Changes in suspended sediment transport in the Town Creek Watershed: interpretation of sediment rating curves

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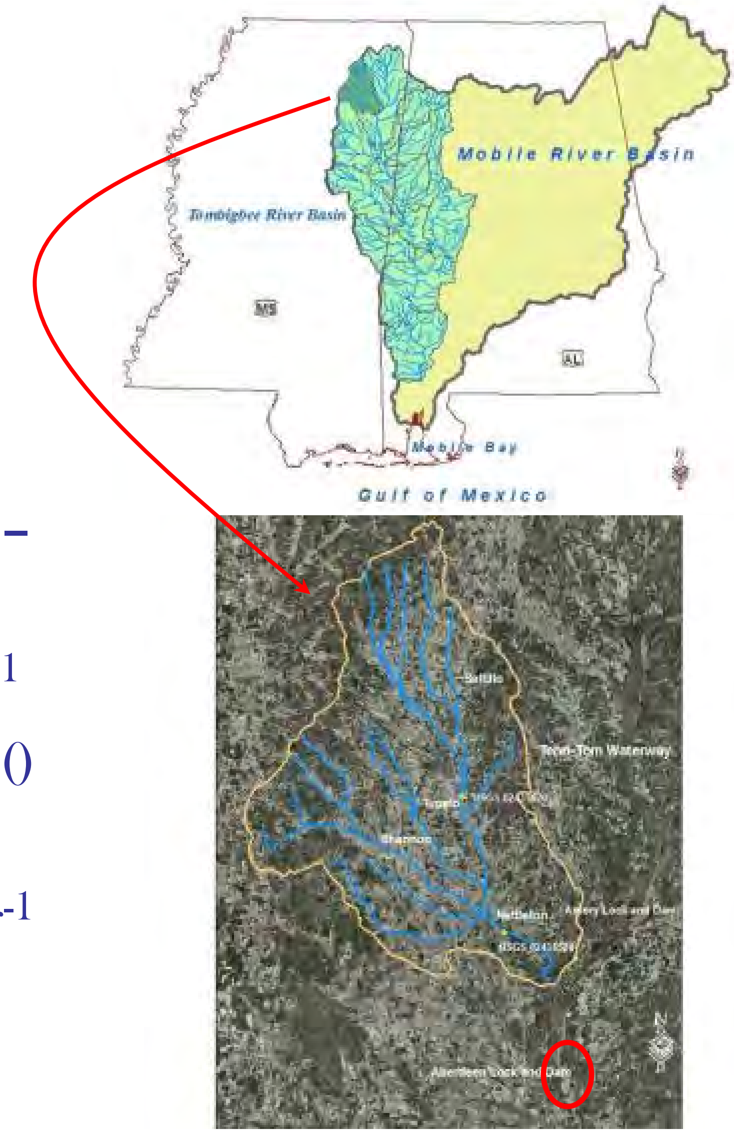
Town Creek Watershed

- Located in the northeastern part of Mississippi within the Southeastern Plains Ecoregion or Ecoregion 65
- Area: 1769 km^2
- 50% upper Tombigbee River basin – Aberdeen Pool on TTW
- Estimated TCW Q_s: 320000 Mg yr^{-1}
- Estimated deposition on AP: 570000 Mg yr^{-1}
- Annual dredging AP: 280000 Mg yr^{-1}



Town Creek Watershed

- MDEQ – MS 2010 Section 303 (d) list of impaired waterbodies from headwater to mouth at the Tombigbee River
- 2006 TMDL – streams located near cultivated lands, road crossings and construction activities – priority for streambank and riparian buffer zone restoration and Q_s reduction

Justification

- To develop remedial measures and future BMPs within the Town Creek watershed for reducing water quality impairment and dredging costs (expressed in terms of a percent reduction of sediment loads), it is necessary to identify the sediment sources and loads currently transported within the watershed.

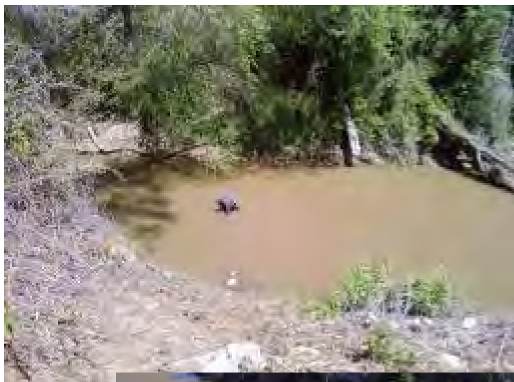
Hypothesis

- Streambank erosion is an important mechanism driving sediment supply in the Town Creek watershed, a representative area within the Southeastern Plains Ecoregion in Mississippi (also identified as Ecoregion 65)

Suspended Sediment Transport Analysis

- To identify trends and possible mechanisms driving sediment supply and exportation by evaluating spatial and temporal variation of suspended sediment yields and loads
- To determine the relations among the sediment rating parameters, suspended sediment load trends, channel evolution and watershed characteristics, in order to identify trends and possible mechanisms driving sediment supply and exportation

Analysis Procedure



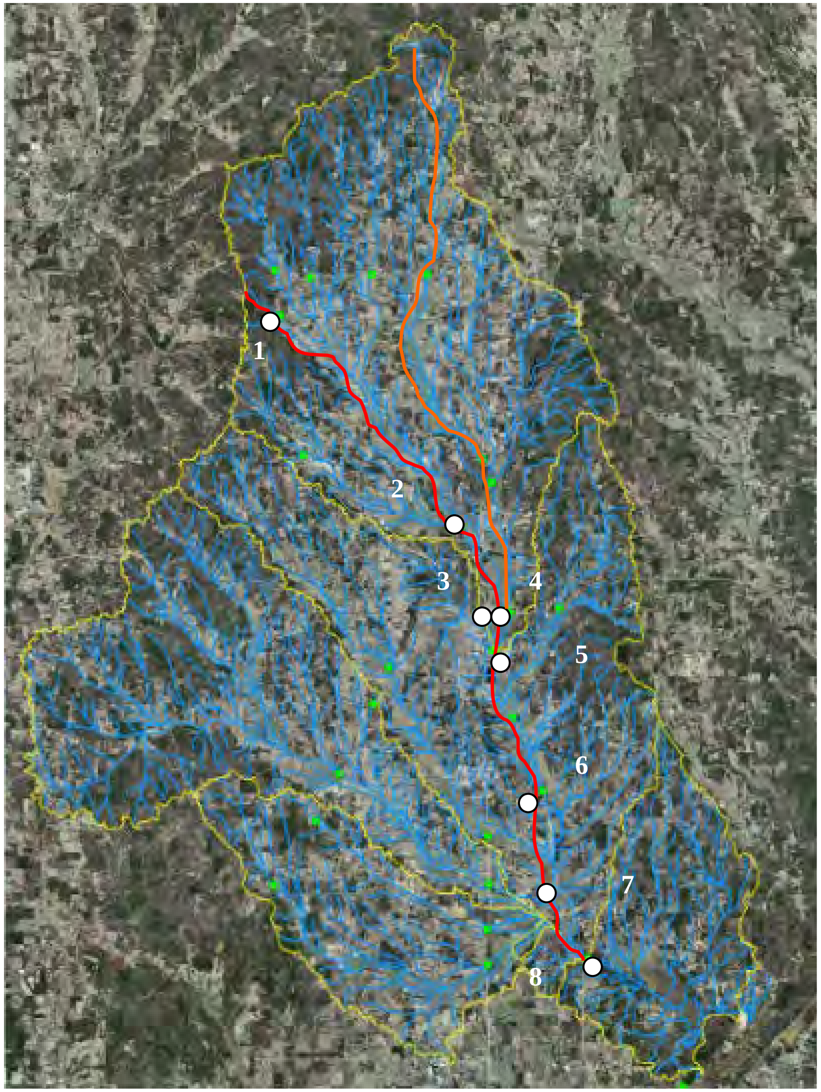
- Variation of suspended sediment loads and yields on 7 stations along the principal channel
- Determined time trends and possible relationships between parameters in the different suspended sediment transport rating relations

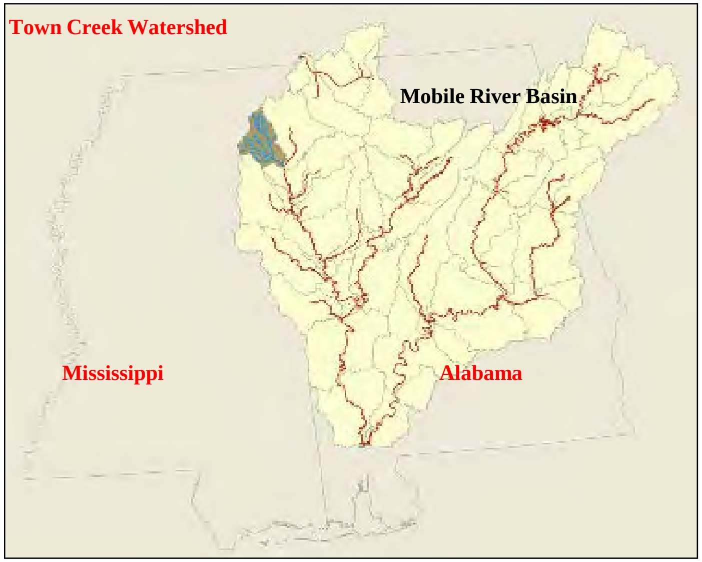
Methods

- Spatially distributed grab sampling
  - Biweekly (May 2008 – May 2009)
  - 7 stations along principal channel
  - Stream velocity (Son Tek Flow)

Methods

- Automatic stream water sampling at 1 automatic monitoring station
  - Daily (February 2009 – May 2009)
  - ISCO model 2700 Station #8 (USGS station 02436500)
- Collection USGS database information for Q, SSC (1980 - 1995)





Grab sampling stations

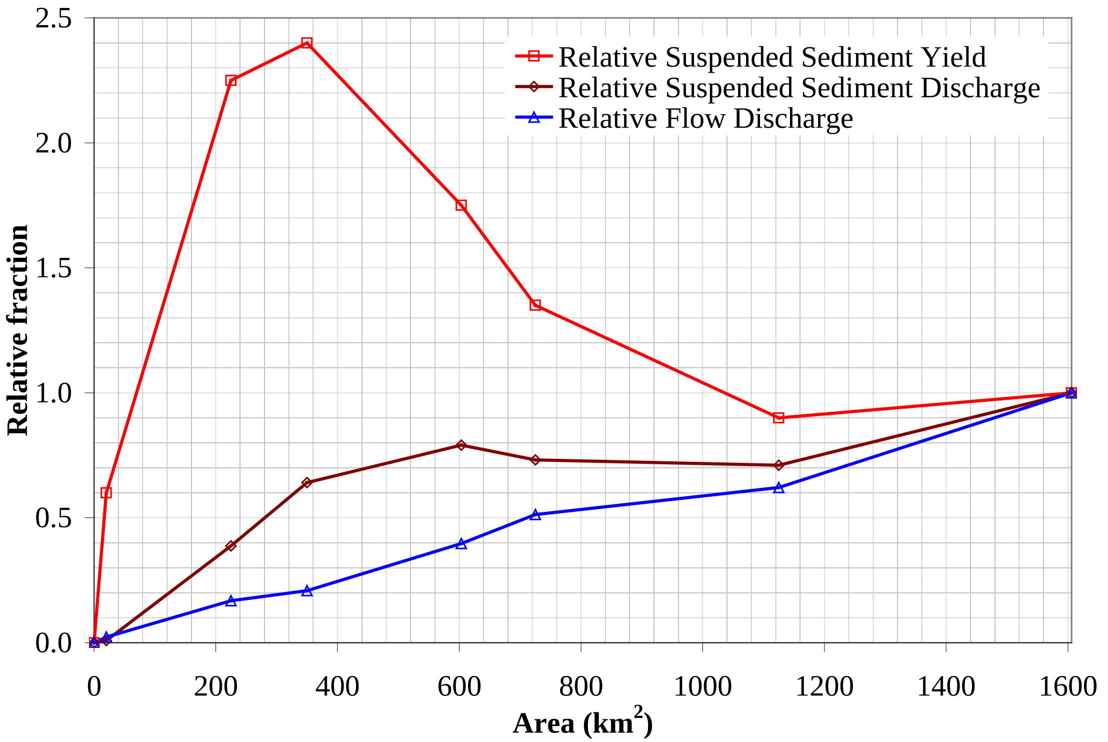
1. Yonaba Ck at Rd 9
2. Town Ck at Natchez Trace
3. Town Ck at Main St. Tupelo, MS
4. Mud Ck at Main St. Tupelo, MS
5. Town Ck at Eason Blvd Tupelo, MS
6. Town Ck at Brewer Rd
7. Town Ck at Hwy 278 near Nettleton, MS
8. Town Ck at USGS Station near Nettleton, MS

Methods

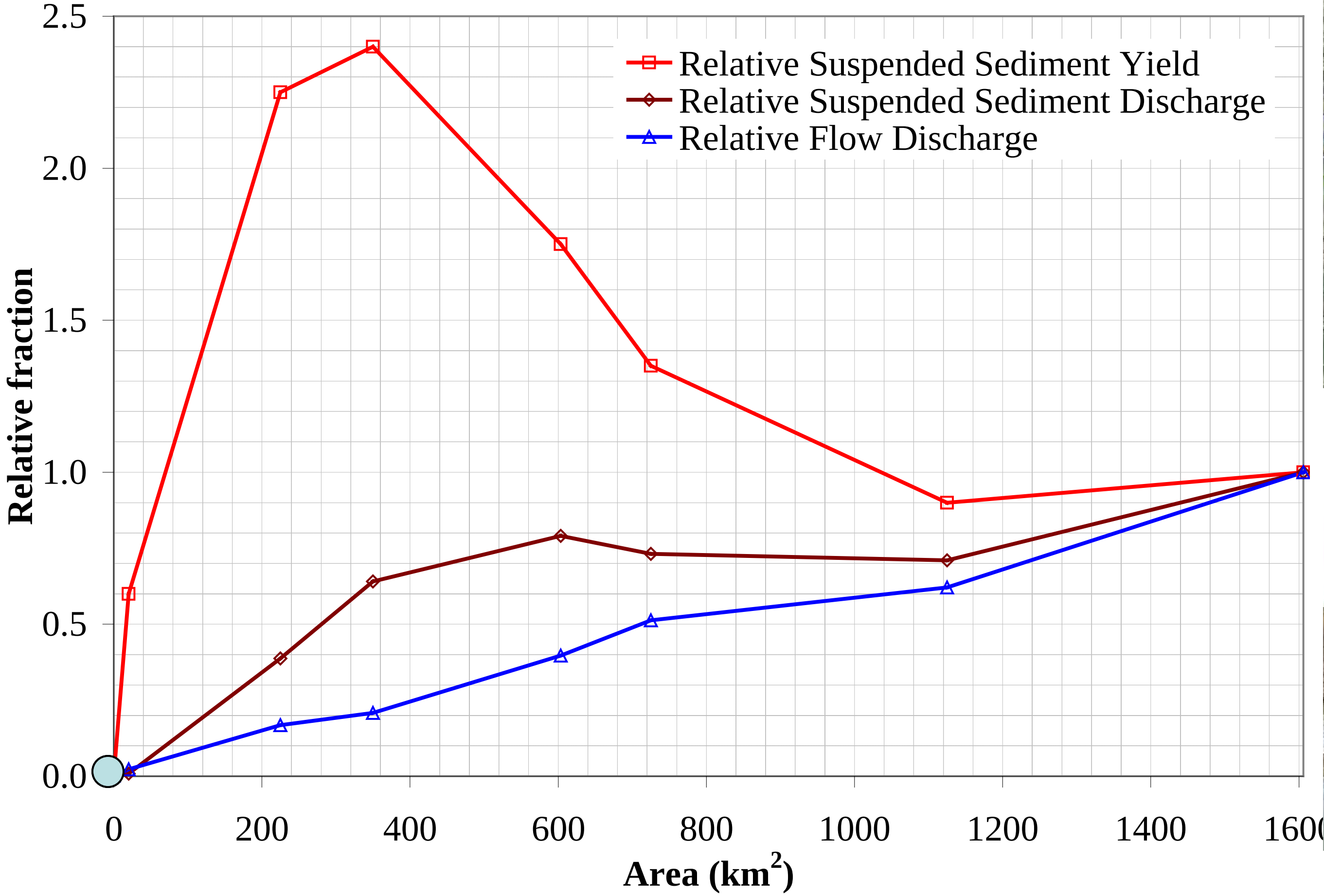
- Laboratory Analysis
  - 500 ml (2 bottles)
  - Filtration TSS (SSC)

Results

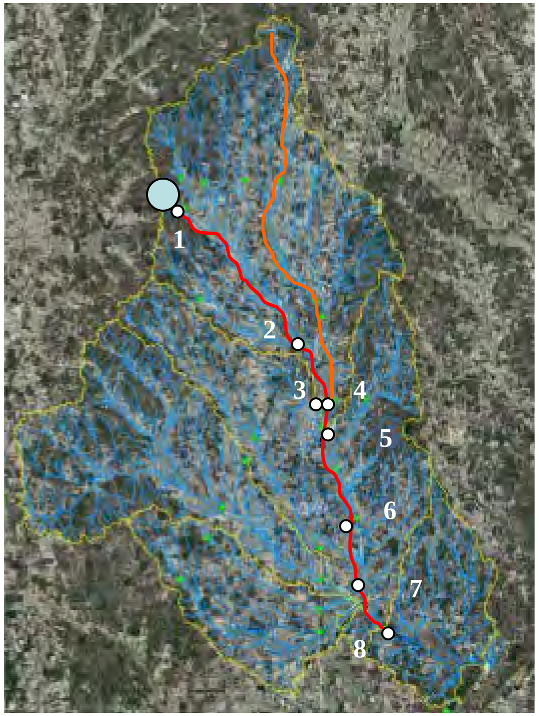
- **Variation of SS Loads**
- *Relative flow discharge, SS loads and yields for each station (May 2008 – May 2009)*



Results

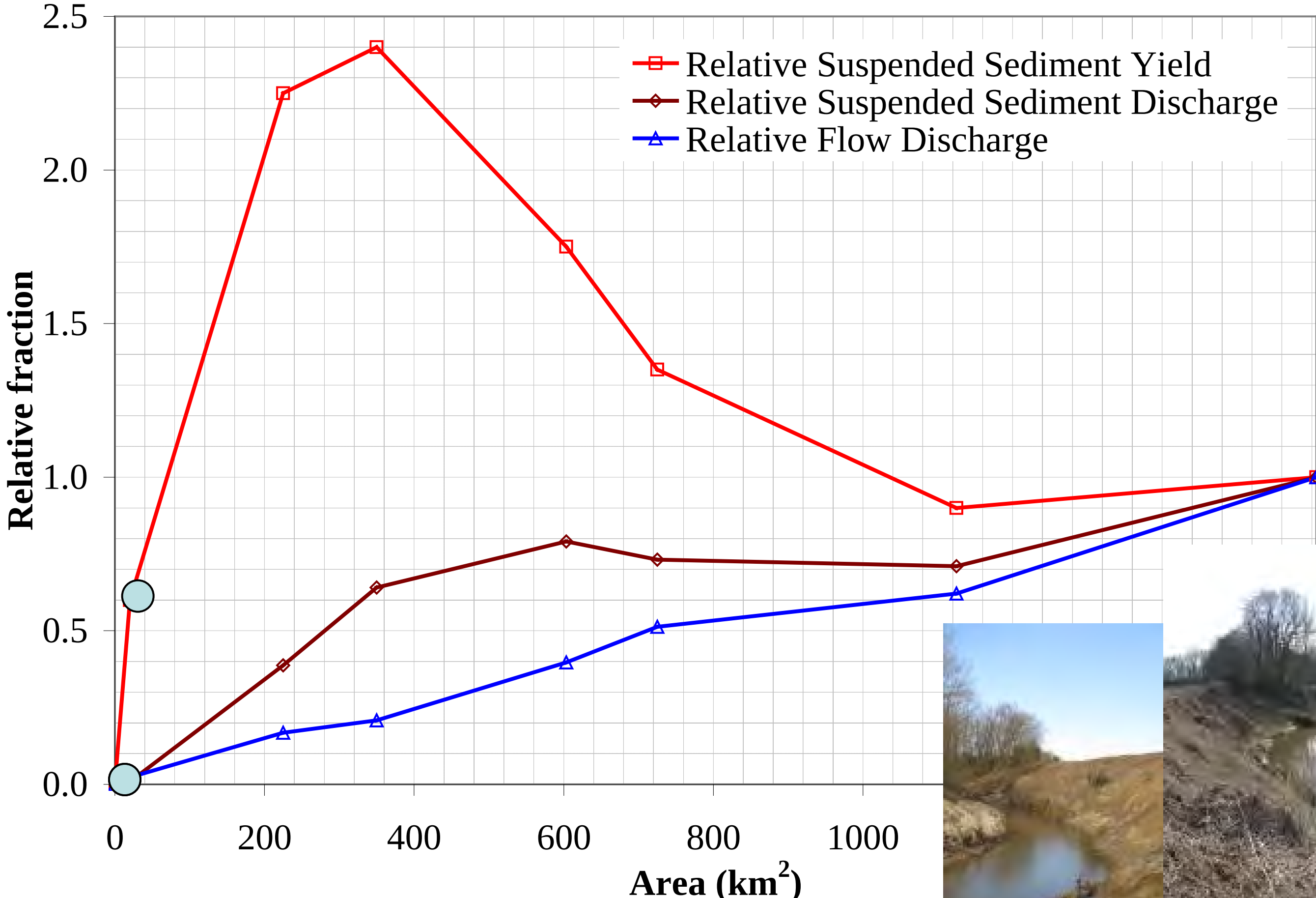


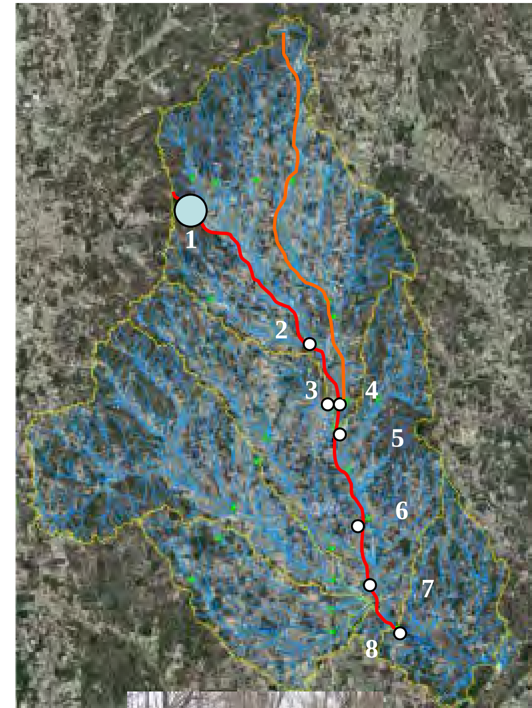
Relative Suspended Sediment Yield
Relative Suspended Sediment Discharge
Relative Flow Discharge
Relative fraction
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
1000
1200
1400
1600
Area (km^2)



1
2
3
4
5
6
7
8

Results


Relative Suspended Sediment Yield
Relative Suspended Sediment Discharge
Relative Flow Discharge
Relative fraction
Area (km^2)
0.0
0.5
1.0
1.5
2.0
2.5
0
200
400
600
800
1000


1
2
3
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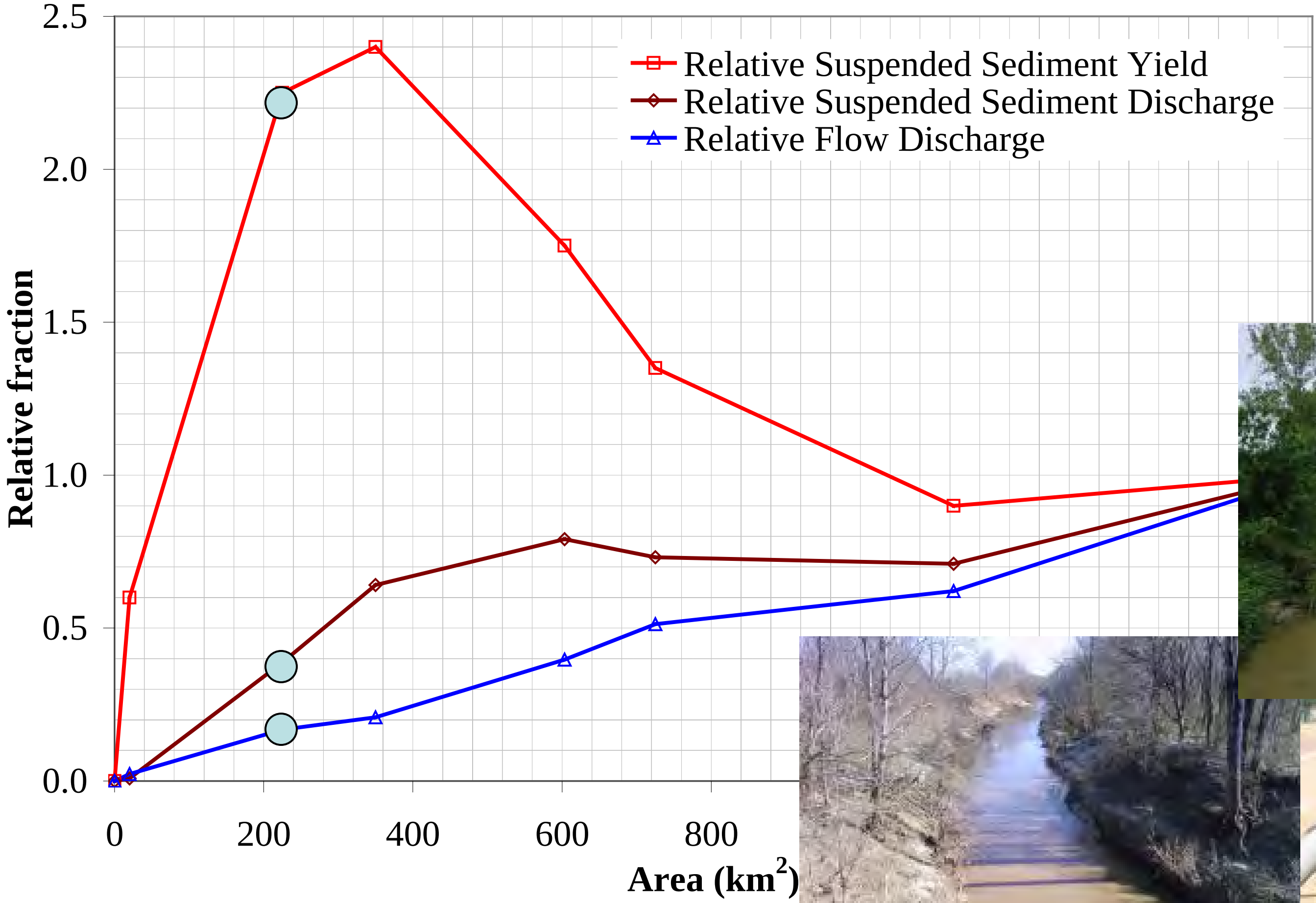
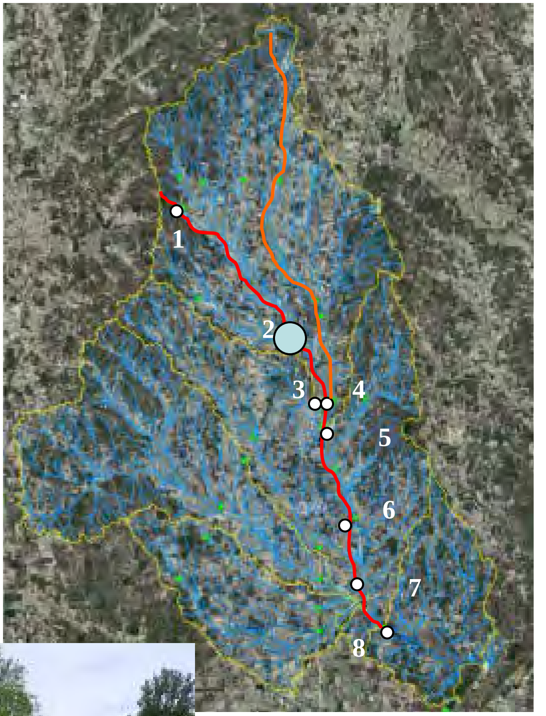
7
8

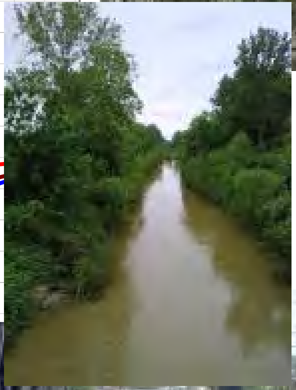
Results



Relative Suspended Sediment Yield
Relative Suspended Sediment Discharge
Relative Flow Discharge
Relative fraction
2.5
2.0
1.5
1.0
0.5
0.0
0
200
400
600
800
Area (km^2)

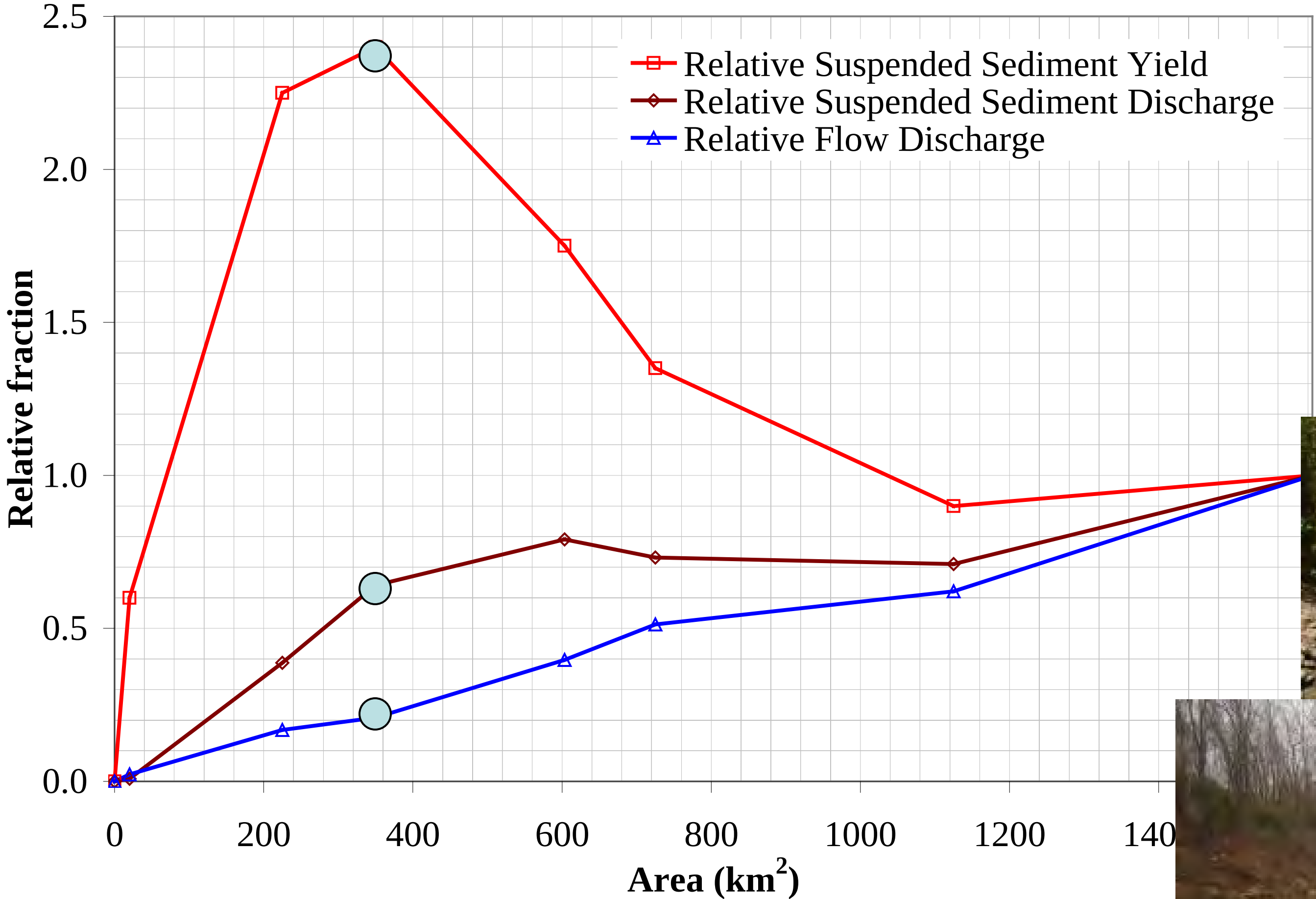


1
2
3
4
5
6
7
8

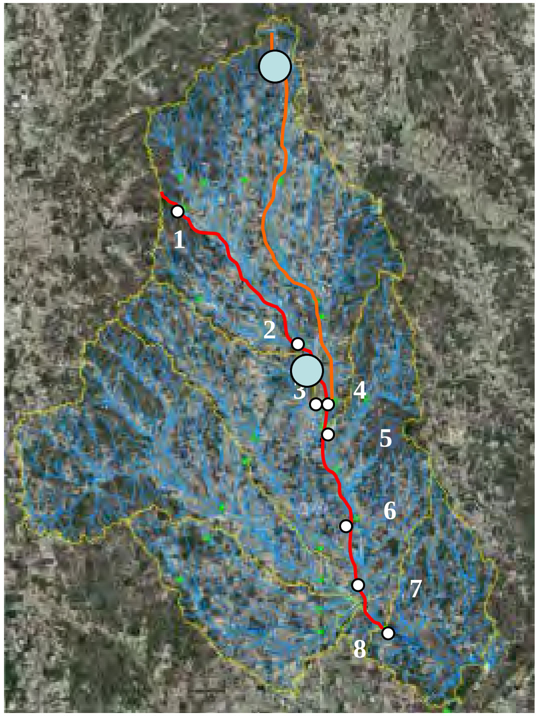


TOWN
CREEK

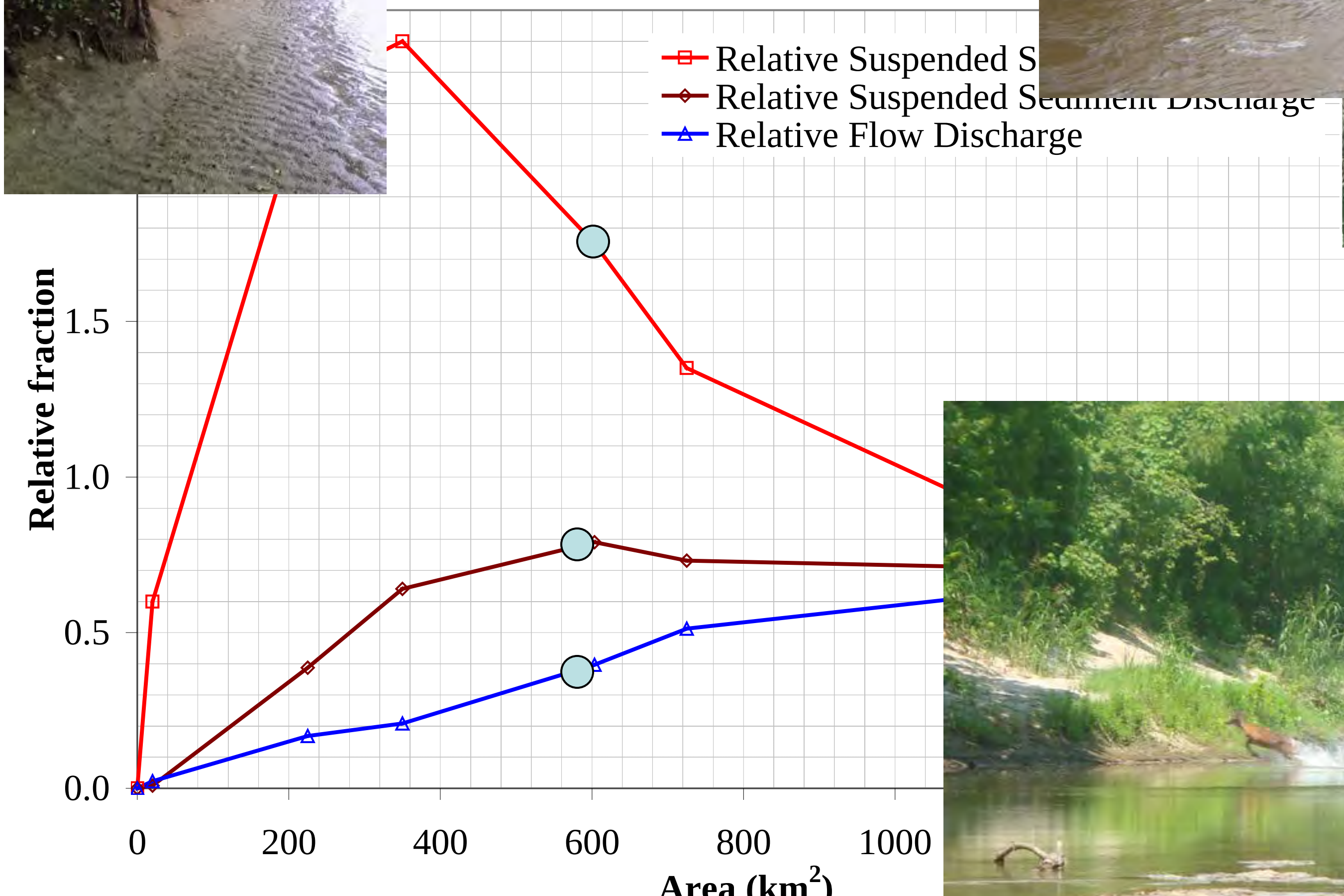
Results

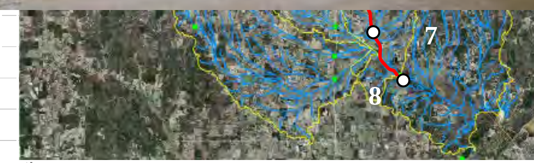


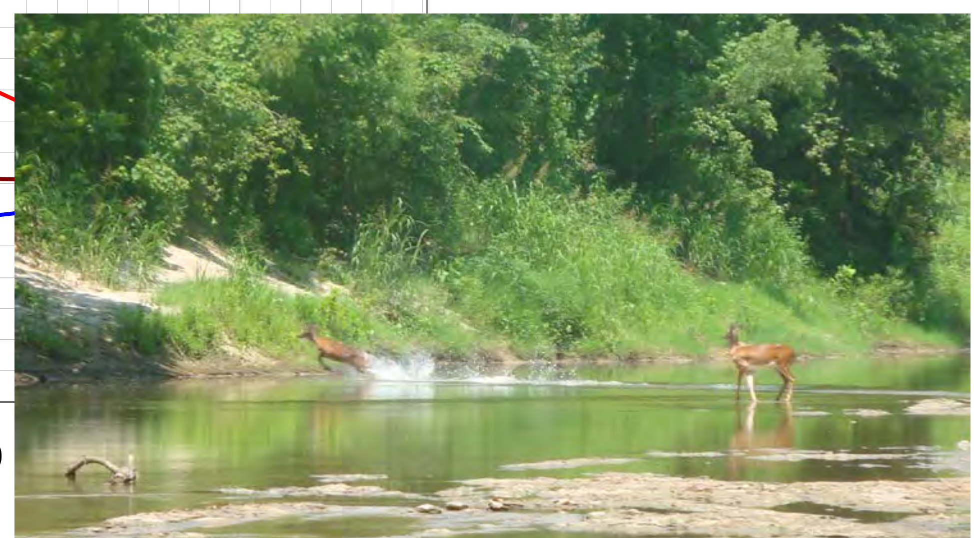
2.5
2.0
1.5
1.0
0.5
0.0
Relative fraction
0
200
400
600
800
1000
1200
140
Area (km^2)
Relative Suspended Sediment Yield
Relative Suspended Sediment Discharge
Relative Flow Discharge



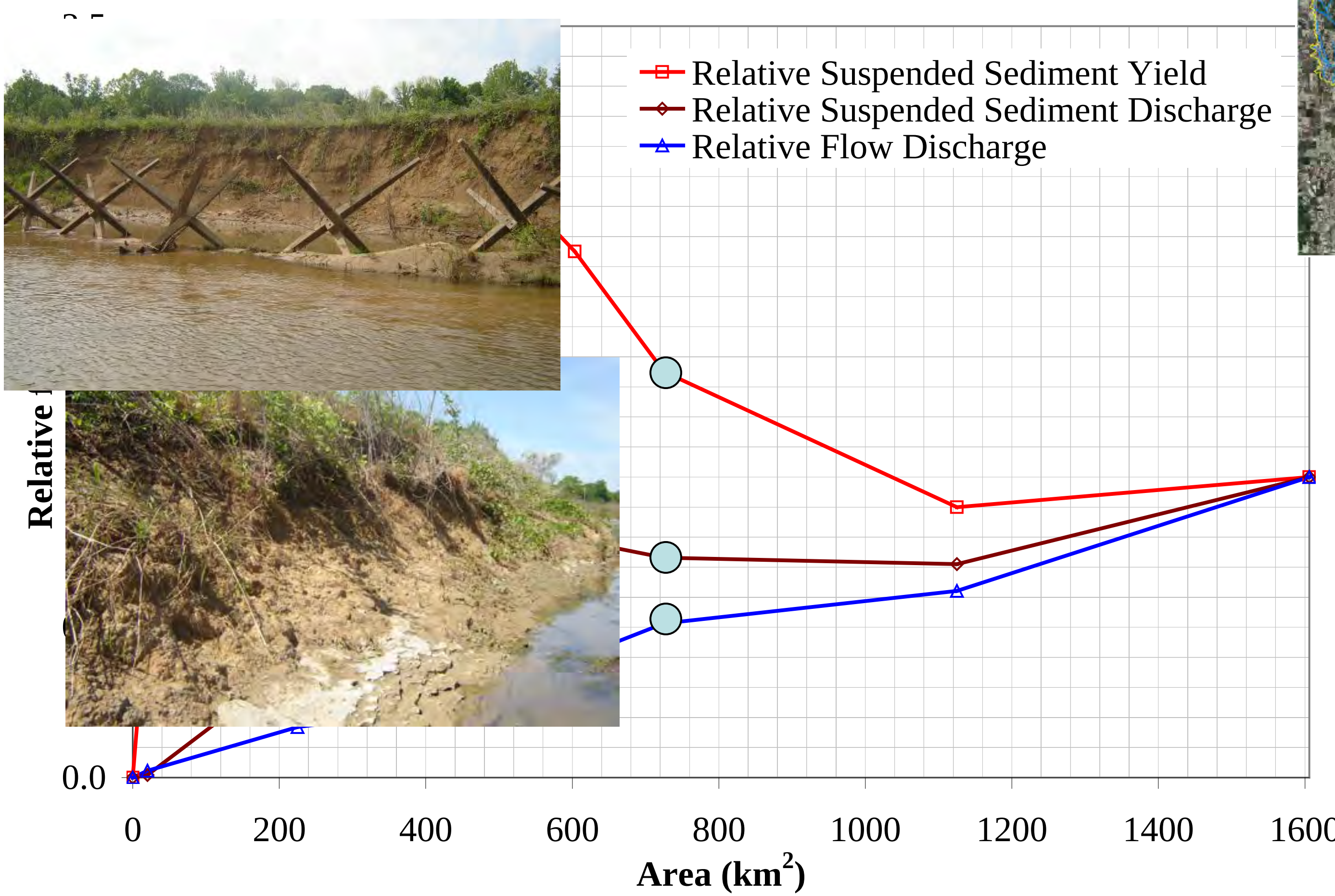
1
2
3
4
5
6
7
8

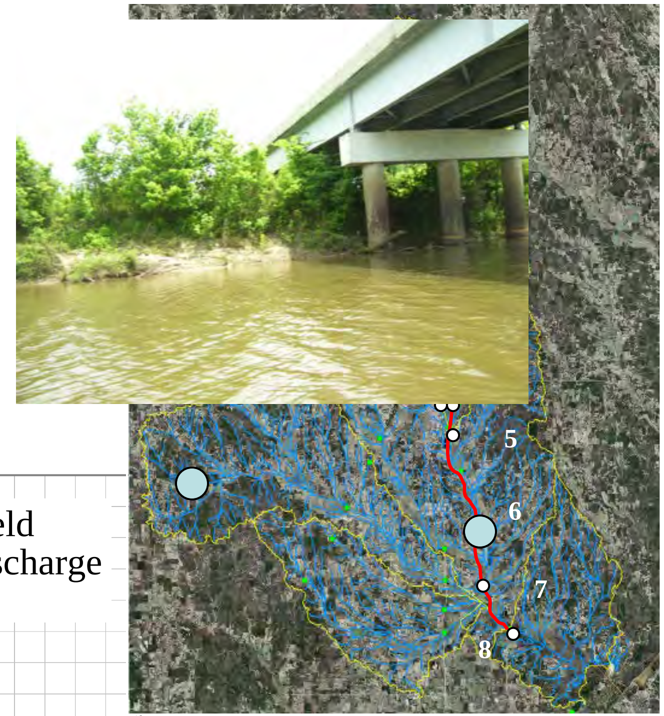

Relative Suspended S
Relative Suspended Sediment Discharge
Relative Flow Discharge
Relative fraction
0.0
0.5
1.0
1.5
0
200
400
600
800
1000
Area (km^2)


7
8



Results


Relative Suspended Sediment Yield
Relative Suspended Sediment Discharge
Relative Flow Discharge
0.0
0
200
400
600
800
1000
1200
1400
1600
Area (km²)

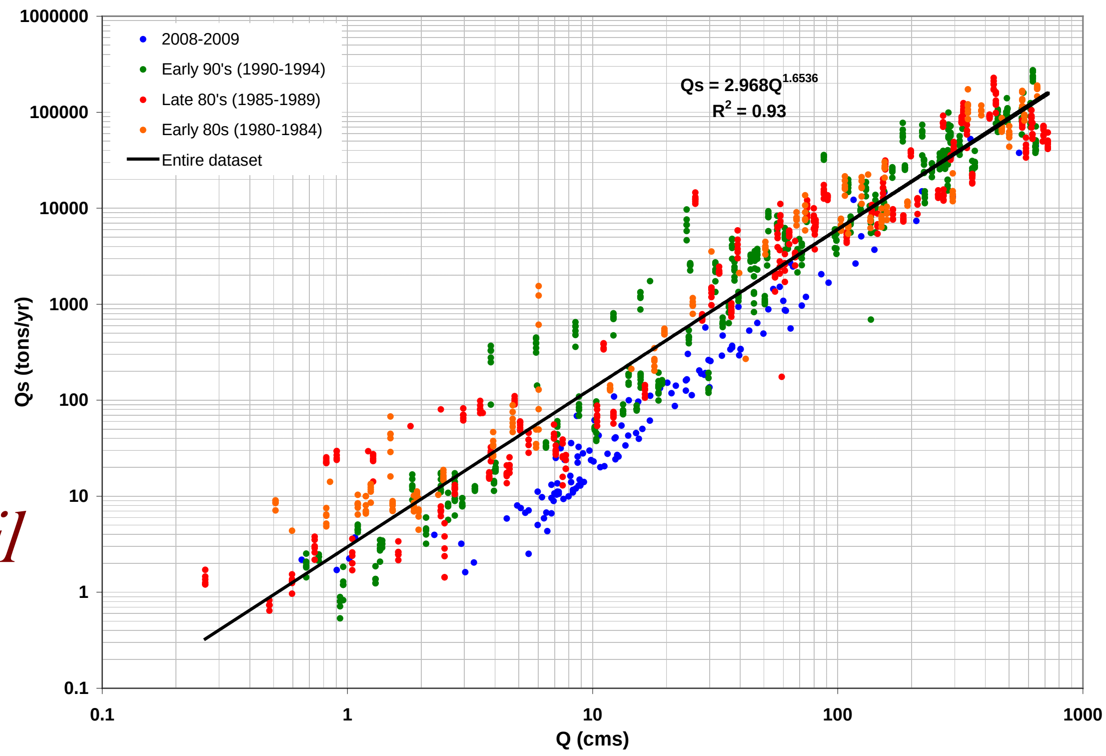

5
6
7
8

Results

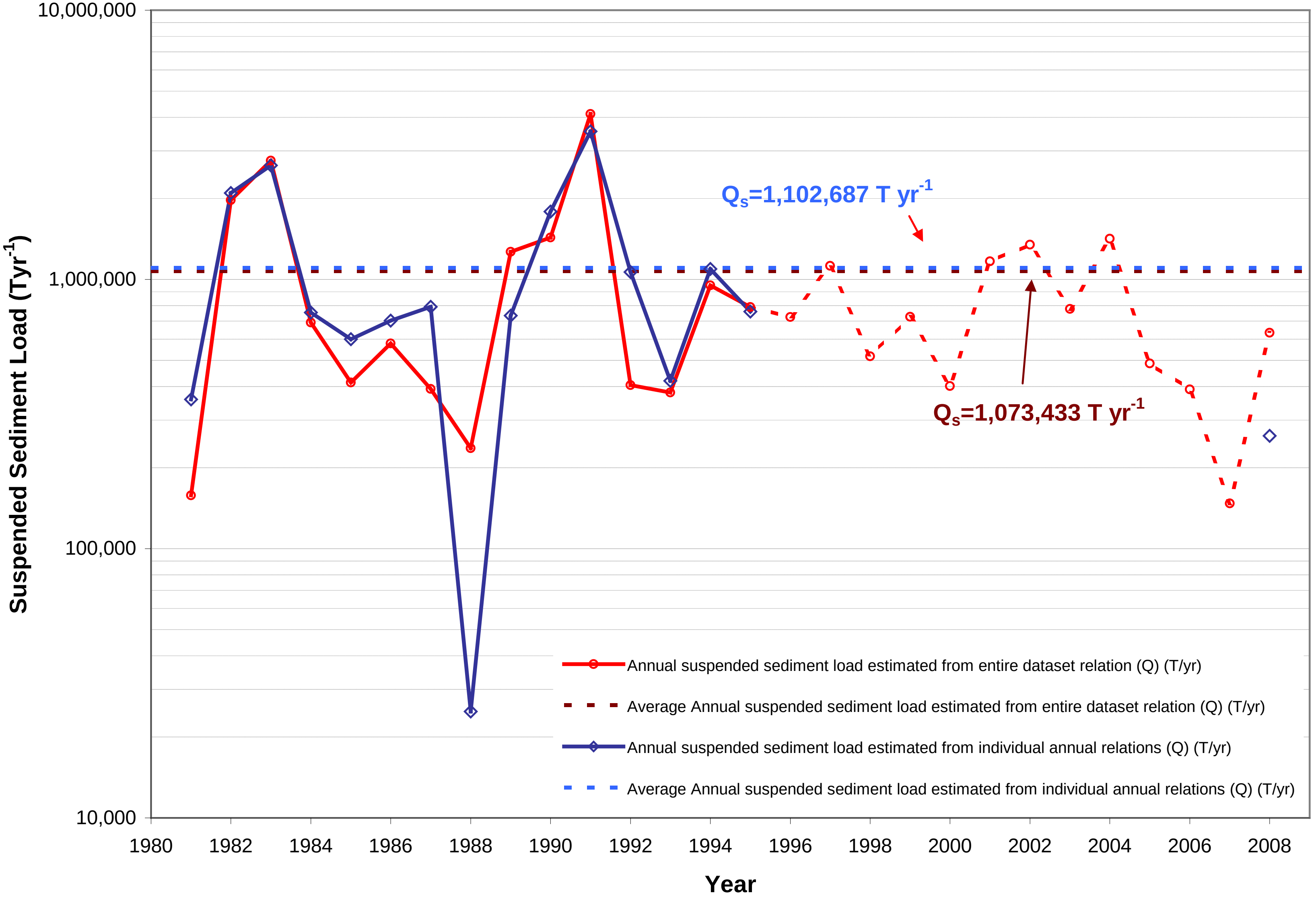
- Analysis of suspended sediment transport rating relations($Q_s = aQ^b$)
  - USGS SSC records from Jan 1, 1981 – Dec 31, 1995 and May 1, 2008 – April 30, 2009
  - Annual Rating Curve
  - *Clusters (1981 – 1985; 1986 – 1990; 1991 – 1995; 2008 – 2009)*

Results

- Analysis of suspended sediment transport rating relations($Q_s = aQ^b$)
  - *USGS SSC records from Jan 1, 1981 – Dec 31, 1995 and May 1, 2008 – April 30, 2009*

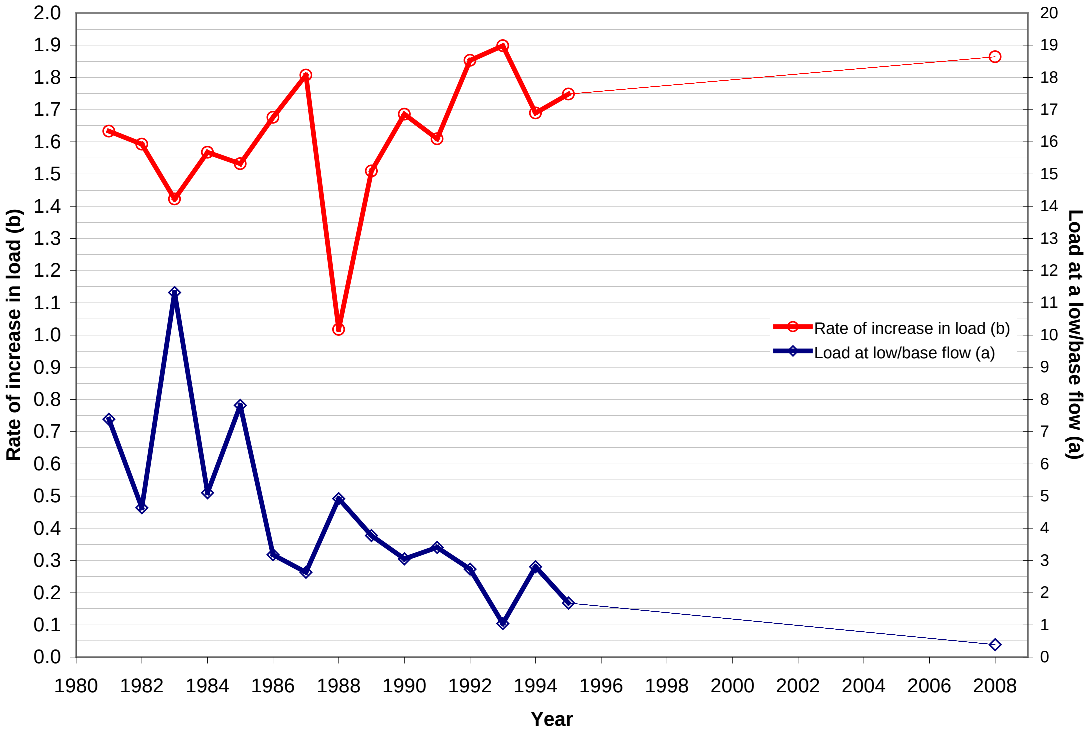


Results

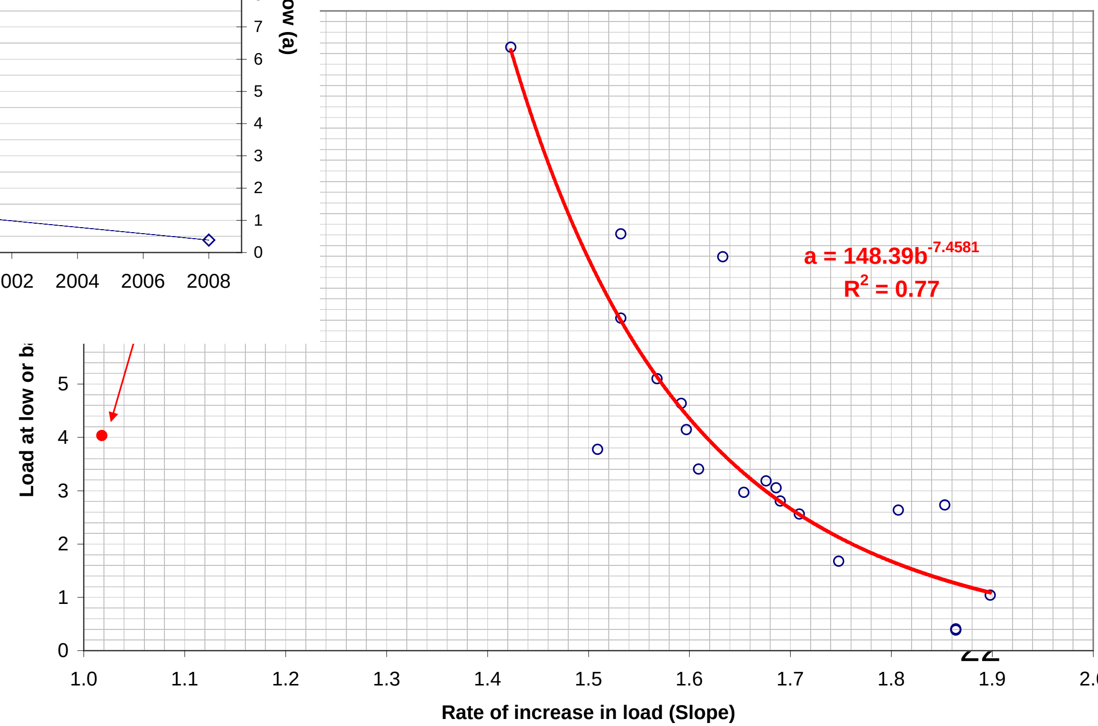


10,000,000
1,000,000
100,000
10,000
Suspended Sediment Load (Tyr-1)
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
Year
Qs=1,102,687 T yr-1
Qs=1,073,433 T yr-1
Annual suspended sediment load estimated from entire dataset relation (Q) (T/yr)
Average Annual suspended sediment load estimated from entire dataset relation (Q) (T/yr)
Annual suspended sediment load estimated from individual annual relations (Q) (T/yr)
Average Annual suspended sediment load estimated from individual annual relations (Q) (T/yr)

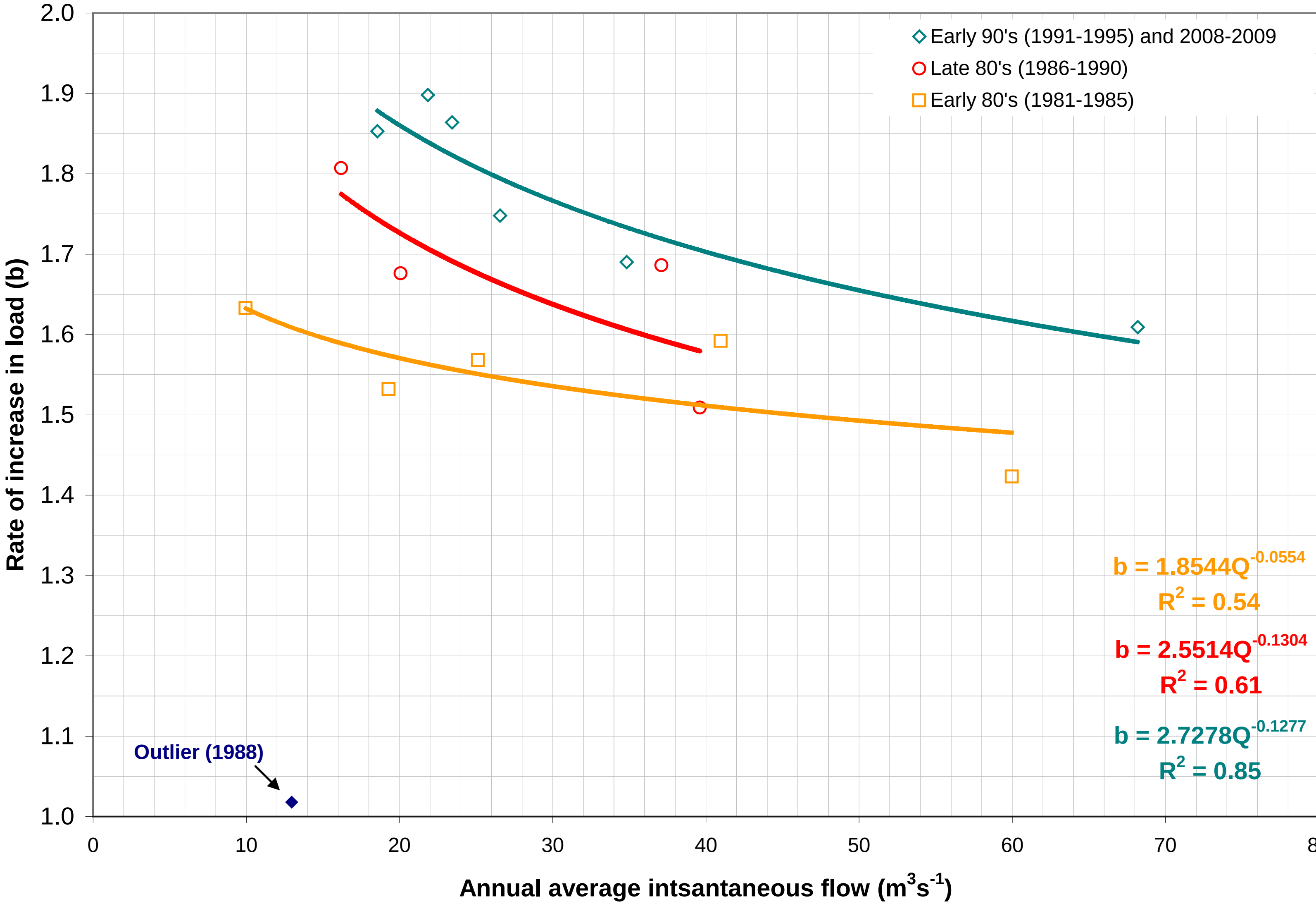
Results



$$Q_s = aQ^b$$

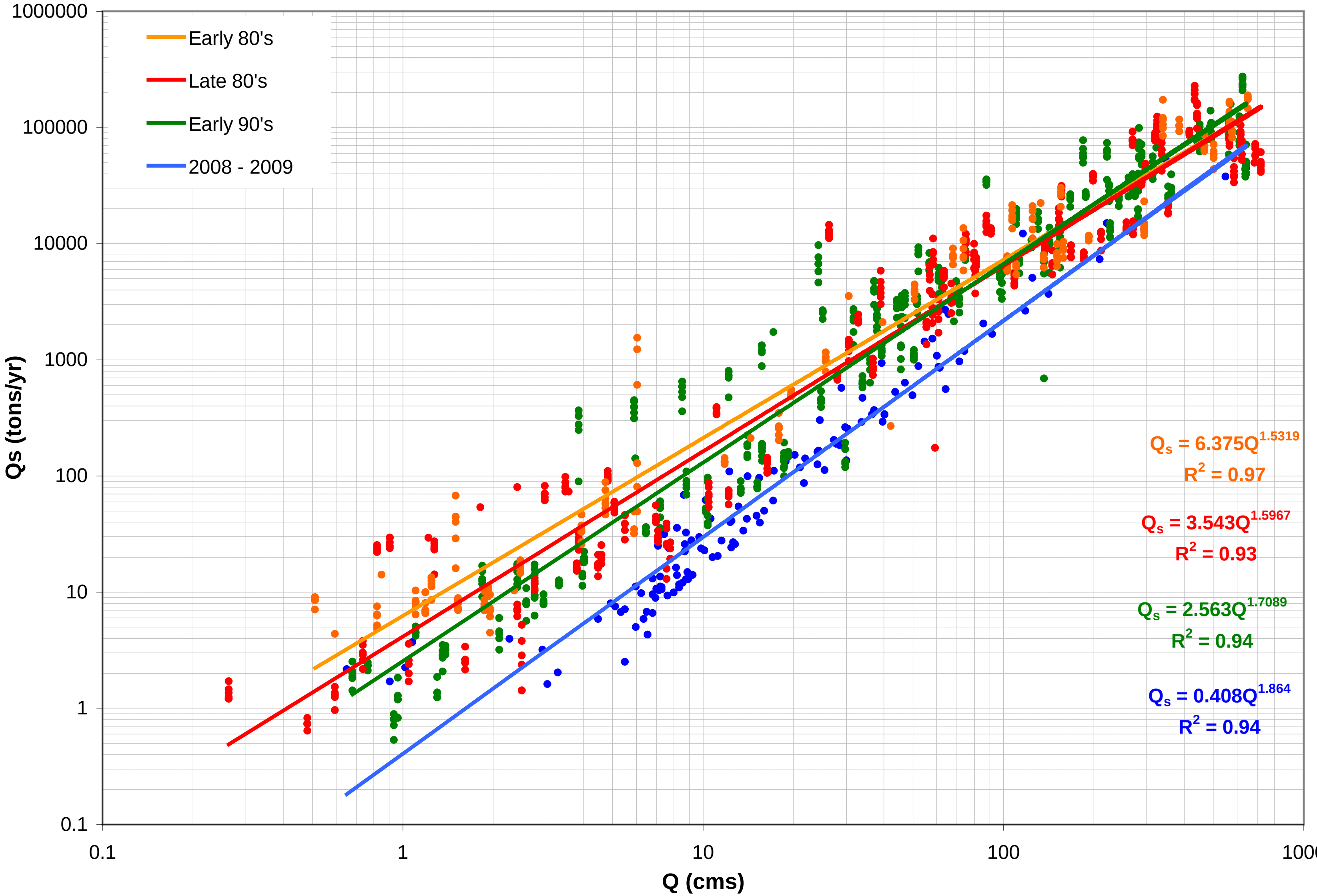


Results



Early 90's (1991-1995) and 2008-2009
Late 80's (1986-1990)
Early 80's (1981-1985)
b = 1.8544Q-0.0554
R2 = 0.54
b = 2.5514Q-0.1304
R2 = 0.61
b = 2.7278Q-0.1277
R2 = 0.85
Outlier (1988)
Rate of increase in load (b)
Annual average intsantaneous flow (m3s-1)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0
10
20
30
40
50
60
70
80

Results



Early 80's
Late 80's
Early 90's
2008 - 2009
$Q_s = 6.375Q^{1.5319}$
$R^2 = 0.97$
$Q_s = 3.543Q^{1.5967}$
$R^2 = 0.93$
$Q_s = 2.563Q^{1.7089}$
$R^2 = 0.94$
$Q_s = 0.408Q^{1.864}$
$R^2 = 0.94$
Qs (tons/yr)
Q (cms)
1000000
100000
10000
1000
100
10
1
0.1
0.1
1
10
100
1000

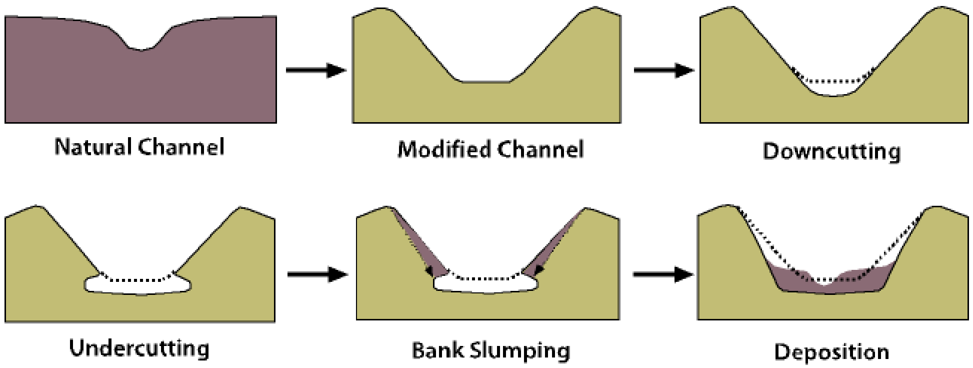
Results

Model	Rating curve coefficient a	Rating curve exponent b	R^2	Effective Flow ($Q_{1.5}$) Load (Td^{-1})	Effective Flow ($Q_{1.5}$) Yield ($Td^{-1}km^2$)	Daily Flow Load* (Tyr^{-1})	Daily Flow Yield ($Tyr^{-1}km^2$)
Early 80's (1981-1985)	6.375	1.545	0.97	106,433	66	1,360,106	847
Late 80's (1986-1980)	3.543	1.597	0.93	136,274	85	682,922	425
Early 90's (1991-1995)	2.563	1.709	0.94	158,336	99	1,612,386	1004
May 2008-April 2009	0.408	1.864	0.94	68,597	40	262,405	163
Entire dataset (1401 records)	2.968	1.654	0.93	127,728	80	1,073,433**	668

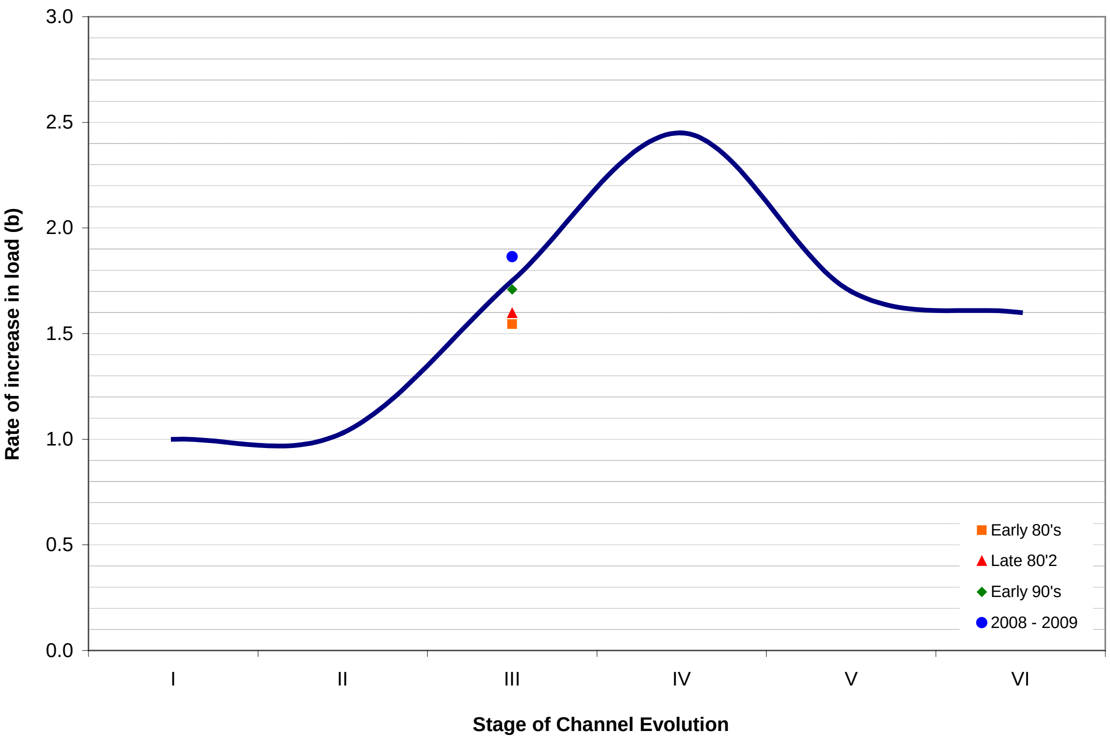
* Average annual value for the years in the cluster.

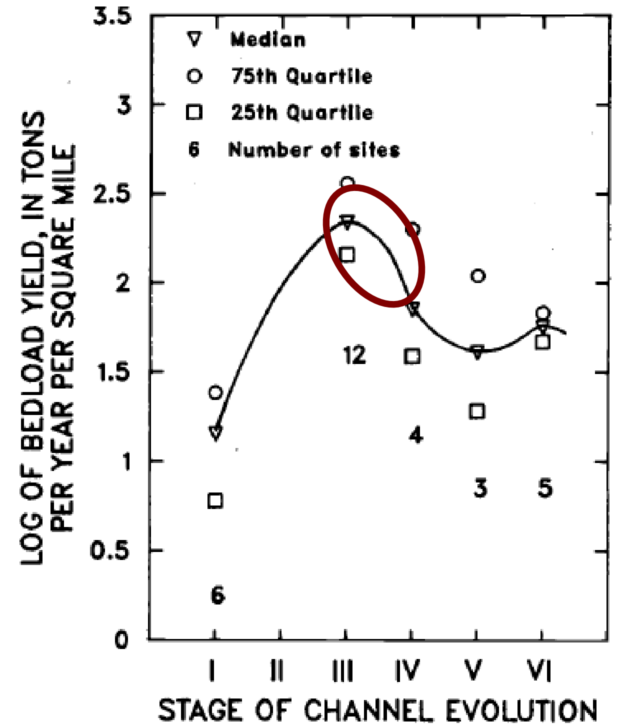
** Average annual value for continuous estimation from January 1 1981 to March 30 2008 and May 1 2008 to April 30 2009

Results



(Adapted from Simon 1989)

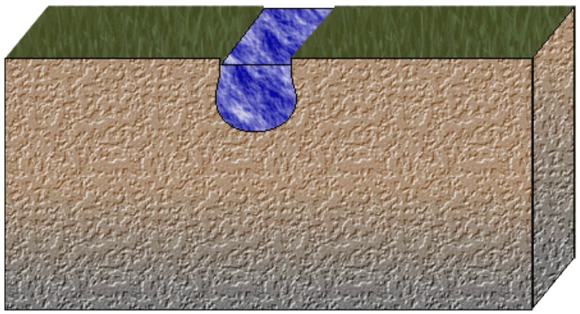


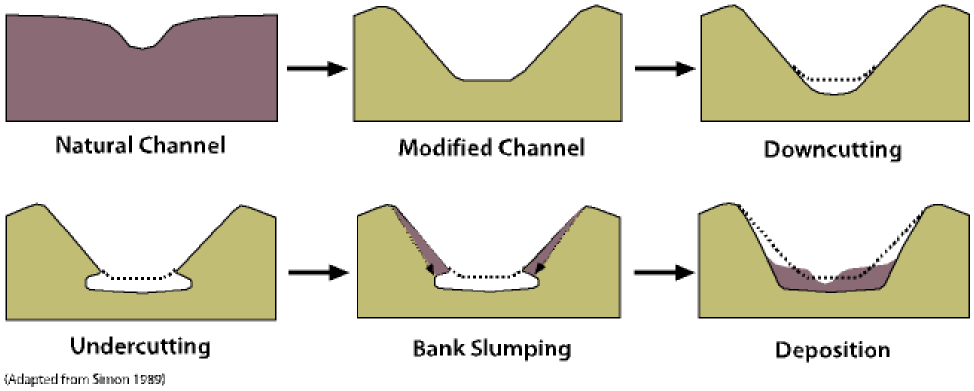


(Simon, 1989)

Results

- In Stage I, yields are relatively low and are a function of contributions from sheet erosion and gully erosion in the fields.
- **Following construction (Stage II),** migrations of knickpoints up tributary streams cause a significant increase in yields during Stage III.
- Streambank failures by mass wasting during Stage IV serve to further increase yields.
- During Stage V, mass wasting slows, main channel exhibits much lower energy conditions, and yields decrease.
- Suspended sediment emanating from tributary streams and gullies continues to be delivered to main channel, thereby maintaining yields during net aggradational phases (Stage VI).





Conclusions

- High spatial and temporal variability of flow and suspended sediment concentrations, discharges and yields in the watershed

- Incised channels in the northern and western area are the major producers of sediment within the Town Creek watershed

- Sediment yield reduced at the watershed outlet when compared with sediment production from headwaters.
  - presence of natural and established sediment control structures
  - wide vegetated channels
  - significant increase in flow along the middle and lower area of the watershed

Conclusions

- Av. Qs at station #8 over 29-yr period 1,000,000 (260,000) Mg yr^{-1}
- SSY at effective flow ($Q_{1.5}$) was 80 (40) Mg d^{-1} km^{-2}
- Both, temporal reduction of Q_s at a specific instantaneous flow and rising of sediment rating exponent shows high erosion potential of important geomorphic processes in a specific area of the watershed
- Streambank erosion processes at the headwaters appear to be acting as the most significant sediment supplier and need to be reduced under a stream restoration process.

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It’s sedimentary, Watson!

Any question?

THANKS