Horse Creek Stewardship Program
2018 Annual Report Summary

FLATWOODS
Consulting Group

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Overview

Created to ensure that Mosaic's mining activities do not adversely affect Horse Creek, Peace River, or Charlotte Harbor

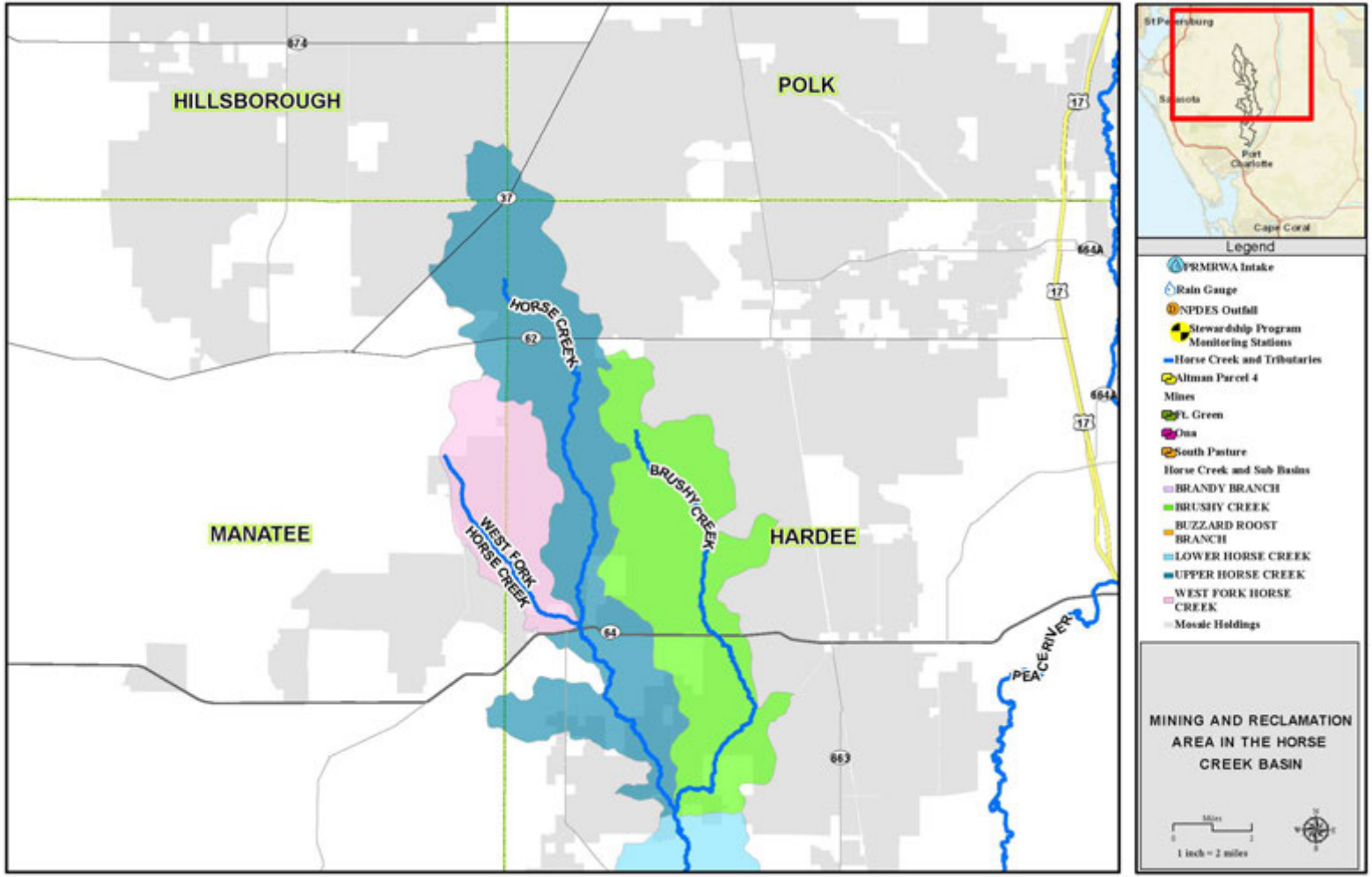
The three components of the plan are:

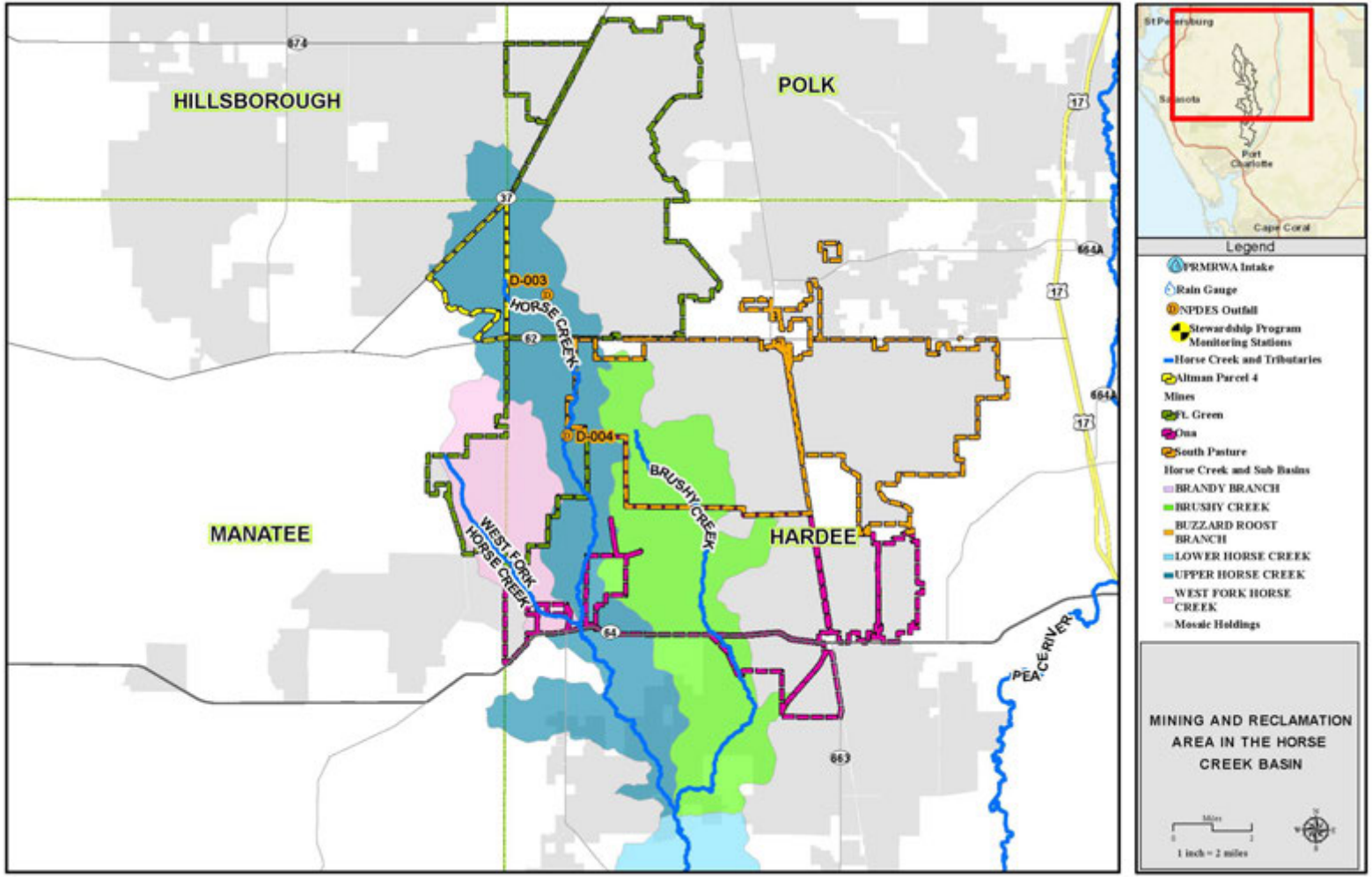
- Monitoring and reporting on stream quality
- Investigating adverse conditions or significant trends
- Implementing corrective action for adverse changes to Horse Creek caused by Mosaic's mining activities

2018 Annual Report Summary

- Project Methods
- Mining and Reclamation
- Summary of Sampling Conditions
- Results and Conclusions: Biology
- Results and Conclusions: Water Quantity
- Results and Conclusions: Water Quality
- Summary of 2018 TDS, Sulfate, and Calcium Impact Assessment

Methods


HILLSBOROUGH
POLK
MANATEE
HARDEE
HORSE CREEK
WEST FORK HORSE CREEK
BRUSHY CREEK
PEACE RIVER
Legend
PRMRWA Intake
Rain Gauge
NPDES Outfall
Stewardship Program Monitoring Stations
Horse Creek and Tributaries
Altman Parcel 4
Mines
FL Green
Ona
South Pasture
Horse Creek and Sub Basins
BRANDY BRANCH
BRUSHY CREEK
BUZZARD ROOST BRANCH
LOWER HORSE CREEK
UPPER HORSE CREEK
WEST FORK HORSE CREEK
Mosaic Holdings
MINING AND RECLAMATION AREA IN THE HORSE CREEK BASIN
1 inch = 2 miles


HILLSBOROUGH
POLK
MANATEE
HARDEE
D-003
D-004
HORSE CREEK
BRUSHY CREEK
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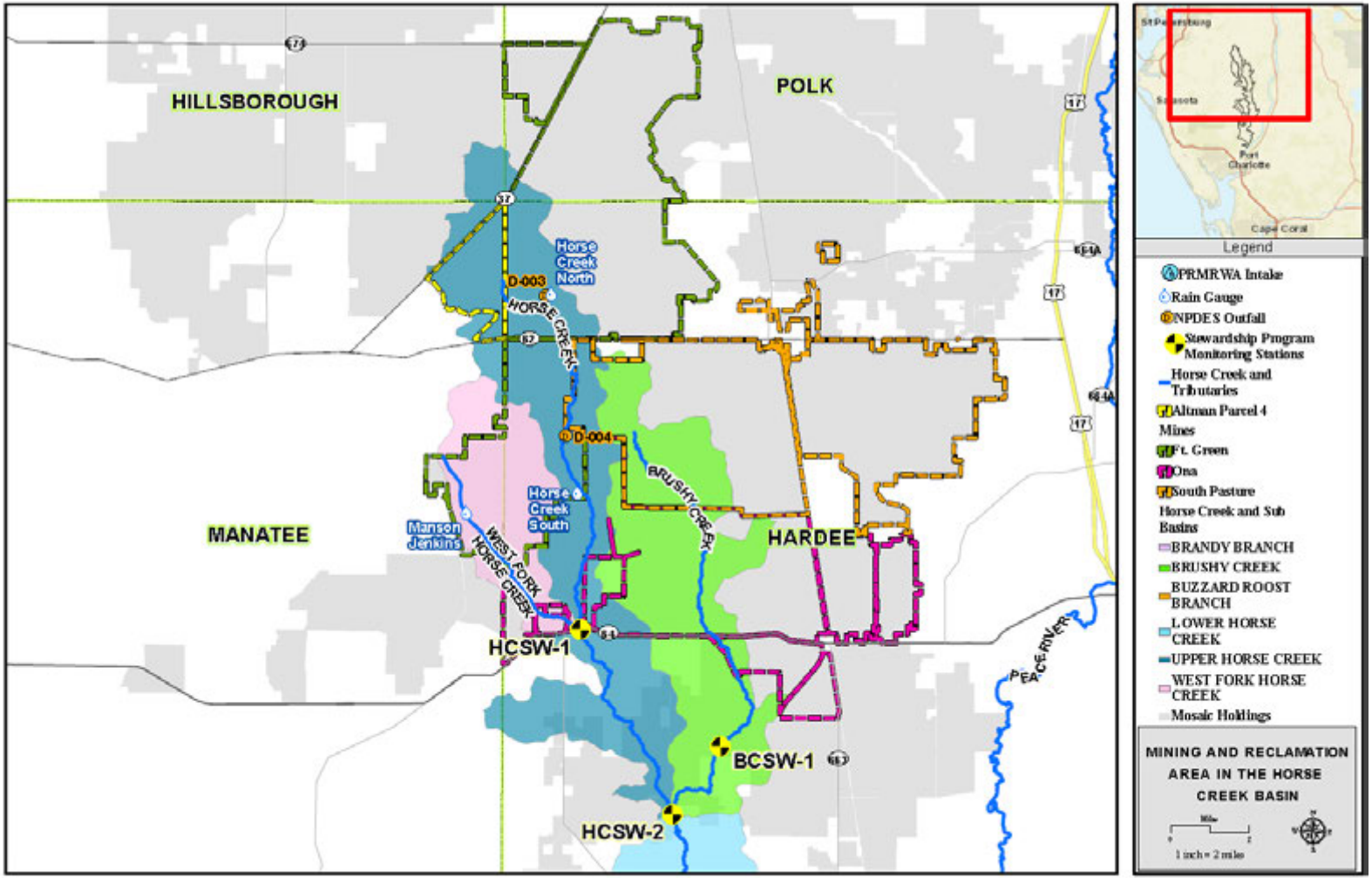
HILLSBOROUGH
POLK
MANATEE
HARDEE
Horse Creek North
D-003
HORSE CREEK
D-004
Horse Creek South
Manson Jenkins
WEST FORK HORSE CREEK
BRUSHY CREEK
HCSW-1
BCSW-1
HCSW-2
PEACE RIVER
Legend
PRMRWA Intake
Rain Gauge
NPDES Outfall
Stewardship Program Monitoring Stations
Horse Creek and Tributaries
Altman Parcel 4
Mines
Ft. Green
Ona
South Pasture
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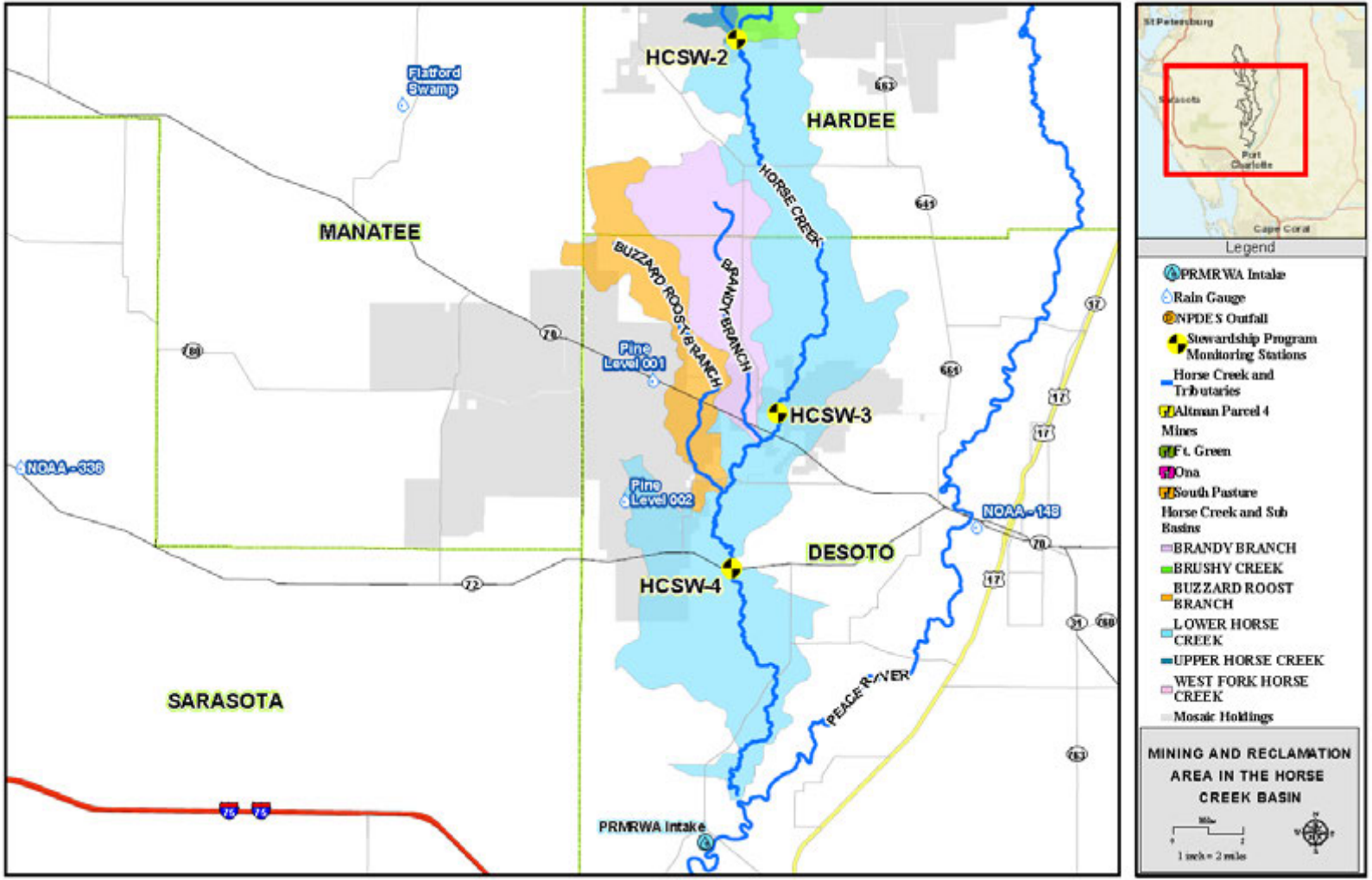
HCSW-2
HARDEE
Flatford Swamp
MANATEE
HORSE CREEK
BUZZARD ROOST BRANCH
BRANDY BRANCH
Pine Level 001
HCSW-3
NOAA - 338
Pine Level 002
NOAA - 148
DESOTO
HCSW-4
SARASOTA
PEACE RIVER
PRMRWA Intake
St Petersburg
Sarasota
Port Charlotte
Cape Coral
Legend
PRMRWA Intake
Rain Gauge
NPDES Outfall
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Water Quantity

Stream Level

- Monthly staff gauge readings at four Horse Creek stations

Discharge

- USGS daily streamflow at HCSW-1 and HCSW-4
- Continuous Mosaic NPDES discharge

Rainfall

- NOAA daily rainfall at Myakka River State Park and Arcadia
- SWFWMD Flatford Swamp daily rainfall
- Mosaic daily rainfall at three upper Horse Creek Basin gauges
- Horse Creek North
- Horse Creek South
- Manson Jenkins

Water Quality

Monthly sampling by Mosaic at four stations

- Stream Conditions
- Field Measurements: Water temperature, pH, dissolved oxygen, specific conductivity, and turbidity
- Lab Analysis of 16 parameters including nutrients, minerals, and mining reagents

Continuous (15-min intervals) sampling by Mosaic at HCSW-1

- pH, dissolved oxygen, specific conductivity, temperature, and turbidity

Additional sampling coincident with biological sampling

- Field parameters of temperature, pH, dissolved oxygen, specific conductivity, and turbidity

Trigger Levels

Pollutant Category	Analytical Parameters	Reporting Units	Trigger Level
General Physio-chemical Indicators	pH	Std. Units	<6.0->8.5
	Dissolved Oxygen Saturation	%	<38% daily average
	Turbidity	NTU	>29
	Color	PCU	<25
Nutrients	Total Nitrogen	mg/L	>3.0
	Total Ammonia	mg/L	>0.3
	Ortho Phosphate	mg/L	>2.5
	Chlorophyll-*a*	mg/L	>15
Dissolved Minerals	Specific Conductance	µS	>1,275
	Total Alkalinity	mg/L	>100
	Calcium	mg/L	>100
	Iron	mg/L	>0.3; >1.0
	Chloride	mg/L	>250
	Fluoride	mg/L	>1.5; >4
	Combined Radium ($^{226}Ra + ^{228}Ra$)	pCi/L	>5
	Sulfate	mg/L	>250
	Total Dissolved Solids	mg/L	>500
Mining Reagents	Petroleum Range Organics	mg/L	Discontinued
	Total Fatty Acids, Incl.Oleic, Linoleic, and Linolenic Acid	mg/L	
	Fatty Amido-Amines	mg/L	

Table 4-4

Biological Sampling

Benthic Macroinvertebrates:

- Stream Habitat Assessment
- Florida Stream Condition Index (SCI) 20 dip-net sweeps in 100m stream segment
- FDEP methodology (SCI-1000)
- Shannon-Wiener Diversity Index

Fish:

- Sampled with 4’ x 8’ seine and electrofishing
- Species richness
- Shannon-Wiener Diversity Index
- Morisita’s Community Similarity Index
- Species Accumulation Curve

Impact Assessments

- Monthly water quality data are submitted to the PRMRWSA for review
- Measurements are compared to “trigger values” that are based on state water quality standards or historical ranges
  - If a parameter is above the trigger value, an impact assessment is completed by Mosaic
    - The impact assessment is accepted as sufficient evidence that the exceedance was not caused by mining
    - Or Mosaic provides additional data or completes other corrective actions
  - Impact Assessments have been requested for several parameters
- 2018 Impact Assessment
  - Part 1: Historical analysis of TDS, calcium, and sulfate
  - Part 2: TDS, calcium, and sulfate in unmined Peace River tributaries. Spring 2020.

Annual Reports

- Annual reports are submitted to the PRMRWSA and the TAG for review.
  - The TAG includes staff from several counties
  - Mosaic presents the results for water quantity, water quality, and biological data collected by the Program
  - The PRMRWSA and the TAG compile questions and comments that are incorporated into the final report draft
  - If any adverse long-term trends are identified in the report, Mosaic will conduct an impact assessment

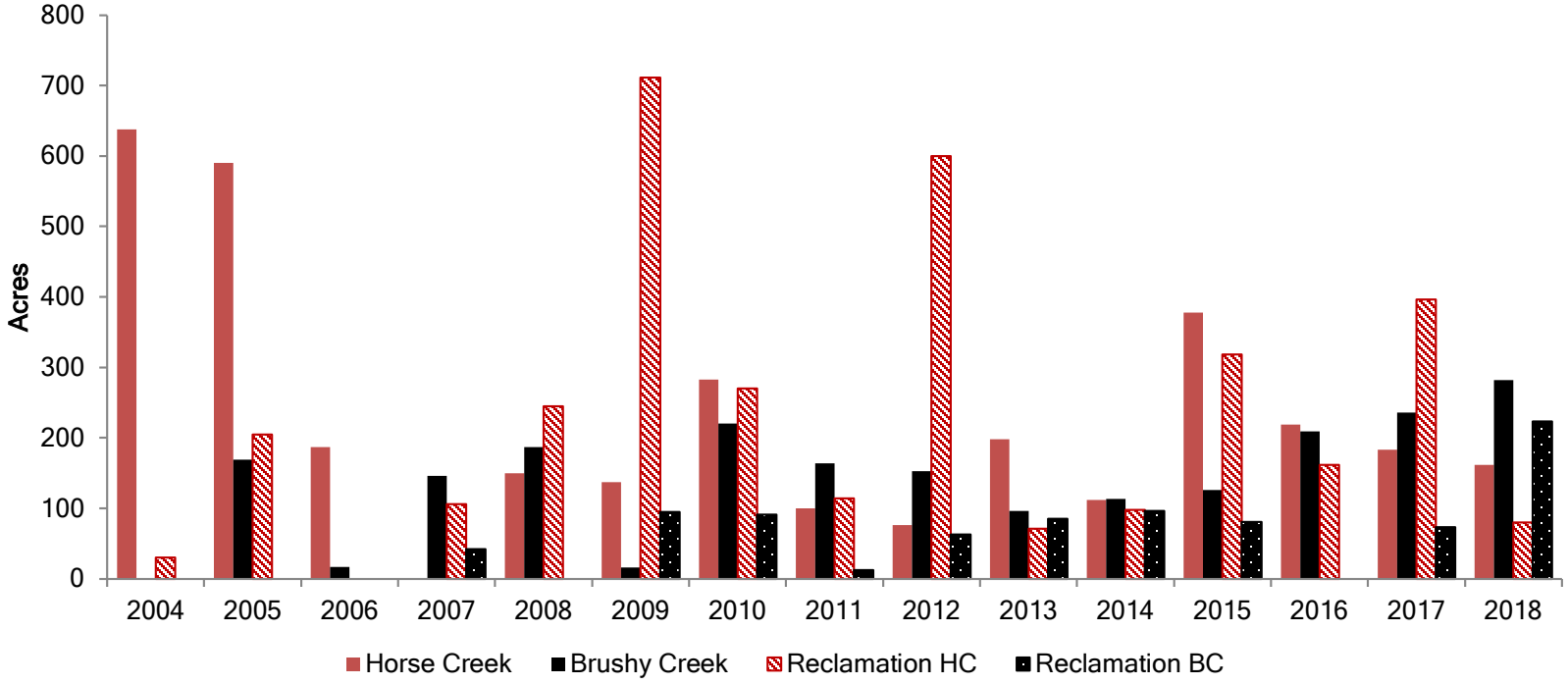
- Annual reports have been produced from 2003 to present.

- A historical report focusing on pre-2003 conditions was also prepared.

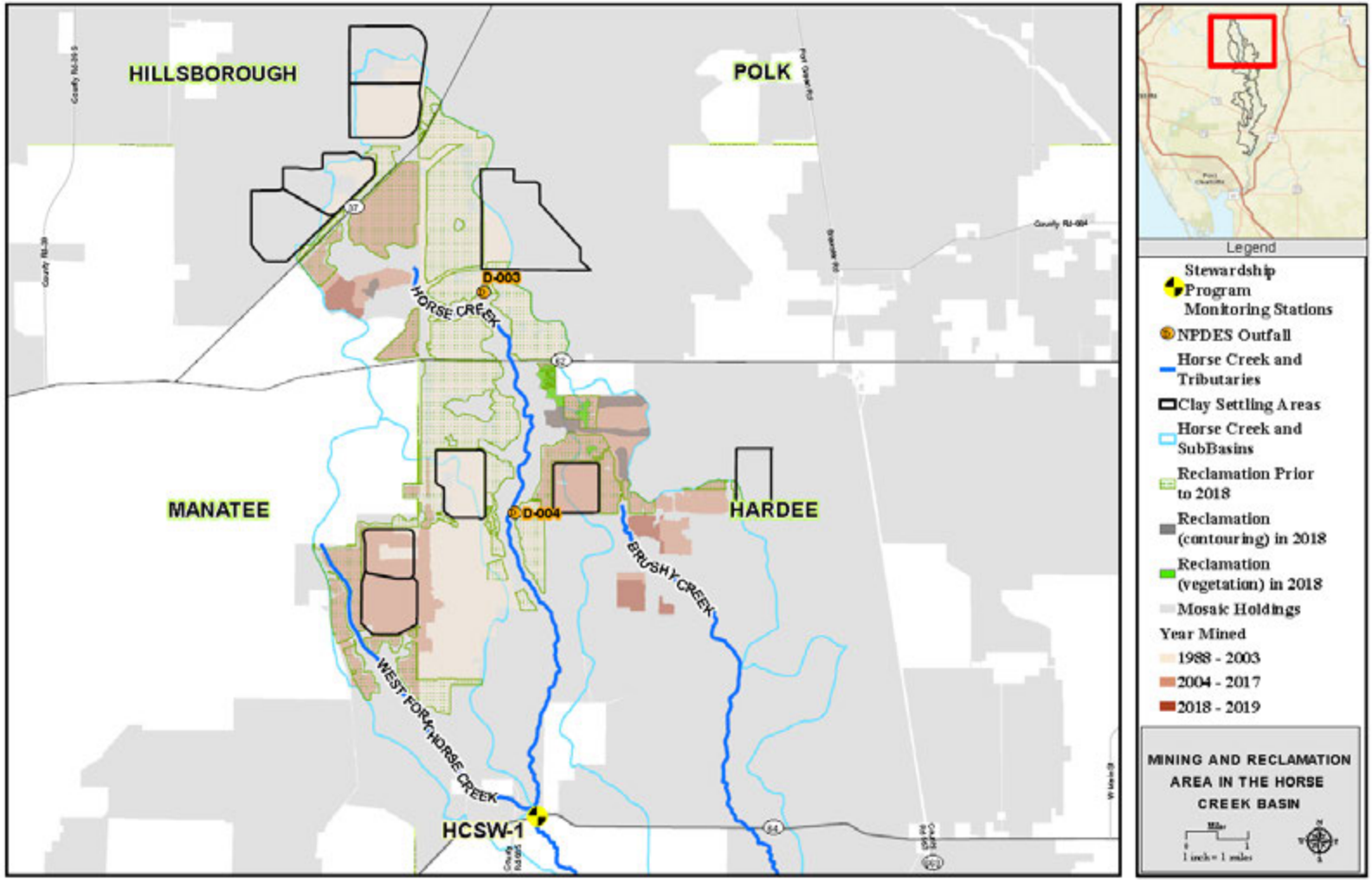
Mining and Reclamation Activities

Used with permission from Matthew Smith, MAS photoART

Mining and Reclamation Activities



Adapted from Table 3-1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HCSW-1
Legend
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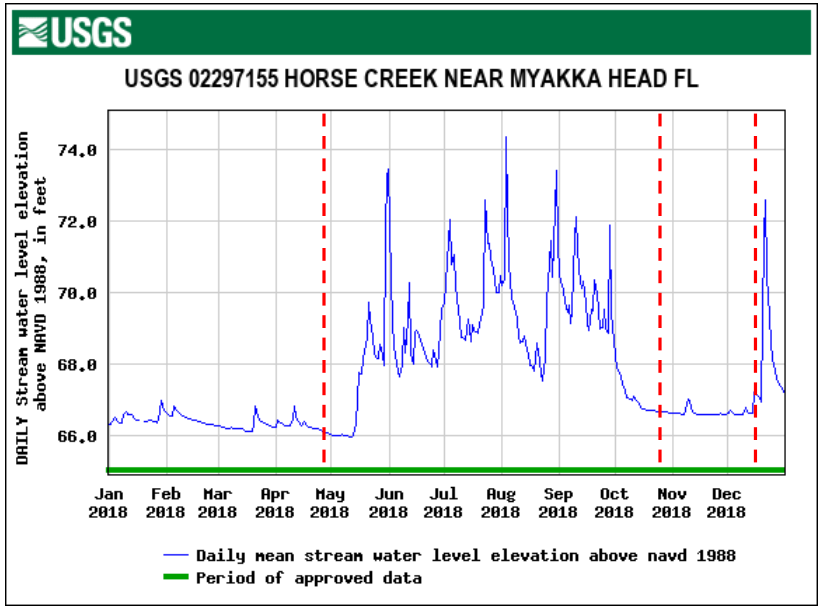
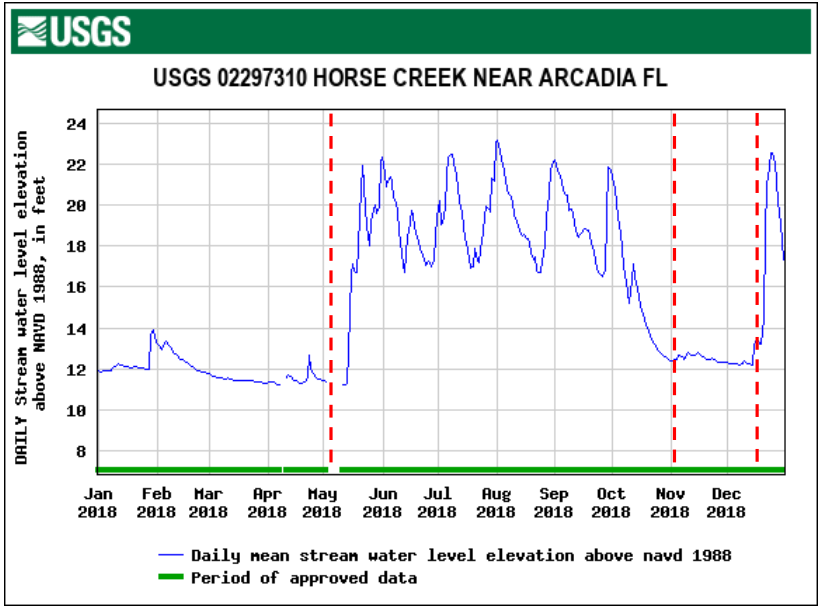
NPDES Outfall
Horse Creek and Tributaries
Clay Settling Areas
Horse Creek and SubBasins
Reclamation Prior to 2018
Reclamation (contouring) in 2018
Reclamation (vegetation) in 2018
Mosaic Holdings
Year Mined
1988 - 2003
2004 - 2017
2018 - 2019
MINING AND RECLAMATION AREA IN THE HORSE CREEK BASIN
1 inch = 1 miles

Summary of Sampling Conditions

Sample Sites





USGS Surface-Water Daily Data for the Nation, U.S. Department of the Interior, waterdata.usgs.gov/nwis/dv?referred_module=sw.

Biological Sampling Summary

Month	Horse Creek Water Quality Sampling Events	Horse Creek Biology Sampling Events	Brushy Creek Water Quality Sampling Events
January	Sampled January 17 (No flow at HCSW-2)		No flow
February	Sampled February 7		Sampled
March	Sampled March 21 (No flow at HCSW-2)		Low flow
April	Sampled April 18 (No flow at HCSW-2)	Sampled April 30 HCSW-1, 3, & 4	Dry
May	Sampled May 24		Sampled
June	Sampled June 20		Sampled
July	Sampled July 11		No access
August	Sampled August 2		
September	Sampled September 6		No access
October	Sampled October 2	Sampled October 30 & 31*	Sampled October 2
November	Sampled November 8		No flow-not sampled
December	Sampled December 12	Sampled December 17 & 18	No flow-not sampled

*electrofishing conducted on December 4 due to equipment malfunction

Table 4-1

Habitat Assessment Scores

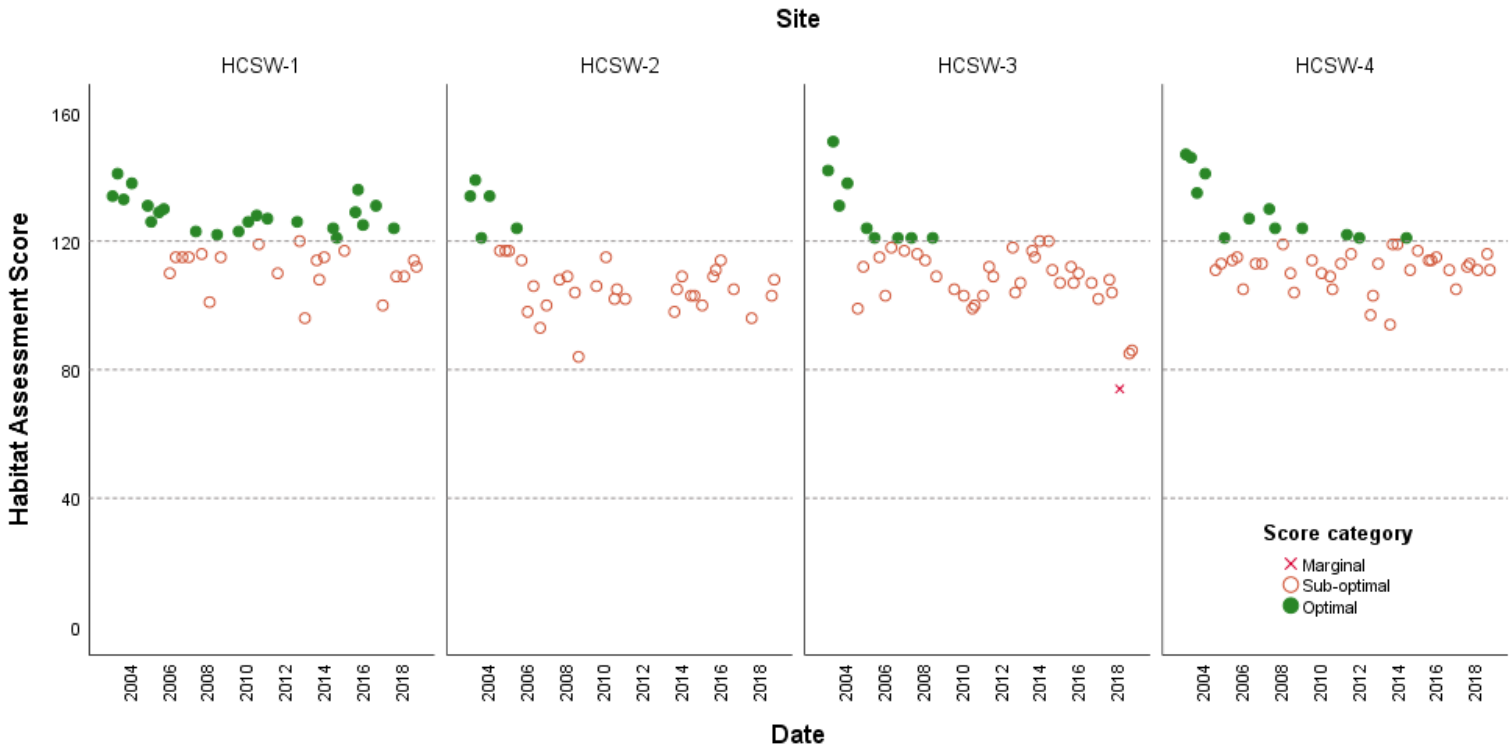


Figure 7-1

Artificial Channelization- 1940s vs. present

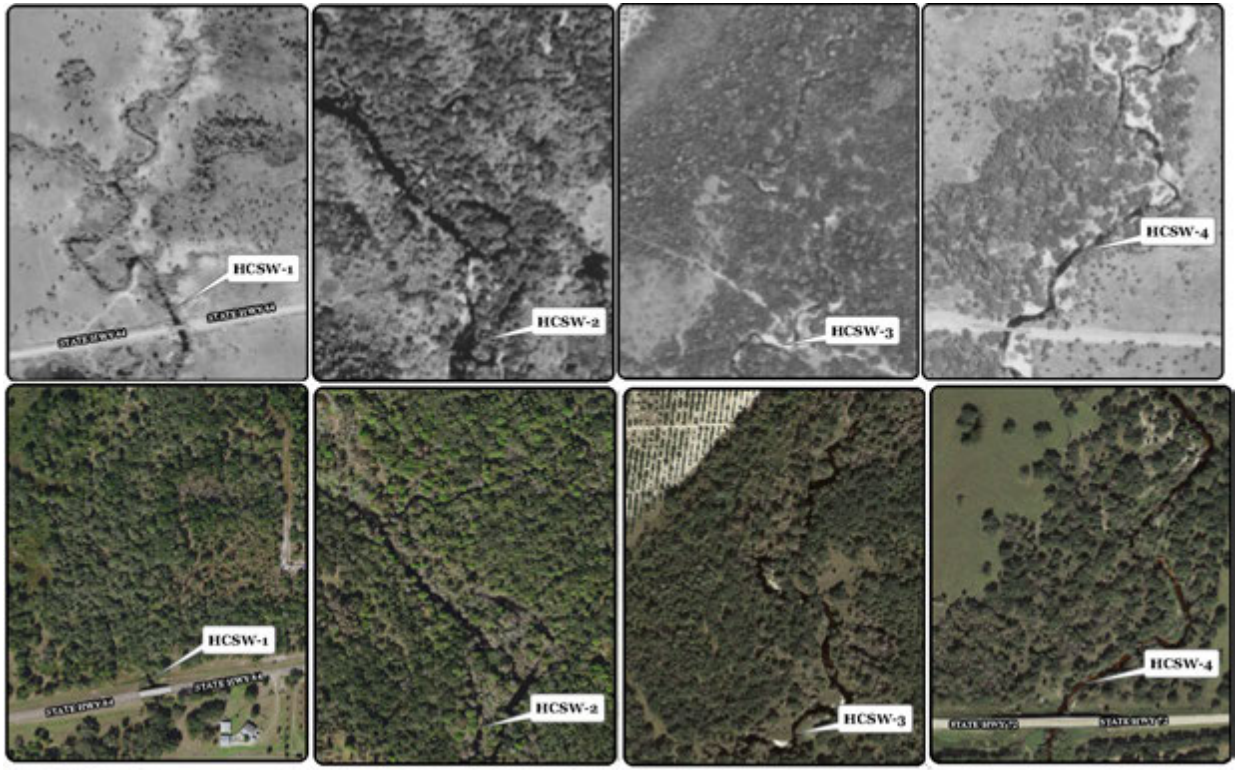


Figure 7-1

SCI Scores

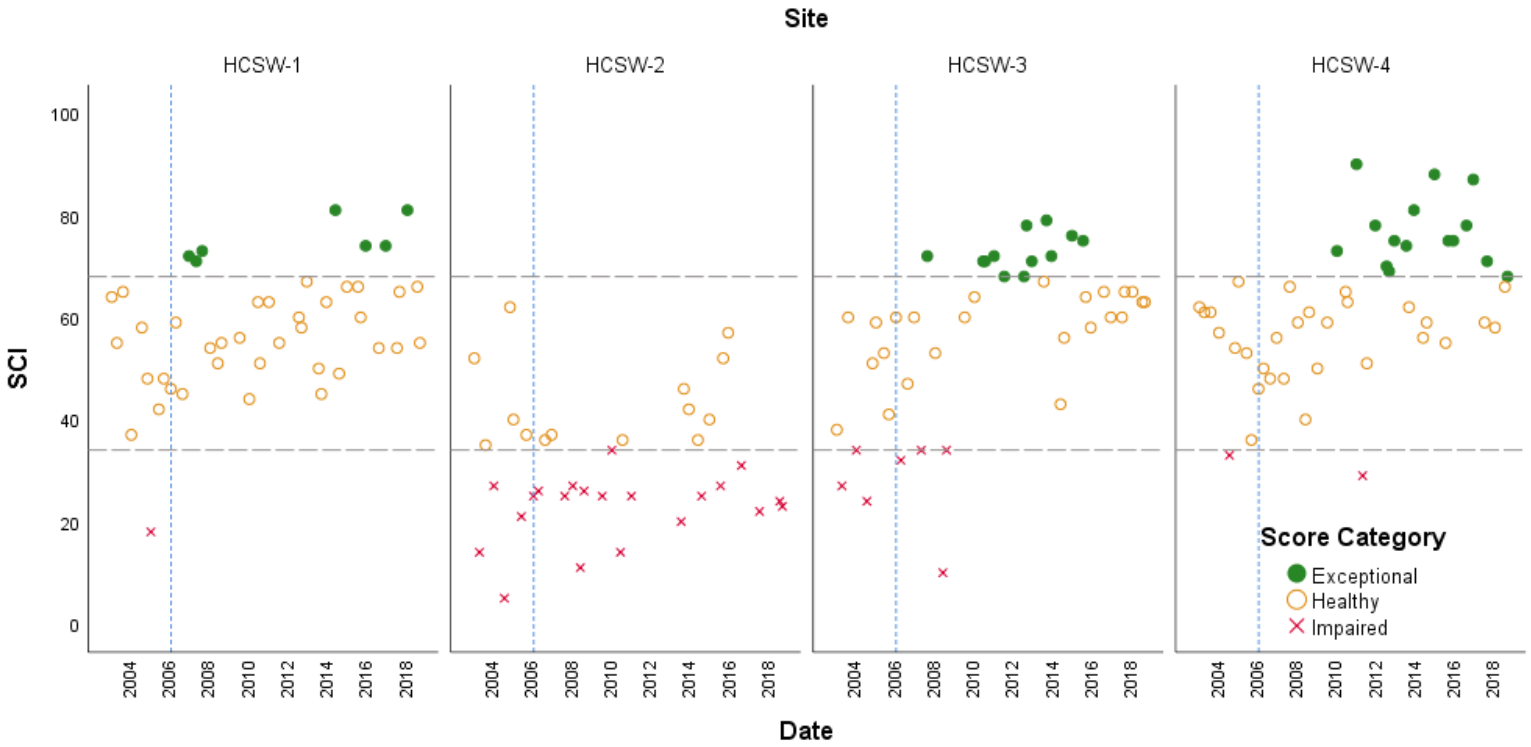


Figure 7-2

Macroinvertebrate Taxa Richness

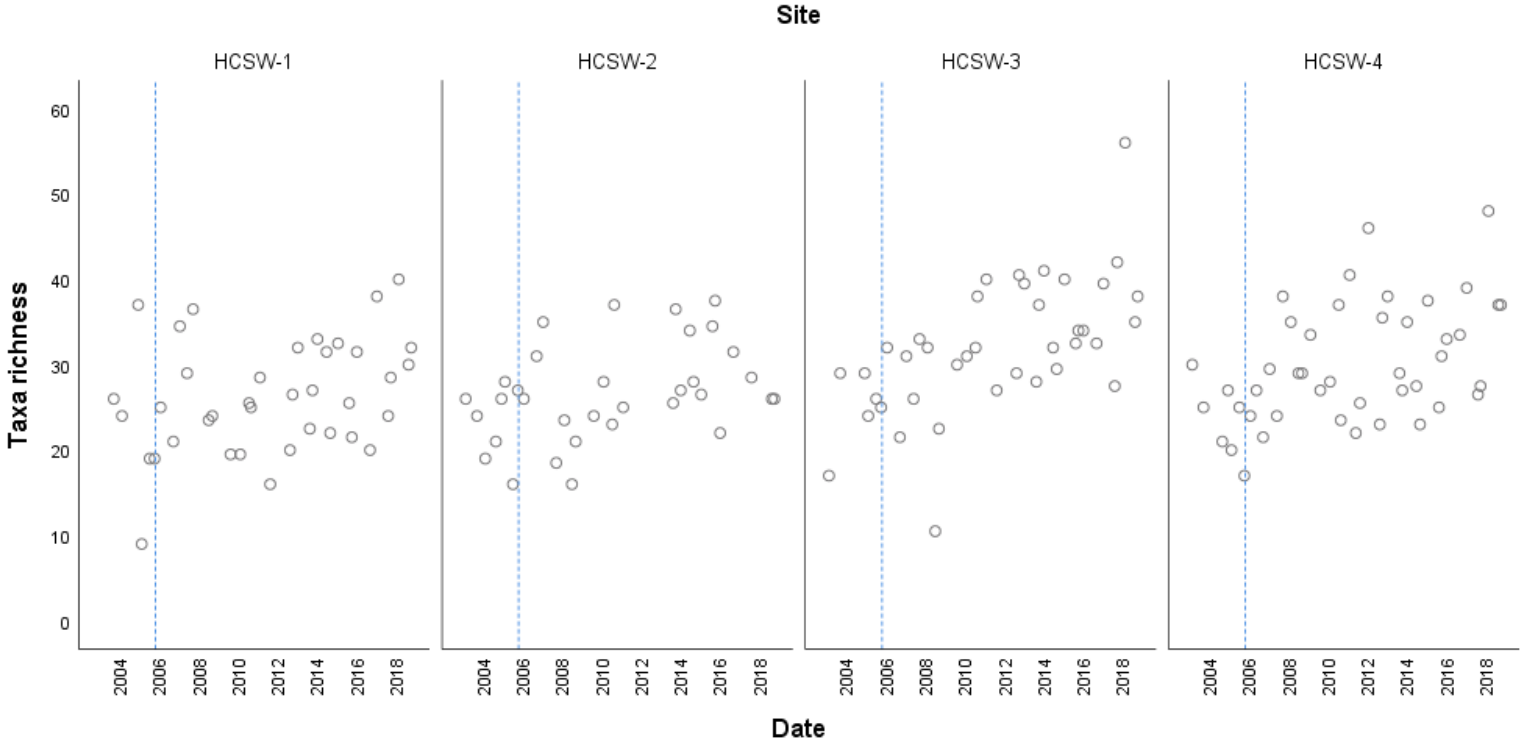


Figure 7-3

Macroinvertebrate Shannon-Wiener Diversity

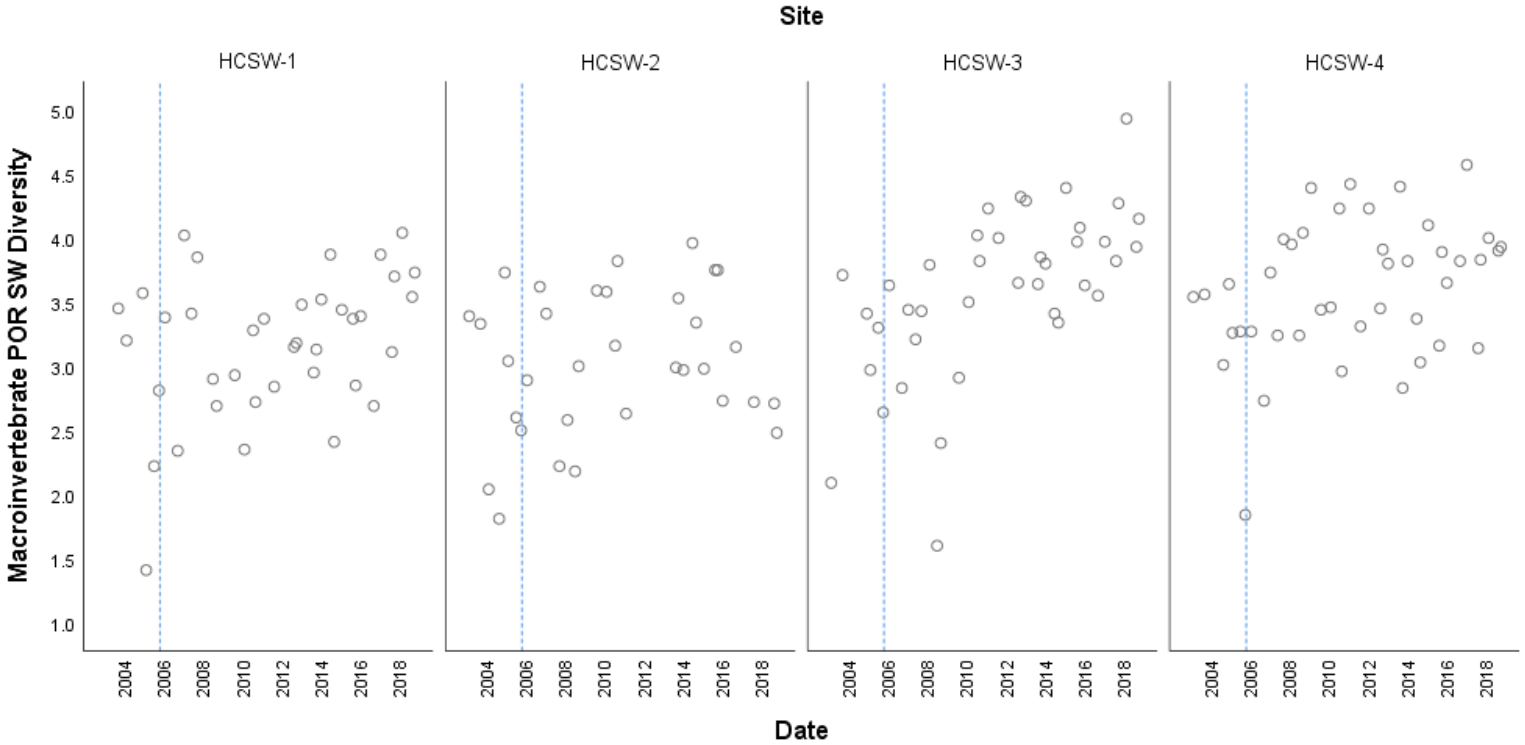


Figure 7-4

Macroinvertebrate Shannon-Wiener Diversity

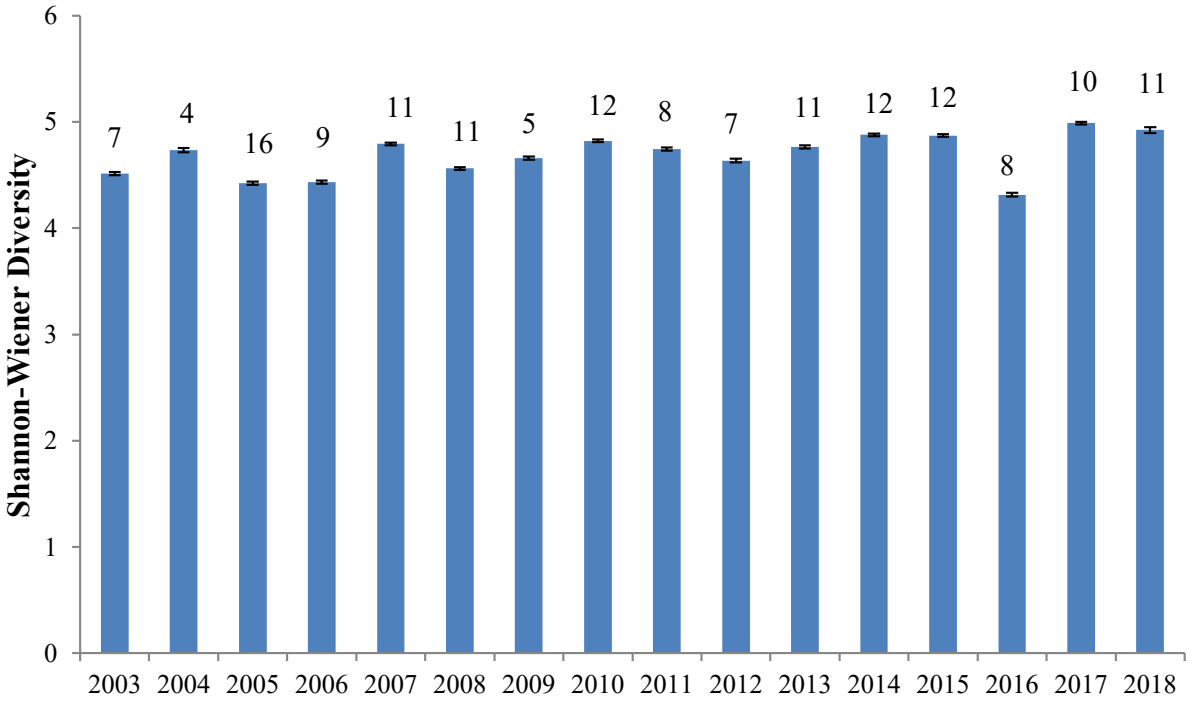


Figure 7-4

Macroinvertebrate Diversity

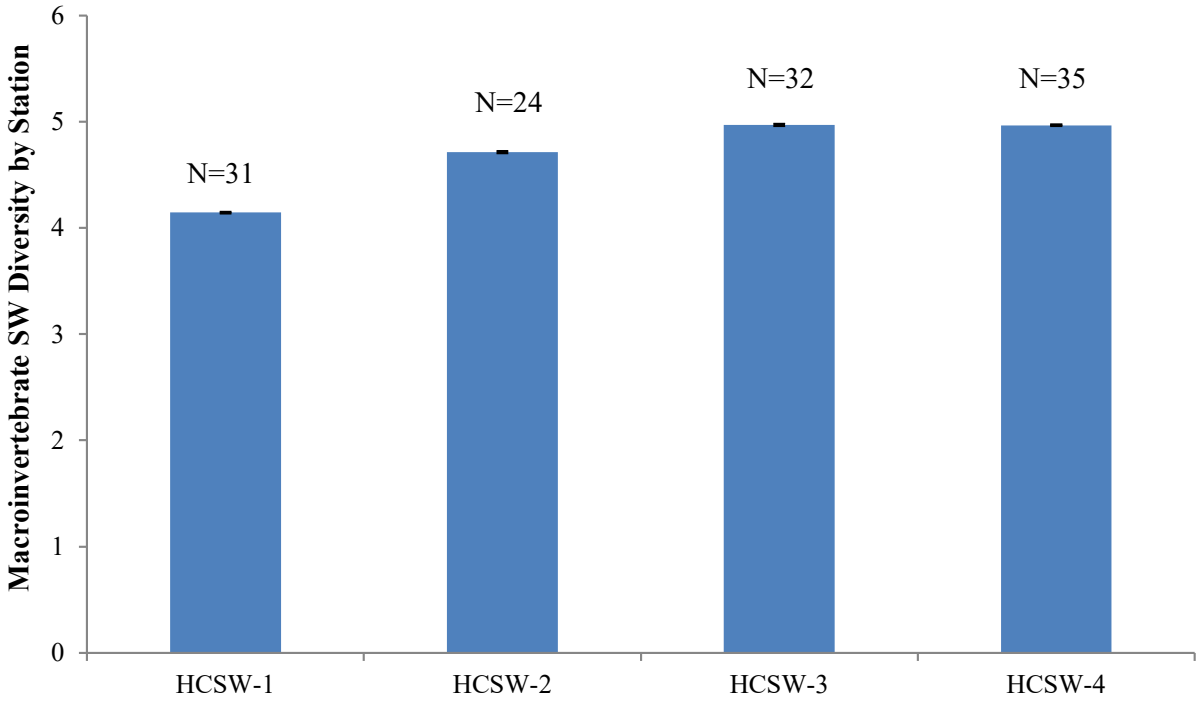


Figure 7-6

Macroinvertebrate Results - 2018

- Habitat Assessment
  - “Sub-optimal” at all sites except HCSW-3 in April which scored a “marginal”
  - Marginal score was primarily due to the lack of suitable productive habitat, water velocity, bank erosion, and riparian buffer quality
- Stream Condition Index
  - Scores at HCSW-1, HCSW-3, and HCSW-4 were in the “healthy” category (>35)
  - The April sample at HCSW-1 attained an “exceptional” score (>68)
  - Scores at HCSW-2 were “impaired” (<34)
    - Low score likely due to the site lacking streamflow and conditions conducive to keeping oxygen in the water to support macroinvertebrate populations
- Biological Diversity
  - Spring 2018 taxa richness was the highest recorded so far at HCSW-1, HCSW-3, & HCSW-4
  - Spring 2018 Shannon-Wiener diversity was the highest on record so far at HCSW-1 & HCSW-3

Macroinvertebrate Results POR

- Stream Condition Index
  - HCSW-1 is the only station with a detected trend in SCI scores for the period 2007-2018 (+2.33/year, Annual Kendall tau = 0.55, $p<0.05$)

- Shannon-Wiener Diversity
  - Overall diversity in 2018 across all four stations was the 2nd highest since 2003.

Fish

Fish Species Richness

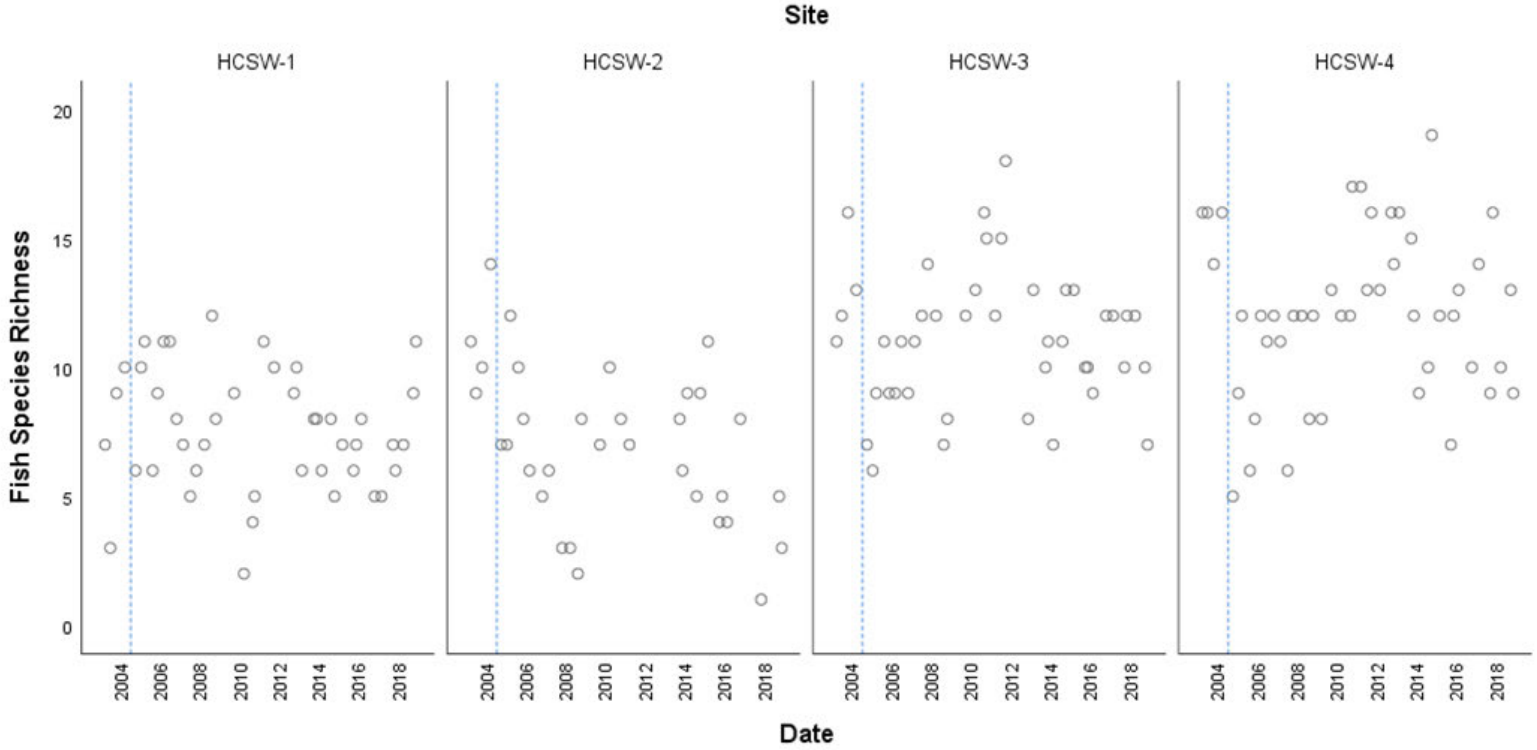


Figure 7-7

Shannon-Wiener Diversity

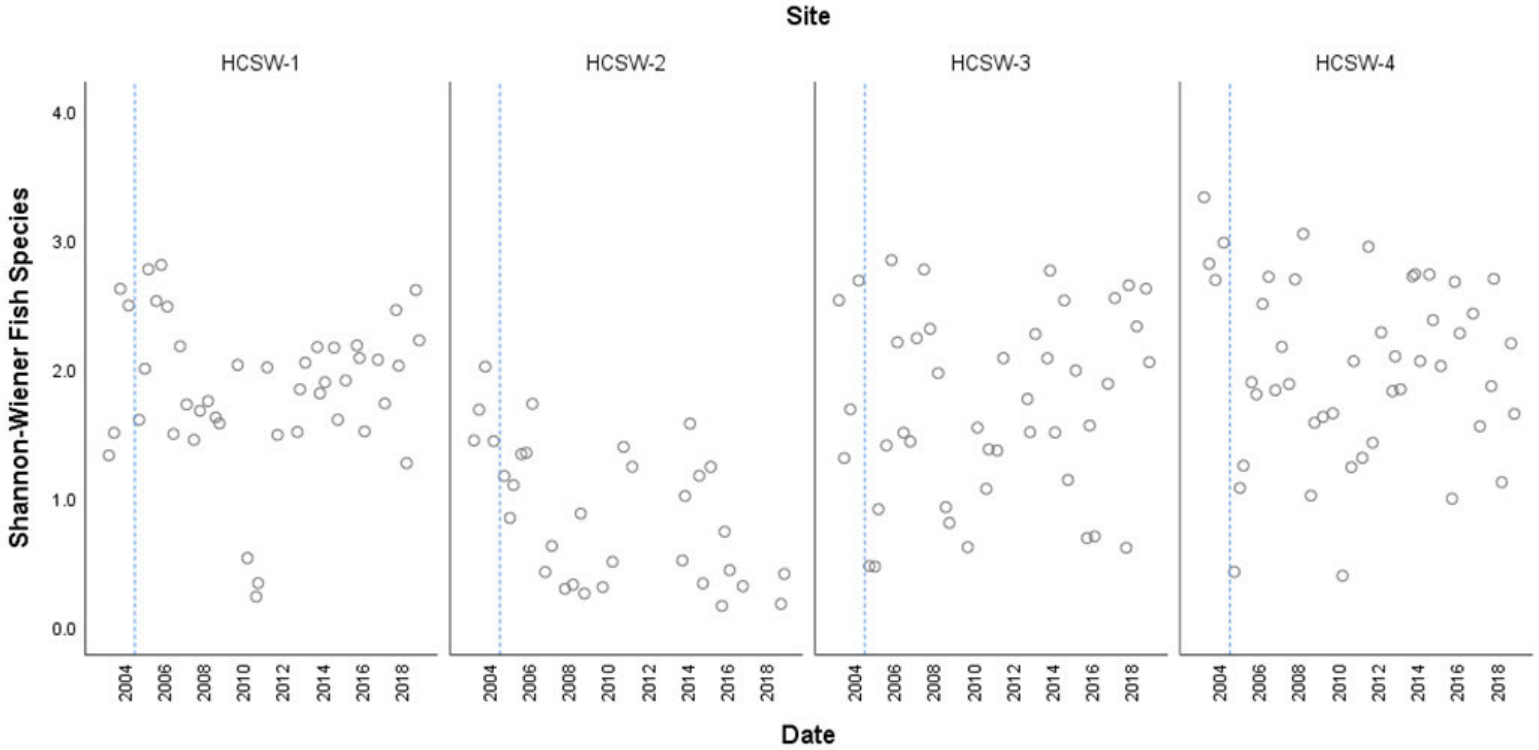


Figure 7-8

Fish Species Diversity – Stations by Year

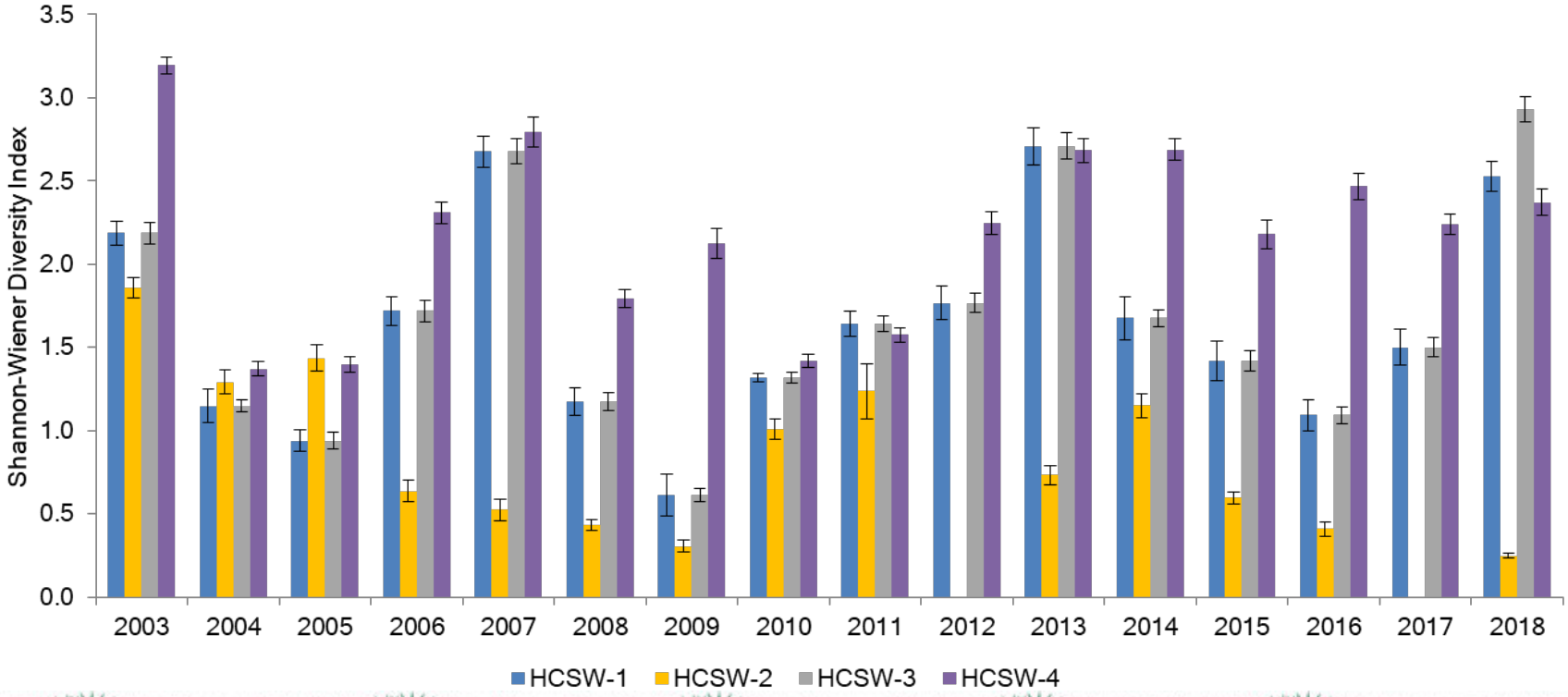


Figure 7-9

Fish Species Diversity – Years

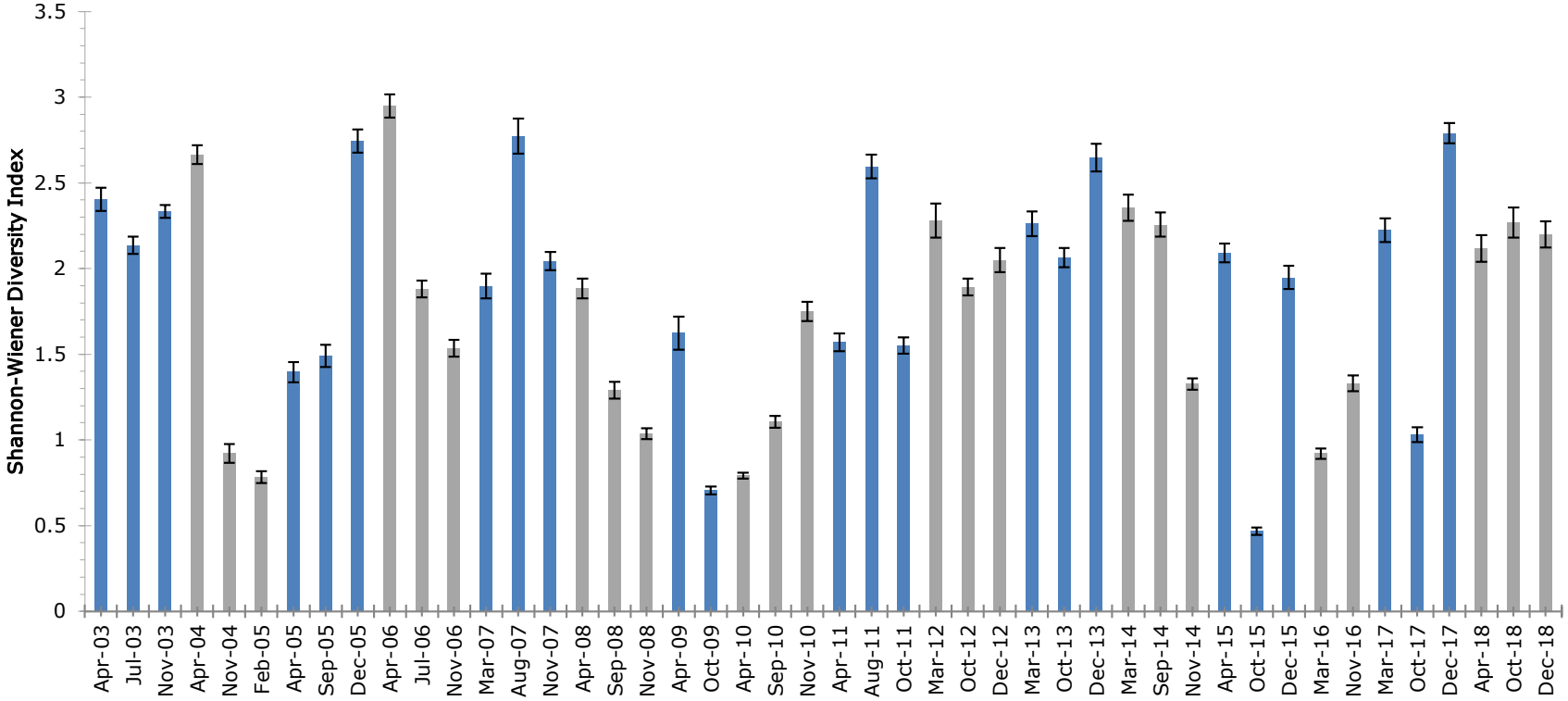


Figure 7-10

Fish Species Diversity – Years

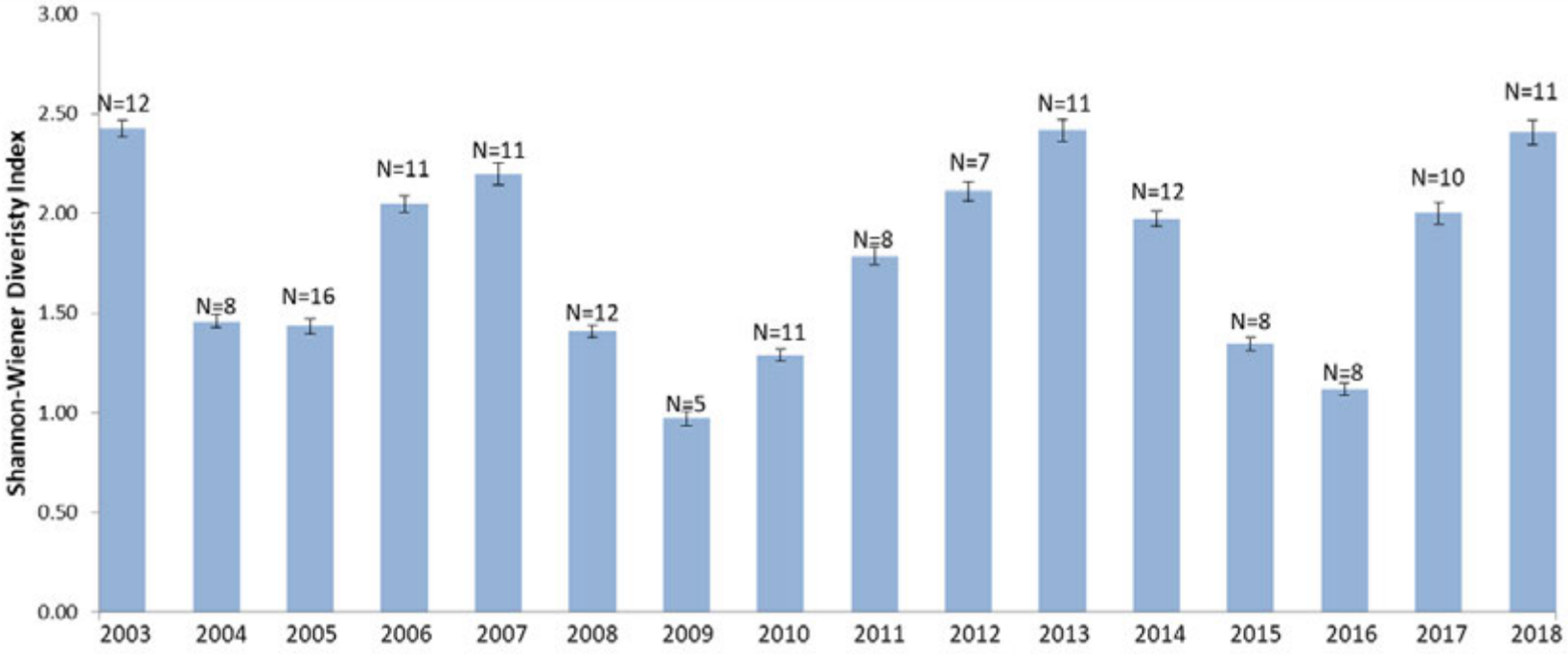


Figure 7-12

Fish Species Diversity – Stations

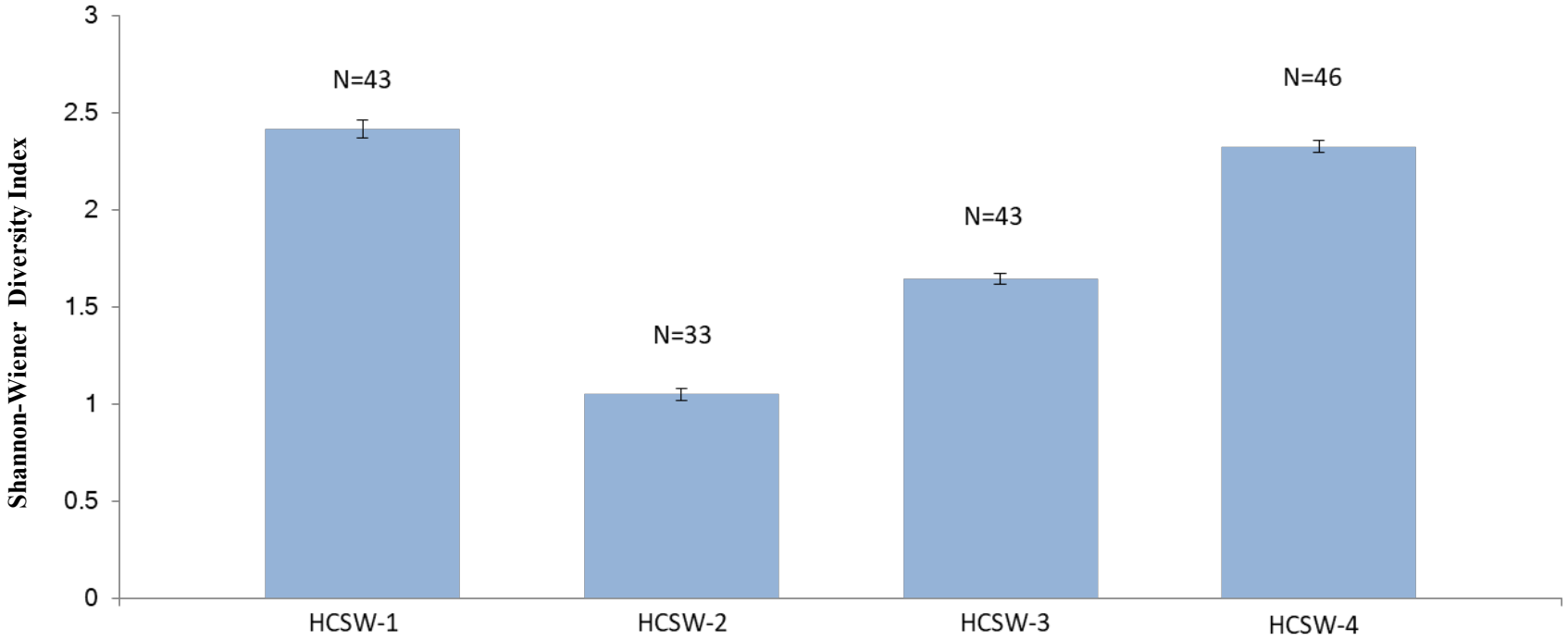


Figure 7-11

Fish Species– Morisita Diversity Index

	HCSW-1	HCSW-2	HCSW-3	HCSW-4
HCSW-1	1	0.80	0.84	0.93
HCSW-2		1	0.99	0.94
HCSW-3			1	0.97
HCSW-4				1

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
2003	1	0.96	0.96	0.99	0.99	0.96	0.92	0.94	0.98	0.98	0.97	0.99	0.95	0.93	0.96	0.96
2004		1	0.98	0.99	0.95	1	0.99	1	0.99	0.95	0.9	0.99	0.99	0.99	0.92	0.9
2005			1	0.98	0.94	0.97	0.94	0.97	0.99	0.94	0.88	0.98	0.96	0.96	0.89	0.88
2006				1	0.99	0.99	0.96	0.98	0.99	0.98	0.95	1	0.98	0.97	0.95	0.95
2007					1	0.96	0.93	0.94	0.97	0.99	0.98	0.99	0.95	0.93	0.98	0.97
2008						1	0.99	1	0.99	0.95	0.9	0.99	1	1	0.93	0.9
2009							1	1	0.96	0.93	0.87	0.97	0.99	1	0.91	0.88
2010								1	0.98	0.95	0.89	0.98	1	1	0.91	0.89
2011									1	0.96	0.92	0.99	0.98	0.97	0.93	0.92
2012										1	0.98	0.98	0.96	0.94	0.97	0.95
2013											1	0.95	0.91	0.88	0.97	0.96
2014												1	0.98	0.97	0.95	0.94
2015													1	1	0.92	0.9
2016														1	0.91	0.88
2017															1	0.97
2018																1

Table 7-4

Species Accumulation Curve

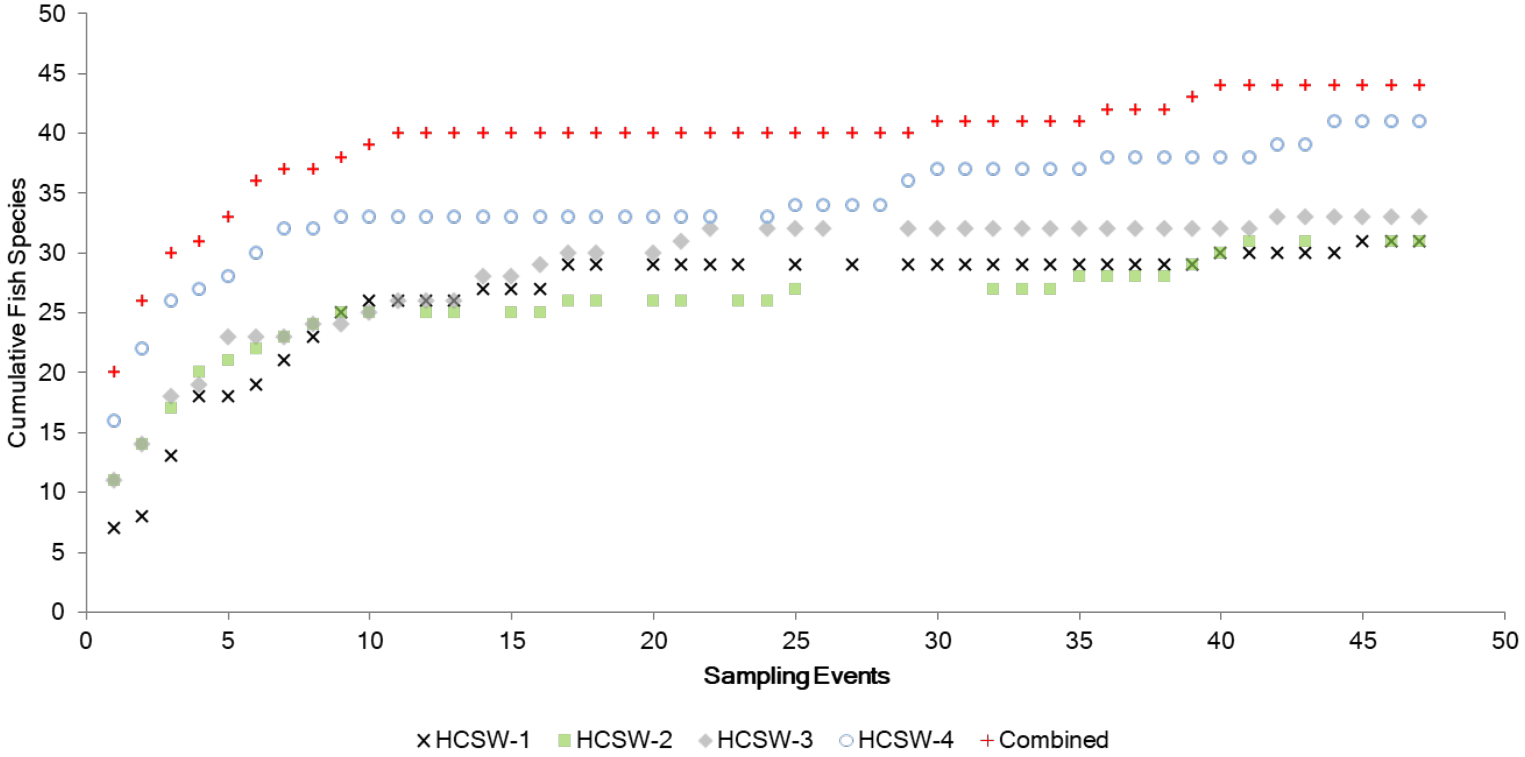


Figure 7-13

2018 Fish Results & Conclusions

- Number of species caught: 21 (historical annual range 18-32)
- Cumulative total 2003-2018: 44
- No new fish species observed in 2018
  - When considered at the station level, two new invasive species observed
    - Vermiculated sailfin catfish (*Pterygoplichthys disjunctivus*) at HCSW-1 during all three sampling events
    - Asian swamp eel (*Monopterus javanensis*) at HCSW-3 during October event
    - 1.8% invasive fish (31% biomass) in 2018 catch
- Most commonly collected groups: livebearers, shiners, sunfishes, and silversides

Fish Results & Conclusions

- Number of species at each station in 2018
  - HCSW-1: 10 native, 4 invasive
  - HCSW-2: 6 native, 1 invasive
  - HCSW-3: 11 native, 3 invasive
  - HCSW-4: 12 native, 5 invasive
- Shannon-Wiener Diversity Index
  - Diversity by sampling event and station in 2018 ranged from 0.17 (HCSW-2, October) to 2.62 (HCSW-3, October)
  - Overall 2018 ranked 9th highest year based on diversity (lowest 2010, highest 2013)
  - Over the period of record, fish richness and diversity was lowest at HCSW-2 and highest at HCSW-1 (diversity) and HCSW-4 (richness)

Fish Results & Conclusions

- Morisita's Index of Similarity
  - When all sampling events for a given station are combined, fish communities were very similar (88% - 99%), with HCSW-1 being the least similar
  - When all sampling events for a given year are combined, fish communities were very similar (87% - 100%)
    - 2005, 2009, and 2016 least similar to 2018
    - 2007 and 2017 most similar to 2018

- Trends
  - No increasing or decreasing trends when all stations were combined and analyzed annually or seasonally adjusted
  - No increasing or decreasing trends for individual stations by annual median diversity; spring, summer, or winter diversity

Water Quantity Results

Rainfall, 2018 Monthly

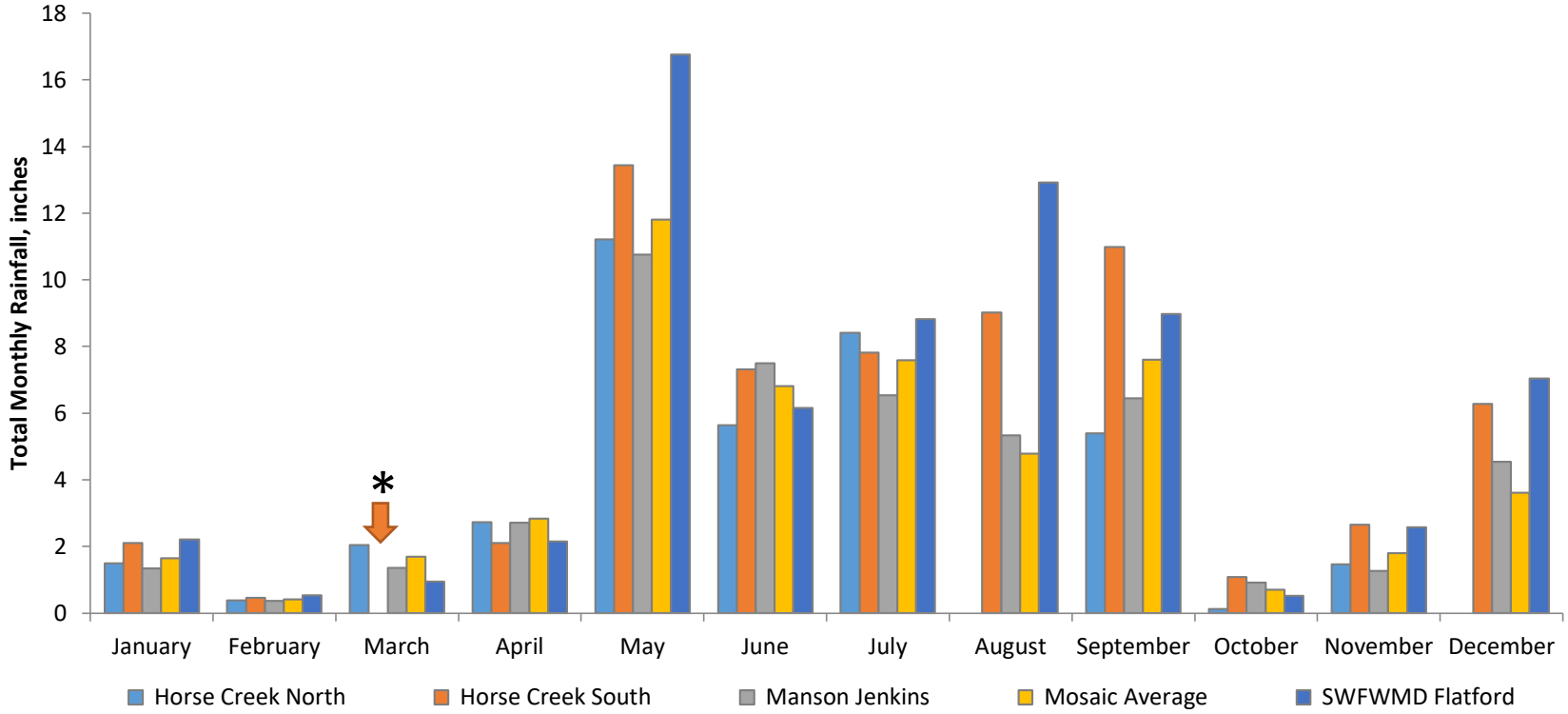


Figure 5-1

Rainfall - Mosaic Gauges

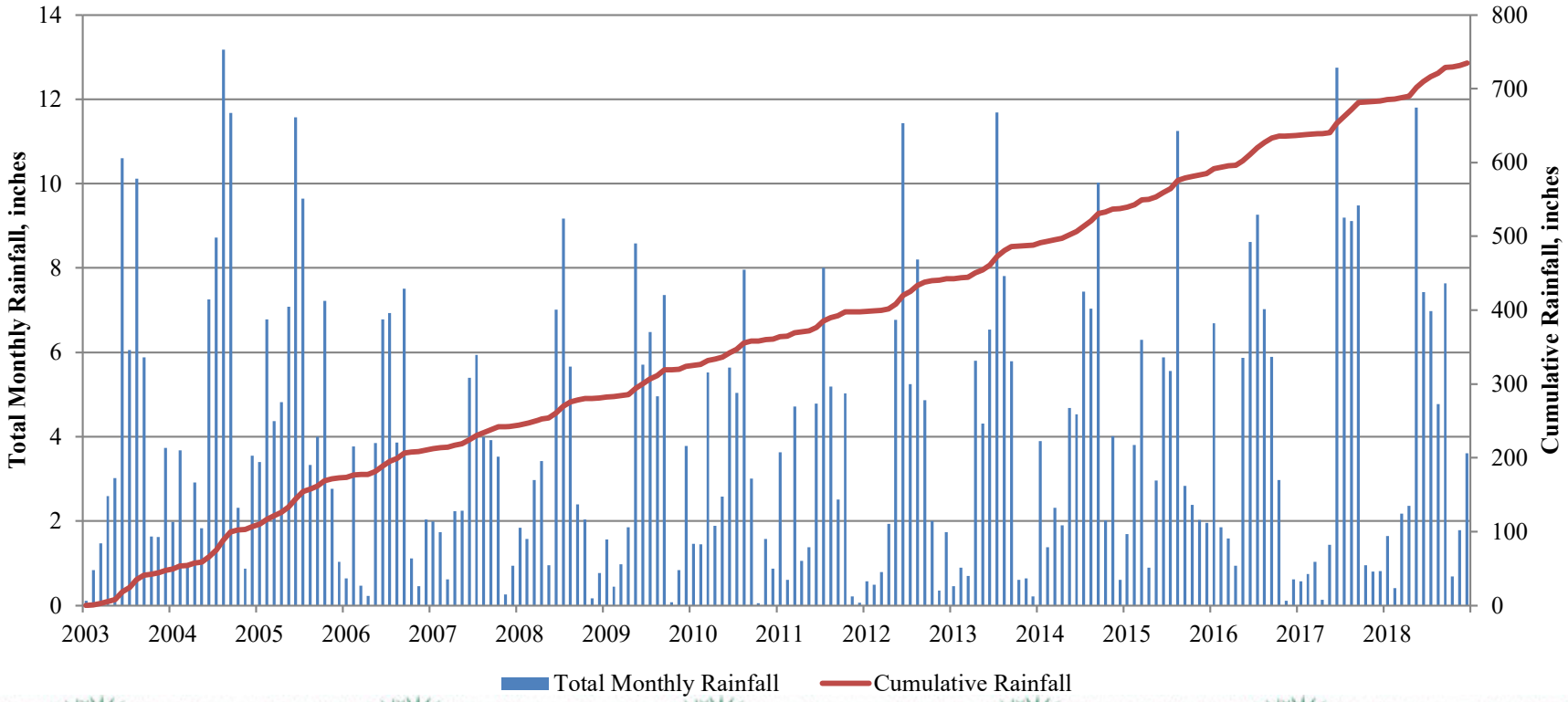


Figure 5-2

Stream Stage, 2018

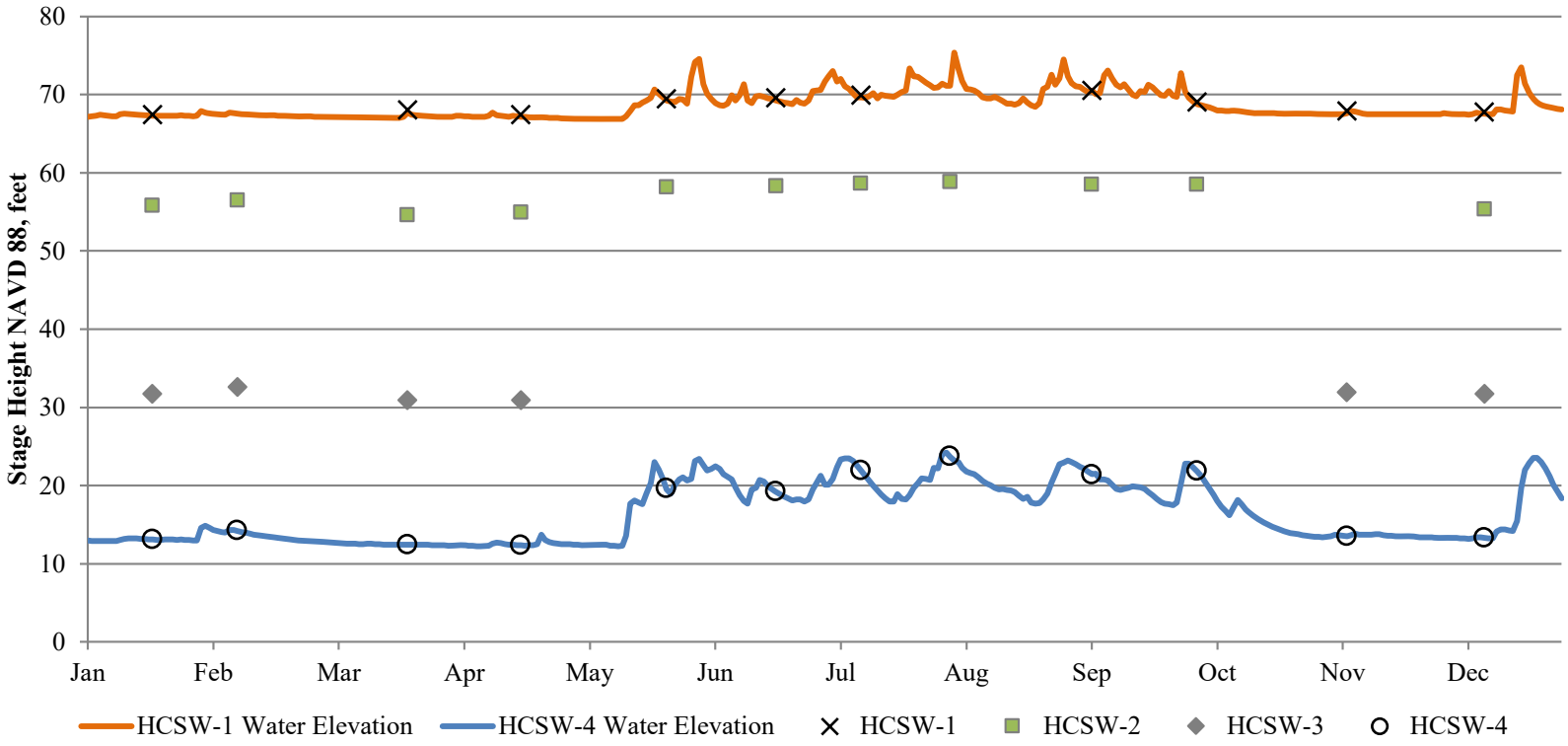


Figure 5-3

Stream Stage Duration in 2018

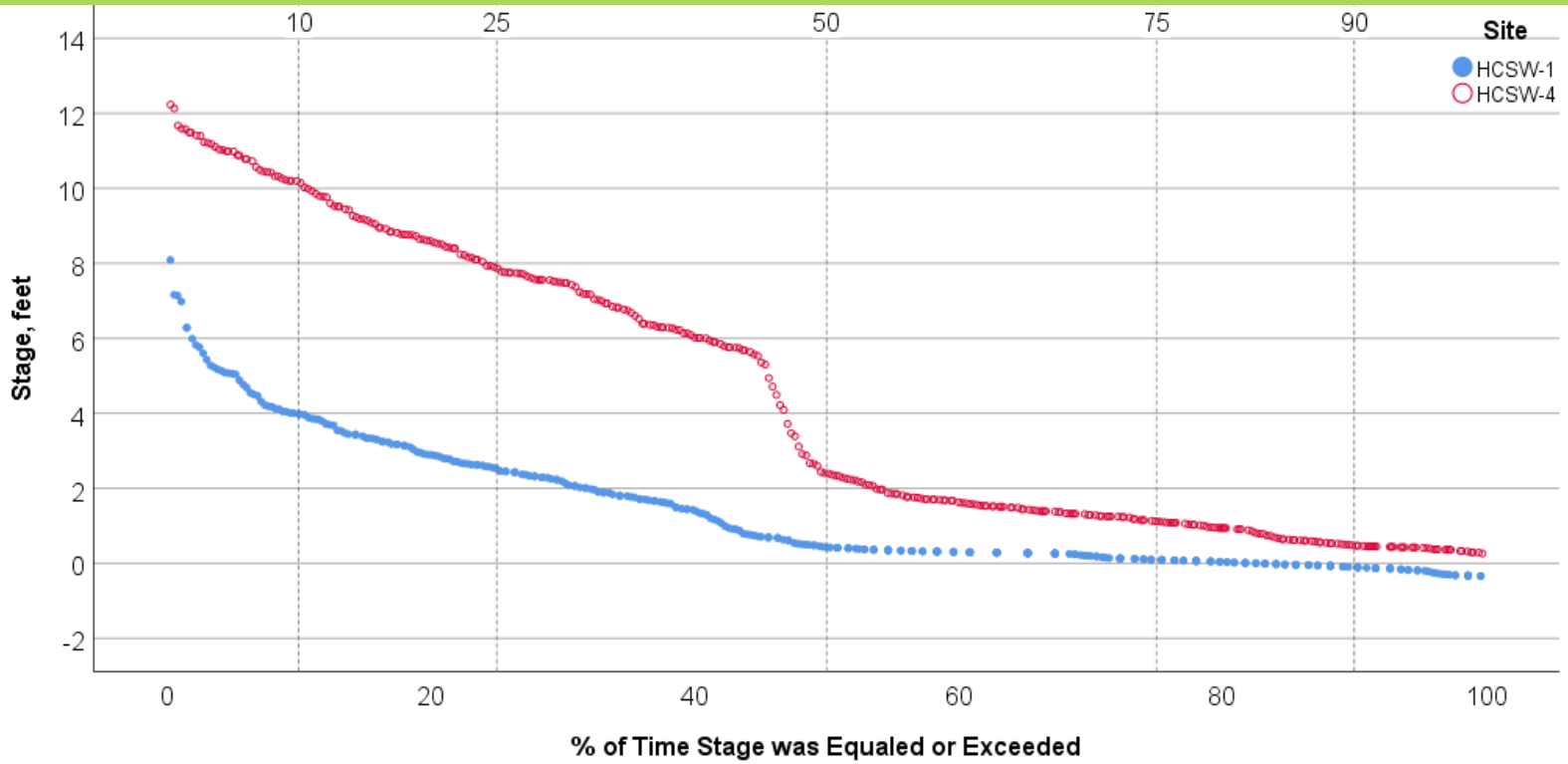


Figure 5-4

Streamflow, 2018

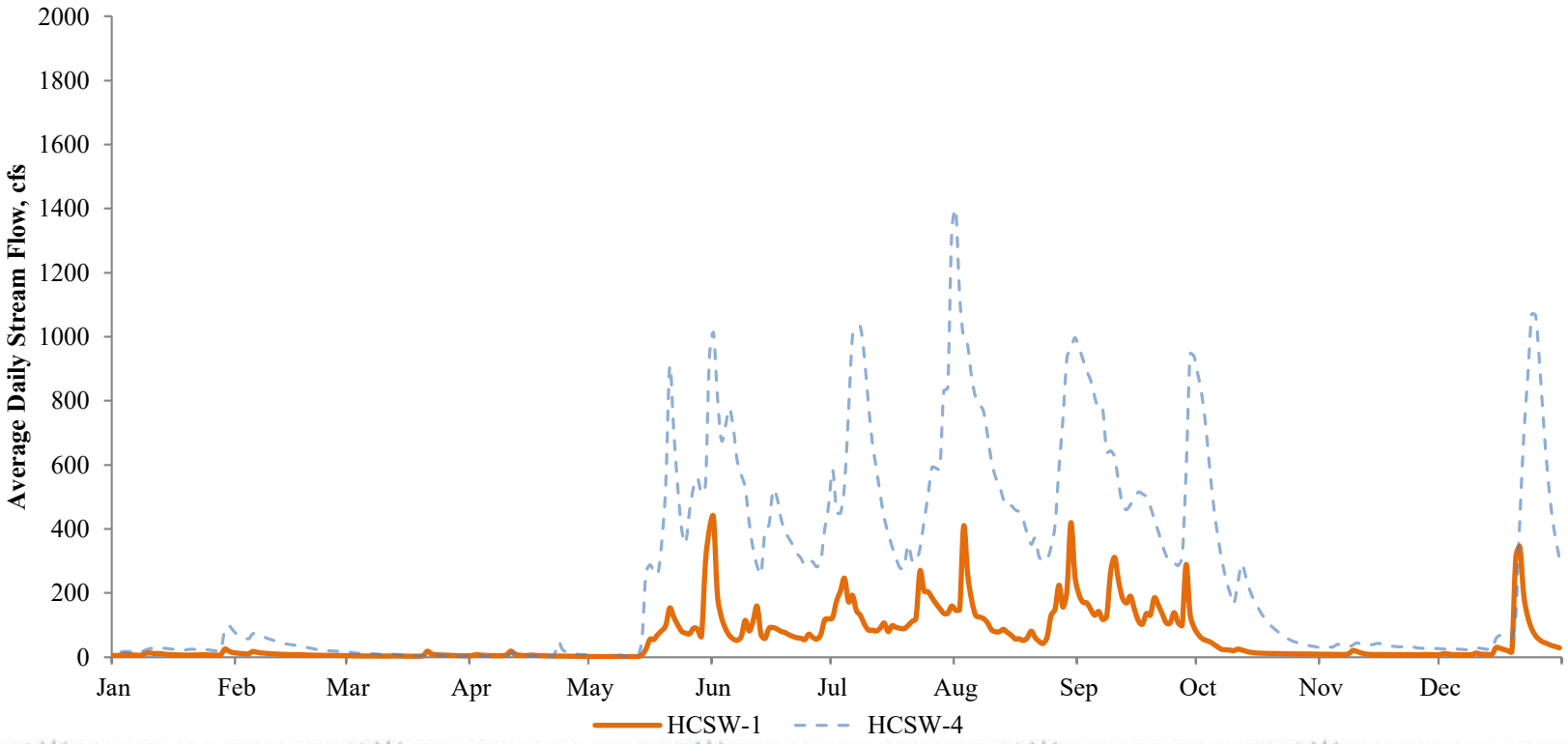
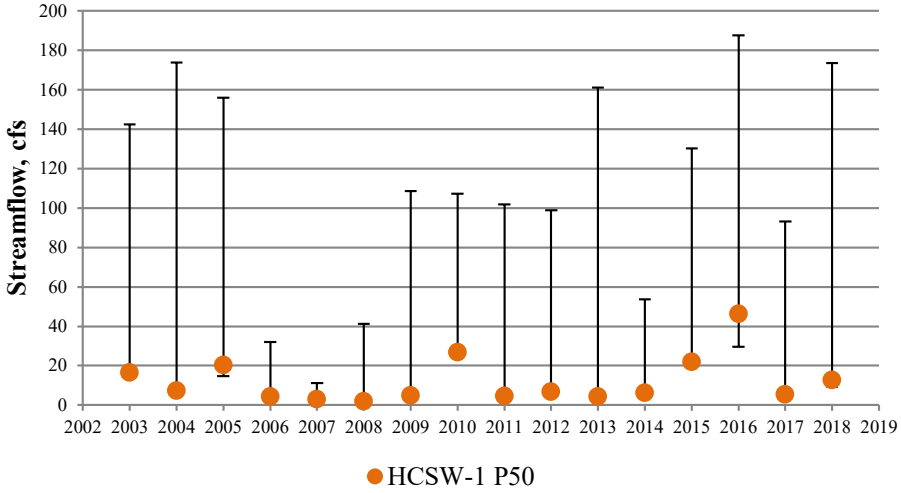


Figure 5-5

Median Streamflow



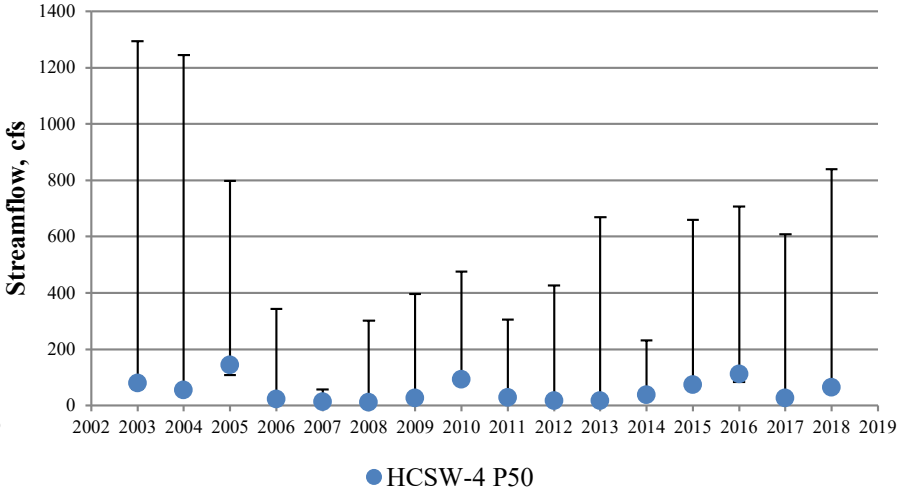


Figure 5-6

Rainfall and Streamflow, 2018 Daily Average

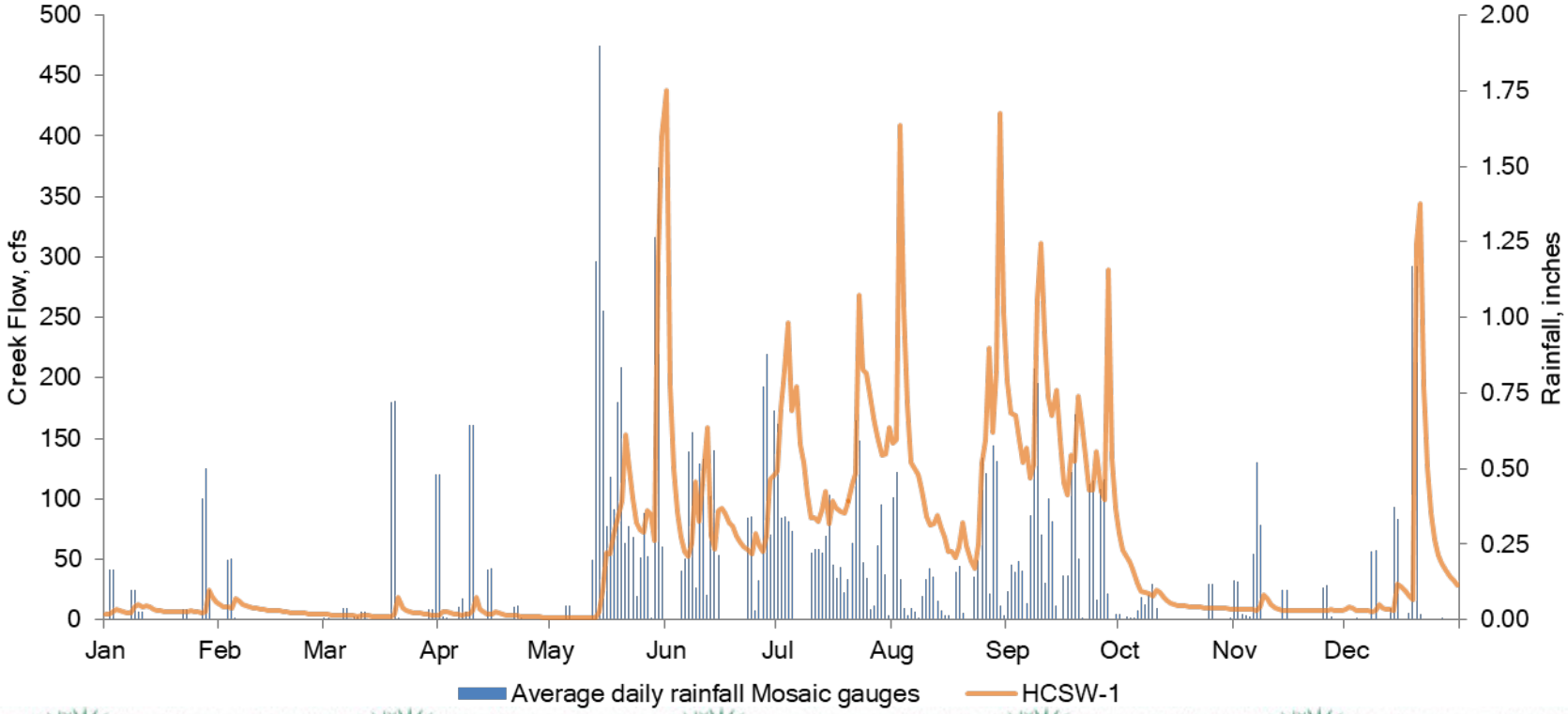


Figure 5-7

Rainfall and Streamflow – Monthly Average

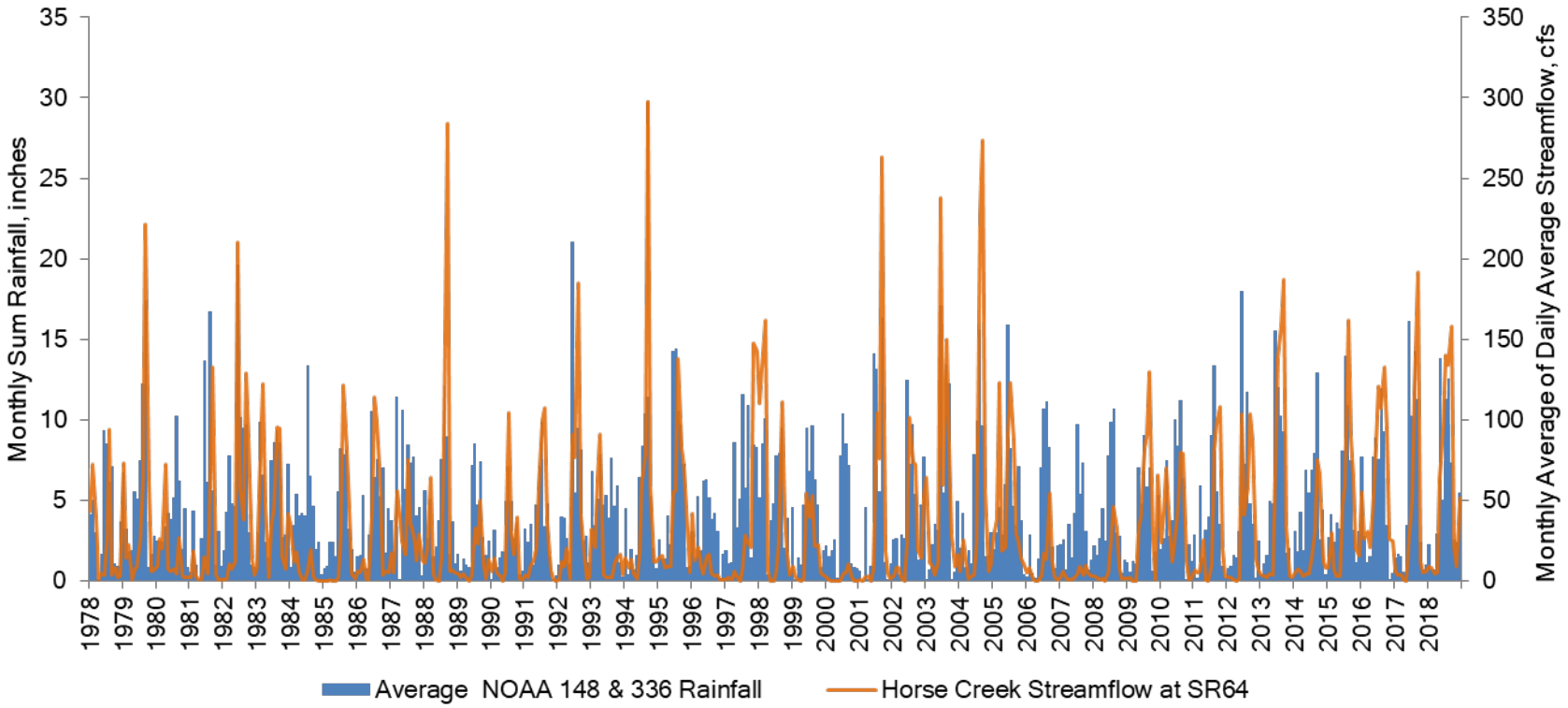


Figure 5-8

Rainfall and Streamflow – Double Mass Curve, 1978-2018

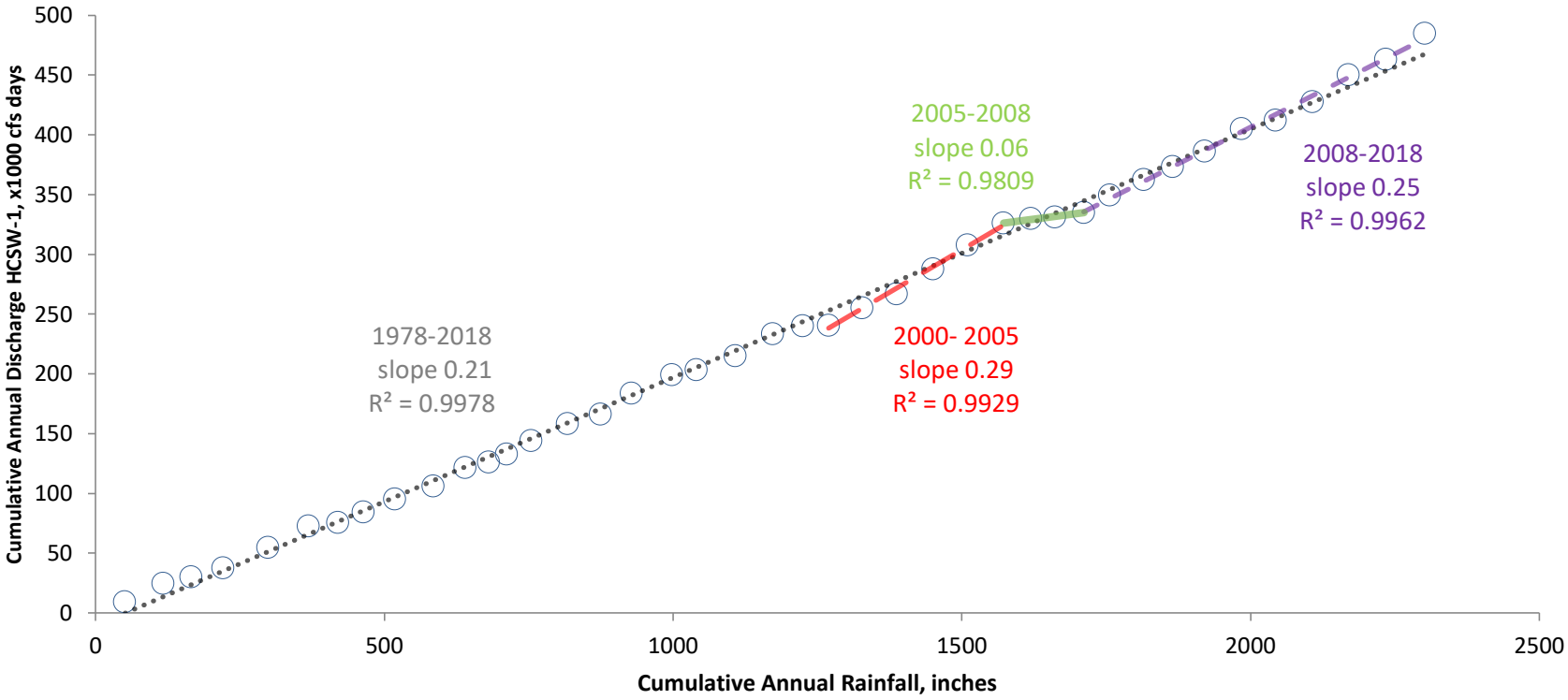


Figure 5-9

Rainfall and Streamflow – Double Mass Curve, 1978-2018

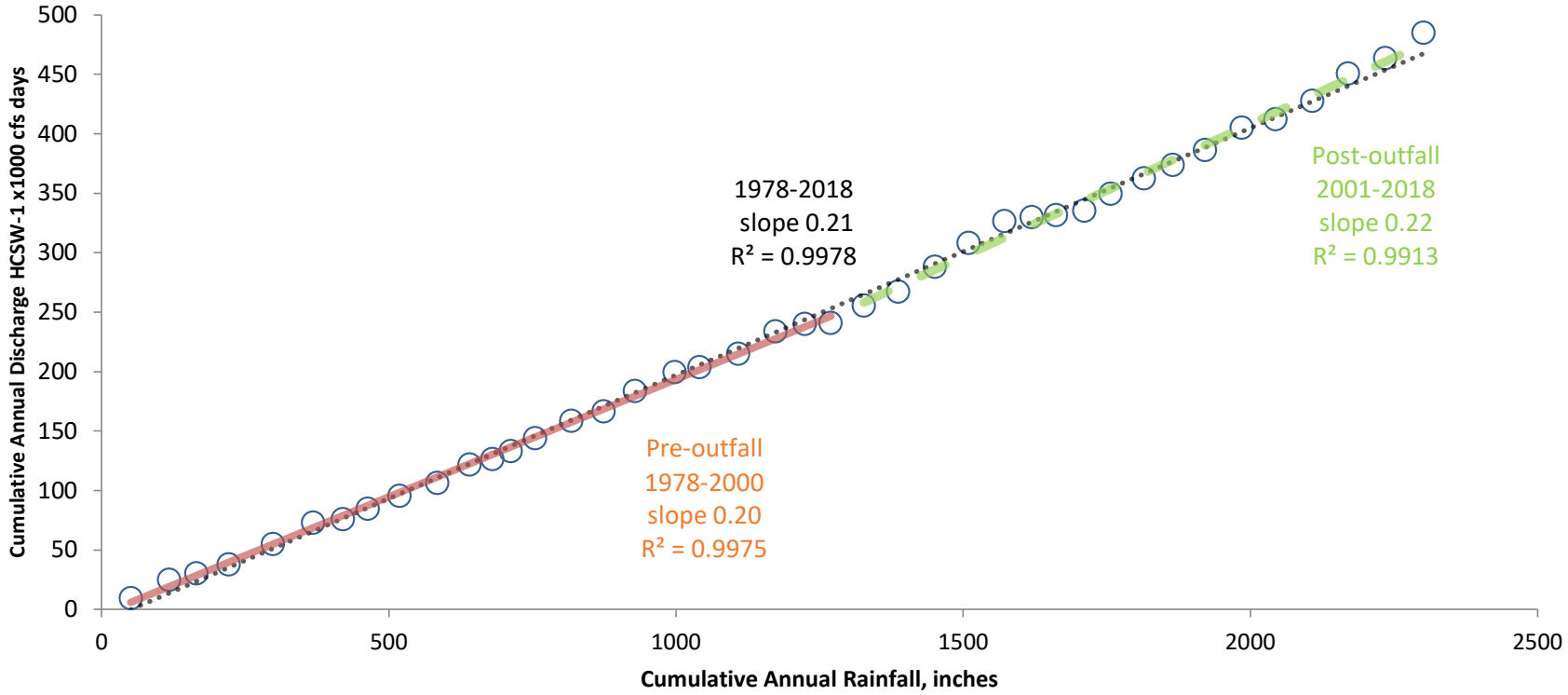


Figure 5-9

Rainfall and Streamflow – 2018 NPDES Discharge

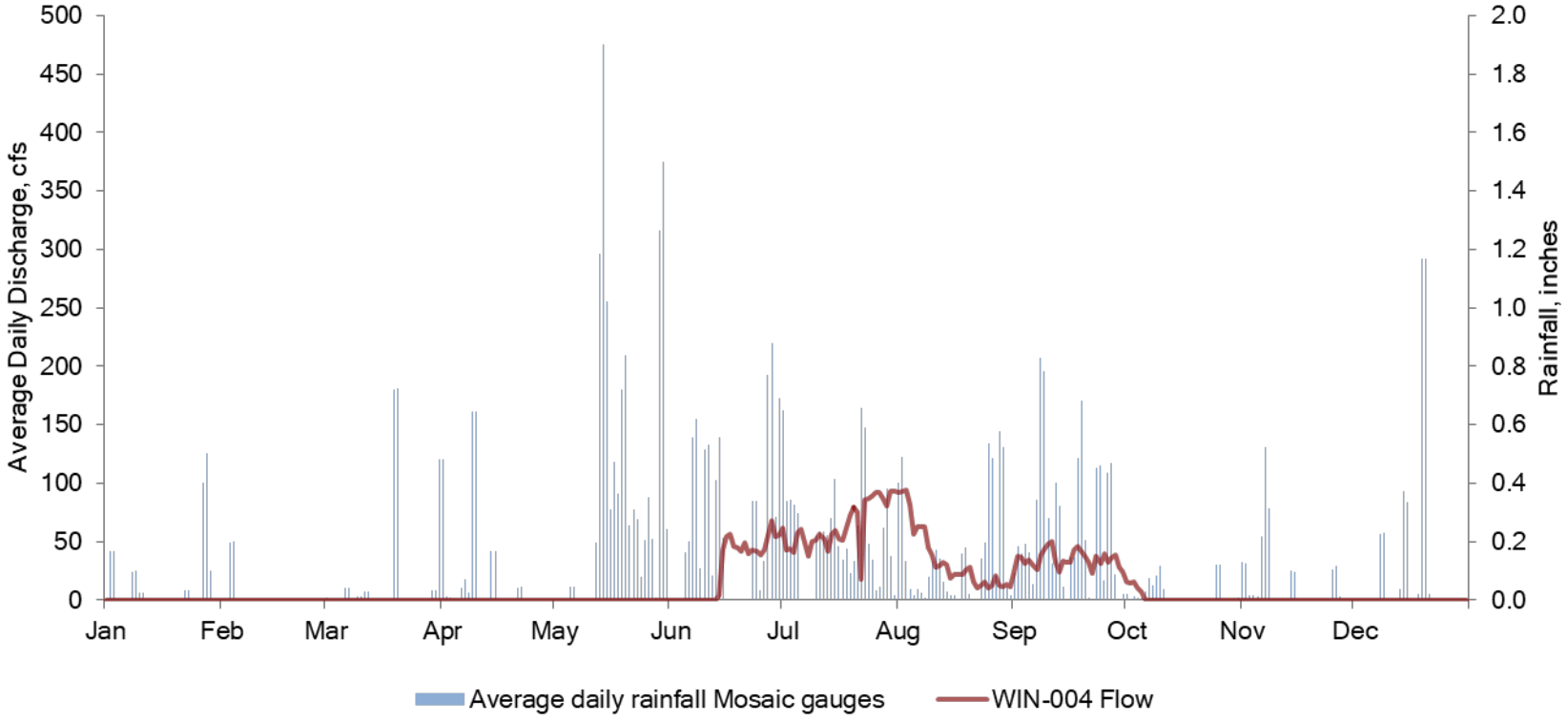


Figure 5-10

Streamflow and NPDES Discharge, 2018

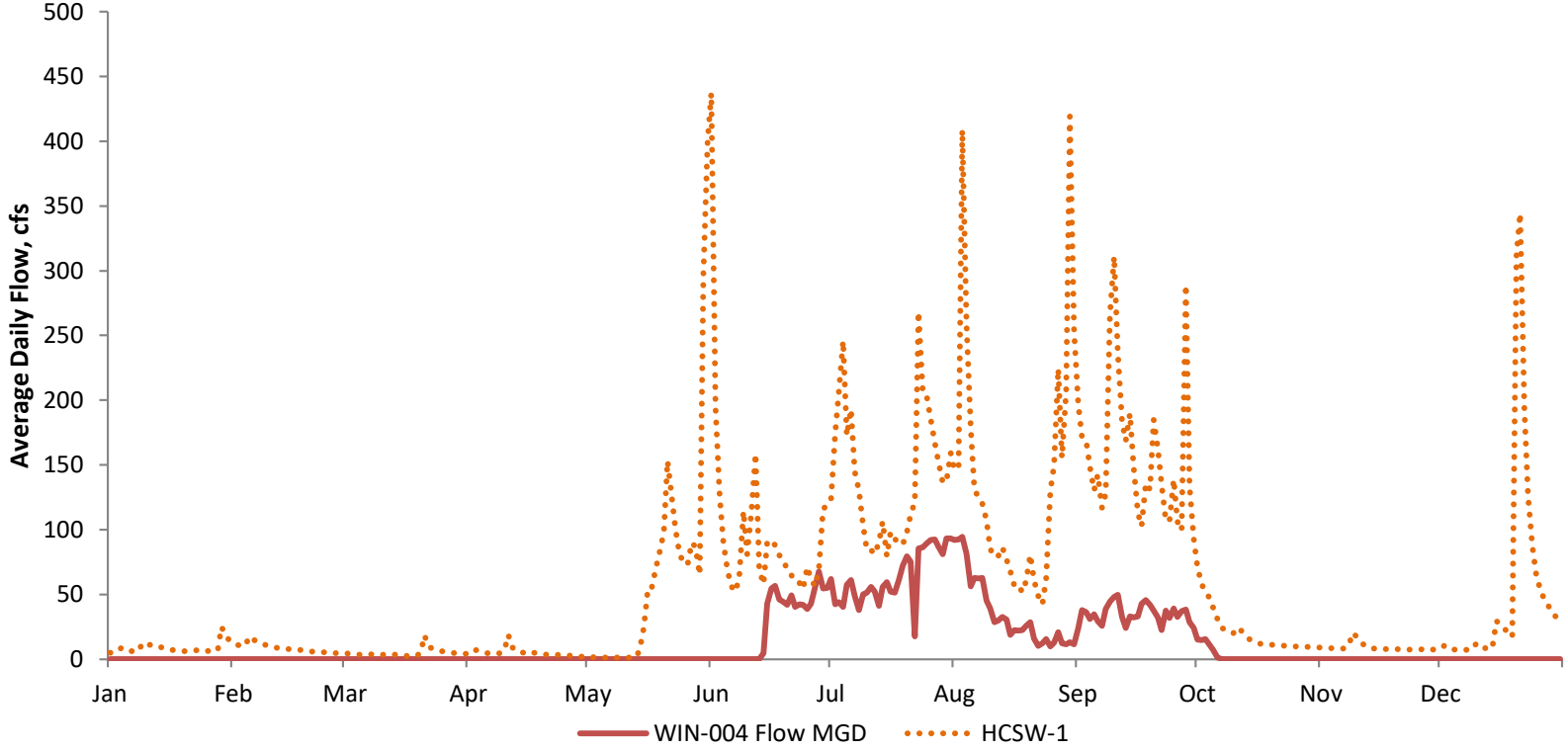
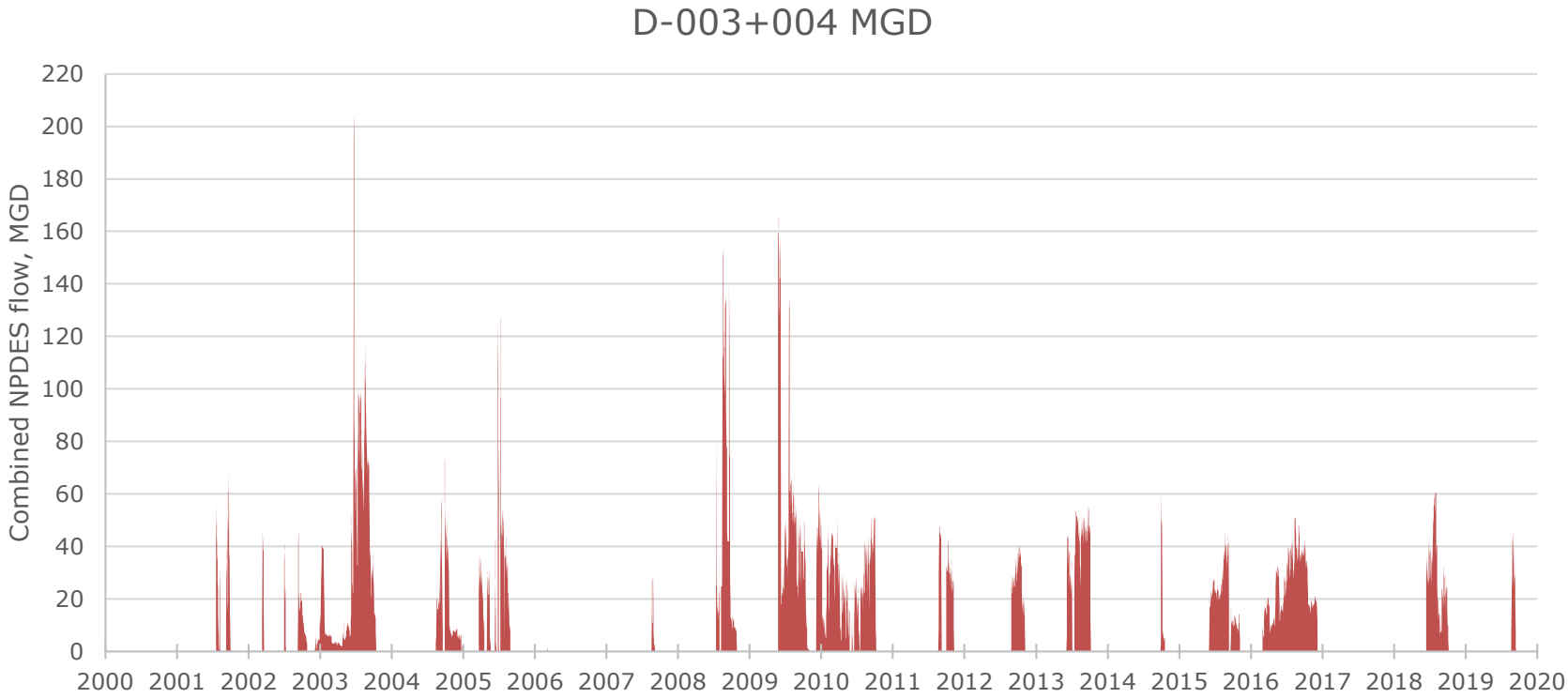


Figure 5-11

Combined NPDES Discharge to Horse Creek, POR



Combined NPDES Discharge to Horse Creek, POR

Year	Total annual flow, MG	Rank
2003	9253	1
2009	8767	2
2016	7047	3
2010	6712	4
2008	4613	5
2013	4597	6
2005	3411	7
2015	3224	8
2018	3201	9
2004	2222	10
2012	1947	11
2011	1766	12
2002	1338	13
2001	1239	14
2014	456	15
2007	210	16
2006	4	17
2017	0	18

Water Quality Results

Water Quality Results - ANOVA

Group	Parameter	F	p-value
Anions	Alkalinity	67.52	<0.001
	Chloride	38.00	<0.001
	Fluoride	62.71	<0.001
	Sulfate	70.15	<0.001
Cations	Calcium, Dissolved	73.06	<0.001
	Iron, Dissolved	0.19	0.902
Nutrients	Chlorophyll-a	42.00	<0.001
	Nitrogen, Ammonia	4.11	0.007
	Nitrogen, Nitrate-Nitrite	89.47	<0.001
	Nitrogen, Total	4.72	<0.001
	Nitrogen, Total Kjeldahl	21.48	<0.001
	Orthophosphate	11.27	<0.001
Physical	Color, Apparent	9.70	<0.001
	Dissolved Solids, Total	62.12	<0.001
	Oxygen, Dissolved (%Sat)	193.90	<0.001
	Oxygen, Dissolved (mg/L)	220.29	<0.001
	pH	59.83	<0.001
	Specific Conductance	56.02	<0.001
	Turbidity	0.77	0.510
Radiological	Radium, Combined	6.03	<0.001

Table 6-2

Correlations with Water Quantity at HCSW-1 and HCSW-4

Group	Parameter	HCSW-1			HCSW-4		
		Rainfall	NPDES	Streamflow	Rainfall	NPDES	Streamflow
Anions	Alkalinity	-			-	-	-
	Chloride	-	-	-	-	-	-
	Fluoride††		+	+	-	-	-
	Sulfate		+	+	-	-	-
Cations	Calcium, Dissolved	-	+		-	-	-
	Iron, Dissolved	+	+	+	+	+	+
Nutrients	Ammonia, Total††		+	+			+
	Chlorophyll-*a*		+	+	+		
	Nitrate-Nitrite††	+			-	-	-
	Nitrogen, Total	+	+	+	+		+
	Nitrogen, Total Kjeldahl	+	+	+	+	+	+
	Orthophosphate						
Physical	Color, Apparent	+	+	+	+	+	+
	Dissolved Solids, Total		+	+	-	-	-
	Oxygen Dissolved†	-	-	-	-	-	-
	Oxygen, Dissolved	-	-	-	-	-	-
	pH	-	-	-	-	-	-
	Specific Conductance	-	+	+	-	-	-
	Turbidity	+	+	+	+	+	+
Radiological	Radium, Total		-	-		-	-

Spearman rank correlation. Statistically significant at $p<0.05$

Table 6-3

Seasonal Kendall Tau

- Non-parametric test for monotonic trends
- Determines water quality trends after correcting for seasonality by only comparing values between similar seasons over time
- Corrected for streamflow if relationship existed
- Used SWFWMD as an alternative to HCSP data - F^-, NO_x, & NH_3
- Went to annual trends only when SWFWMD data collection changed to bi-monthly
- Produces a trend slope estimate
- Trend detection limited by
  - <5 years of data
  - Changes in method detection limits for parameters/proportion of non-detects

Seasonal Trends over Time 2003-2018

Parameter	HCSW-1 Slope	HCSW-4 Slope	Discussion
Alkalinity	2.32 mg/L/yr	0.54 mg/L/yr	Discussed in Historical Assessment
Calcium	1.1 mg/L/yr		Discussed in Historical Assessment
Chlorophyll-a	-0.03 mg/M^3/yr	-0.05 mg/M^3/yr	Not an adverse trend
Color		2.82 PCU/yr	Not an adverse trend
DO (mg/L)	0.04 mg/L/yr		Not an adverse trend
Fluoride	0.01 mg/L/yr		Slope very small in magnitude.
Iron	-0.01 mg/L/yr	-0.01 mg/L/yr	Not an adverse trend
Nitrogen, Total Kjeldahl		0.02 mg/L/yr	Slope very small in magnitude; not at upstream station.
pH	0.04 SU/yr	0.02 SU/yr	Slope very small in magnitude. Isolated step change.
Specific Conductance	12.1 µS/yr	5.7 µS/yr	Discussed in Historical Assessment
Sulfate	4.24 mg/L/yr		Discussed in Historical Assessment
TDS	9.04 mg/L/yr		Discussed in Historical Assessment
Turbidity		0.09 NTU/yr	Slope very small in magnitude; not at upstream station.

Table 6-5

Proposed Changes to Kendall-Tau Trend Test Procedure

- Previous reports used season median of log-flow and respective parameter to calculate flow-adjusted values, i.e., the flow value and water quality value were collected on separate days within a season.

- We propose flow adjusting water quality values with the real-time log-flow values then calculating seasonal medians of those flow-adjusted values before running trend test. We can begin this in the 2019 report.

Proposed changes to Kendall-tau trend test procedure

Analyte	HCSW-1 Slope		HCSW-4 Slope	
	Current	Proposed	Current	Proposed
Alkalinity	2.32	1.97	0.54	1.07
Calcium, Dissolved	1.1	1.10		0.82
Chlorophyll-a	-0.03		-0.05	
Color, Total			2.82	2.52
Dissolved Solids, Total	9.04	9.38		5.54
Fluoride*	0.010	0.008		0.003
Iron, Dissolved	-0.01	-0.01	-0.01	-0.01
Nitrogen, Ammonia*	<0.001			
Nitrogen, Total Kjeldahl			0.02	
Oxygen, Dissolved (mg/L)	0.04	0.04		
Oxygen, Dissolved (%Sat)		0.87		
pH	0.04	0.04	0.02	0.03
Radium, Total			-0.02	
Specific Conductance	12.1	12.1	5.69	10.04
Sulfate	4.24	3.79		4.12
Turbidity			0.09	0.06

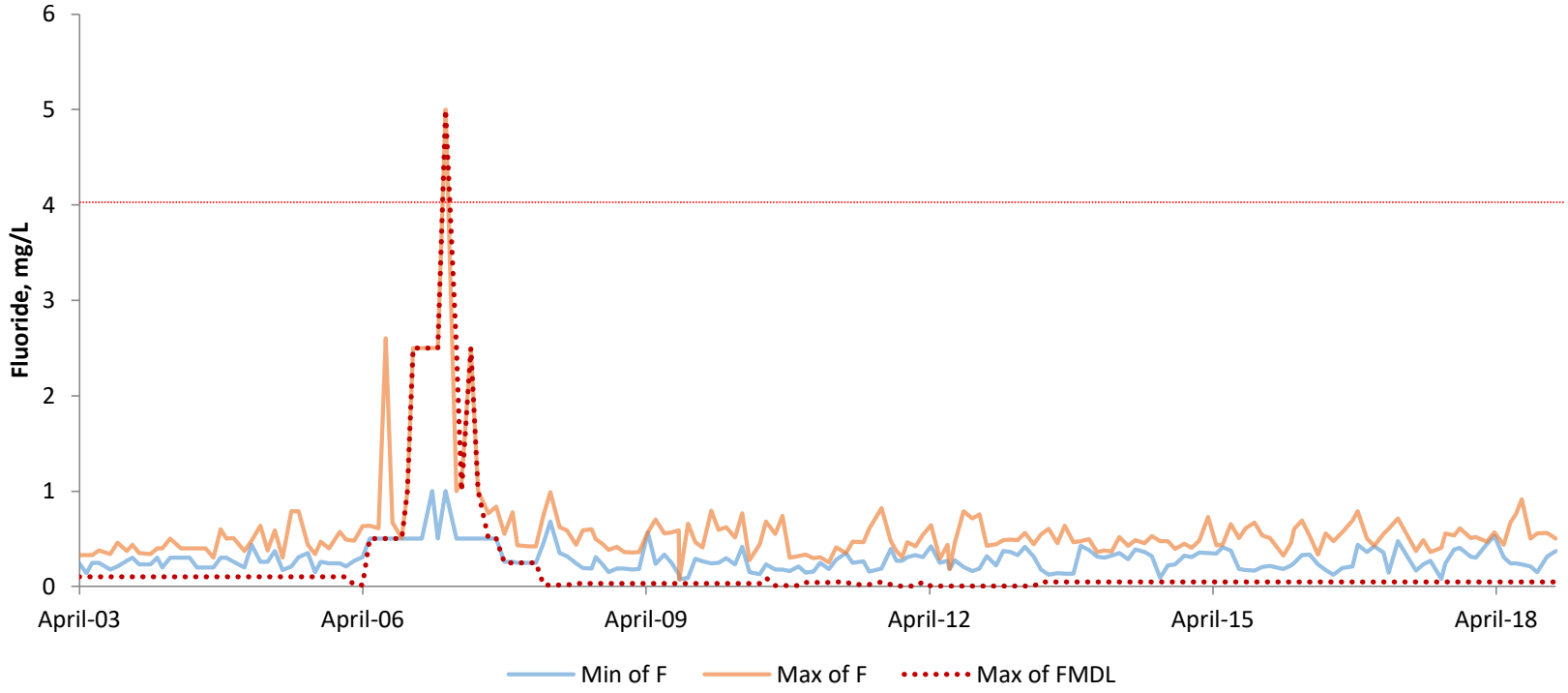
*Annual Kendall test

Proposed Changes to Kendall-Tau Trend Test Procedure

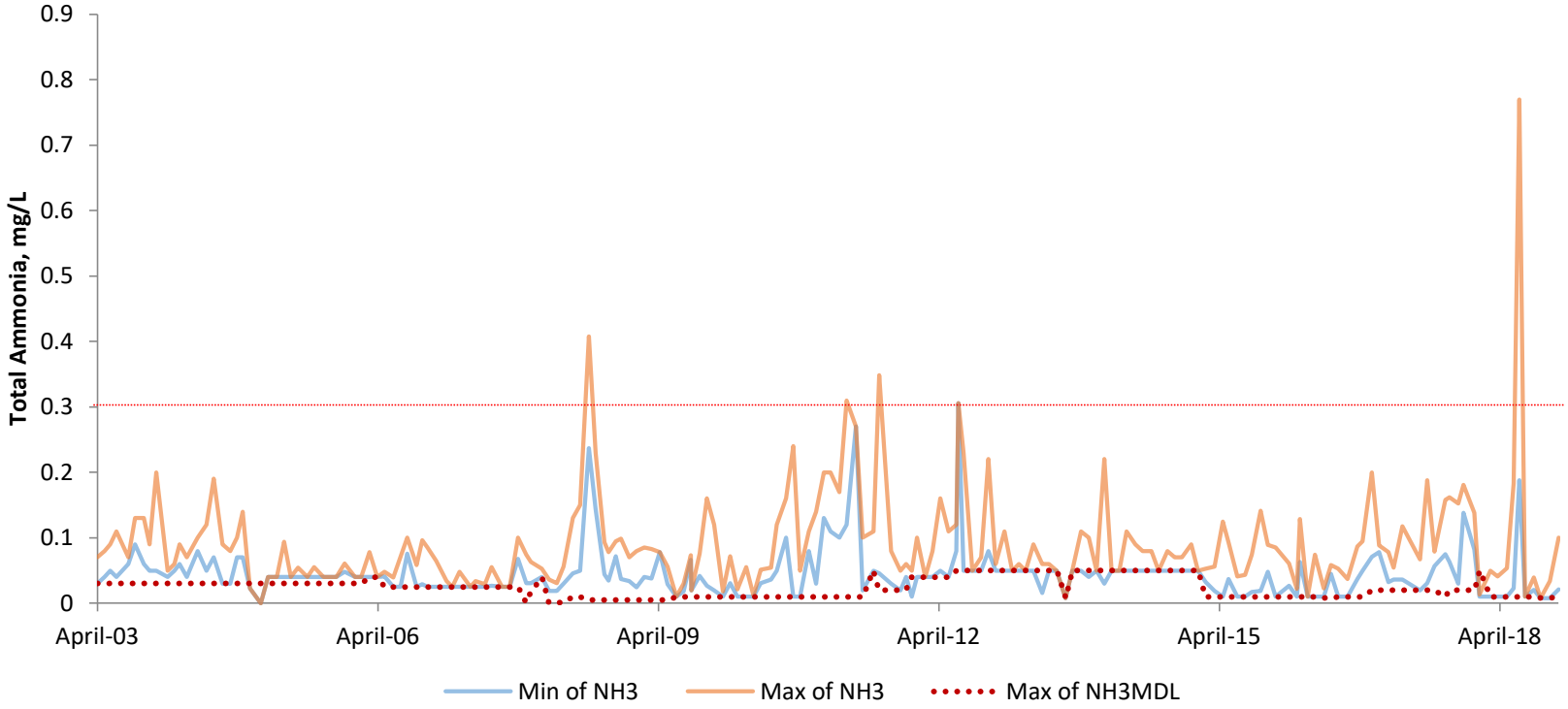
- "Parameters whose MDLs have changed over the course of the program were omitted from the analysis because of limited comparable data between sampling events and stations (i.e., fluoride, nitrate-nitrite, ammonia)."

- "Data for parameters whose method detection limits have changed several times over the HCSP (fluoride, nitrate-nitrite, ammonia) would have to be truncated to the highest detection limit, thereby reducing the available data for the test. As a result, trends were evaluated using alternative data collected by SWFWMD for these parameters; SWFWMD reduced sampling frequency in 2011, so seasonal trend tests may not be as accurate for those parameters."
  - We propose omitting this language and utilizing both the Mosaic and State of Florida datasets

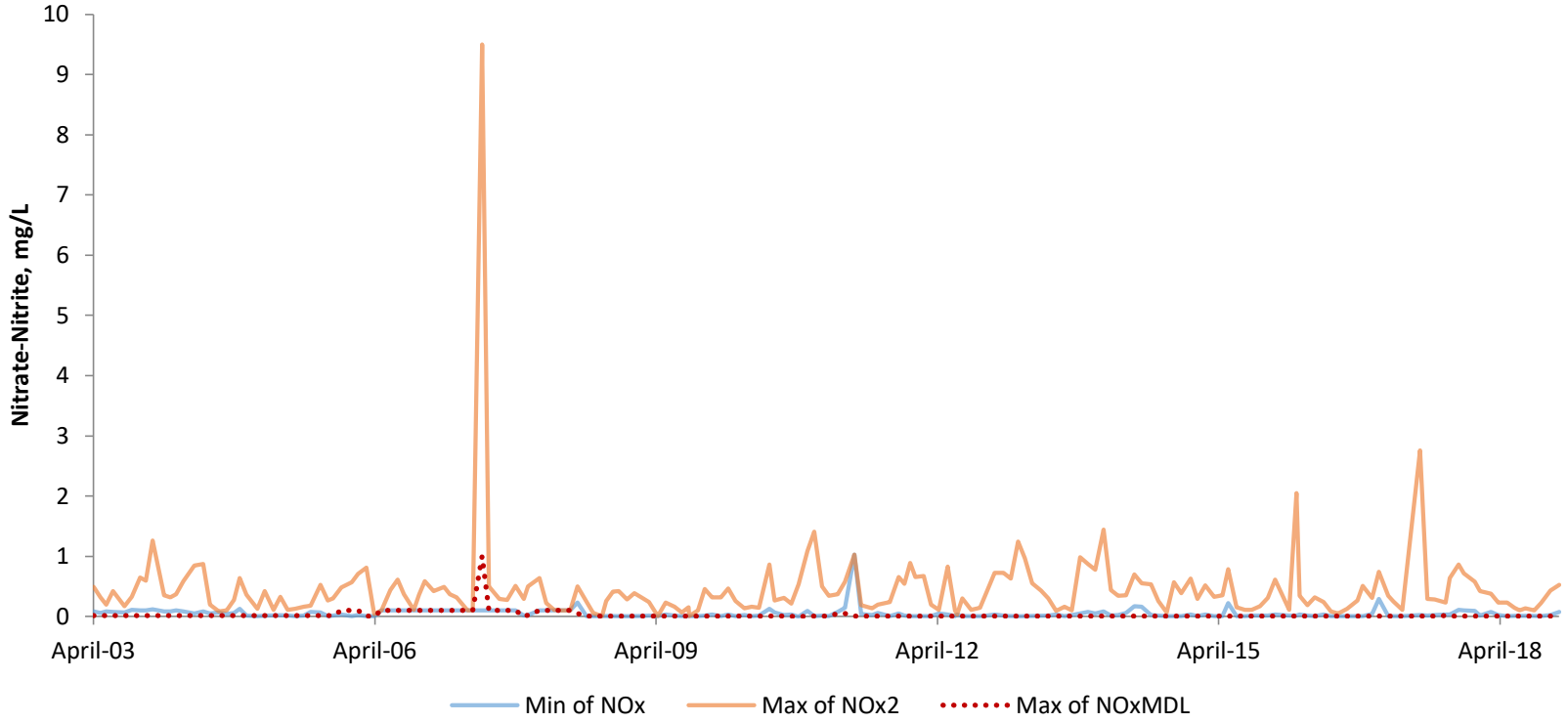
Proposed Changes to Kendall-Tau Trend Test Procedure



Proposed Changes to Kendall-Tau Trend Test Procedure



Proposed Changes to Kendall-Tau Trend Test Procedure



Trigger Level Exceedances

Station ID	Month	Analyte	Concentration	Trigger Level
HCSW-1	April	Alkalinity (mg/L)	120	100
HCSW-4	March	Calcium, Dissolved (mg/L)	106	100
HCSW-2	May	Dissolved Oxygen (%Saturation)	10.8	37.5
HCSW-2	June	Dissolved Oxygen (%Saturation)	13.1	42.7
HCSW-2	July	Dissolved Oxygen (%Saturation)	27	38.5
HCSW-2	October	Dissolved Oxygen (%Saturation)	39.5	39.8
HCSW-2	November	Dissolved Oxygen (%Saturation)	39.1	40.6
HCSW-3	May	Dissolved Oxygen (%Saturation)	32.7	35.9
HCSW-3	June	Dissolved Oxygen (%Saturation)	31.5	36.4
HCSW-4	May	Dissolved Iron (mg/L)	0.651	0.3
HCSW-4	June	Dissolved Iron (mg/L)	0.581	0.3
HCSW-4	July	Dissolved Iron (mg/L)	0.518	0.3
HCSW-4	August	Dissolved Iron (mg/L)	0.461	0.3
HCSW-4	September	Dissolved Iron (mg/L)	0.460	0.3
HCSW-4	October	Dissolved Iron (mg/L)	0.309	0.3
HCSW-3	January	Dissolved Solids, Total (mg/L)	742	500
HCSW-3	April	Dissolved Solids, Total (mg/L)	604	500
HCSW-4	January	Dissolved Solids, Total (mg/L)	520	500
HCSW-4	March	Dissolved Solids, Total (mg/L)	697 F	500
HCSW-2	July	Nitrogen, Ammonia (mg/L)	0.77 F	0.3
HCSW-3	July	Nitrogen, Ammonia (mg/L)	0.38 F	0.3
HCSW-4	July	Nitrogen, Ammonia (mg/L)	0.54 F	0.3
HCSW-3	April	Sulfate (mg/L)	290	250
HCSW-4	March	Sulfate (mg/L)	355	250

F -qualifier indicates that the analyte was detected in both the sample and the field blank

Table 6-4

2018 pH

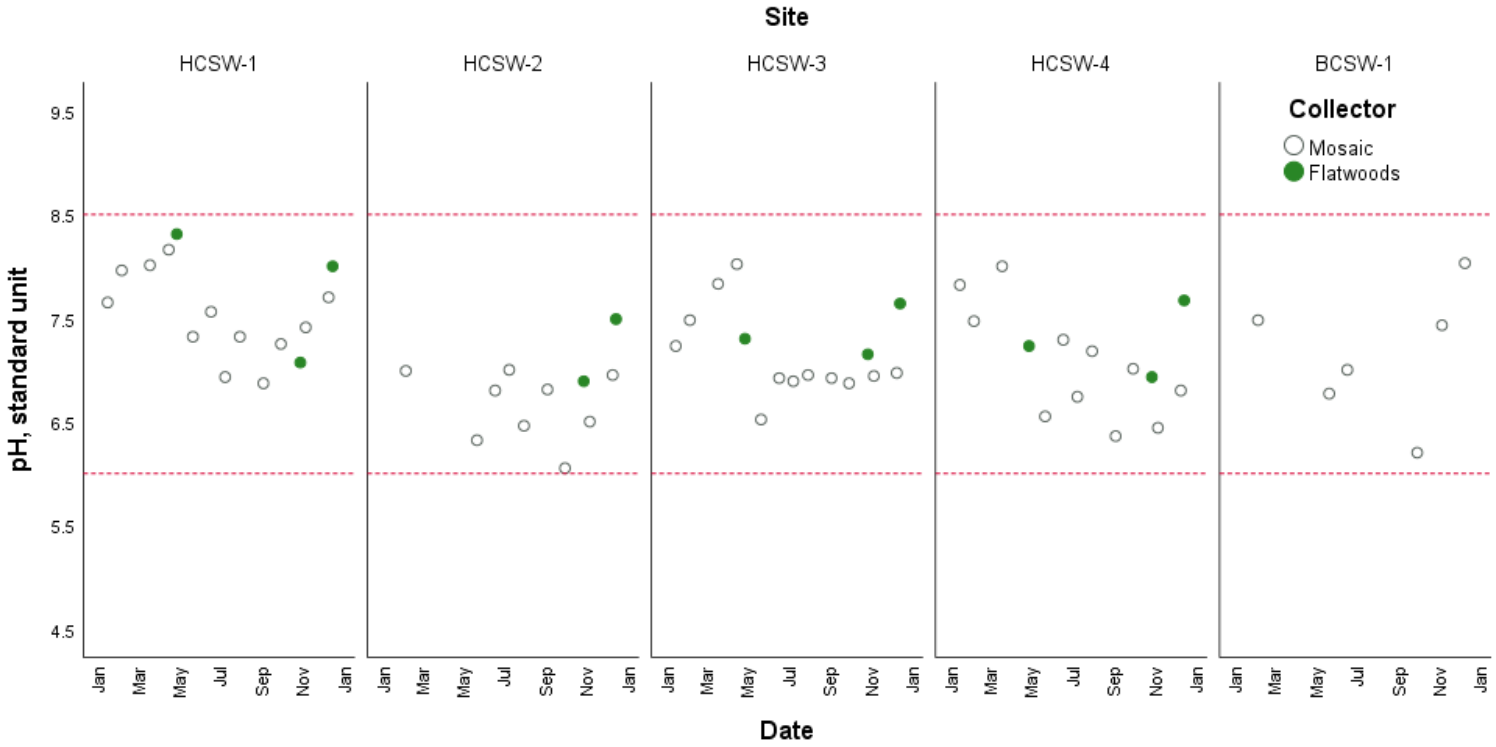


Figure 6-1

Unattended pH and Streamflow at HCSW-1

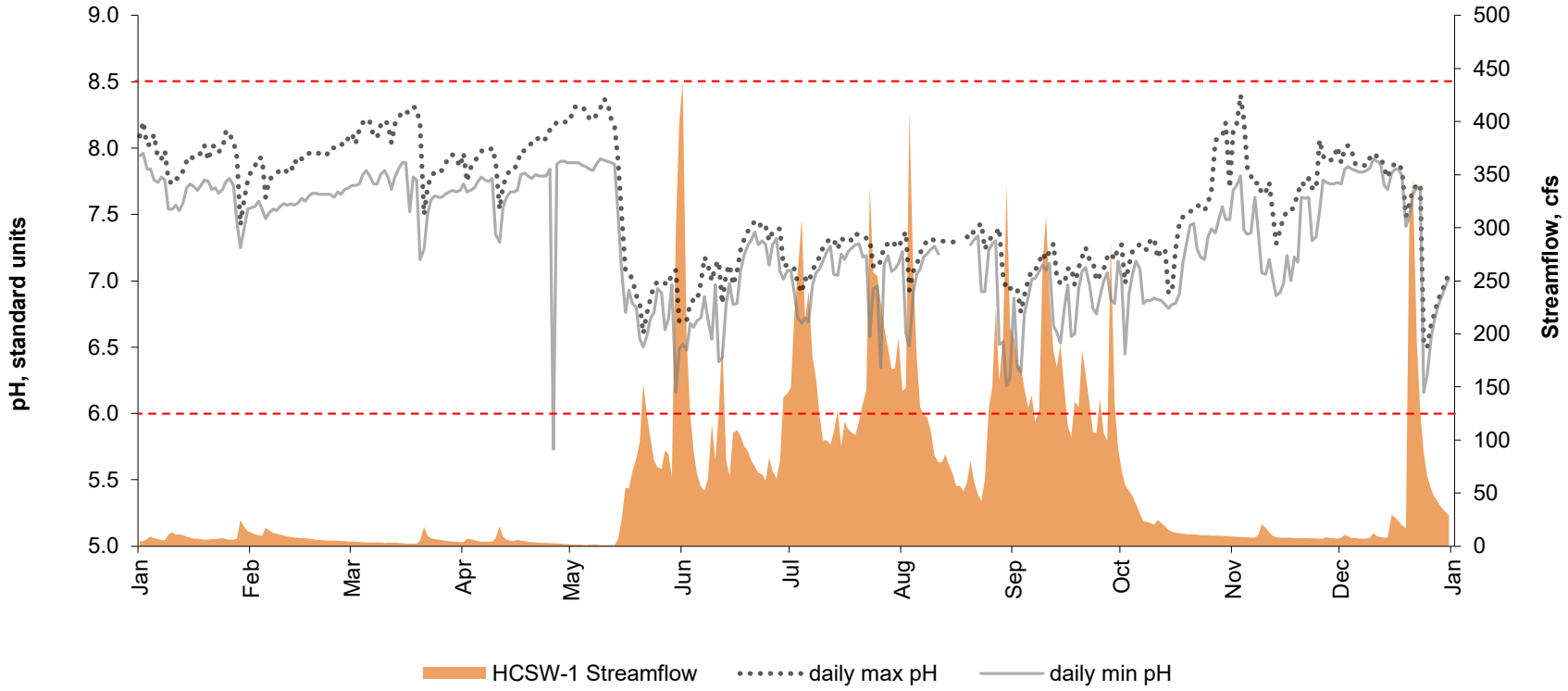


Figure 6-2

POR pH

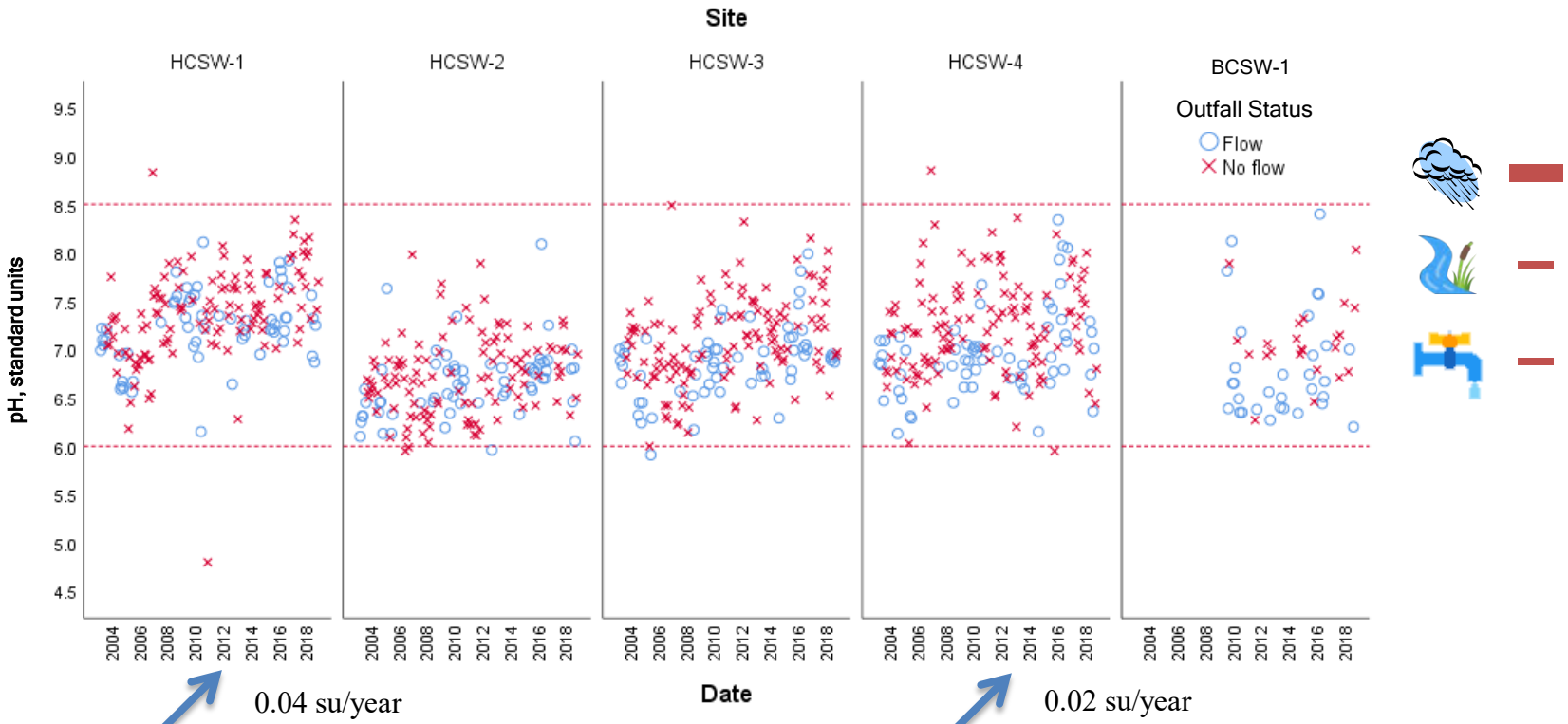


Figure C-1

2018 Dissolved Oxygen Saturation

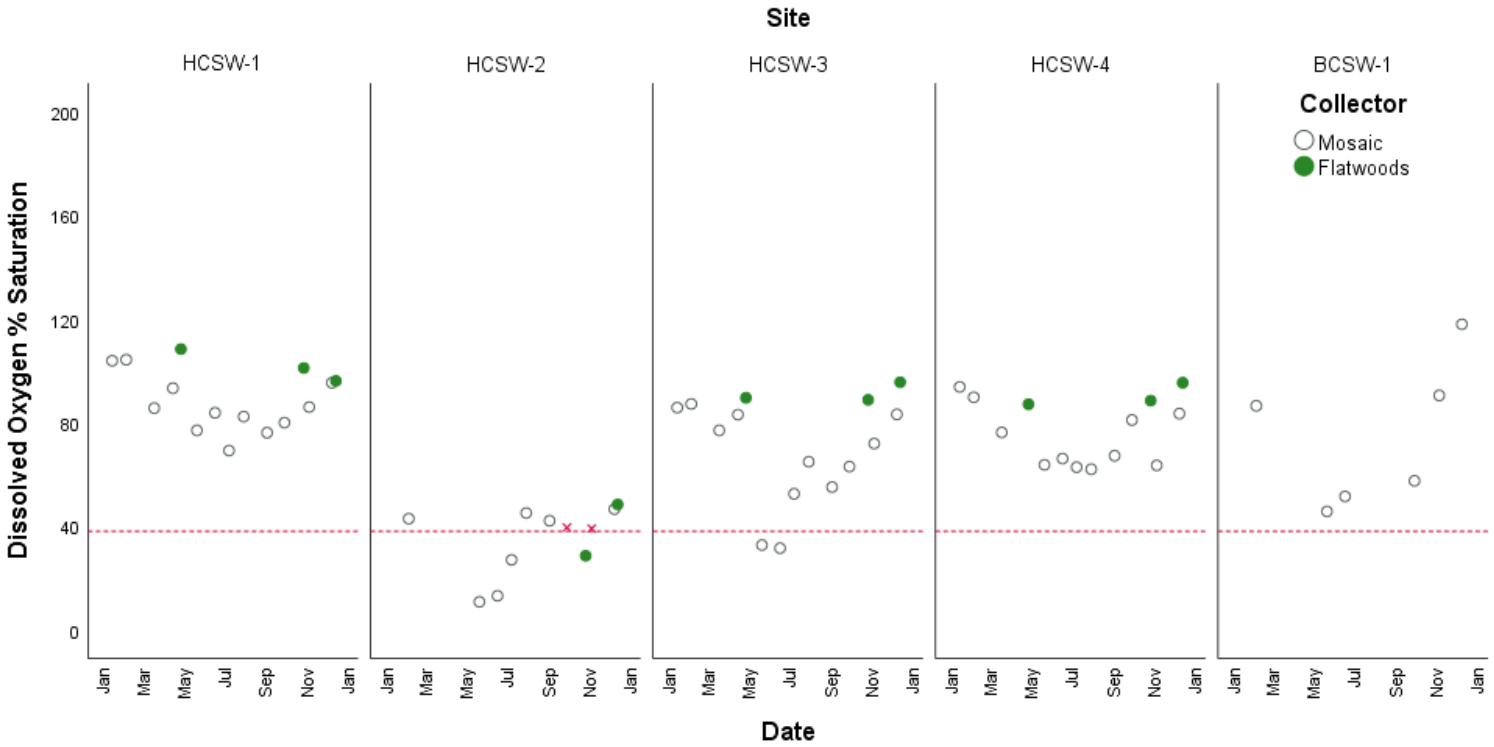


Figure 6-3

Unattended DO Saturation and Streamflow at HCSW-1

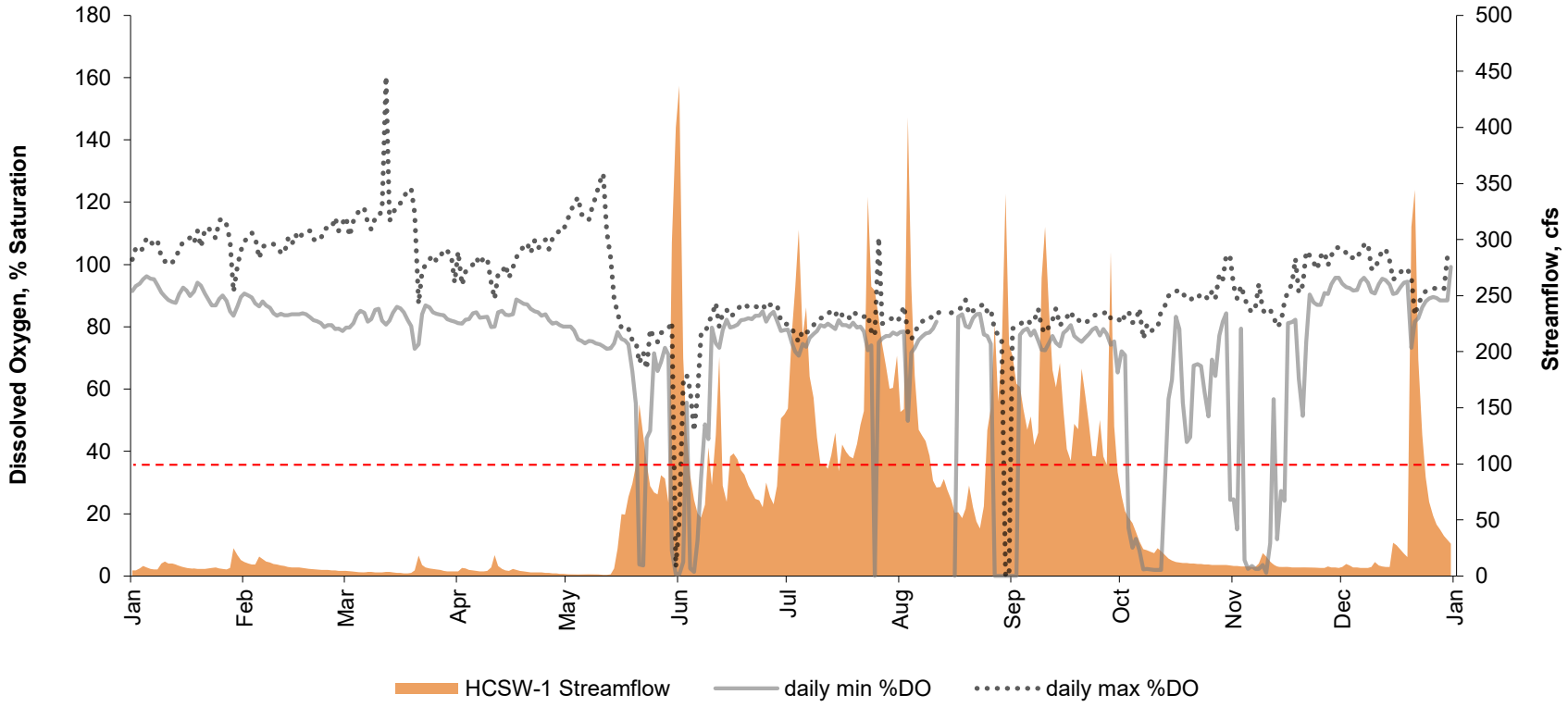


Figure 6-4

POR DO Saturation

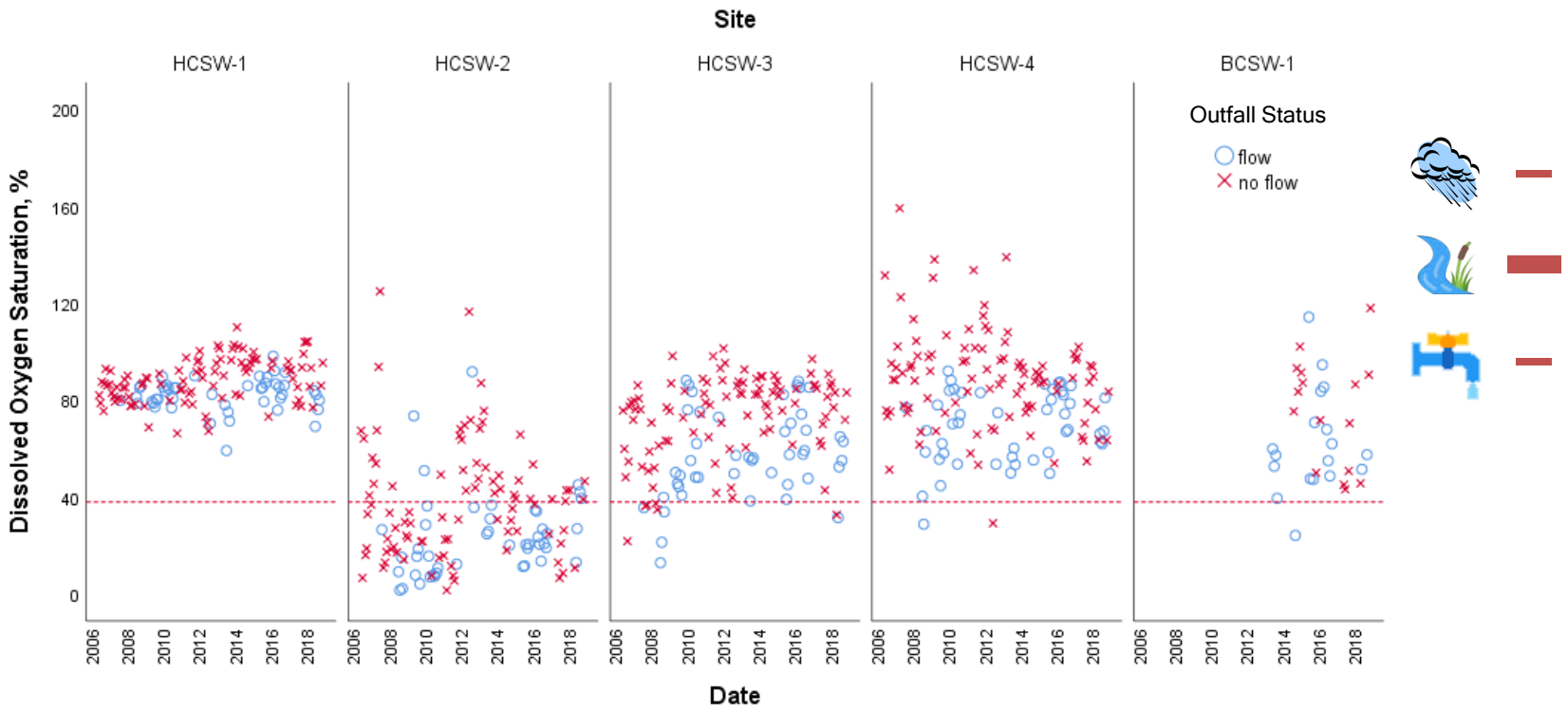


Figure C-3

2018 Turbidity

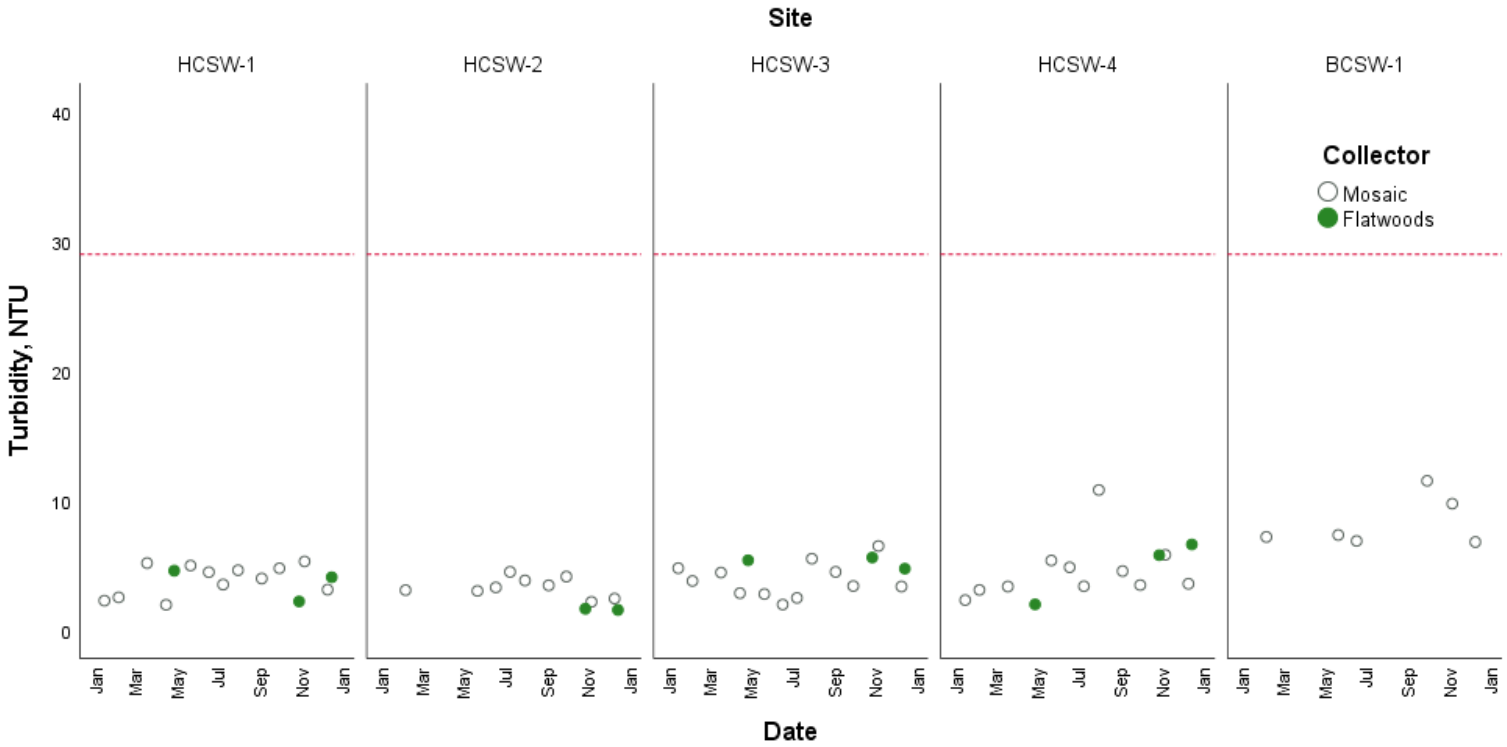


Figure 6-5

Unattended Turbidity and Streamflow at HCSW-1

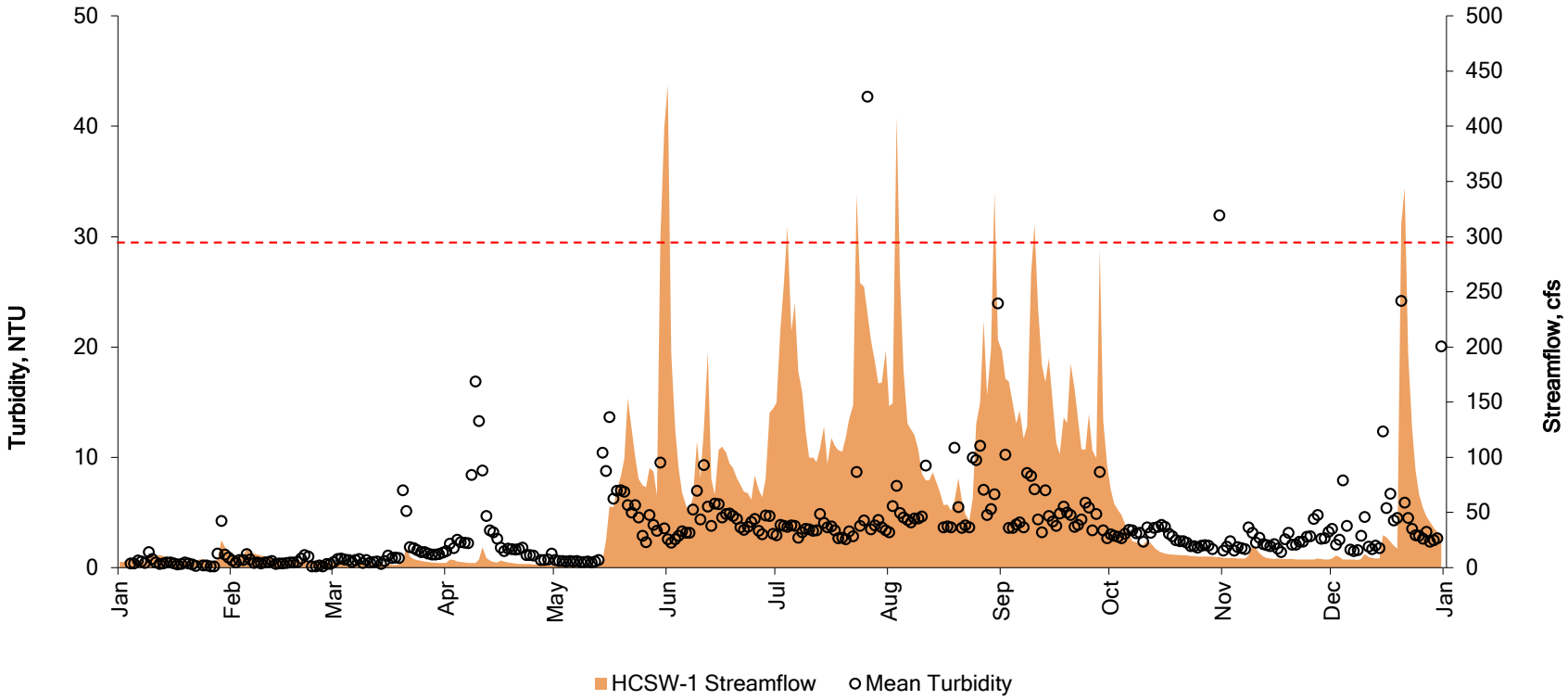
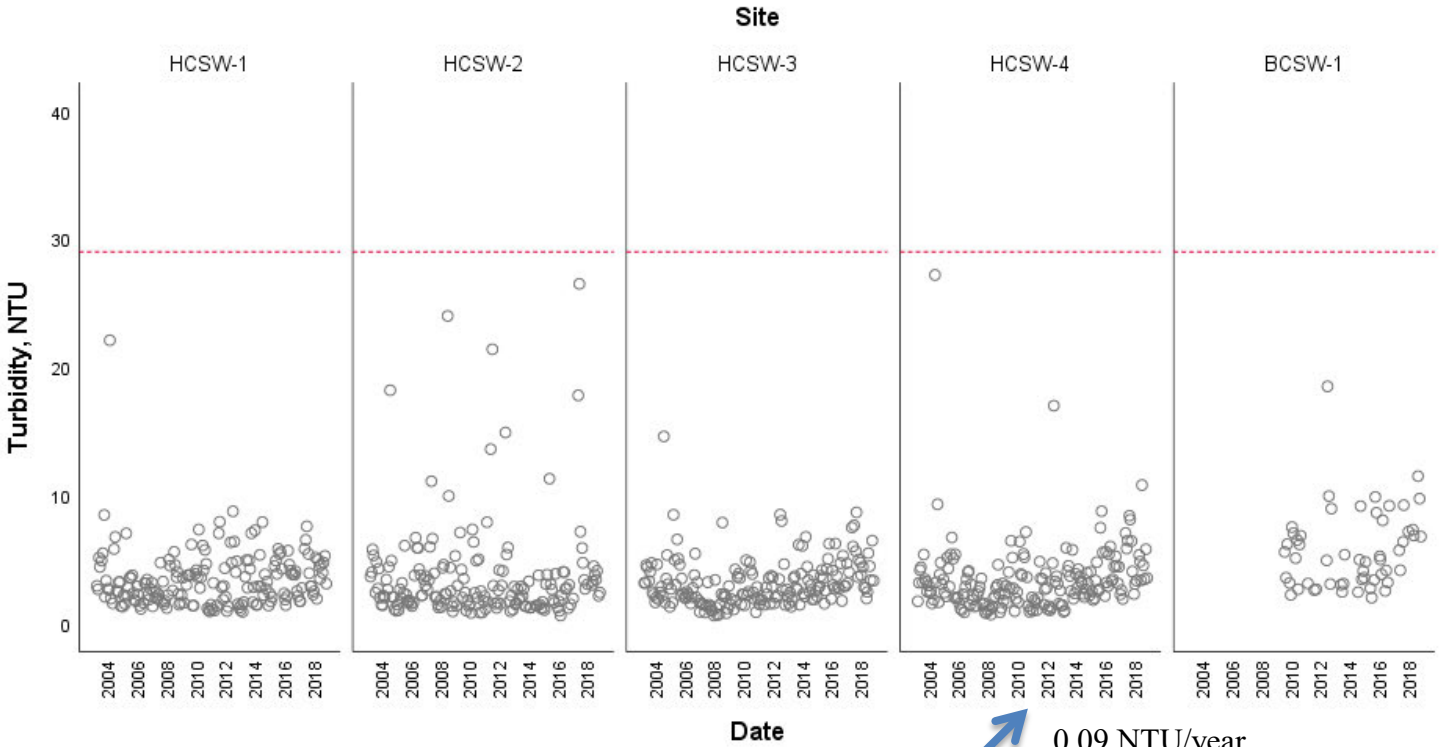


Figure 6-6

POR Turbidity



0.09 NTU/year

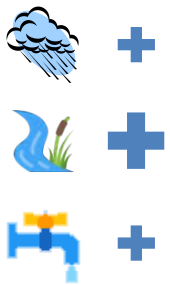


Figure C-4

NPDES Turbidity, POR

2018 Apparent Color

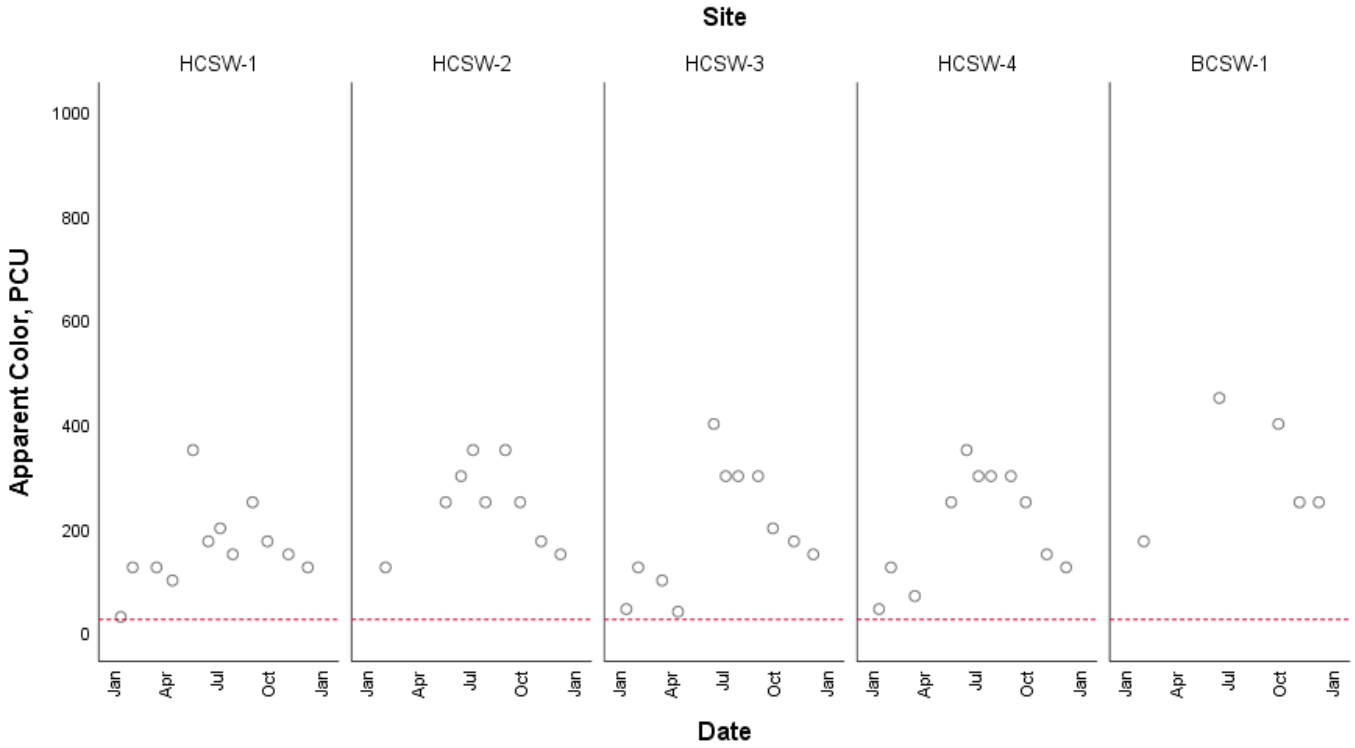


Figure 6-7

POR Apparent Color

2.82 PCU/year

Figure C-5

2018 Total Nitrogen

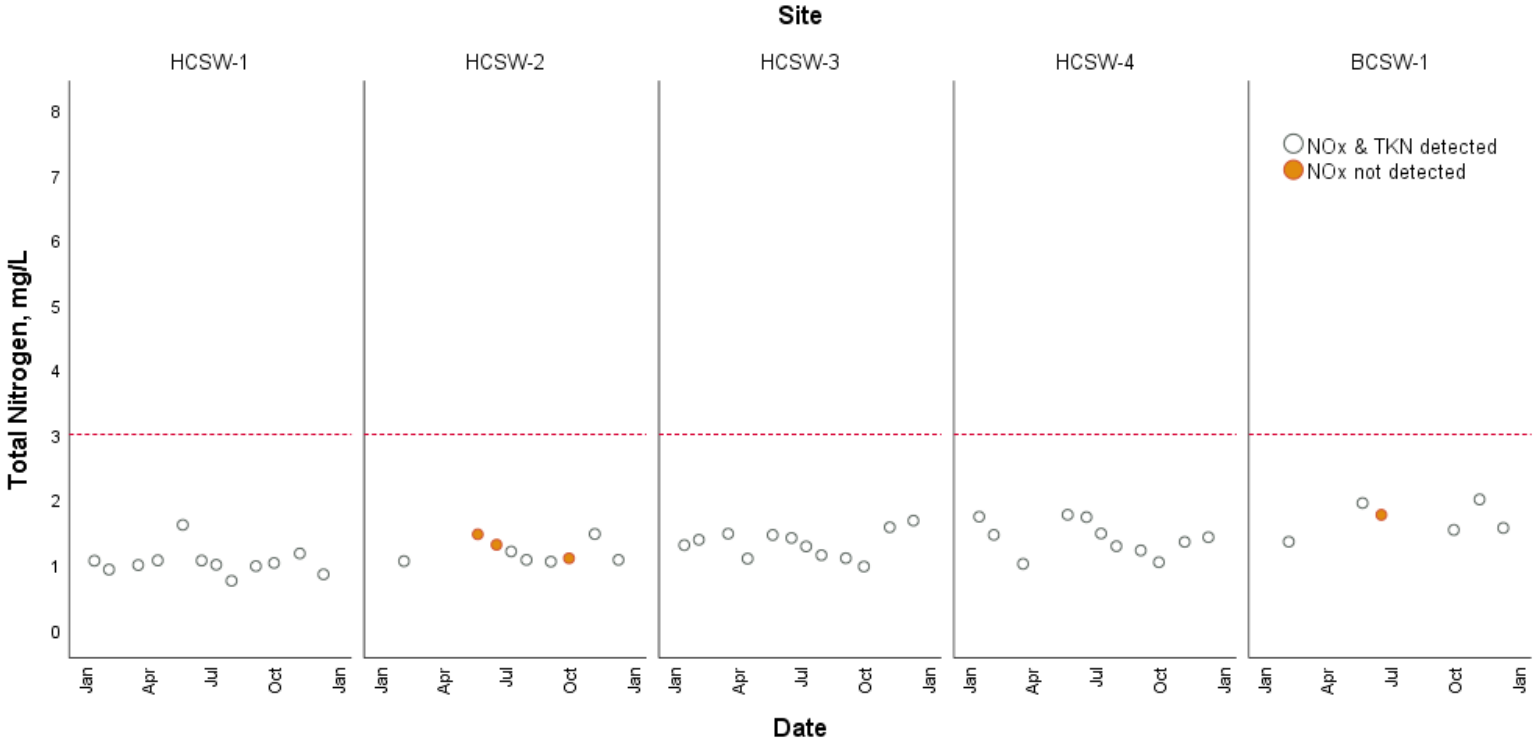
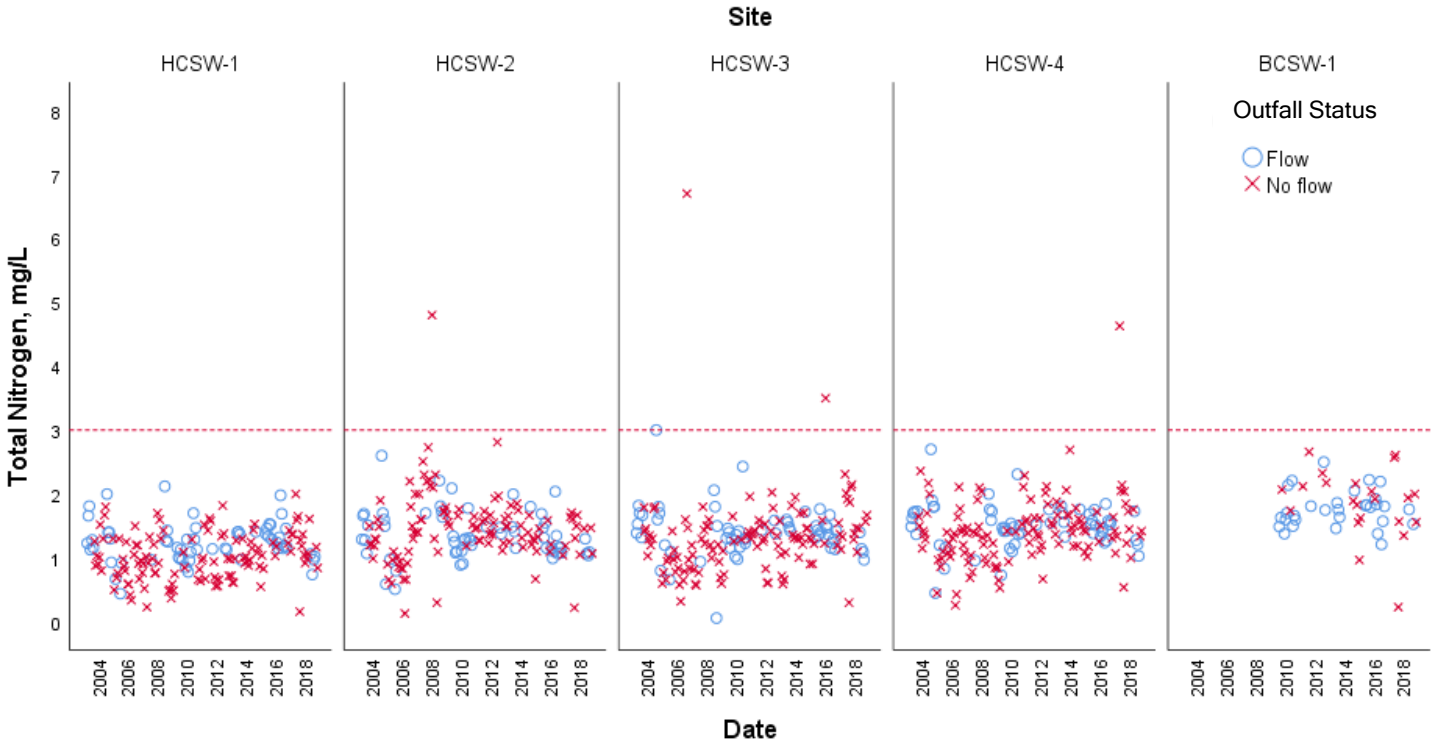


Figure 6-8

POR Total Nitrogen



2018 Total Kjeldahl Nitrogen

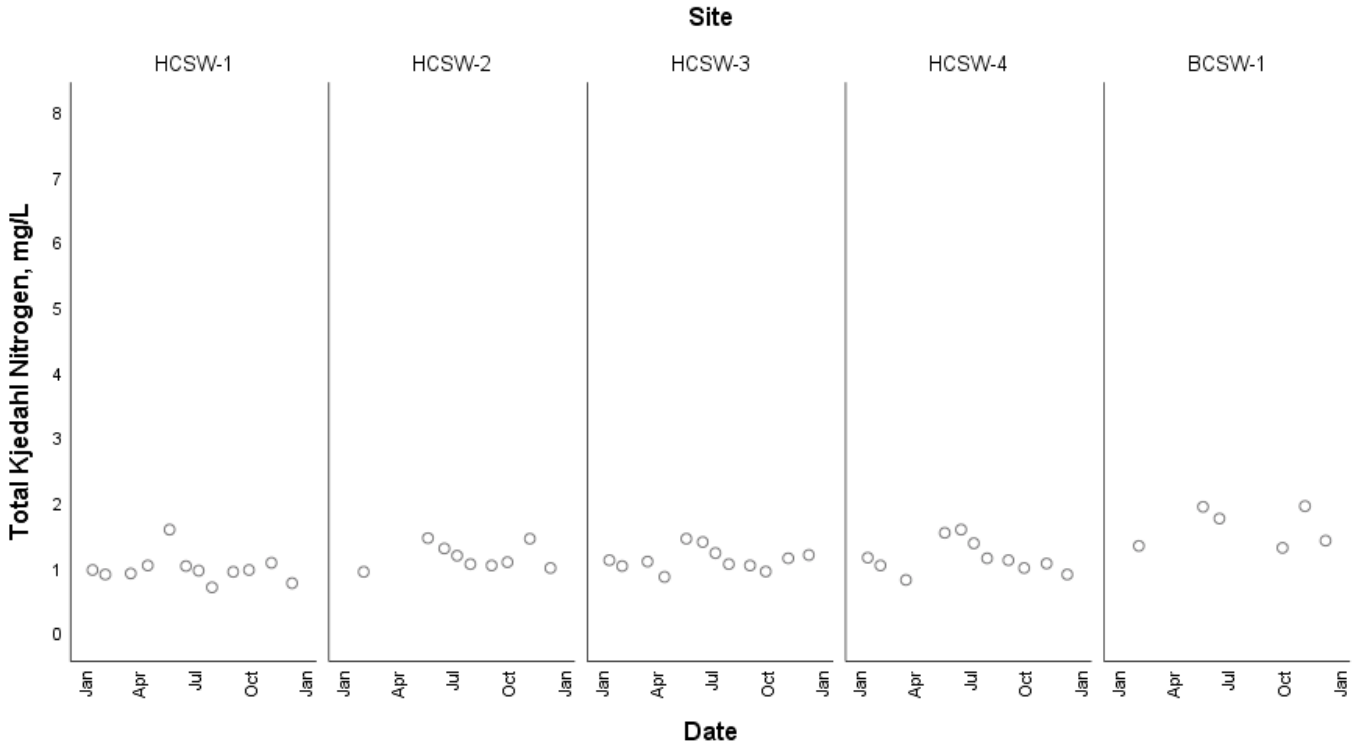
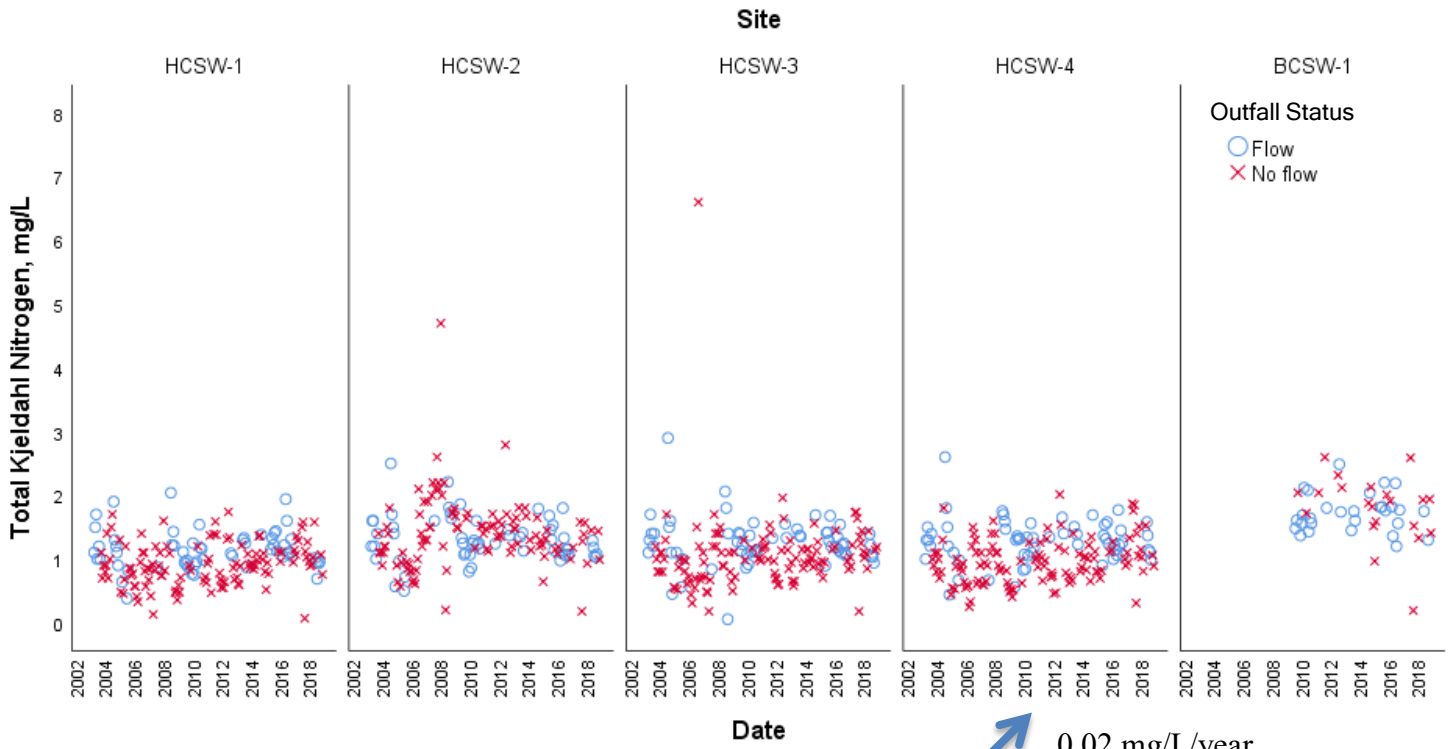


Figure 6-9

POR Total Kjeldahl Nitrogen



0.02 mg/L/year

Figure C-7

2018 Nitrate-Nitrite

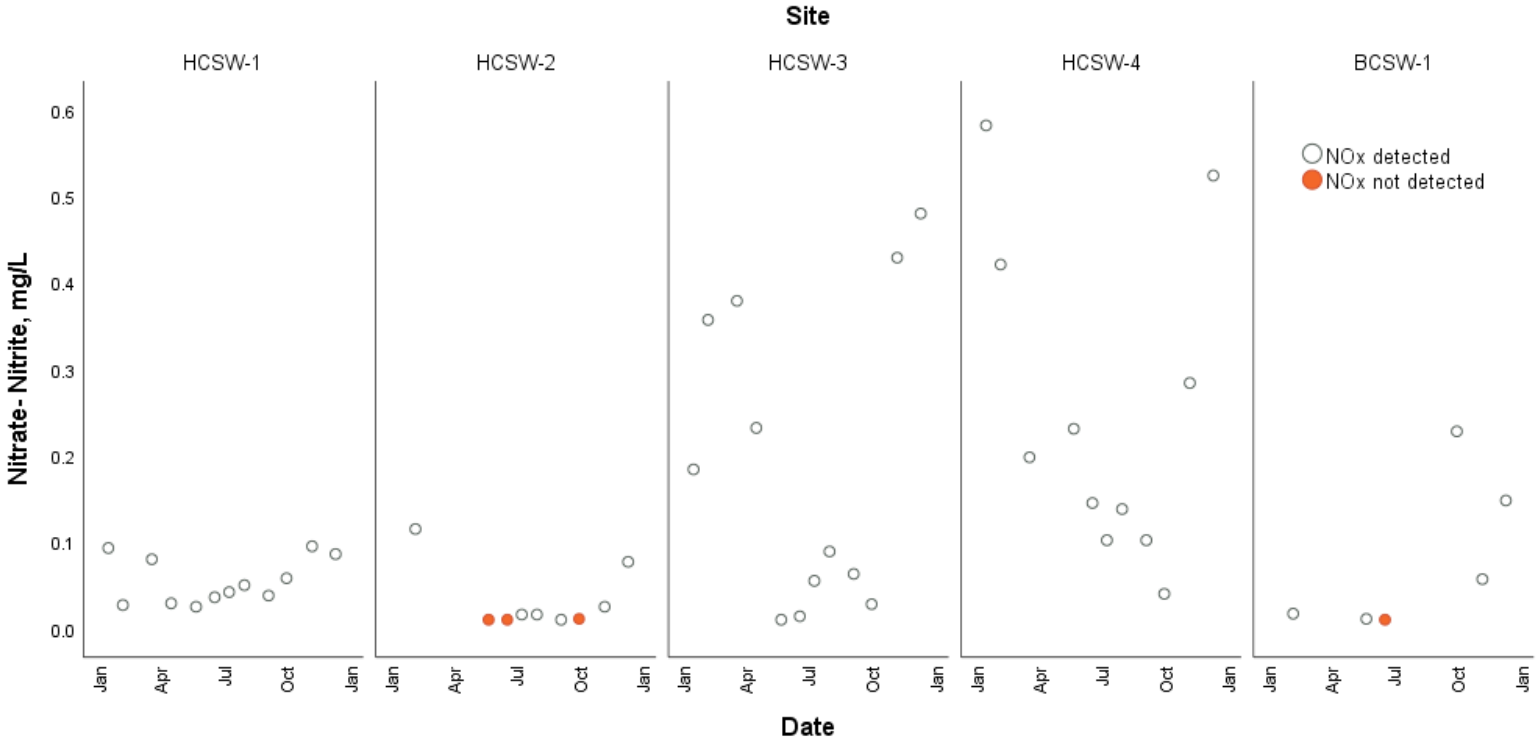
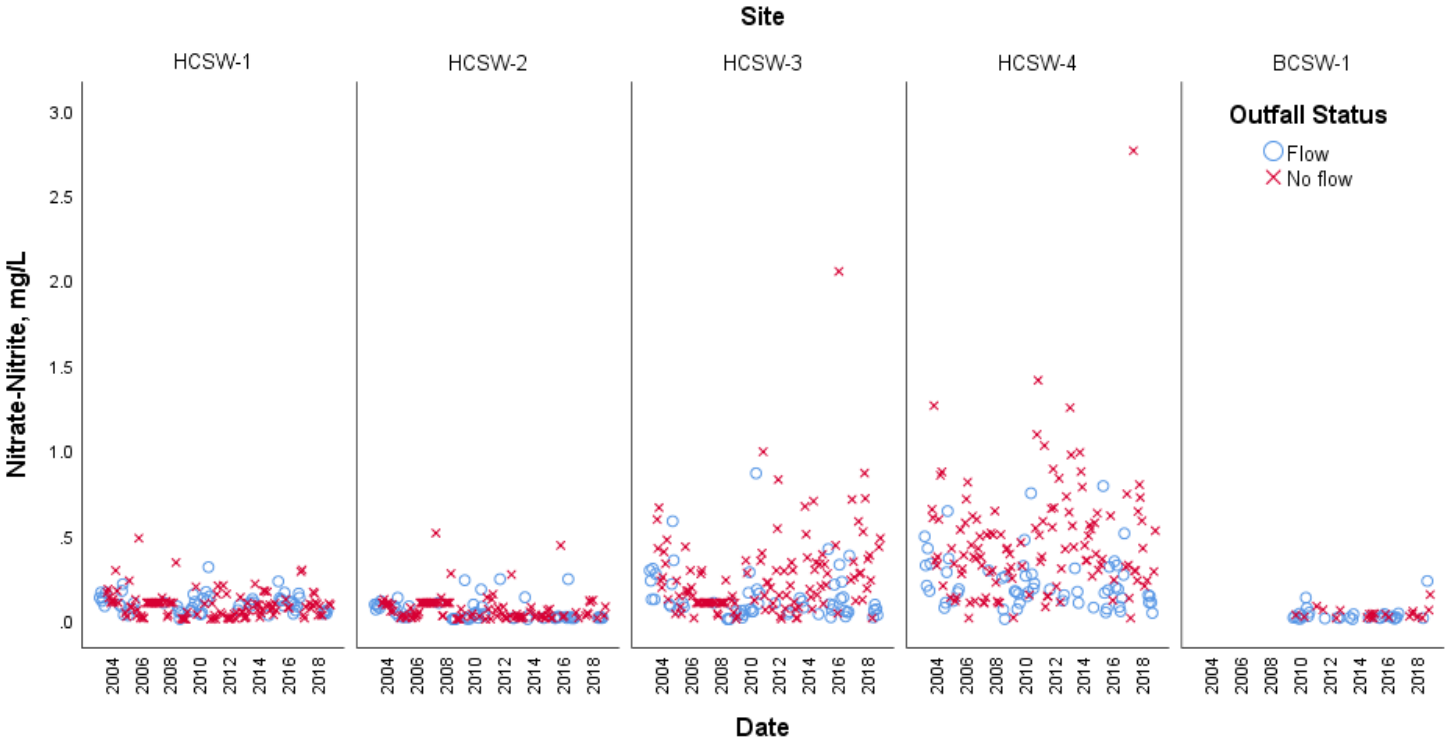


Figure 6-10

POR Nitrate-Nitrite



2018 Total Ammonia

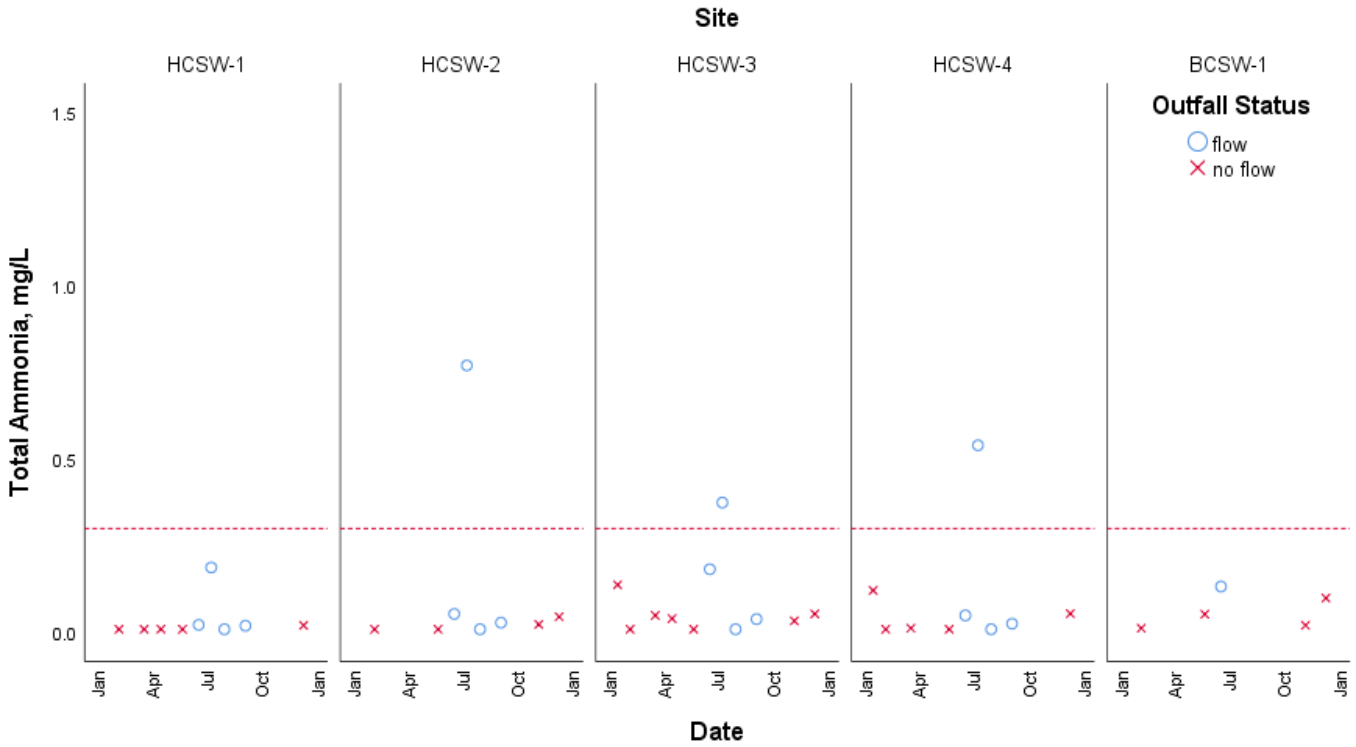
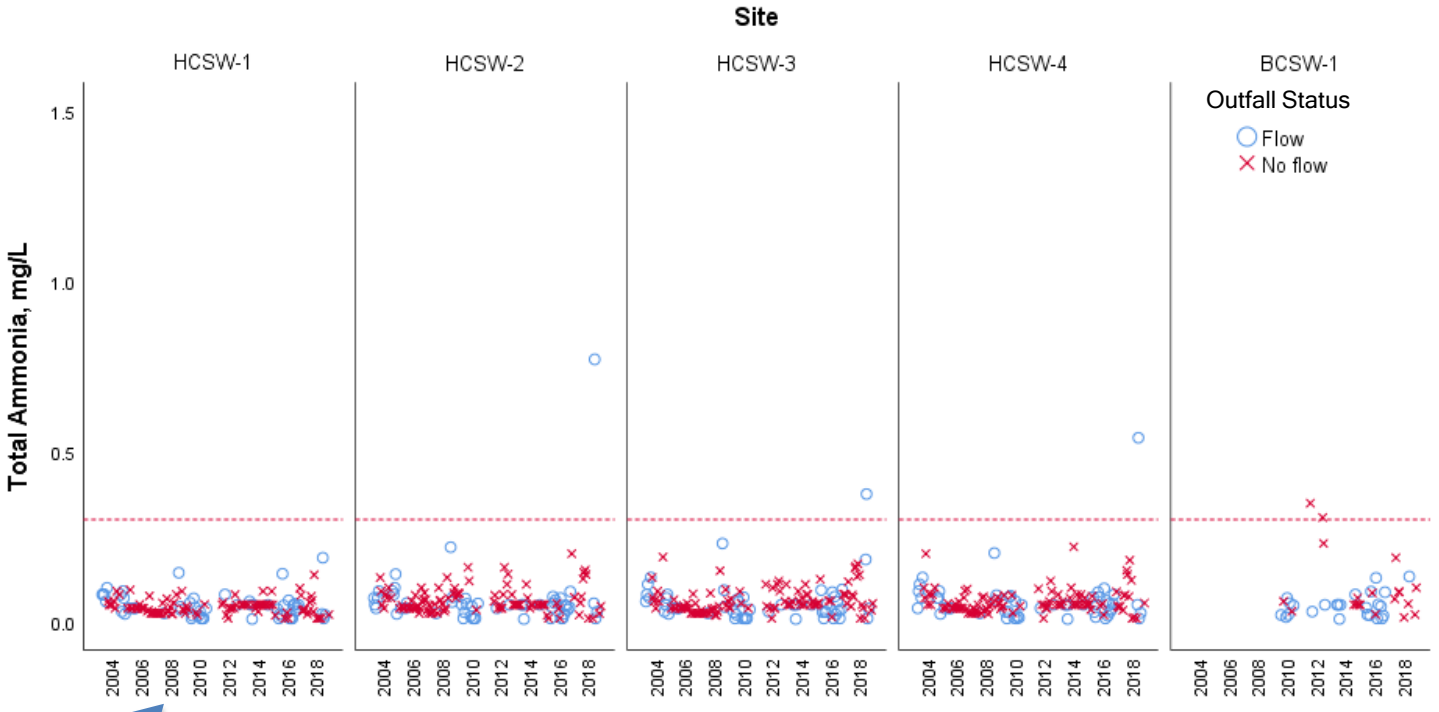


Figure 6-11

POR Total Ammonia



<0.001 mg/L/year

2018 Orthophosphate

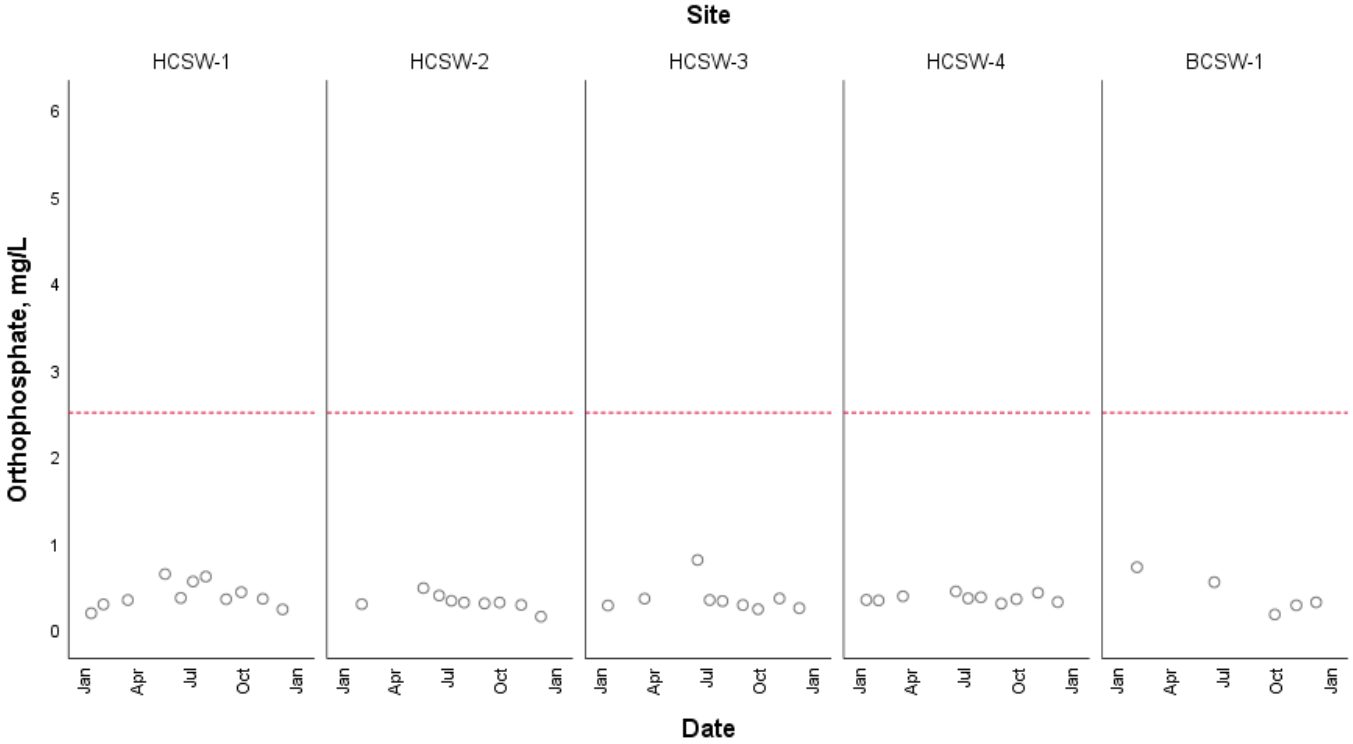


Figure 6-12

POR Orthophosphate

Figure C-10

2018 Chlorophyll-a, corrected

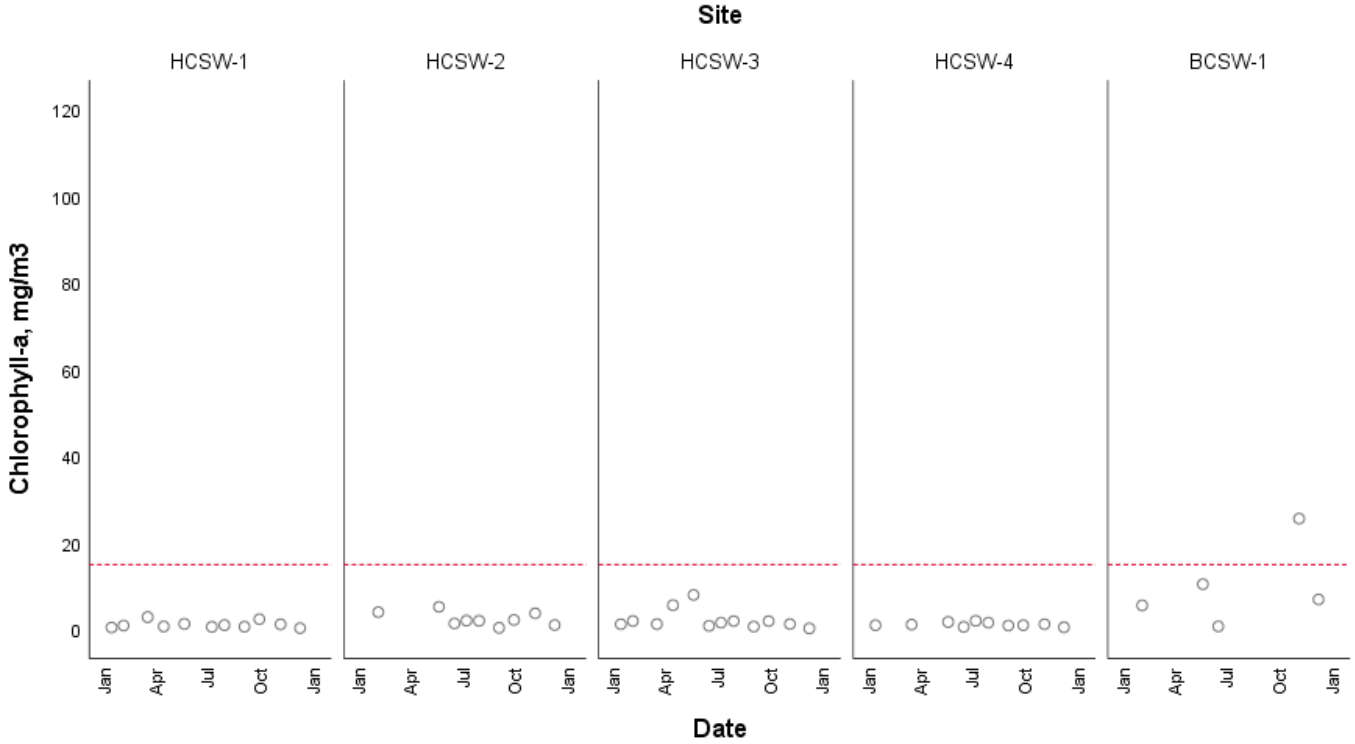
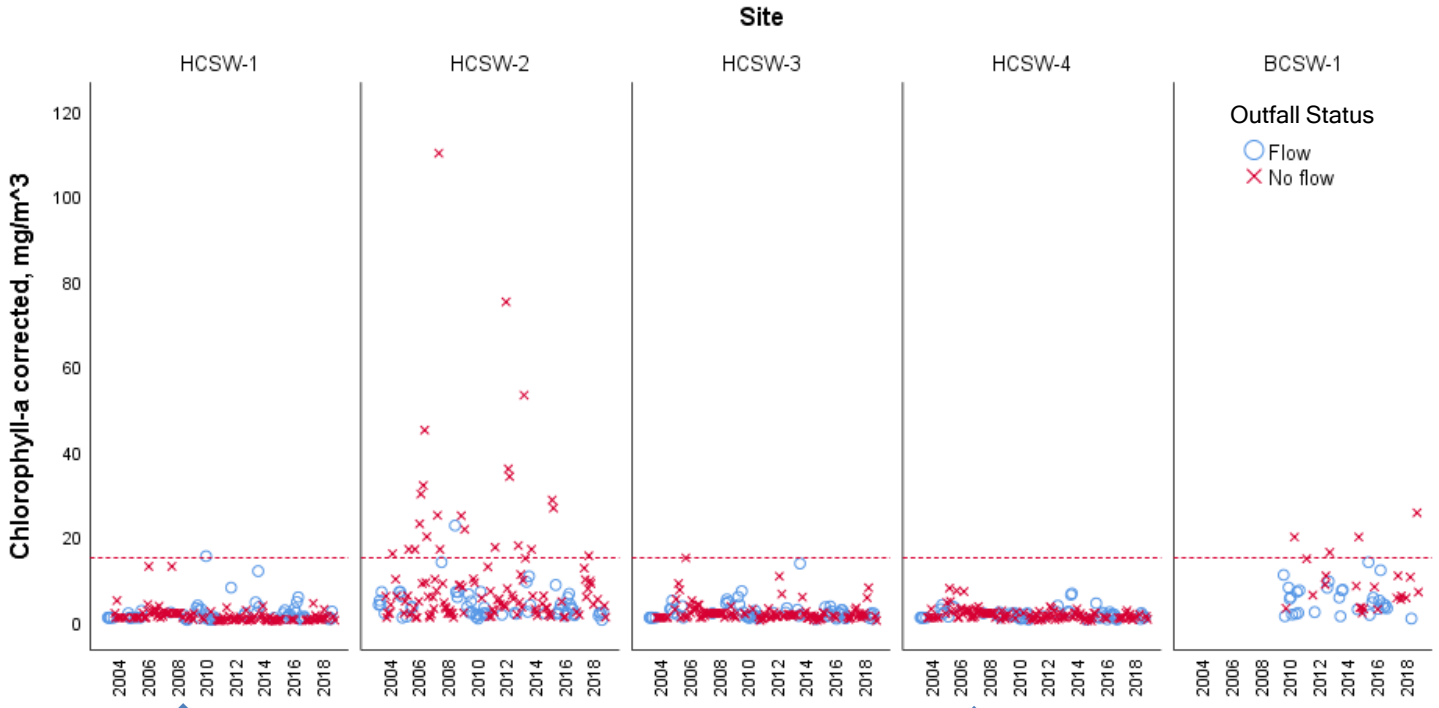


Figure 6-13

POR Chlorophyll-a, corrected



0.03 mg/L/year

0.05 mg/L/year

Figure C-11

2018 Specific Conductivity

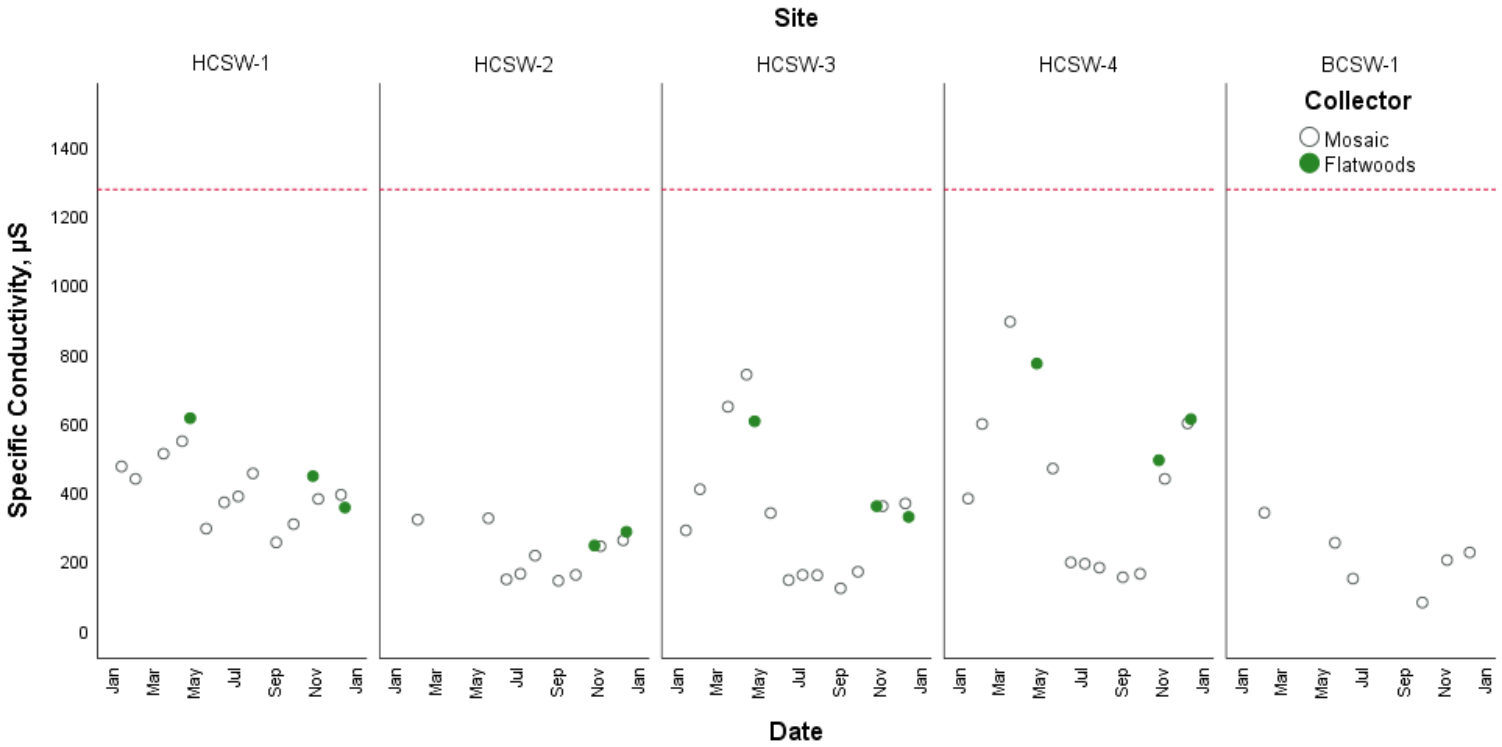


Figure 6-14

Unattended Specific Conductivity and Streamflow at HCSW-1

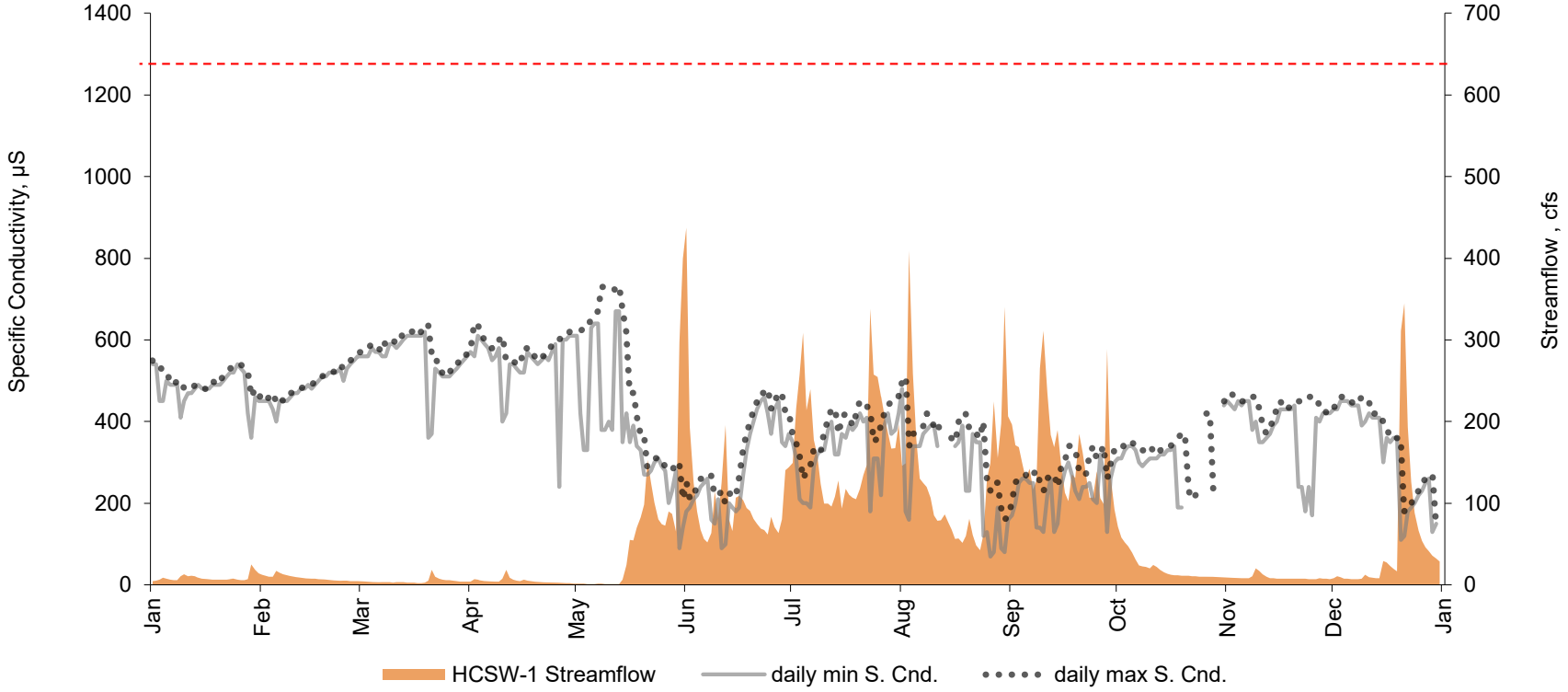
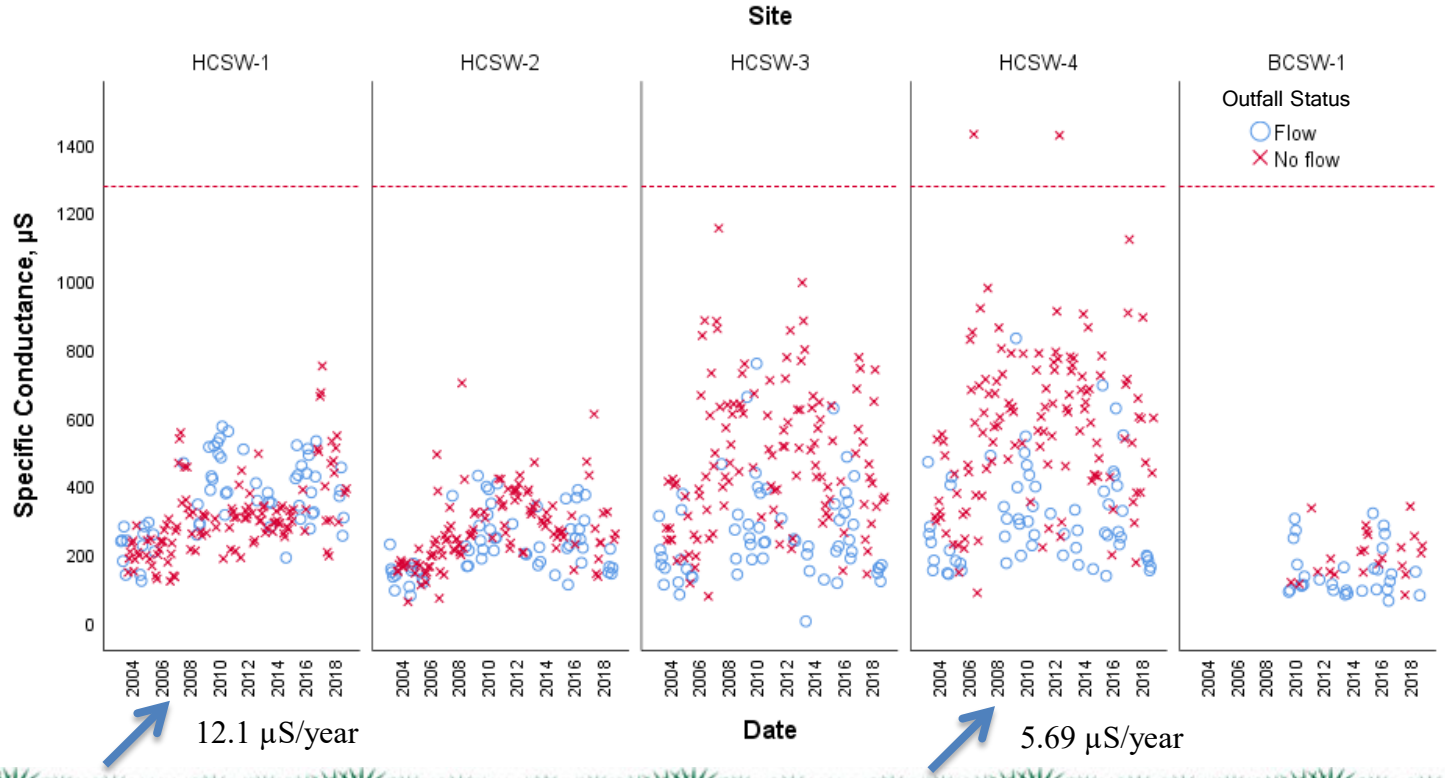


Figure 6-15

POR Specific Conductivity



2018 Dissolved Calcium

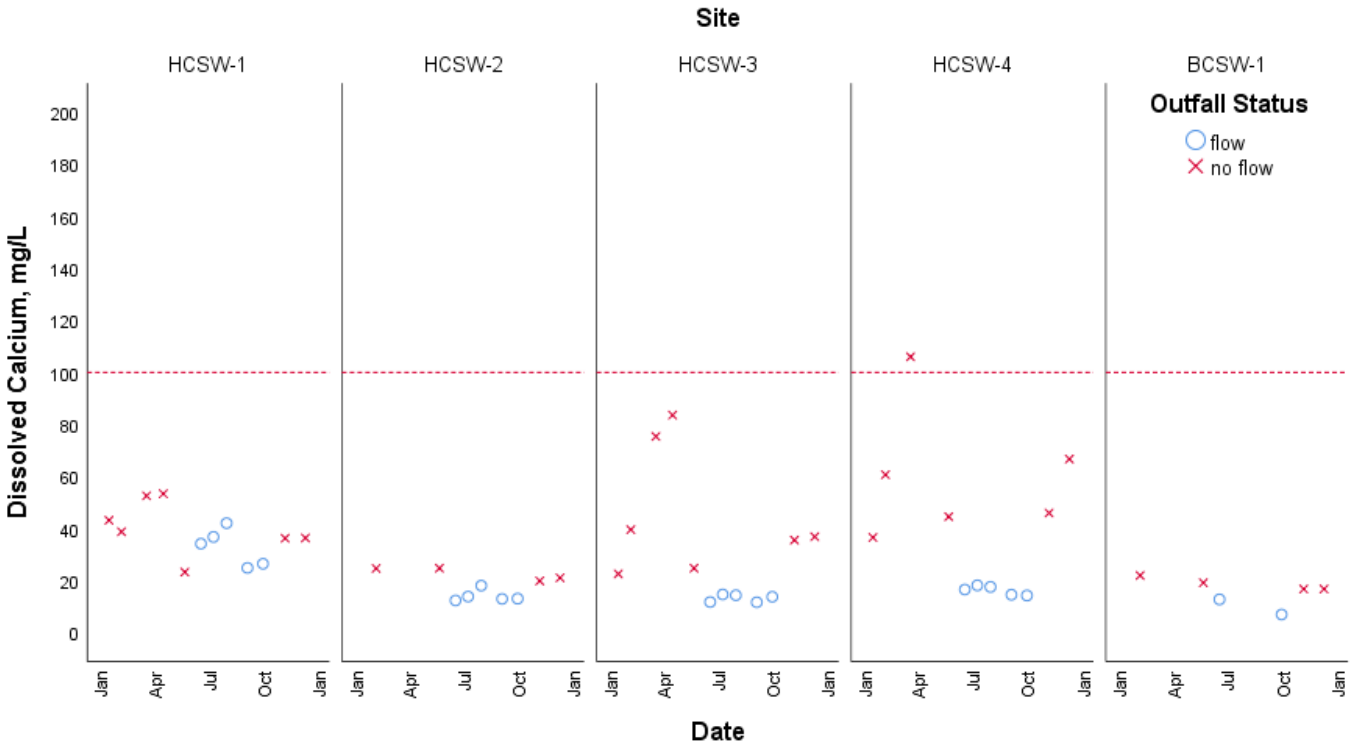


Figure 6-16

POR Dissolved Calcium

1.1 mg/L/year

Figure C-13

2018 Dissolved Iron

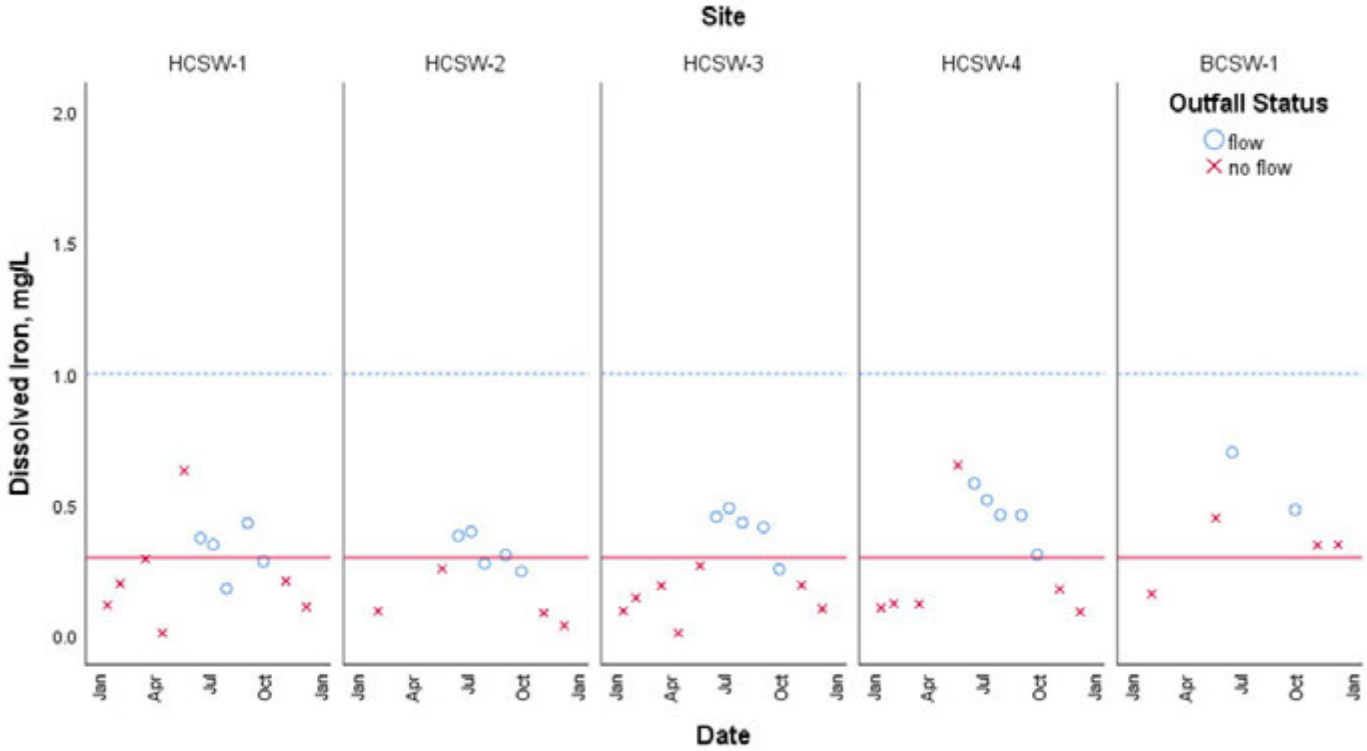
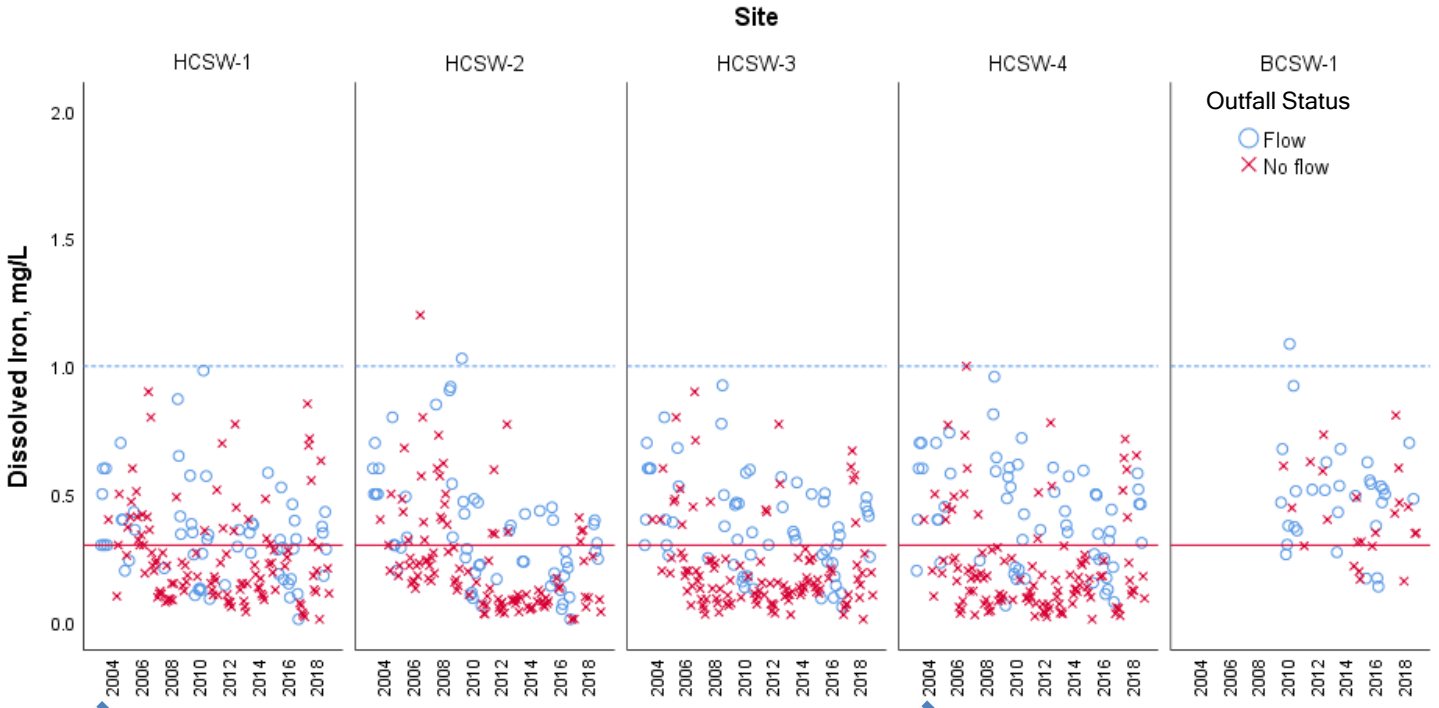


Figure 6-17

POR Dissolved Iron



0.01 mg/L/year

0.01 mg/L/year

Figure C-14

2018 Alkalinity

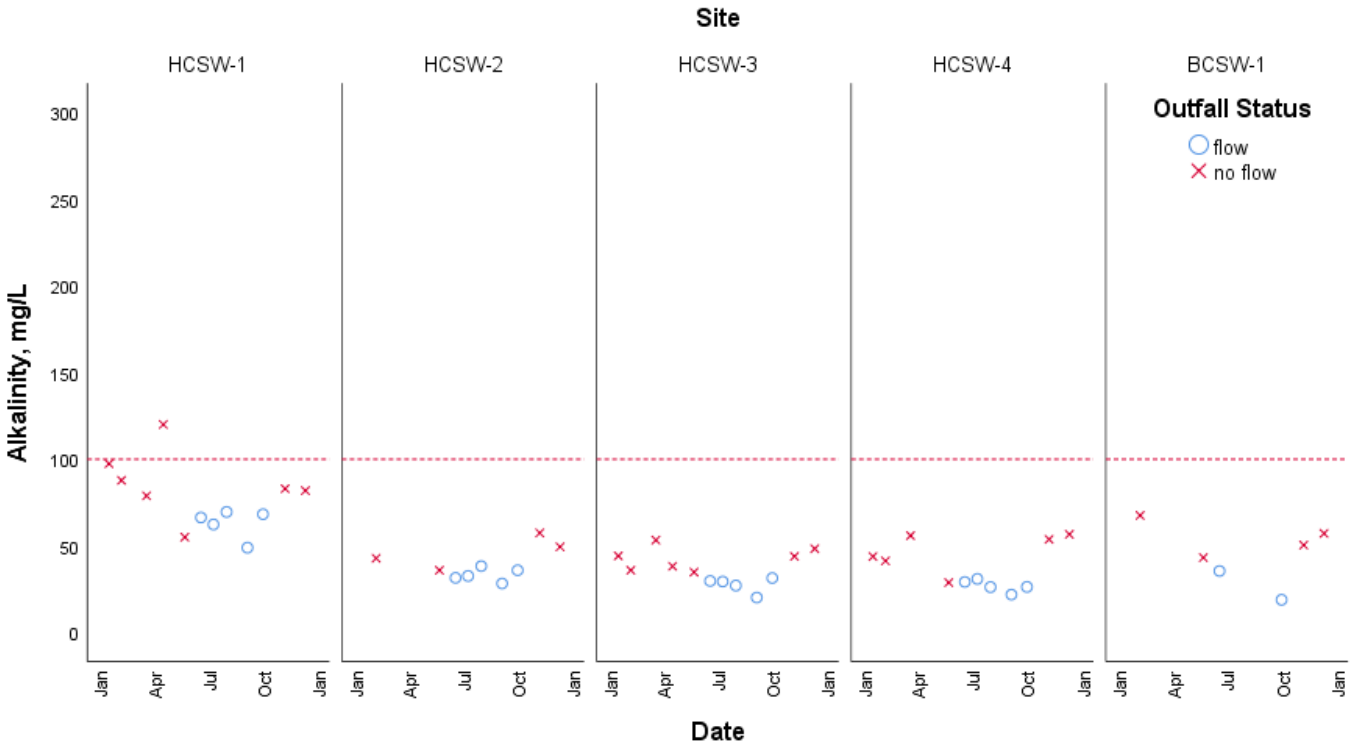
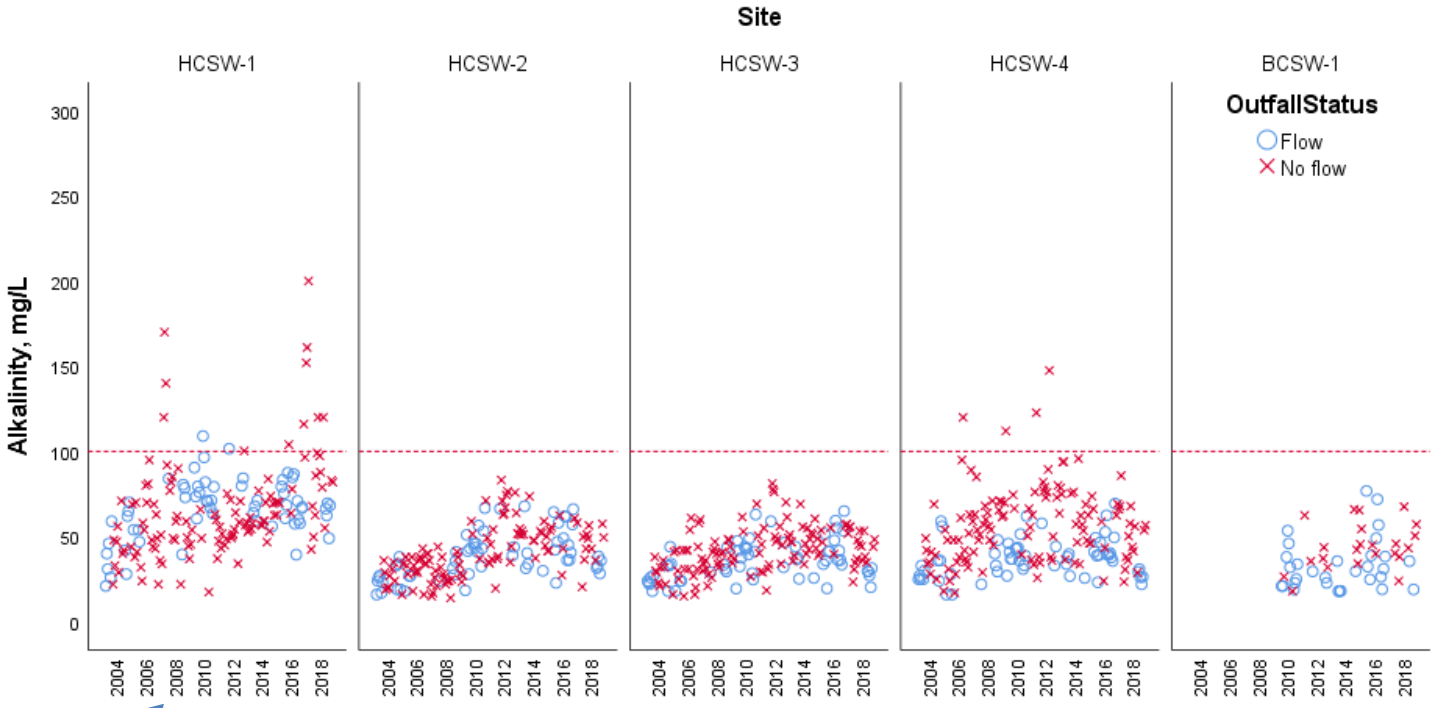


Figure 6-18

POR Alkalinity



2.32 mg/L/year

0.54 mg/L/year

Figure C-15

2018 Chloride

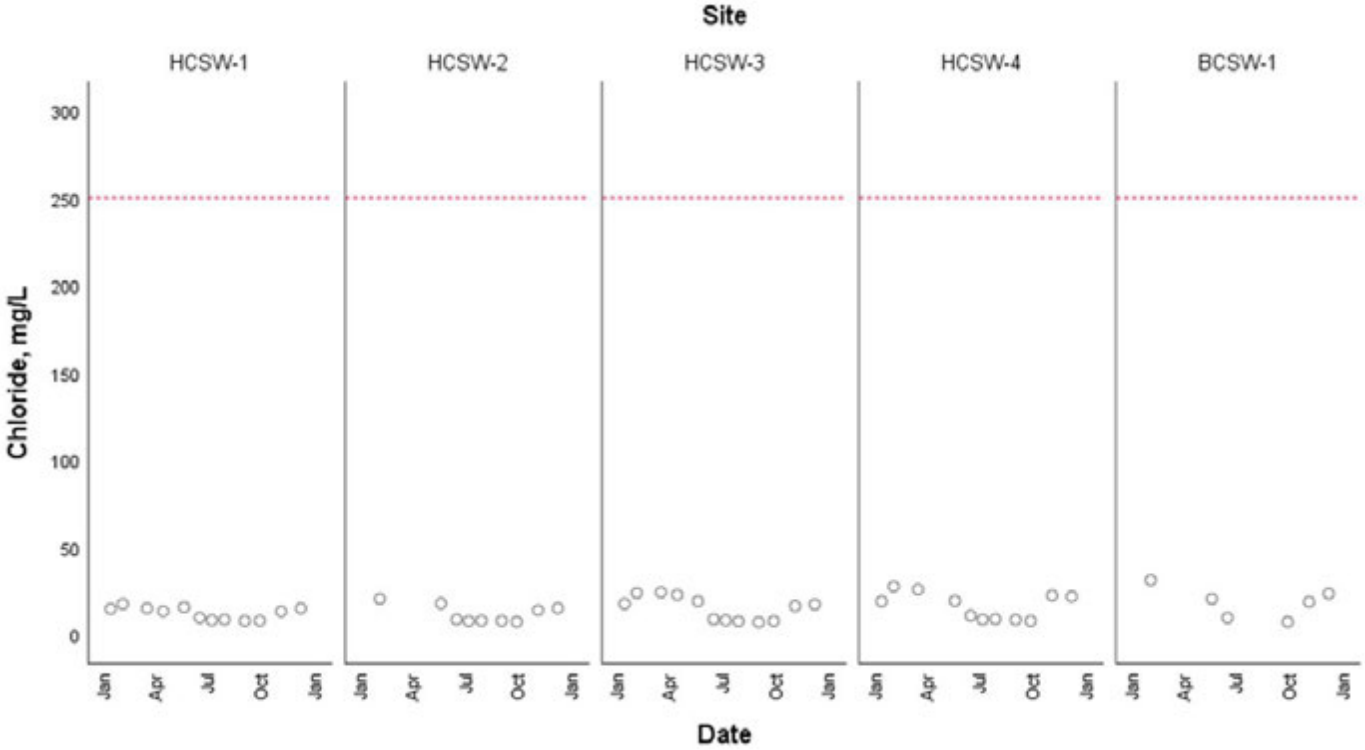
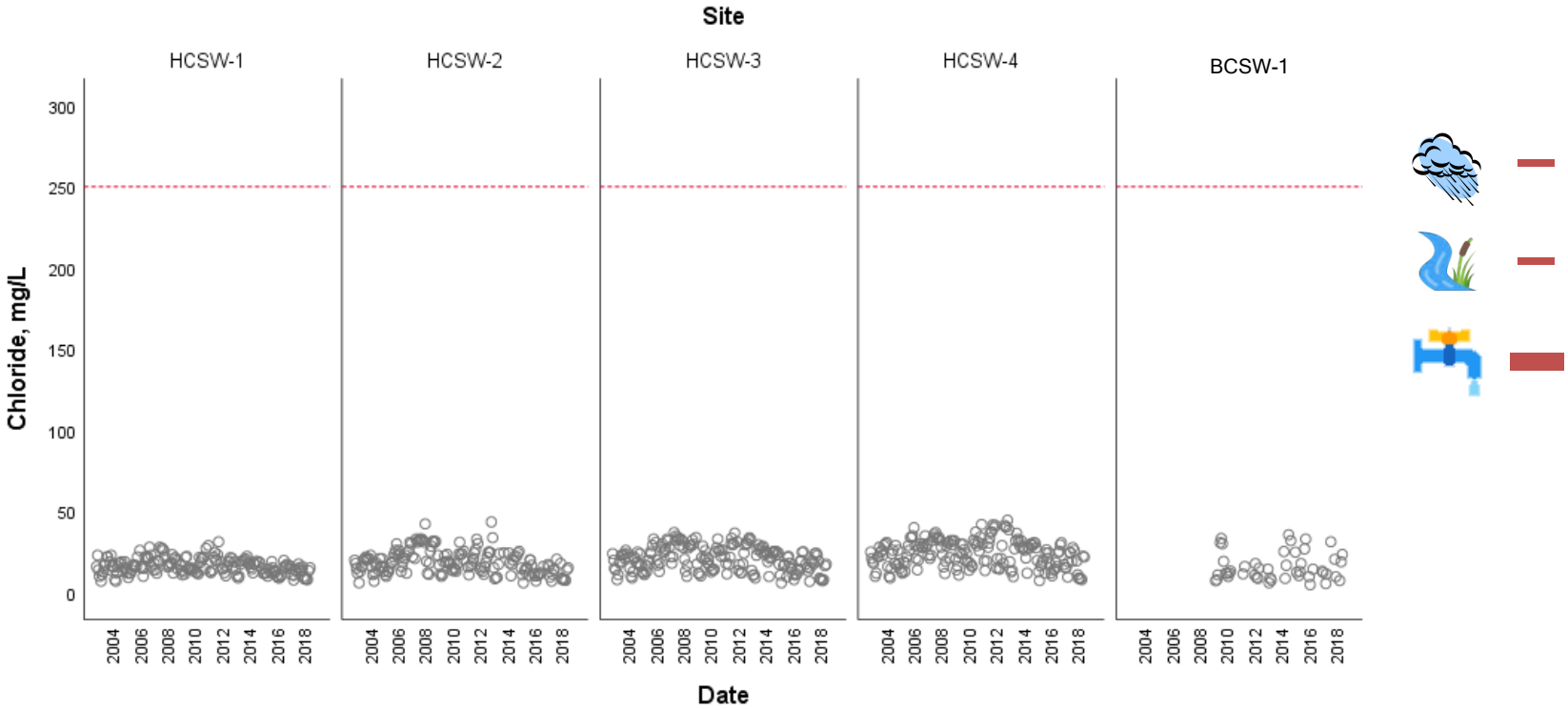


Figure 6-19

POR Chloride



2018 Fluoride

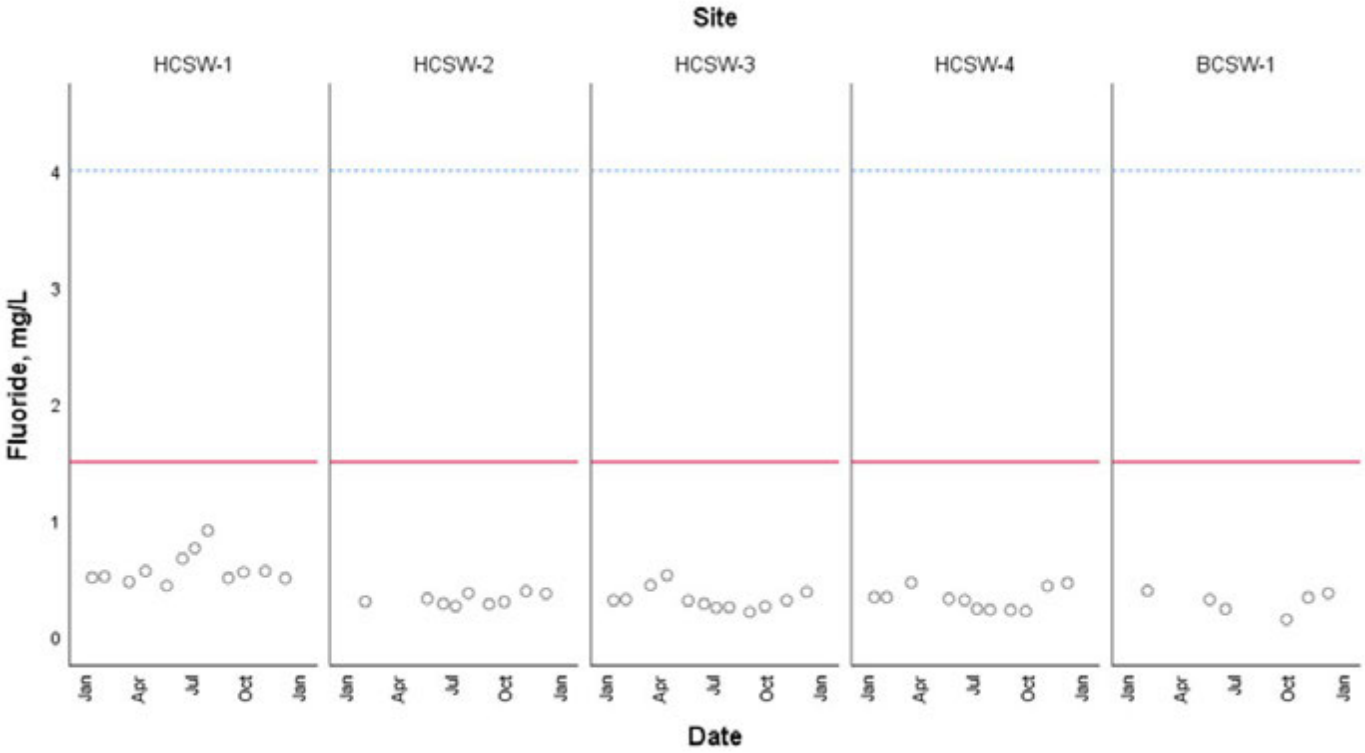
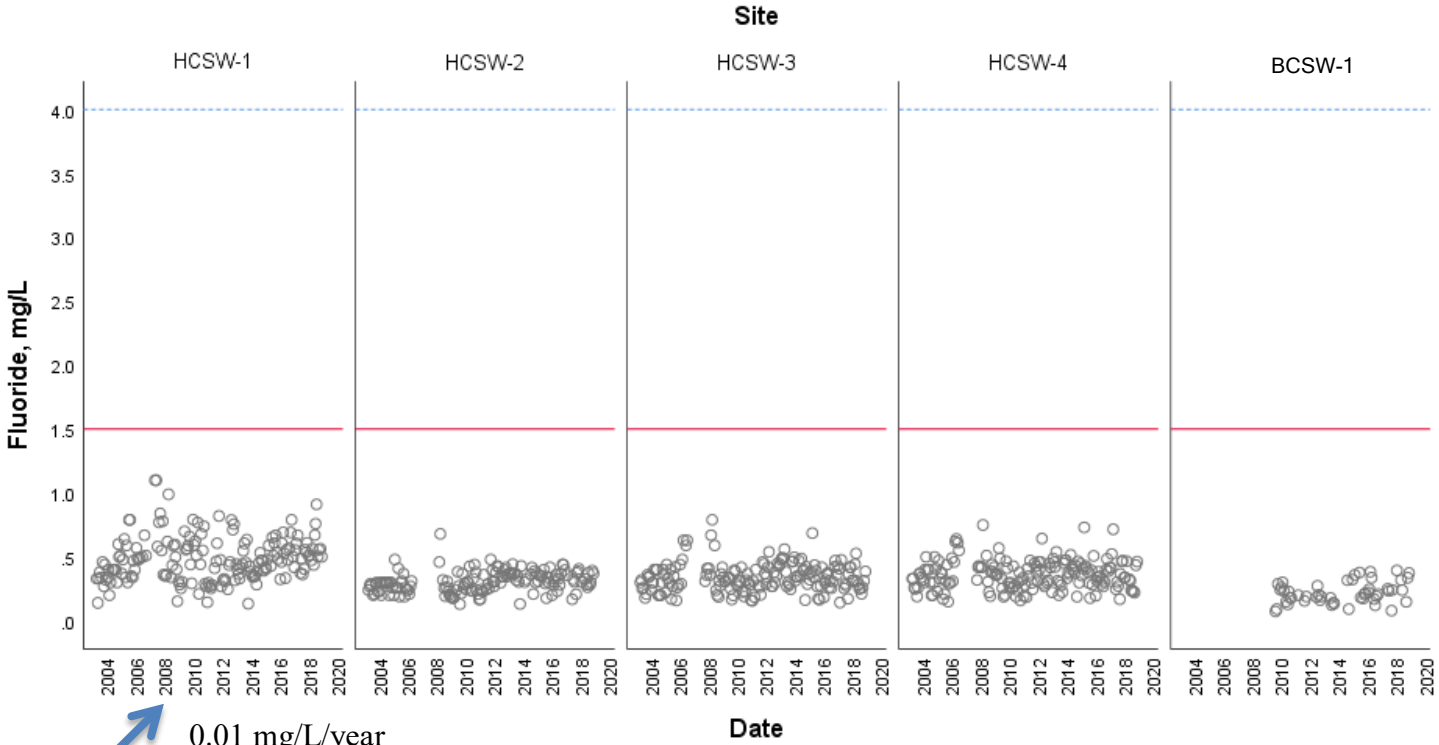


Figure 6-20

POR Fluoride



0.01 mg/L/year

Figure C-17

2018 Sulfate

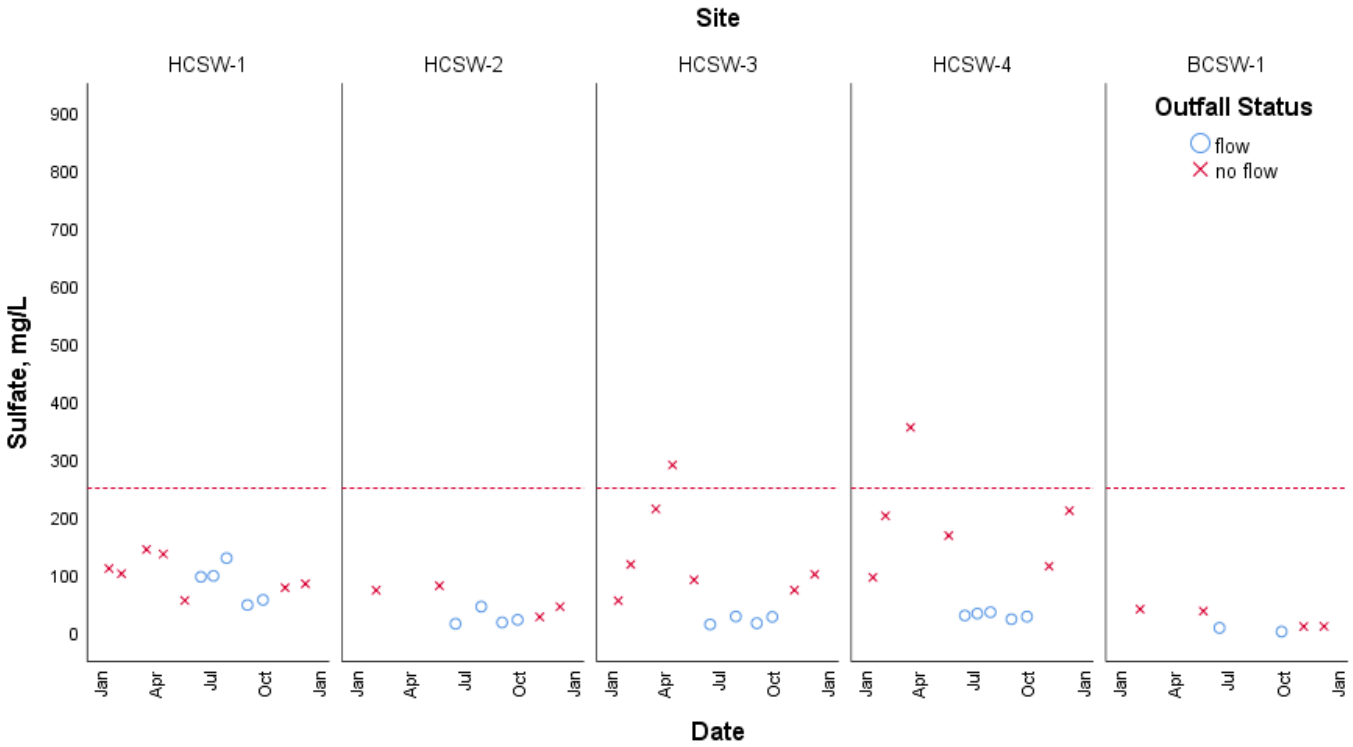
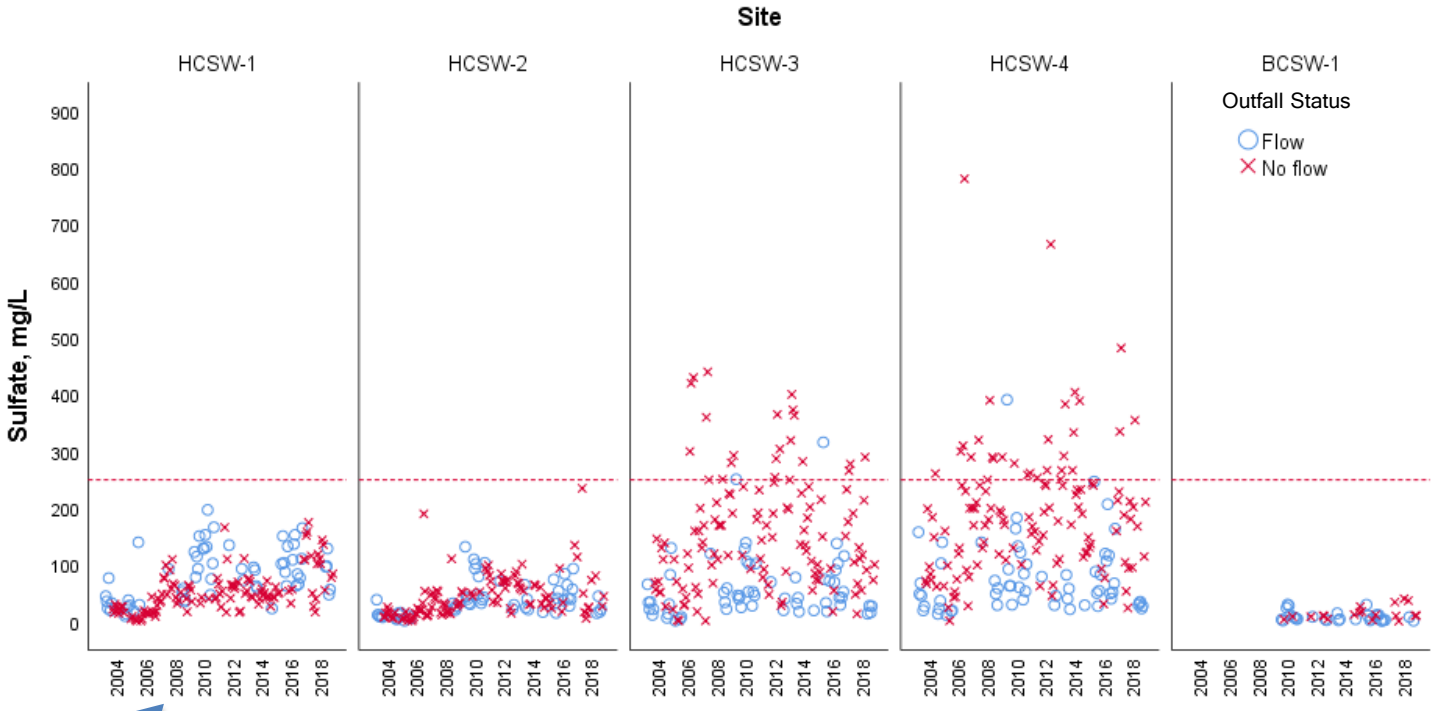


Figure 6-21

POR Sulfate



4.24 mg/L/year

2018 Total Dissolved Solids

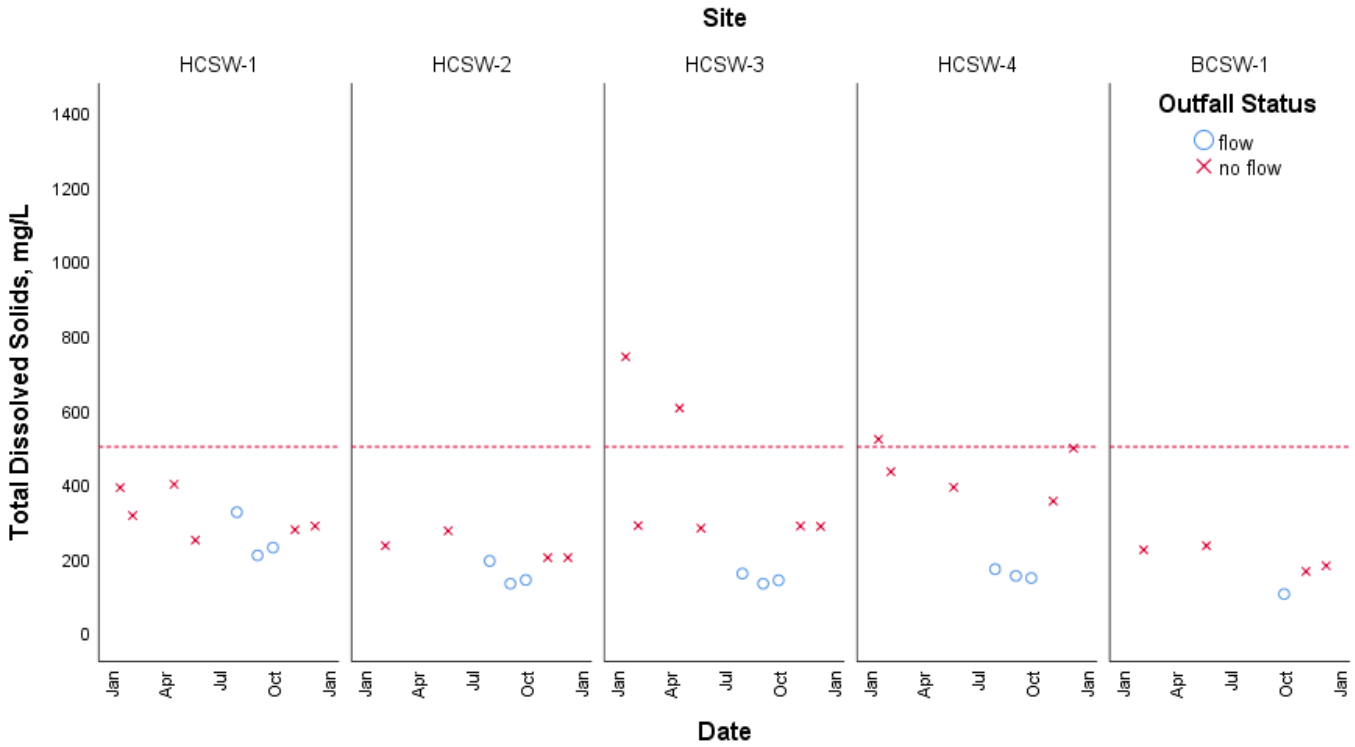
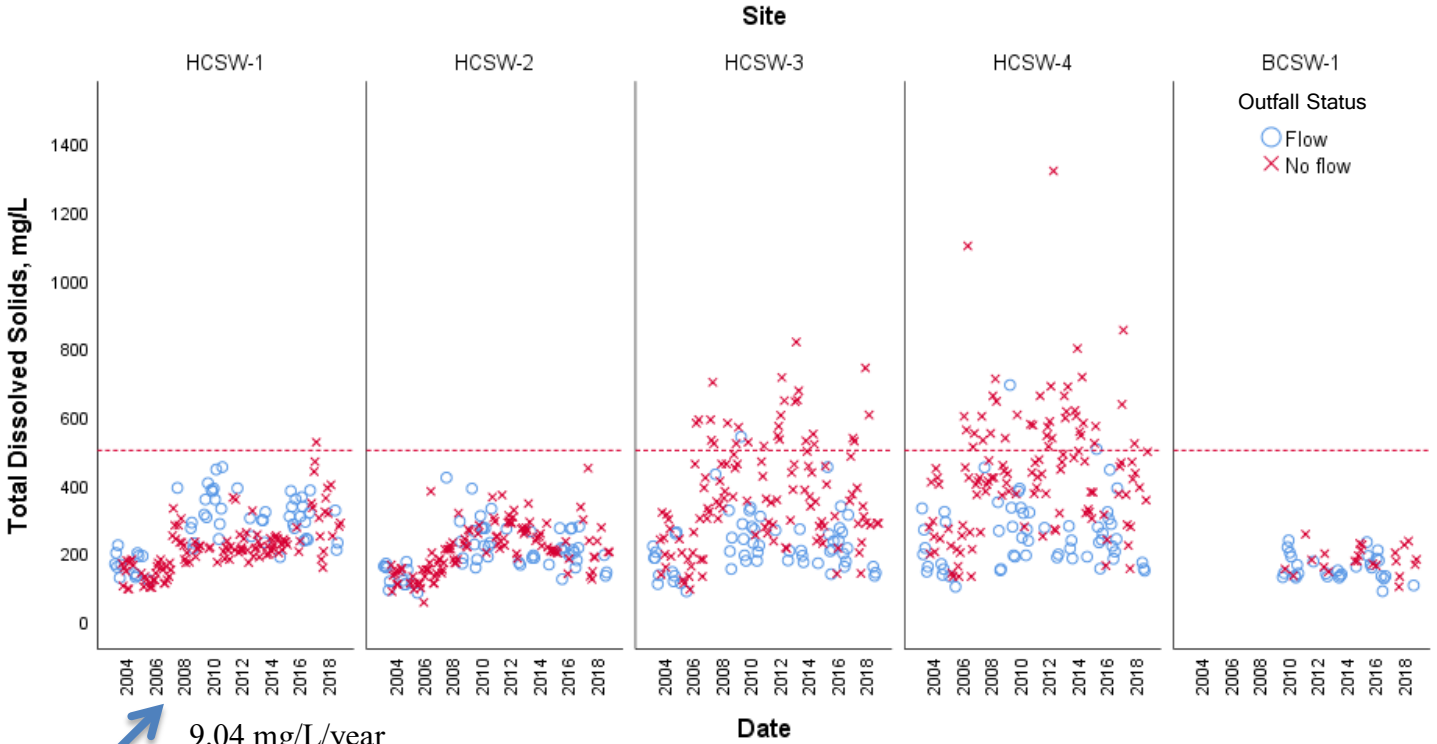


Figure 6-22

POR Total Dissolved Solids



9.04 mg/L/year

2018 Combined Radium

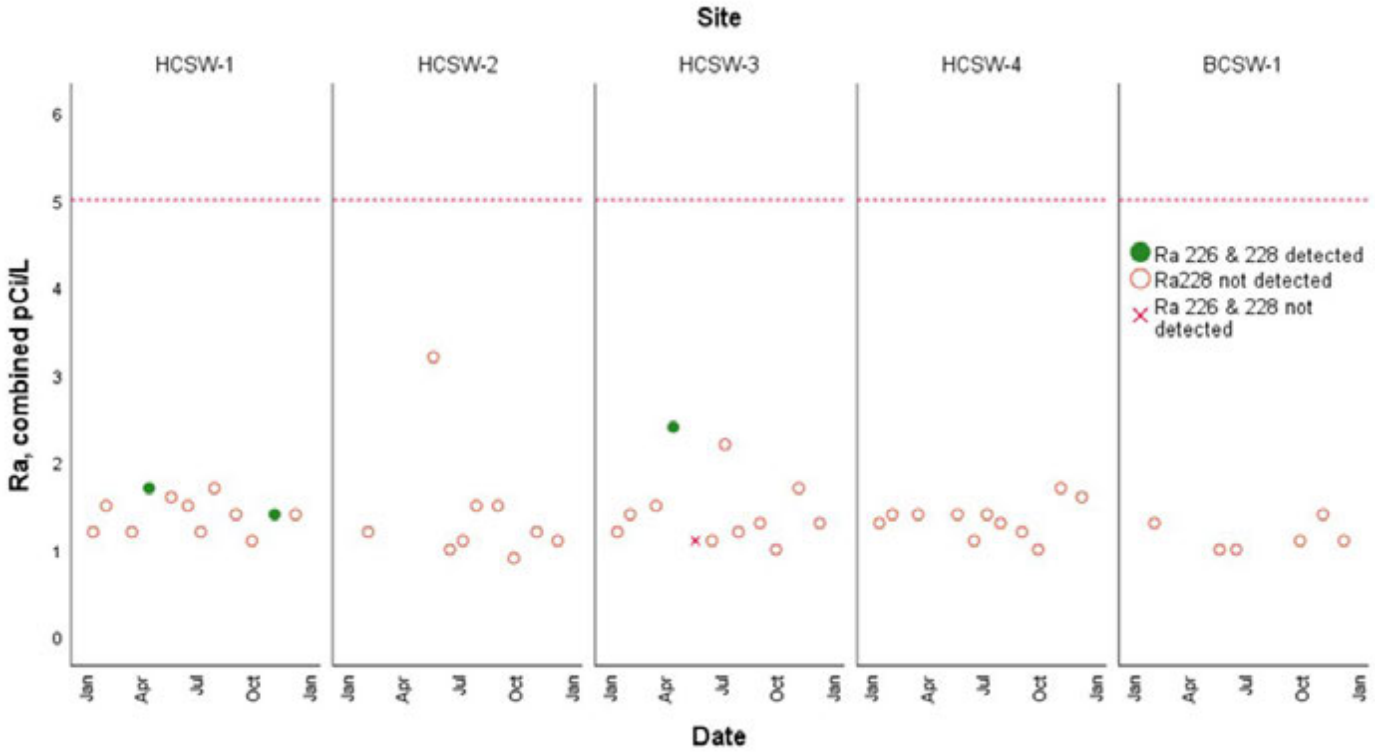
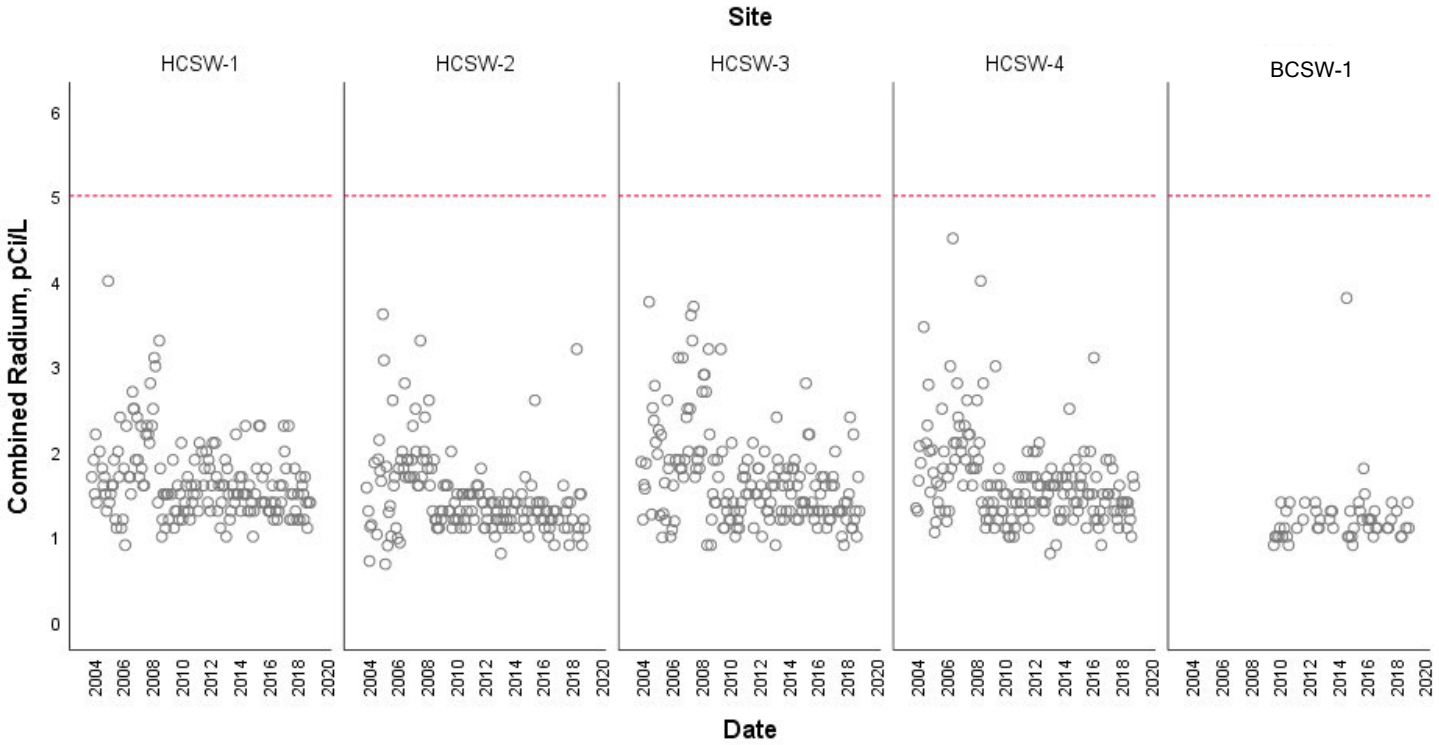


Figure 6-23

POR Combined Radium



Water Quality Conclusion - 2018

- 24 water quality exceedances in 2018
  - 1 at HCSW-1 (Alkalinity)
  - 6 at HCSW-2 (D[illegible] (5) and NH_3 (1))
  - 6 at HCSW-3 (D[illegible] (2), TDS (2), SO_4 (1), and NH_3 (1))
  - 11 at HCSW-4 (F[illegible] (6), SO_4 (1), NH_3 (1), TDS (2), and Ca(1))
- Site closest to outfalls has the least number exceedances.
- HCSW-2 unlike other sites due to upstream impoundment and prairie. Longer residence time, periods of reduced or no water velocity, thick anaerobic organic benthic layer
- NH_3 exceedances were F-qualified, Field blank > trigger value, and HCSW-1< trigger value
- HCSW-4 Fe similar to other sites but site has a lower trigger level
- HCSW-1 alkalinity exceedance occurred 495 days after the last discharge
- SO_4, TDS, and Ca exceedances occurred only at sites in lower basin
- SO_4, TDS, Ca, and specific conductance trend was detected 2003-2018 - discussed in impact assessment

Water Quality Conclusion at HCSW-1

- 326 exceedances, 13 parameters, all sites, POR
  - 18, 73, 72, and 163 exceedances at HCSW-1, HCSW-2, HCSW-3, and HCSW-4, respectively
- HCSW-1: 13 Alkalinity, 1 Chlorophyll-a, 1 Color, 2 pH, and 1 TDS
  - 3 of 18 occurred concurrently with NPDES discharge

Date	Analyte	Concentration	Trigger Level	NPDES, cfs
1/5/2010	Alkalinity (mg/L)	109	100	34.5
2/2/2010	Chlorophyll-a (mg/m^3)	15.4	15	51.6
10/24/2011	Alkalinity (mg/L)	102	100	42.3

2018 Impact Assessment

FLATWOODS
Consulting Group

Impact Assessment - TDS, SO_4 & Ca

2018 Impact Assessment:

- Part 1: Historical analysis of TDS, calcium, and sulfate
  - The objective was to determine if Mosaic activities in the Upper Horse Creek Basin were contributing to the TDS, dissolved calcium, and sulfate exceedances documented in the HCSP

- Part 2: Ambient water quality assessment measuring TDS, calcium, and sulfate in neighboring streams not affected by mining against variable flow conditions
  - Hypothesis: elevated values occur under low-flow conditions

Data Sources

- Existing historical groundwater data collected through Mosaic's Hydrogeologic Investigation and Monitoring Plan of Study (HIMPOS)
- Wastewater data from Mosaic's National Pollutant Discharge Elimination System (NPDES) Discharge Monitoring Report (DMR) data
- Flow data collected by United States Geological Survey (USGS) gauging stations
- Surface water data from the HCSP and the State of Florida's Impaired Waters Rule (IWR) database - Run 54
- Upper and Lower Horse Creek basins were characterized and scored using the Landscape Development Intensity Index (LDI) and SWFWMD land use shapefiles (1990, 1999, & 2011)
  - LDI calculated across entire watershed instead of typical 100m buffer of upstream reach

Dominant ions

- Average molar concentrations of each ion in the upper and lower Horse Creek basins:
  - $CaCO_3$, Na^+ and Ca^{2+} most abundant ions in upper basin
  - $CaCO_3$, SO_4^{2-} and Ca^{2+} most abundant ions in lower basin

- Average ionic concentrations are elevated in the lower basin relative to the upper basin, with the exception of Na^+

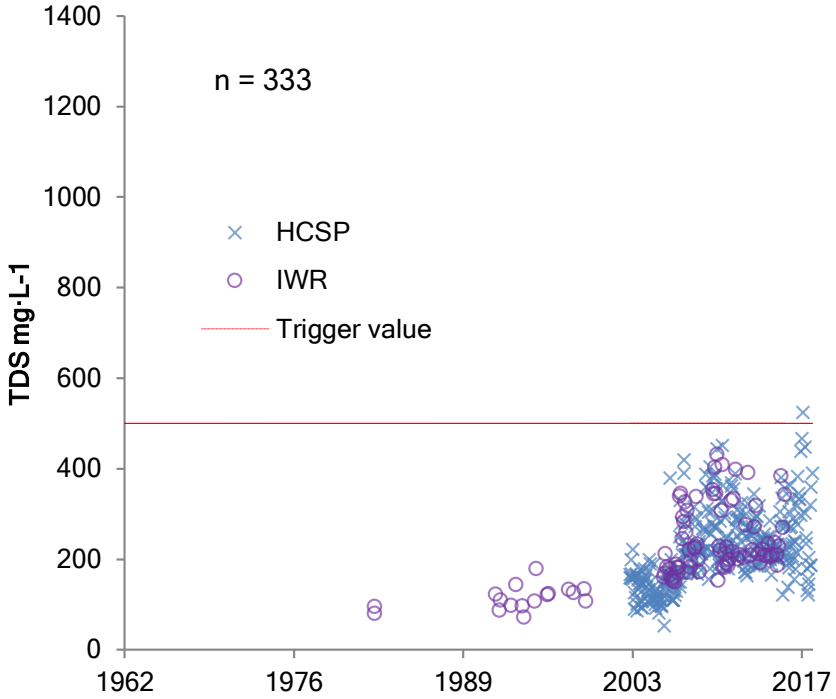
- Suggests that there are different processes and/or contributions driving water chemistry in the two basins

Time and Location of Exceedances

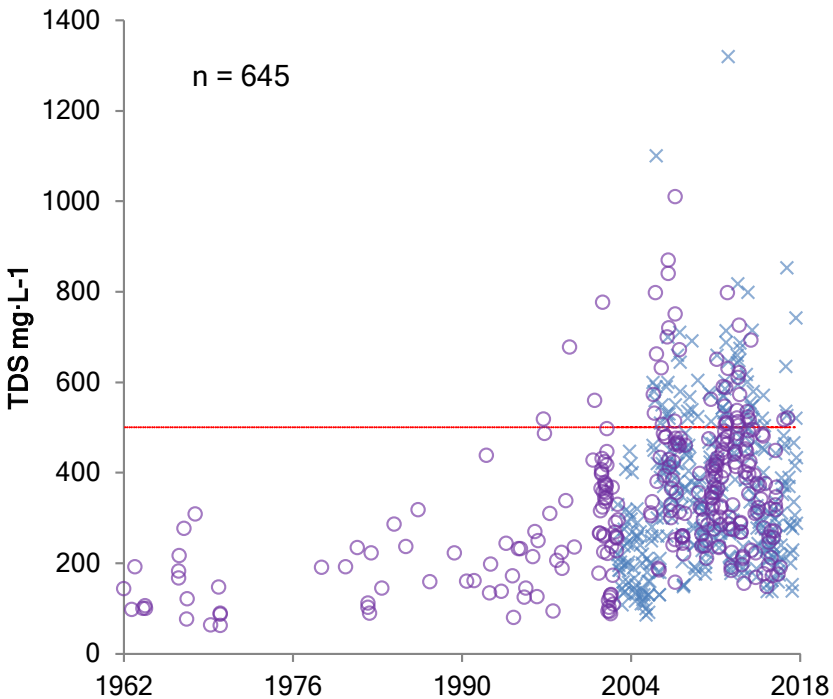
- Wingate and Fort Green Mines and their respective outfalls are upstream of all four monitoring stations
- Wingate D-004 outfall is ~4.2 miles downstream of Fort Green D-003 outfall
- HCSW-1 closest to and ~5.5 downstream of Wingate D-004
  - HCSW-1 is the closest representation to the full impact of the outfalls
- Pre-mining exceedances first occurred in 1997 and 1999 all in the Lower Basin
- Exceedances in the Lower Basin have become more frequent since the mid-2000s
- First and only exceedance (TDS, SO_4, or Ca) in the Upper Basin was April 11, 2017 (TDS only)
  - Prior to that exceedance, most recent NPDES discharge through the outfalls occurred 124 days earlier
  - Stream flow consisted of no effluent, no surface runoff, and 100% groundwater seepage

	HCSW-1	HCSW-2	HCSW-3	HCSW-4
Number of combined (TDS, calcium and sulfate) exceedances, period of record	1	0	60	144
Date of first recorded exceedance	4/11/2017	NA	3/28/2006	3/6/1997

Total Dissolved Solids, POR

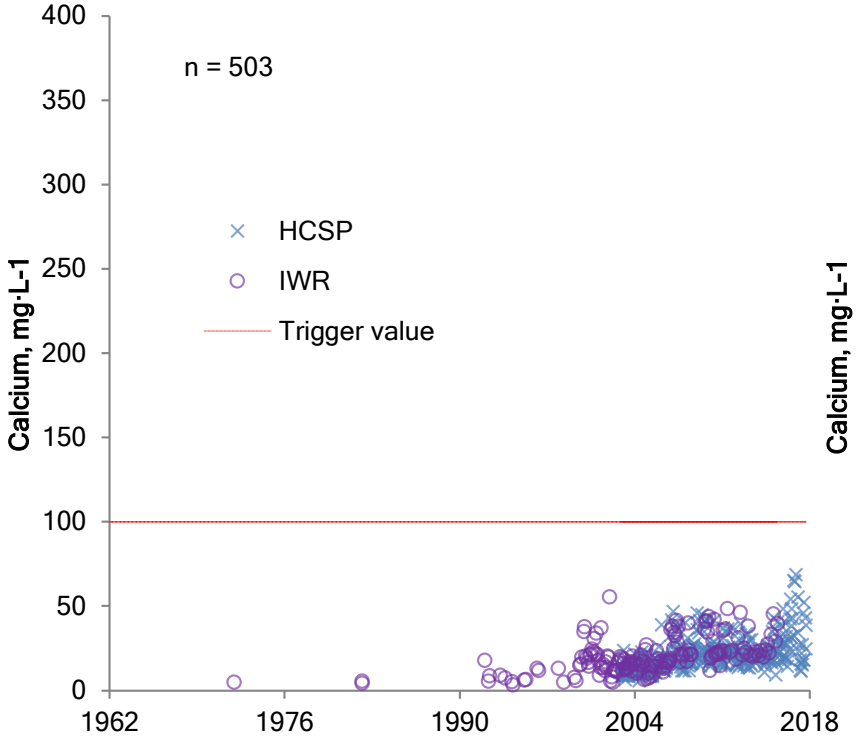


Upper Horse Creek

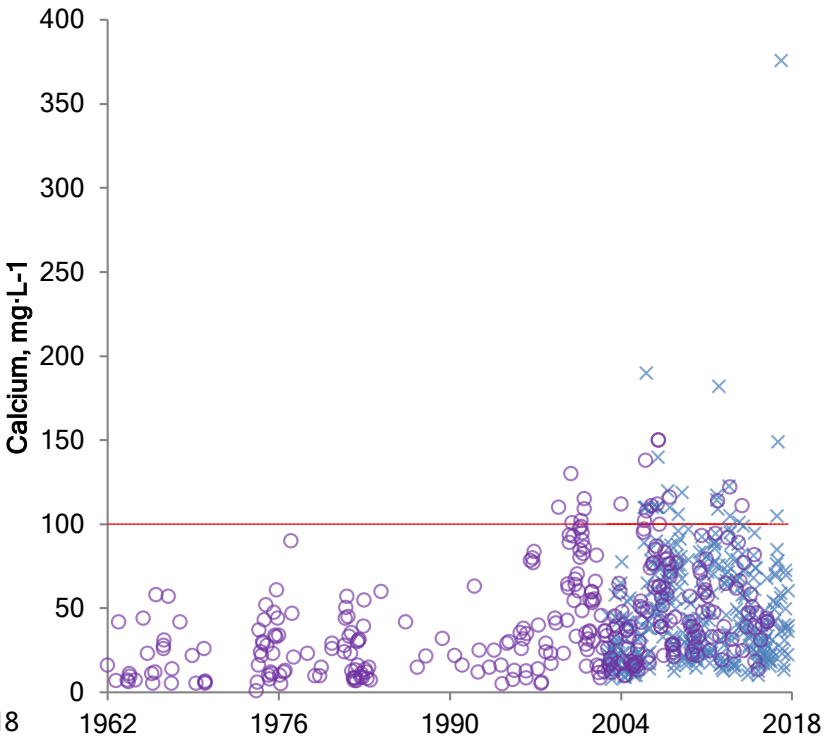


Lower Horse Creek

Calcium, POR

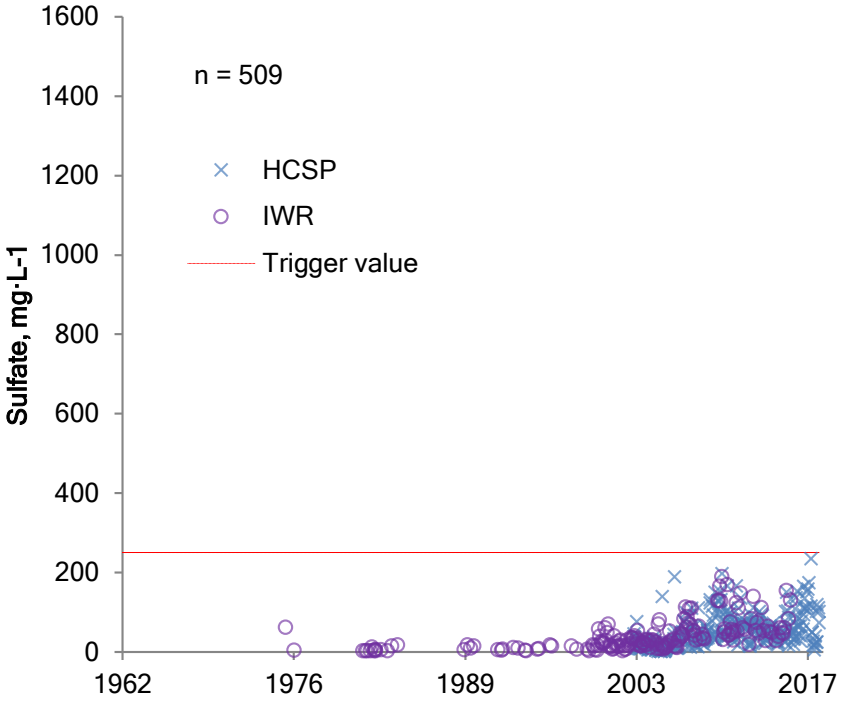


Upper Horse Creek

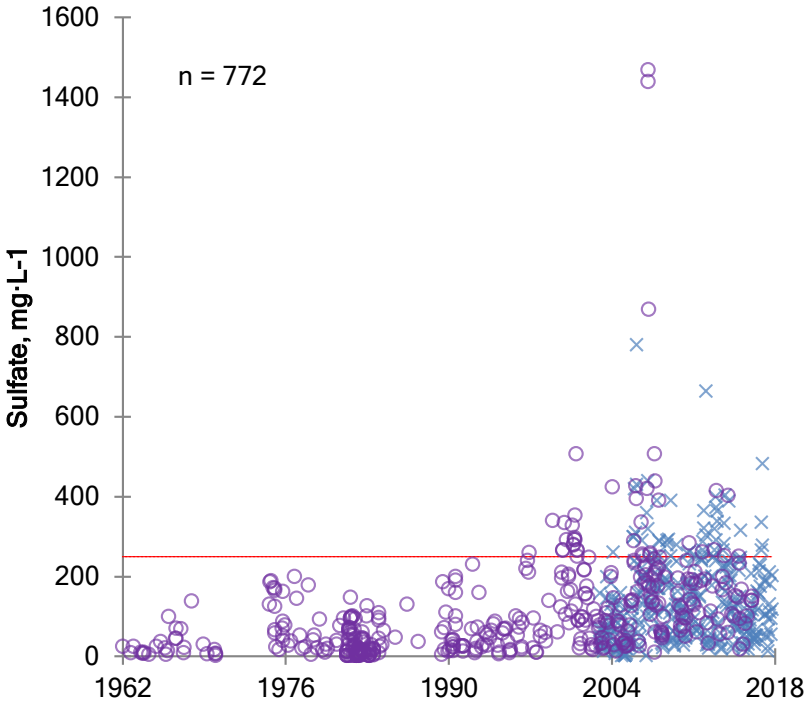


Lower Horse Creek

Sulfate, POR

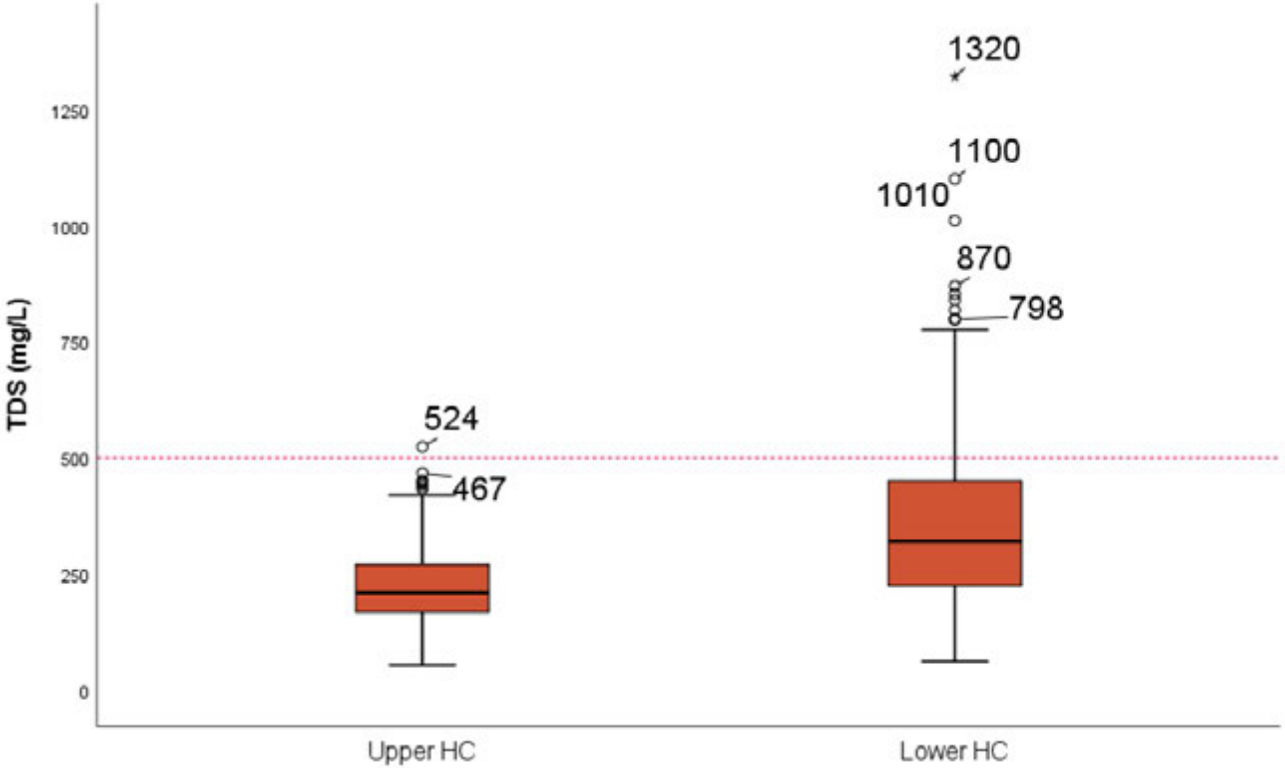


Upper Horse Creek

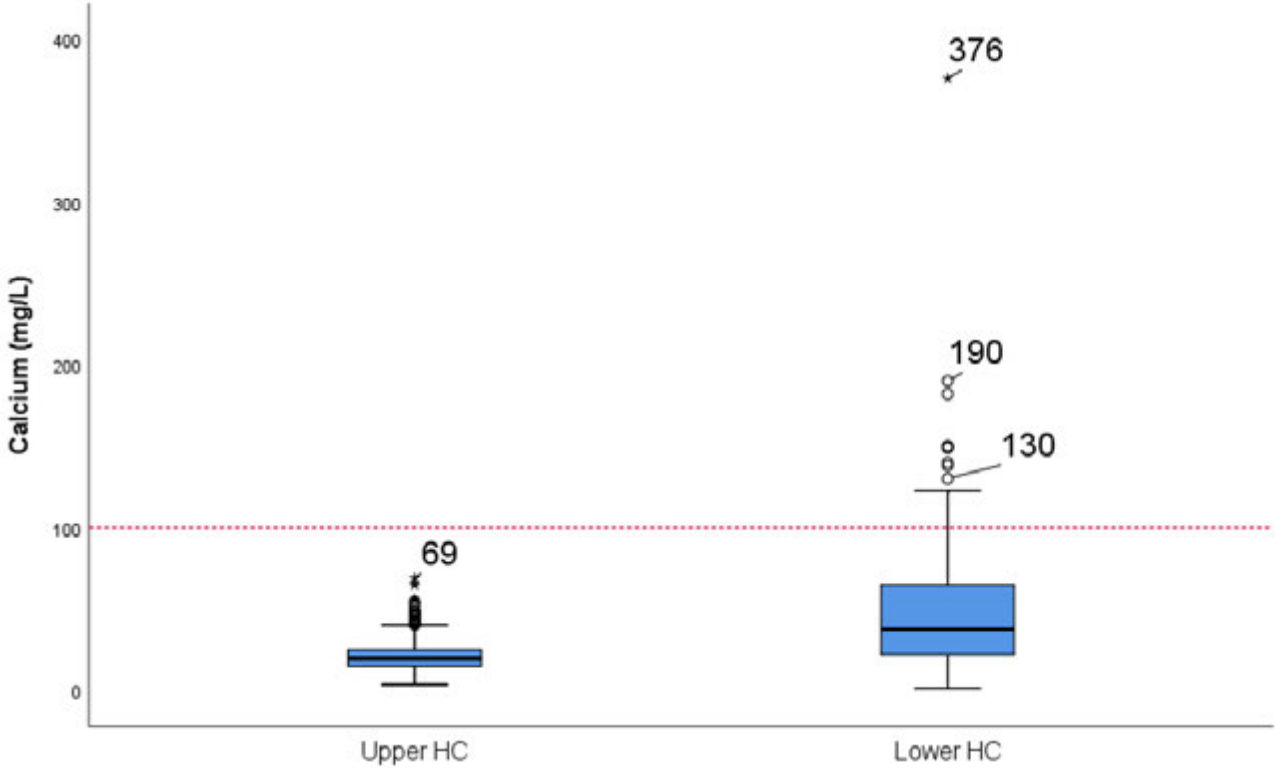


Lower Horse Creek

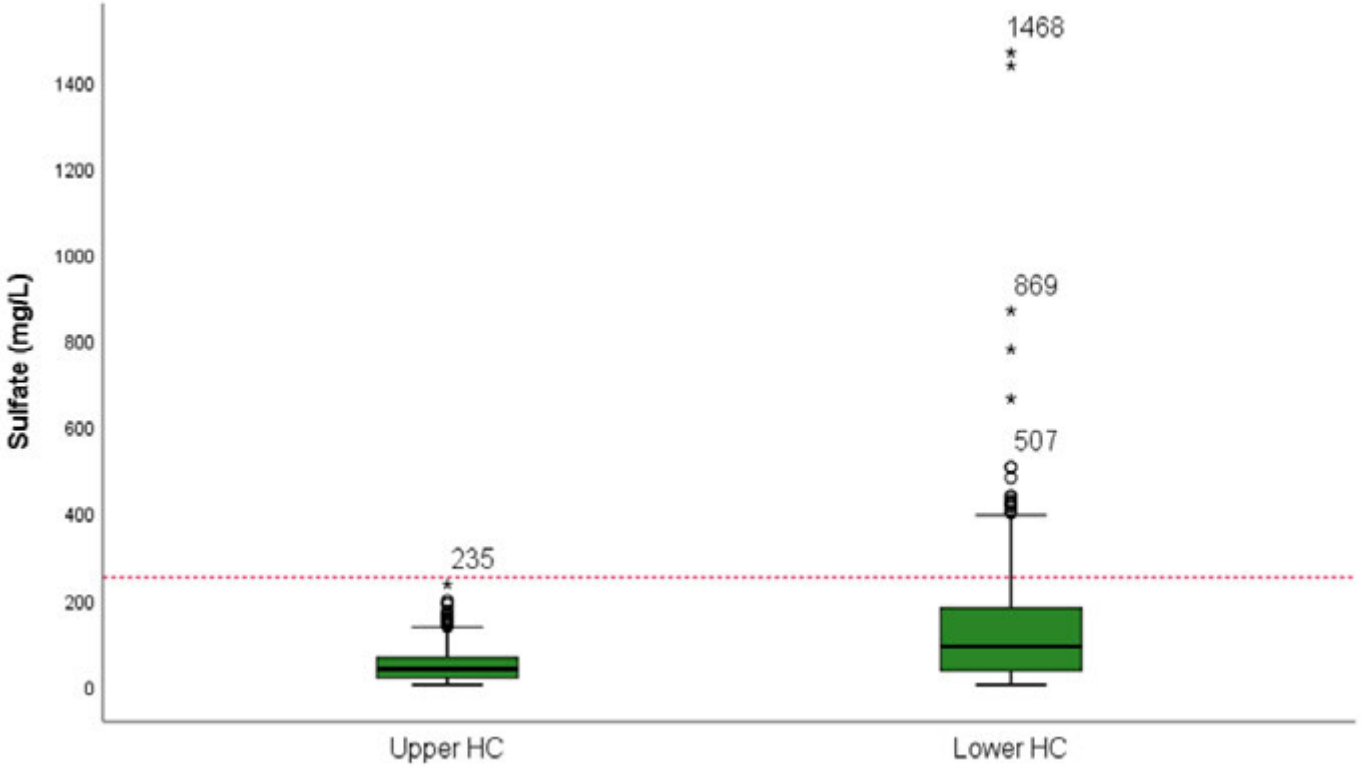
TDS – Upper and Lower Basins



Calcium – Upper and Lower Basins



Sulfate – Upper and Lower Basins



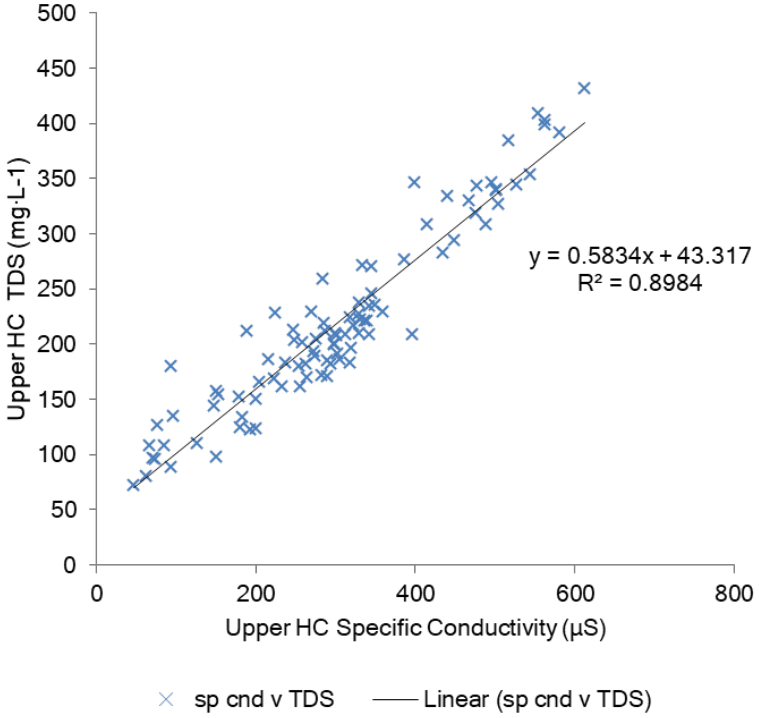
Estimating TDS from Specific Conductivity

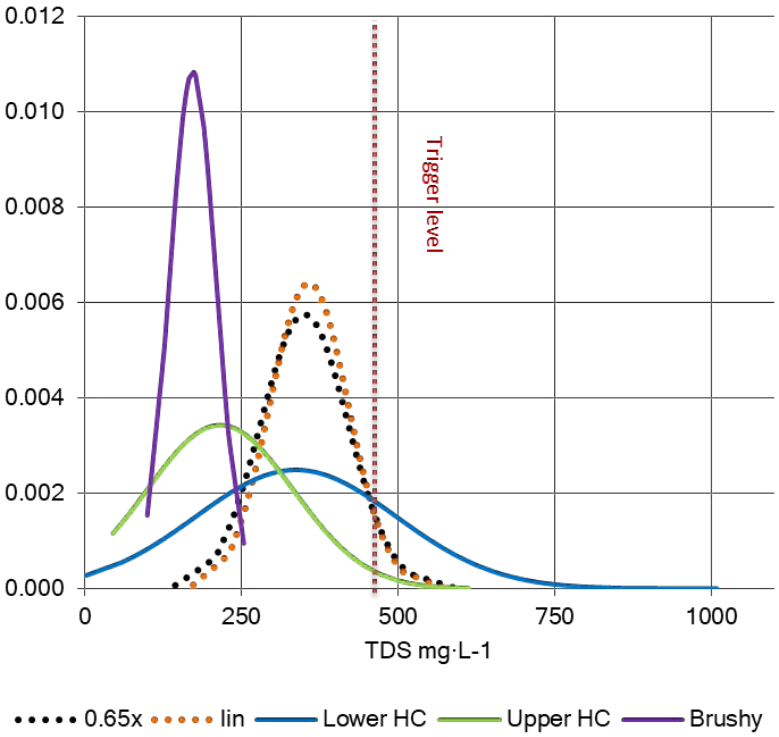
- Wingate and Fort Green NPDES wastewater permits do not require TDS, but do require specific conductivity, which can be used to estimate TDS

- A notable exception to effluent making up a fraction of creek flow occurred on June 3, 2009
  - TDS exceedances that day only occurred at HCSW-3 and HCSW-4
  - TDS value at HCSW-1 was below the trigger level

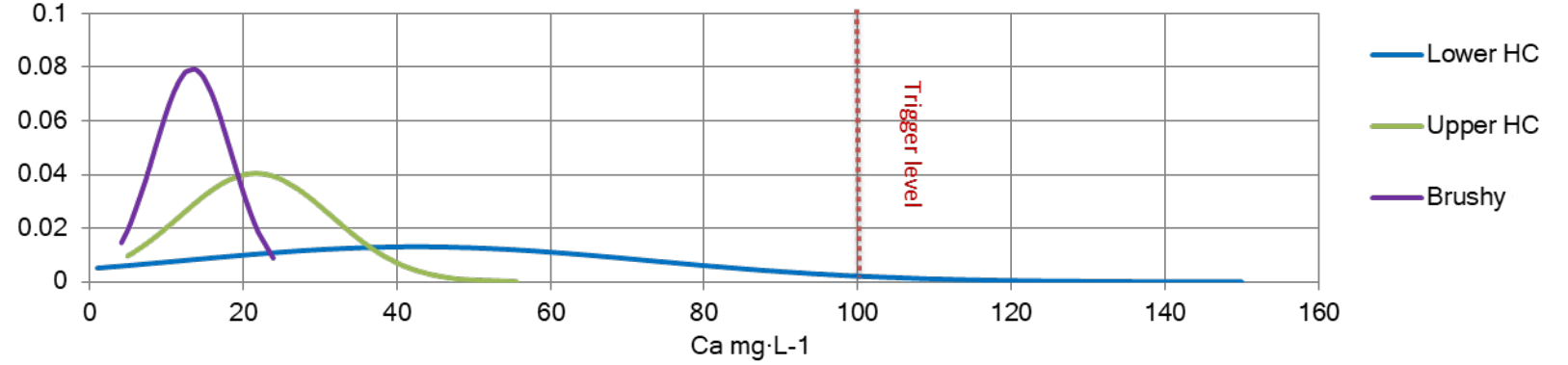
- No calcium or sulfate exceedances in the Upper Basin

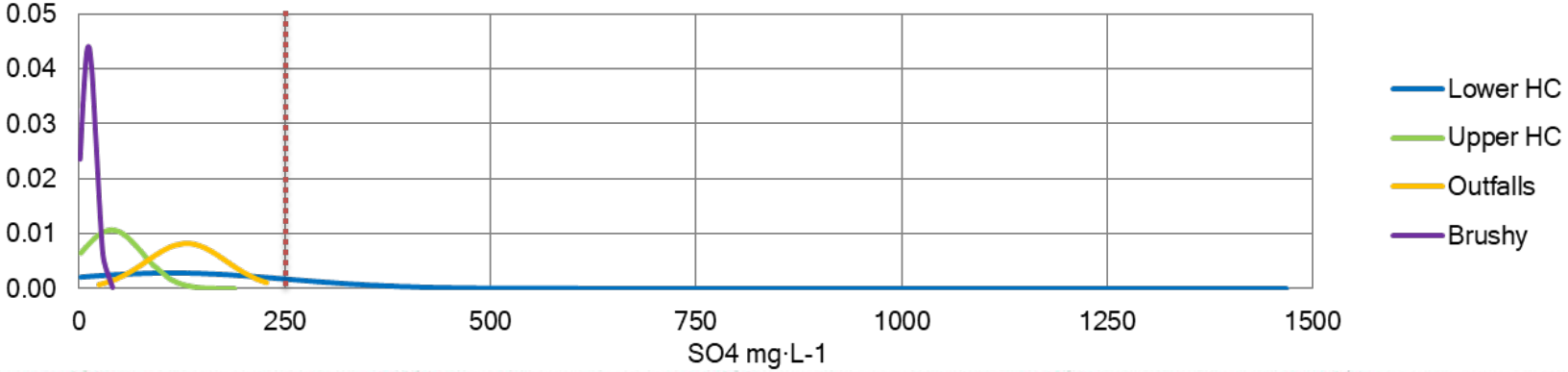
Estimating TDS from Specific Conductivity





Normal Distribution Charts





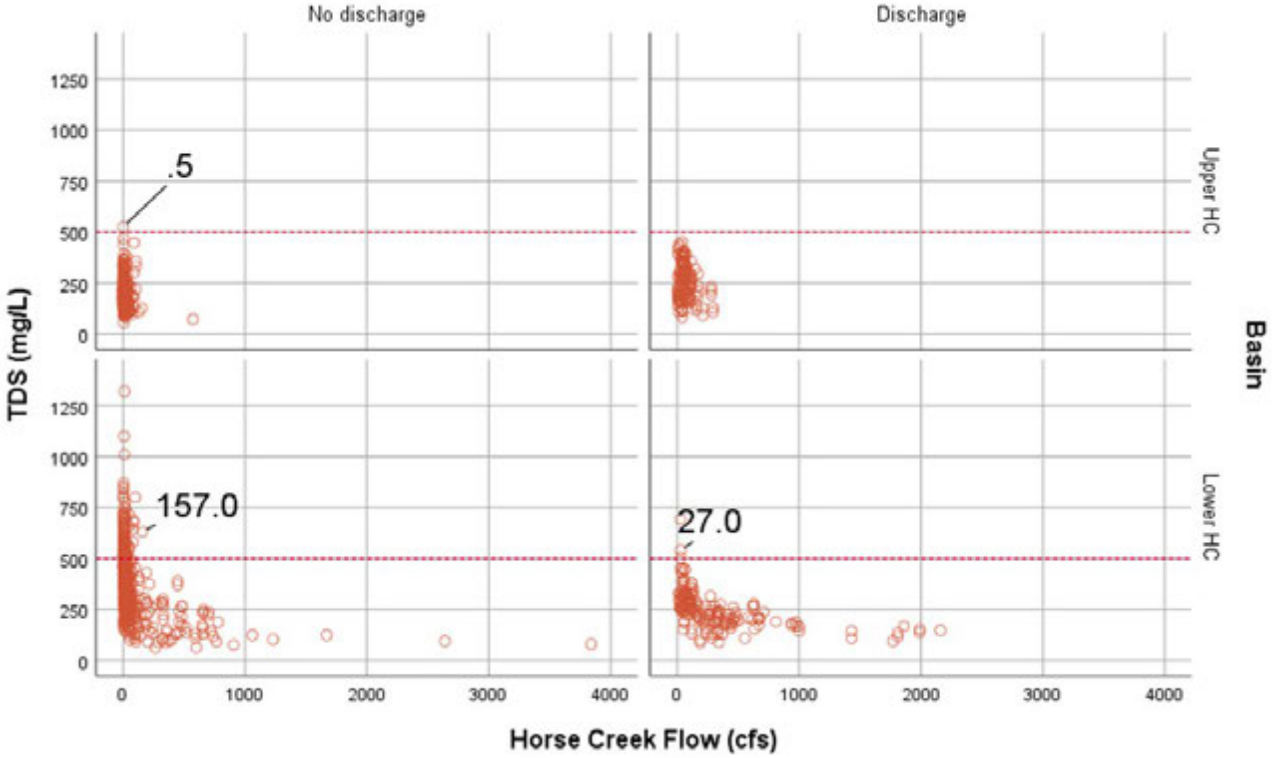
Observations

- TDS, sulfate and calcium concentrations in Horse Creek tended to be lower when there was a discharge through either outfall than when there was no discharge

- Discharges are driven by stormwater – not process demand

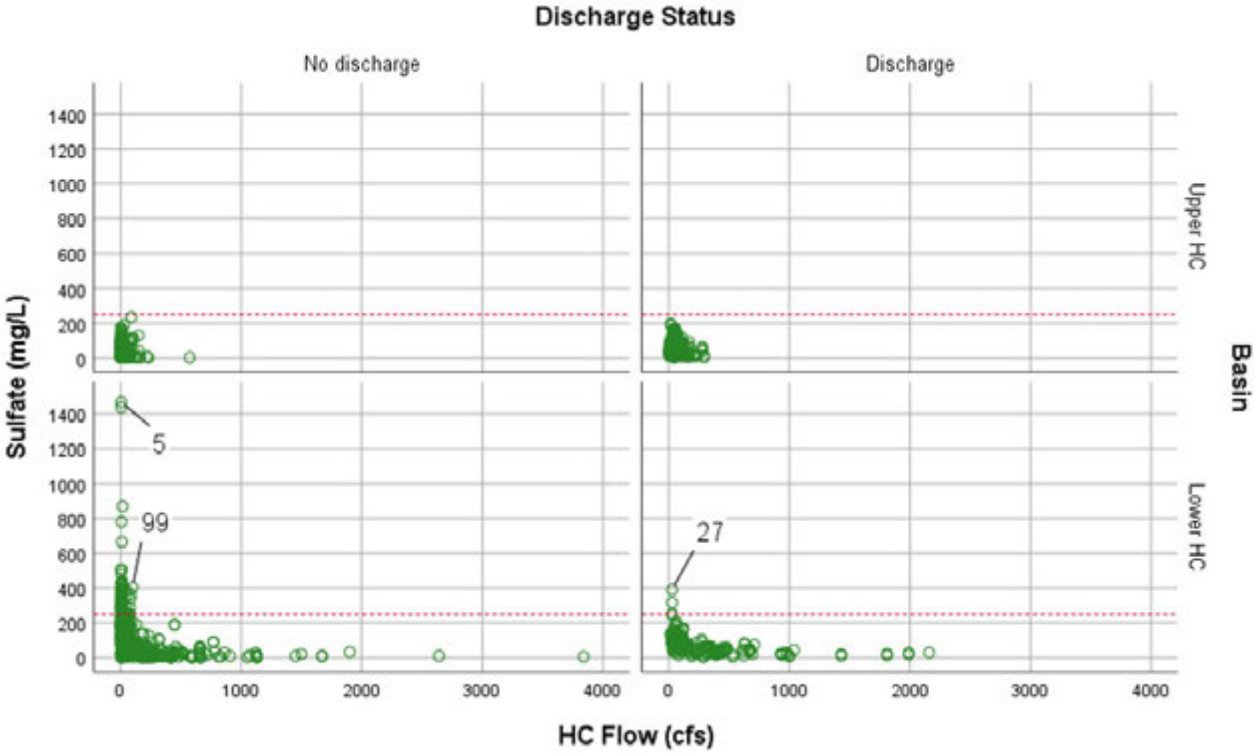
- All TDS, calcium, and sulfate exceedances (except June 3, 2009 and June 3, 2015) occurred when the outfalls were:
  - Inactive
  - Often long inactive (9-503 days)
  - Horse Creek was under very low flow conditions

Flow vs. TDS


No discharge
Discharge
TDS (mg/L)
1250
1000
750
500
250
0
.5
157.0
27.0
Upper HC
Lower HC
Basin
0
1000
2000
3000
4000
Horse Creek Flow (cfs)

Flow vs. Calcium

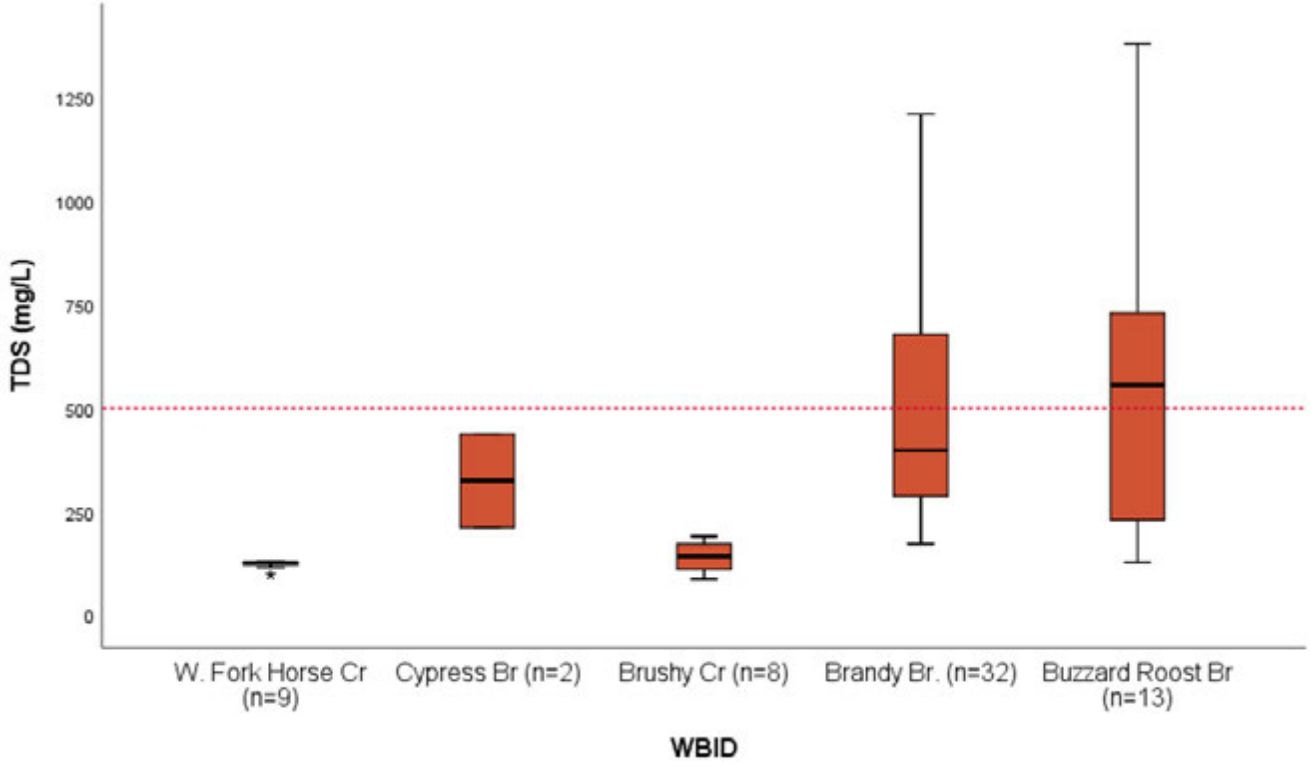
Flow vs. Sulfate



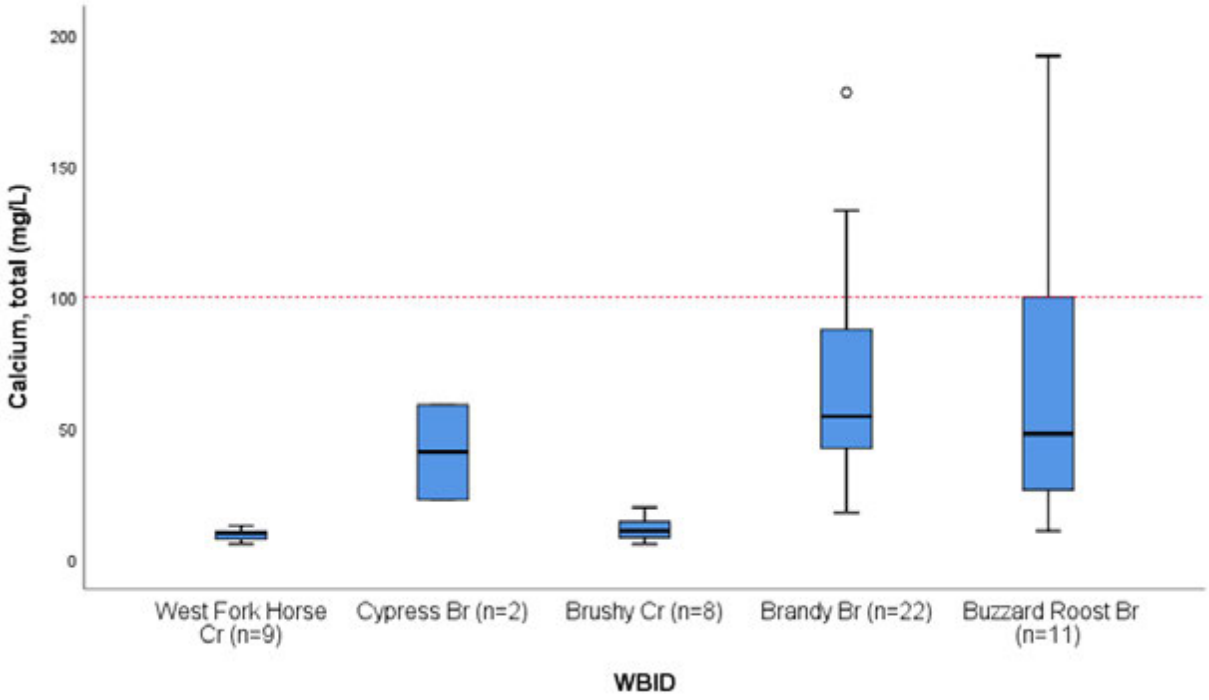
Historical Analysis

- Approximately 40 tributaries drain into Horse Creek between just north of HCSW-1 and HCSW-4
- Six are named system with designated WBIDs
- Four have some historical TDS, sulfate, and calcium data
- Cypress Branch and Brushy Creek
  - Drain into Upper Basin
  - No excursions above trigger levels
- Brandy Branch and Buzzard Roost Branch
  - Drain into Lower Basin
  - Excursions above trigger levels since the start of their period of records
  - Neither watershed has been mined or has a permitted wastewater discharge

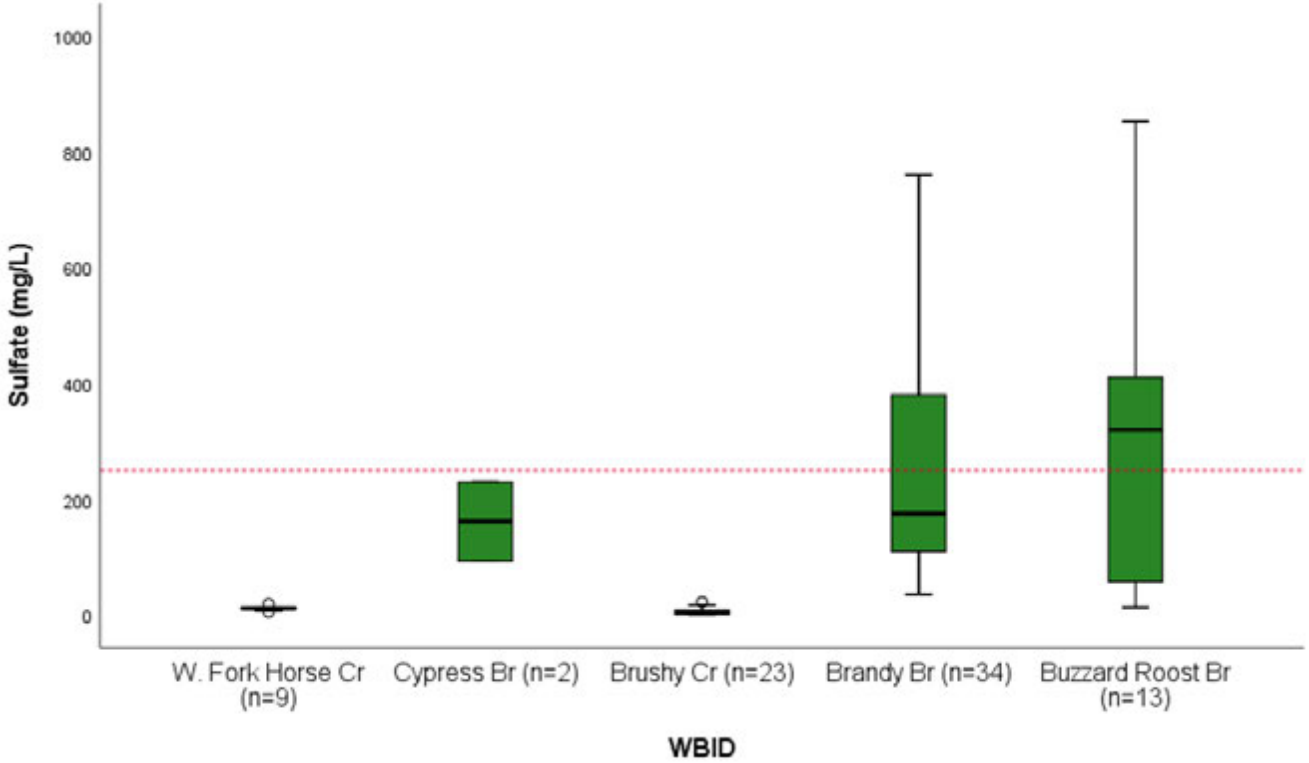
TDS – Major Tributaries



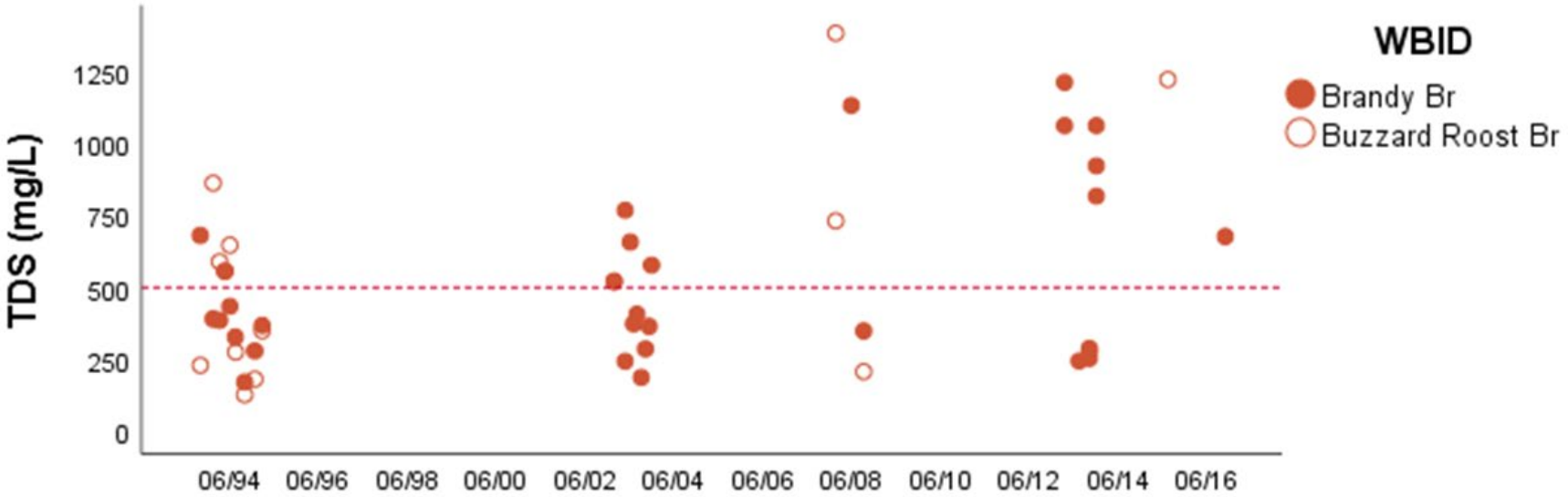
Calcium – Major Tributaries



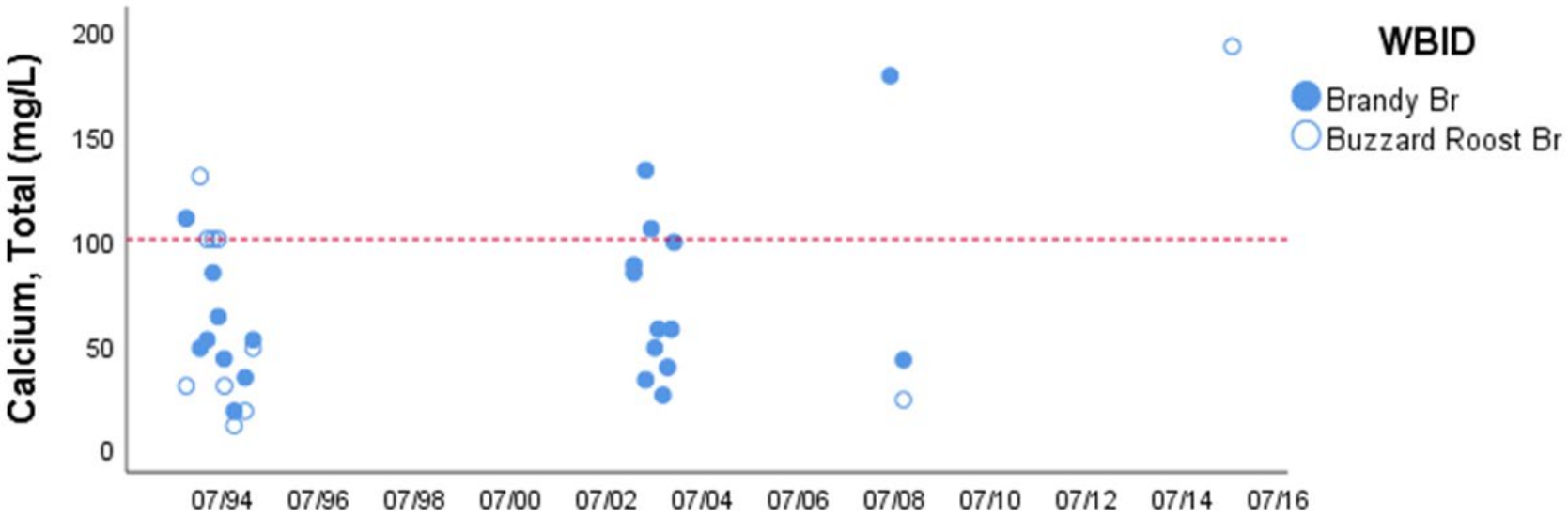
Sulfate – Major Tributaries



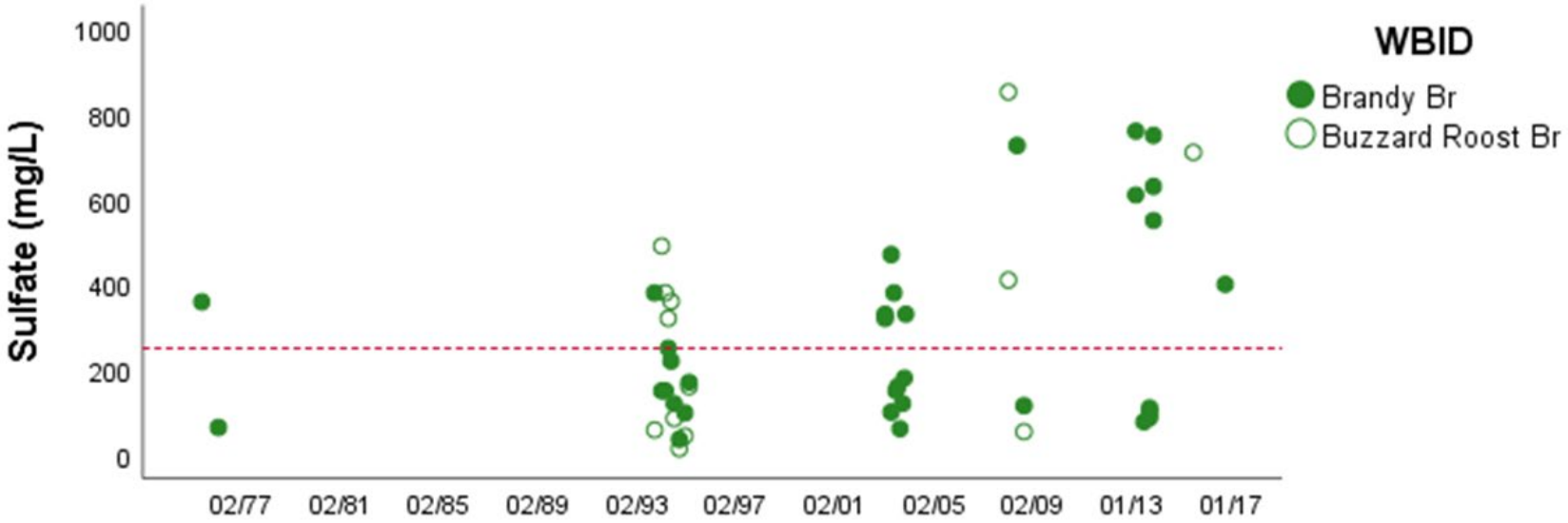
TDS – Major Tributaries



Calcium – Major Tributaries



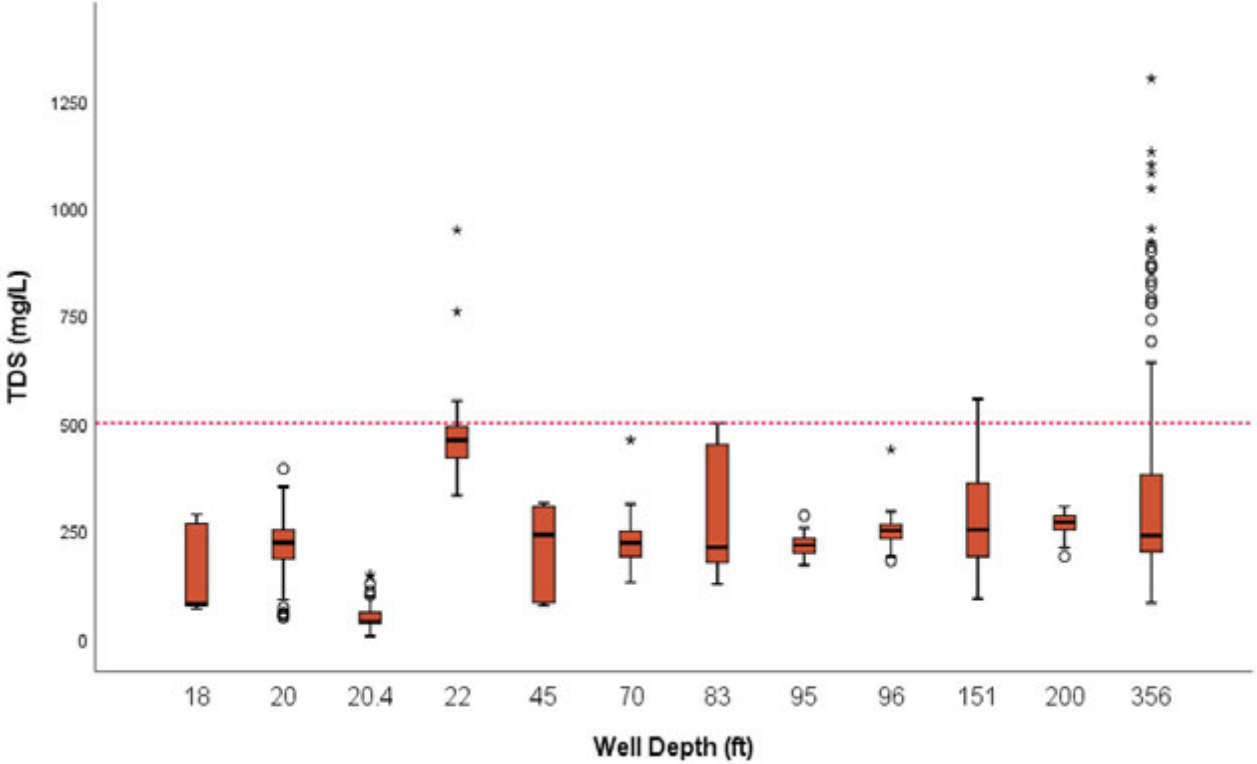
Sulfate – Major Tributaries



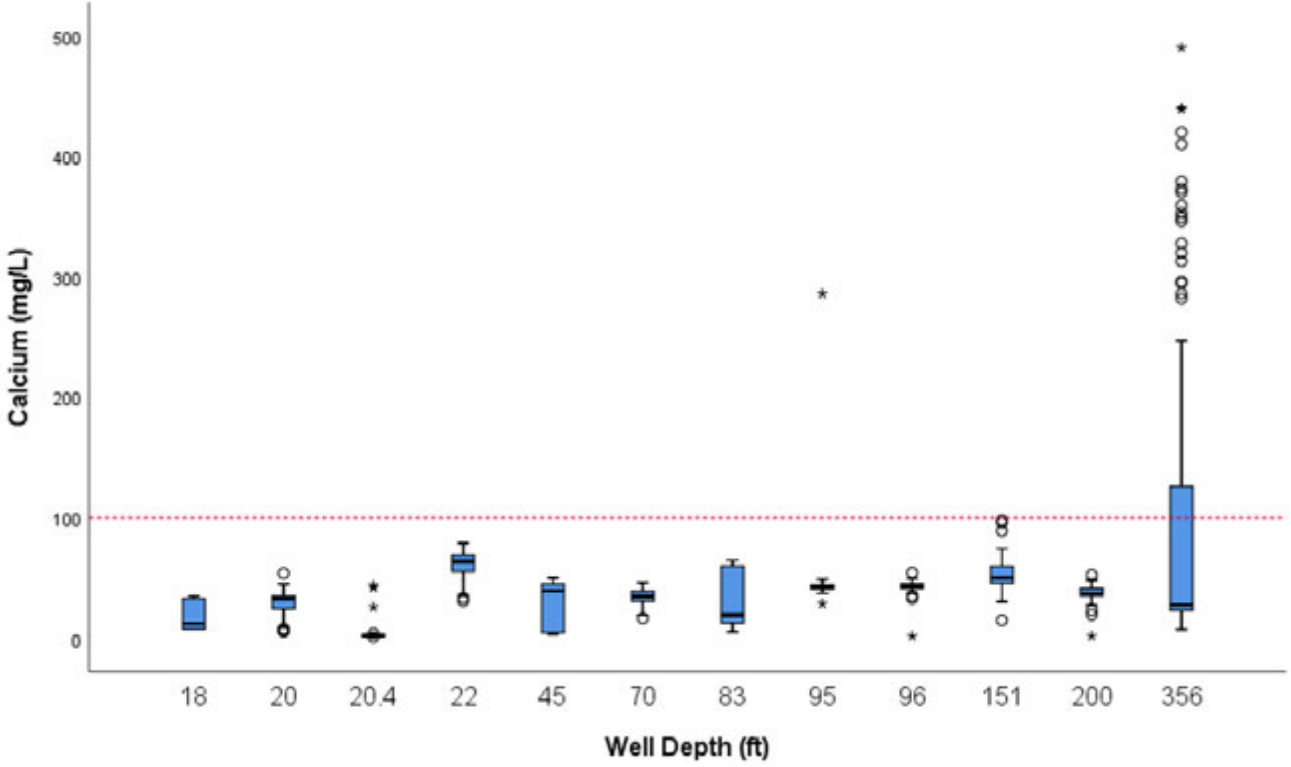
Groundwater

- Mosaic maintains a number of monitoring wells as part of their Hydrogeological Investigation and Monitoring Plan of Study (HIMPOS)
- Located in Wingate Mine and drilled to depths from 18’ to 356’
- Bulk of TDS data was below trigger level
- Bulk of TDS data above trigger level occurred in the deepest well at 356’
- All but one calcium value in wells <356’ were below trigger level
- All sulfate values regardless of depth were below trigger level

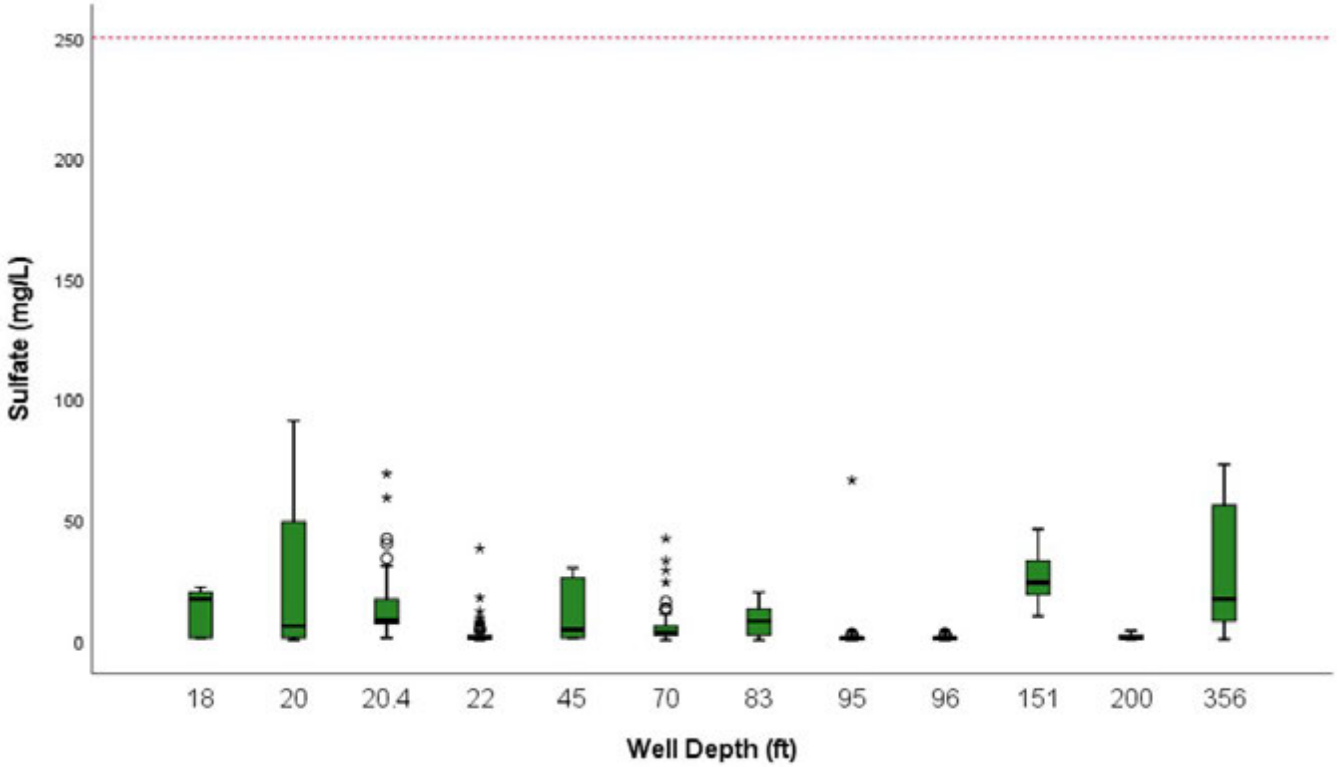
TDS – HIMPOS Wells



Calcium – HIMPOS Wells



Sulfate – HIMPOS Wells



Historical Analysis Conclusions

- 231 of 232 TDS, sulfate, and dissolved calcium exceedances have occurred in the Lower Basin
- Trigger value exceedances occurred before Mosaic outfalls were online
  - Exceedances do occur more regularly in recent times
- All days but two, exceedances have occurred when the outfalls were not discharging – and had not been for weeks
- Exceedances also occur when Horse Creek is under low-flow conditions – suggesting non-point source input
- Neither the surficial groundwater data nor the outfall water quality data demonstrate excessively high levels for either of the three parameters

Historical Analysis Conclusions

- HCSW-3 and HCSW-4 have records of regular exceedances
- Values for all three parameters in the Lower Basin began to fluctuate more in the 1990's, when natural lands were being converted to intensive human uses
- Agricultural practices are linked to increased TDS and dissolved ions in adjacent freshwater systems
  - Elevated ions evident at Brandy Branch and Buzzard Roost Branch
- Lower Basin is more influenced by agriculture than the Upper Basin

Land Use Change

WBID	Whole-Basin Landscape Development Index			2011 Land Use Break Down				
	1990	1999	2011	Natural	Silviculture	Land Clearing/ Agriculture	Low Intensity Development	High Intensity Development
Upper Horse Creek	2.14	3.66	4.11	30%	<1%	39%	1%	30%
Lower Horse Creek	2.42	2.47	2.66	35%	1%	30%	5%	<1%
Brushy Creek	2.04	2.06	2.81	41%	0%	48%	1%	10%

Ambient Water Quality Assessment

- Two tributaries of the Peace River within conceptual phosphate limit without mining:
  - Charlie Creek
  - Limestone Creek

- Characterized the aquatic habitat condition using applicable approved DEP methods:
  - FT3001 Physical/Chemical Characterization
  - FT3100 Stream and River Habitat Assessment
  - Landscape Development Index
  - Human Disturbance Gradient

- Sampling conducted consists of 15 TDS, calcium, and sulfate samples at each site no less than one week apart

- Field measurements taken at each sampling event include DO, specific conductivity, pH, depth, temperature, turbidity, water velocity, and secchi depth

- Currently in progress, 14/15 samples collected

Questions & Comments

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