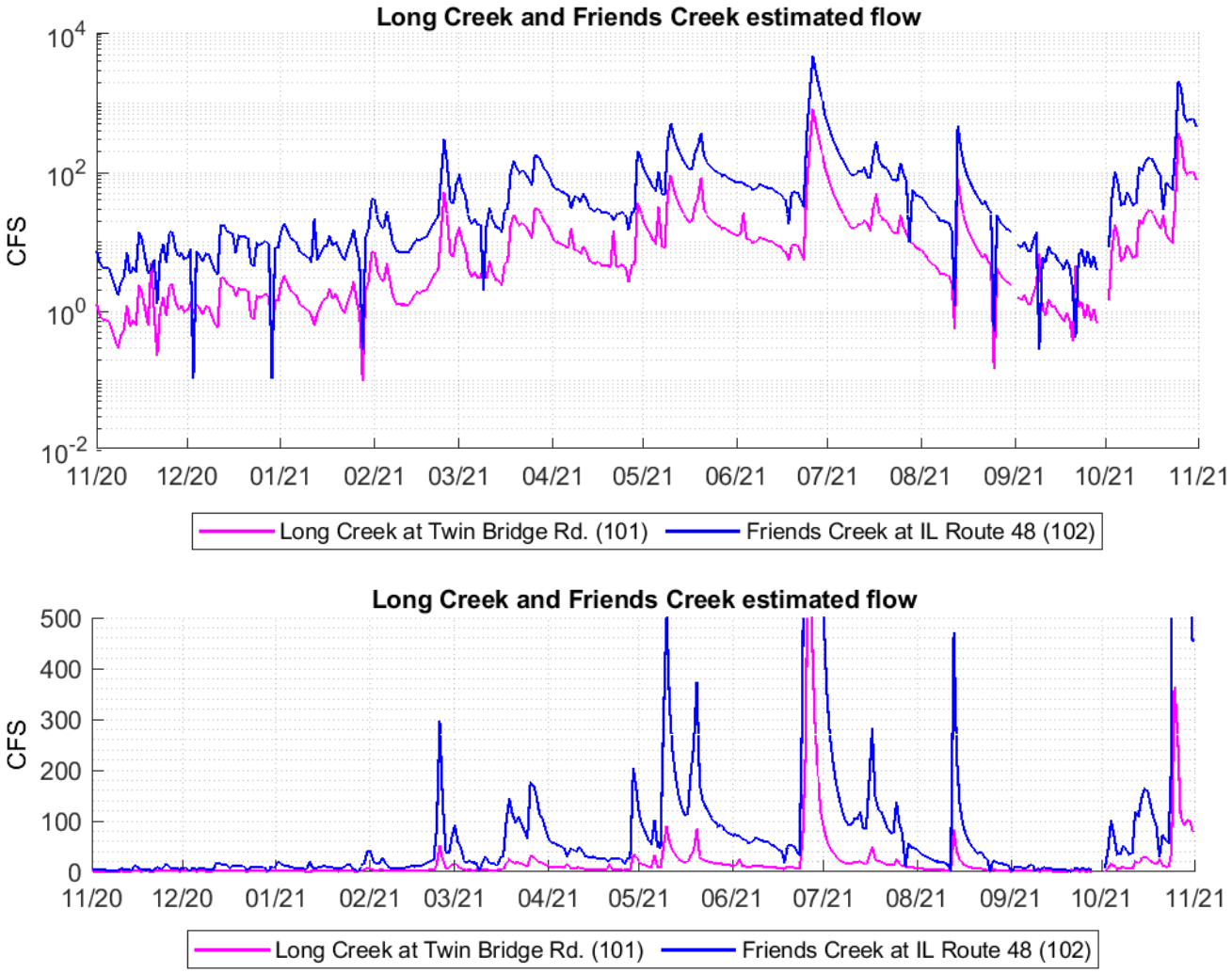


Figure 5 – Estimated flow at Friends Creek and Long Creek calibrated on Salt Creek data. (Upper graph has a log scale , lower graph has a linear scale.)

Table 4 presents the difference between median and mean flow values. The large difference between the statistics indicates that high flow events have an important influence on the estimation of the total volume, and also the sediment and nutrient yields.

Table 4 – Mean and Median flow at Long Creek and Friends Creek

Flow in CFS	Median	Mean
Long Creek (101)	5	19
Friends Creek (102)	27	106

4. Nitrate Data

Nitrate results from the three stations is presented in Figure 6 and summarized in Table 5. There were 21 sampling events, the 10 mg/L standard was exceeded at all three stations in mid-May and also at Long Creek in early-June. Friends Creek reported the highest concentration (12.08 mg/L), and also had the highest average (4.24 mg/L) over the first year of monitoring.

The March and May/June nitrate increases correspond to higher flow periods during/after nutrient application on agricultural lands in the watershed. There were not significant storm/runoff events in the spring and early summer as is typical (Figure 7). The largest storm events were in the summer and fall.

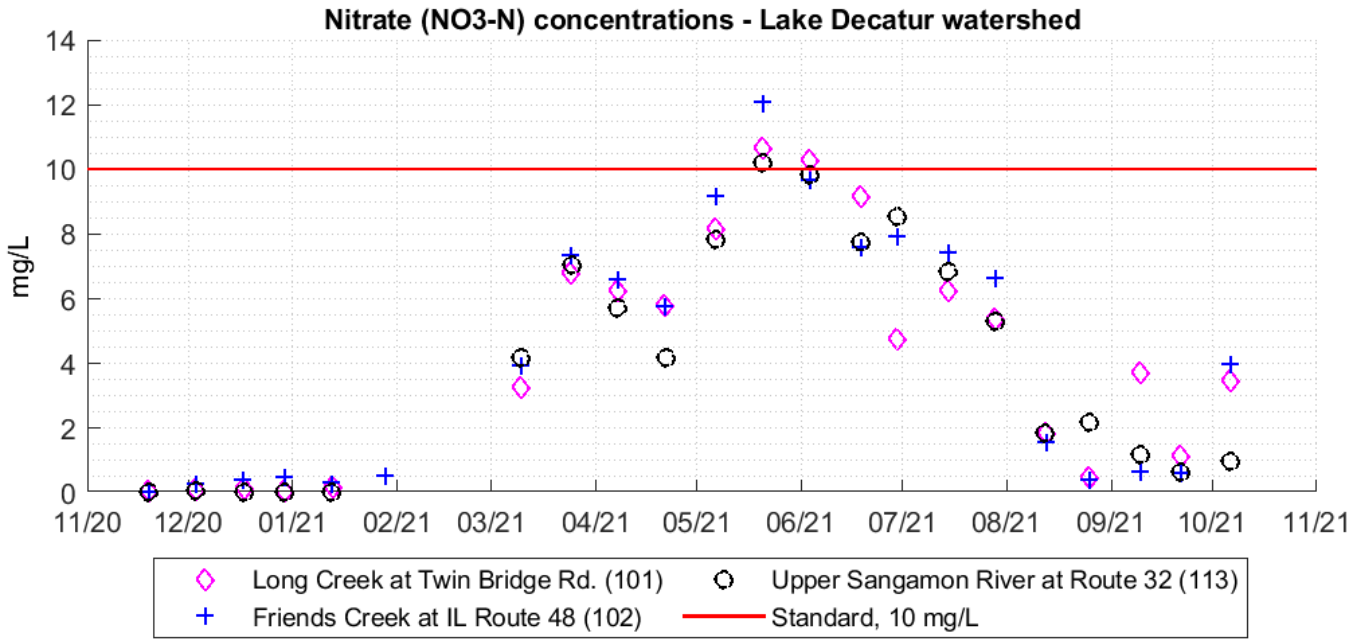


Figure 6 – Nitrate concentrations at the three stations compared to the drinking water standard

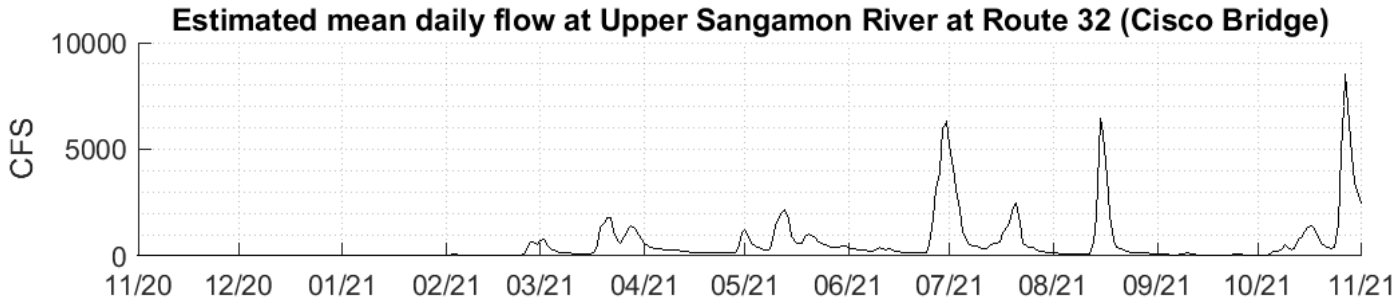


Figure 7 – Estimated flow at station 113 based on the USGS automatic station

Table 5 – Summary statistics of nitrate concentrations 2020 - 2021

ID	Period	# samples	Avg.	Min	Median	95th Percentile	Max	# above standard	%above standard
101	11/20/2020 – 10/21/20	21	4.19	0.05	3.72	10.45	10.67	2	9.5%
102	11/20/2020 – 10/21/20	22	4.24	0.04	3.95	10.63	12.08	1	4.5%
113	11/20/2020 – 10/21/20	21	4.02	0.02	4.16	9.99	10.18	1	4.8%

101: Long Creek at South Twin Bridge Rd.
102: Friends Creek at IL Route 48
113: Upper Sangamon River at Route 32 (Cisco Bridge)

5. Phosphorus Data

Total phosphorus results from the three stations are presented in Figure 8 and Table 6. There were only four sampling events starting in August 2021, all samples were above the 0.05 mg/L standard for lakes (for reference purposes). Long Creek reported the highest values and had a high range between 0.257 mg/L and 0.082 mg/L. Phosphorus analysis will be expanded upon after a complete year of data is captured.

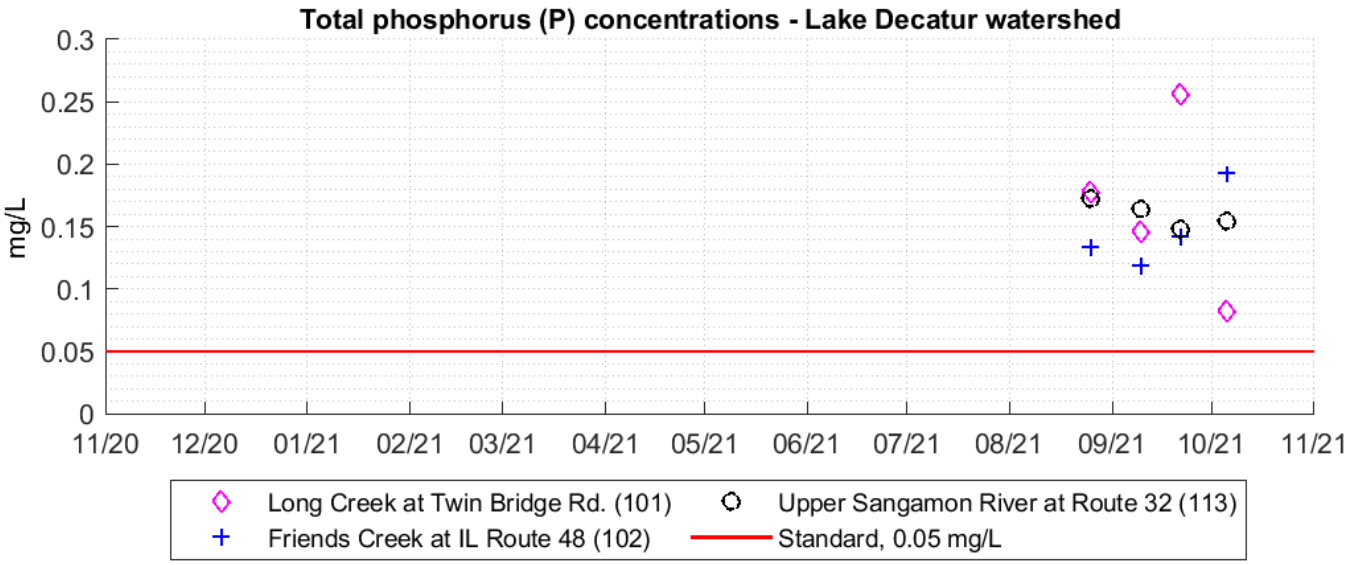


Figure 8 – Phosphorus concentrations at the three stations compared to the 0.05 mg/L standard for lakes

Table 6– Summary statistics of total phosphorus concentrations 2020 - 2021

ID	Period	# of samples	Avg.	Min	Median	95th Percentile	Max	# above standard	%above standard
101	08/2021 – 10/2021	4	0.166	0.082	0.162	0.257	0.257	4	100%
102	08/2021 – 10/2021	4	0.146	0.118	0.137	0.192	0.192	4	100%
113	08/2021 – 10/2021	4	0.160	0.148	0.159	0.172	0.172	4	100%

101: Long Creek at South Twin Bridge Rd.
102: Friends Creek at IL Route 48
113: Upper Sangamon River at Route 32 (Cisco Bridge)

6. Suspended Sediment Data

Suspended sediment concentration (SSC) results from the three stations are presented in Figure 9 and summarized in Table 7. There were 36 to 38 sampling events, the highest flow peaks are not represented by the dataset. These are the events that typically transport the majority of the annual sediment load, and capturing these events will be a focus of 2022 sampling.

SSC concentrations vary along the year and generally correlate to seasonality and flows. SSC concentrations were highest at Friends Creek (102) and lowest at the Upper Sangamon station (113). Interestingly, higher concentrations were found during winter months when flows were particularly low, perhaps due to less dilution in the waters. It is important to note that SSC concentrations do not equate to yield or loading.

A focus of 2022 monitoring will be to capture more storm and flood events, especially during the spring and early summer.

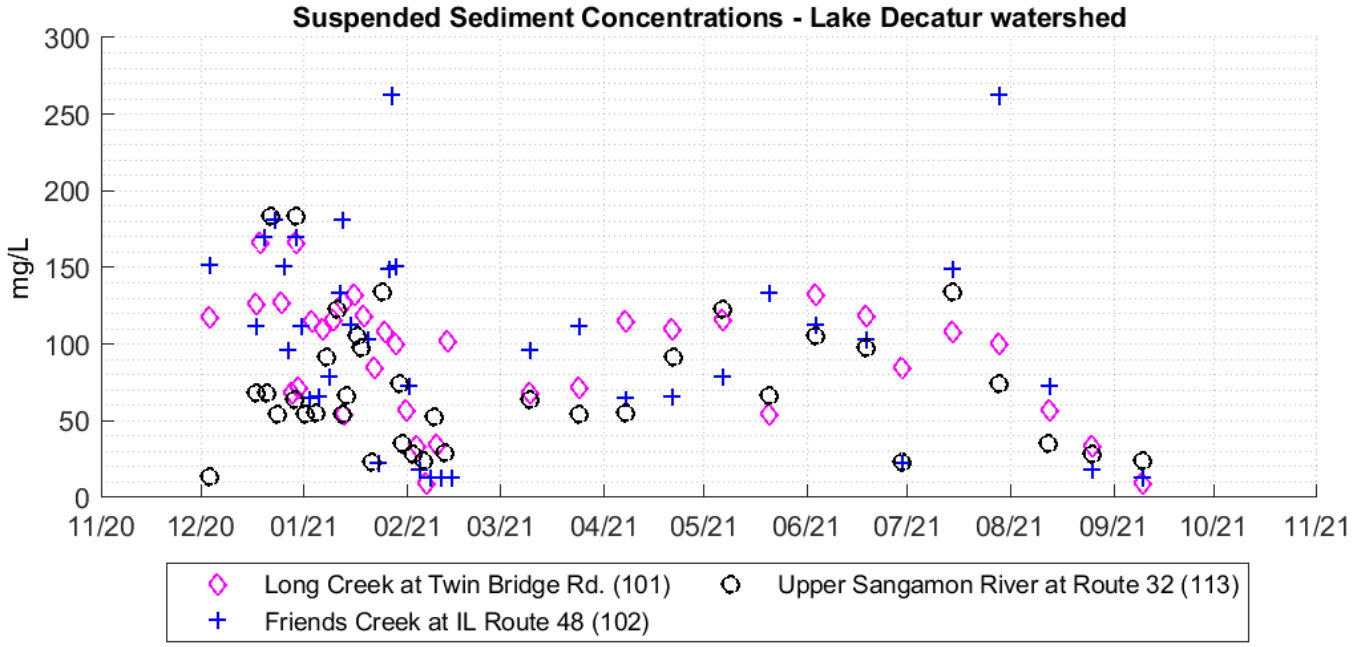


Figure 9– Suspended sediment concentrations at the three stations

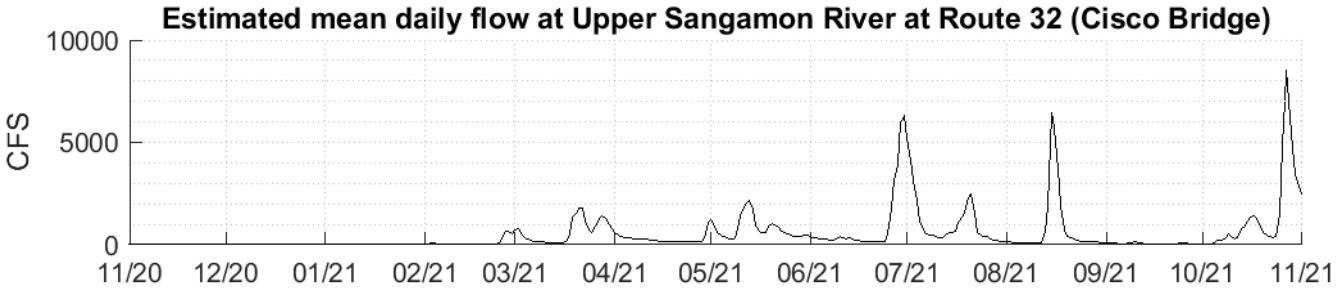


Figure 10 – Estimated flow at the Upper Sangamon station at Route 32 bridge (station 113)

Table 7 – Summary statistics of suspended sediment concentrations 2020 - 2021

ID	Period	# of samples	Average	Min	Median	95th Percentile	Max
101	12/2020 – 09/2021	36	92.2	9.3	104.7	155.9	166.3
102	12/2020 – 09/2021	38	102.4	12.4	103.0	229.6	262.3
113	12/2020 – 09/2021	37	71.8	13.6	63.7	166.0	183.2

6.1 Sediment Yields

Provisional sediment yield estimates are made for the three stations representing 80 % of the Lake Decatur watershed based on the first year of monitoring. It is important to note that these estimates are provisional and are limited in several ways: (i) flow estimates are interpolated, (ii) large storm / runoff events are not well represented by the datasets, (iii) a majority of bedload is not directly measured and is thereby estimated. The method also uses a standard rating curve as there is insufficient SSC data to represent all of the individual runoff and storm events.

It is also important to note that the first year of monitoring had a below average water year, and there was not a major storm/runoff event in the spring / early summer. These factors result in the 2021 water year likely having lower sediment yields that typical.

Sediment yield estimates are calculated from the SSC concentration and flow data, using the following equations:

$$Concentration\left(\frac{mass}{volume}\right) \times Flow\left(\frac{volume}{time}\right) = Loading\left(\frac{mass}{time}\right) \quad , \qquad \boldsymbol{Eq.2}$$

6.1.1 Upper Sangamon (station 113)

Yu (2018) produced a rating curve between sediment loading and flow at the USGS station at Monticello as part of his PhD thesis:

$$\log(Q_s) = 1.04 \times \log(Q_w) + 0.87 \quad , \boldsymbol{Eq.3}$$

where:
Qs = sediment loading tons/day
Qw = discharge (m^3/s)

Figure 11 presents daily sediment yield estimates for station 113 using this relationship which estimates a total of **54,395** tons of sediment yield between November 1, 2020 and October 31, 2021, this includes a 15% bedload factor. Upwards of 2,000 tons/day of sediment loading are estimated during larger flow / runoff events.

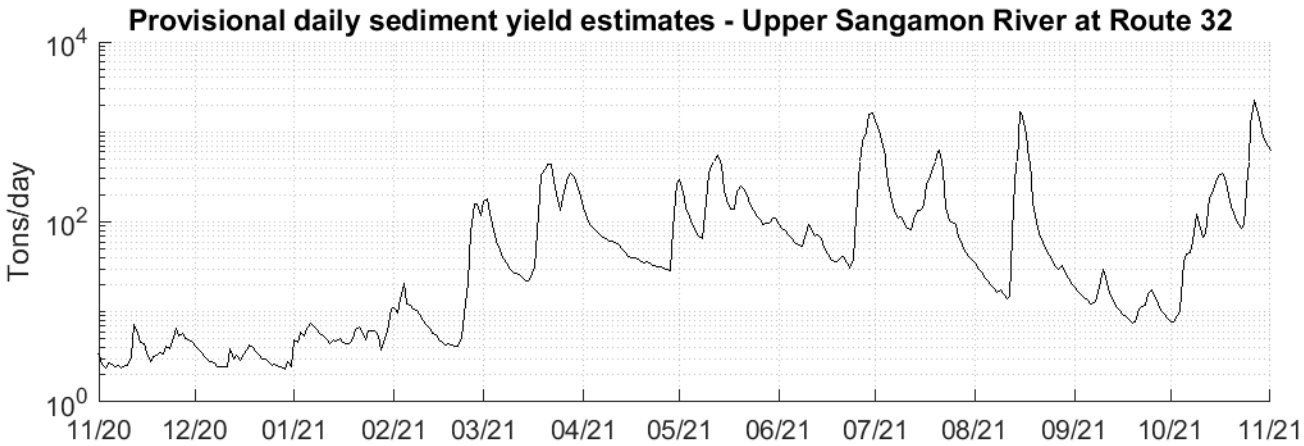


Figure 11 – Sediment loading estimated based on Yu (2018) rating curve

A rating curve specifically for station 113 is still in development, there is not yet sufficient data representing higher flows since there has only been one year of monitoring so far. Figure 12 shows a preliminary rating curve using SSC and interpolated flow. Applying this relationship estimates a total of **28,750** tons of sediment yield between November 1, 2020 and October 31, 2021, this includes a 15% bedload factor.

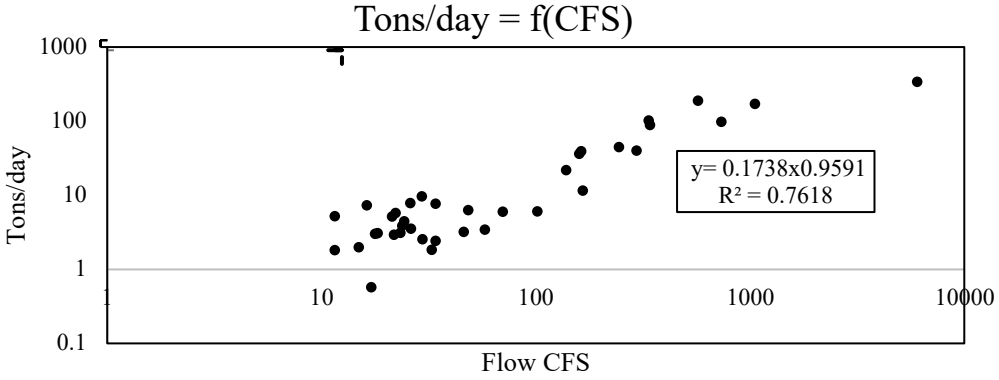


Figure 12 – Relationship between loading and flow at Sangamon station based on 2020 and 2021 available data

$$\log(Q_s) = 0.9591 \times \log(Q_w) - 0.75995 \quad , \boldsymbol{Eq.4}$$

where:
Qw: discharge in CFS
Qs: Loading in tons/day

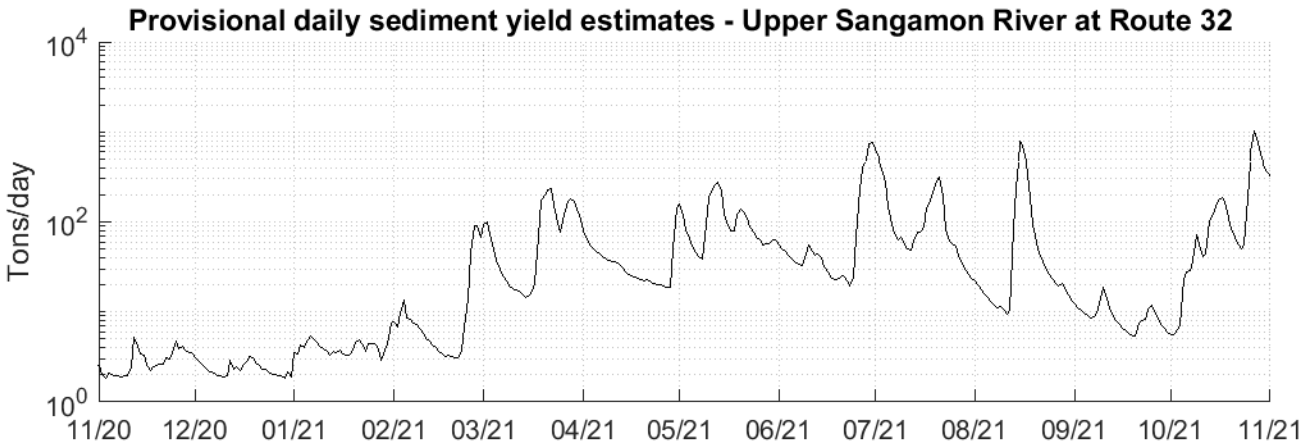


Figure 13 – Sediment loading estimated based on provisional rating curve at station 113

6.1.2 Long Creek and Friends Creek (stations 101 and 102)

Long Creek and Friends Creek sediment loading estimates are also made using a similar method and the preliminary rating curves are presented in Figure 14. Equation 5 and 6 were applied to derive daily and annual sediment loading estimates.

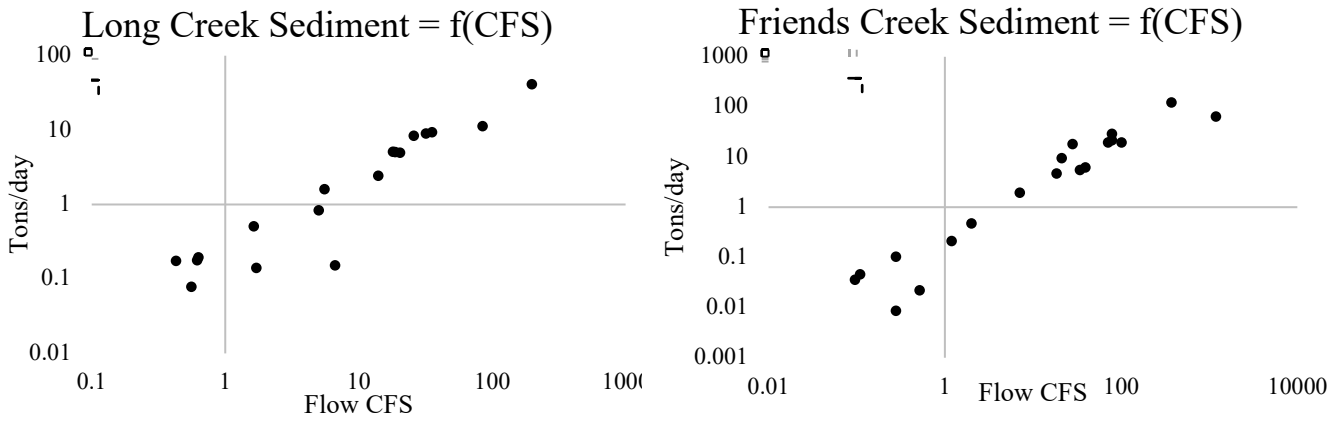


Figure 14 – Preliminary sediment flow rating curves for Long Creek and Friends Creek

$$\log(Q_{101s}) = 0.9843 \times \log(Q_{101w}) - 0.6824\,, \boldsymbol{Eq.5}$$

Qw: discharge in CFS
Qs: Loading in tons/day

$$\log(Q_{102s}) = 1.0147 \times \log(Q_{102w}) - 0.6910\,, \boldsymbol{Eq.6}$$

Qw: discharge in CFS
Qs: Loading in tons/day

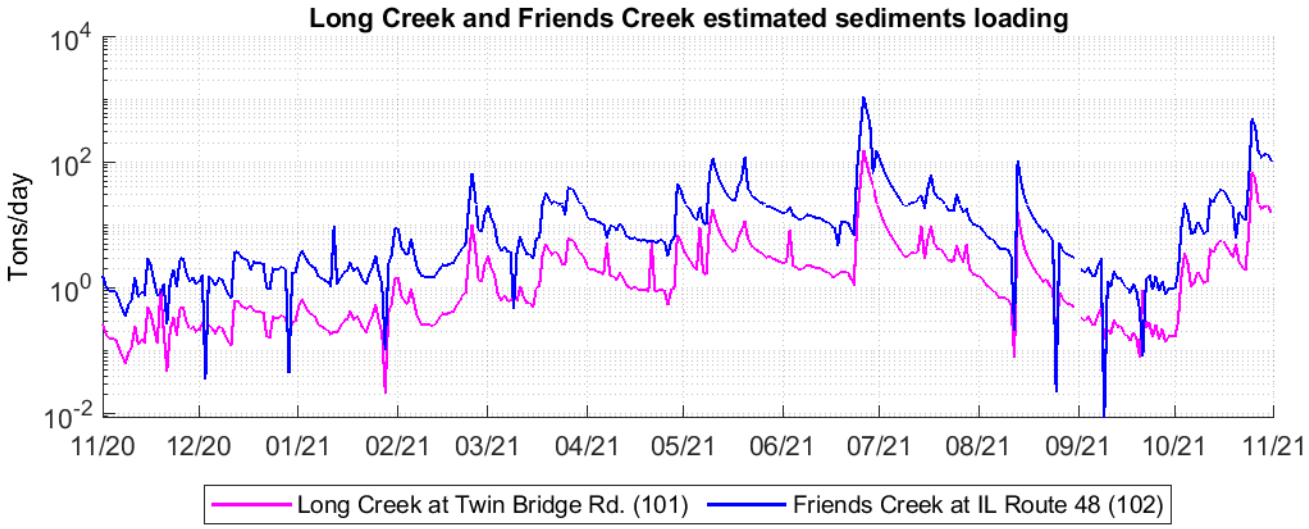


Figure 15 – Estimated sediment loading from Long and Friends Creeks

Figure 15 presents the daily sediment yield estimates for the monitoring period which estimates a total of **9,960** tons and **7,820** tons at Friends Creek and Long Creek, respectively between November 1, 2020 and October 31, 2021. These values include a 15% bedload factor.

7. Conclusions

The first year of watershed monitoring has established three important stations on the Upper Sangamon River, Long Creek and Friends Creek capturing important baseline data at bi-weekly temporal resolution to improve characterization of sediment and nutrient loading to Lake Decatur. Continuous real-time monitoring at the Upper Sangamon station commenced in late 2021 in partnership with NGRREC. This station will record nitrate, turbidity, flow and other water quality parameters at 2-hour intervals and is equipped with a telemetry system to observe data in real-time. Continuous flow monitoring sensors are being considered for the Long Creek and Friends Creek stations.

In 2020/2021, nitrate concentrations in the watershed exceeded the state drinking water standard for a short period in May and June but otherwise was below the standard for the remainder of the year. However, nitrate concentrations did regularly exceed the 3.8 mg/L Illinois Nutrient Science Advisory Committee (INSAC) guideline for wadable streams in the northern ecoregion, the average nitrate concentration at all three stations exceeded 4.0 mg/L. Total phosphorus concentrations in the watershed exceeded the state standard for lakes (0.05 mg/L) at all stations and all four sampling events. All of the phosphorus results except for one event at Long Creek had concentrations that exceeded the INSAC guideline of 0.113 mg/L for rivers the northern ecoregion.

Suspended sediment concentrations were highest at Friends Creek, the average concentration was 102.4 mg/L and the maximum values exceeded 260 mg/L during storm events in the winter and summer. Although there is no regulatory sediment standard for rivers and streams in Illinois, the IEPA has a statistical guideline of 116 mg/L for streams which is an indicator of conditions to support aquatic life. All three stations had average concentrations below 116 mg/L, however, all stations regularly exceeded this value during runoff / storm events.

Provisional sediment yield estimates were made for the 2020/2021 monitoring period based on the station specific sediment data and mean daily flows interpolated from nearby USGS stations. Those provisional estimates are outlined below for the period of 11/1/2020 – 10/31/2021.

- 28,750 – 54,395 tons: Upper Sangamon River at Route 32 bridge
- 9,960 tons: Friends Creek at IL Route 48
- 7,820 tons: Long Creek at Twin Bridge Rd.

Provisional estimates suggest sediment yield in the range of 46,530 – 72,175 tons from 80% of the Lake Decatur watershed during the first year of monitoring. Extrapolating to the remaining 20% of the watershed suggests sediment yield during this period in the range of 55,836 – 86,610 tons. Based on this data, Friends Creek had the highest loading per unit area (0.60 tons/acre/yr) and the Upper Sangamon had the lowest (0.07 – 0.135 tons/acre/yr). This is expected, as the smaller watershed has a steeper gradient and more efficient sediment transport whereas the Upper Sangamon at Route 32 is a much larger river system with a lower gradient and more complex sediment storage and transport dynamics.

Based on a dredging cost of $10.23/ton ($8.28/yd^3) estimated from the City's recent dredging program, $570,000 – $886,000 worth of sediment may have been transported in the first year of monitoring.

It is important to note that these estimates are provisional and are limited in several ways: (i) flow estimates are interpolated using correlation with other stations, (ii) large storm / runoff events are not well represented by the datasets, (iii) a majority of bedload is not directly measured and is thereby assumed at 15% for now. The method also uses a standard rating curve as there is insufficient SSC data to represent all of the individual runoff and storm events through the year.

Also, the first year of monitoring exhibited a below average water year, and there was not a major storm/runoff event in the spring / early summer. These factors result in the 2021 water year likely having lower sediment yields than typical or average.

Sediment yield estimates will improve as the monitoring program is refined, advances and more data are collected. The bedload monitoring program led by UIUC for the Upper Sangamon River will start in 2022 and will support more accurate estimates of bedload, which may significantly affect sediment load estimates. There will be greater focus on capturing large storm / runoff events which are responsible for large proportions of annual sediment loads. Lastly, direct monitoring of stream flow at the three stations will enable more accurate estimates of loading and not rely on extrapolation from nearby USGS stations.