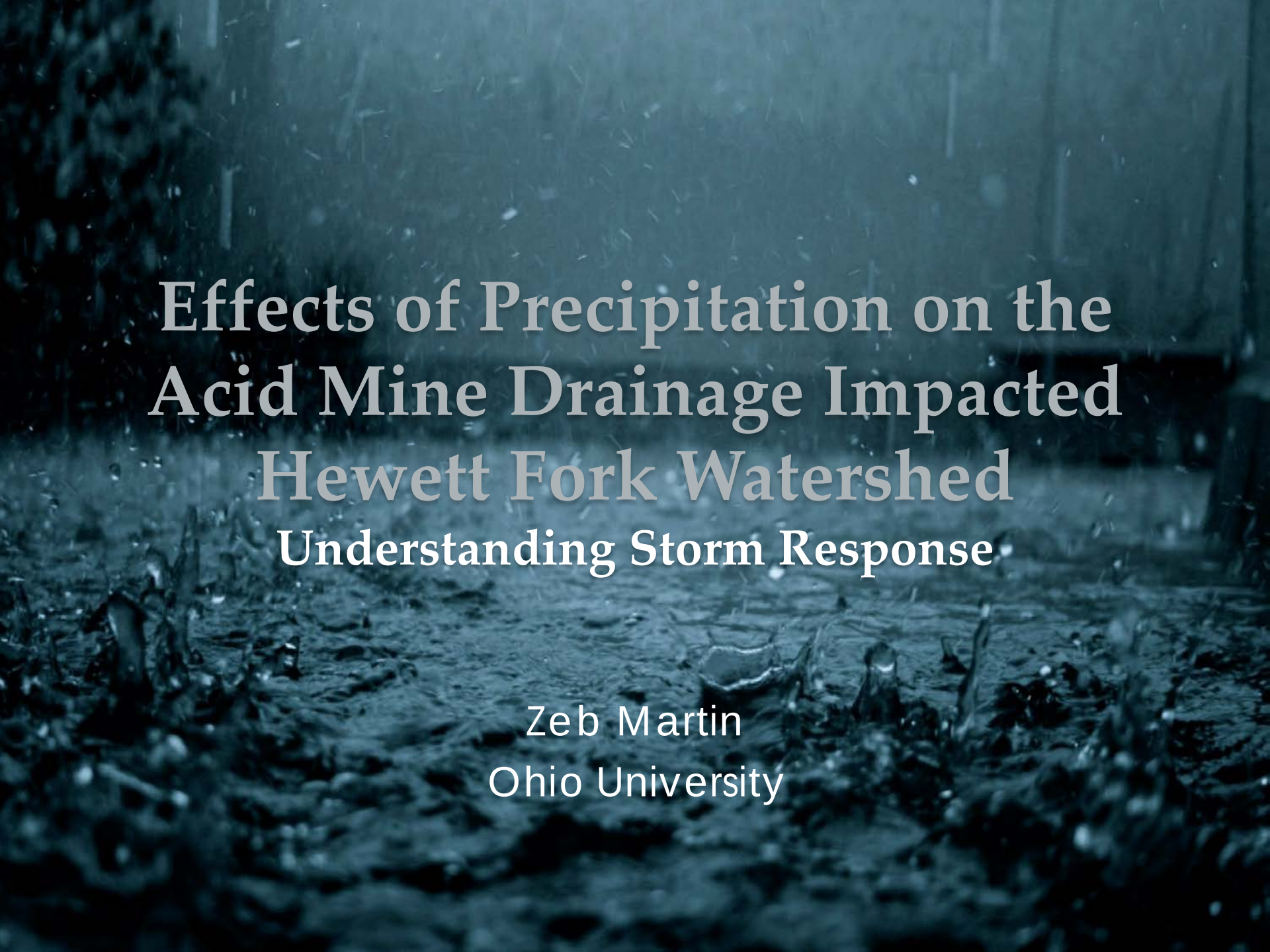


Effects of Precipitation on the Acid Mine Drainage Impacted Hewett Fork Watershed

Understanding Storm Response

Zeb Martin
Ohio University

Contents

- Project Overview
- Objectives of the Research
- Project Area
- Background of Literature
- Methodology
- Results
- Conclusion
- Recommendations

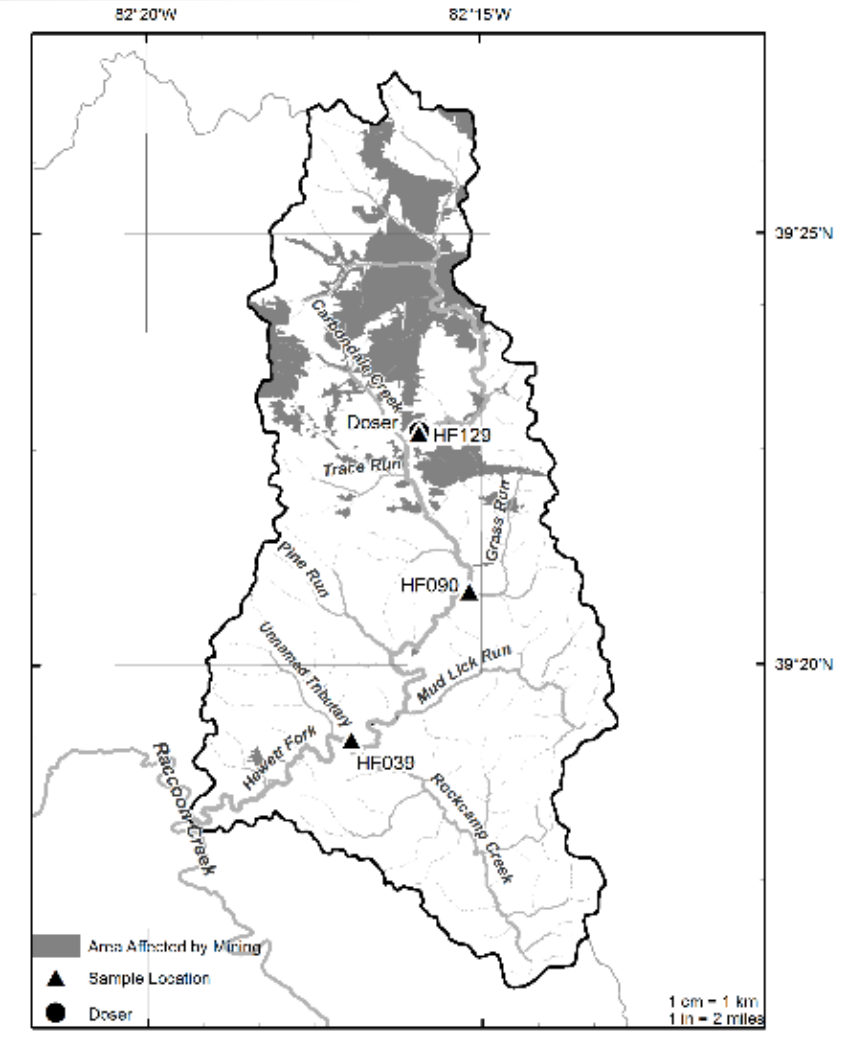
Project Overview

- Examination of storm response in an AMD impacted streams using new and emerging auto-sampler technologies, to track and analyze the changing geochemical environment within AMD receiving streams over the course of selected storm events.

Objectives of the Research

- Study the storm response of water quality in AMD impacted streams.
- Determine if flushing events impair water quality and go untreated by remediation efforts.
- Provide data that reflects how the water chemistry is changing in real time during a storm.
- Fill a knowledge gap in current theories of what is limiting biological recovery.

Project Area



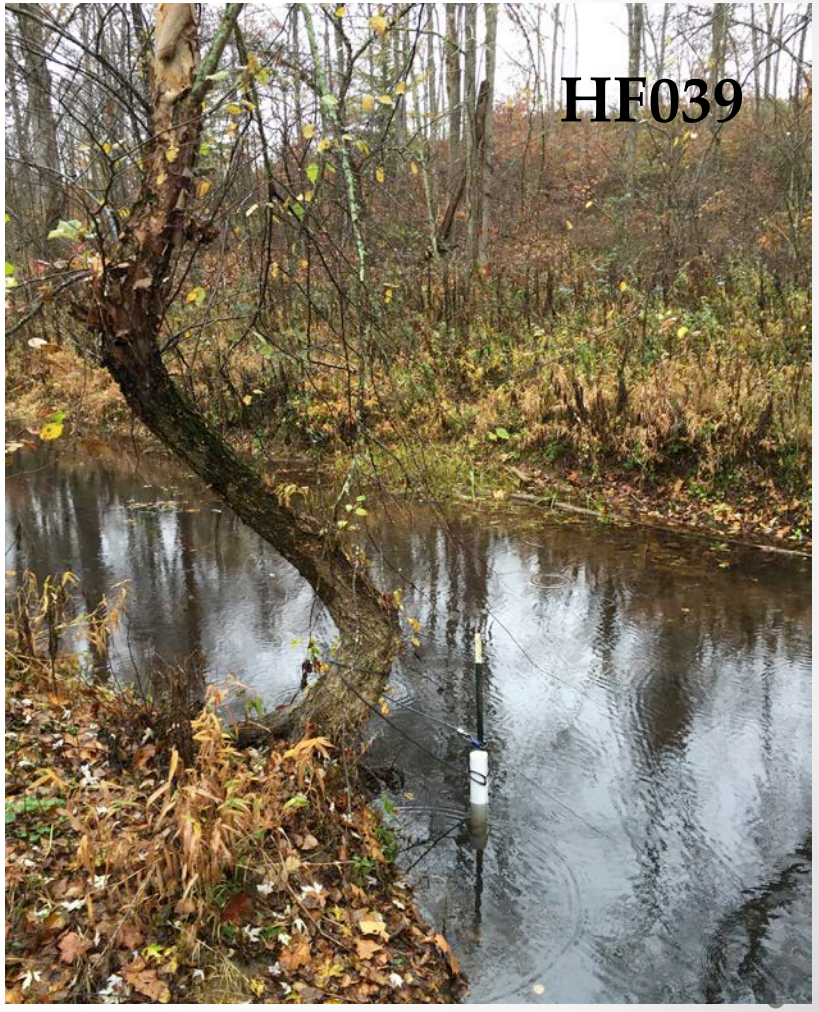
Hewett Fork

- Drainage area of 104.89 square kilometers
- 79.6 percent forest cover
- Headwater stream and second largest tributary to Raccoon Creek at 24.8 km long.
- The headwaters of Raccoon Creek are among the worst mine-related problems in Ohio
- Approximately 1,200 acres of abandoned mines and coal refuse piles are located within the drainage basin.
- Currently being actively remediated by lime doser

Selected Field Sites

- Three major AMD inputs are treated at a single location in Carbondale, OH., and discharges into Hewett Fork at field site **HF129**.
- **HF090** is 4.5 km downstream of HF129, and represents the downstream extent of the mixing zone where limited biological recovery can be seen.
- **HF039** is 11.4 km downstream of HF129, and represents the zone in which water quality and biological metrics are both being met

Field Sites



Background

- What does the literature say?
  - Most research based on annual loading
    - Does not account for geochemical changes during storms
    - High flows are critical because they are associated with high loads
  - Grab samples
    - Does not account for geochemical changes during storms
    - Safety risk
    - Cost
  - Limited biological recovery
    - Episodic events
    - Extended mixing zone

Methods: Data Collection

- HF129 – Diver and Baro
  - Depth, pH, conductivity, and temperature
- HF090, HF039 - two auto-samplers paired with YSI data sondes
  - pH, conductivity, temperature, TDS
- HF190, HF120, HF090, HF039 - Flow measurements
  - Marsh-McBirney Model 2000 Flo-Mate
  - Recorded in feet per second

Auto-Samplers

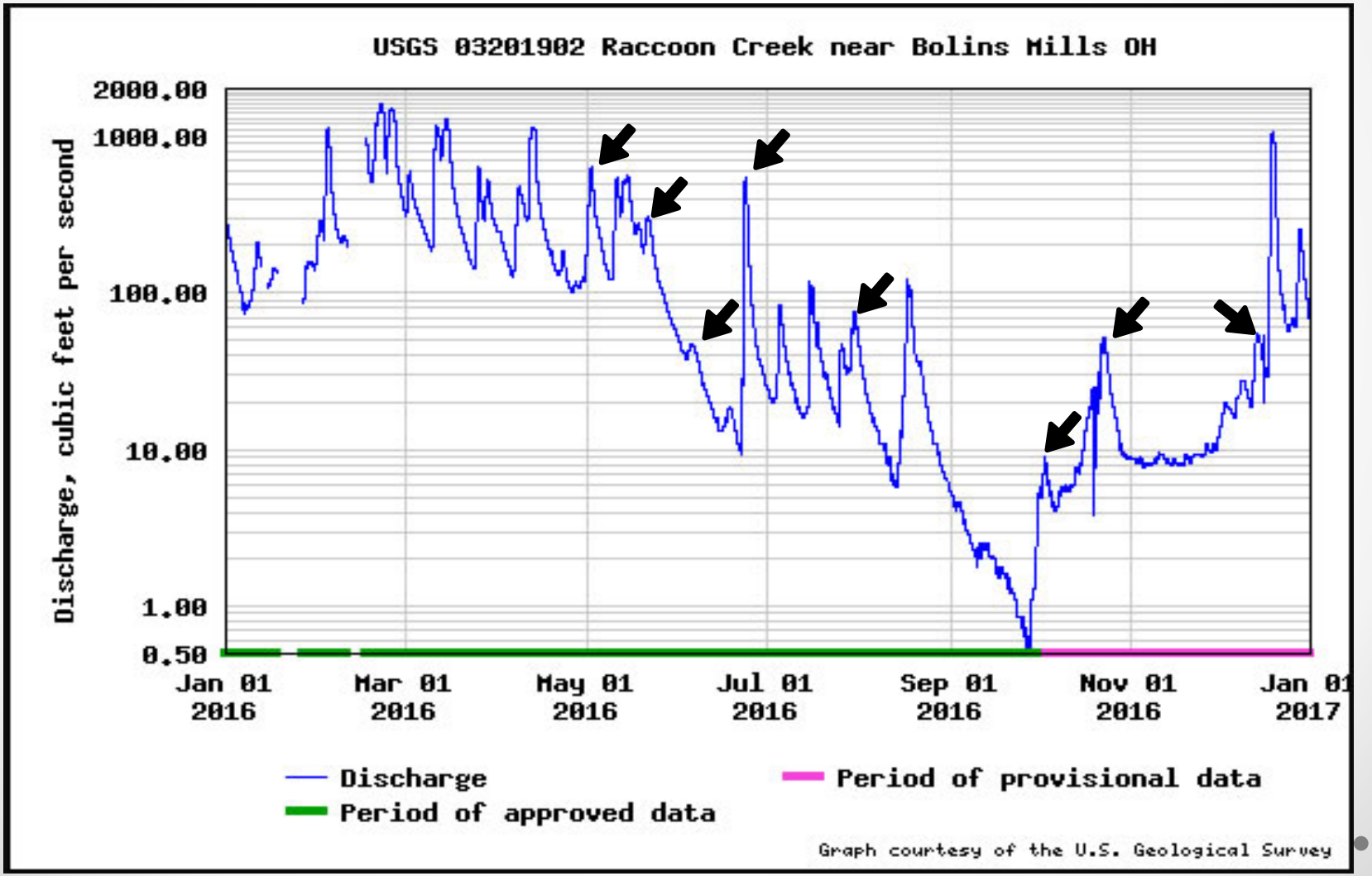
Methods: Storm Sampling

- 8 sampling events sampled from 5/1/16 – 12/6/16
  - Seasons based on water year
    - 4 spring storms
    - 2 summer storms
    - 2 Fall storms
- Sampling was triggered by a predicted precipitation event =< 1cm
  - EPA recommends 72 hours in between sampling
- Collected 1 sample every hour for 24 hours using auto-samplers
  - Collected a total of 216 samples at HF039
  - Collected a total of 192 samples at HF090

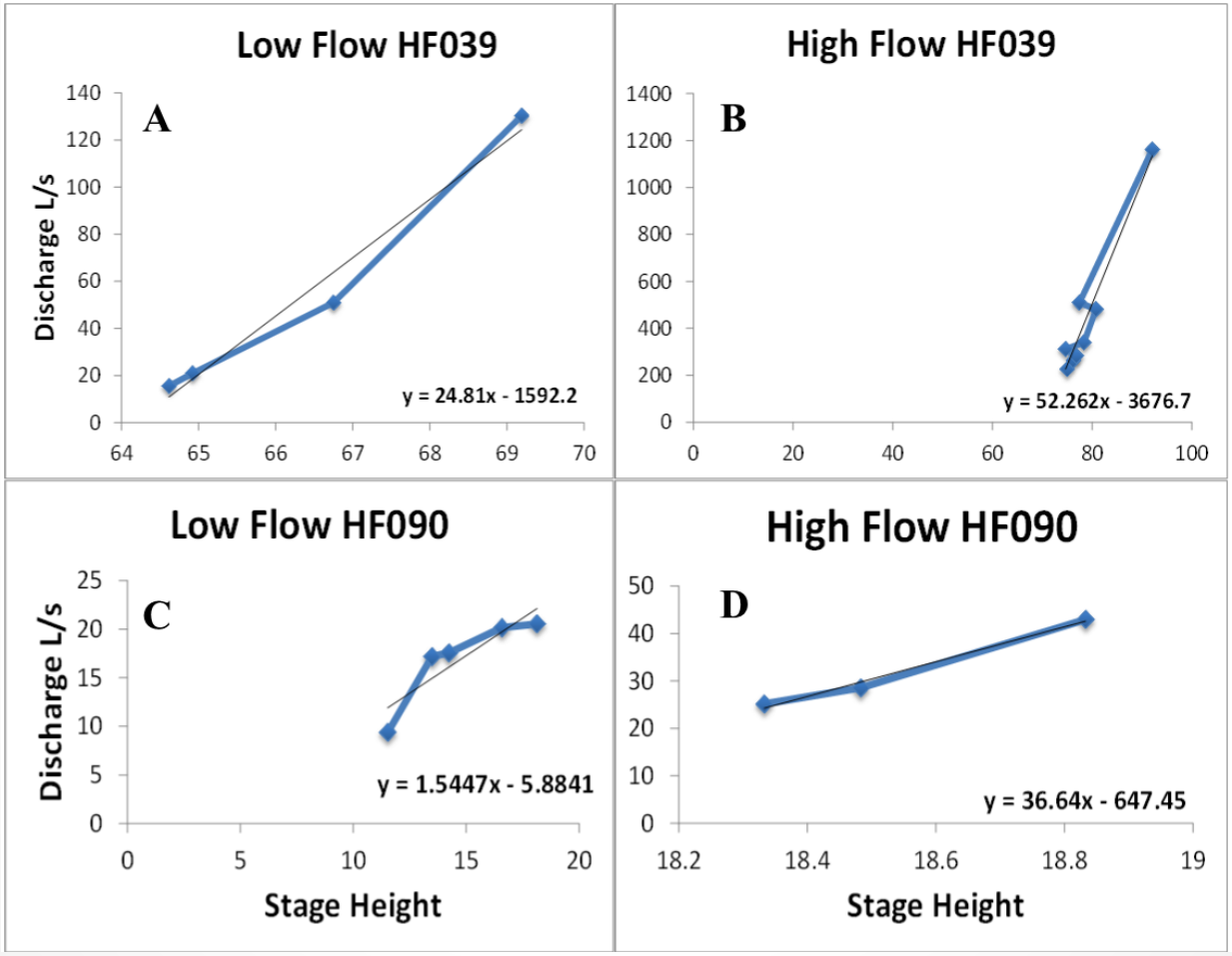
Methods: Discharge

- USGS Bolins Mills gauge station data used to create hydrograph for 2016
  - Used to determine water year seasons
- Flow measurements were collected 7 times at HF039 and HF090
  - Discharge calculated using velocity-area method
  - Equipment failure at HF039

Water Year 2016



Discharge


Low Flow HF039
A
Discharge L/s
y = 24.81x - 1592.2
High Flow HF039
B
y = 52.262x - 3676.7
Low Flow HF090
C
Discharge L/s
y = 1.5447x - 5.8841
Stage Height
High Flow HF090
D
y = 36.64x - 647.45
Stage Height

Methods: Lab Analysis

- Collected water samples were split
  - Analyzed at ISEE Lab at OU
    - Preserved in 20% nitric acid at <4°C
    - Analyzed for **total** Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Sr, and Zn on ICP-OES (iCAP 6300 Duo)
  - Analyzed in Watershed Lab at OU
    - Purged of air and stored at <4°C
    - Analyzed for Acidity (Hach 8202), Alkalinity (820), Sulfate (8051)

What is Storm Response?

- Purging and Sparing ~ Lewis & Grant 1979
- Sparing – removal of oxygen from the reaction site due to flooding
- Purging – flushing of accumulated oxidation products by storm run-off
- Is that it?
  - Mixed
  - Consistent

Storm Response:

F=Flushing, D=Dilution, M=Mixed, & C=Consistent

HF039

Prior Dry Days	Sampling Date	Sulfate	Net Acidity	Al	Ba	Ca	Fe	K	Mg	Mn	Na	Sr
1	4/30/16-5/1/2016	D	M	F	C	D	F	F	D	F	D	D
2	5/20/16-5/21/2016	M	M	F	C	D	F	F	D	M	F	D
8	6/4/16-6/5/2016	D	M	C	C	C	D	C	D	F	C	C
5	6/22/16-6/23/2016	D	C	F		D	F	F	D	F	D	D
1	7/28/16-7/29/2016	F	C	D	C	D	D	D	D	D	D	F
9	9/28/16-9/29/2016	C	M	F	D	M	F	F	D	F	M	F
0	10/20/16-10/22/2016	D	M	F	D	D	M	F	D	F	D	D
0	12/5/16-12/6/2016	D	C	D	C	C	M	D	D	F	D	D

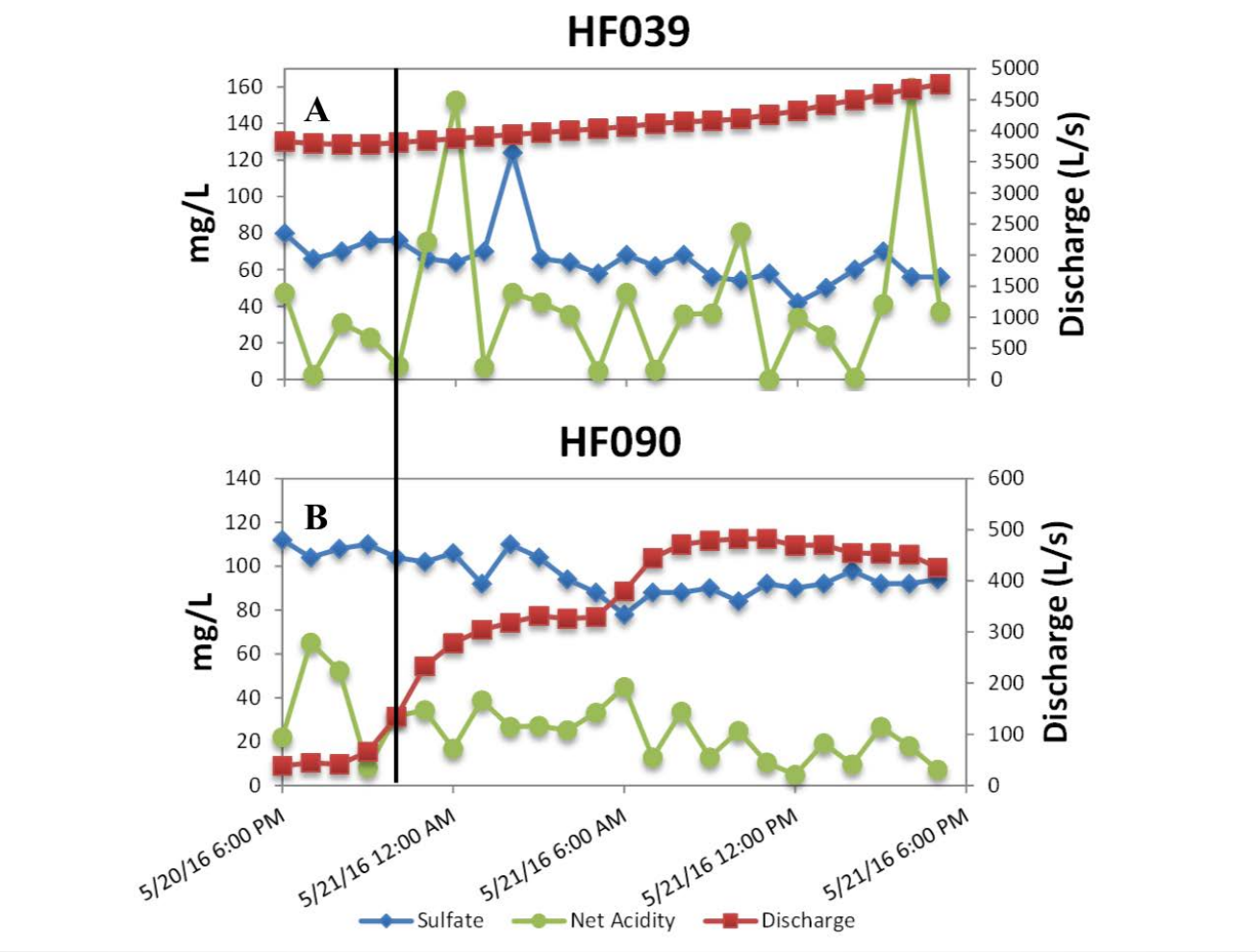
HF090

Prior Dry Days	Sampling Date	Sulfate	Net Acidity	Al	Ba	Ca	Fe	K	Mg	Mn	Na	Sr
1	4/30/16-5/1/2016	D	C	F	F	D	F	F	D	F	D	D
2	5/20/16-5/21/2016	D	M	F	C	D	F	F	D	D	D	D
8	6/4/16-6/5/2016	D	M	D	C	F	M	C	F	C	F	F
5	6/22/16-6/23/2016	D	D	F		D	F	D	F	F	D	D
1	7/28/16-7/29/2016	D	F	F	D	F	F	D	F	D	F	F
0	10/20/16-10/22/2016	D	D	F	F	D	F	F	F	F	D	D
0	12/5/16-12/6/2016	M	C		C	C	F	D	F	F	D	D

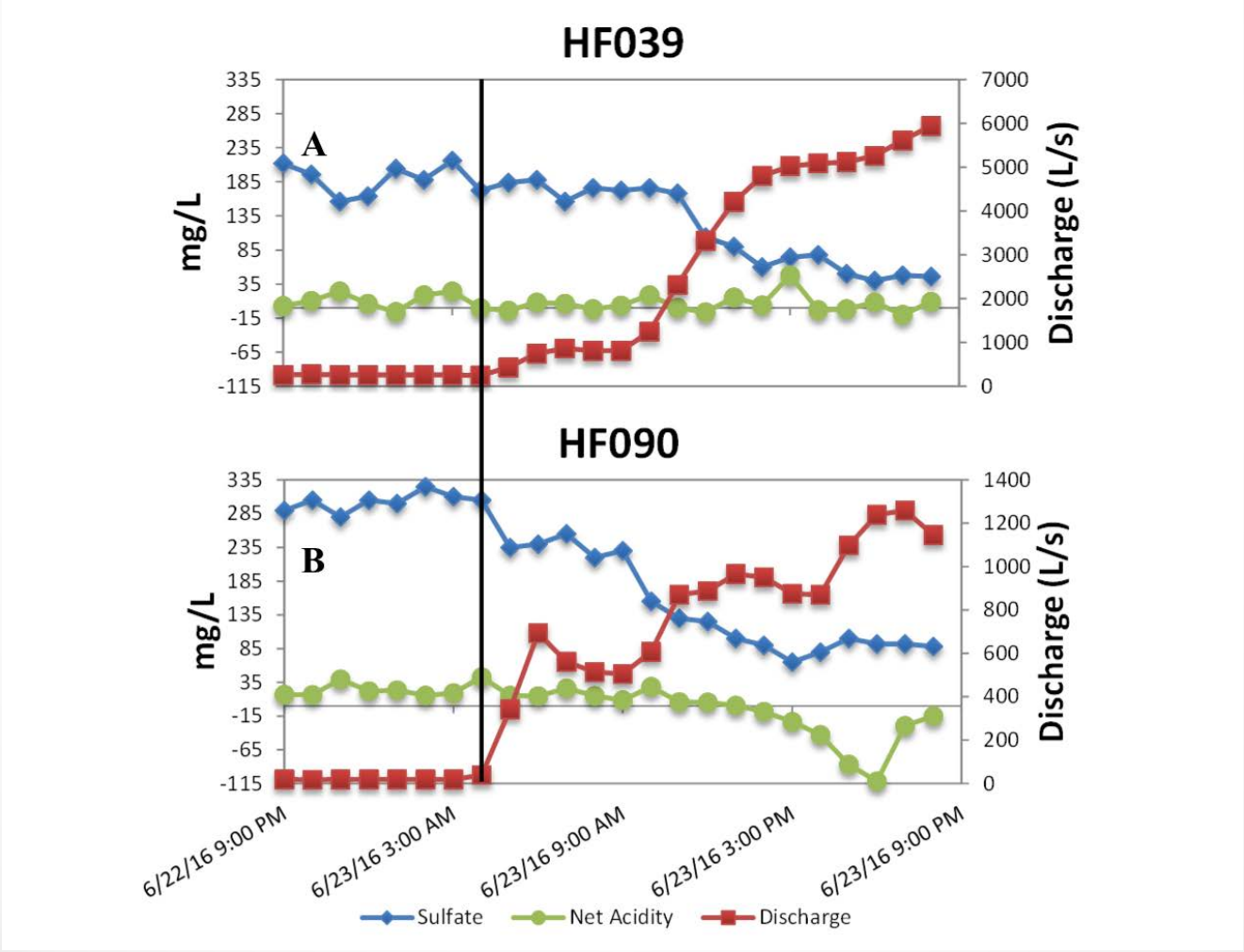
Similar Responses

- Primary Response Groups
  - Flushing
    - Al, Fe, K, & Mn
  - Dilution
    - Ca, Mg*, Na, Sr, & Sulfate
  - Consistent
    - Ba
  - Mixed
    - Net Acidity

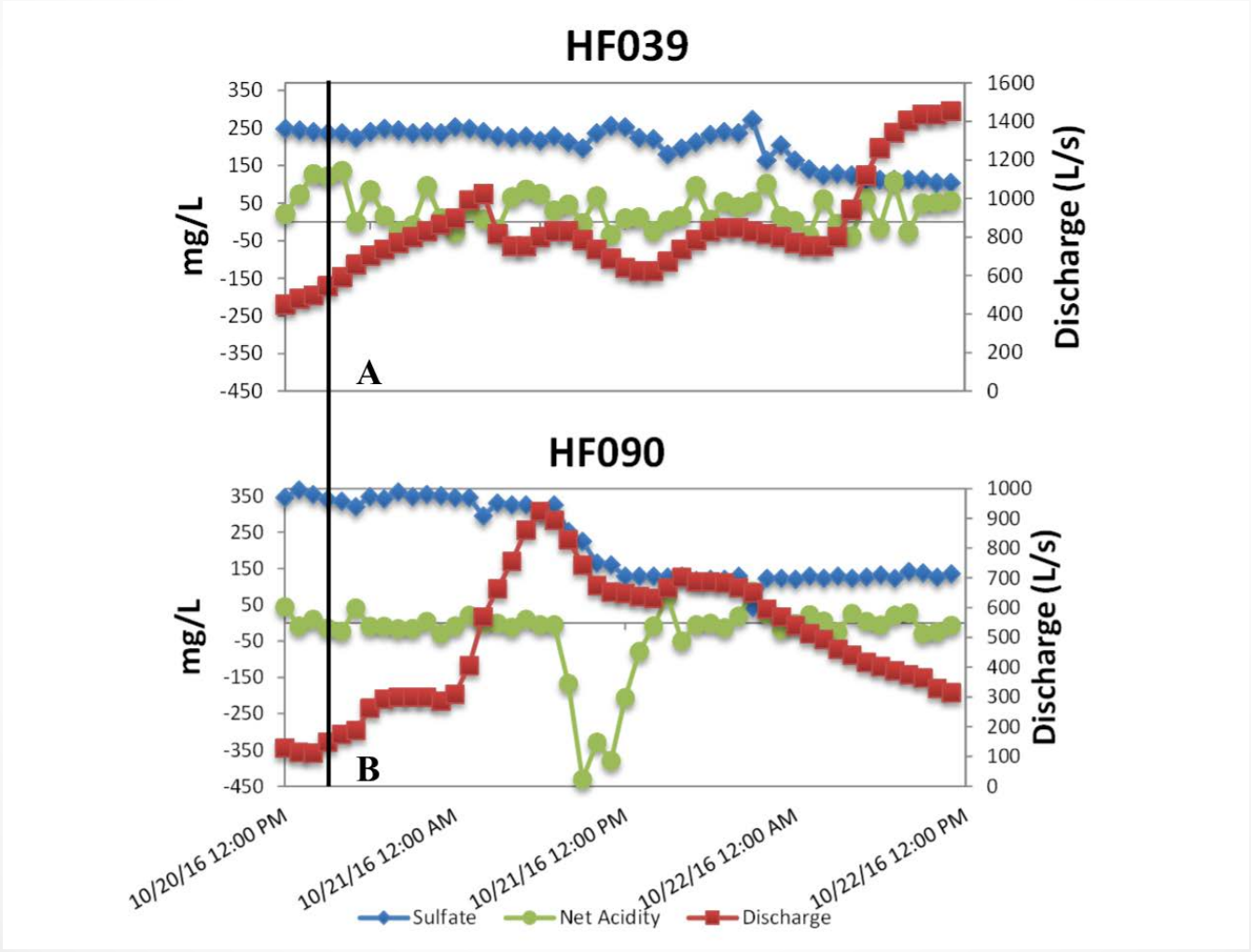
Net Acidity Response



Net Acidity Response

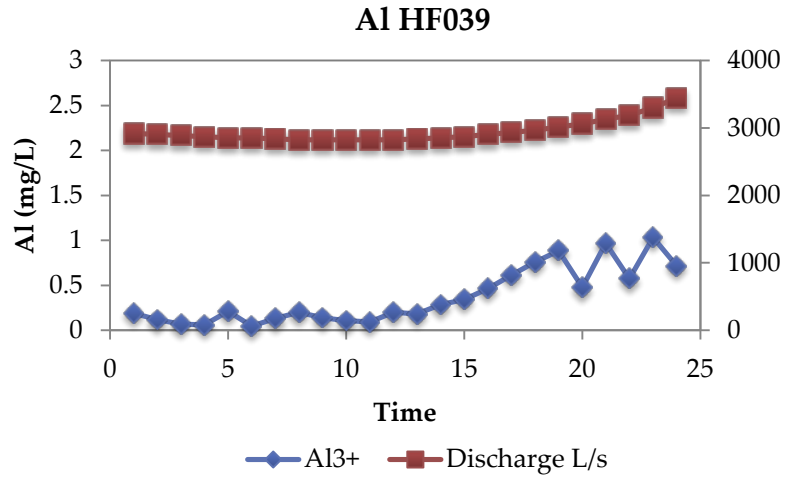


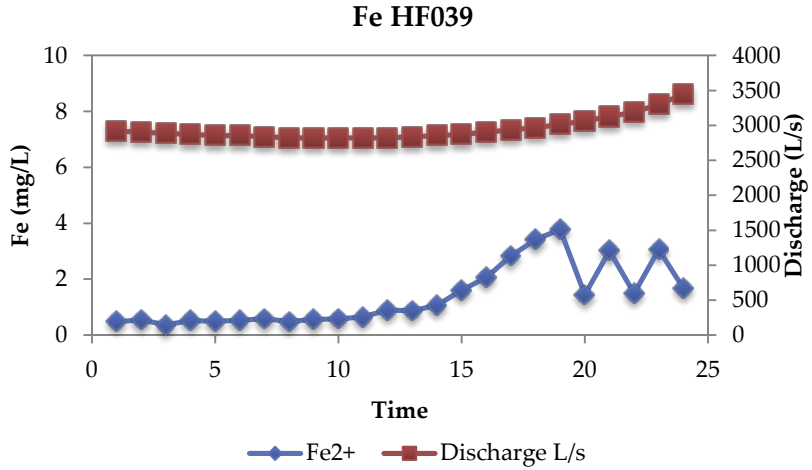
Net Acidity Response

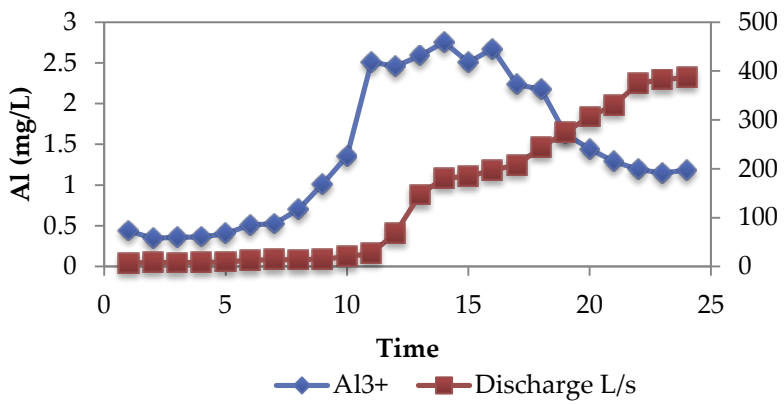


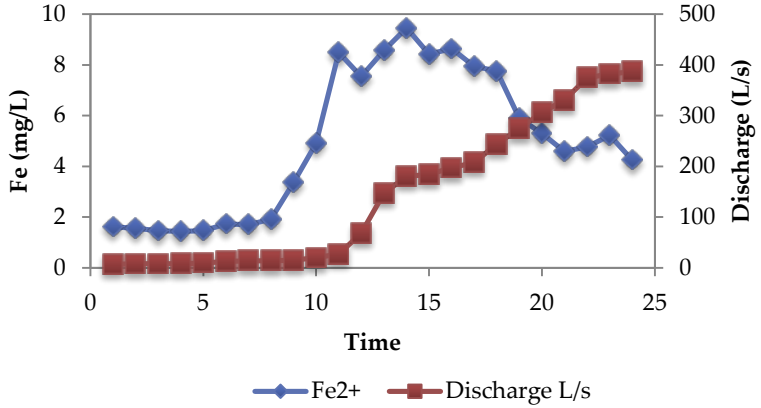
Primary Flush:

4/30/16 – 5/1/16



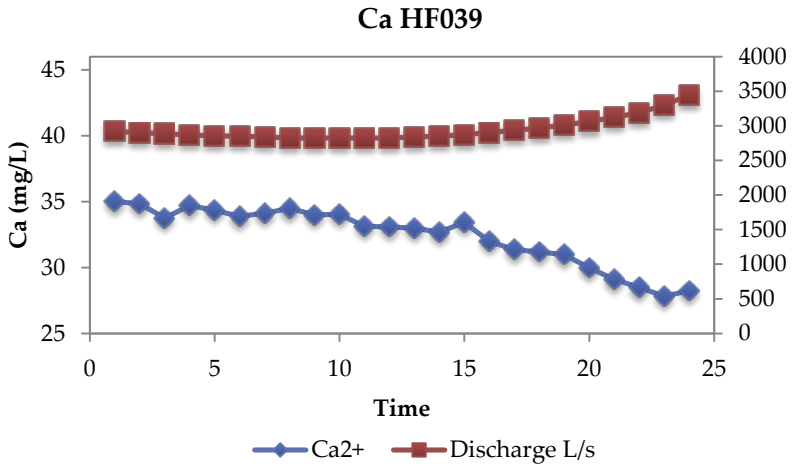


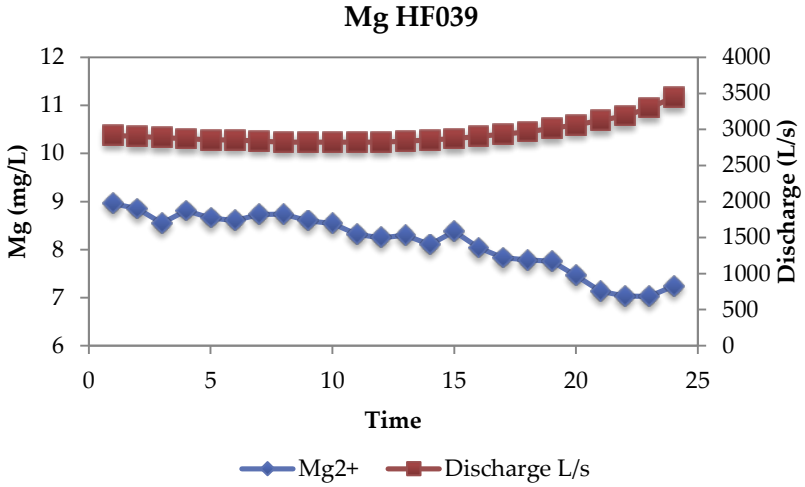


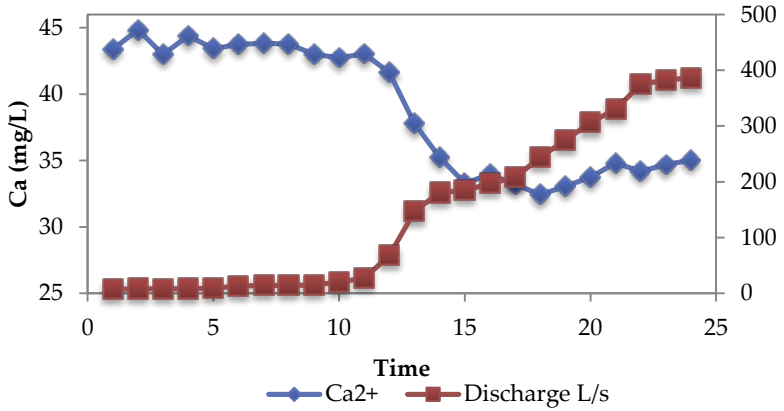


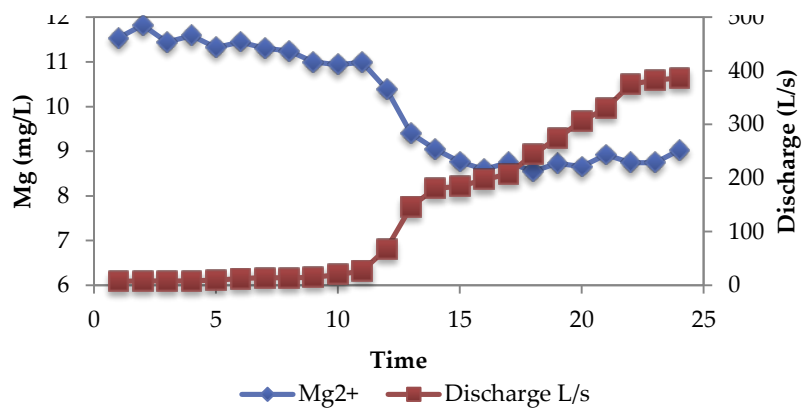
Primary Dilution:

4/30/16 – 5/1/16



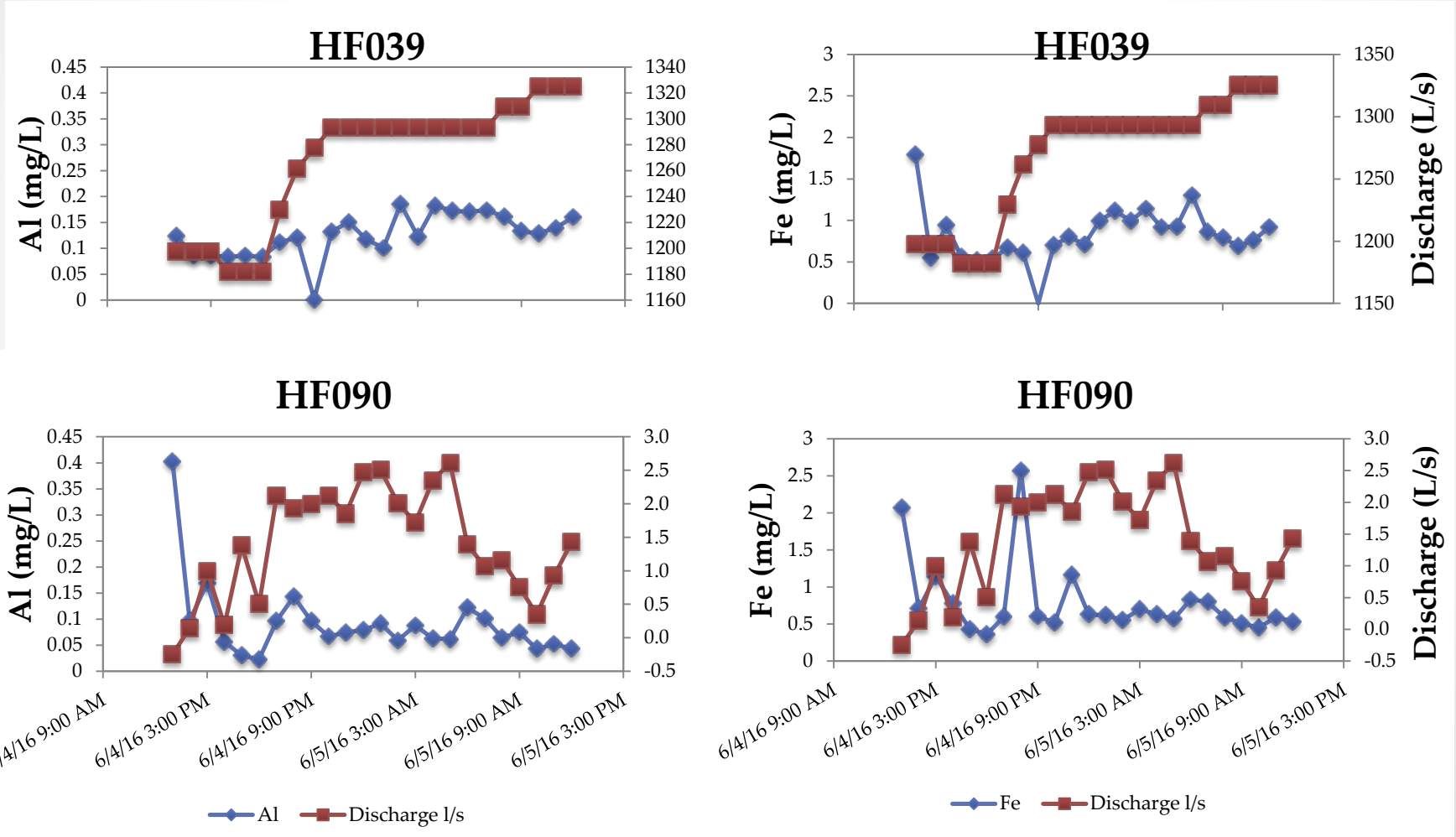






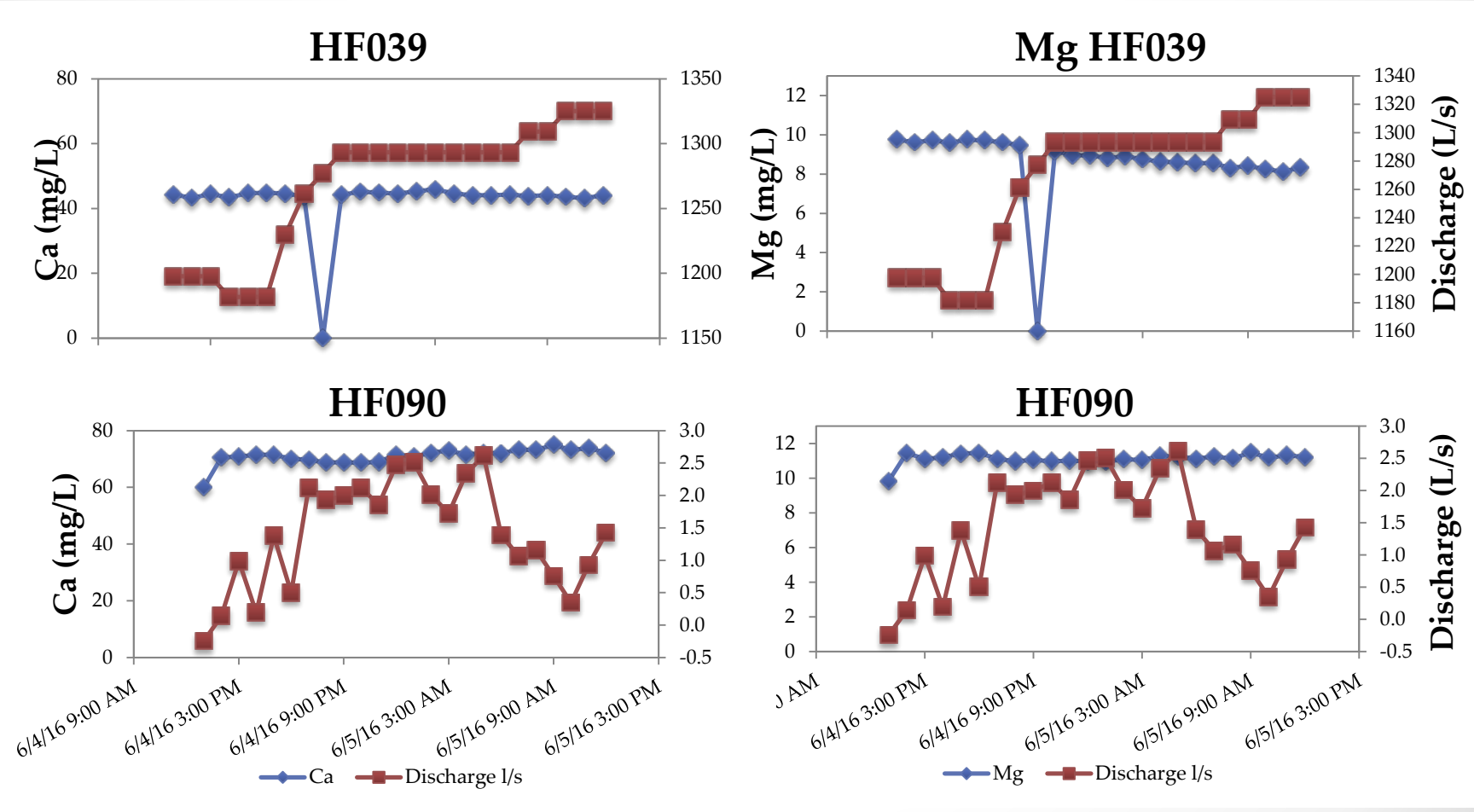
Diverging response:

6/4/16 – 6/5/16



Diverging response:

6/4/16 – 6/5/16



Inconsistent Metals

- No primary response displayed
  - As – only detected at HF039 during 9/28/16 – 9/29/16
  - Cu – 4/30/16 – 5/1/16, 9/28/16 – 9/29/16, & 10/20/16 – 10/22/16
  - Ni – only detected during 10/20/16 – 10/22/16
  - Pb - only detected at HF039 during 9/28/16 – 9/29/16
  - Zn – 7/28/16 – 7/29/16, 9/28/16 – 9/29/16, 10/20/16 – 10/22/16, & 12/5/16 – 12/6/16

Critical Conditions

- Acidic flushes were seen in the spring and fall storms downstream at the downstream site
- Al and Fe also flush during the early spring and early fall storms at the downstream site
- Al and Fe consistently flushed at the upstream site throughout the study

Conclusions

- Storm response in AMD impacted watersheds is important to understand
- Precipitation is not the ultimate driver of response pattern
- Response patterns differ between parameters, seasons, sites, and antecedent conditions
- Antecedent soil conditions may be responsible for determining response patterns

Recommendations

- Watershed managers working in AMD impacted streams should implement storm flow monitoring to better understand the fate and transport of pollutant materials through their watersheds

- Further studies should be completed to understand the interactions of precipitation run-off events and soil moisture content

Questions?