An Evaluation of Sediment and Nutrient Loading to Galveston Bay from The Trinity River

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Coastal Studies Unit

U.S. Department of the Interior
U.S. Geological Survey

- Physical Water Properties – Water Temperature, pH, Specific Conductance, Dissolved Oxygen Concentration, Turbidity

- Nutrients – Total and Filtered Components, Ammonia, Nitrite, Nitrite+Nitrate, Orthophosphate

- Sediment – Suspended Sediment Concentration and Sand/Fine Break

USGS

- ❑ Discharge
- ❑ Bed Load / Bed Material
- ❑ Backscatter and Sediment Attenuation - ADVM

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Livingston

10 miles

Goodrich

20 miles

Romayer

40 miles

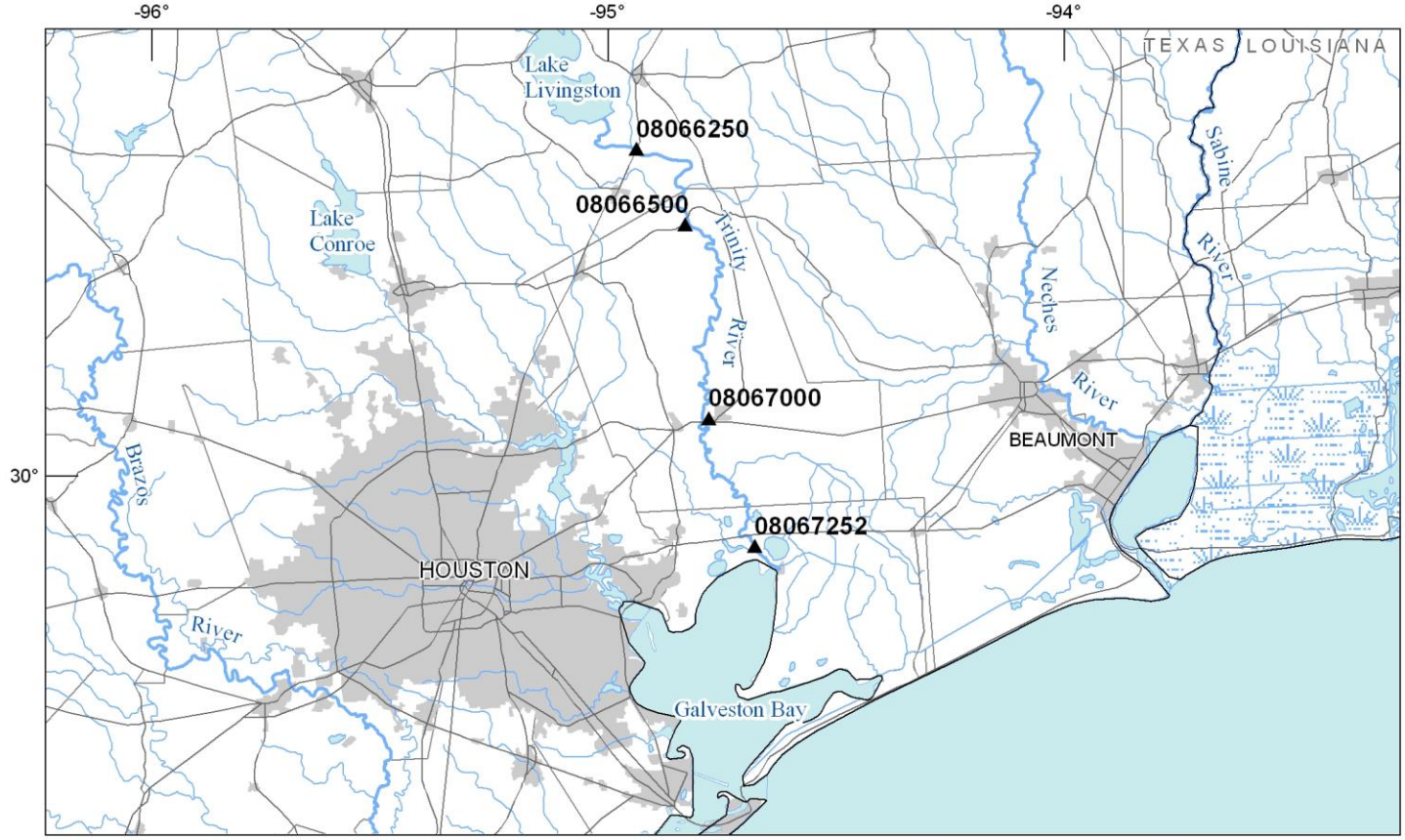
Liberty

30 miles

Wallisville

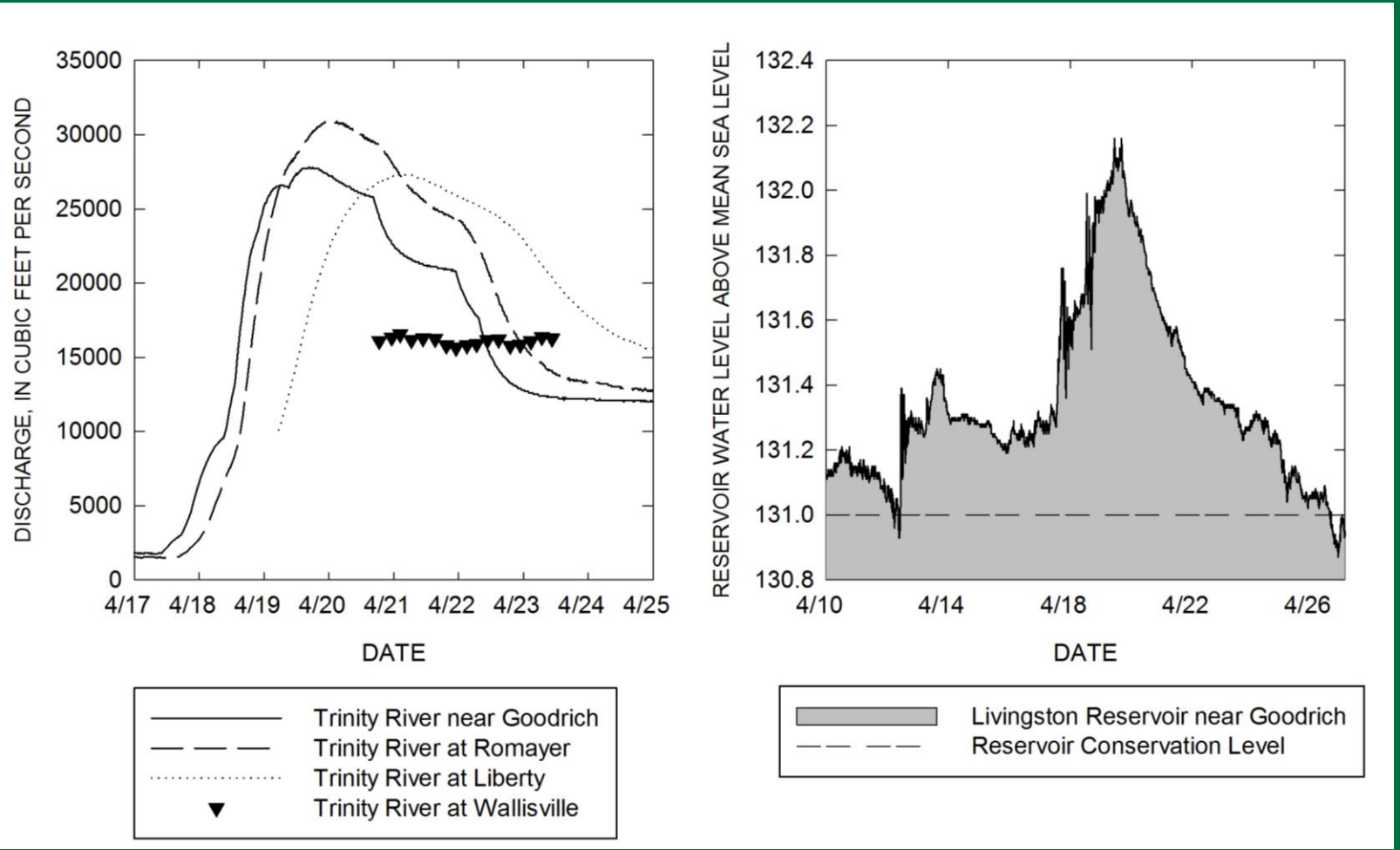
4 miles

Trinity Bay

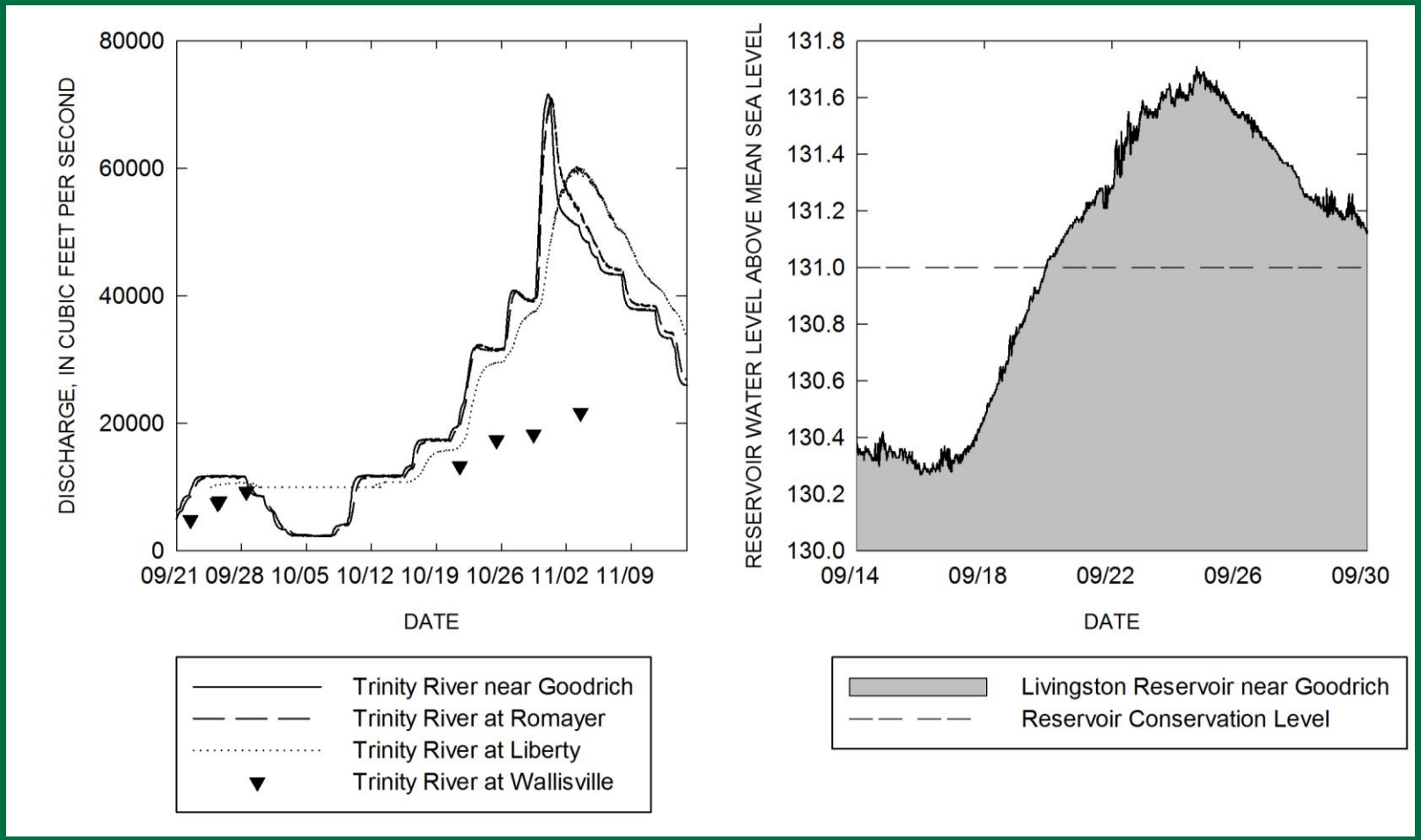


USGS

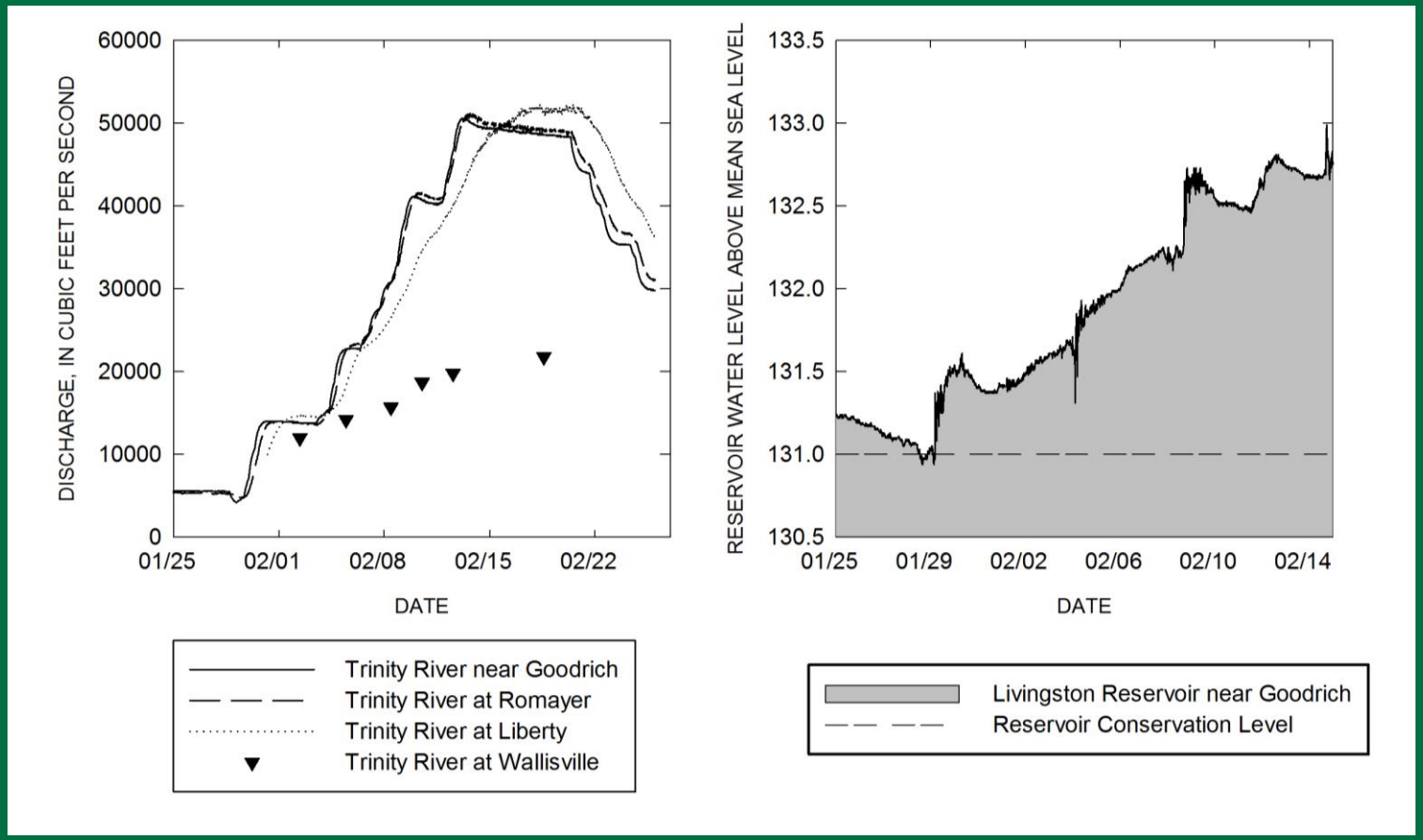
Event 1


DISCHARGE, IN CUBIC FEET PER SECOND
35000
30000
25000
20000
15000
10000
5000
0
4/17
4/18
4/19
4/20
4/21
4/22
4/23
4/24
4/25
DATE
Trinity River near Goodrich
Trinity River at Romayer
Trinity River at Liberty
Trinity River at Wallisville
RESERVOIR WATER LEVEL ABOVE MEAN SEA LEVEL
132.4
132.2
132.0
131.8
131.6
131.4
131.2
131.0
130.8
4/10
4/14
4/18
4/22
4/26
DATE
Livingston Reservoir near Goodrich
Reservoir Conservation Level

Event 2

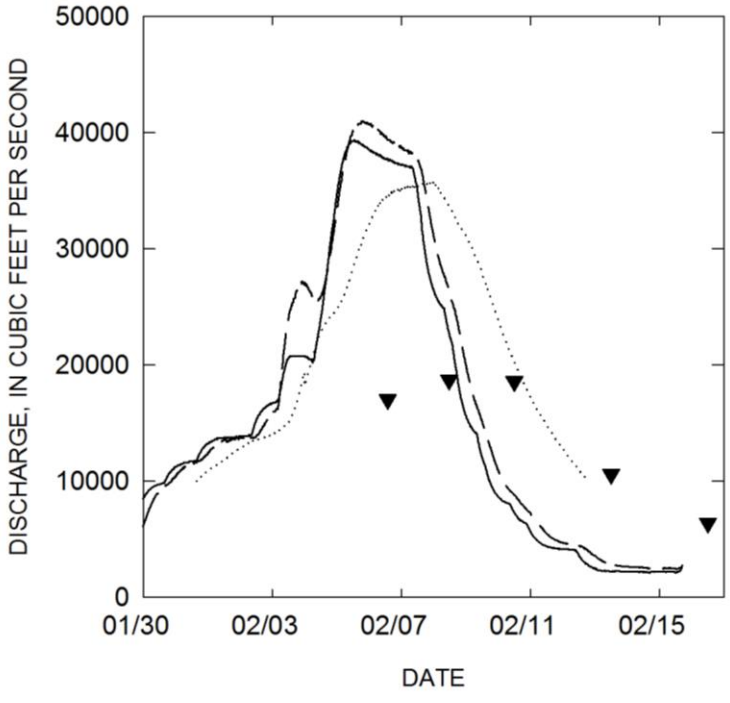

DISCHARGE, IN CUBIC FEET PER SECOND
80000
60000
40000
20000
0
09/21 09/28 10/05 10/12 10/19 10/26 11/02 11/09
DATE
Trinity River near Goodrich
Trinity River at Romayer
Trinity River at Liberty
Trinity River at Wallisville
RESERVOIR WATER LEVEL ABOVE MEAN SEA LEVEL
131.8
131.6
131.4
131.2
131.0
130.8
130.6
130.4
130.2
130.0
09/14
09/18
09/22
09/26
09/30
DATE
Livingston Reservoir near Goodrich
Reservoir Conservation Level

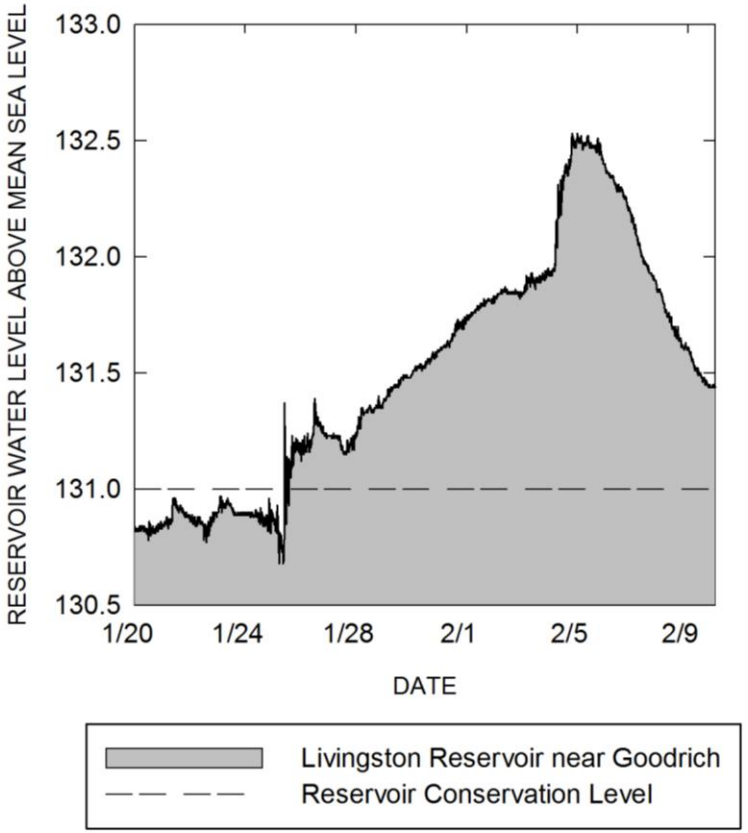
Event 3


DISCHARGE, IN CUBIC FEET PER SECOND
60000
50000
40000
30000
20000
10000
0
01/25
02/01
02/08
02/15
02/22
DATE
Trinity River near Goodrich
Trinity River at Romayer
Trinity River at Liberty
Trinity River at Wallisville
RESERVOIR WATER LEVEL ABOVE MEAN SEA LEVEL
133.5
133.0
132.5
132.0
131.5
131.0
130.5
01/25
01/29
02/02
02/06
02/10
02/14
DATE
Livingston Reservoir near Goodrich
Reservoir Conservation Level

USGS

Event 4

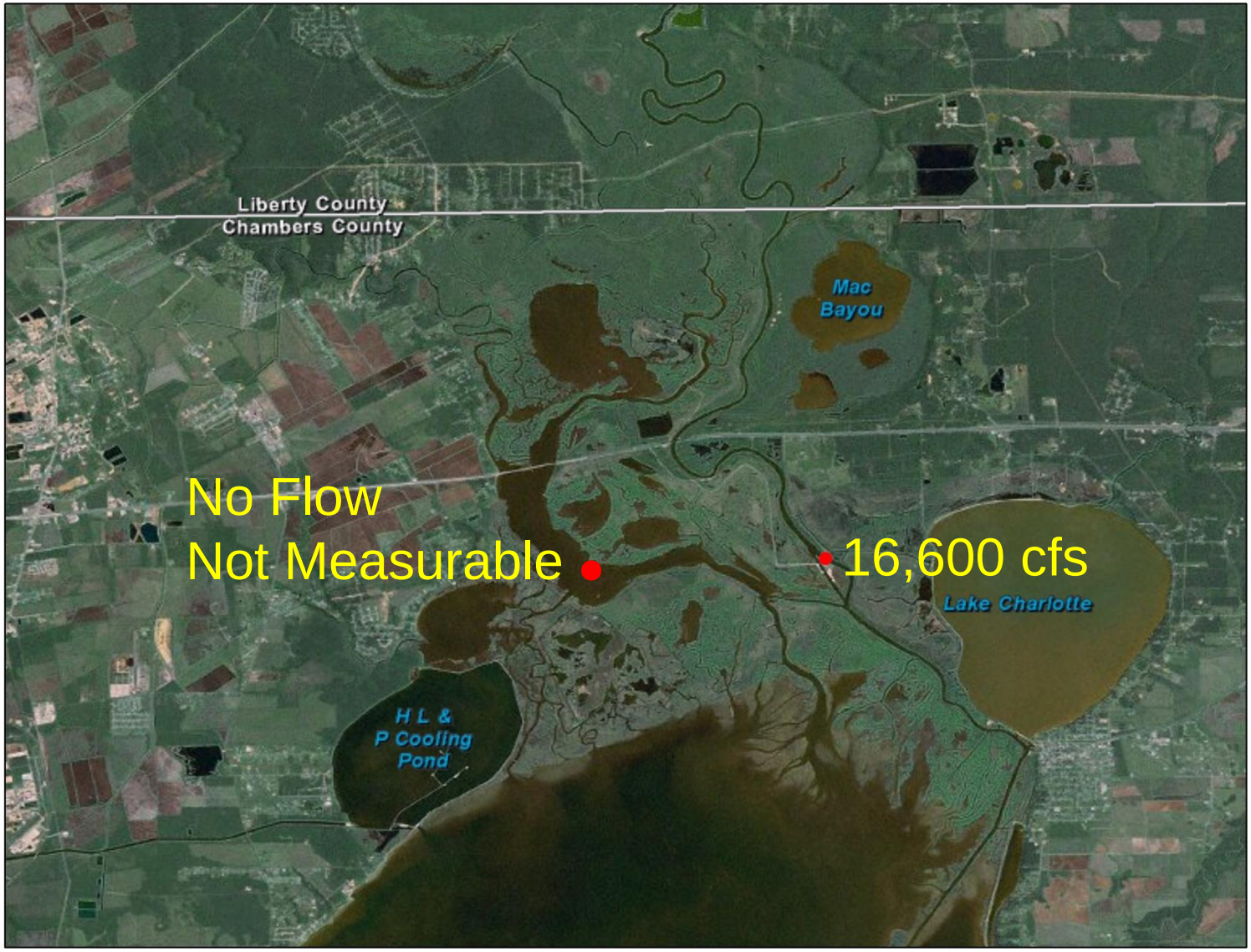

DISCHARGE, IN CUBIC FEET PER SECOND
50000
40000
30000
20000
10000
0
01/30
02/03
02/07
02/11
02/15
DATE
Trinity River near Goodrich
Trinity River at Romayor
Trinity River at Liberty
Trinity River at Wallisville


RESERVOIR WATER LEVEL ABOVE MEAN SEA LEVEL
133.0
132.5
132.0
131.5
131.0
130.5
1/20
1/24
1/28
2/1
2/5
2/9
DATE
Livingston Reservoir near Goodrich
Reservoir Conservation Level

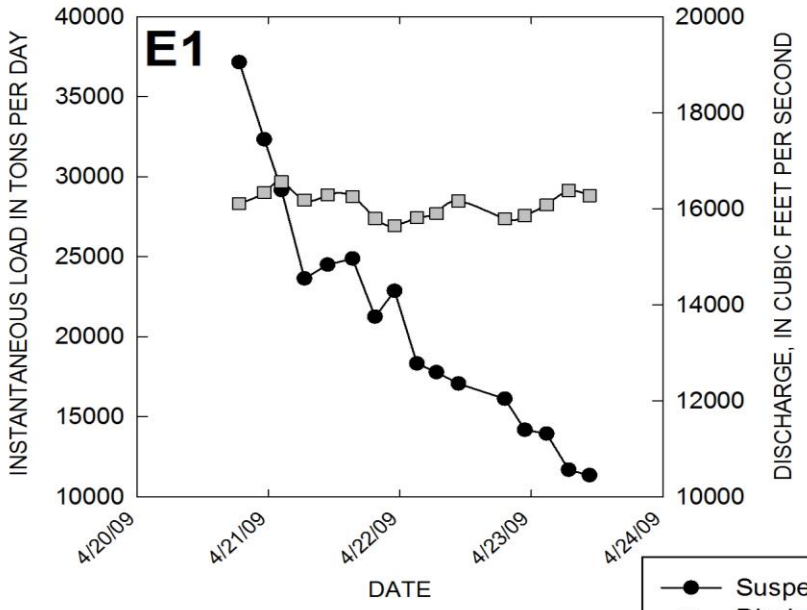
USGS

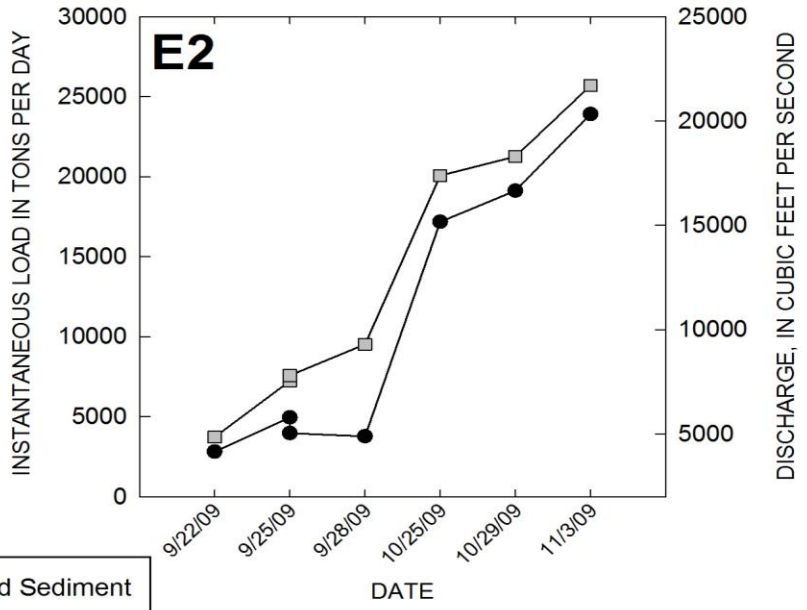

Liberty County
Chambers County
Mac
Bayou
Lake Charlotte
H L &
P Cooling
Pond

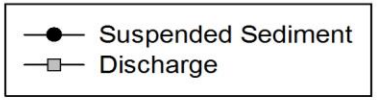
USGS

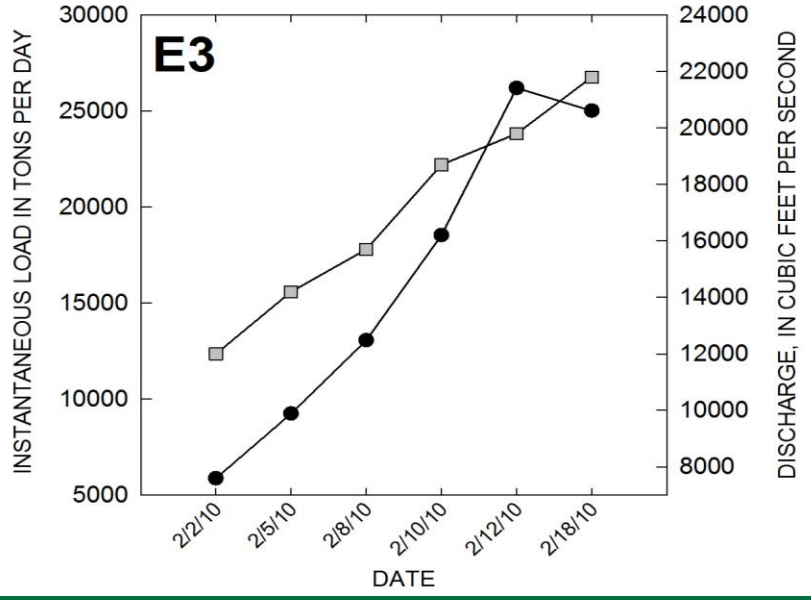

Liberty County
Chambers County
Mac Bayou
No Flow
Not Measurable
16,600 cfs
Lake Charlotte
H L & P Cooling Pond

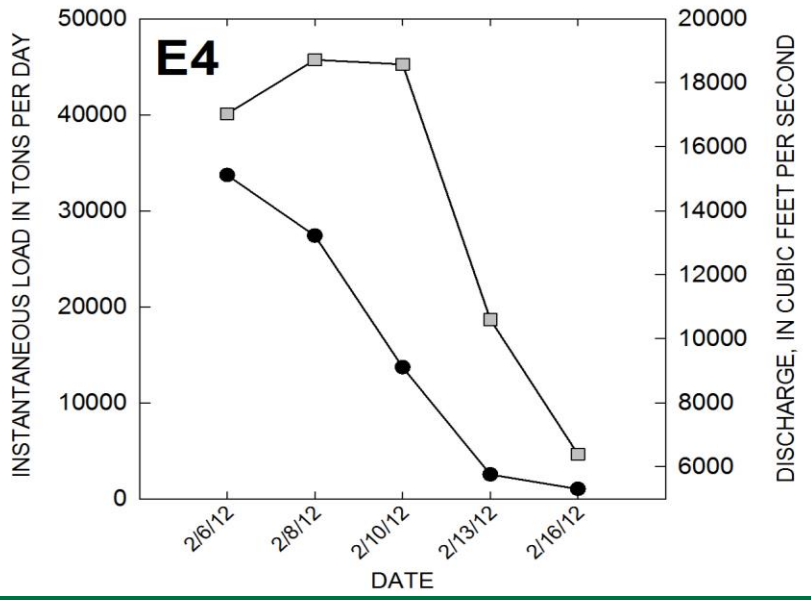
USGS

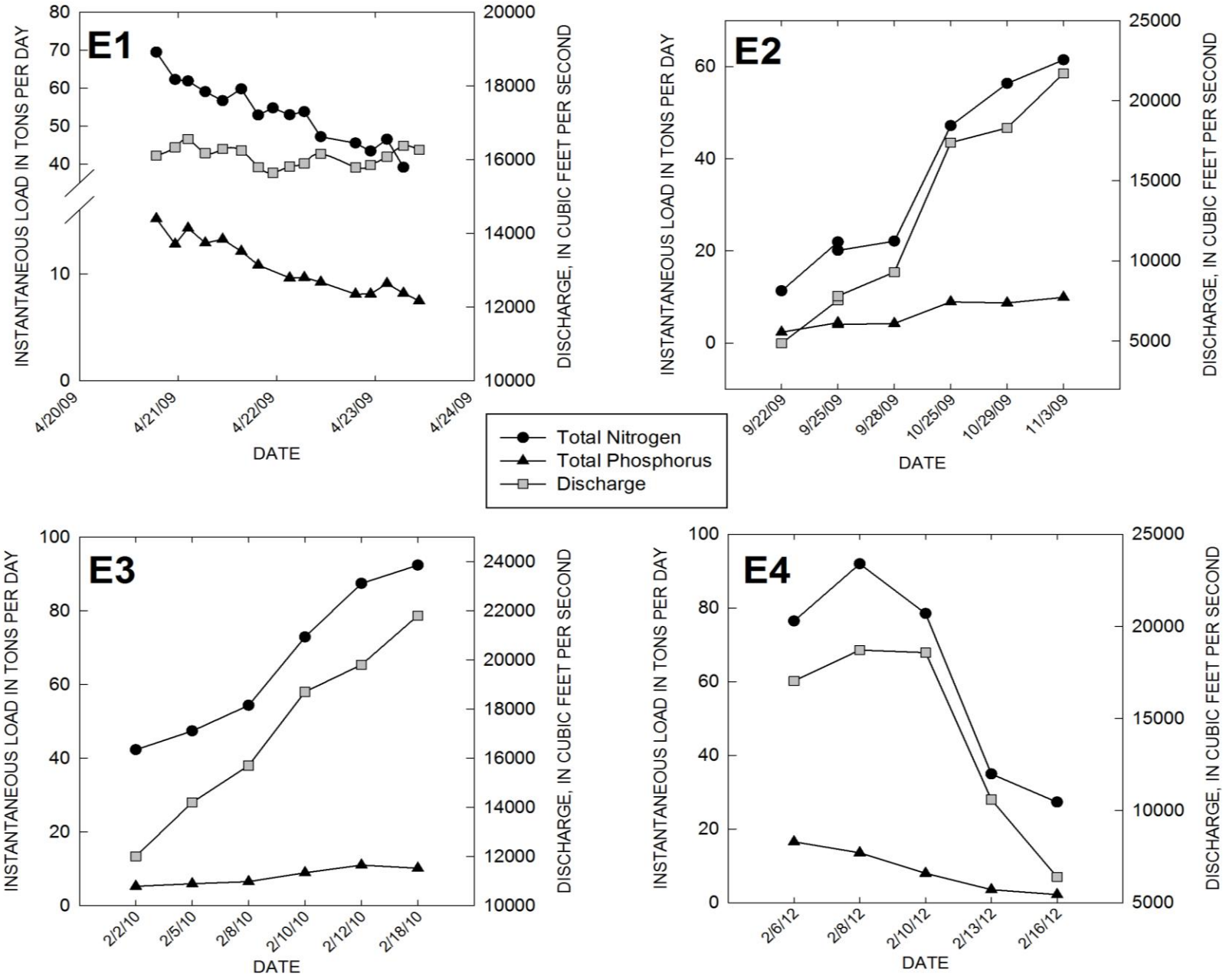

E1
INSTANTANEOUS LOAD IN TONS PER DAY
DISCHARGE, IN CUBIC FEET PER SECOND
40000
35000
30000
25000
20000
15000
10000
20000
18000
16000
14000
12000
10000
4/20/09
4/21/09
4/22/09
4/23/09
4/24/09
DATE


E2
INSTANTANEOUS LOAD IN TONS PER DAY
DISCHARGE, IN CUBIC FEET PER SECOND
30000
25000
20000
15000
10000
5000
0
25000
20000
15000
10000
5000
9/22/09
9/25/09
9/28/09
10/25/09
10/29/09
11/3/09
DATE


Suspended Sediment
Discharge


E3
INSTANTANEOUS LOAD IN TONS PER DAY
DISCHARGE, IN CUBIC FEET PER SECOND
30000
25000
20000
15000
10000
5000
24000
22000
20000
18000
16000
14000
12000
10000
8000
2/2/10
2/5/10
2/8/10
2/10/10
2/12/10
2/18/10
DATE


E4
INSTANTANEOUS LOAD IN TONS PER DAY
DISCHARGE, IN CUBIC FEET PER SECOND
50000
40000
30000
20000
10000
0
20000
18000
16000
14000
12000
10000
8000
6000
2/6/12
2/8/12
2/10/12
2/13/12
2/16/12
DATE


E1
INSTANTANEOUS LOAD IN TONS PER DAY
DISCHARGE, IN CUBIC FEET PER SECOND
DATE
4/20/09
4/21/09
4/22/09
4/23/09
4/24/09
E2
9/22/09
9/25/09
9/28/09
10/25/09
10/29/09
11/3/09
E3
2/2/10
2/5/10
2/8/10
2/10/10
2/12/10
2/18/10
E4
2/6/12
2/8/12
2/10/12
2/13/12
2/16/12
Total Nitrogen
Total Phosphorus
Discharge

Regression Methods

- Regression of Water-Quality Constituents, Why?
- To create predictive statistical relations between readily acquired continuous field data and selected water-quality constituents acquired through periodic sampling and laboratory analysis.

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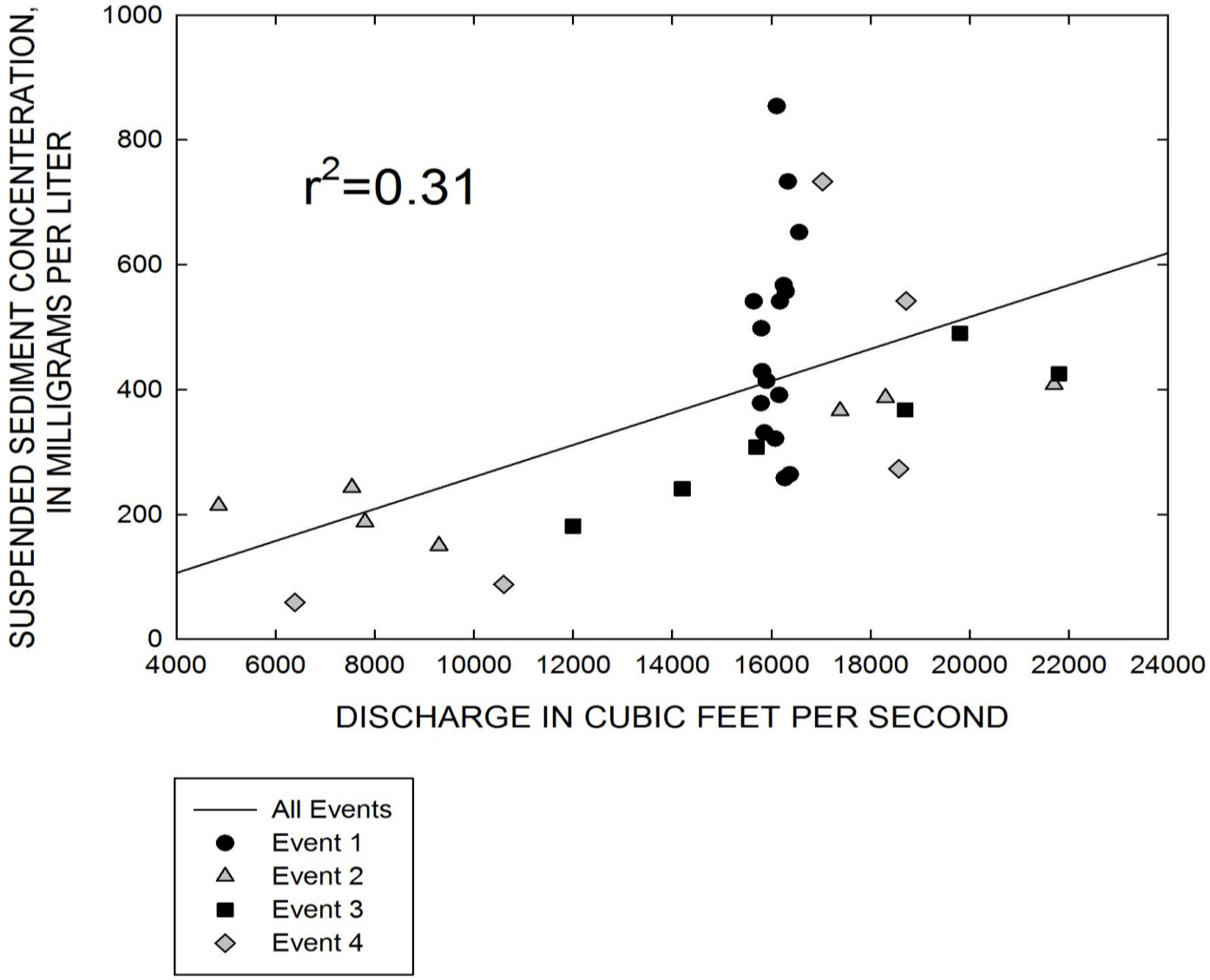
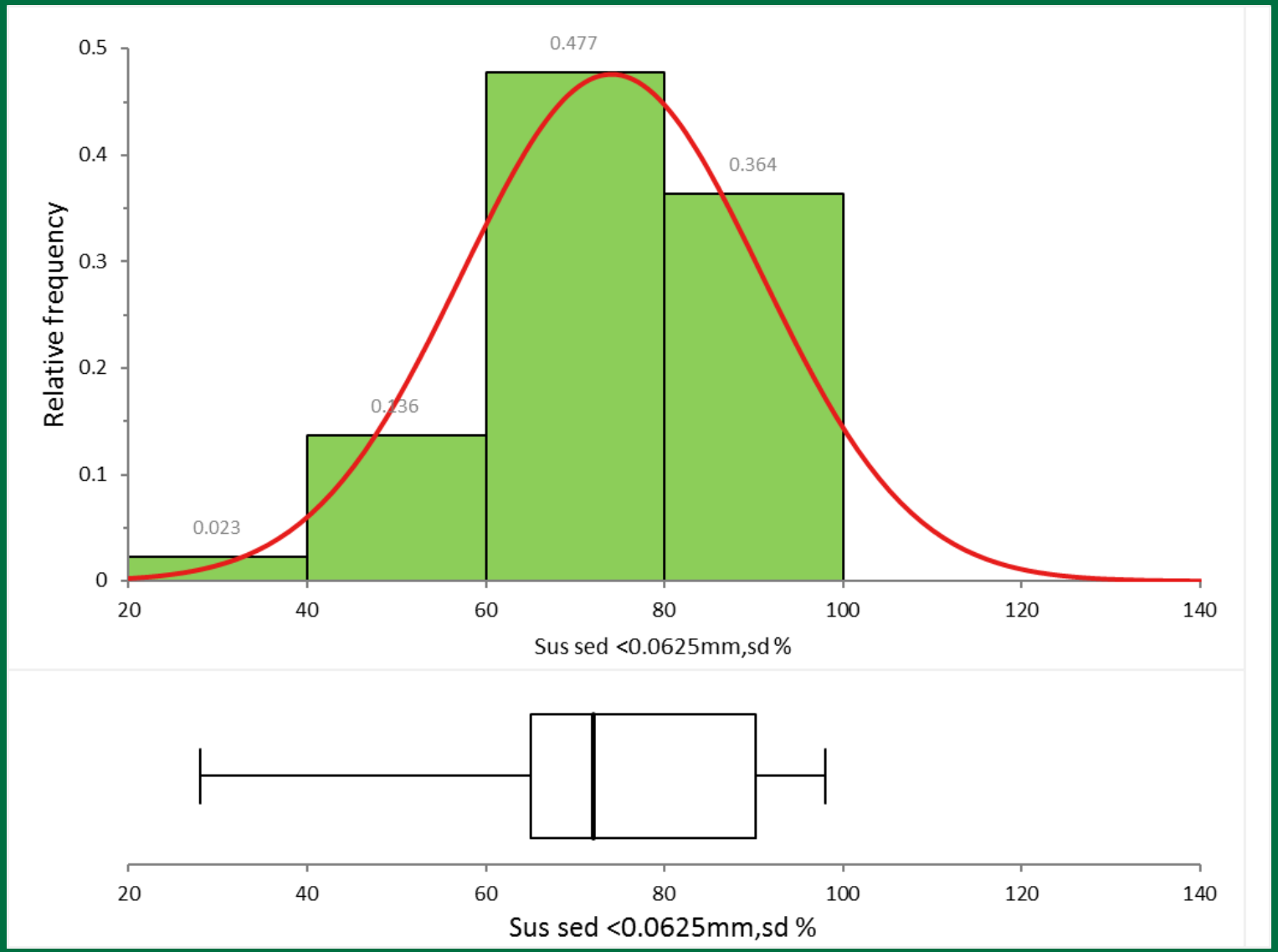
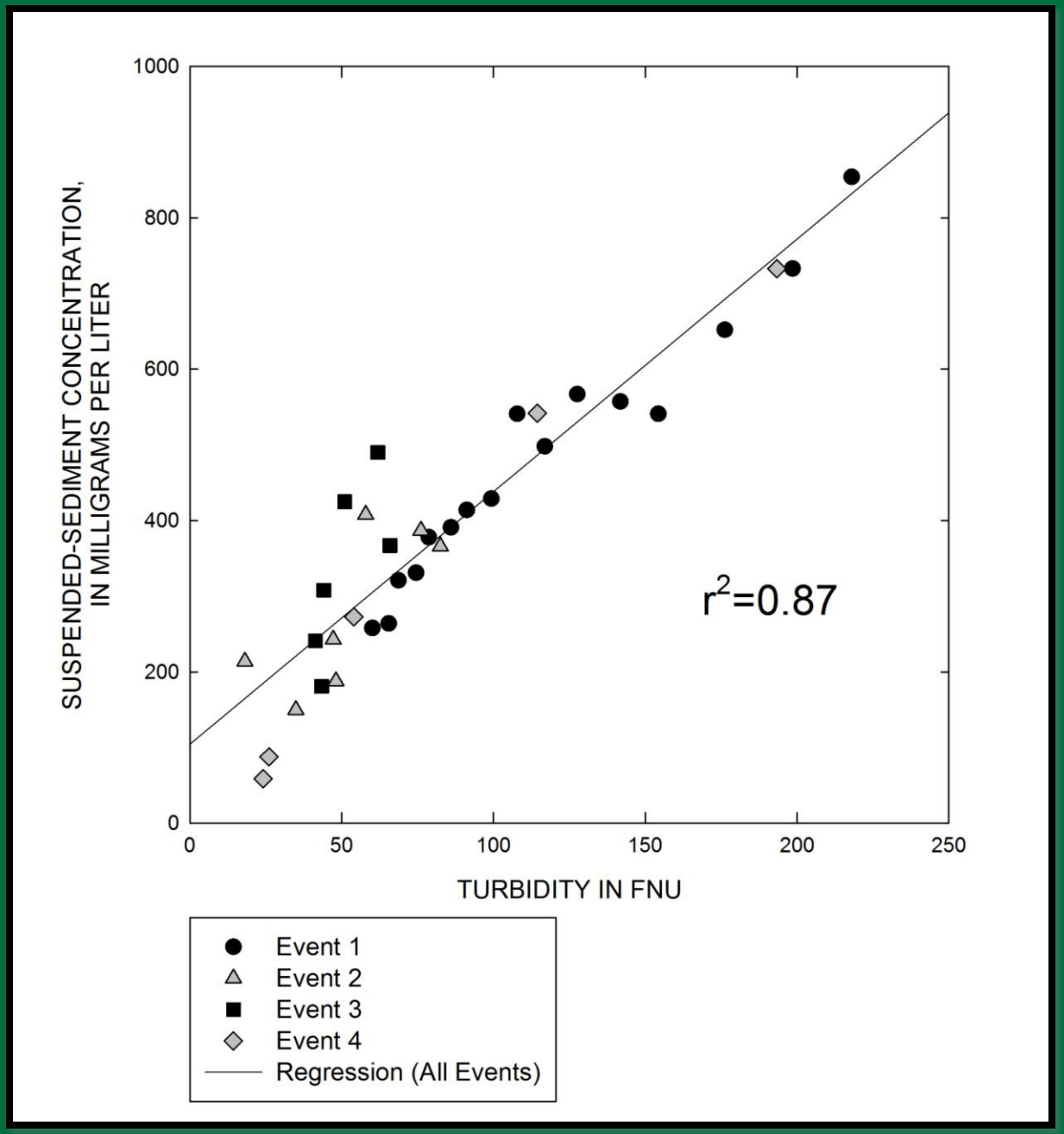

SUSPENDED SEDIMENT CONCENTRATION, IN MILLIGRAMS PER LITER
1000
800
600
400
200
0
r^2=0.31
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
DISCHARGE IN CUBIC FEET PER SECOND
All Events
Event 1
Event 2
Event 3
Event 4

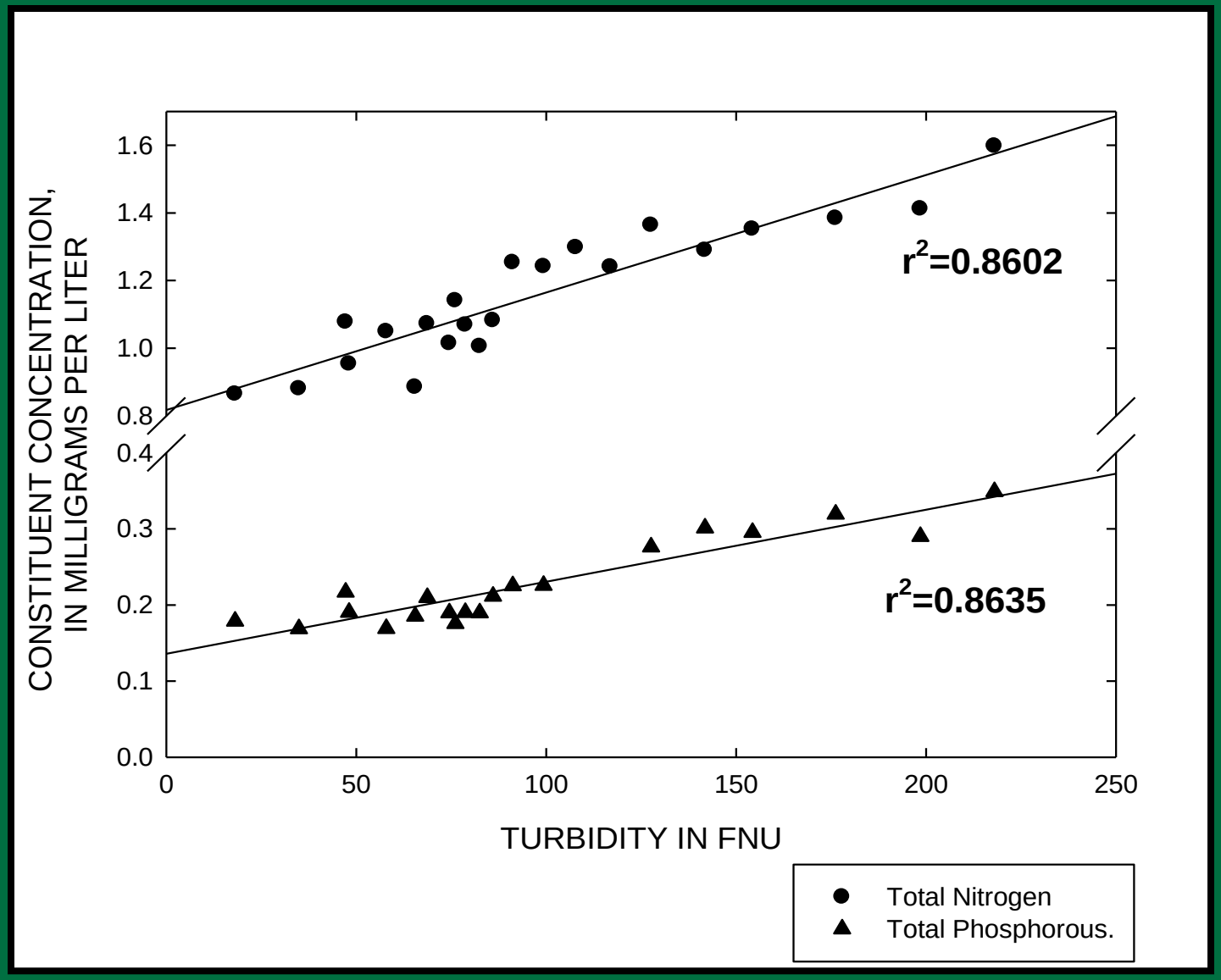
USGS


0.5
0.4
0.3
0.2
0.1
0
Relative frequency
0.477
0.364
0.136
0.023
20
40
60
80
100
120
140
Sus sed <0.0625mm,sd %
20
40
60
80
100
120
140
Sus sed <0.0625mm,sd %

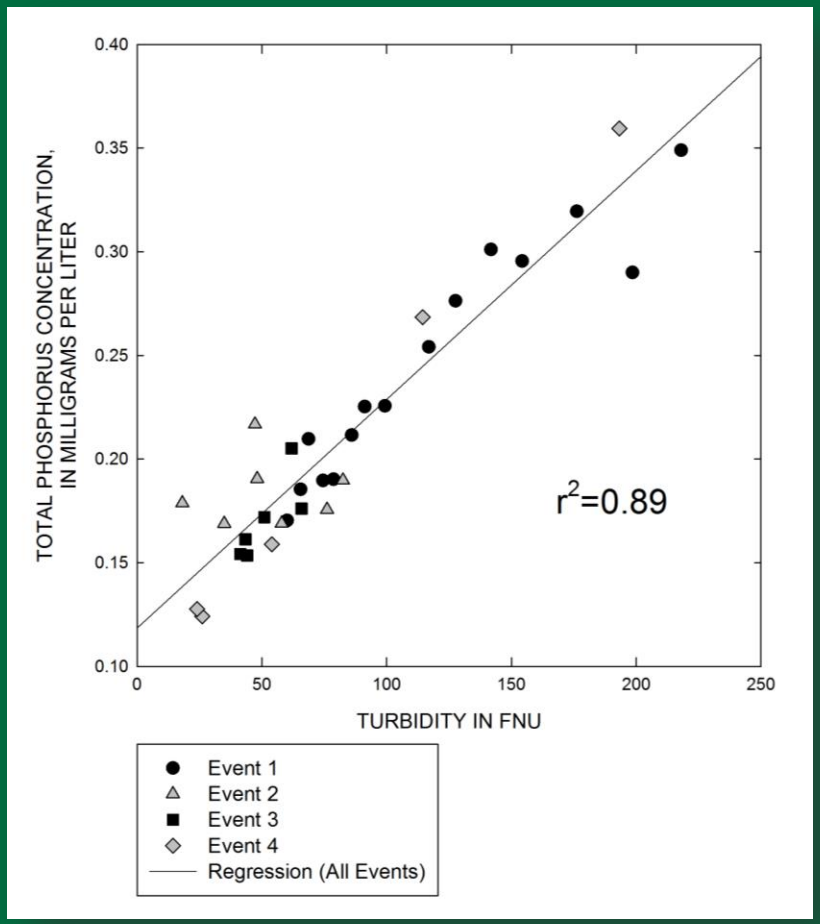
USGS

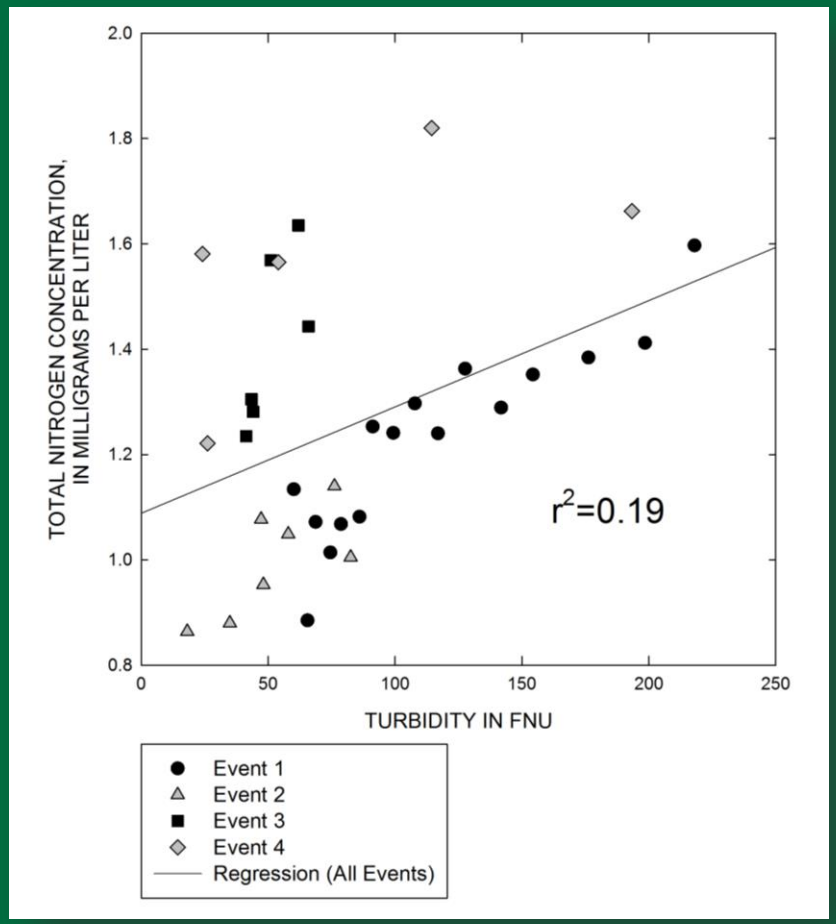

SUSPENDED-SEDIMENT CONCENTRATION, IN MILLIGRAMS PER LITER
1000
800
600
400
200
0
0
50
100
150
200
250
TURBIDITY IN FNU
r^2=0.87
Event 1
Event 2
Event 3
Event 4
Regression (All Events)

USGS

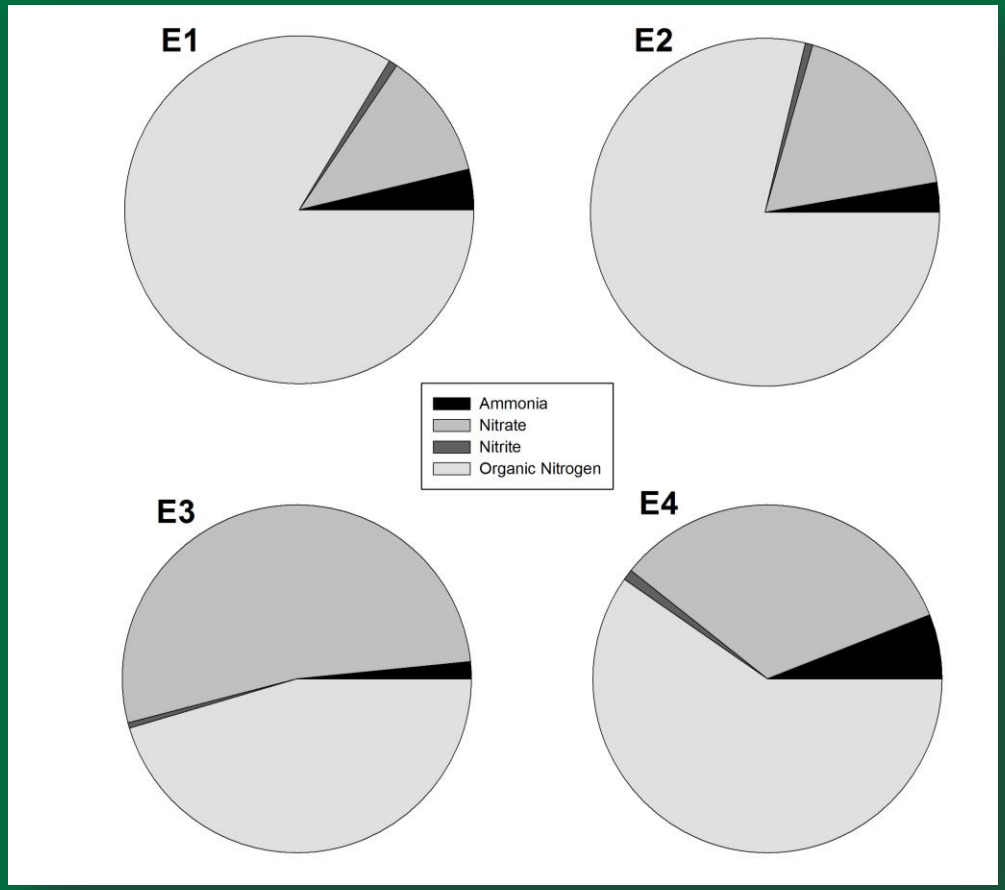

CONSTITUENT CONCENTRATION, IN MILLIGRAMS PER LITER
1.6
1.4
1.2
1.0
0.8
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
TURBIDITY IN FNU
r2=0.8602
r2=0.8635
Total Nitrogen
Total Phosphorous.

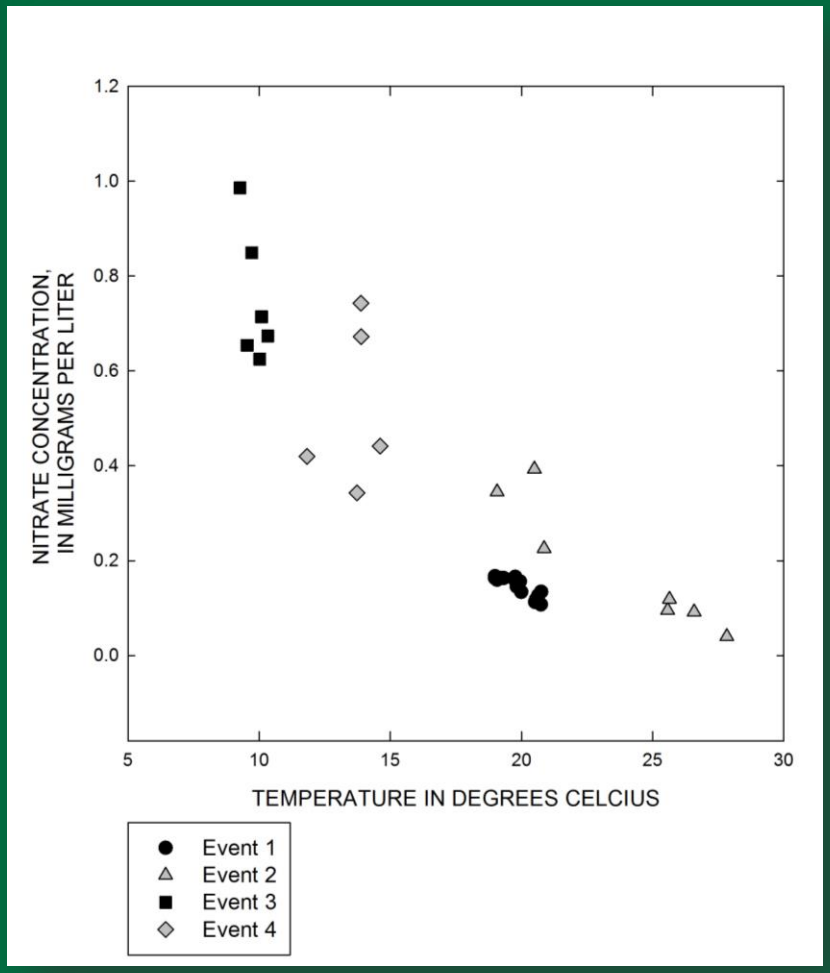
USGS


TOTAL PHOSPHORUS CONCENTRATION, IN MILLIGRAMS PER LITER
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0
50
100
150
200
250
TURBIDITY IN FNU
r2=0.89
Event 1
Event 2
Event 3
Event 4
Regression (All Events)


TOTAL NITROGEN CONCENTRATION, IN MILLIGRAMS PER LITER
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0
50
100
150
200
250
TURBIDITY IN FNU
r2=0.19
Event 1
Event 2
Event 3
Event 4
Regression (All Events)

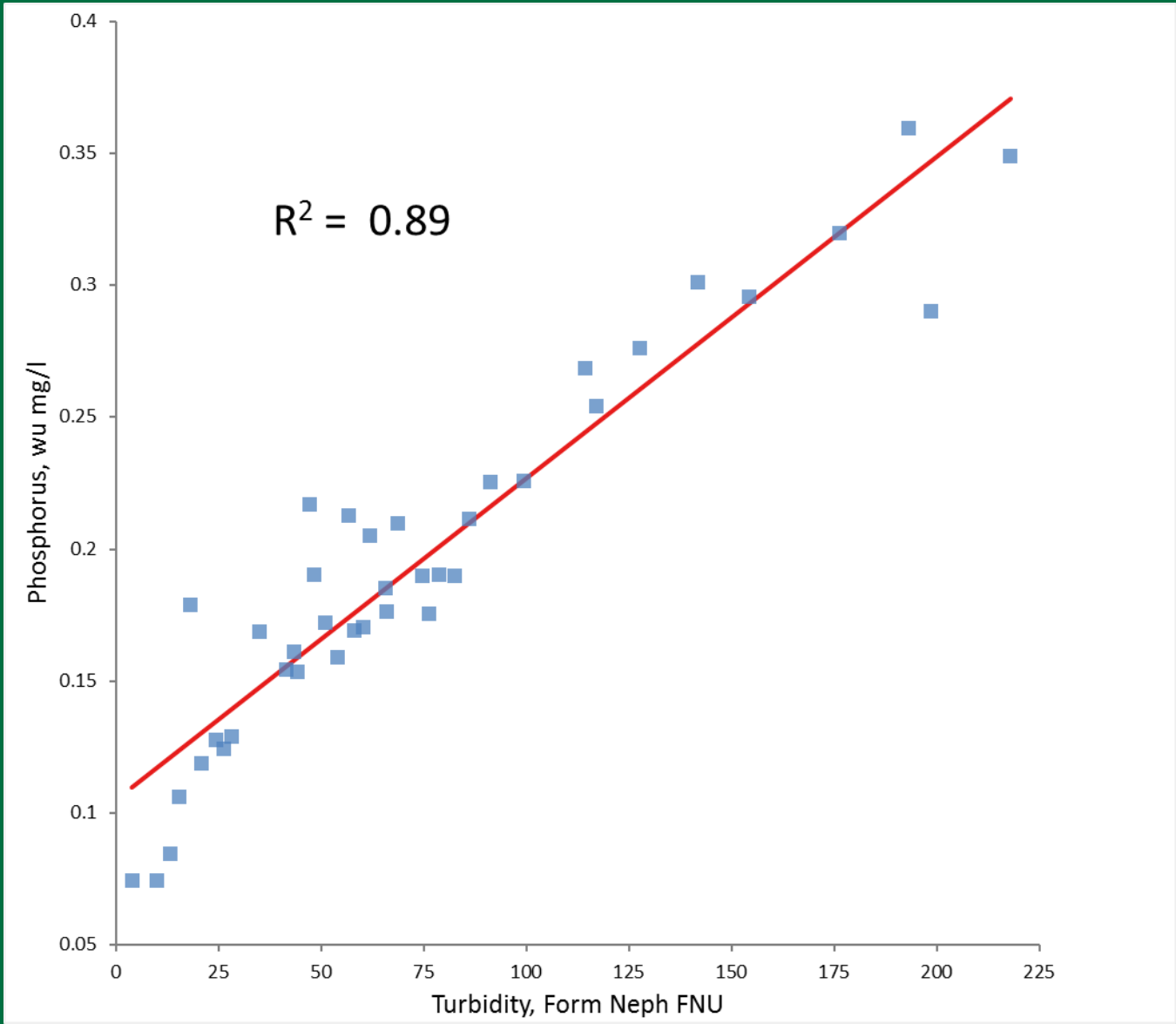
USGS


E1
E2
E3
E4
Ammonia
Nitrate
Nitrite
Organic Nitrogen


NITRATE CONCENTRATION, IN MILLIGRAMS PER LITER
1.2
1.0
0.8
0.6
0.4
0.2
0.0
5
10
15
20
25
30
TEMPERATURE IN DEGREES CELCIUS
Event 1
Event 2
Event 3
Event 4

USGS

Phosphorous



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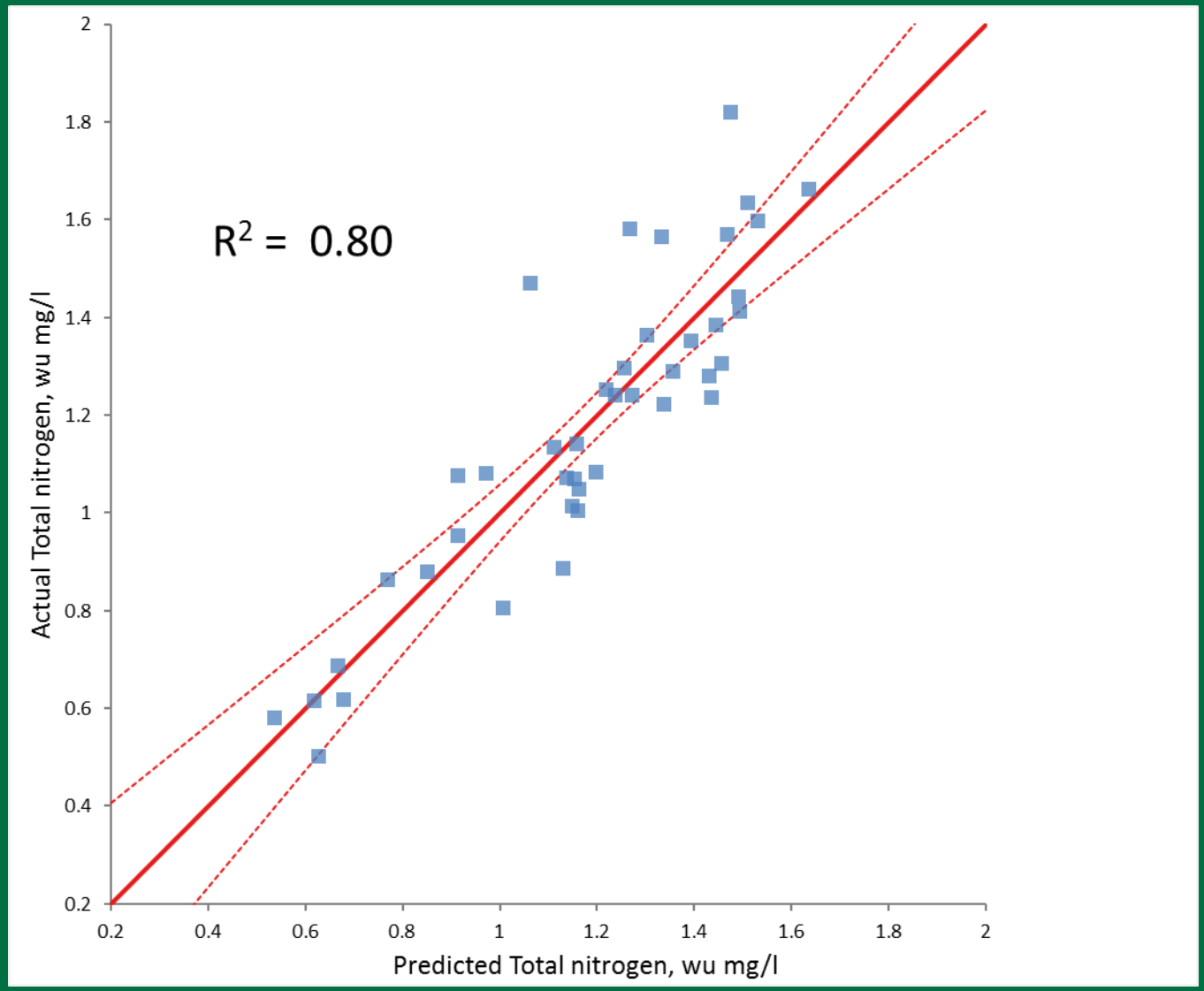
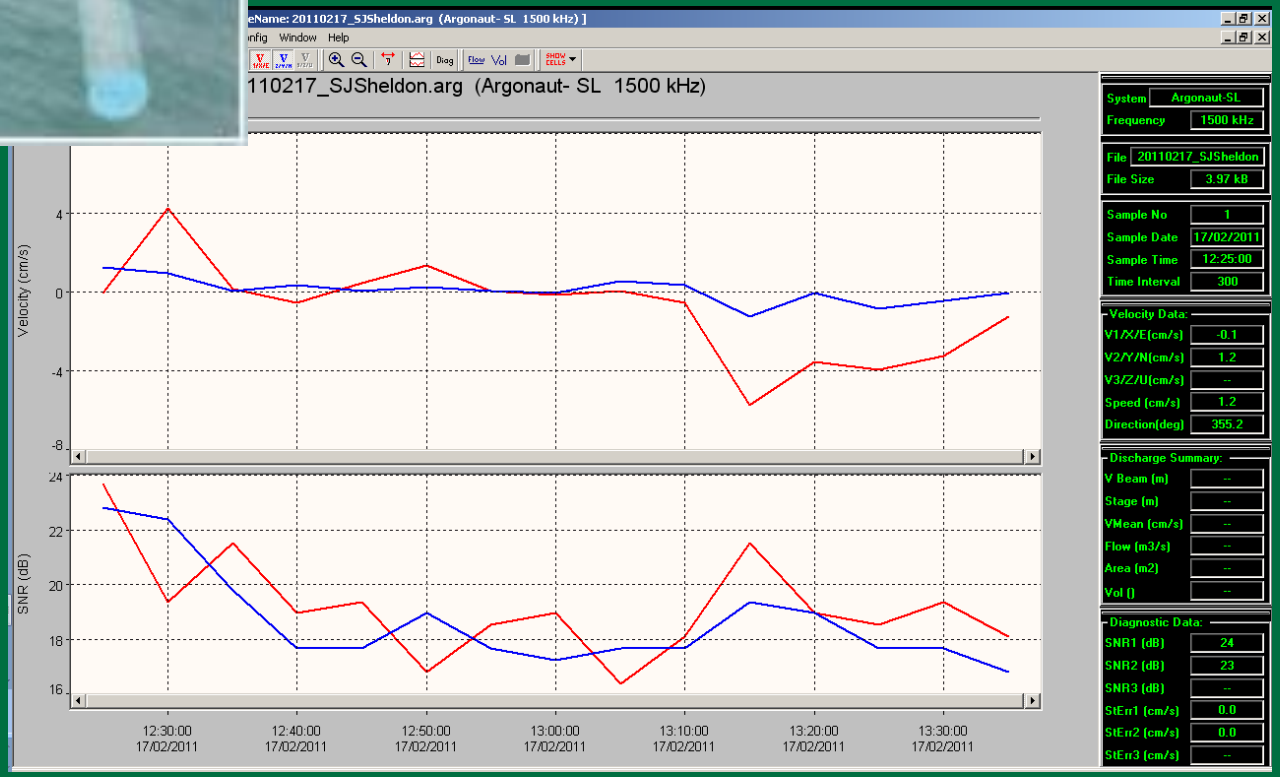
Total Nitrogen

Under low turbidity conditions the total nitrogen becomes more influenced by the effect of temperature as preserved by the regression coefficient on temperature



USGS

Acoustic Backscatter



USGS

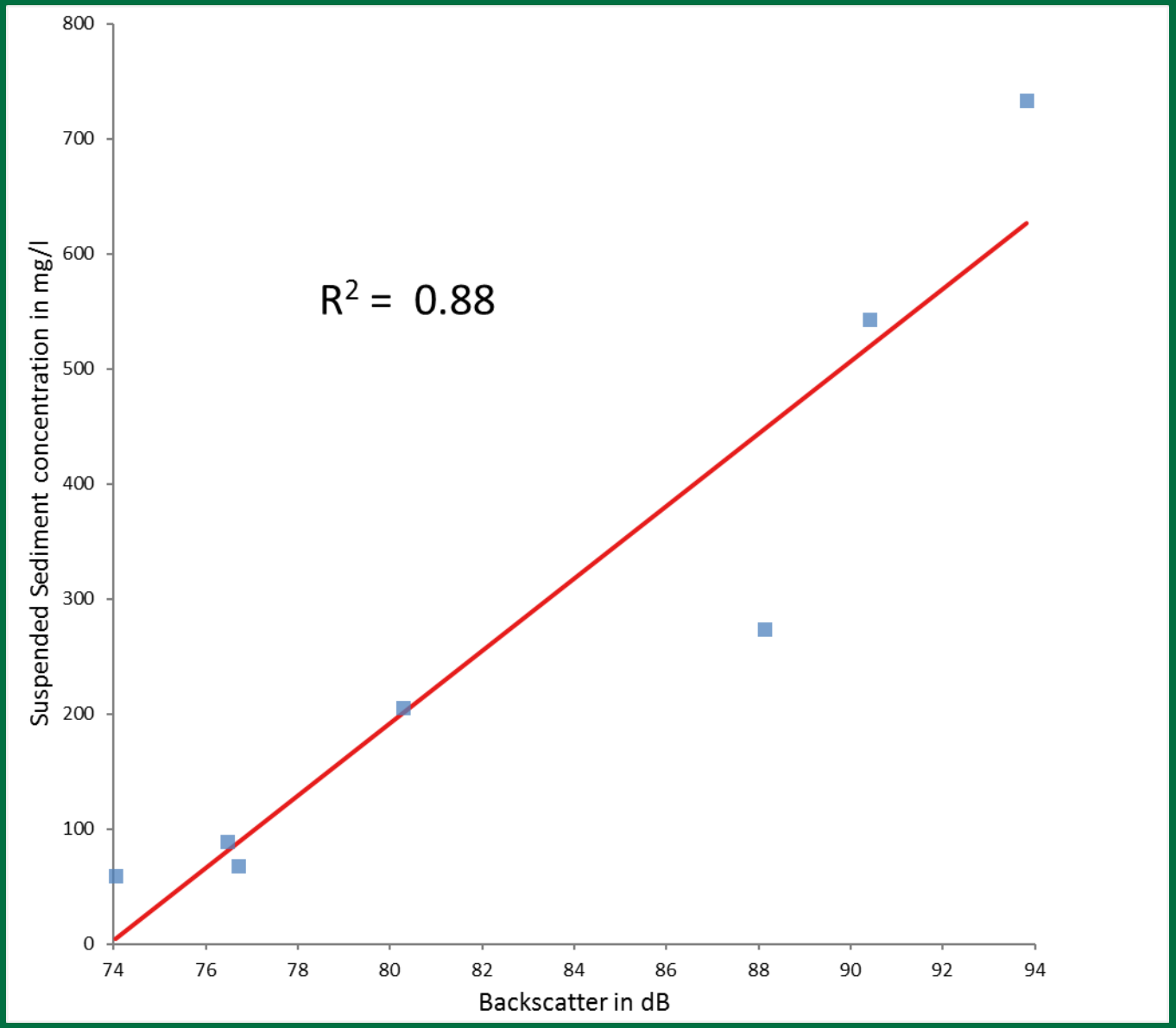
Acoustic Advantage

- Fouling
- Index velocity for discharge
- Temperature and Acoustic Signal
- Better response in highly turbid environments
  - (i.e. Turbidity sensors can “peg”)

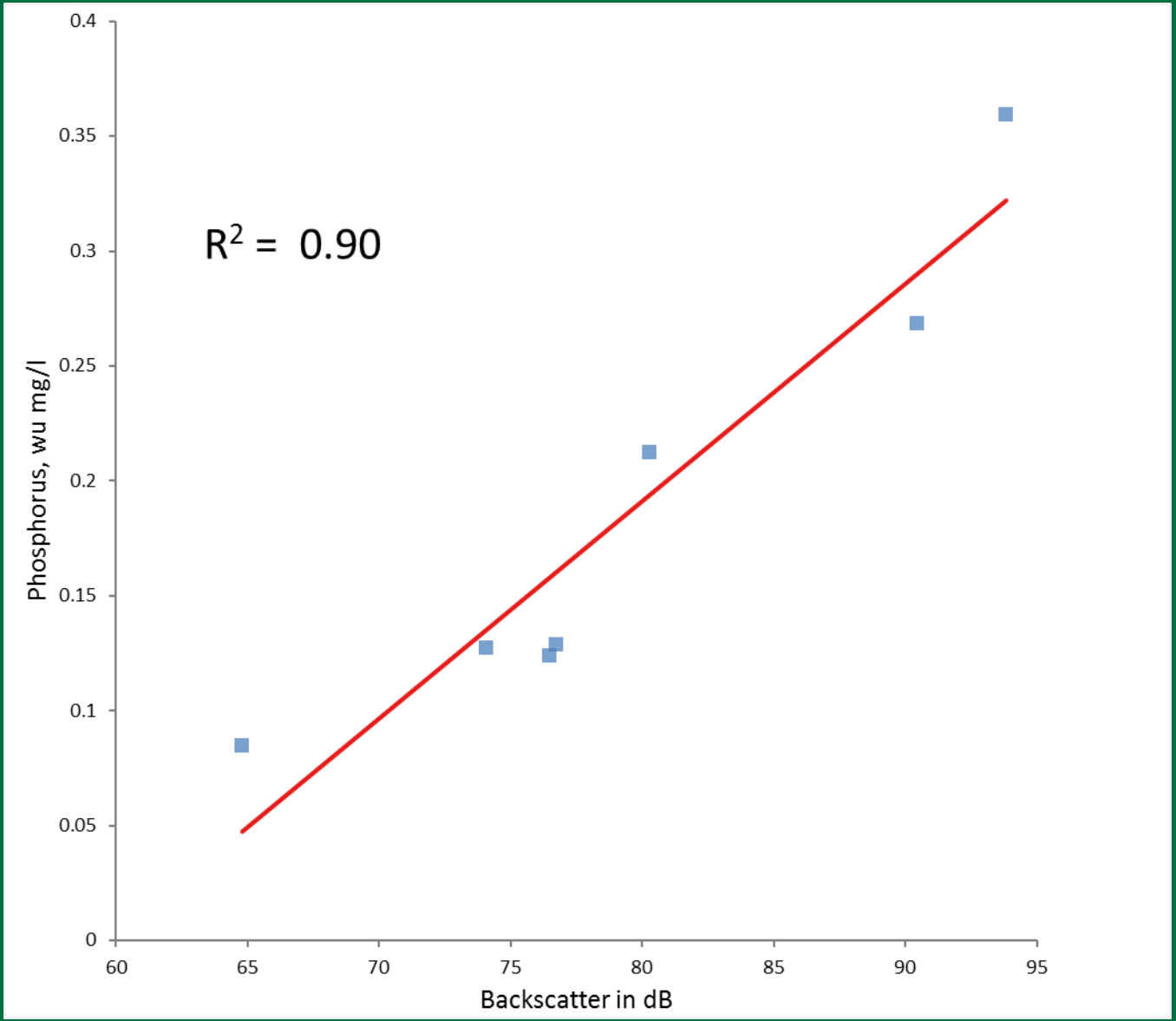
USGS

USGS

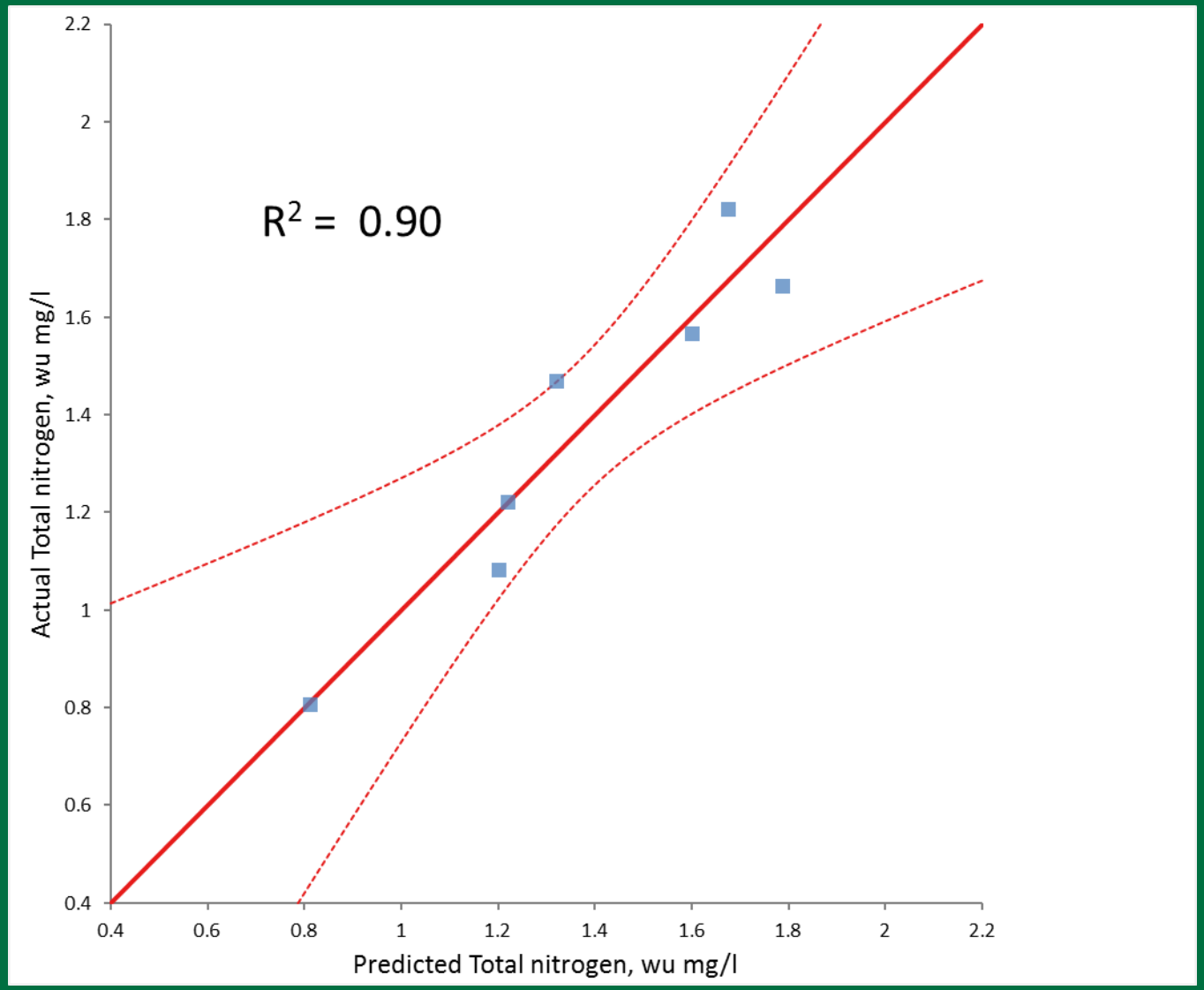
Trinity River



USGS


R^2 = 0.90
Phosphorus, wu mg/l
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
60
65
70
75
80
85
90
95
Backscatter in dB

USGS


$R^2 = 0.90$
Actual Total nitrogen, wu mg/l
Predicted Total nitrogen, wu mg/l
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2

USGS

Lessons Learned

- Sediment and nutrient loading along the Trinity River can be highly variable and may be influenced by differences in flood-discharge magnitude, duration, origin of floodwater runoff into the Trinity River system, and timing of sample collection.
- Wetlands and bayhead delta may play a vital role in dampening discharge and sequestering sediment and nutrients
- Monitoring with surrogate development may provide the best understanding of loads entering Galveston Bay from the Trinity River.

USGS

What's Next?

- Bed Load / Bed Material
  - Total Loading?
- Continue exploring the ADVM
  - Index Velocity
- GBEP
  - San Jacinto River
  - Trinity River
- TWDB
  - Colorado River
  - Guadalupe River

USGS

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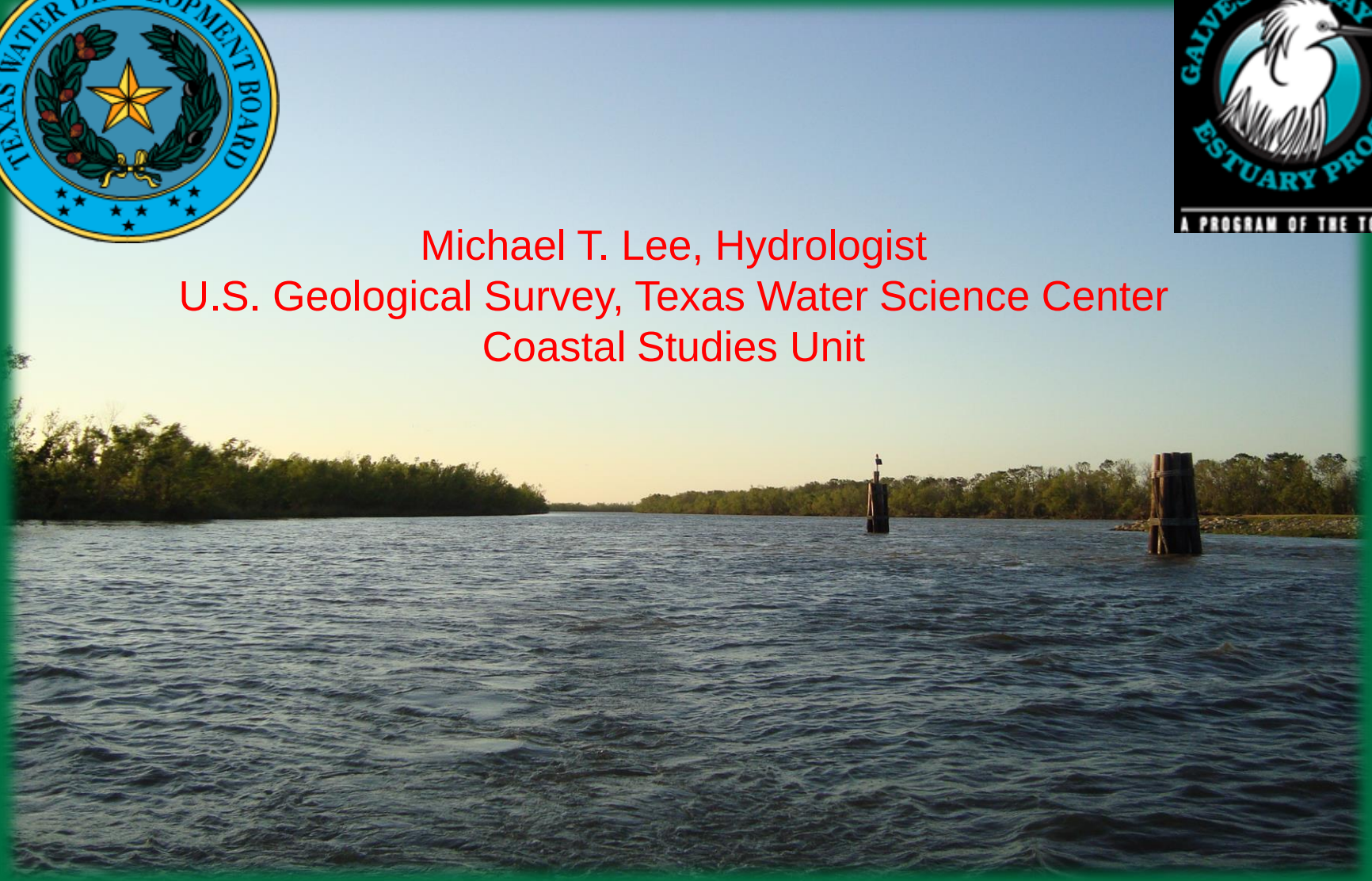
U.S. Geological Survey, Texas Water Science Center
Coastal Studies Unit



Trinity River