DEVELOPING A STRATEGY TO MINIMIZE THE IMPACT OF CATASTROPHIC FLOODING EVENTS PRELIMINARY (DRAFT) RESULTS

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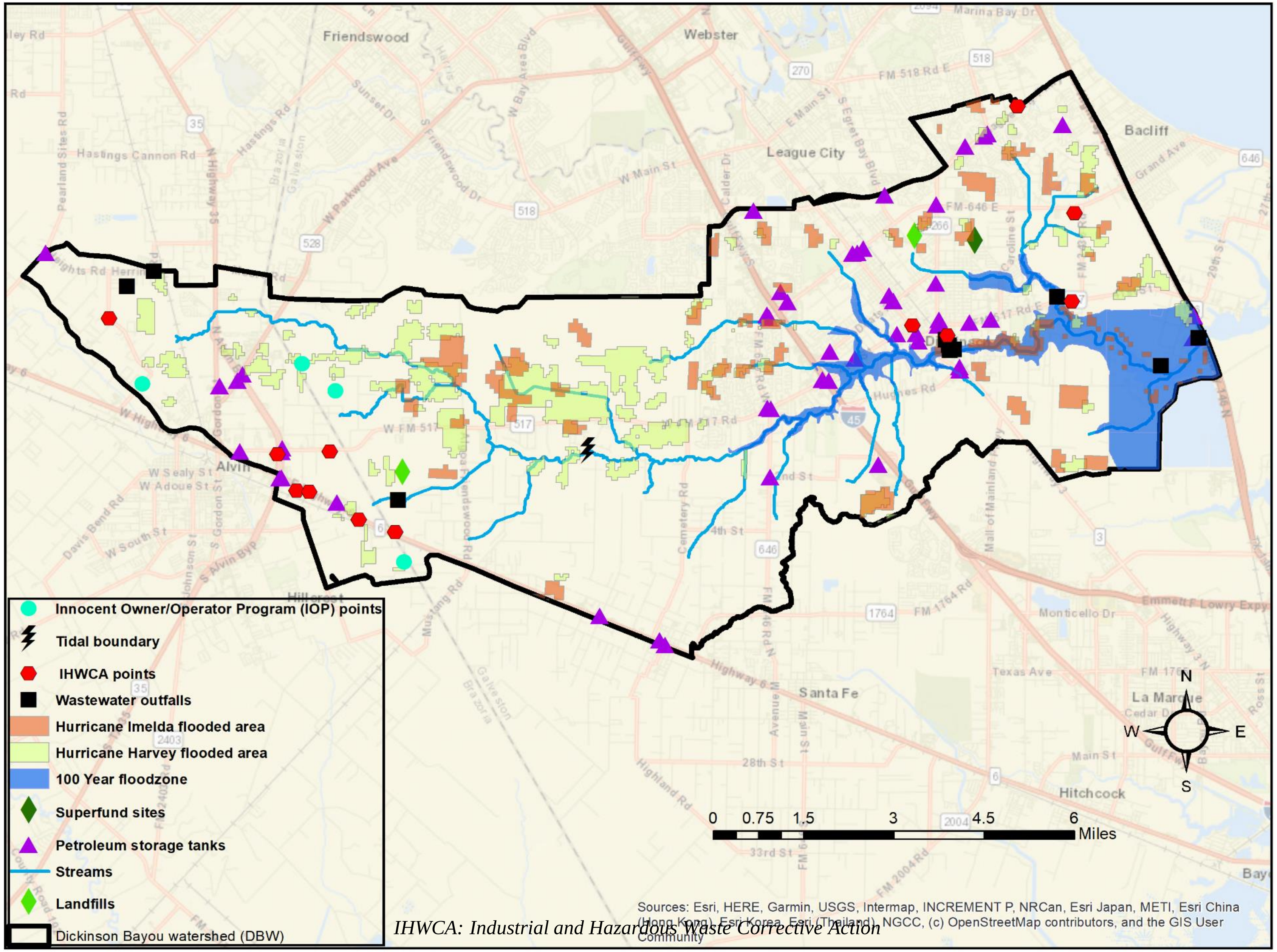
Dickinson Bayou Watershed



IHWCA: Industrial and Hazardous Waste Corrective Action

Water Sampling

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Tier 1-3: References for Compounds of Concern (COCs) Maximum Contaminant Limits (MCL)

(1) https://www.tceq.texas.gov/assets/public/waterquality/standards/tswqs2018/2018swqs_allsections_nopreamble.pdf

(2) Oil and Grease as a Water Quality Index Parameter for the Conservation of Marine Biota Mónica Eljaiek-Urzola 1,* , Nora Romero-Sierra 2 , Laura Segrera-Cabarcas 2 , David Valdelamar-Martínez 2 and Édgar Quiñones-Bolaños 1 1 Faculty of Engineering, Universidad de Cartagena, Cartagena 130015, Colombia; equinonesb@unicartagena.edu.co 2 Faculty of Engineering, Civil Engineering Program, Universidad de Cartagena, Cartagena 130015, Colombia;

(3) Ambient Interim Water Quality Guidelines for Phenols Prepared pursuant to Section 2(e) of the Environment Management Act, 1981 Summary Report April 19, 2002

(4) OFFICE OF WATER 820-F-12-058 Recreational Water Quality Criteria

(5) National Primary Drinking Water Regulations, EPA 816-F-09-004 | MAY 2009

(6) Review of Phosphorus Control in the United States and Their Effects on Water Quality, David W. Litke, U.S. GEOLOGICAL SURVEY, Water-Resources Investigations Report 99–4007 (1999)

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Tier 1: COCs Detected Above MCL

Parameter Group	Parameter	Units	Value	Station	Date	MCL (1,2,3,4,&6)	MCL (5)
Chemical	Phenolics, Total	mg/L	0.053	11436	4/21/2021	0.05	NA
VOCs	Dichloromethane (Methylene Chloride)	UG/L	5,400	20728	2/4/2021	5	5
Metals	Mercury (Hg)	ug/ml	0.0095	11436	3/10/2021	0.0011	2
Metals	Copper (Cu)	ug/ml	0.0038	HWY3	4/21/2021	0.00096	1,300
Metals	Nickel (Ni)	ug/ml	0.0083	11436	3/10/2021	0.00099	NA
Metals	Selenium(Se)	ug/ml	0.14	HWY3	4/21/2021	0.05	50
Metals	Thallium (Tl)	ug/ml	0.00031	BB	6/9/2021	0.00012	2
Metals	Zinc (Zn)	ug/ml	0.056	HWY3	2/4/2021	0.00097	5,000
Dioxins	16 Dioxins Detected (single maximum)	pg/L	78.2	HWY 3	2/5/2021	0.078	3.00E-11
Nutrients	Chlorophyll-a	ug/L	64.61	GB	4/21/2021	10	NA
Nutrients	Total Coliform	MPN/100mL	155,312	GB	9/16/2021	NA	5%>1
Nutrients	E. coli	MPN/100mL	51,721	HWY528	9/16/2021	399	5%>1
Nutrients	Enterococci	MPN/100mL	1,789	11467	9/16/2021	104	NA
Nutrients	Phosphorus, total	mg/L as P	0.58	11467	8/25/2020	0.1	NA
Nutrients	Orthophosphate	mg/L as P	0.24	HWY3	8/4/2021	0.1	NA

VOC= Volatile Organic Compounds

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Tier 2: COCs Detected Below MCL

Parameter Group	Parameter	Units	Value	Station	Date	MCL (1,2,3,4,&6)	MCL (5)
Chemical	Cyanide, Total	mg/L	0.002	HWY528	8/4/2021	0.0056	0.2
Chemical	Oil and Grease, Nonpolar (SGT-HEM)	mg/L	3	11434	8/4/2021	10	NA
VOCs	Acetone	UG/L	14	HWY528	6/9/2021	50	NA
VOCs	Chloroform	UG/L	8.3	HWY528	8/4/2021	70	NA
VOCs	2-Butanone (MEK)	UG/L	4.4	11436	6/9/2021	13,865	NA
VOCs	Bromodichloromethane	UG/L	3.2	HWY528	8/4/2021	10.2	NA
VOCs	Toluene	UG/L	0.26	BB	8/4/2021	1,000	1,000
VOCs	Trichloroethene (TCE)	UG/L	0.13	11436	8/4/2021	5	5
Metals	Aluminium(Al)	ug/ml	0.62	11434	6/9/2021	0.991	50
Metals	Antimony (Sb)	ug/ml	0.0018	20728	4/21/2021	NA	6
Metals	Arsenic (As)	ug/ml	0.054	HWY3	4/21/2021	0.078	10
Metals	Barium (Ba)	ug/ml	0.28	20475	4/21/2021	2	2,000
Metals	Beryllium (Be)	ug/ml	0.19	11436	4/21/2021	NA	4
Metals	Cadmium (Cd)	ug/ml	0.0026	HWY3	4/21/2021	0.00875	5
Metals	Chromium (Cr)	ug/ml	0.003	11436	2/4/2021	0.0106	100
Metals	Iron(Fe)	ug/ml	0.45	11436	4/21/2021	NA	300
Metals	Lead (Pb)	ug/ml	0.00085	11434	6/9/2021	0.0053	15
Metals	Manganese (Mn)	ug/ml	0.25	20475	4/21/2021	NA	50
Metals	Silver (Ag)	ug/ml	0.00067	HWY3	4/21/2021	0.0008	100
PCB	PCB, Total	ng/L	0.63	BB	4/21/2021	0.64	500
Nutrient	Ammonia	mg/L as N	0.079	RS	2/4/2021	1,900	NA
Nutrient	Nitrite plus nitrate	mg/L as N	0.34	HWY528	8/4/2021	10	1000

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Tier 3: COCs Detected Without MCL

Parameter Group	Parameter	Units	Value	Station	Date	MCL (1,2,3,4,&6)	MCL (5)
VOCs	Chloromethane	UG/L	3.7	11467	8/4/2021	NA	NA
VOCs	Bromochloromethane	UG/L	1.1	HWY3	2/4/2021	NA	NA
VOCs	Dibromochloromethane	UG/L	0.76	HWY528	8/4/2021	NA	NA
VOCs	Carbon Disulfide	UG/L	0.65	11436	8/4/2021	NA	NA
VOCs	Naphthalene	UG/L	0.13	11436	8/4/2021	NA	NA
VOCs	4-Isopropyltoluene	UG/L	0.1	20728	8/4/2021	NA	NA
Metals	Cobalt (Co)	ug/ml	0.00082	HWY3	4/21/2021	NA	NA
Metals	Magnesium(Mg)	ug/ml	203	11436	4/21/2021	NA	NA
Metals	Strontium (Sr)	ug/ml	1.27	HWY3	4/21/2021	NA	NA
Metals	Tin (Sn)	ug/ml	0.0011	HWY3	4/21/2021	NA	NA
Metals	Vanadium (V)	ug/ml	0.064	11436	2/4/2021	NA	NA
PAH	Total PAHs with Perylene	ng/L	156.62	HWY3	2/5/2021	NA	NA
PAH	Total PAHs without Perylene	ng/L	155.7	HWY3	2/5/2021	NA	NA
PAH	Total NS&T PAHs	ng/L	66.18	HWY3	2/5/2021	NA	NA
Nutrient	COD	mg/L	57.3	HWY3	4/21/2021	NA	NA
Nutrient	Total suspended solids	mg/L	77.7	20728	2/4/2021	NA	NA
Nutrient	Nitrogen, Kjeldahl, total	mg/L as N	5.028	11467	8/25/2020	NA	NA

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Tier 1: COCs Detected Above CRP Max

Parameter Group	Parameter	Units	Value	Station	Date	CRP Value	Station	Date
Metals	Silver (Ag)	ug/ml	0.00067	HWY3	4/21/2021	0.0005	11460	7/8/1997
Metals	Selenium(Se)	ug/ml	0.14	HWY3	4/21/2021	0.002	11460	7/8/1997
Metals	Copper (Cu)	ug/ml	0.004	HWY3	4/21/2021	0.003	11460	7/8/1997
Metals	Chromium (Cr)	ug/ml	0.003	11436	2/4/2021	0.003	11460	7/8/1997
Metals	Arsenic (As)	ug/ml	0.0544	HWY3	4/21/2021	0.00375	11460	7/8/1997
Metals	Zinc (Zn)	ug/ml	0.056	HWY3	2/4/2021	0.004	11460	7/8/1997
Metals	Aluminium(Al)	ug/ml	0.62	11434	6/9/2021	0.041	11460	7/8/1997
Micro	Total Coliform	MPN/100mL	15,5312	GB	9/16/2021	11,000	11460	2/27/1973
Micro	Enterococci	MPN/100mL	1,789	11467	9/16/2021	12	11455	7/13/1979
Nutrient	COD	mg/L	57.3	HWY3	4/21/2021	27	11460	7/17/1975
Nutrient	E. coli	MPN/100mL	51,721	HWY528	9/16/2021	1,600	11460	6/25/1998

CRP = Texas Clean Rivers Program https://www.tceq.texas.gov/waterquality/clean-rivers

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Tier 2: COCs Detected Below CRP Max

Parameter Group	Parameter	Units	Value	Station	Date	CRP Value	Station	Date
Metals	Lead (Pb)	ug/ml	0.00085	11434	6/9/2021	0.001	11460	7/8/1997
Metals	Cadmium (Cd)	ug/ml	0.00265	HWY3	4/21/2021	0.005	11460	7/8/1997
Metals	Nickel (Ni)	ug/ml	0.00835	11436	3/10/2021	0.011	11460	7/8/1997
Nutrient	Ammonia	mg/L as N	0.0795	RS	2/4/2021	1.4	11460	12/8/2005
Nutrient	Nitrite plus nitrate	mg/L as N	0.345	HWY528	8/4/2021	1.87	11467	5/6/1999
Nutrient	Orthophosphate	mg/L as P	0.24	HWY3	8/4/2021	3.73	11472	7/1/1985
Nutrient	Phosphorus, total	mg/L as P	0.58	11467	8/25/2020	6.03	11467	11/28/1984
Nutrient	Nitrogen, Kjeldahl, total	mg/L as N	5.03	11467	8/25/2020	62.2	11467	10/7/2008
Nutrient	Chlorophyll-a	ug/L	64.61	GB	4/21/2021	89.2	11460	10/7/1985

CRP = Texas Clean Rivers Program https://www.tceq.texas.gov/waterquality/clean-rivers

Tier 3: COCs Detected Without CRP Data 1/2

Parameter Group	Parameter	Units	Value	Station	Date
VOC	Dichloromethane (Methylene Chloride)	UG/L	5,400	20728	2/4/2021
VOC	Acetone	UG/L	14	HWY528	6/9/2021
VOC	Chloroform	UG/L	8.3	HWY528	8/4/2021
VOC	2-Butanone (MEK)	UG/L	4.4	11436	6/9/2021
VOC	Bromodichloromethane	UG/L	3.2	HWY528	8/4/2021
VOC	Toluene	UG/L	0.26	BB	8/4/2021
VOC	Trichloroethene (TCE)	UG/L	0.13	11436	8/4/2021
VOC	Chloromethane	UG/L	3.7	11467	8/4/2021
VOC	Bromochloromethane	UG/L	1.1	HWY3	2/4/2021
VOC	Dibromochloromethane	UG/L	0.76	HWY528	8/4/2021
VOC	Carbon Disulfide	UG/L	0.65	11436	8/4/2021
VOC	Naphthalene	UG/L	0.13	11436	8/4/2021
VOC	4-Isopropyltoluene	UG/L	0.1	20728	8/4/2021
Chemical	Phenolics, Total	mg/L	0.053	11436	4/21/2021
Chemical	Cyanide, Total	mg/L	0.002	HWY528	8/4/2021
Chemical	Oil and Grease, Nonpolar (SGT-HEM)	mg/L	3	11434	8/4/2021

CRP = Texas Clean Rivers Program https://www.tceq.texas.gov/waterquality/clean-rivers

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Tier 3: COCs Detected Without CRP Data 2/2

Parameter Group	Parameter	Units	Value	Station	Date
Dioxins	16 Dioxins Detected (max)	pg/L	78.2	HWY 3	2/5/2021
Metals	Mercury (Hg)	ug/ml	0.0095	11436	3/10/2021
Metals	Thallium (Tl)	ug/ml	0.00031	BB	6/9/2021
Metals	Antimony (Sb)	ug/ml	0.0018	20728	4/21/2021
Metals	Barium (Ba)	ug/ml	0.28	20475	4/21/2021
Metals	Beryllium (Be)	ug/ml	0.19	11436	4/21/2021
Metals	Iron(Fe)	ug/ml	0.45	11436	4/21/2021
Metals	Manganese (Mn)	ug/ml	0.25	20475	4/21/2021
Metals	Cobalt (Co)	ug/ml	0.00082	HWY3	4/21/2021
Metals	Magnesium(Mg)	ug/ml	203	11436	4/21/2021
Metals	Strontium (Sr)	ug/ml	1.27	HWY3	4/21/2021
Metals	Tin (Sn)	ug/ml	0.0011	HWY3	4/21/2021
Metals	Vanadium (V)	ug/ml	0.064	11436	2/4/2021
PAH	Total PAHs with Perylene	ng/L	156.62	HWY3	2/5/2021
PAH	Total PAHs without Perylene	ng/L	155.7	HWY3	2/5/2021
PAH	Total NS&T PAHs	ng/L	66.18	HWY3	2/5/2021
PCB	PCB, Total	ng/L	0.63	BB	4/21/2021
Nutrient	Total suspended solids	mg/L	77.7	20728	2/4/2021

CRP = Texas Clean Rivers Program https://www.tceq.texas.gov/waterquality/clean-rivers

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Tropical Storm Nicholas
September 12, 2021 – September 18, 2021

Tropical Storm Nicholas

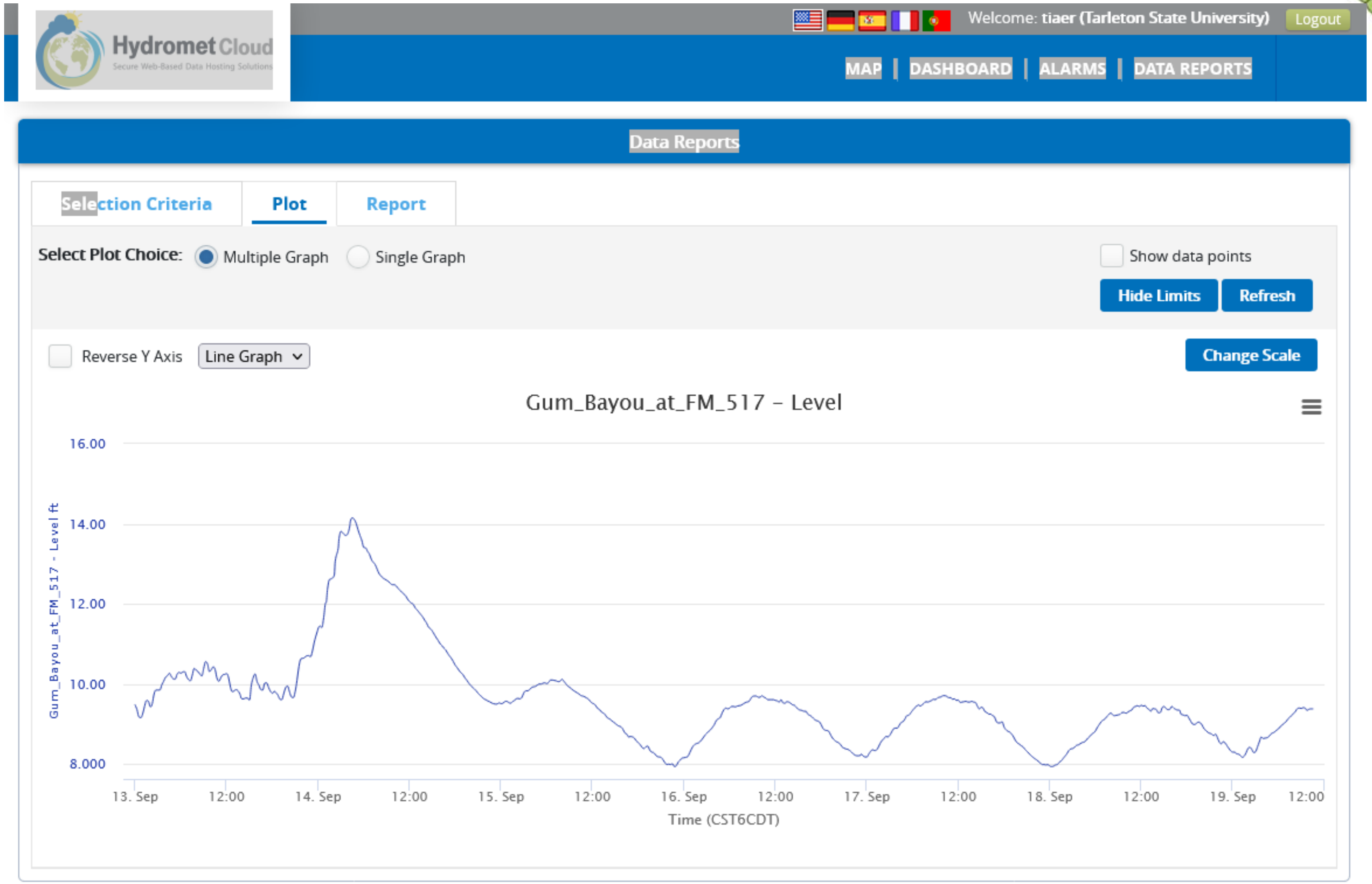
In addition to the continuous monitoring for flow and water levels, on September 12, 2021 TIAER staff deployed analytical equipment to additionally monitor:

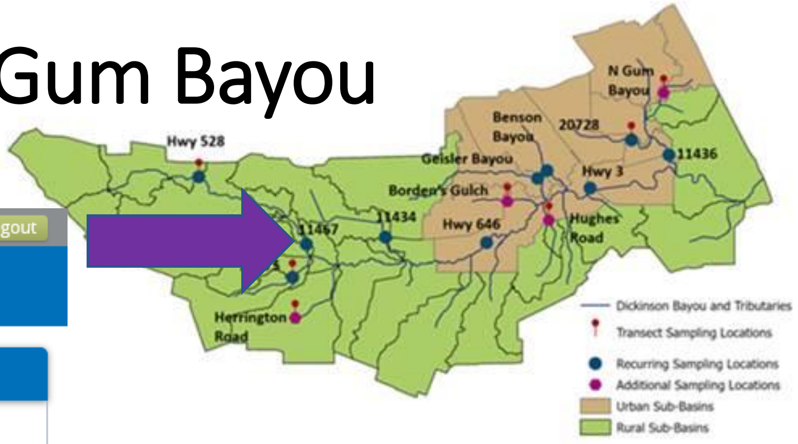
- Temperature
- Dissolved Oxygen
- Conductivity
- pH

Tropical Storm Nicholas

TIAER Staff monitored the storm, returning to the watershed on September 15, 2021 for water sampling

Water level during tropical storm Nicholas at Gum Bayou





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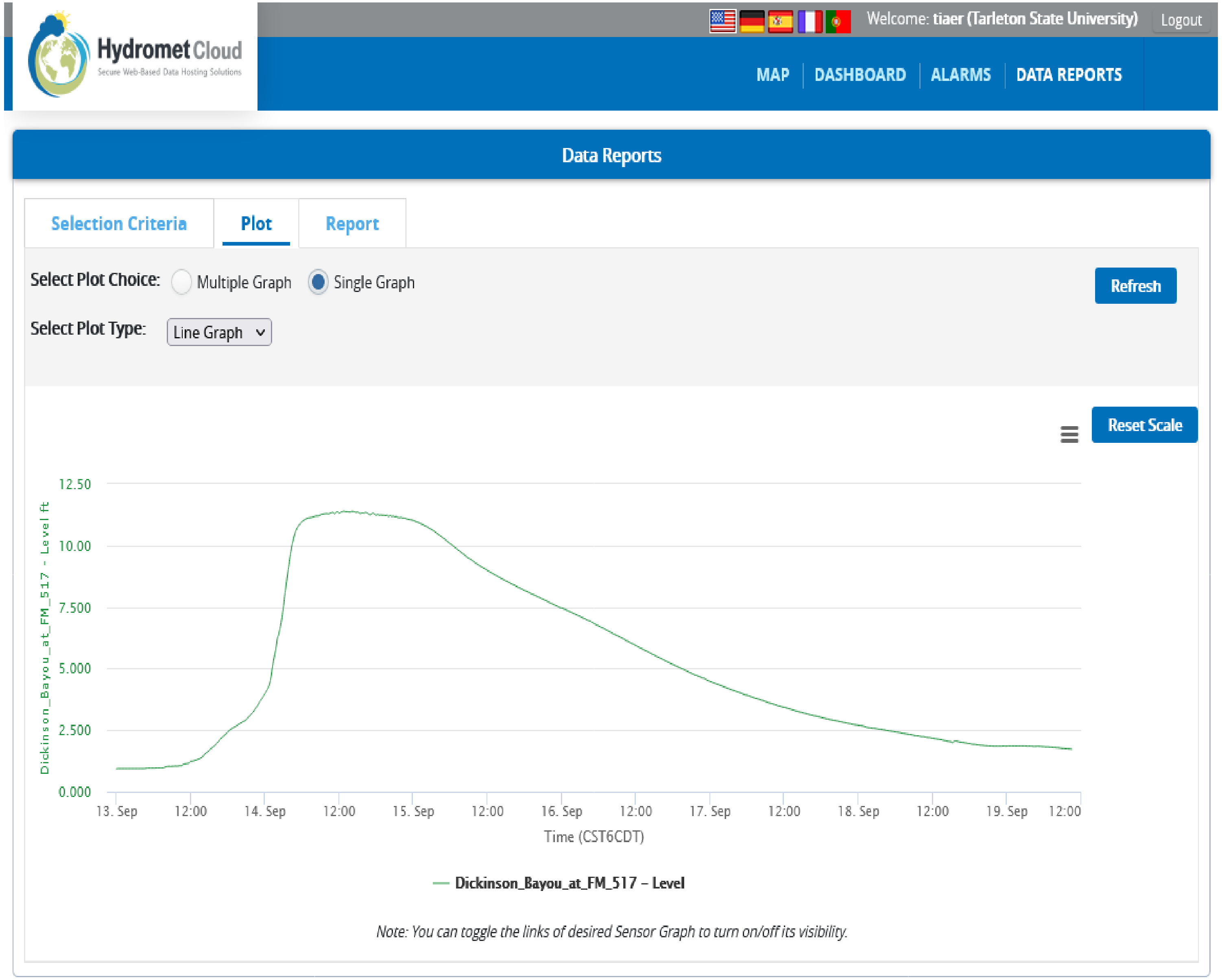
Water level during tropical storm Nicholas at Dickinson Bayou on FM 517



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Microbiological Samples were collected on September 15th 2021, chemical samples on the September 16th 2021.

Another set of monitoring samples were collected on the September 20th 2021 (micro) and September 21st 2021 (chem) for after storm WQ comparison (the sixth baseline/monitoring event)

Tropical Storm Nicholas Water Sample results

- Microtox® testing system identified one site, Benson Bayou (BB), as having potential toxic effects.
- The chemical data will provide more specific information on potential toxicants when completed.

EC50(%) 45%	**5min Incubation**	**15min Incubation**
Phenol control (10%)	13.46%	10.13%
Benson Bayou BB	52.56%	84.76%

EC50: 50% Decreases in Bioluminescence.

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Were samples taken during TS Nick event different from background levels?

- In order to determine if there was a significant difference between the background values (baseline) and the rain event (TS Nick), the data were statistically analyzed using the Wilcoxon Rank Sum test.
- Results of the test were compared to the significance level of p=0.05; a difference is indicated when the calculated p value is less than the significance level.
- The MCL and CRP values were included when available.
- Data from Tropical Storm Nick was available for comparison for chemical oxygen demand, Total Kjeldahl Nitrogen, Nitrate-Nitrite Nitrogen, Total Suspended Solids, Enterococci, *E. coli*, Total coliforms, Total Phenolics, and Oil and Grease (Hexane Extractable Material).

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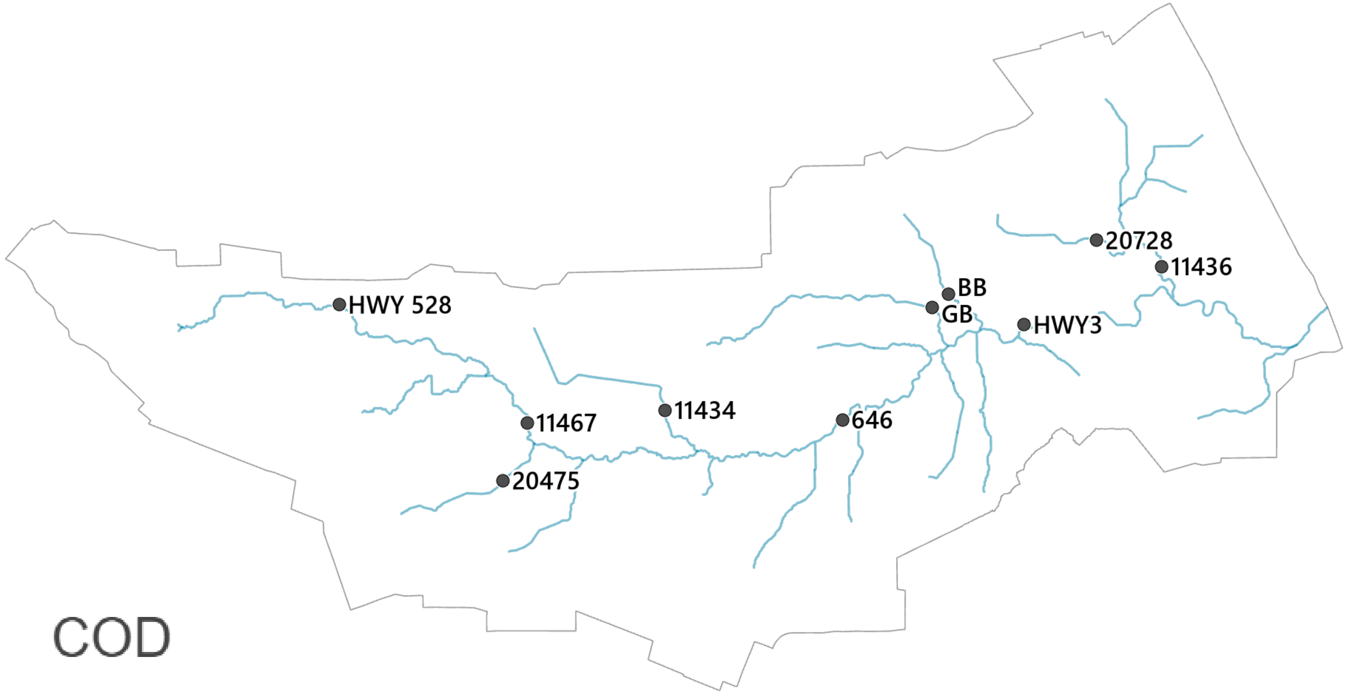
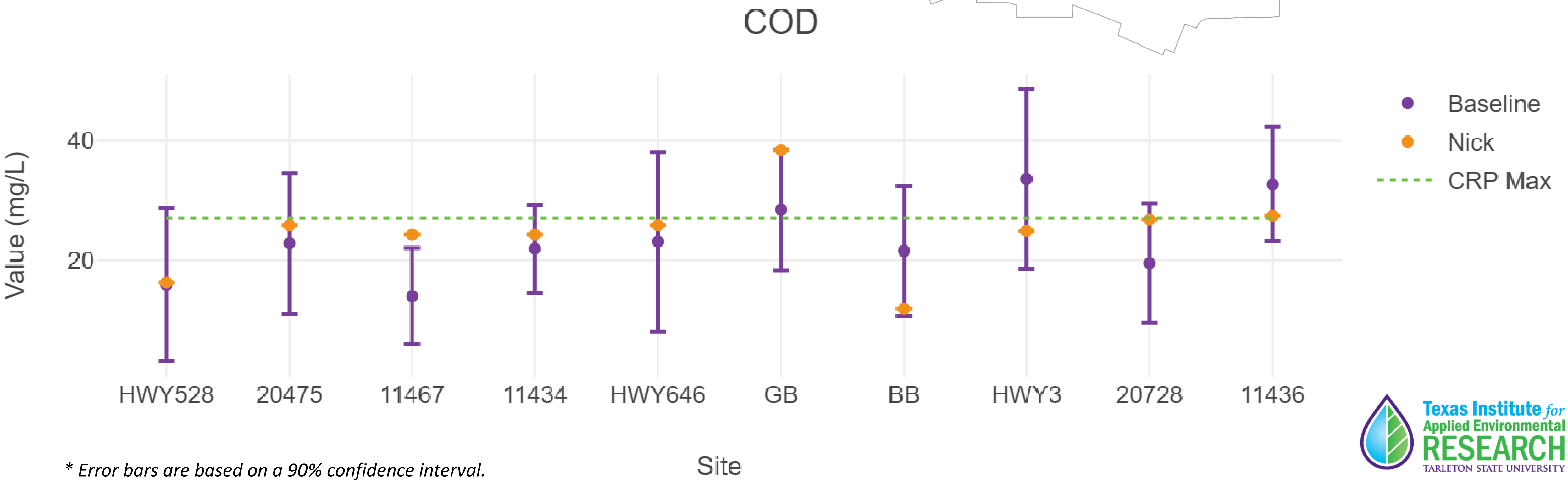
Tropical Storm Nicholas Chemical Oxygen Demand (COD) data from TIAER lab

Wilcoxon Rank Sum Test Result:
No significant difference (p= 0.80)





** Error bars are based on a 90% confidence interval.*

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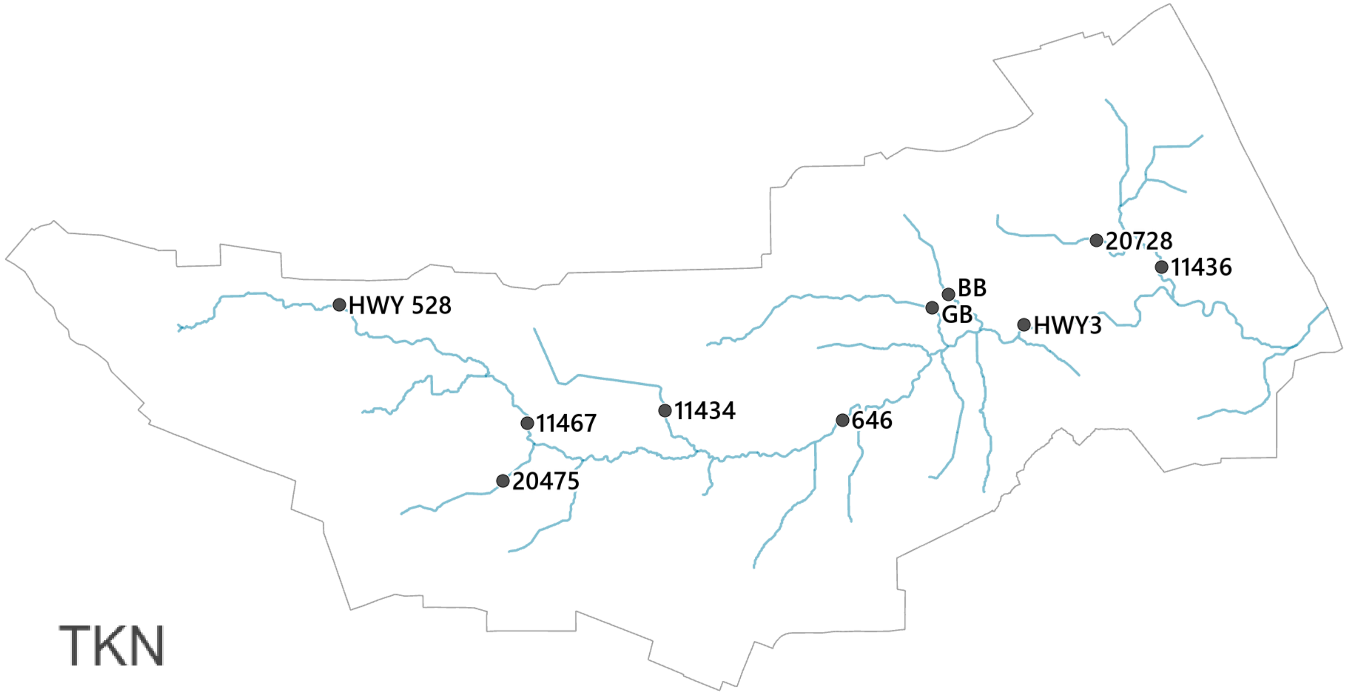
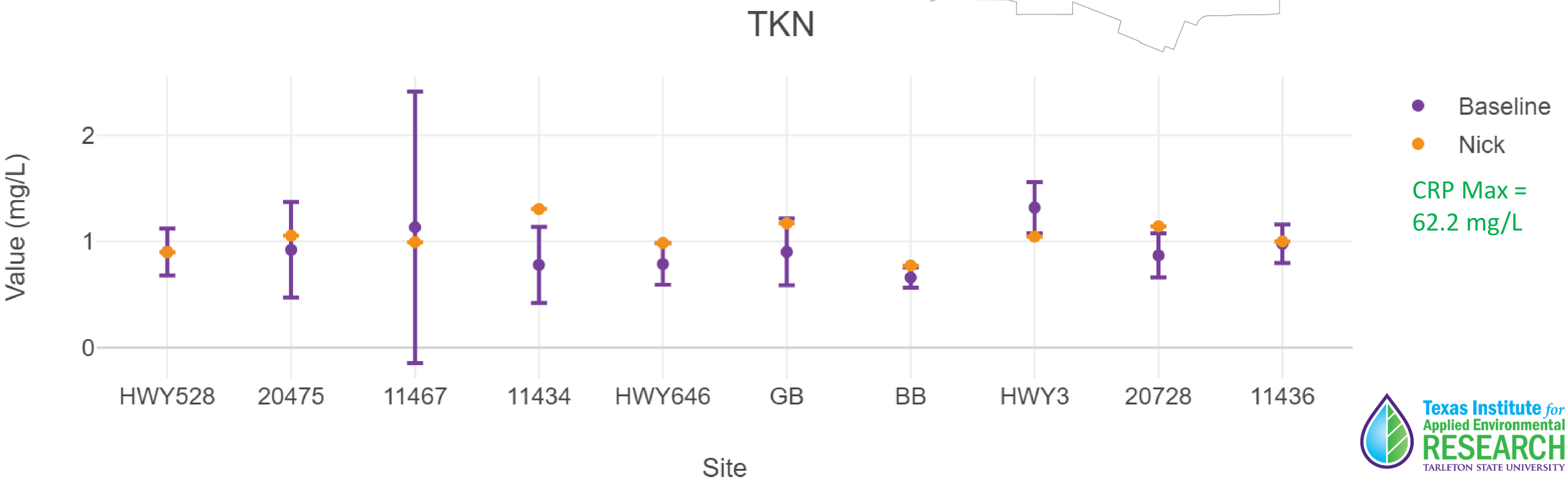
Tropical Storm Nicholas Total Kjeldahl Nitrogen as N (TKN) data from TIAER lab

Wilcoxon Rank Sum Test Result:
No significant difference (p= 0.12)





CRP Max = 62.2 mg/L

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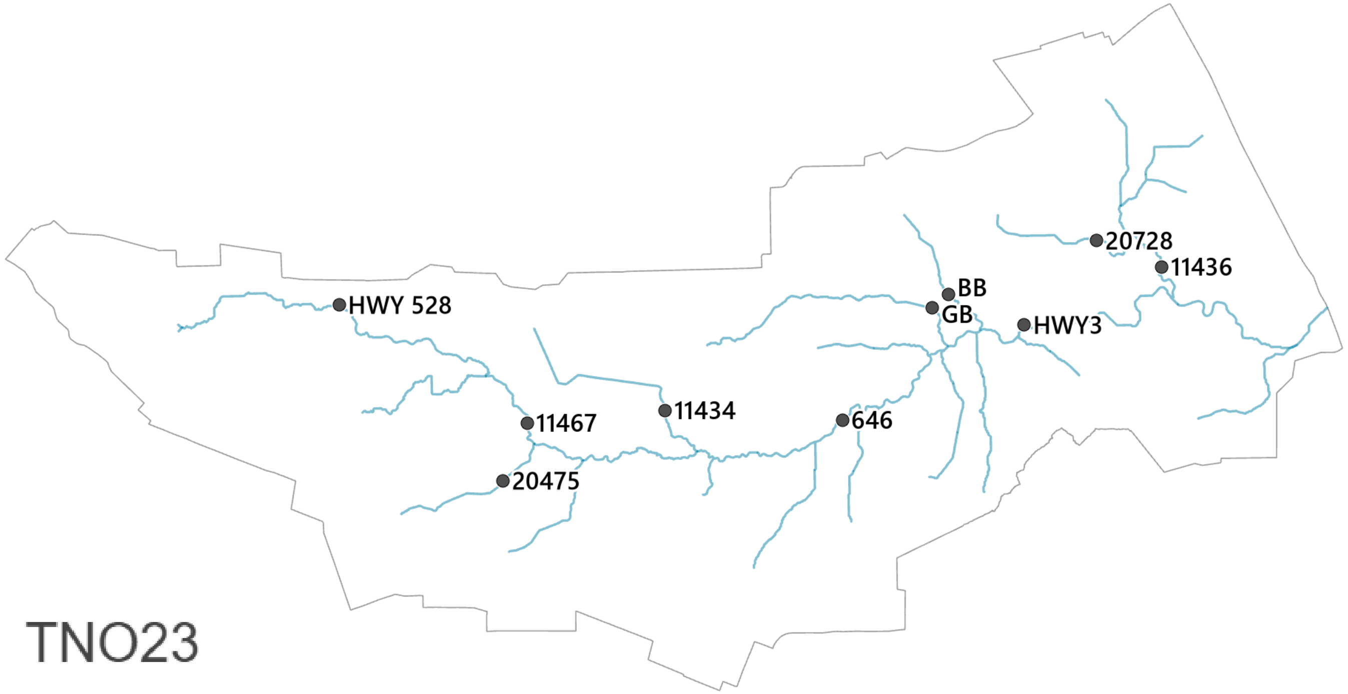
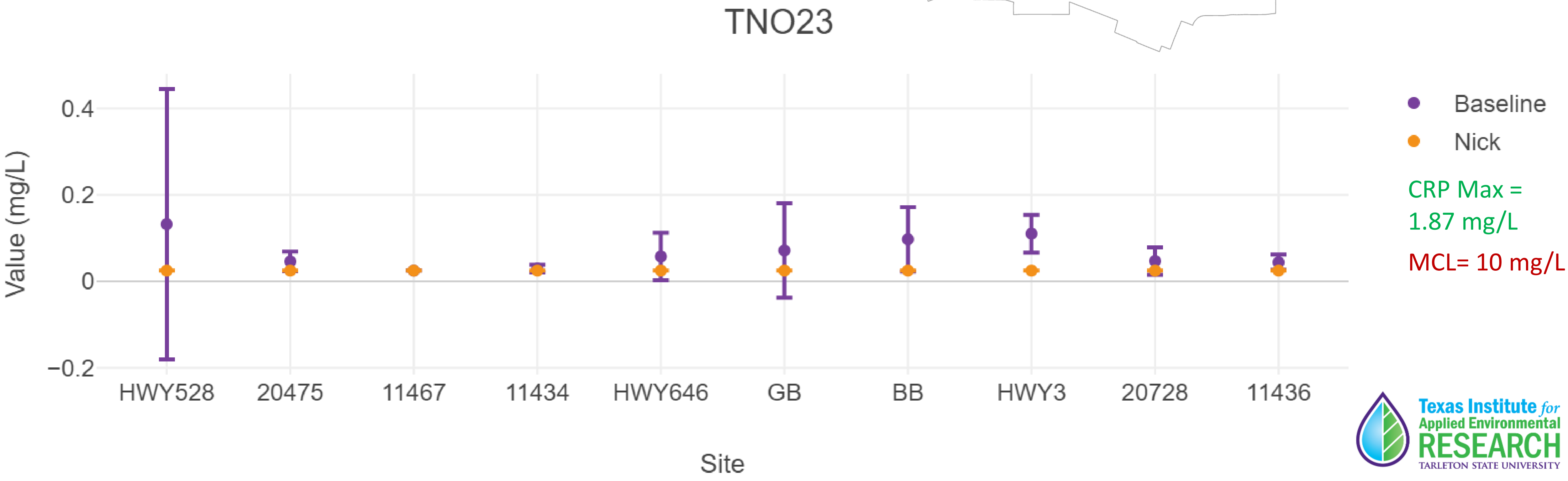
Tropical Storm Nicholas Total Nitrate/Nitrite as N (TNO23) data from TIAER lab

Wilcoxon Rank Sum Test Result:
Significant difference (p= 0.02)





CRP Max = 1.87 mg/L

MCL= 10 mg/L

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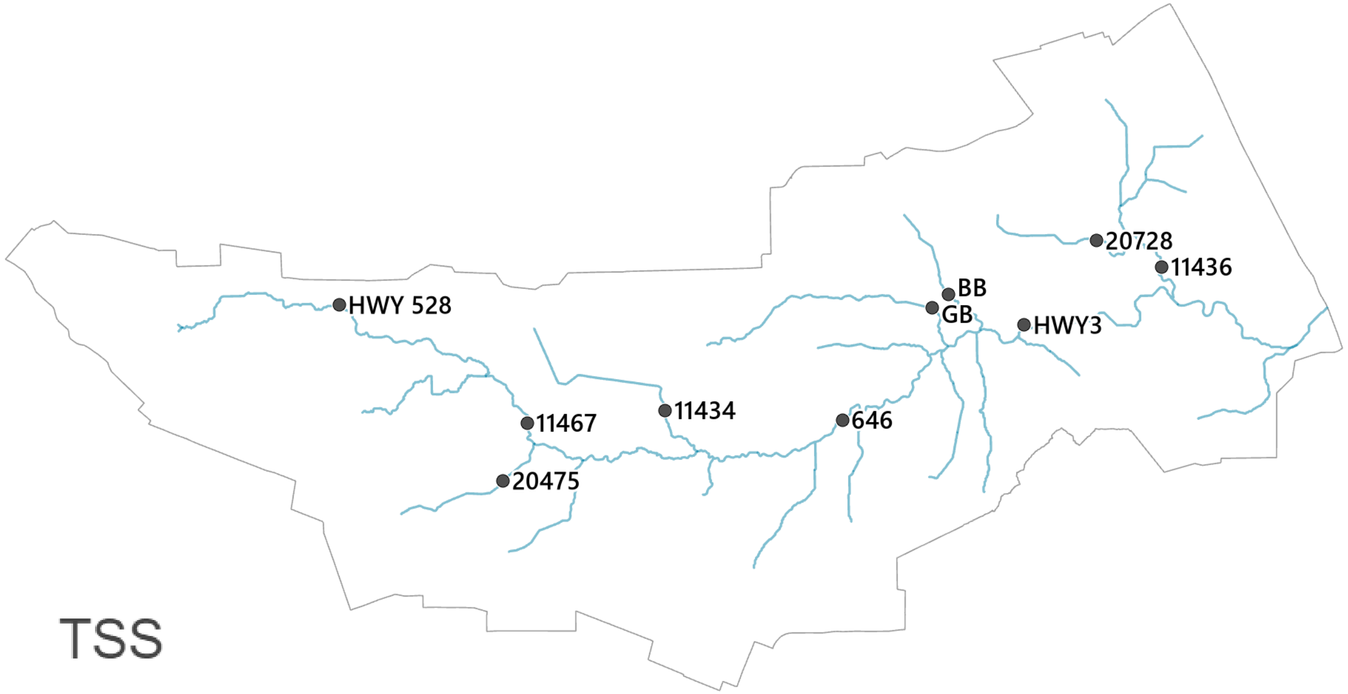
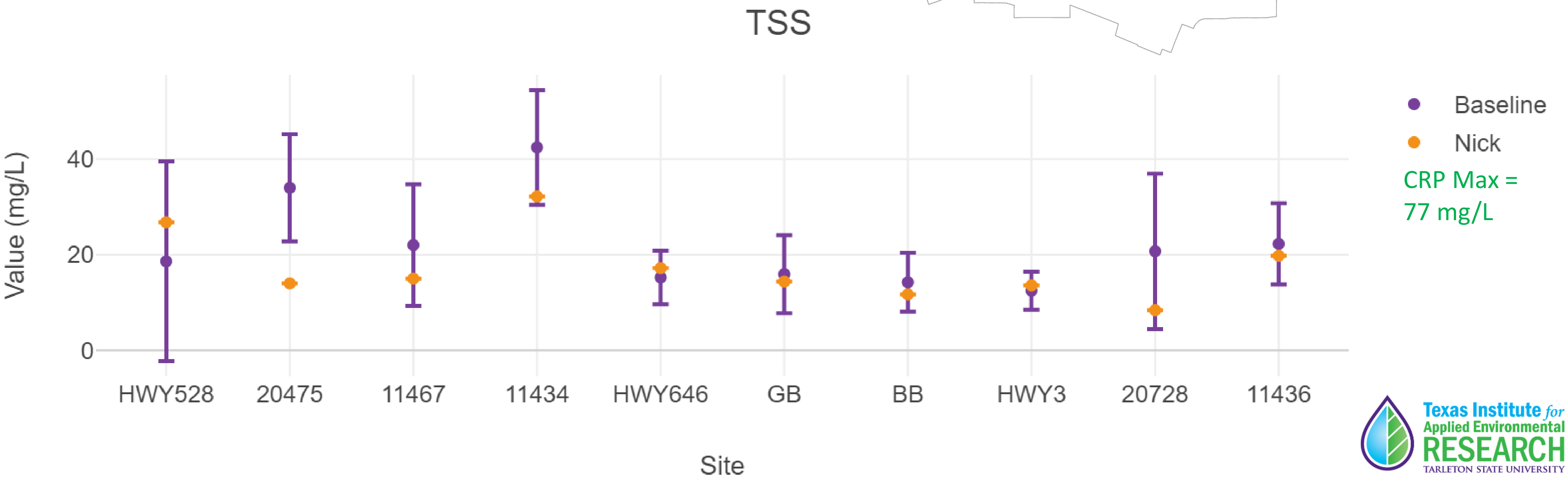
Tropical Storm Nicholas Total Suspended Solids (TSS) data from TIAER lab

Wilcoxon Rank Sum Test Result:
No significant difference (p= 0.49)

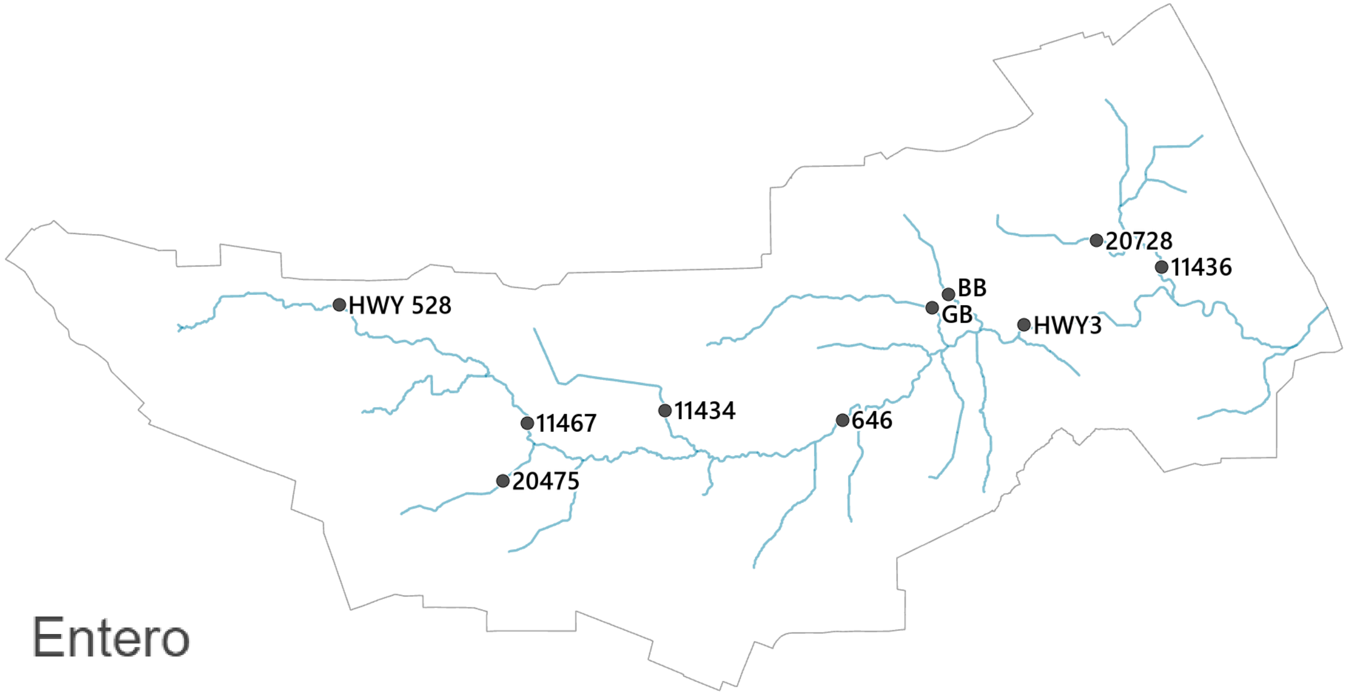


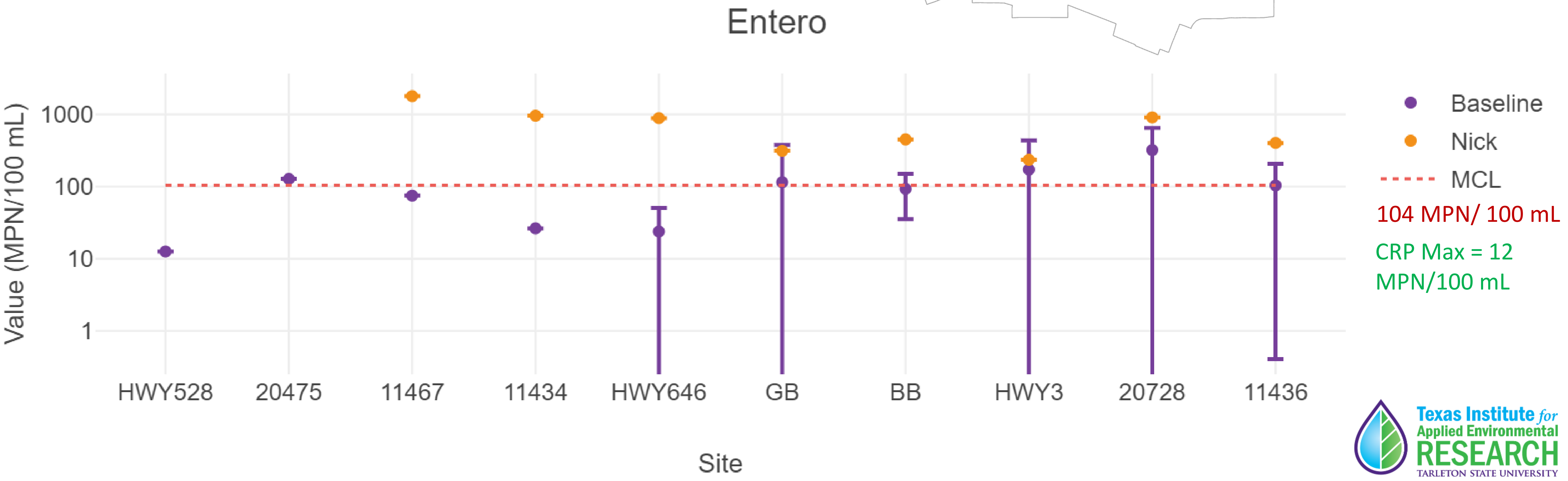


CRP Max = 77 mg/L

Tropical Storm Nicholas Enterococci (Entero) data from TIAER lab

Wilcoxon Rank Sum Test Result:
Significant difference (p= 0.0002)





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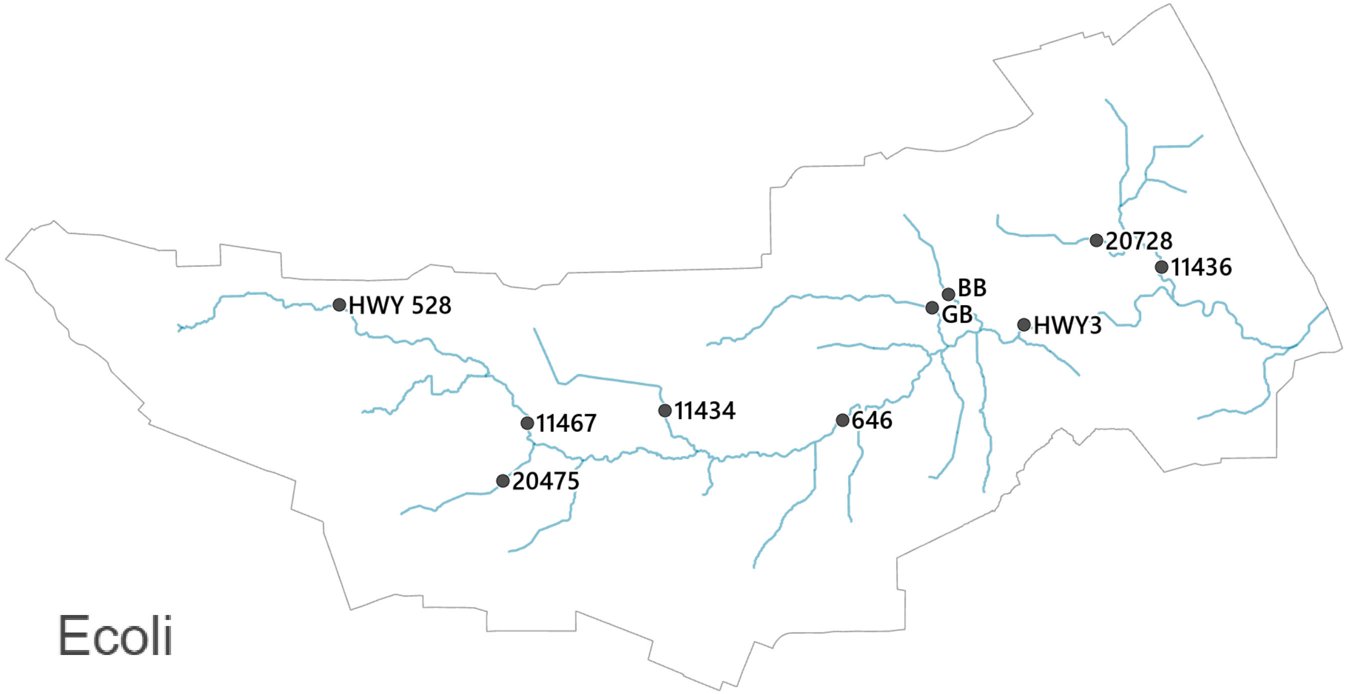
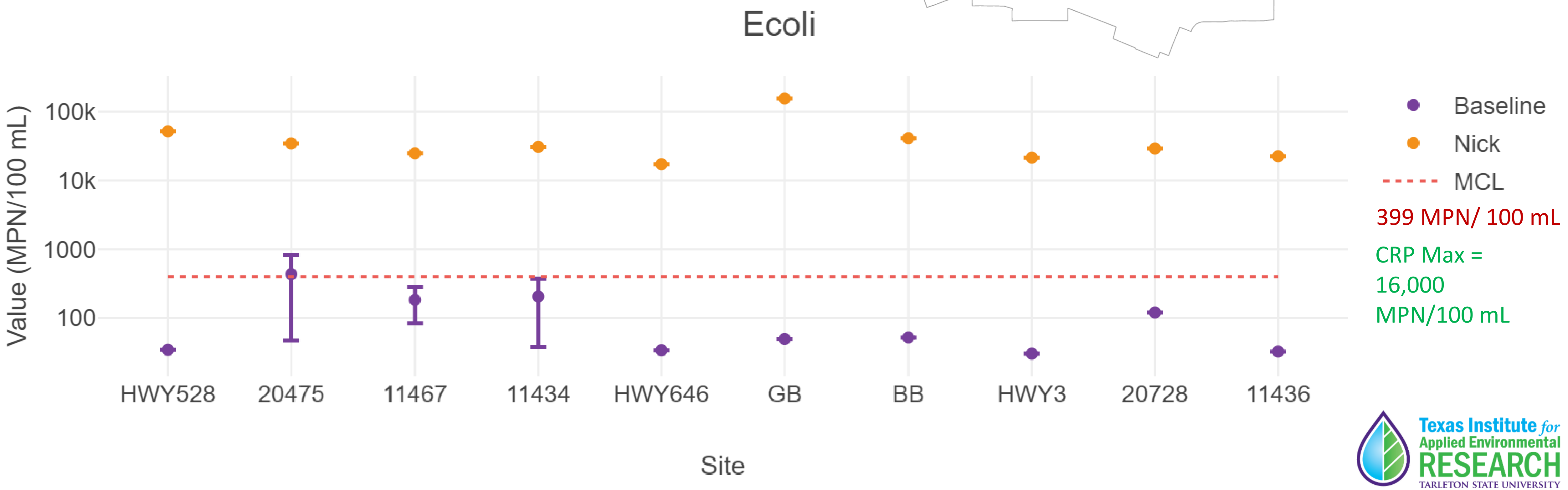
Tropical Storm Nicholas Escherichia coli (Ecoli) data from TIAER lab

Wilcoxon Rank Sum Test Result:
Significant difference (p= 0.000005)





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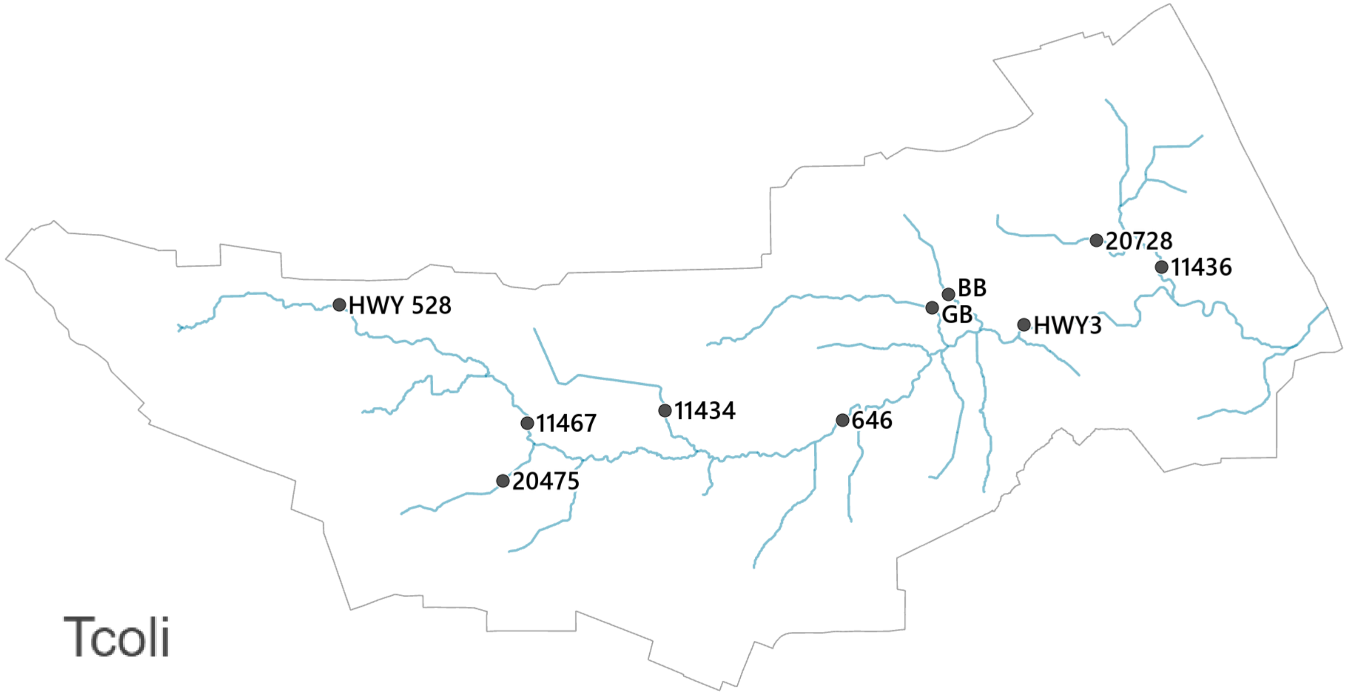
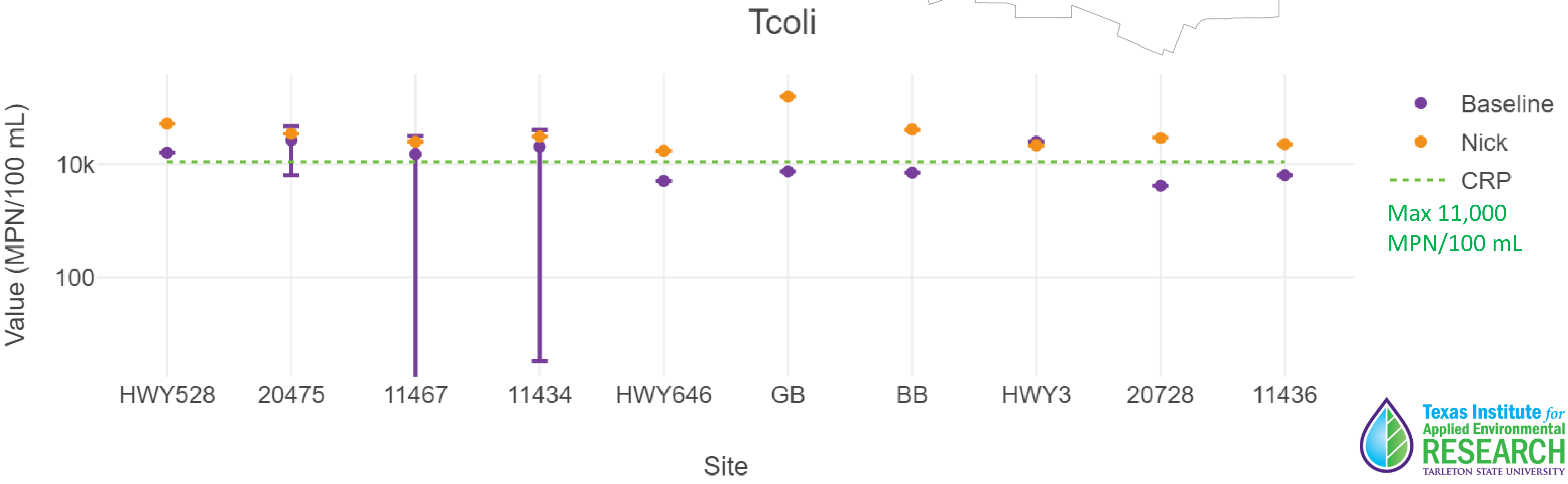
Tropical Storm Nicholas Total Coliforms (Tcoli) data from TIAER lab

Wilcoxon Rank Sum Test Result:
Significant difference (p= 0.01)





Max 11,000 MPN/100 mL

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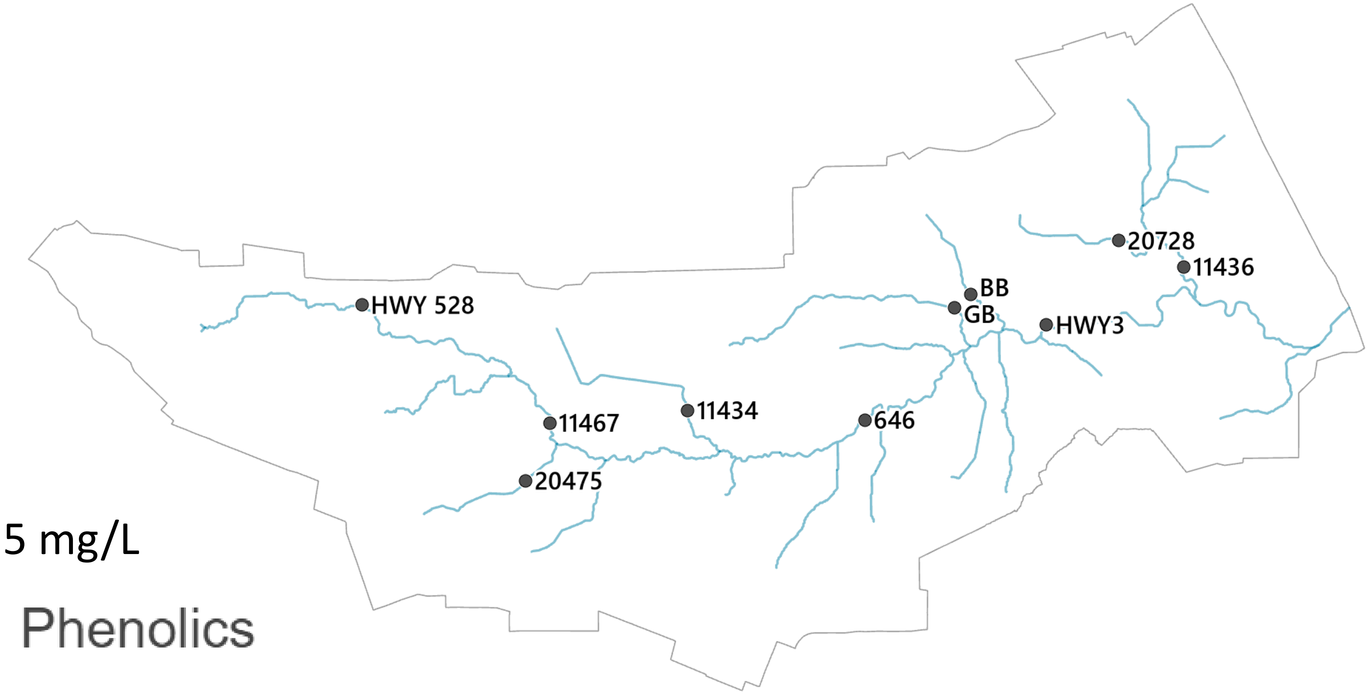
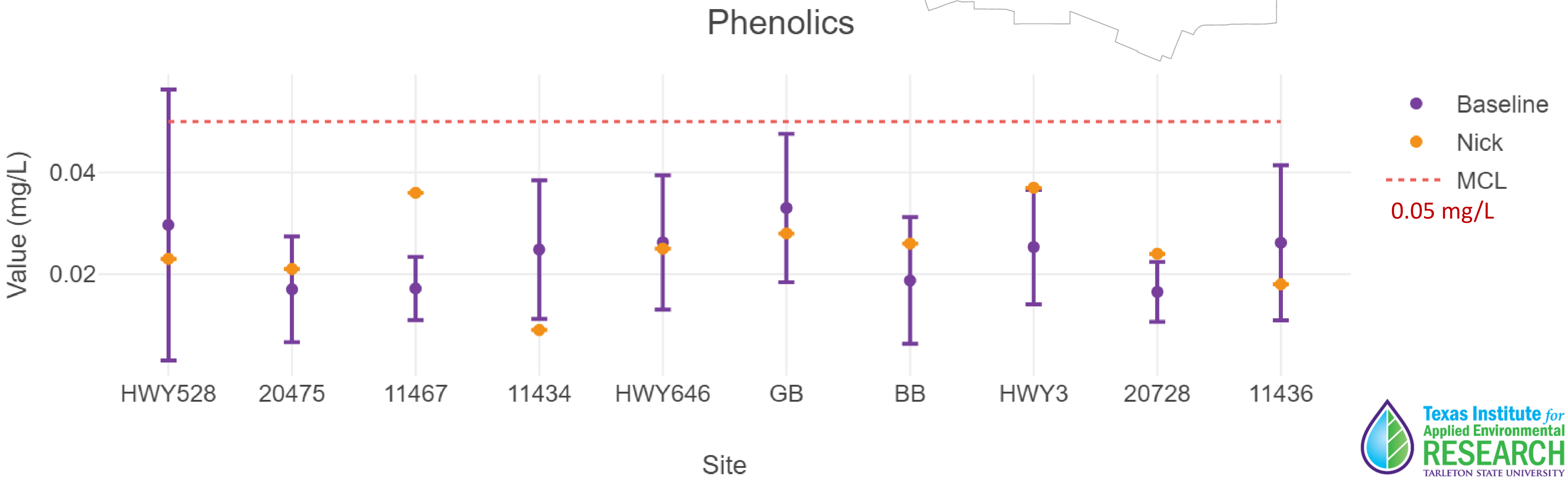
Tropical Storm Nicholas Total Phenolics data from ALS lab

Wilcoxon Rank Sum Test Result:
No significant difference (p= 0.27)



MCL (1) = 0.5 mg/L



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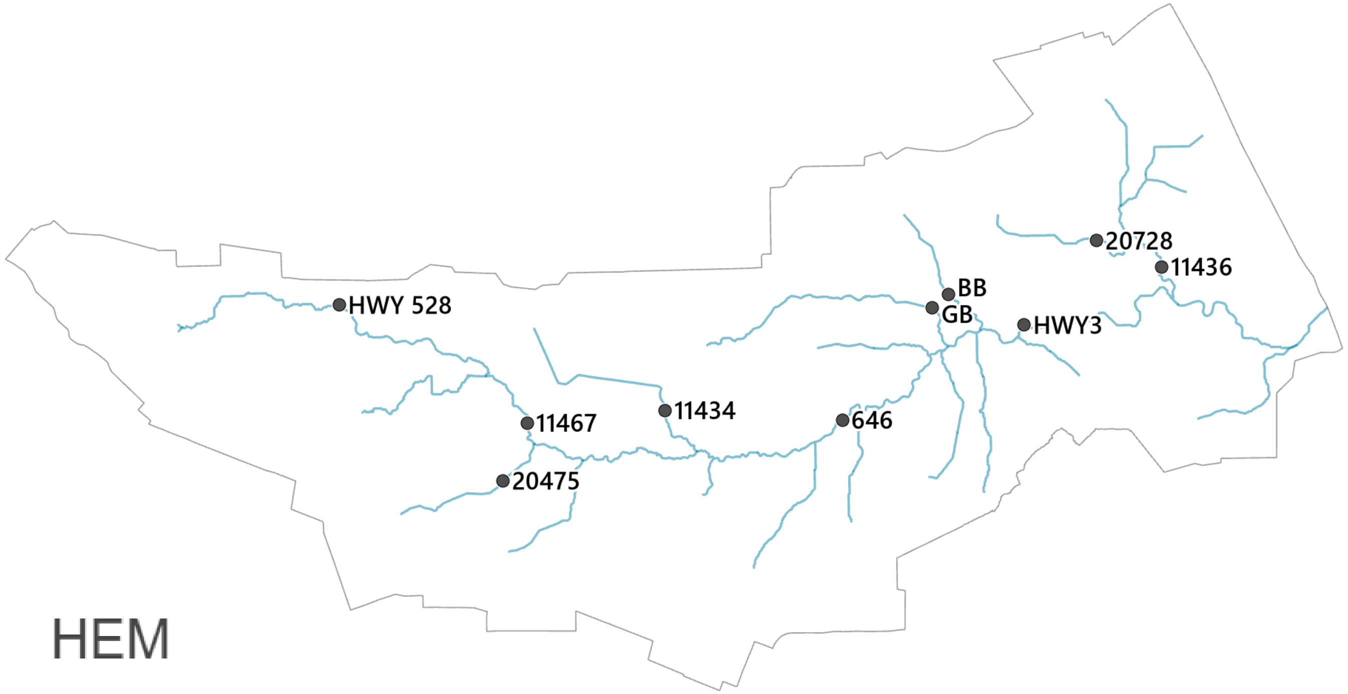
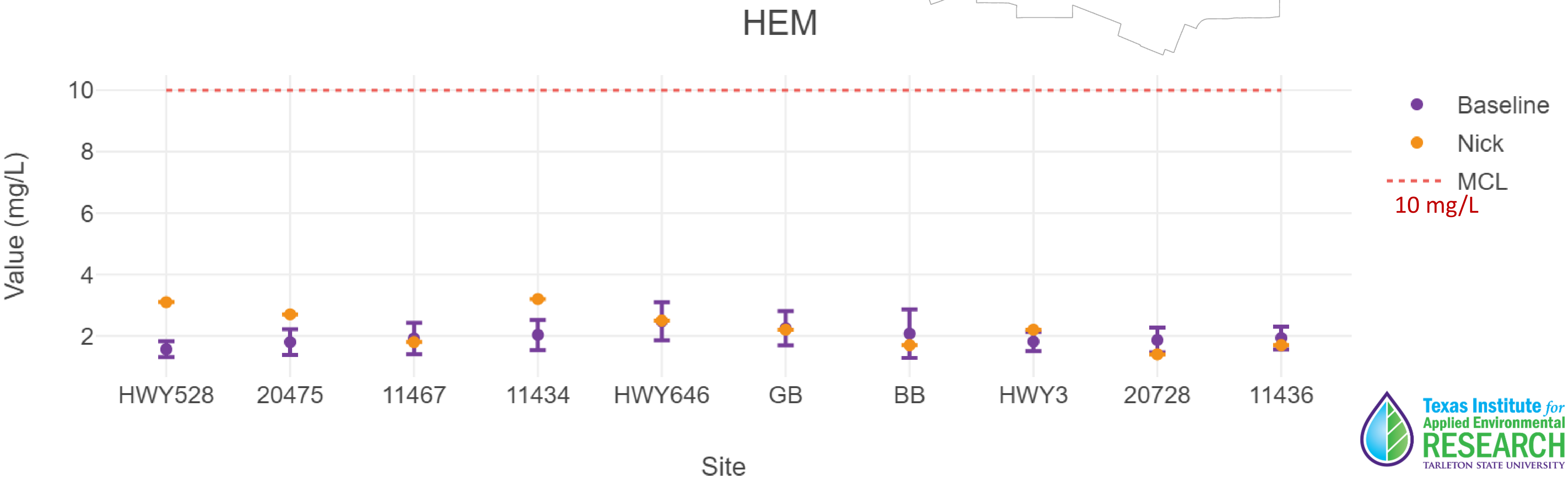
Tropical Storm Nicholas Hexane Extractable Materials (HEM)data from ALS lab

Wilcoxon Rank Sum Test Result:
No significant difference (p= 0.16)





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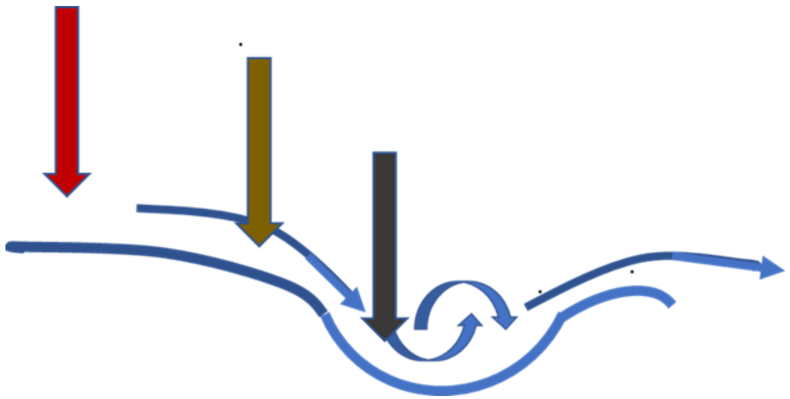
Were samples taken during TS Nick event different from background levels?

- Data from Tropical Storm Nick was significantly different at p=0.05 for Nitrate-Nitrite Nitrogen, Enterococci, *E. coli*, and Total coliforms.
- Additional metals and organics data is pending and will be evaluated when available.

Soil Sampling



Soil and Sediment Assessments across the Dickinson Bayou

Research objective: Track flow of soil-associated contaminants during storm events

Erosion and runoff from the land into the bayou

Transport of sediments from streams onto streambanks during flooding with sands deposited near streambanks and clays further from the stream

Churning of water within the bayou resulting in the suspension of sediments from streambanks and the stream bottom and movement of sediments downstream

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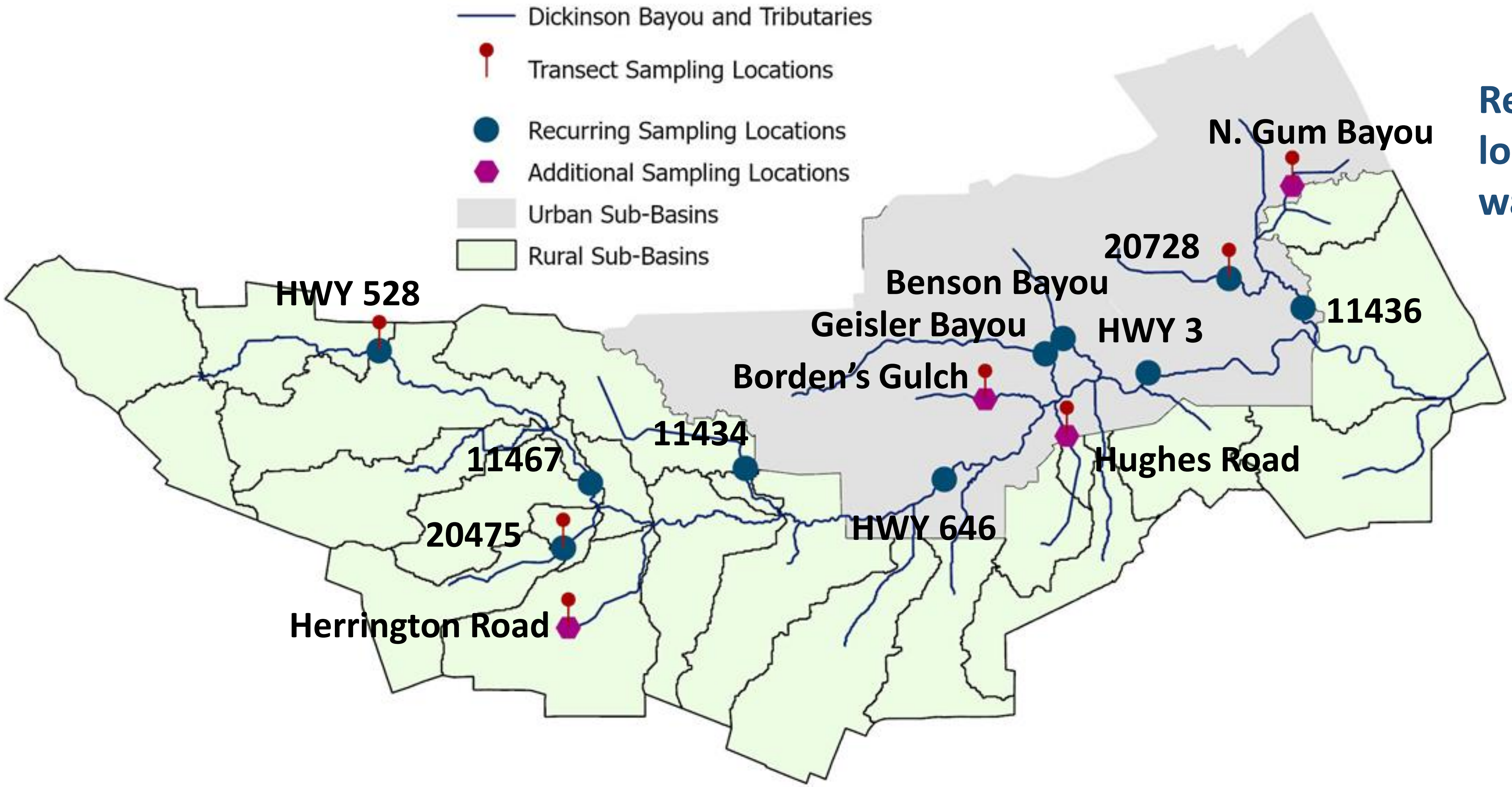
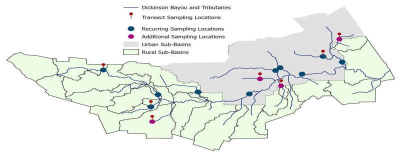
Soil and sediment sampling locations on Dickinson Bayou and tributaries



Recurring sampling locations are also used for water quality sampling

Note: On graphs shown in this presentation, the sampling sites are shown from source to the outlet of the bayou

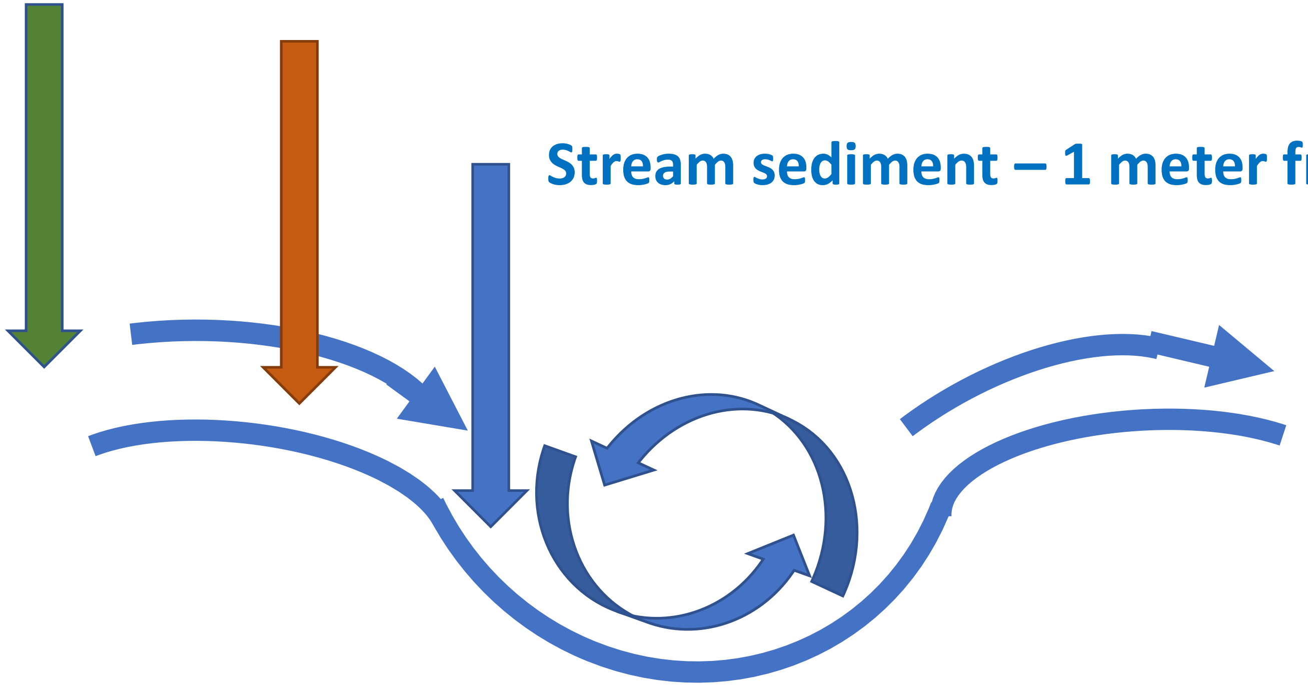


Depending on storm intensity, soil and sediment transport can impact various locations within the stream and on the stream bank

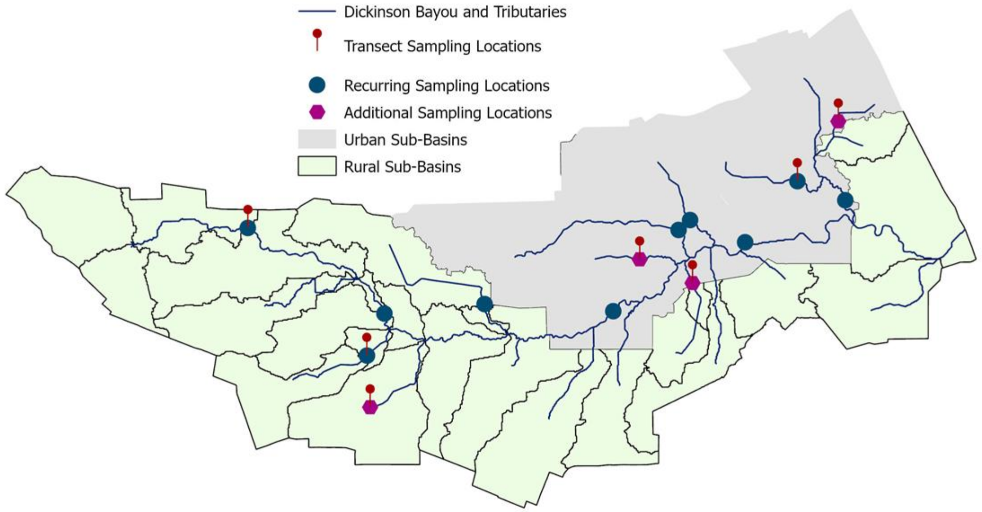
Flood plain soil – on shoulder of stream bank – variable distance from stream (4 – 10 meters)

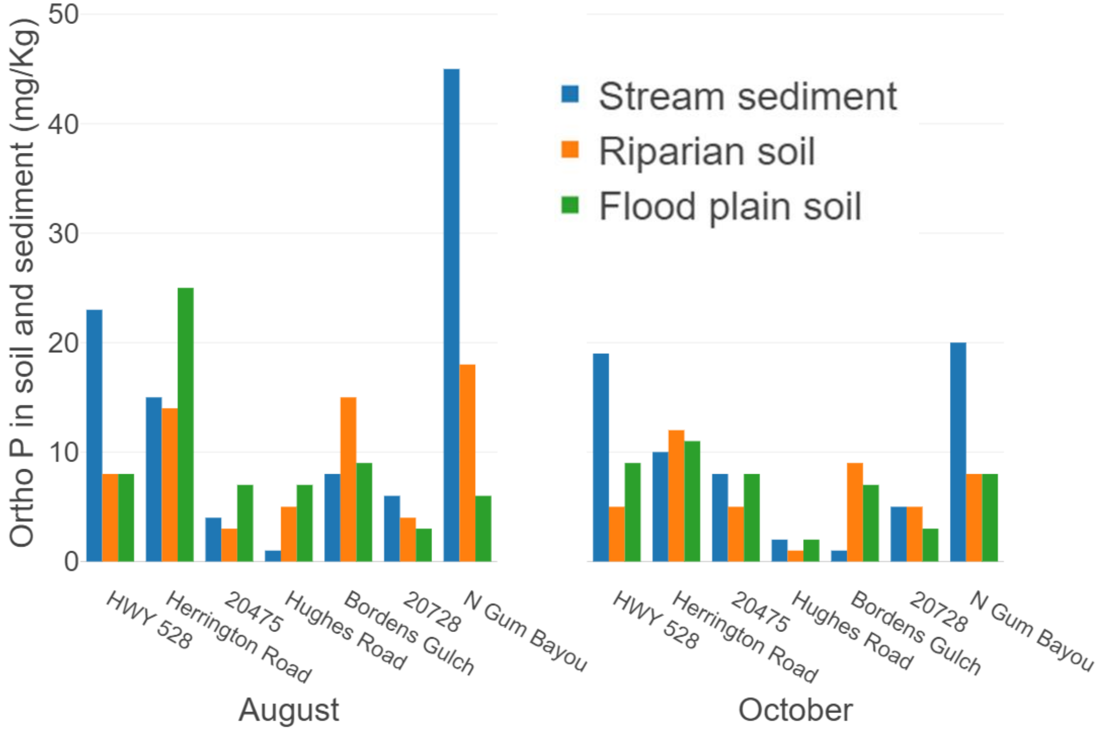
Riparian soil – 1 meter from stream on the bank

Stream sediment – 1 meter from bank, within the stream

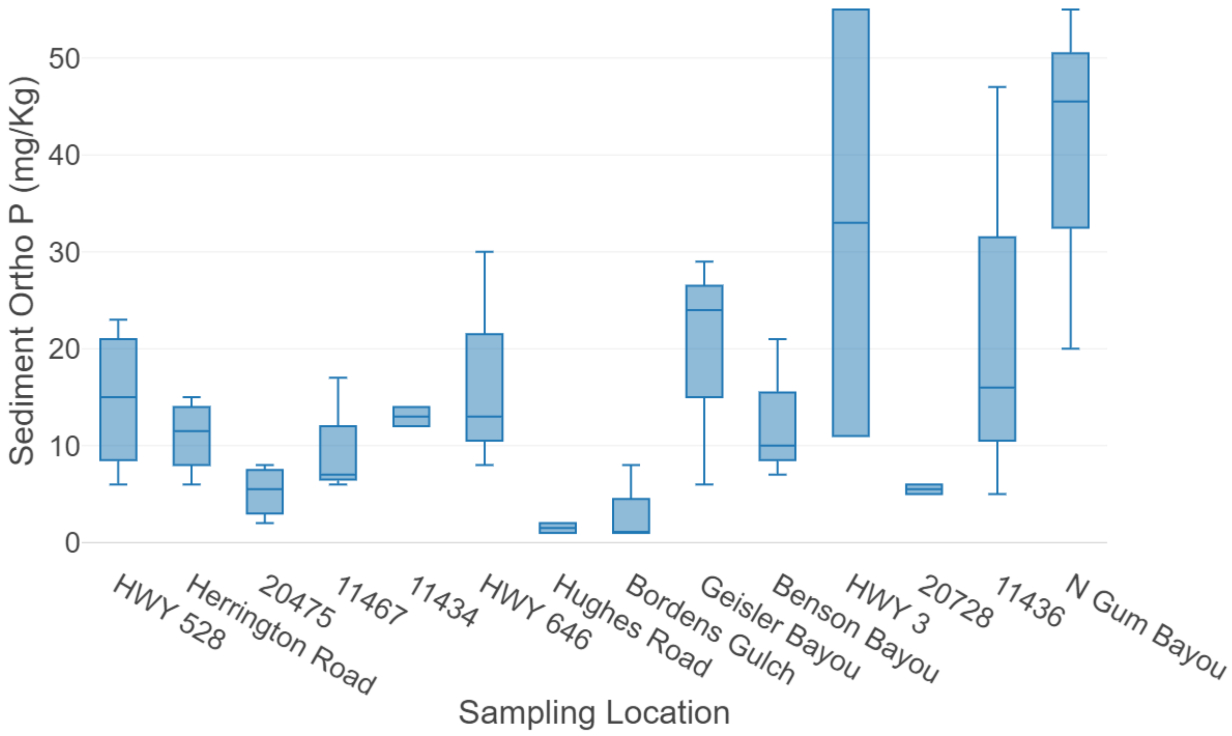


Changes in sediment Ortho P due to a major storm event

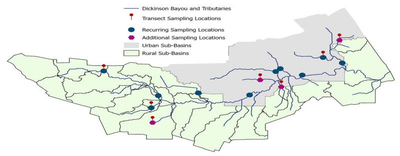




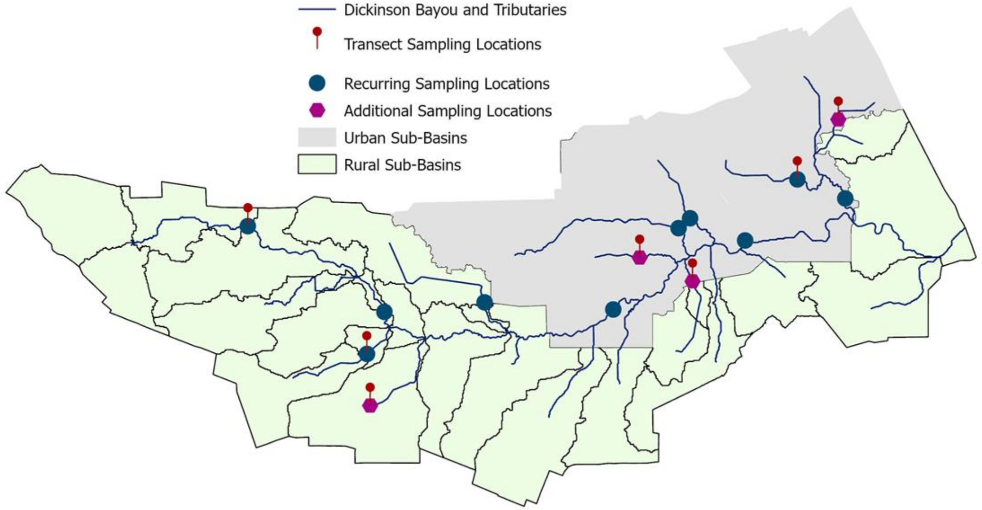
Differences in in stream sediment ortho P across the 2 months

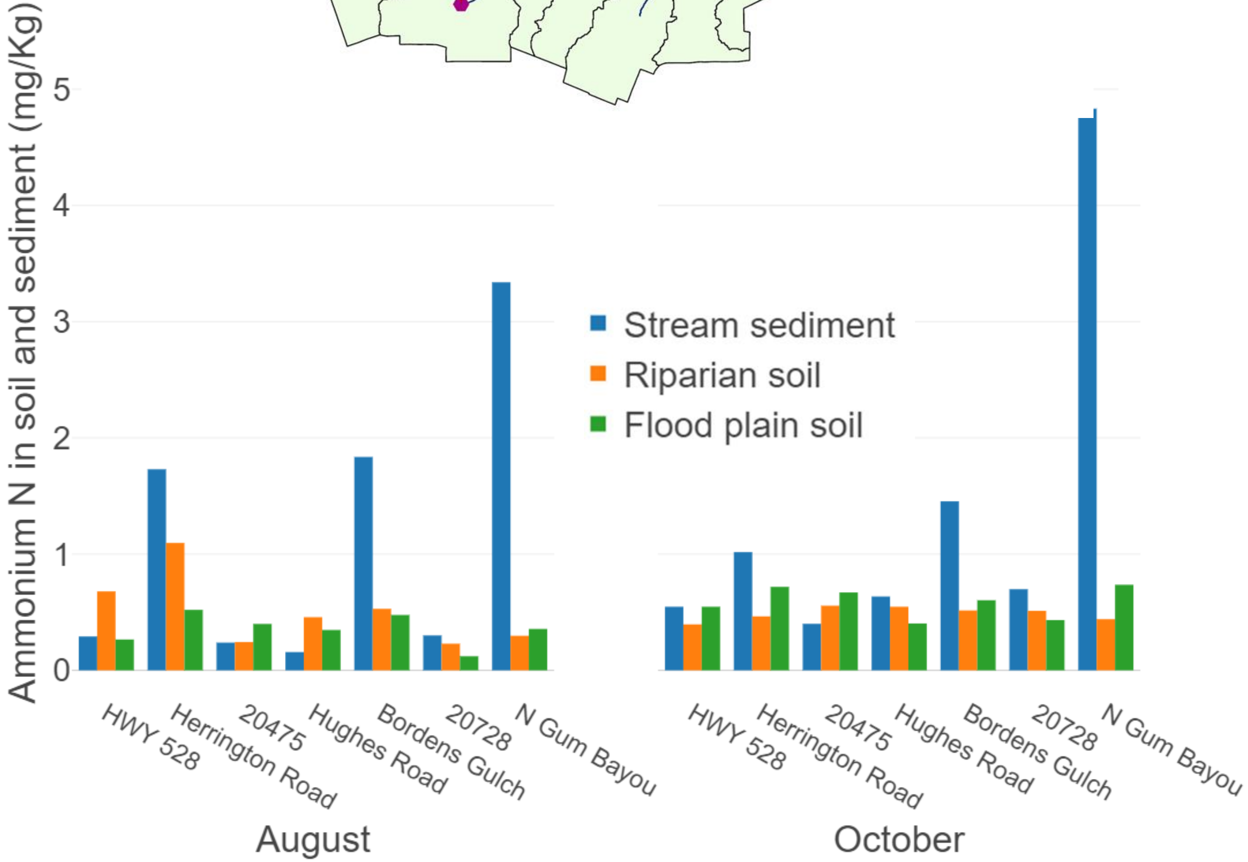


$p = 0.397$ for differences across August and October
$p = 0.003$ for differences across sampling locations
$p = 0.860$ for differences across transects

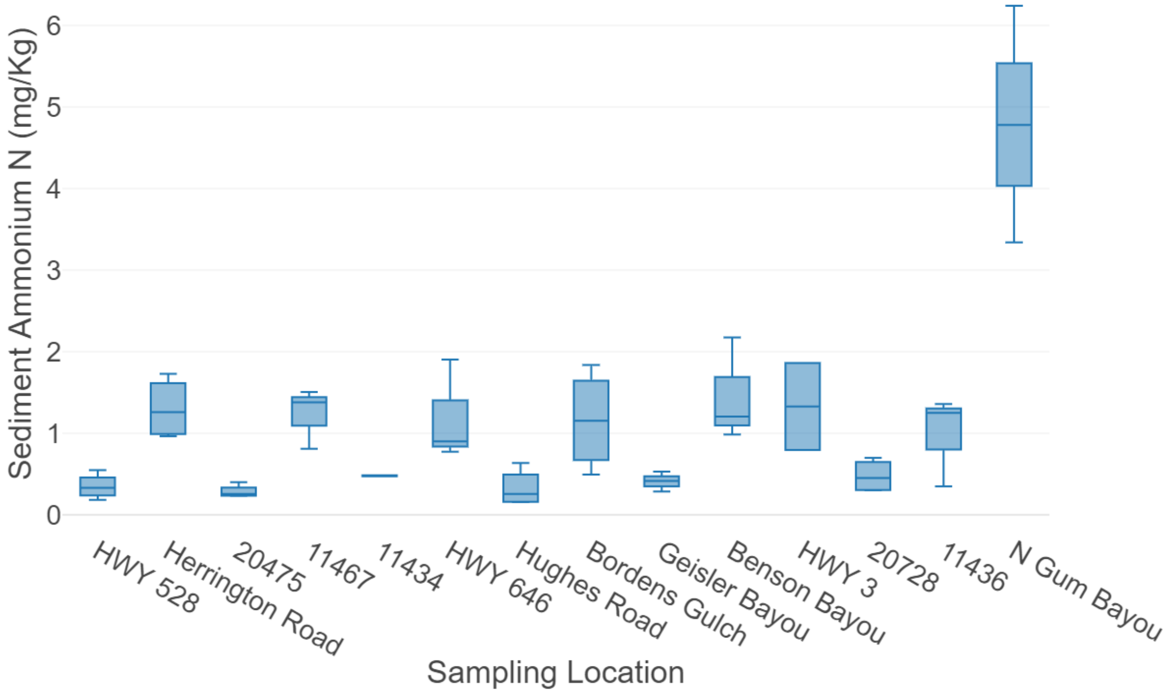


Changes in sediment ammonium N due to a major storm event

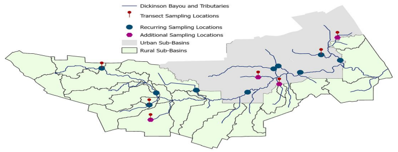




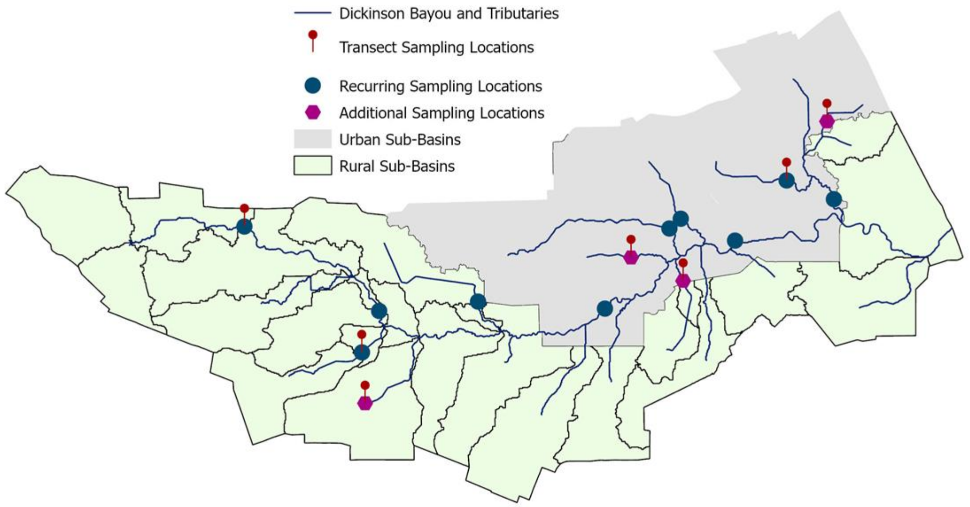
Differences in in stream sediment ammonium N across the 2 months

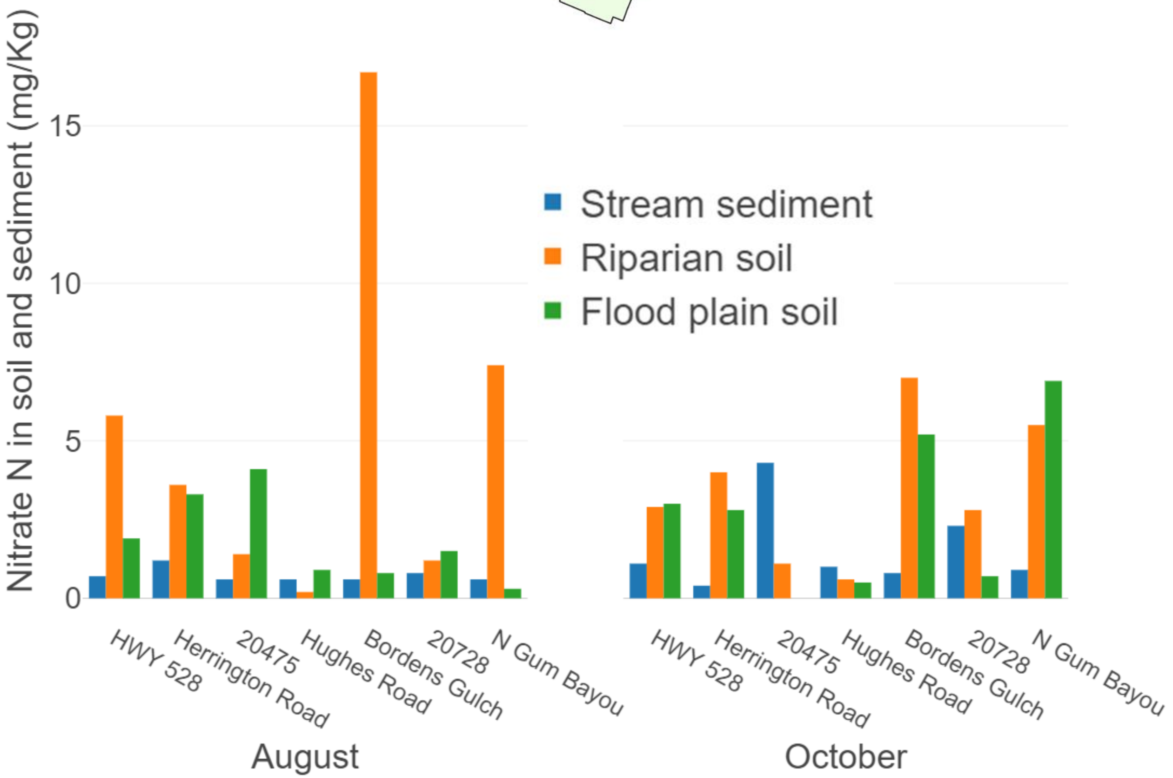


p = 0.521 for differences across August and October
p = 0.251 for differences across sampling locations
p = 0.020 for differences across transects

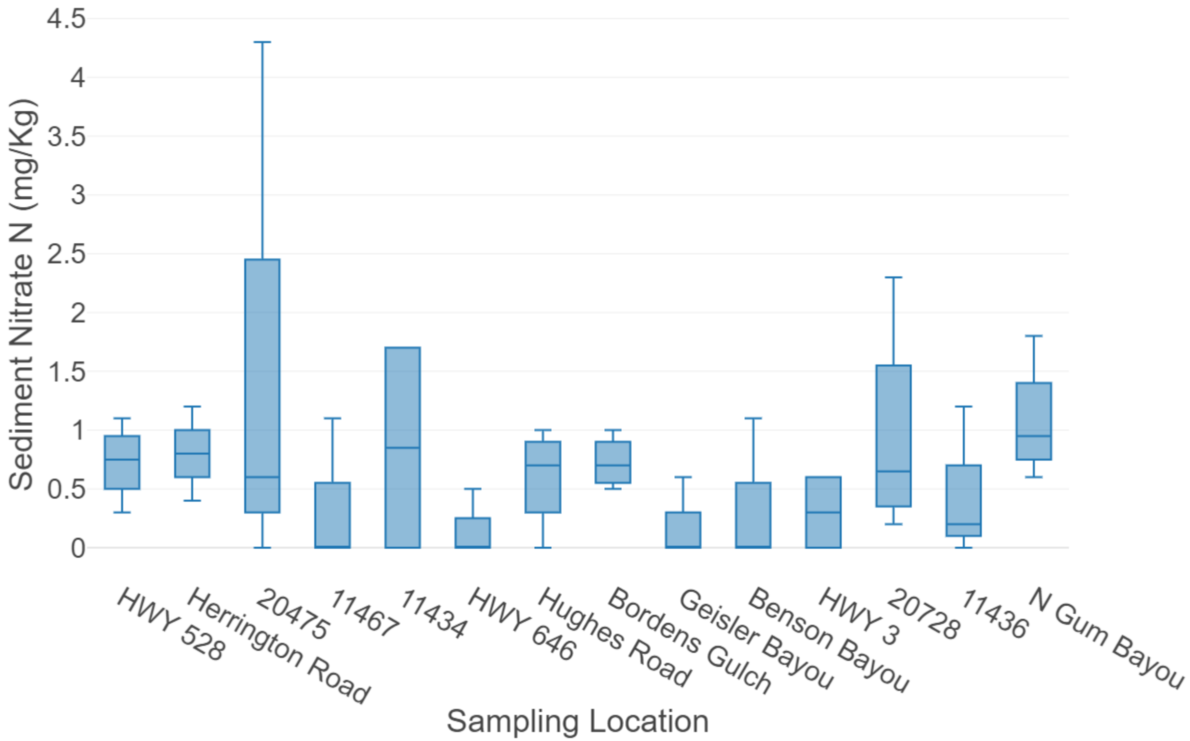


Changes in sediment nitrate N due to a major storm event

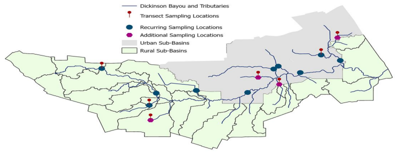




Differences in in stream sediment nitrate N across the 2 months

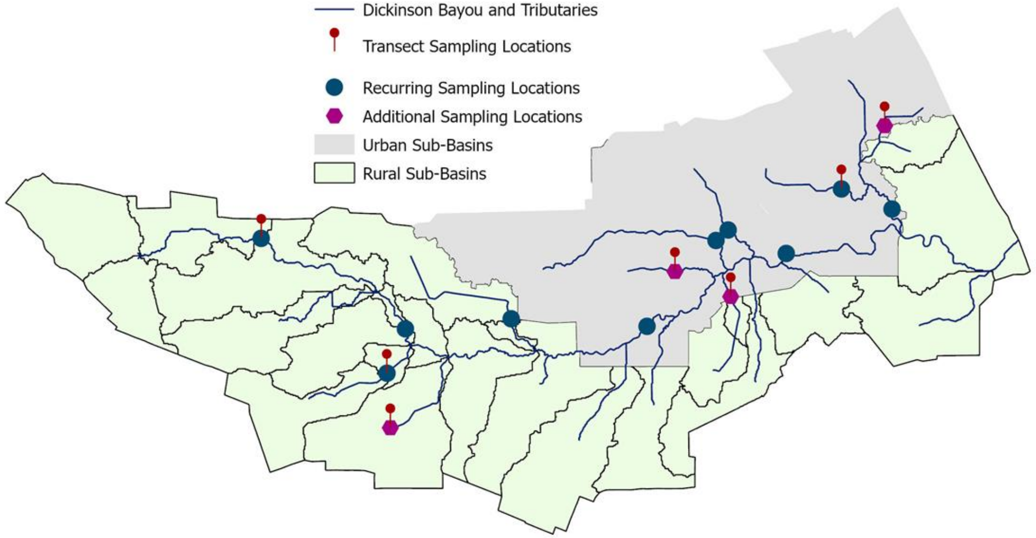


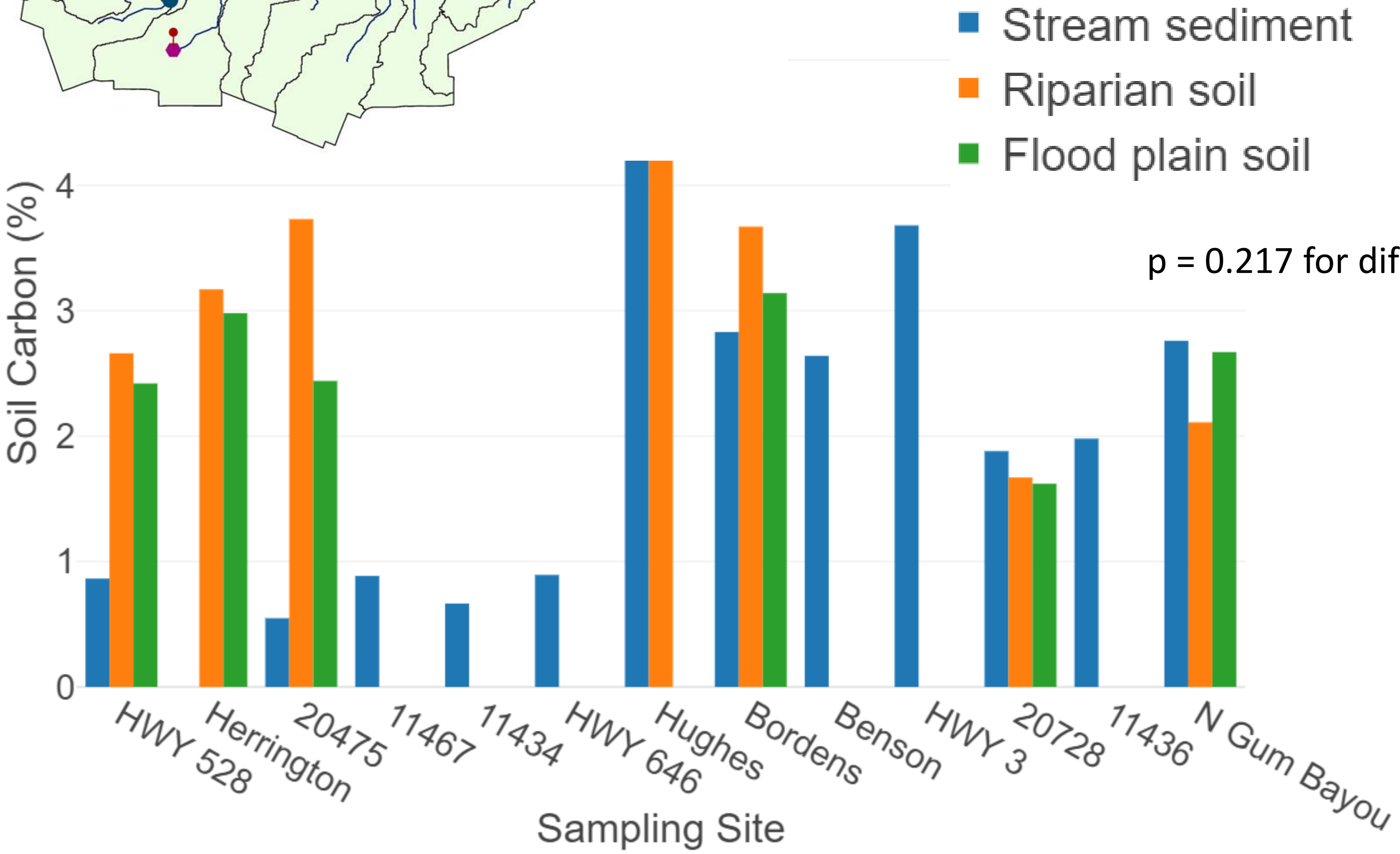
p = 0.013 for differences across August and October
p = 0.071 for differences across sampling locations
p = 0.277 for differences across transects



Soil carbon (%) across the Dickinson Bayou

(preliminary data)





p = 0.217 for differences across sampling locations

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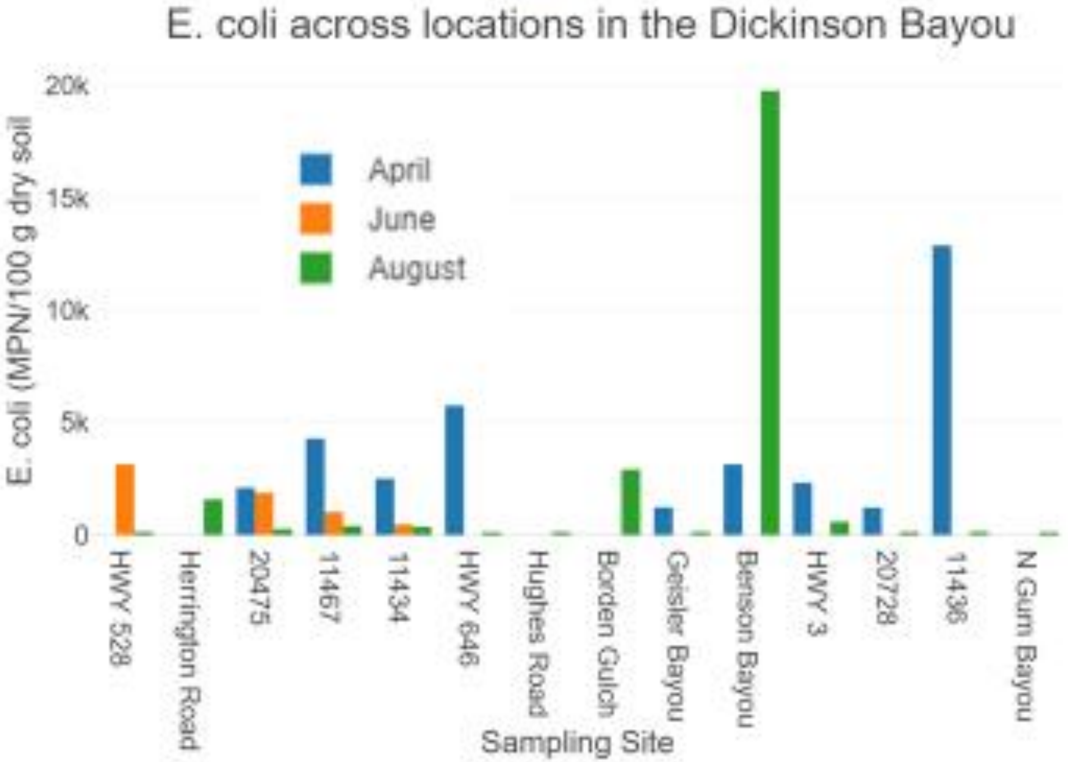
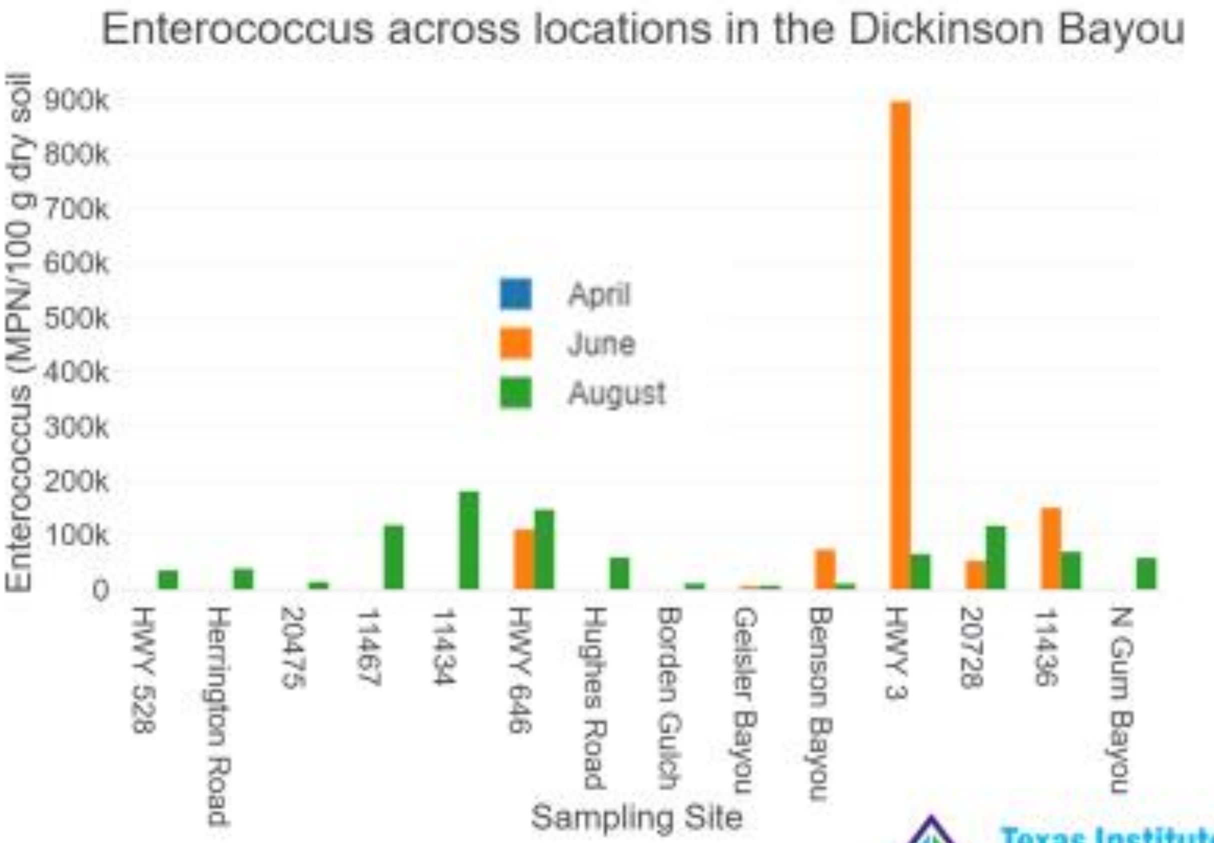
Microbial populations across the Dickinson Bayou

(awaiting post-storm October data)



p = 0.637 for differences across sampling sites



p = 0.304 for differences across sampling sites

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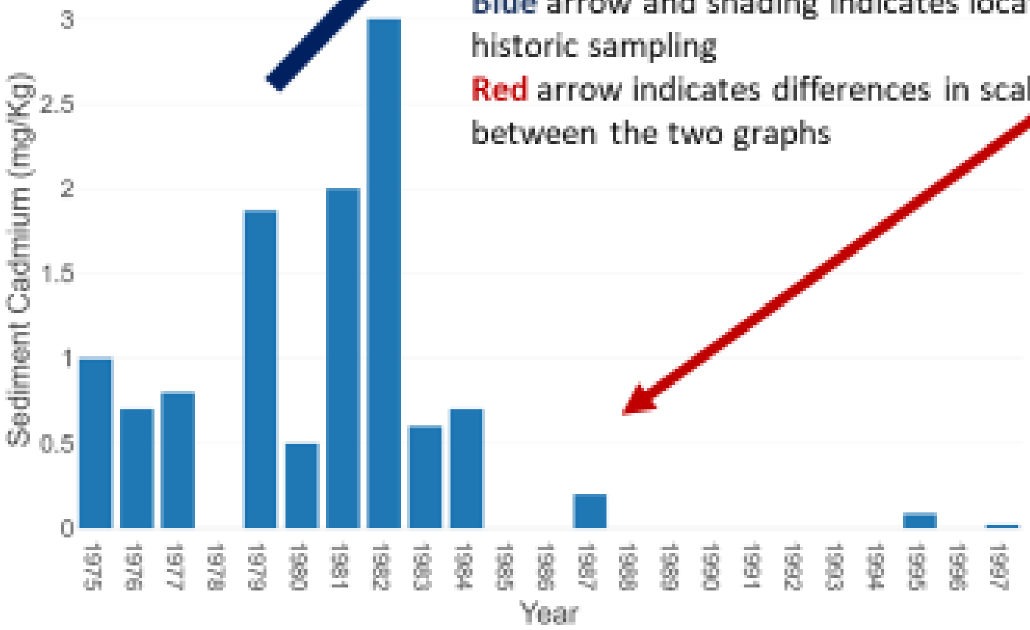
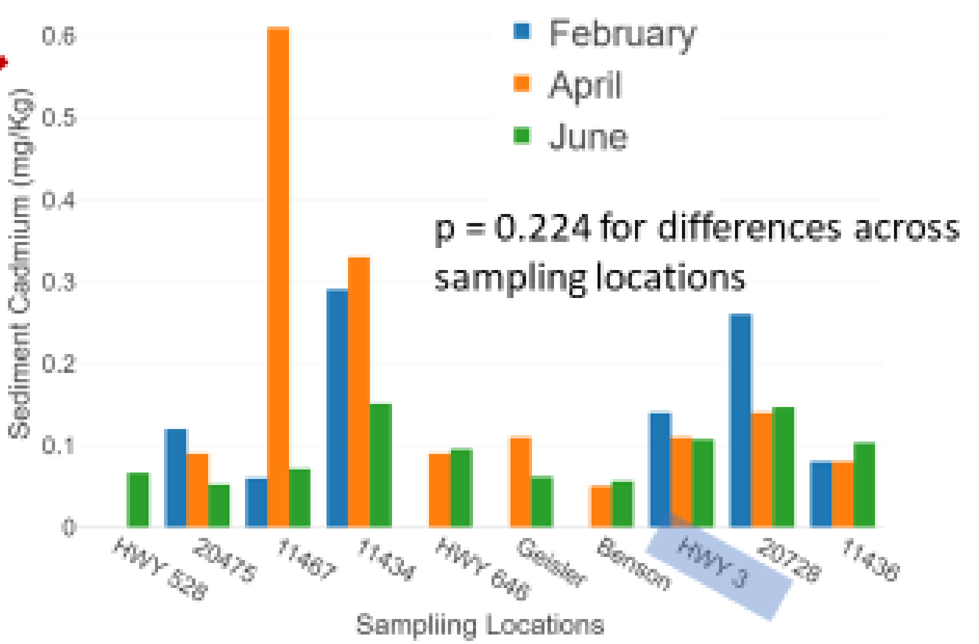
Historical and TIAER project sediment cadmium levels – Dickinson Bayou

Critical level of Cd in soil = 0.8 mg/Kg

Note:
Blue arrow and shading indicates location of historic sampling
Red arrow indicates differences in scale between the two graphs



TCEQ Clean Rivers Project (CRP) Data



TIAER Project Data - 2021

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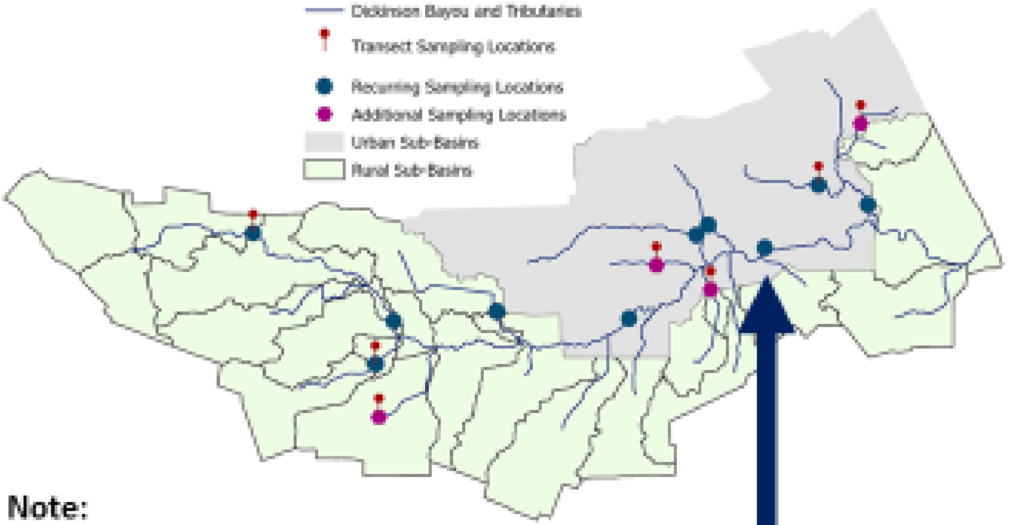
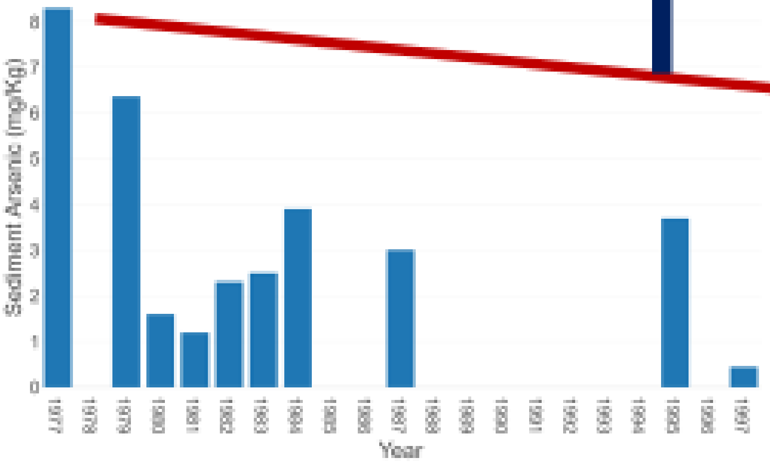
Historical and TIAER project sediment arsenic levels – Dickinson Bayou

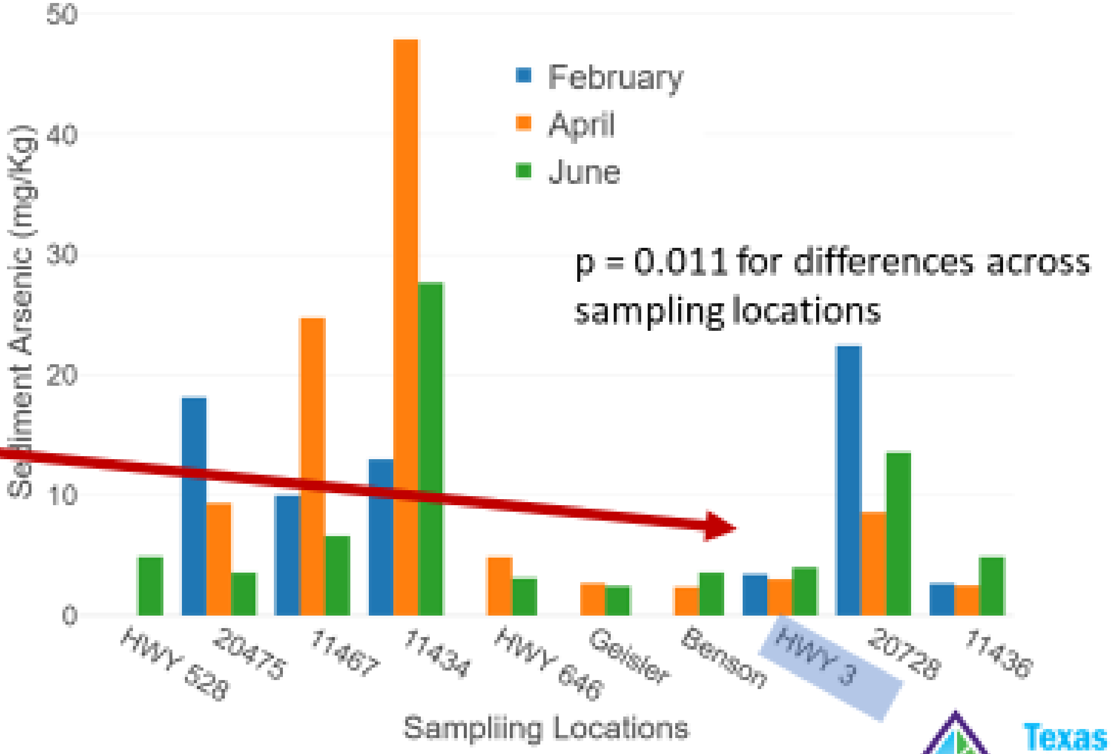
Critical level of arsenic in soil = 0.39 mg/Kg



Note:
Blue arrow and shading indicates location of historic sampling
Red arrow indicates differences in scale between the two graphs



TCEQ Clean Rivers Project (CRP) Data



TIAER Project Data - 2021

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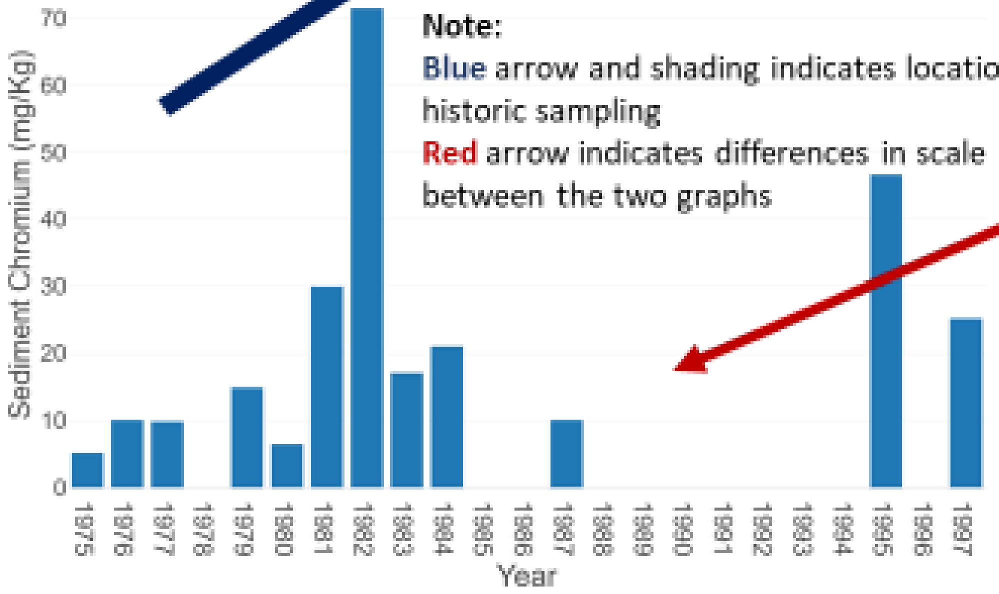
Historical and TIAER project sediment chromium levels – Dickinson Bayou

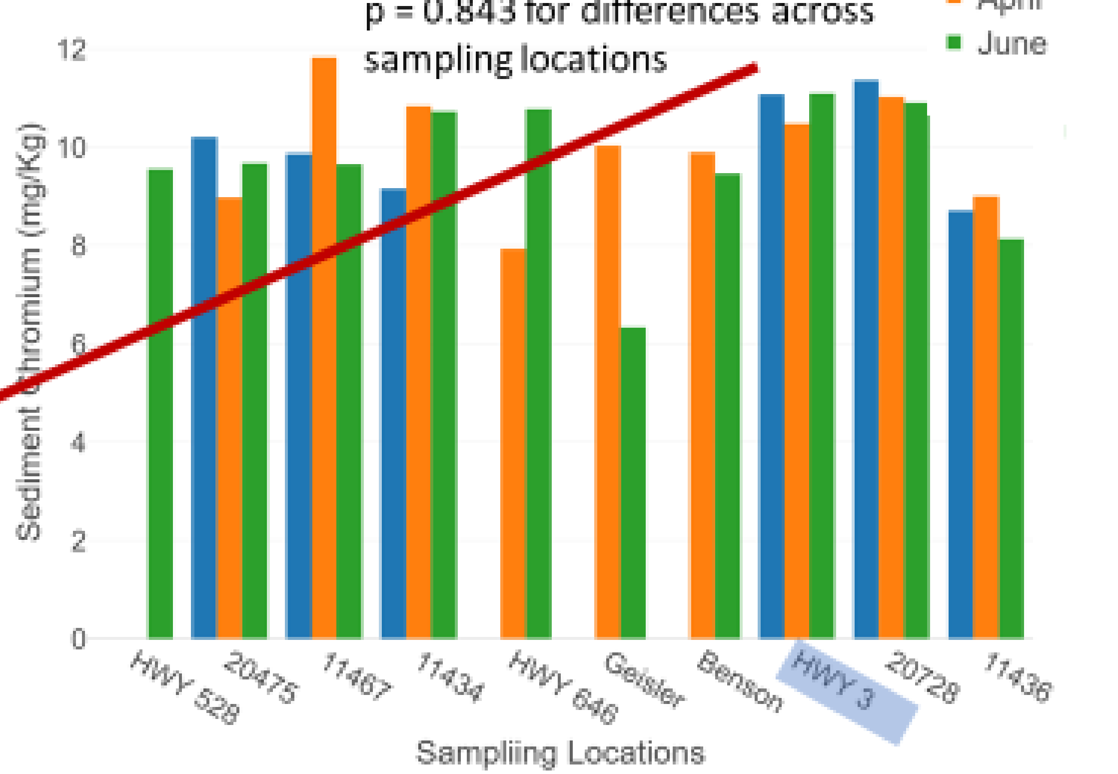


Note:
Blue arrow and shading indicates location of historic sampling
Red arrow indicates differences in scale between the two graphs

TCEQ Clean Rivers Project (CRP) Data

Critical level of Cr in soil = 100 mg/Kg

$p = 0.843$ for differences across sampling locations



TIAER Project Data - 2021

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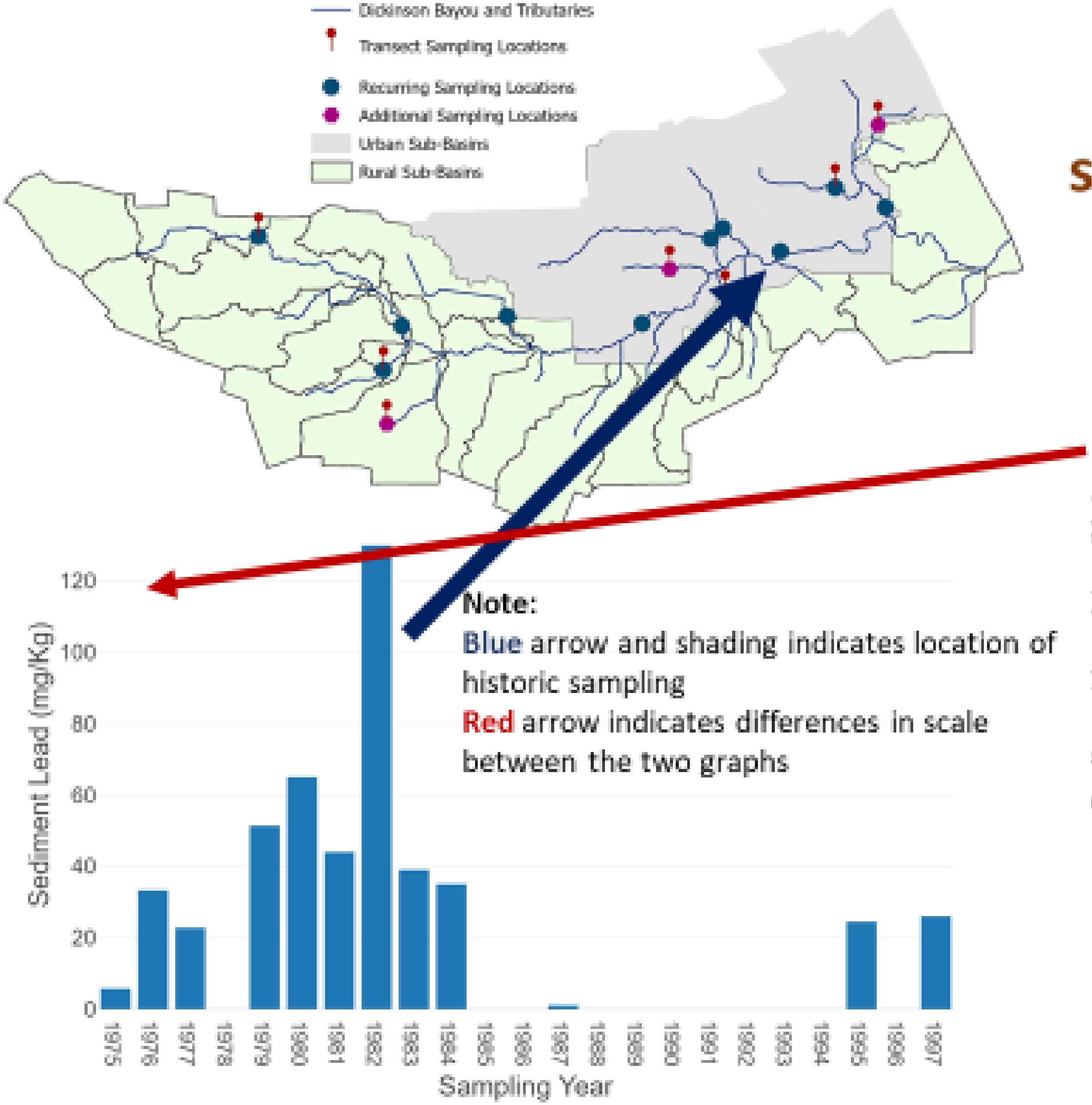
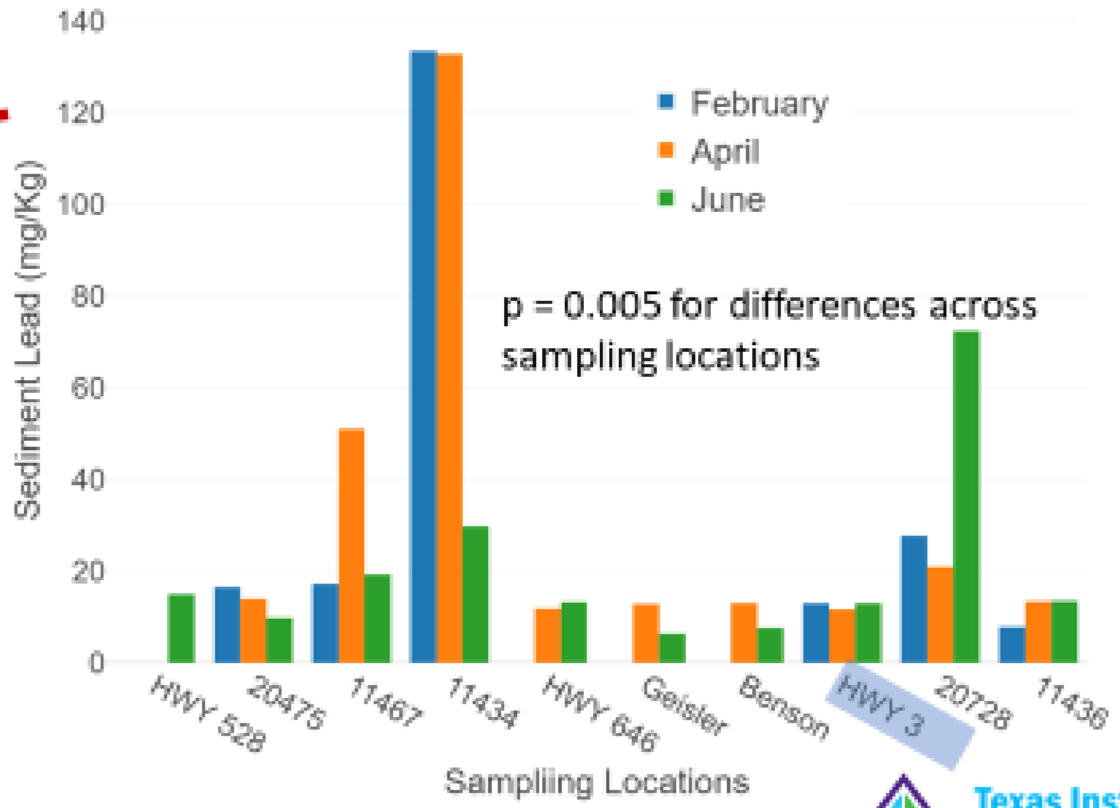
Historical and TIAER project sediment lead levels – Dickinson Bayou

Critical level of lead in sediments = 400 mg/Kg



Note:
Blue arrow and shading indicates location of historic sampling
Red arrow indicates differences in scale between the two graphs

TCEQ Clean Rivers Project (CRP) Data



TIAER Project Data - 2021

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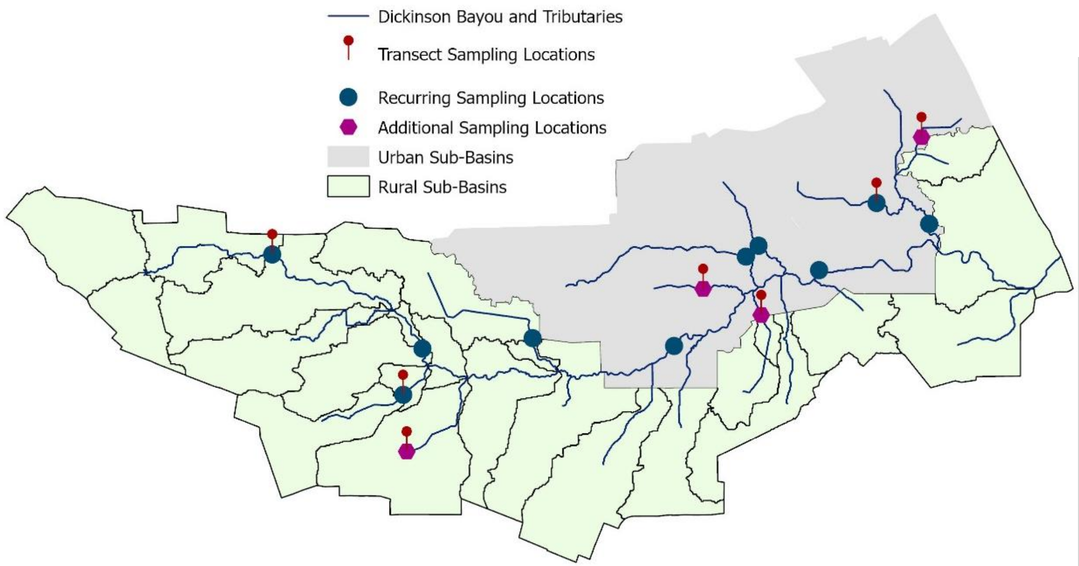

	Historical Data *			Data from TIAER Project		
COC	**High value (mg/Kg)**	**Sampling date**		**High value (mg/Kg)**	**Sampling location**	**Sampling date**
Barium	299.5	10/26/1982		1,018	11436	6/9/2021
Copper	26	10/5/1983		16.19	11434	4/21/2021
Selenium	2.45	9/6/2012		0.79	20728	4/21/2021
Silver	3	10/19/1981		0.12	20728	4/21/2021
Zinc	167.5	10/6/1987		165	11467	4/21/2021
HEM	not available	N/A		1,330	11434	2/5/2021
	µg/Kg			**µg/Kg**		
Mercury	1.3	11/20/1980		0.025	11436	6/9/2021
Acetone	not available	N/A		280	HWY 3	10/3/2021
2-Butanone	not available	N/A		72	HWY 3	10/3/2021
Carbon Disulfide	not available	N/A		15	HWY 3	10/3/2021
Methylene Chloride	not available	N/A		48	HWY 3	2/5/2021
Phenolicss	not available	N/A		0.34	Benson	4/21/2021
Toluene	not available	N/A		0.72	Giesler	4/21/2021

Additional metals and hydrocarbons detected in project sediment samples collected across the Dickinson Bayou

*All historical data taken from HWY 3

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Preliminary observations based on soil and sediment contaminant research

- **Nutrients**
  - Nutrient levels tend to be higher in tributaries than in the main stem
  - Higher nutrient levels in some tributaries may help identify contaminant sources
  - No direct relationship determined between soil and water nutrient levels
- **Other contaminants**
  - Project analyzed arsenic levels relatively high compared to historic and critical levels for human health, but did not appear to contribute to arsenic in water
  - While cadmium, chromium, lead, and mercury were consistently detectable in all sampling locations, these levels were relatively low compared to critical levels
  - Various hydrocarbons were occasionally found throughout the Dickinson Bayou, but at relatively low levels
- **Tropical storm Nicholas appears to have had a limited effect on transport of sediment-bound contaminants analyzed to date**

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On-going soil and sediment contaminant research

- Two additional sampling events – November 2021 and January 2022
- Geostatistical assessment of contaminants across the watershed
- Evaluation of impacts of storm event on contaminant transfers
  - Comparisons of sediment and riparian assessments
  - Assessments of sediment and soil analyses in relation to water assessments using multivariate analyses
- Interaction with modeling team to help validate models

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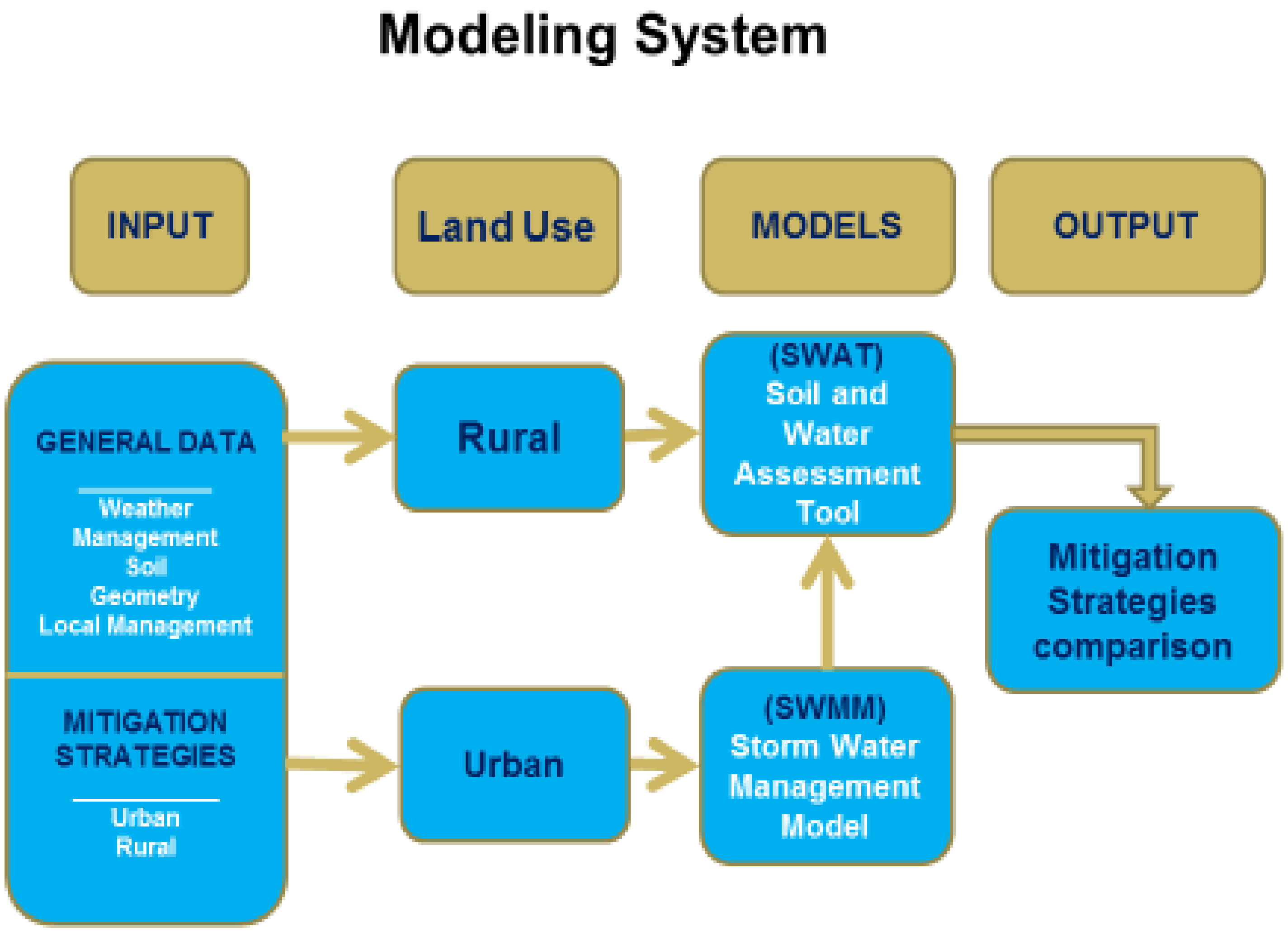
Modeling

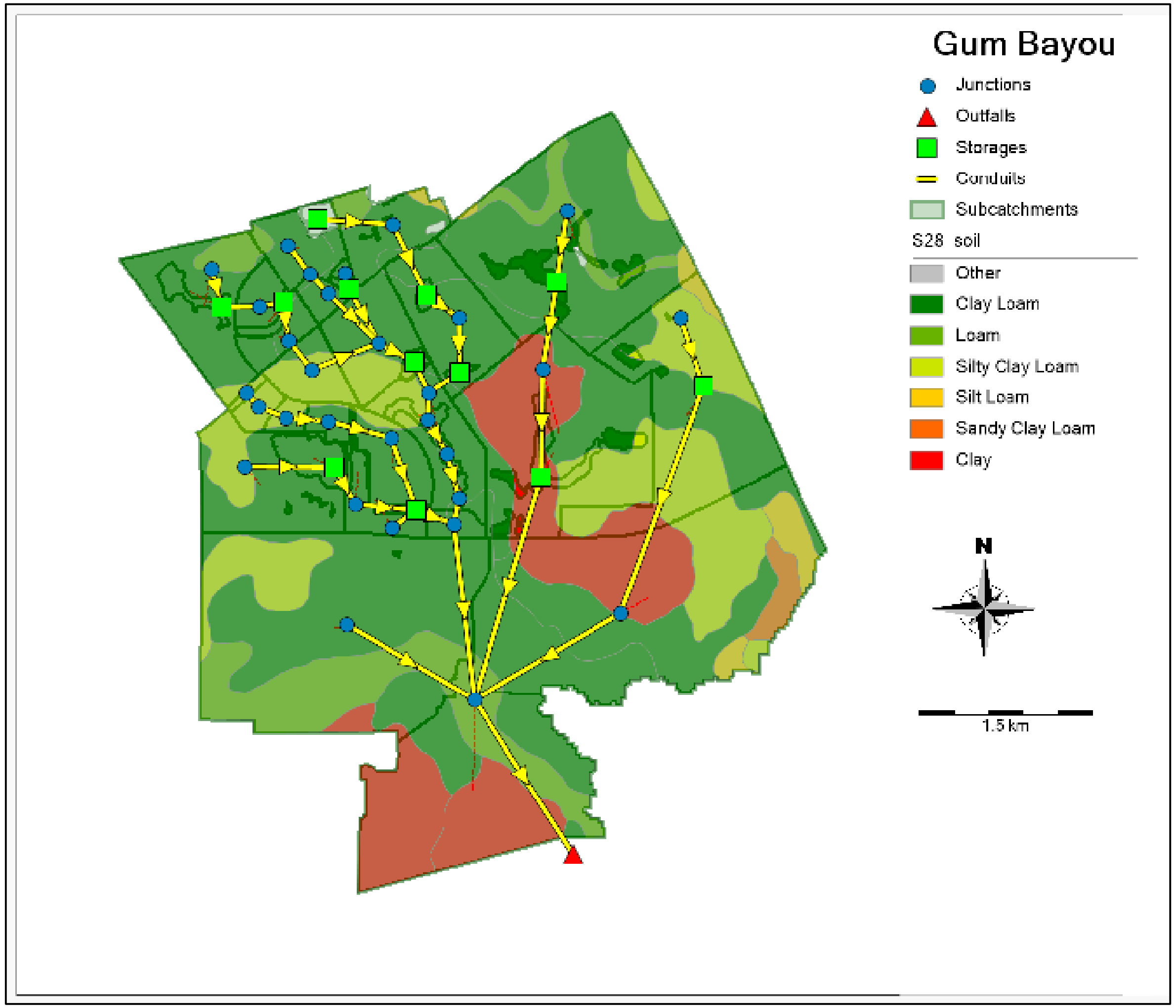
TIAER'S Modeling System for DBW



- Rural- Soil and Water Assessment Tool (SWAT)
- Urban- Personal Computer Storm Water Management Model (PCSWMM)
- Model Integration- SWAT&PCSWMM

Procedure for Modeling (SWAT & PCSWMM)

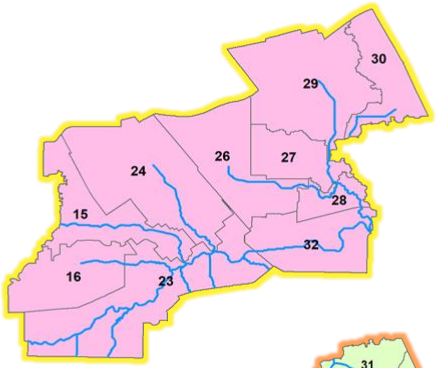
- Data collection and preparation
- Model set up
- Calibration and validation
- Mitigation strategies



Model Set up

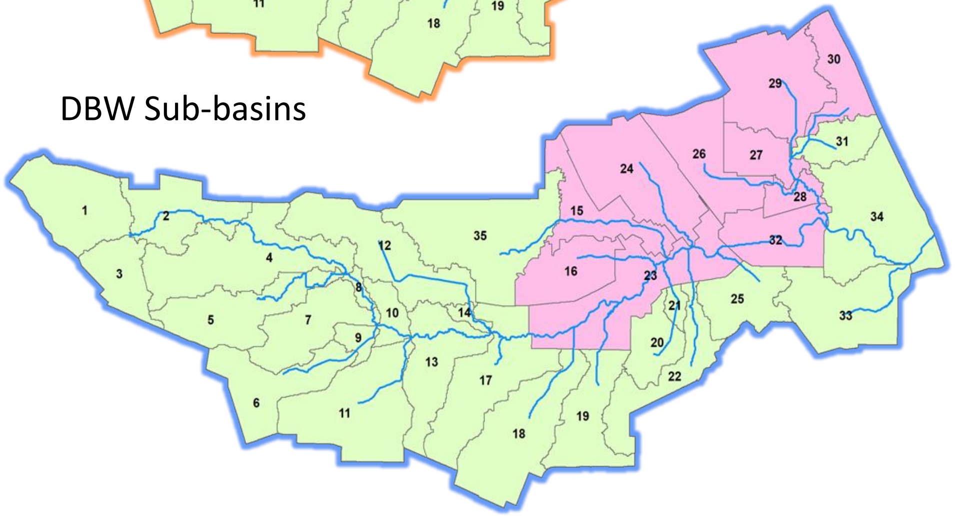
- Delineated the DBW into urban and rural sub-basins based on the predominant land use
- All together, we have 35 sub-basins
  - 25 Rural
  - 10 urban.
- Rural watersheds: SWAT
- Urban watersheds: PCSWMM&SWAT

DBW Urban Sub-basins



DBW Rural Sub-basins

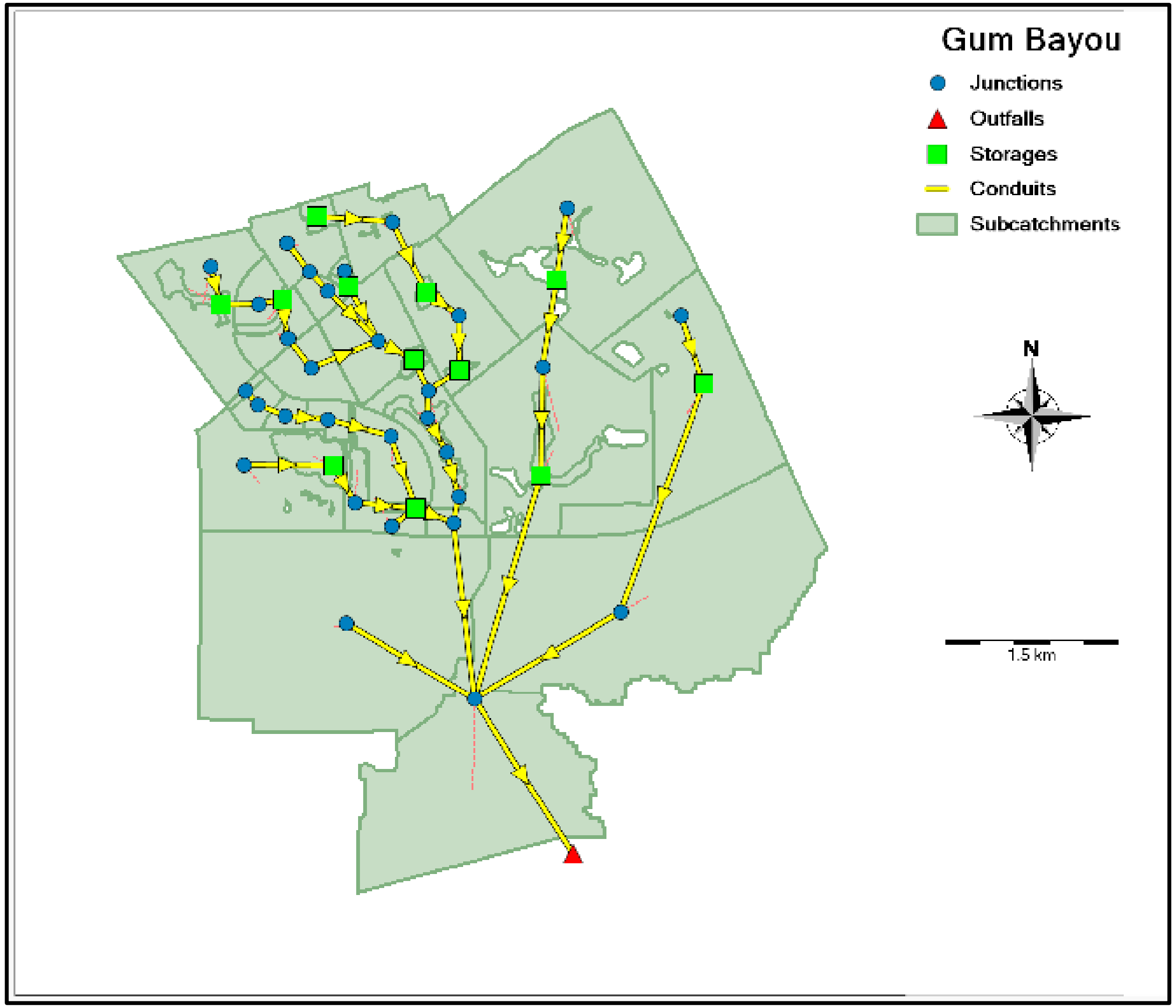
DBW Sub-basins



Urban Modeling Procedure-PCSWMM

- Set up watershed model for Gum Bayou in PCSWMM

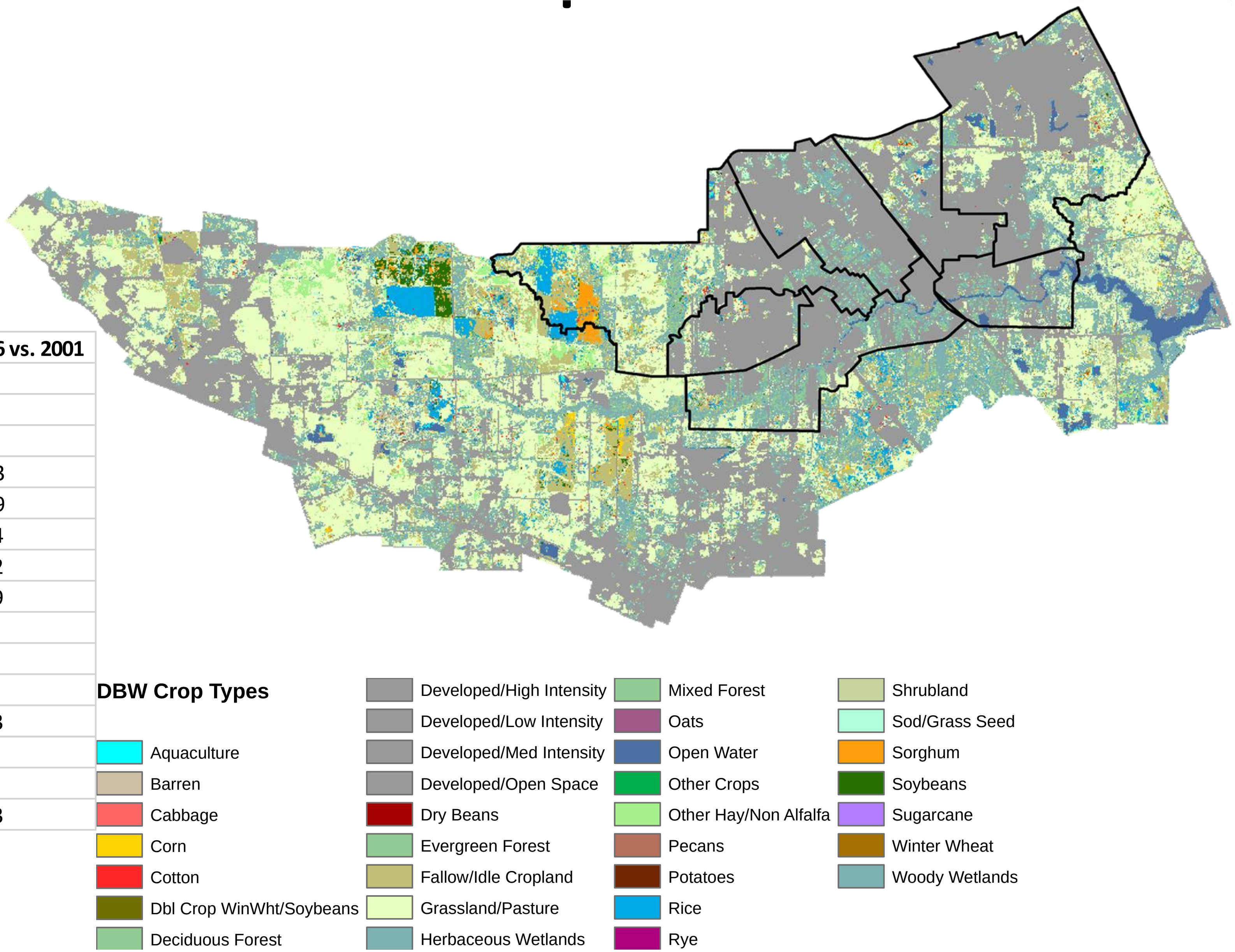
- Set up pollutant model for Gum Bayou in PCSWMM
- Currently working on validating urban model for Gum Bayou
- Output result will be fed into SWAT



Data Collection and Preparation

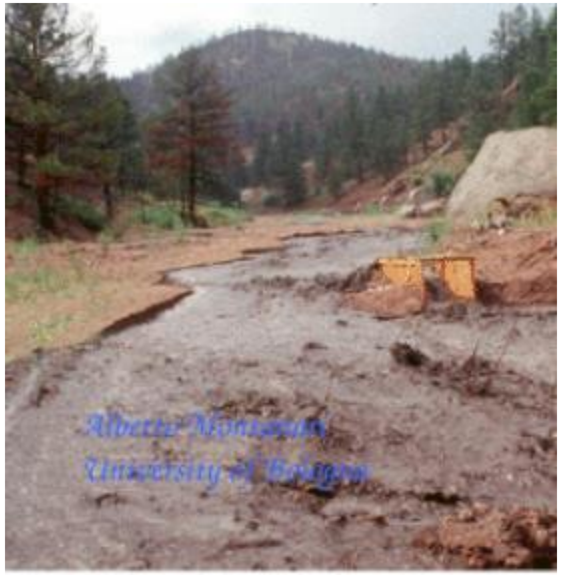
Land use change (2001-2016)

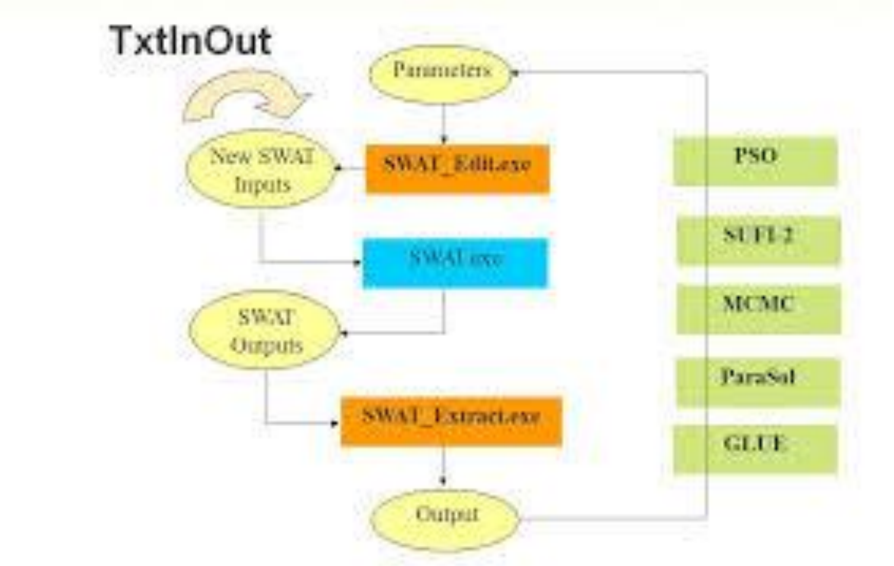
Land use Category	Change Indicator	% change 2016 vs. 2001
Open Water	↑	19.3
Developed, Open Space	↑	14.8
Developed, Low Intensity	↑	34.8
Developed, Medium Intensity	↑	132.3
Developed, High Intensity	↑	123.9
Barren Land	↓	-20.4
Deciduous Forest	↓	-41.2
Evergreen Forest	↓	-22.9
Mixed Forest	↓	-8.9
Shrub/Scrub	↑	9.7
Herbeceous	↓	-0.1
Hay/Pasture	↓	-25.3
Cultivated Crops	↓	-0.1
Woody Wetlands	↓	-8.9
Emergent Herbaceous Wetlands	↓	-23.3

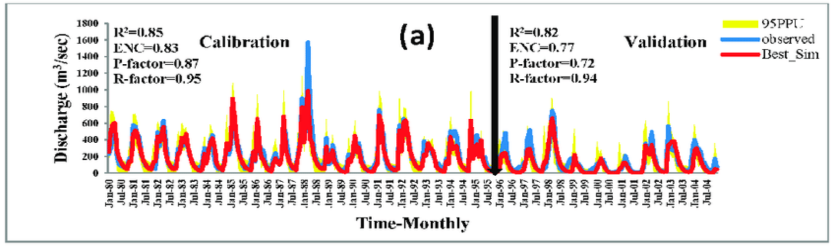


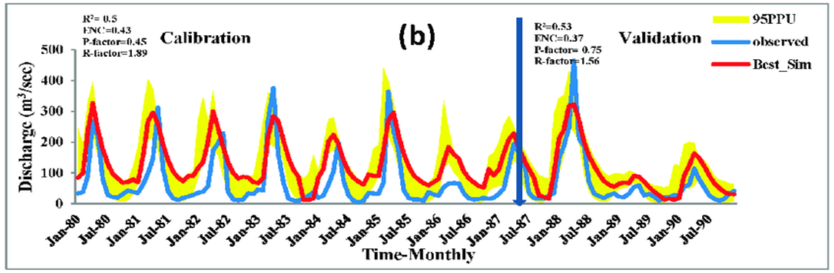
Model Calibration and Validation

- Calibration of PCSWMM model for runoff and contaminants
- Validation of PCSWMM model for runoff and contaminants
- Calibration of SWAT model for flow and contaminants
- Validation of SWAT model for flow and contaminants









Source: https://cupdf.com/document/model-calibration-and-validation.html
https://swat.tamu.edu/media/114860/usermanual_swatcup.pdf
https://www.researchgate.net/figure/a-Calibration-and-validation-of-the-SWAT-model-at-monthly-scale-at-Dokan-station-in_fig3_328719452

Proposed Mitigation Strategies for Rural Sub-basins

- Cropland Conversion to Pasture
- Nutrient Management
- Incorporate Manure with Tillage
- No Till
- Pet Waste Management
- Resource Efficient Landscaping- Ornamental
- Resource Efficient Landscaping- Trees
- Resource Efficient Landscaping- Turfgrass
- Vegetation
- Reservoirs, wetland, and ponds
- Cover crops
- Filter strips, waterways, and forest buffers

Source: https://mrbdc.mnsu.edu/sites/mrbdc.mnsu.edu/files/public/org/lakecrystal/bmp_rural.html
https://agfaxweedsolutions.com/2017/01/27/texas-cotton-best-management-practices-auxin-tolerant-crop-tech/
https://releeconservation.com/bmps/

Proposed Mitigation Strategies for Channels

- Stream Stabilization
- Channel Protection
- Riparian Forest Buffer
- Mulching
- Stream Restoration

Source: https://agbmps.osu.edu/bmp/open-channeltwo-stage-ditch-nrcs-582
https://www.semswa.org/education-outreach/water-quality-1/types-of-water-quality-bmps/
https://www.lucasswcd.org/ag-best-management-practices.html
https://www.researchgate.net/figure/BMPs-in-the-Lake-Soyang-basin-a-multistage-sedimentation-basin-b-gabion-wall-c_fig2_320360121

Proposed Mitigation Strategies for Urban Sub-basins

- Check Dam
- Diversion Dike
- Filter Strips
- Grade Stabilization Structure
- Grassed Waterway
- Green Roofs
- Interceptor Swale/Rain Garden
- Pipe Slope Drain
- Porous Pavement
- Porous Pavement with Grass
- Sediment Basin
- Silt Fence
- Stone Outlet Sediment Trap
- Terrace
- Triangular Sediment Dike
- Wetland Creation

Source: https://mrbdc.mnsu.edu/sites/mrbdc.mnsu.edu/files/public/org/lakecrystal/bmp_rural.html
https://chesapeakestormwater.net/the-bubbas/2019-bubbas/2019-best-ultra-urban-bmp/
https://watermotion.com/green-roofs-as-a-stormwater-best-management-practice/
https://www.purdue.edu/fnr/extension/urban-best-management-low-impact-development-practices/