The Effects of Urbanization on Baird Creek, Green Bay, WI

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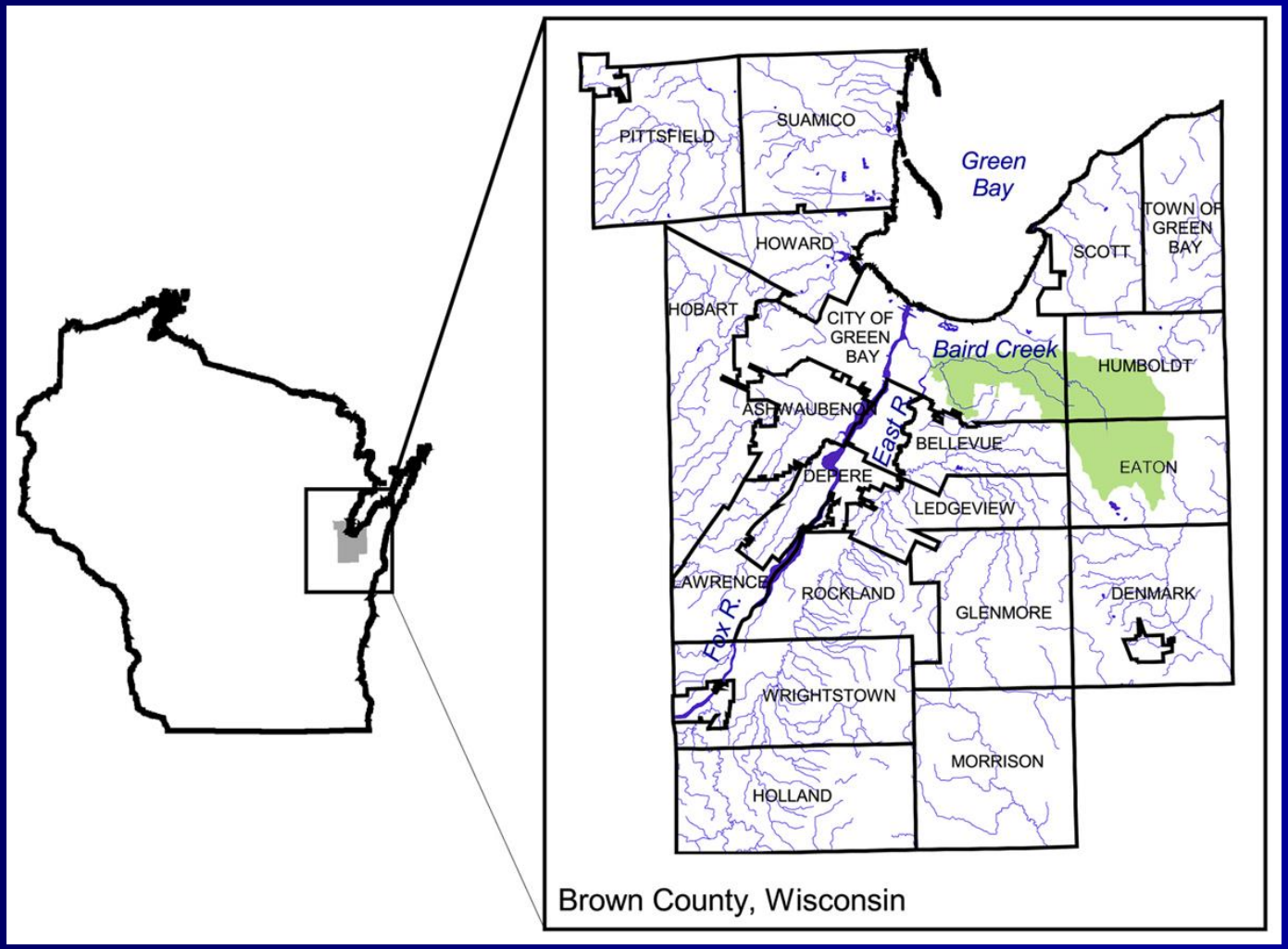
Presentation Outline

- Overview of the Baird Creek Watershed
- Research Questions
- Methods
- Results
  - Water Quality
  - Channel Morphology
- Modeling Future Change
- Conclusions

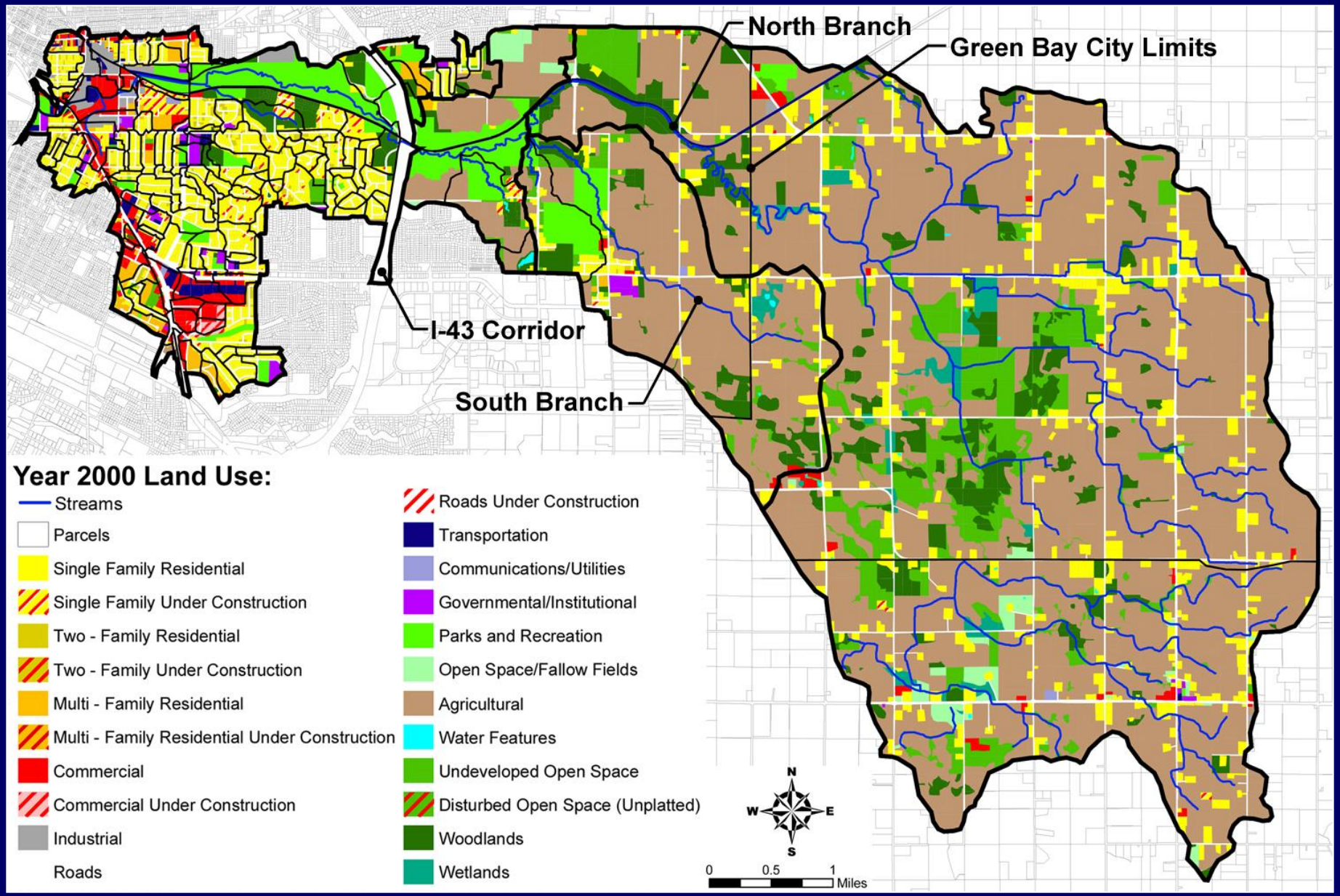
Overview of the Baird Creek Watershed

The Baird Creek Watershed

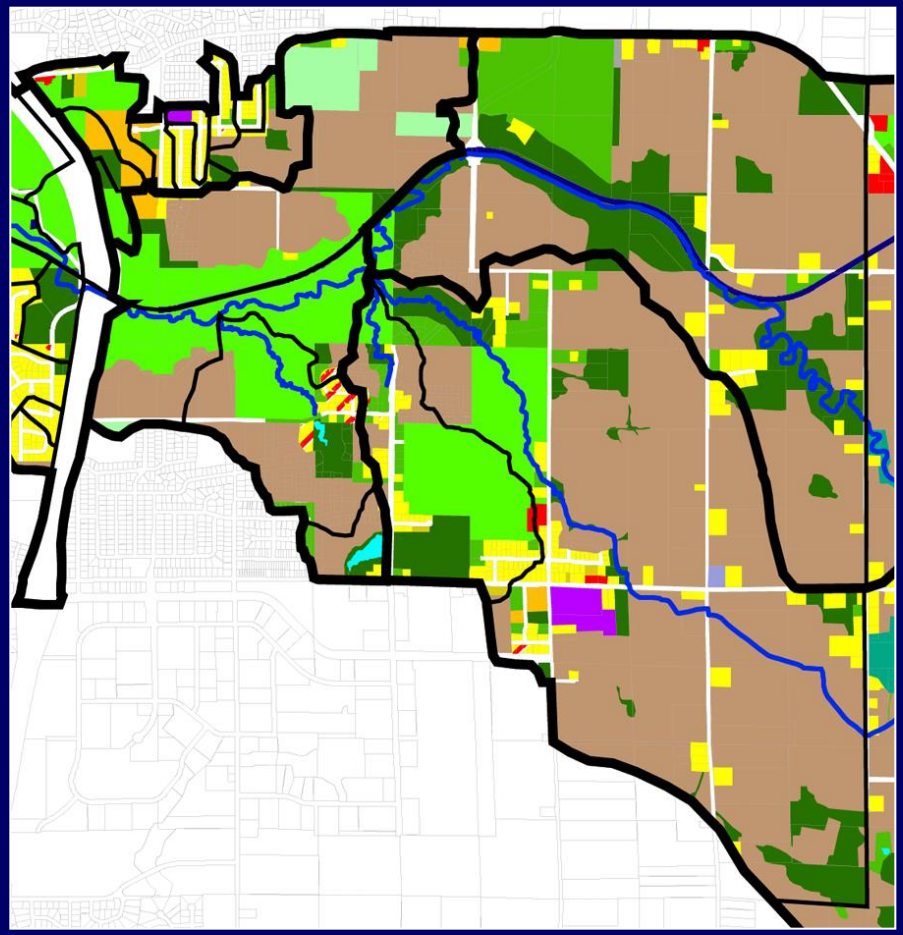


Baird Creek is Unique

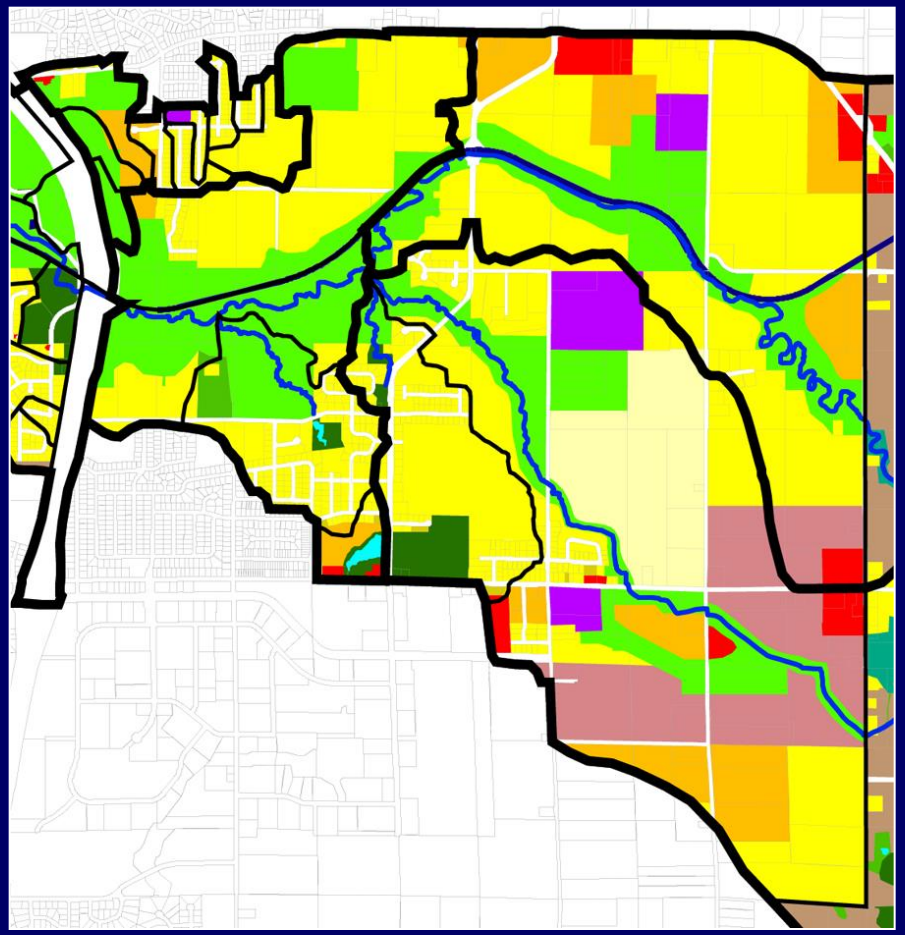
- Diverse fish community
- Baird Creek Greenway
- Active community support


North Branch
Green Bay City Limits
I-43 Corridor
South Branch
Year 2000 Land Use:
Streams
Parcels
Single Family Residential
Single Family Under Construction
Two - Family Residential
Two - Family Under Construction
Multi - Family Residential
Multi - Family Residential Under Construction
Commercial
Commercial Under Construction
Industrial
Roads
Roads Under Construction
Transportation
Communications/Utilities
Governmental/Institutional
Parks and Recreation
Open Space/Fallow Fields
Agricultural
Water Features
Undeveloped Open Space
Disturbed Open Space (Unplatted)
Woodlands
Wetlands
N
W
E
S
0
0.5
1
Miles

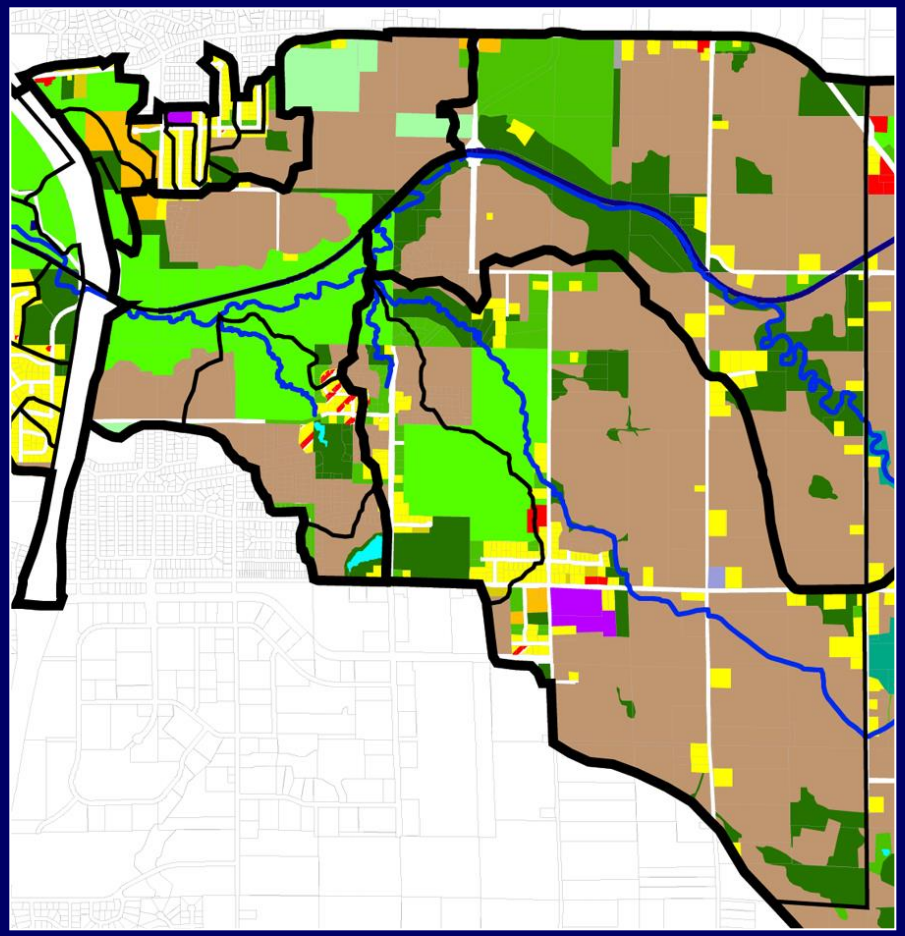
2000 Land Use



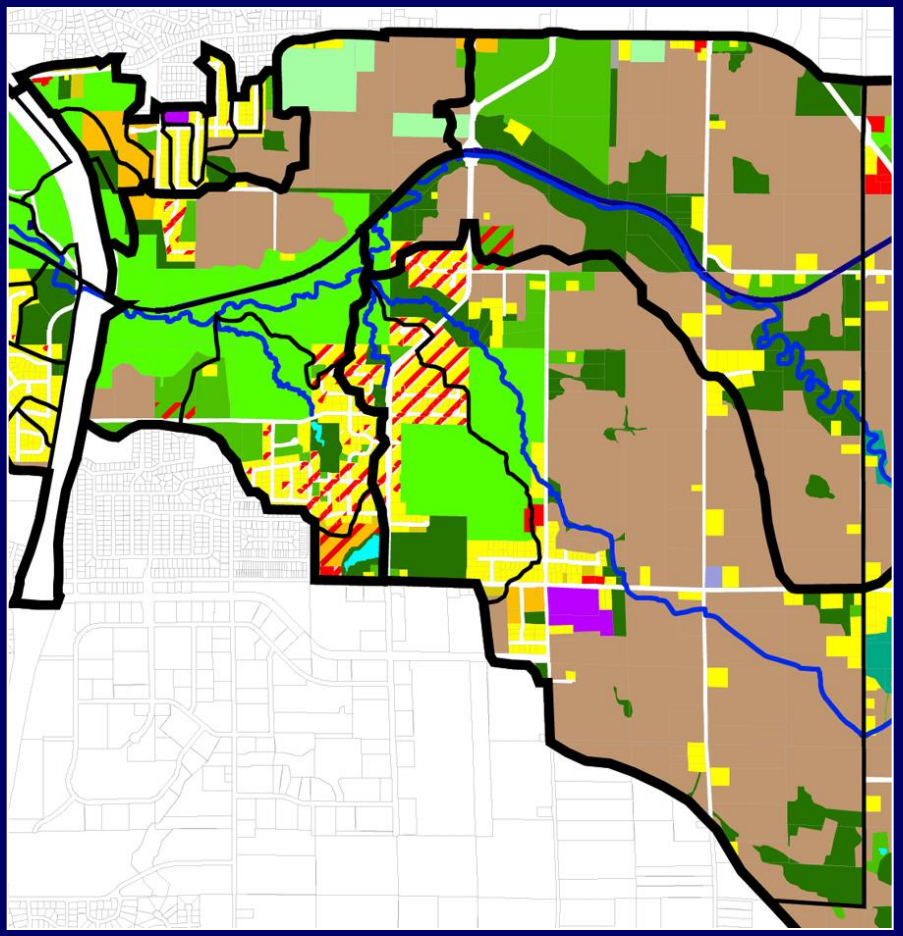
Projected 2022



2000 Land Use



2004 Land Use



Impervious Cover

Watershed	2000 Aerials	May 2004	2022 Smart Growth Plan
USGS Station at Superior Road	5.6%	6.1%	11.8%
North Branch	5.4%	5.5%	8.0%
South Branch	6.8%	8.2%	29.5%
Main Channel Below Confluence	5.6%	11.0%	24.6%
Christa McAuliffe Park Ravine	5.6%	19.8%	24.5%
Huron-Sitka Detention Basin Ravine	11.3%	17.8%	30.2%

South vs. North Branches

Research Questions:

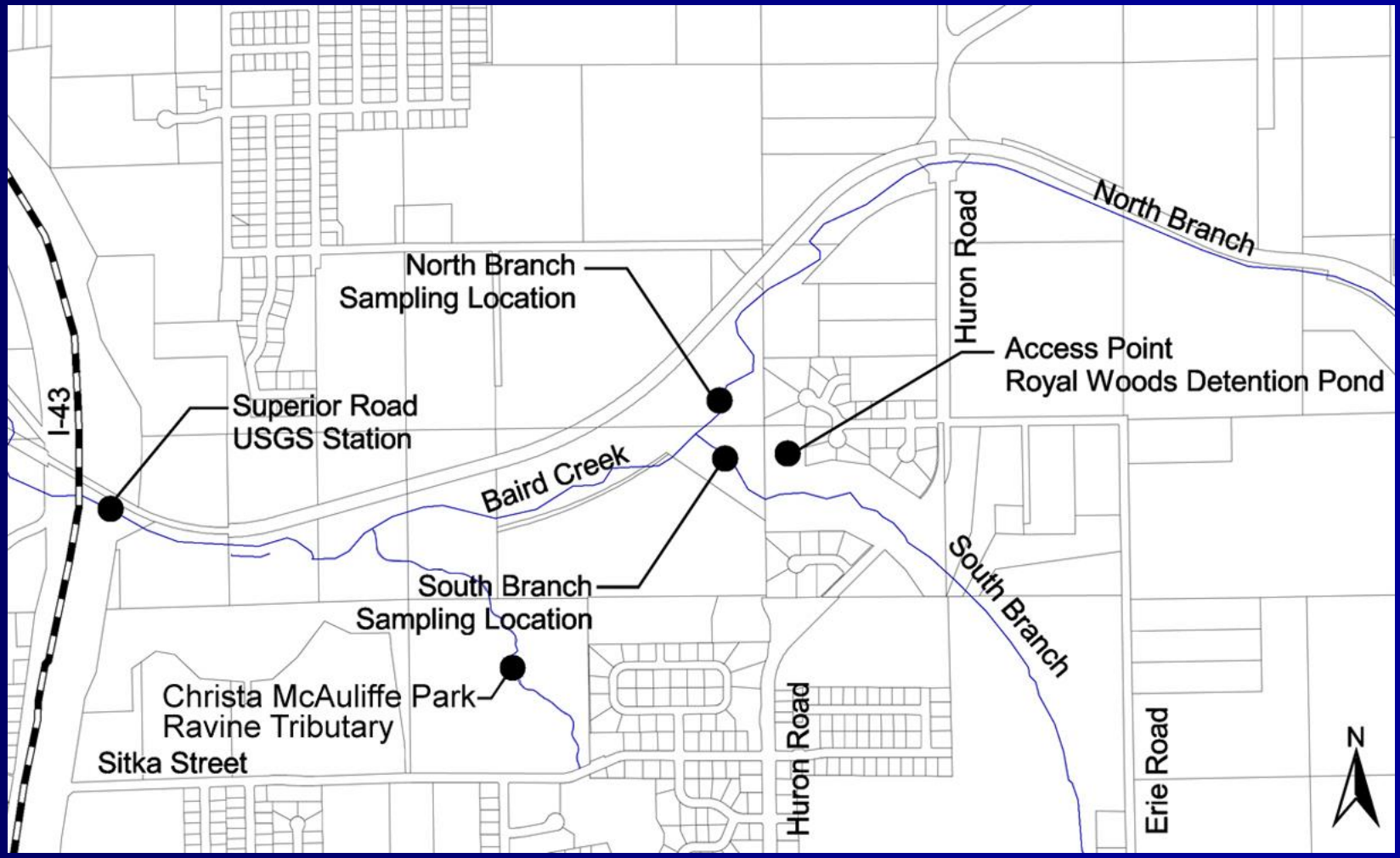
- Do differences exist in the water quality of the agricultural and urbanizing tributaries of Baird Creek?
- Has the channel morphology of Baird Creek and its tributaries changed in response to hydrologic alterations in the urbanizing watershed?
- Is the L-THIA watershed development assessment tool a viable model for assessing the impact of future development on water quality in Baird Creek?

Methods

Methodology

- Three sampling locations:
  - USGS Station on Superior Road
  - South and North Branches at confluence
- Precipitation data recorded at USGS site
- Event samples at USGS site triggered by flow, at other sites on hourly intervals
- Low-flow samples collected at all sites using the EWI method

Sampling Locations



Water Sampling Equipment Upstream Sites

Water Sampling Equipment Downstream USGS Station

YSI 6200
Multiparameter Sonde

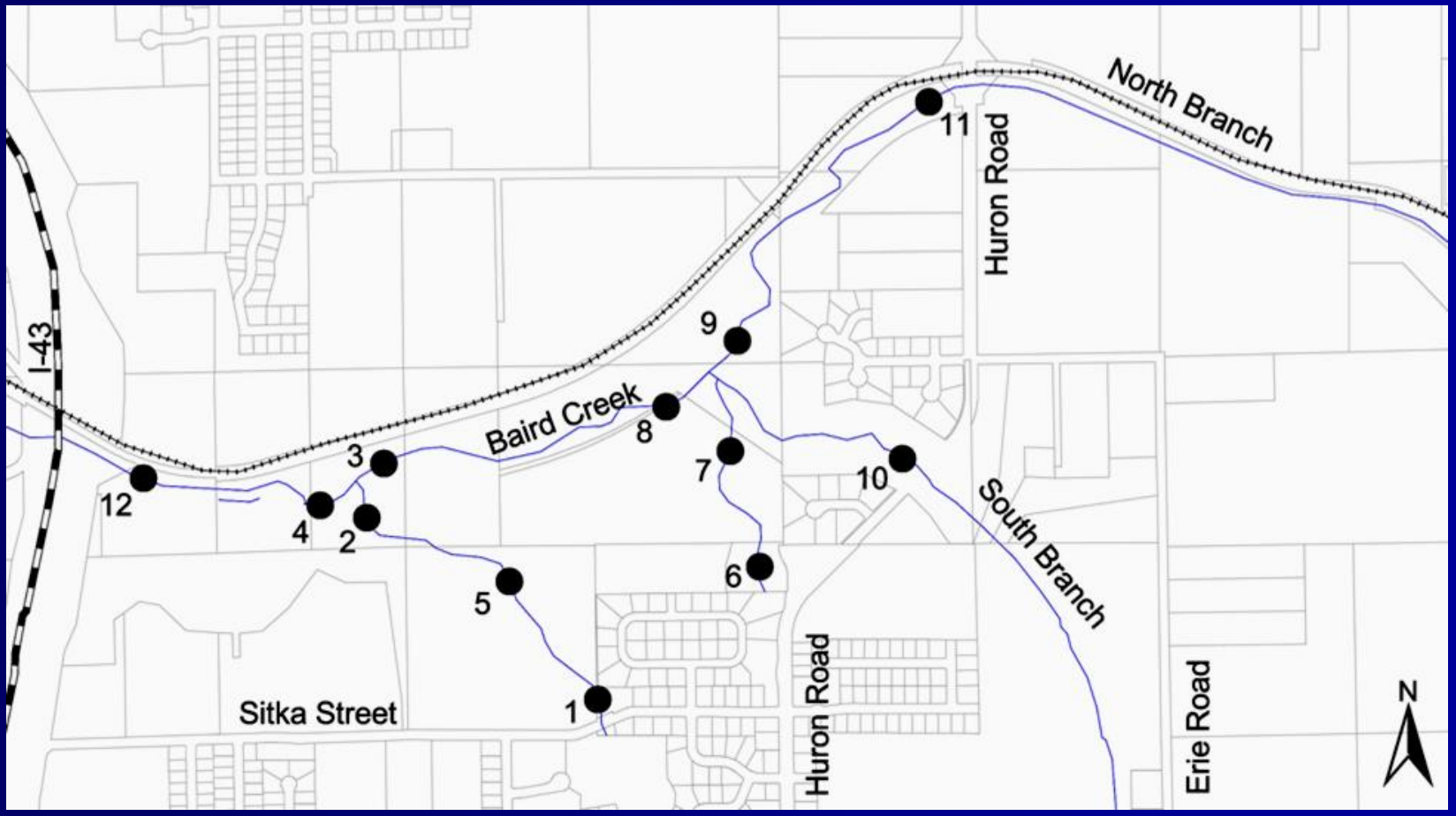
Discharge Calculations

- Upstream sites calculated using a flow meter, sonde readings, and staff gages
- High flows utilized the float method

Channel Morphology

- Reassess sites measured by AES, Inc., in 2002
- Compare changes in bankfull width and channel area enlargement between surveys

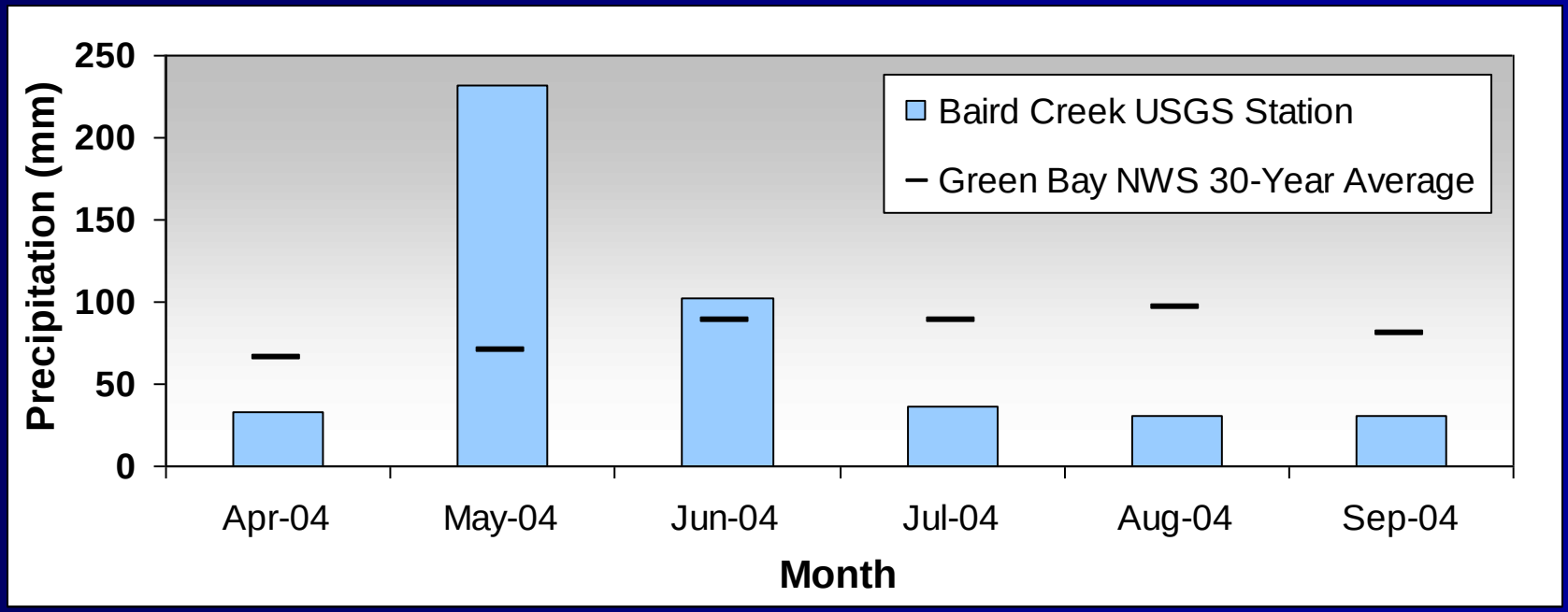
Channel Assessment Locations



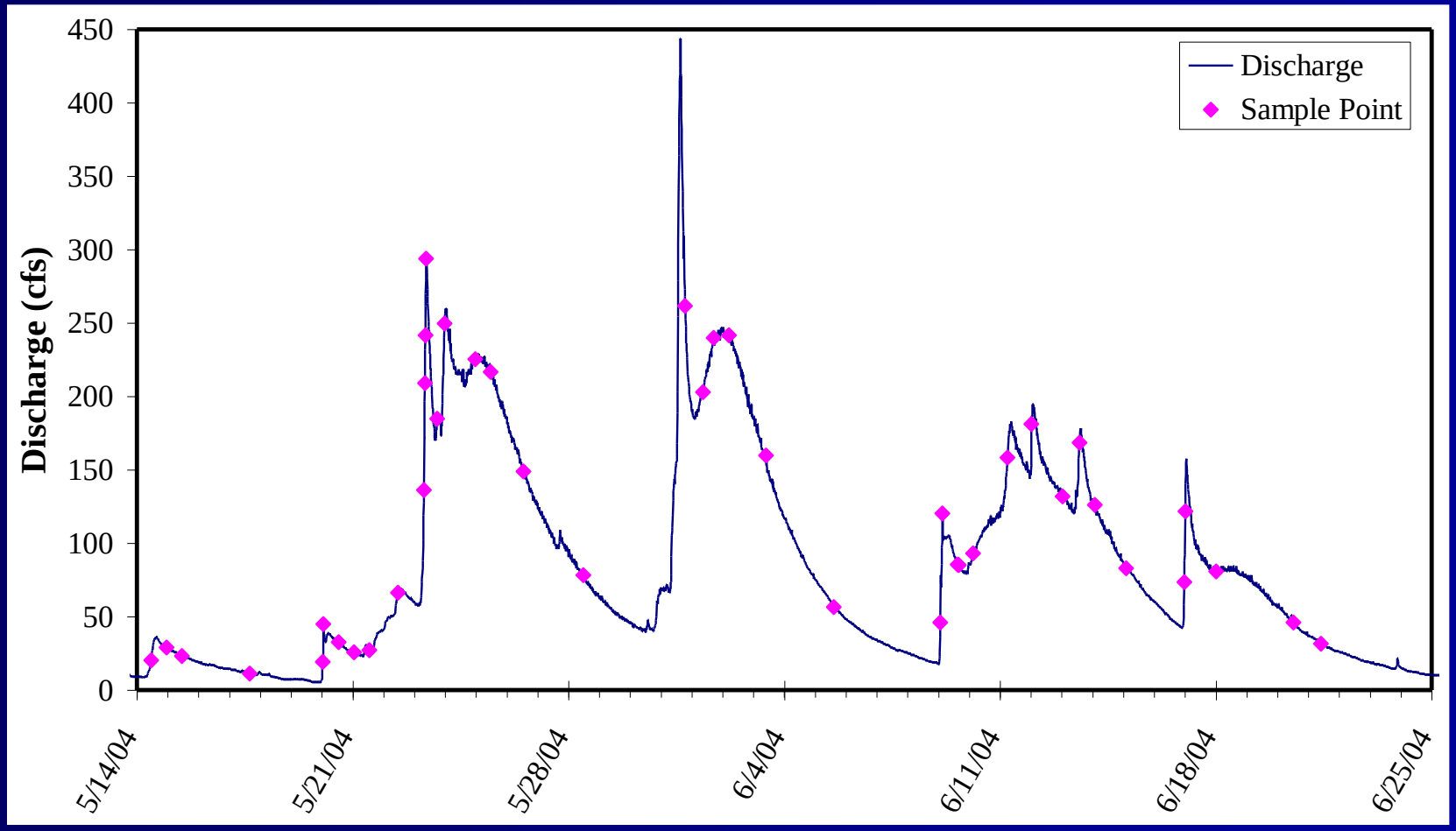
Results:
Water Quality

2004 Precipitation

- It rained and rained…then stopped!
- No sonde data upstream from May 2004



Typical Storm Hydrograph USGS Station Site

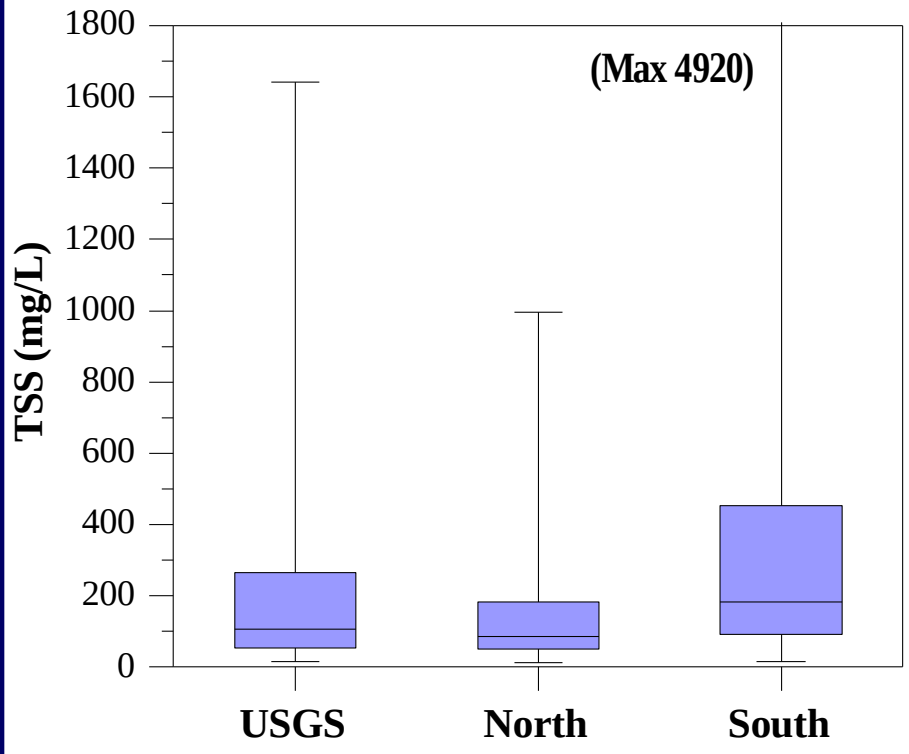


Water Quality Samples

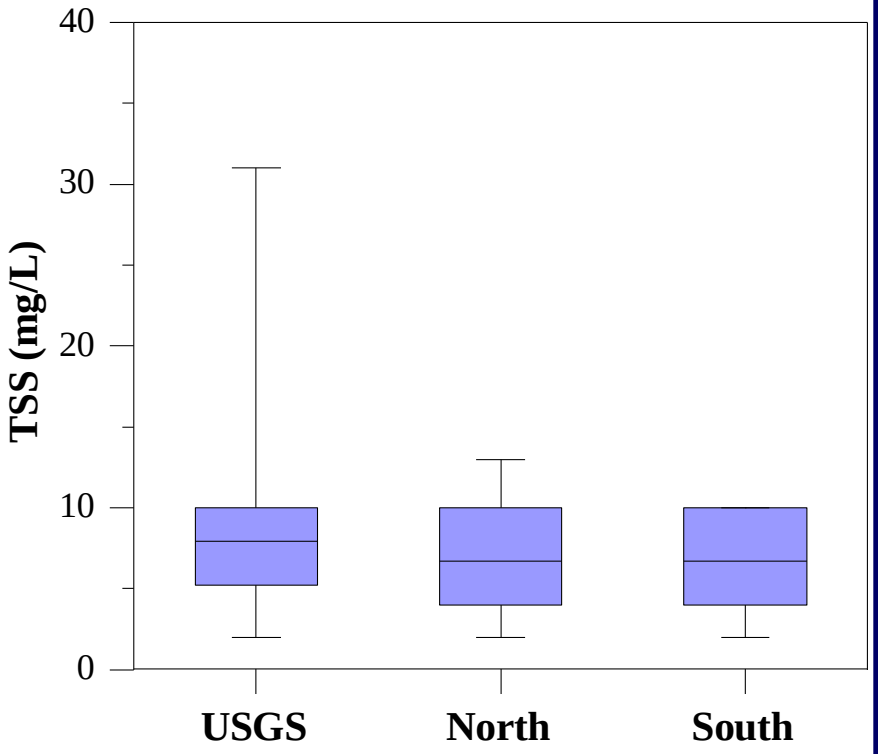
- 14 events sampled from April to December 2004
- 223 total samples collected during storm event and low-flow conditions:
  - 63 at USGS Station site
  - 85 at North Branch site
  - 75 at South Branch site
- Concentrations compared between sites using ANOVA on ranked data with a Tukey comparison procedure

Sediment Samples

Event

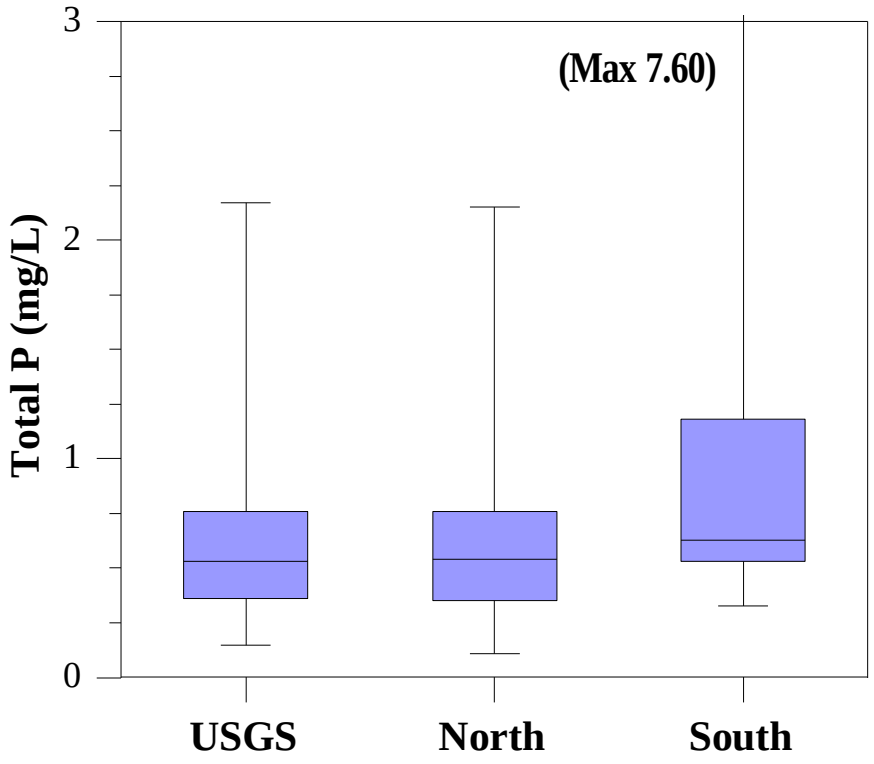


Low Flow

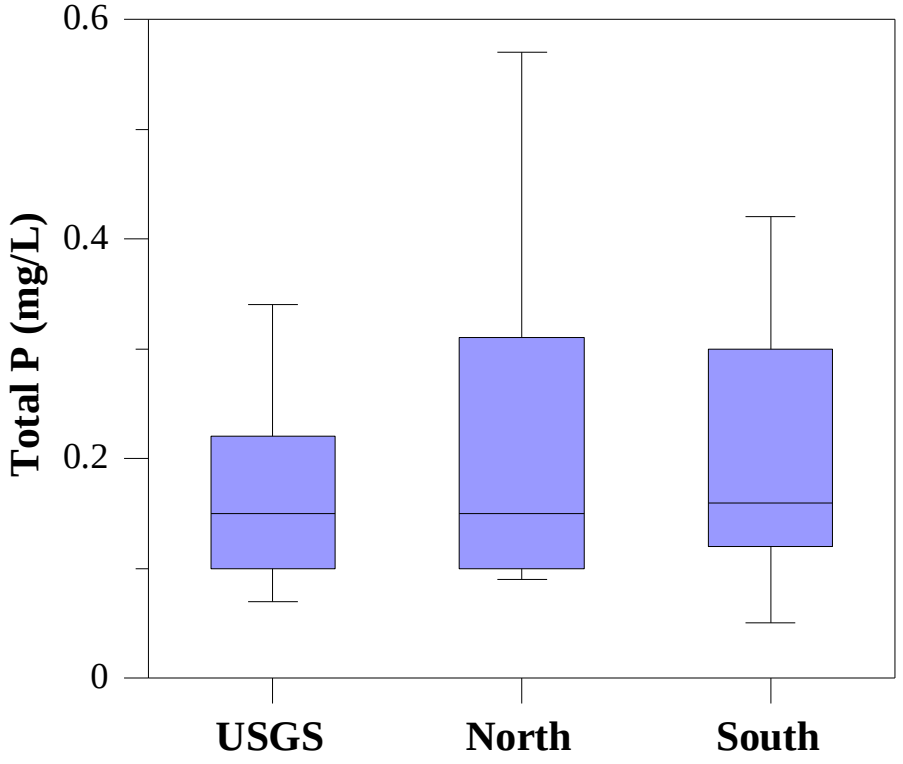


Total Phosphorus Samples

Event

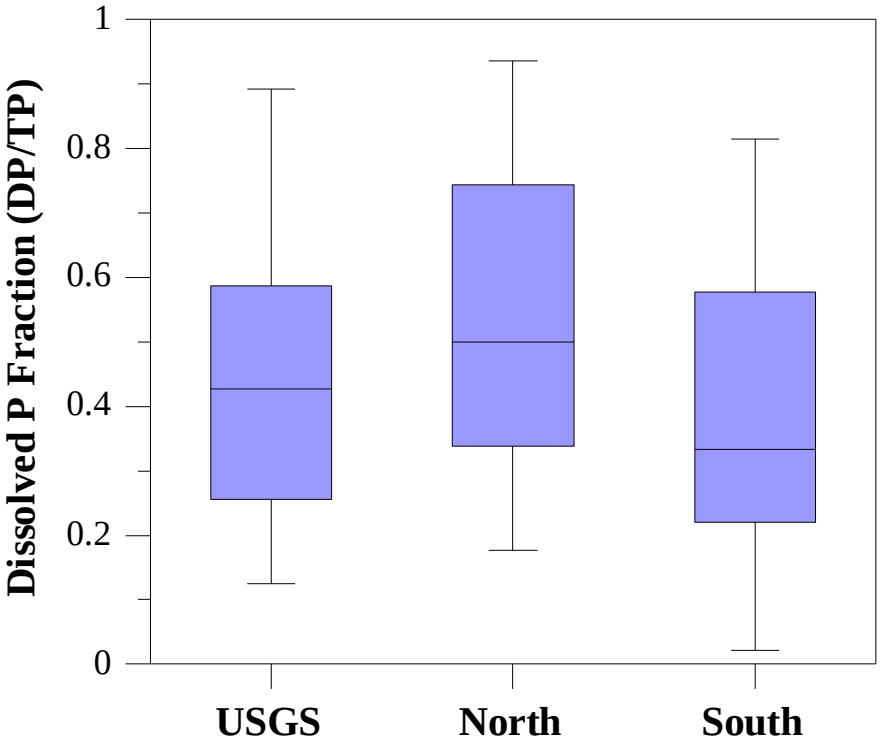


Low Flow

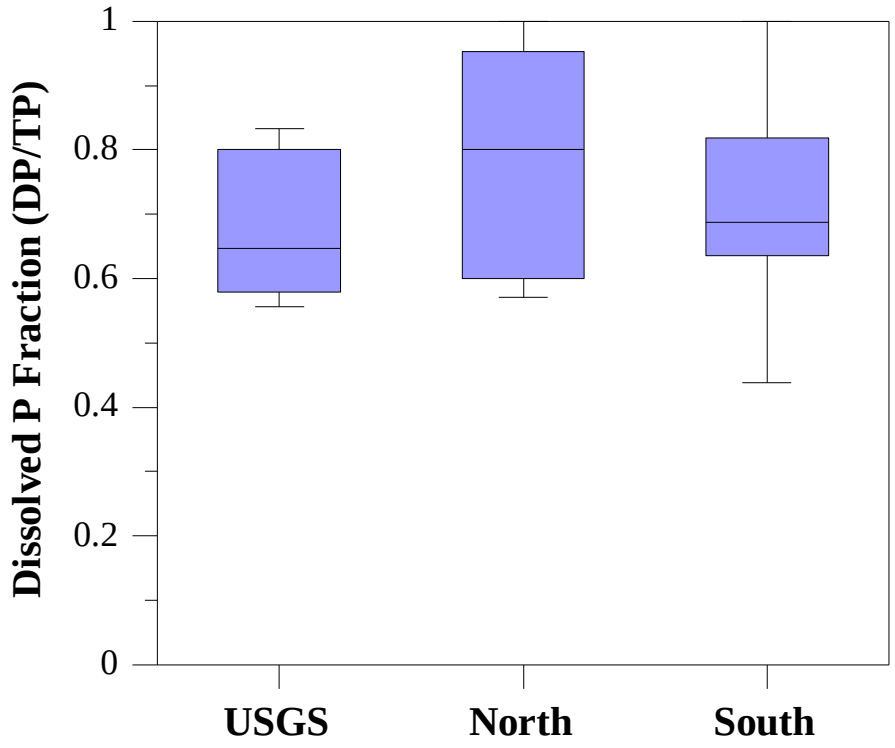


Dissolved Phosphorus Samples

Event



Low Flow

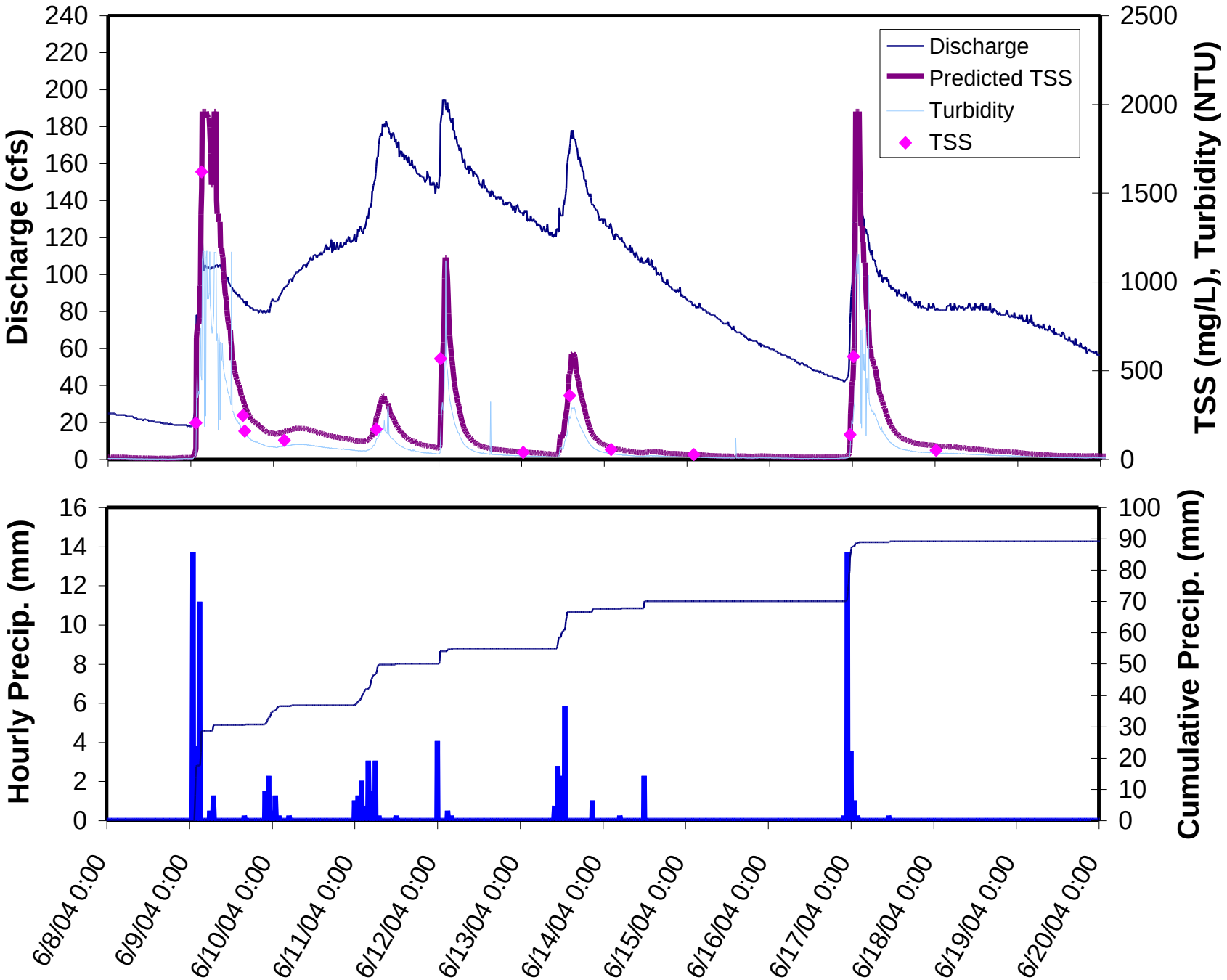


Load Calculations

- USGS calculated loads downstream based on sediment concentrations
- Loads also calculated both at USGS site and North Branch site using relationship between TSS-Turbidity
- South Branch sampling difficulties prevent accurate load calculations

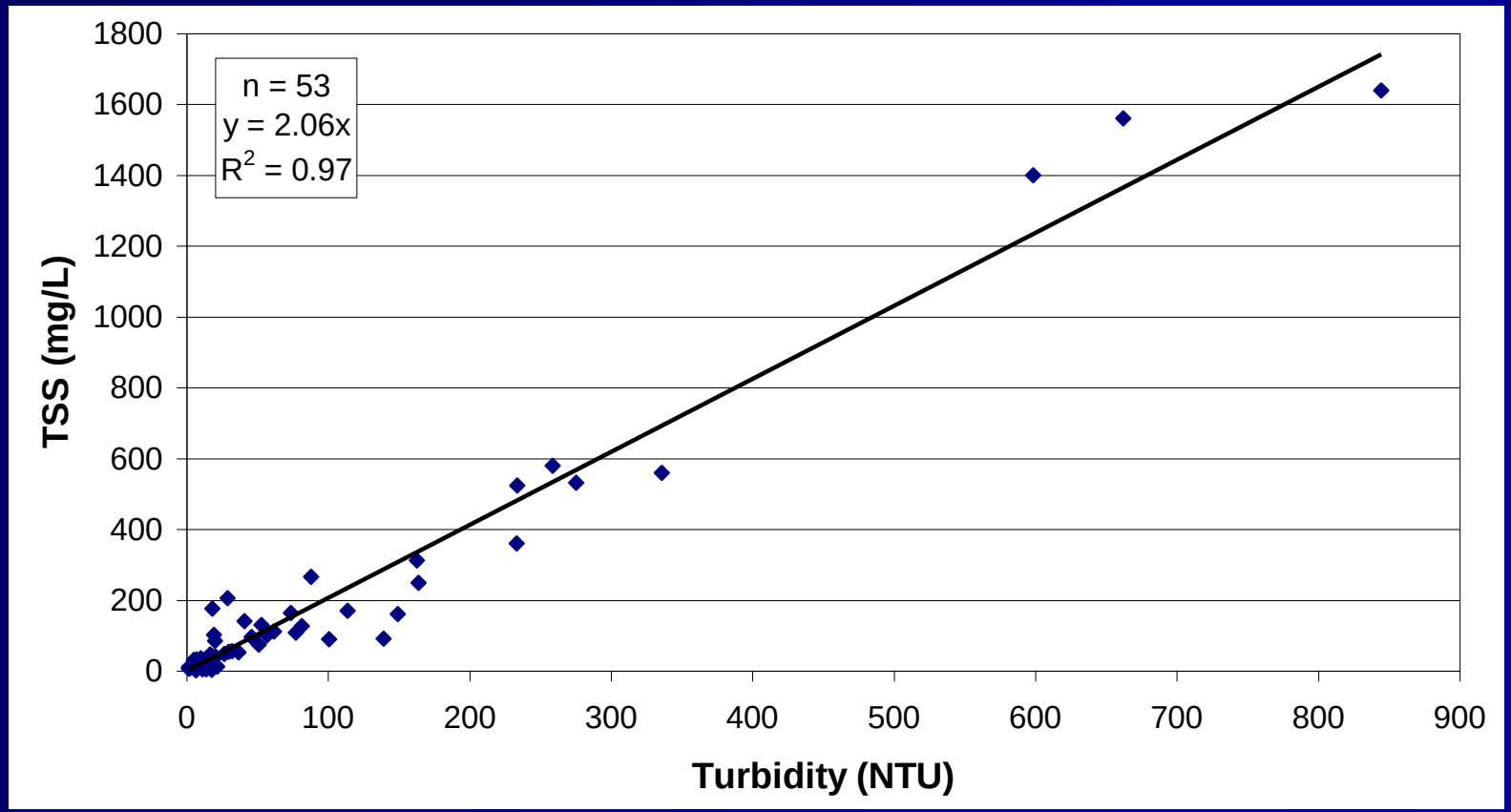
South Branch Difficulties…

South Branch Difficulties…


Discharge (cfs)
TSS (mg/L), Turbidity (NTU)
Discharge
Predicted TSS
Turbidity
TSS
Hourly Precip. (mm)
Cumulative Precip. (mm)
6/8/04 0:00
6/9/04 0:00
6/10/04 0:00
6/11/04 0:00
6/12/04 0:00
6/13/04 0:00
6/14/04 0:00
6/15/04 0:00
6/16/04 0:00
6/17/04 0:00
6/18/04 0:00
6/19/04 0:00
6/20/04 0:00

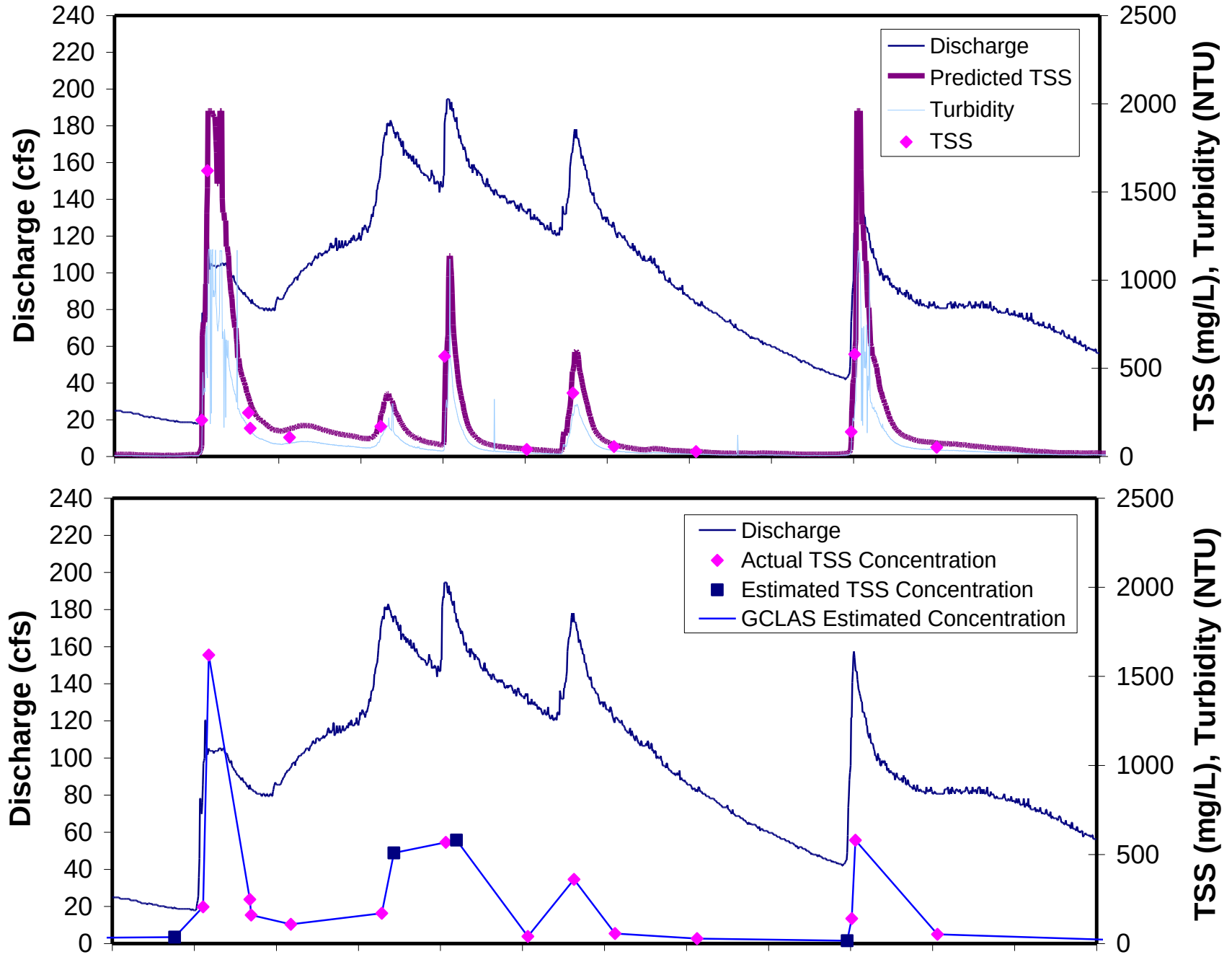
Sediment – Turbidity USGS Station Site

TSS mg/L = 2.0628(Turbidity NTU)



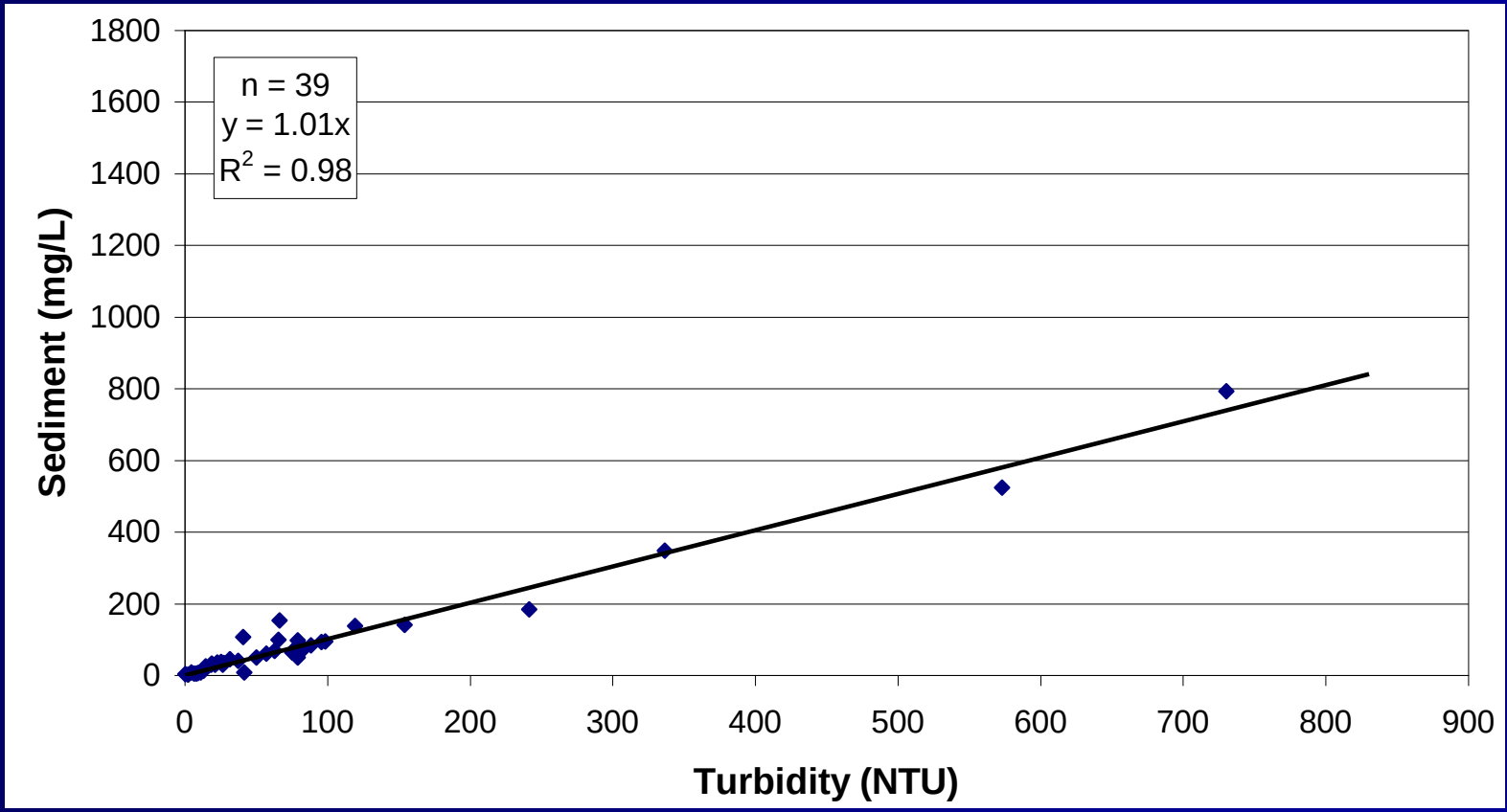
Comparison between Load Calculation Methods

Date	Turbidity-Predicted Suspended Solids Load, metric tons	USGS GCLAS Suspended Solids Load, metric tons	Percent Difference
06/09/04	173.7	102.5	+ 69%
06/10/04	37.8	29.9	+ 26%
06/11/04	59.9	147.0	- 59%
06/12/04	89.4	111.6	- 20%
06/13/04	61.9	51.0	+ 21%
06/14/04	12.2	11.4	+ 7%
06/15/04	3.8	4.3	- 11%
06/16/04	3.0	2.4	+ 28%
06/17/04	123.9	57.5	+ 115%
06/18/04	11.6	7.7	+ 50%
06/19/04	4.1	3.9	+ 5%
06/20/04	1.7	1.9	- 11%
Totals:	**583.0**	**531.0**	**+10%**


Discharge (cfs)
TSS (mg/L), Turbidity (NTU)
Discharge
Predicted TSS
Turbidity
TSS
Discharge (cfs)
TSS (mg/L), Turbidity (NTU)
Discharge
Actual TSS Concentration
Estimated TSS Concentration
GCLAS Estimated Concentration

Sediment – Turbidity North Branch Site

Sediment mg/L = 1.0119(Turbidity NTU)



Sediment Load Comparison June 8 – June 20, 2004

	Mean Daily Discharge ft^3/s	Turbidity Predicted Suspended Solids Load, metric tons
USGS Station	97.2	583.0
North Branch	67.2	192.4

- North Branch:
  - 65-70% of total discharge
  - 30-40% of total sediment load

Phosphorus Load

- Calculation of instantaneous Total P concentrations:
  - Particulate P = 0.0013(TSS) + 0.0334
    n = 19, R^2 = 0.99, p < 0.0001
  - LN(DP Fraction) = -0.9687(Total P) – 0.1252
    n = 19, R^2 = 0.77, p < 0.0001
  - Total P = Particulate P + DP
- P Load = Total P x Q

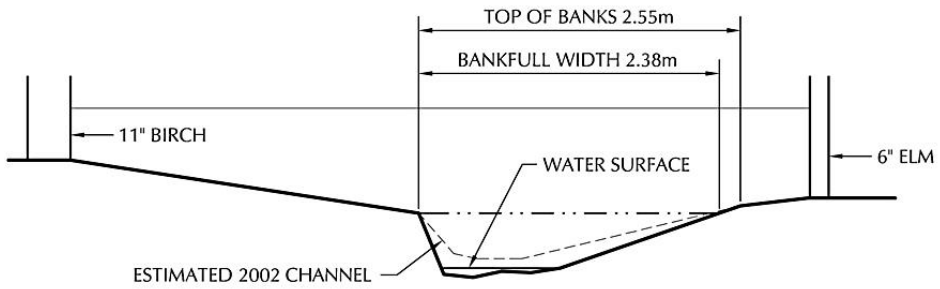
Phosphorus Load Comparison June 8 – June 20, 2004

	Mean Daily Discharge ft^3/s	Total Phosphous Load, metric tons
USGS Station	97.2	1649
North Branch	67.2	1074

- North Branch:
  - 65-70% of total discharge
  - 60-70% of total phosphorus load

Results:
Channel Morphology

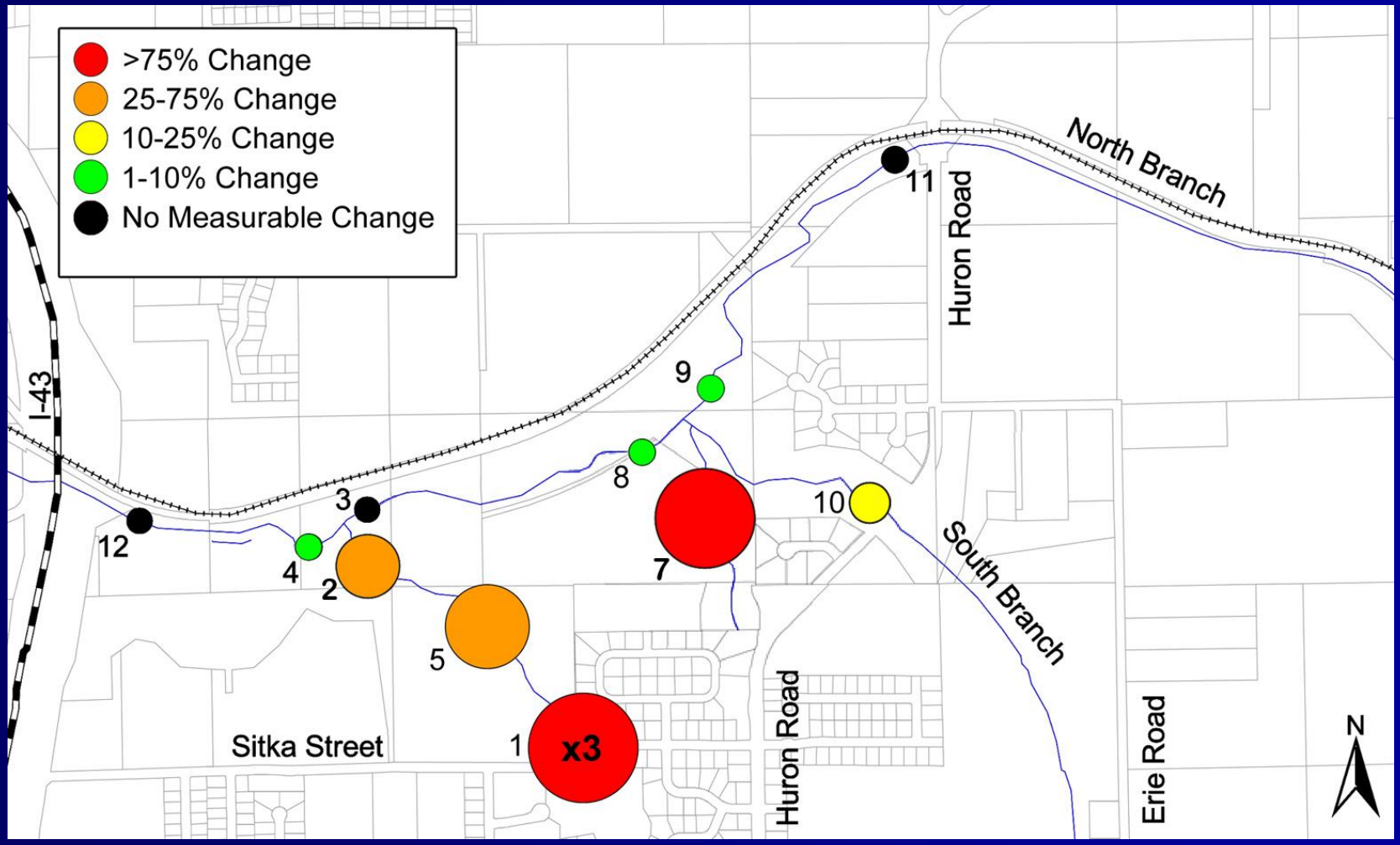
Channel Morphology Assessment



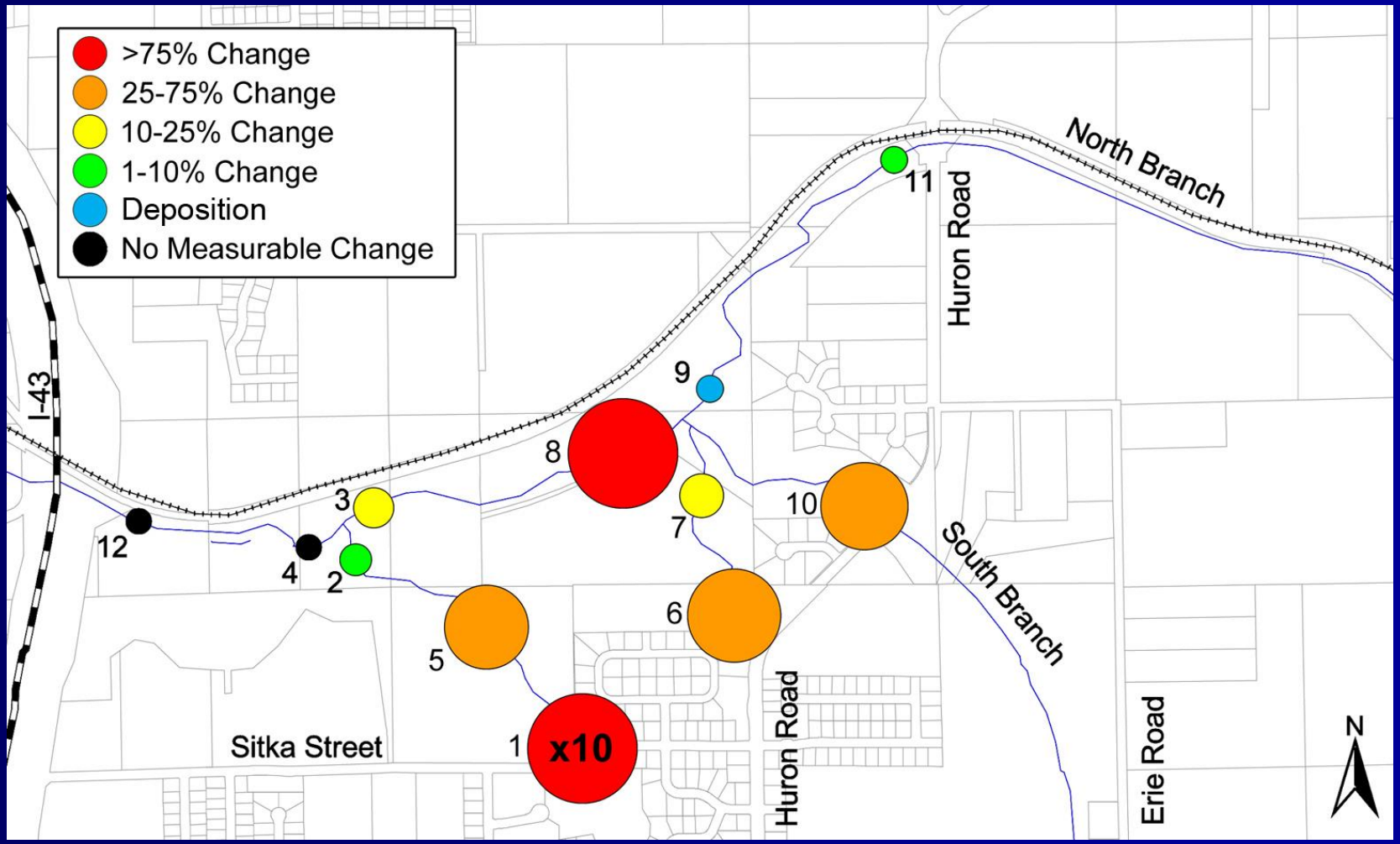
Site: 5	Stream Branch: McAuliffe Park Ravine	Date: 07/12/2004	Scale: 3/4" = 1 meter

Site 5 facing downstream.

Change in Bankfull Width, 2002 – 2004



Channel Enlargement, 2002 – 2004



Sediment Deposition Above Assessment Site #2

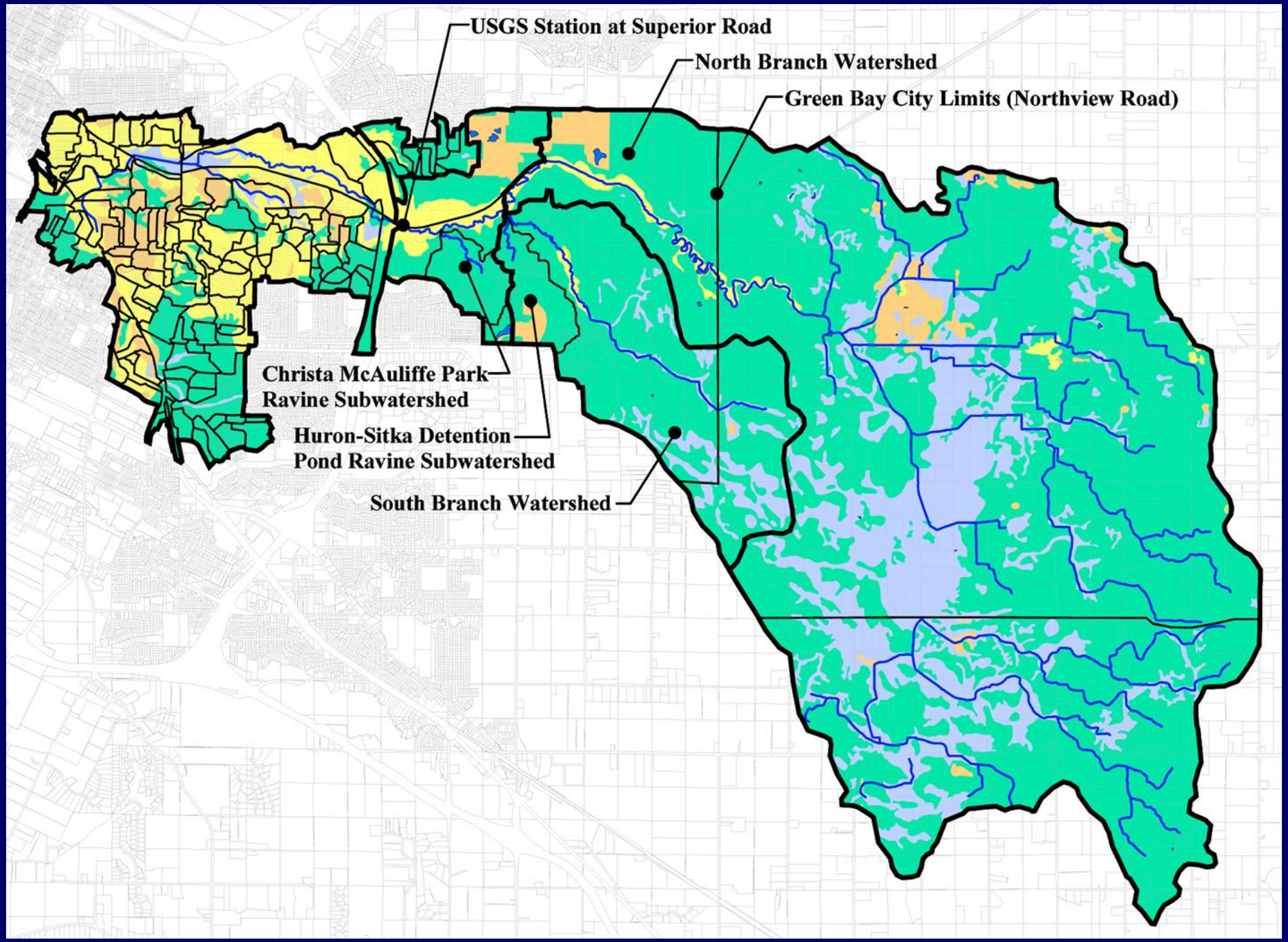
Preliminary Evaluation of the L-THIA Watershed Development Assessment Tool

The L-THIA Model

- Developed by Purdue and US EPA
- Simplified model to quickly estimate impacts of different land use scenarios
- Used by BLRPC to assess impacts of development outside City limits

Limitations of L-THIA

- Does not consider:
  - Snowmelt and frozen ground
  - High antecedent moisture conditions
  - Landscape position, topography, pollutant delivery ratios, or routing
- Assumes agriculture all tile drained and deeply cultivated
- Only 8 land use categories, assuming total build-out


USGS Station at Superior Road
North Branch Watershed
Green Bay City Limits (Northview Road)
Christa McAuliffe Park
Ravine Subwatershed
Huron-Sitka Detention
Pond Ravine Subwatershed
South Branch Watershed

Conversion to L-THIA Land Use Categories

Detailed Land Use	L-THIA Assumed Land Use
Single Family Residential	Low Density Residential
Two Family Residential	High Density Residential
Multi-Family Residential	High Density Residential
Residential - Mixed Use / Traditional	High Density Residential
Commercial	Commercial
Commercial - Business Park	Industrial
Industrial	Industrial
Roads	Commercial
Railroad	Industrial
Utilities	Industrial
Institutional	High Density Residential
Parks and Recreation	Forest
Fallow Fields / Derelict Property	Grass / Pasture
Agriculture	Agriculture
Water Features	Water / Wetlands
Woodlands and Wetlands	Forest
Undeveloped Open Space	Grass / Pasture
Disturbed Open Space (Unplatted)	Grass / Pasture

Preliminary Assessment of L-THIA Modeling Results

Scenario	Annual Runoff Volume (m^3)	Phosphorus Load (kg)	Phosphorus Yield (kg/ha)	Suspended Solids Load (metric ton)	Suspended Solids Yield (metric ton/ha)
Water Year 2004 Observations	19,400,280	12,606	2.31	3,947	0.72
SWAT Prediction - 2000 Baseline Scenario	-	5,156	0.89	1,521	0.26
L-THIA Prediction - 2004 Land Use	4,597,643	4,284	0.79	375	0.07
L-THIA Prediction - 2022 Land Use	4,791,723	4,086	0.75	366	0.07

Conclusions

Conclusions

- Do differences exist in the water quality of the agricultural and urbanizing tributaries of Baird Creek?
  - South Br. TSS and total P concentrations were significantly higher than North Br.
  - Only 18.5% of the watershed upstream of the USGS station contributed **60-70%** of the sediment over summer storm events
  - Although phosphorus loads related to discharge, they were not proportional to subwatershed area

Fish Trends
(1998-2004, St. Norbert College & UWM)

- Decline of sensitive fish species:
  - Redside Dace, Fantail Darter, Rosy Face Shiner
- Increase of tolerant fish species:
  - Blacknose Dace, Green Sunfish

http://fish.dnr.cornell.edu

Conclusions

- Has the channel morphology of Baird Creek and its tributaries changed in response to hydrologic alterations in the urbanizing watershed?
  - All channel morphology assessment sites on urbanizing tribs increased in bankfull width and cross-sectional area since 2002
  - Fewer impacts were observed downstream at main channel sites

Conclusions

- Is the L-THIA watershed development assessment tool a viable model for assessing the impact of future development on water quality in Baird Creek?
  - Phosphorus yields were fairly consistent with SWAT modeling
  - Sediment yields were drastically lower than SWAT or WY04 observations
    - Bank erosion
    - Construction site erosion
    - Treatment of agricultural runoff by L-THIA

Implications for Future Land Use Management

- Protection of riparian areas alone will not protect stream integrity
- Must address development layout and the design of impervious surfaces

Suggested Best Management Practices

- Decrease lot frontage and setback dimensions
- Eliminate excess on-street parking in subdivisions
- Utilize rain gardens, bioswales, and infiltration basins
- Preserve existing woodlands
- Modify detention basins to provide additional capacity for smaller storm events
- Enforce construction erosion control ordinances

Opportunities for Future Research

- Continue North Branch sampling
- Particle size analysis for sediment
- Detailed channel geomorphology assessment – bank materials and size
- Analyze the effectiveness of BMPs

Acknowledgements

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- Dr. Kevin Fermanich
- Dr. Tim Ehlinger and the UW-Milwaukee crew
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- Green Bay Metropolitan Sewerage District Laboratory
- City of Green Bay Public Works Dept.
- City of Green Bay Parks, Recreation, and Forestry Dept.
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