Seasonal Trends in Water Quality in a Treated Acid Mine Drainage Impaired Stream

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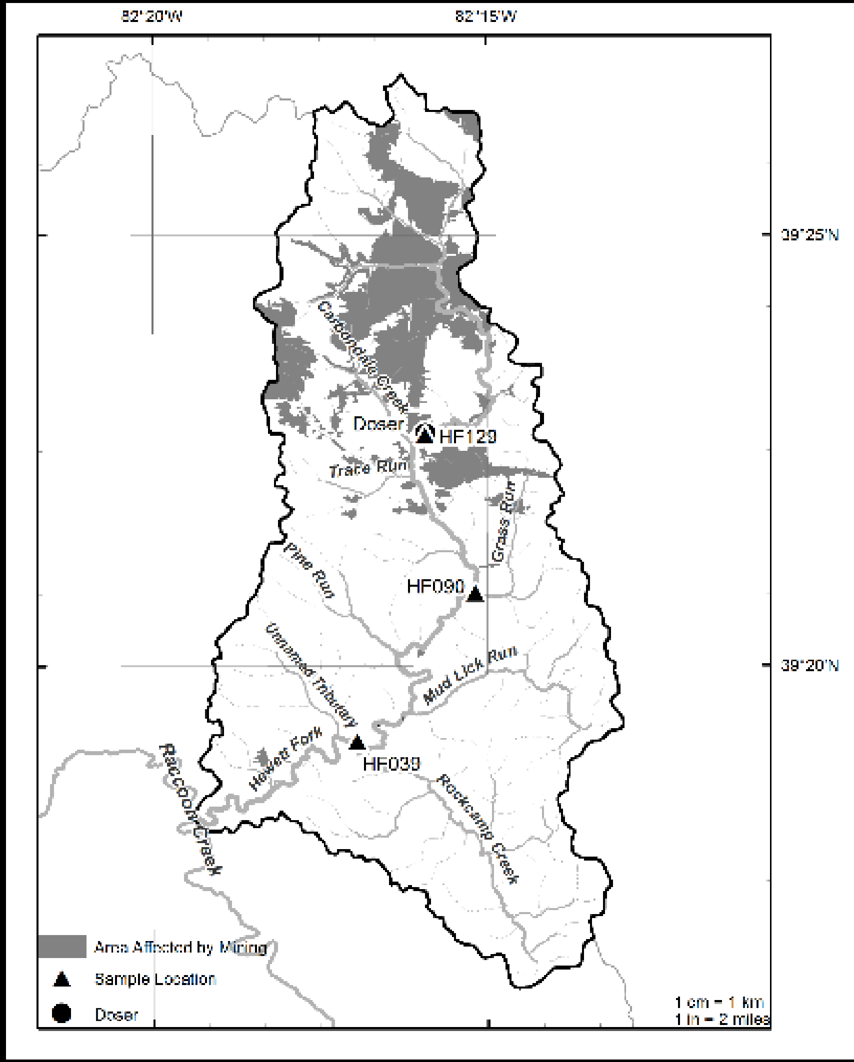
Zeb Martin

Ohio University

What can continuous monitoring tell us about how AMD impaired streams behave seasonally?

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

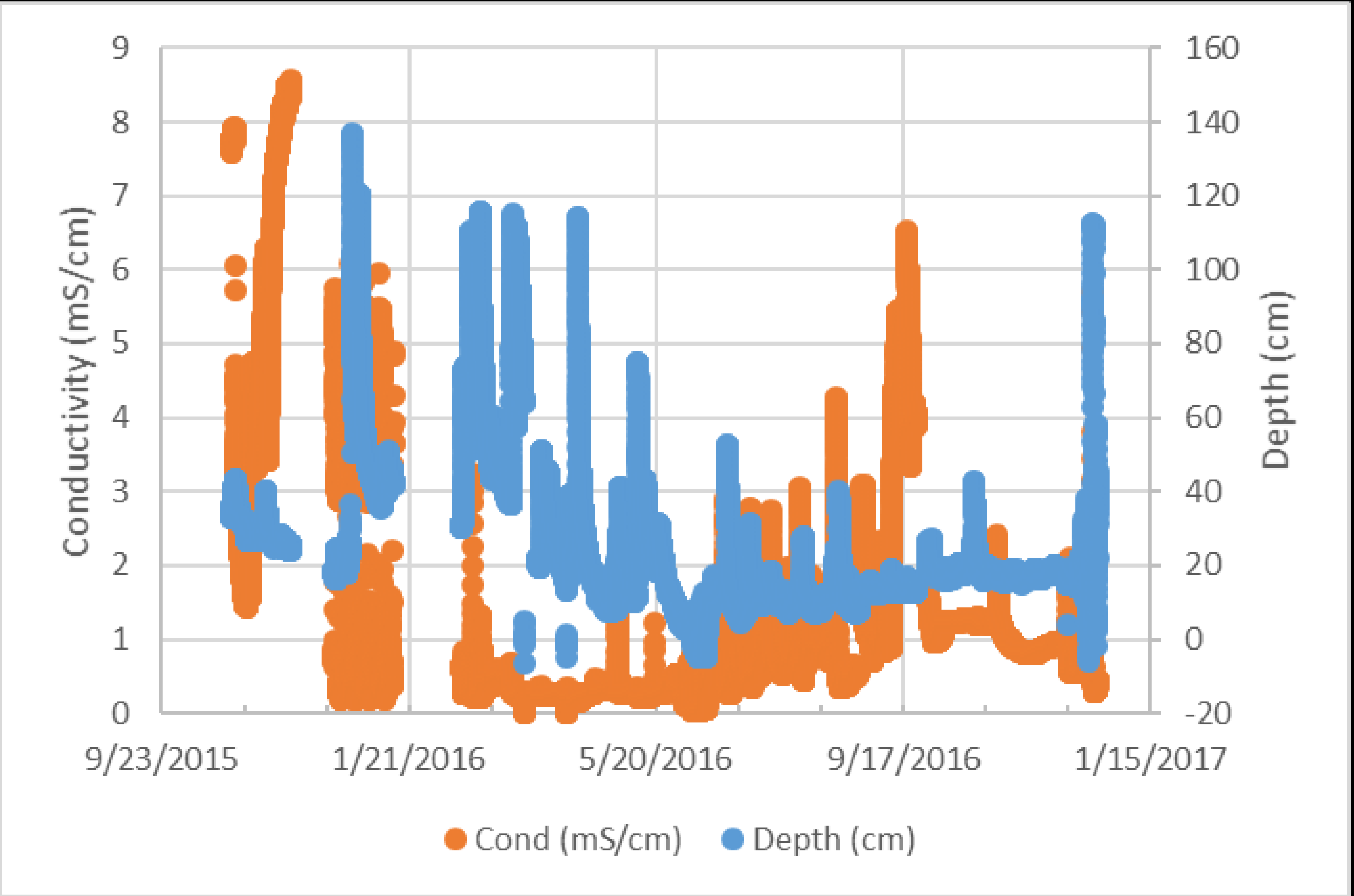
- Two major AMD inputs are treated at a single location in Carbondale, OH, and discharges into Hewett Fork at field site **HF129**.
- **HF090** is 4.5 km (2.3 miles) downstream of HF129, and represents the downstream extent of the mixing zone where limited biological recovery can be seen.
- **HF039** is 11.4 km (7 miles) downstream of HF129, and represents the zone in which water quality and biological metrics are both being met.

Field Sites

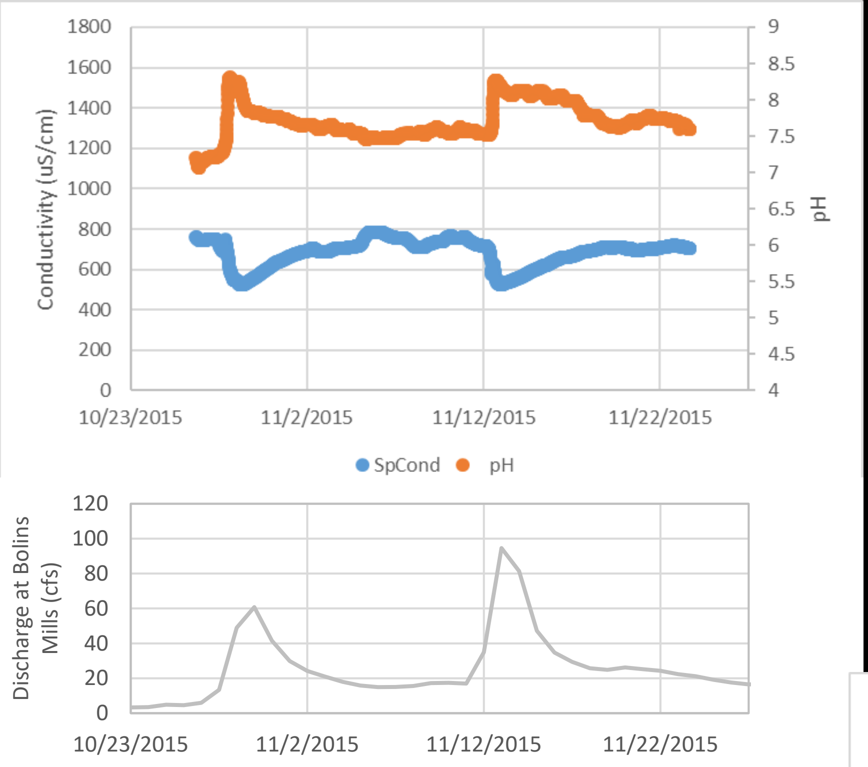
What is Storm Response?

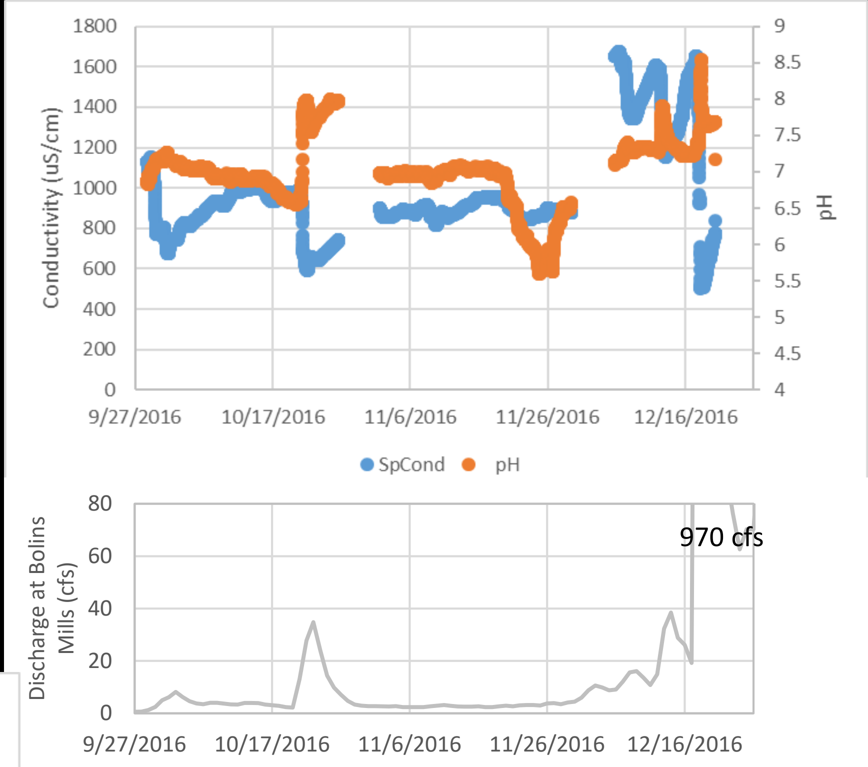
- Purging and Sparing
- Sparing – removal of oxygen from the reaction site due to flooding
- Purging – flushing of accumulated oxidation products by storm run-off
- Is that it?
    - Mixed mechanism
    - Consistent concentration

Long-term monitoring of storm response

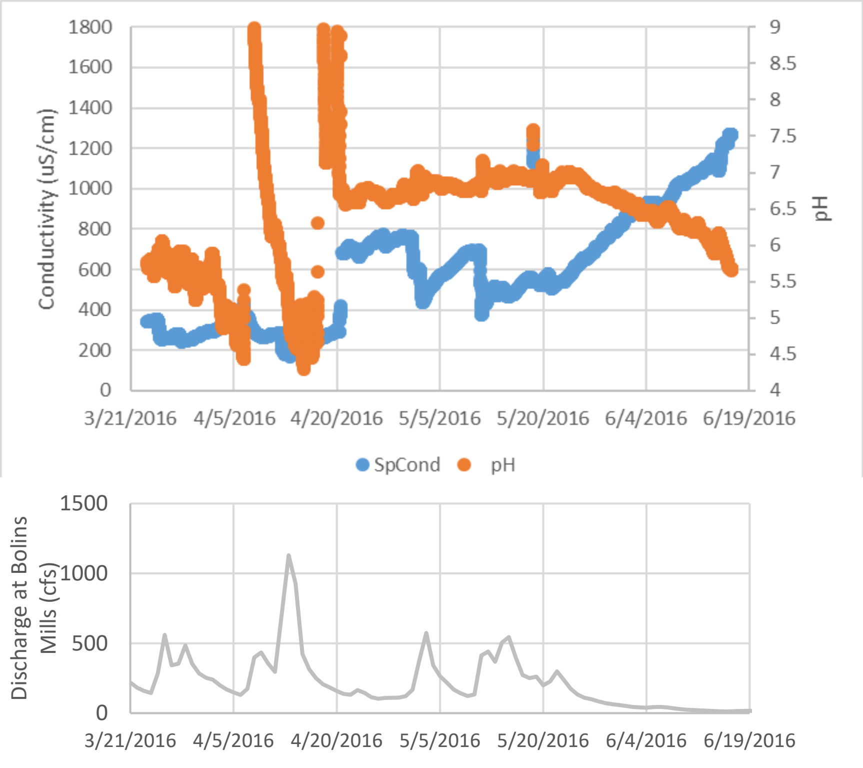


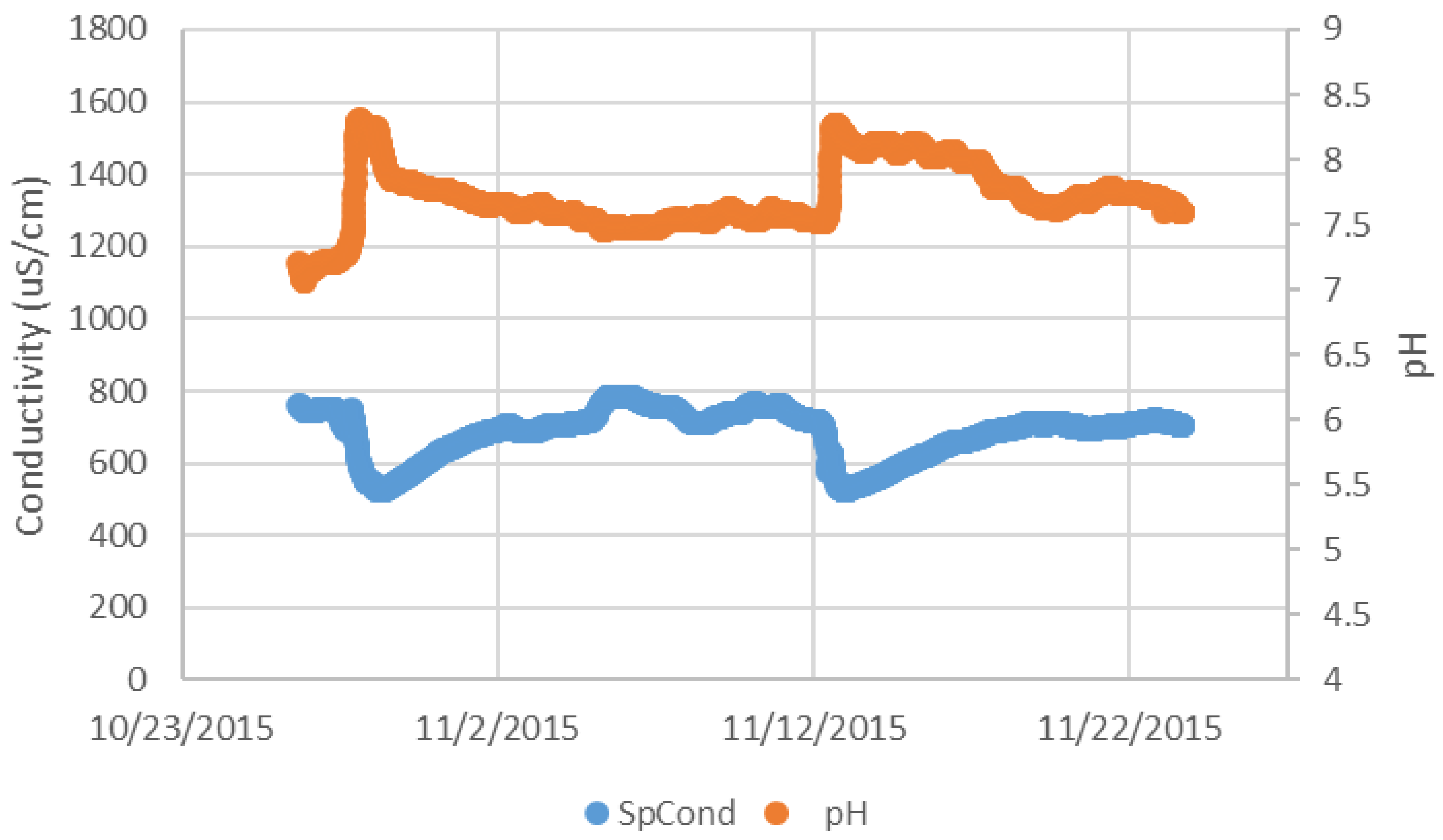
Seasonal variation in water depth and conductivity 20 m downstream of doser discharge





Seasonal water quality 4.5 km downstream from doser





1800
1600
1400
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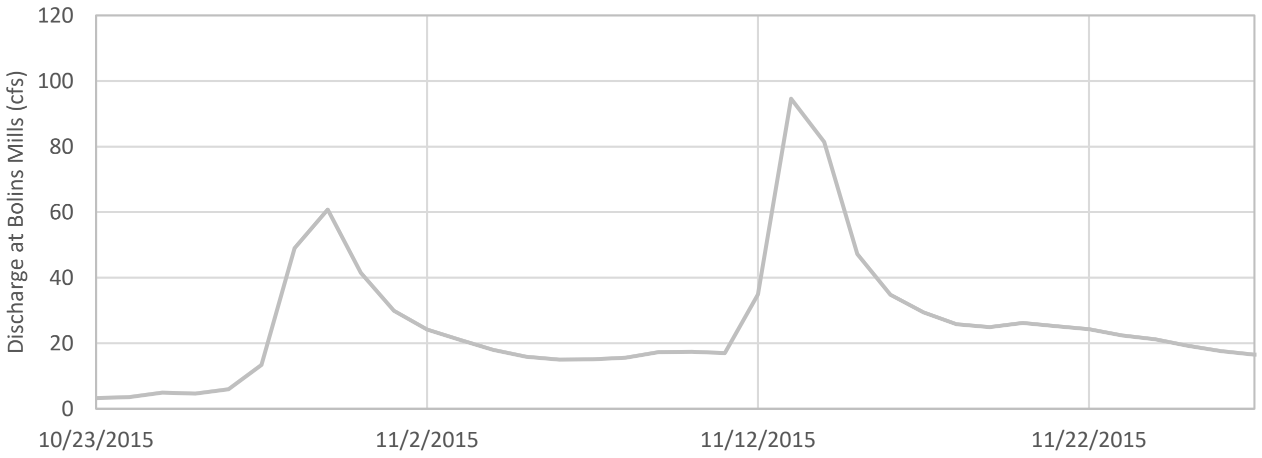
Conductivity (uS/cm)
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
pH
10/23/2015
11/2/2015
11/12/2015
11/22/2015
SpCond
pH



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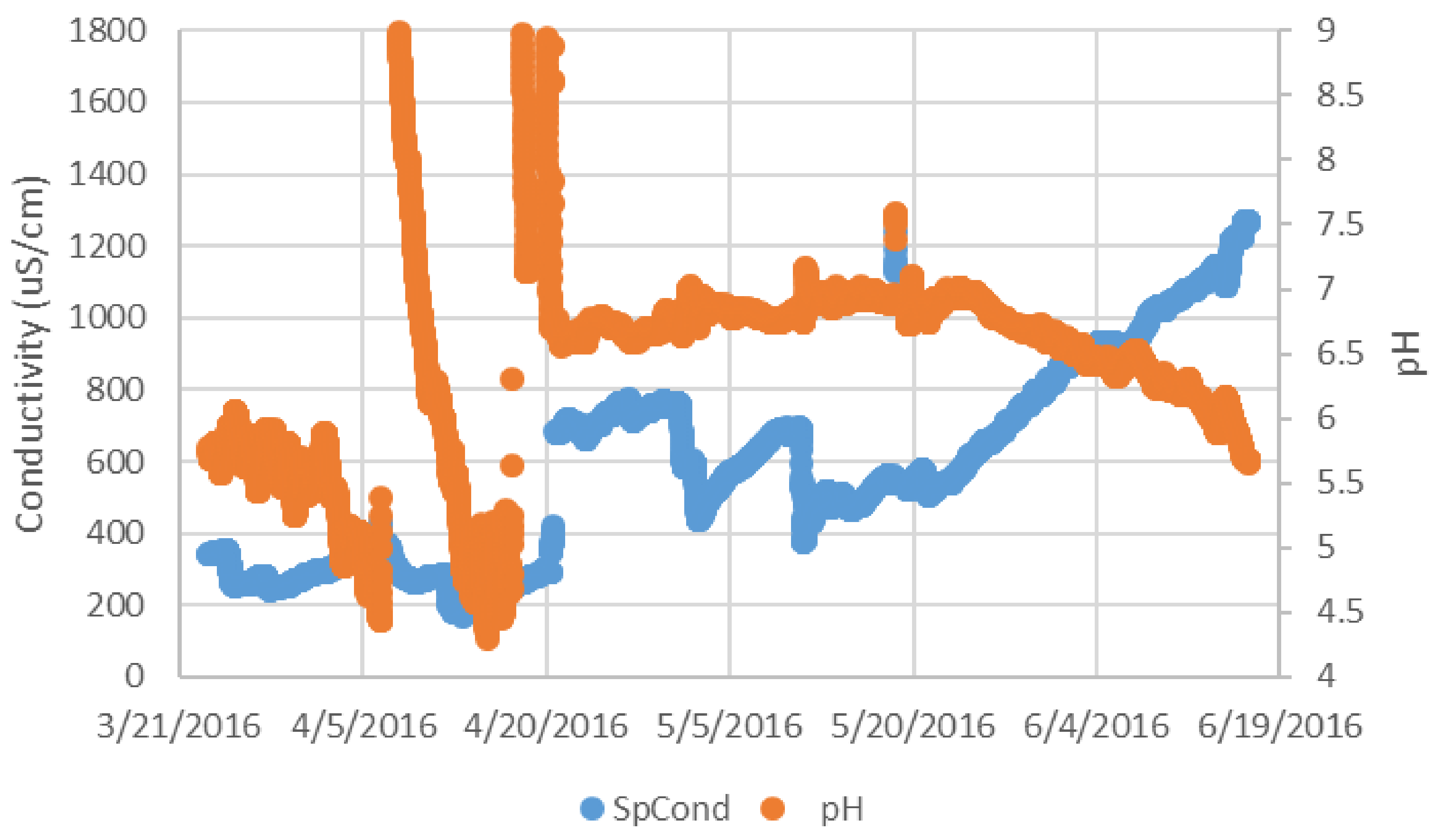
Discharge at Bolins Mills (cfs)
10/23/2015
11/2/2015
11/12/2015
11/22/2015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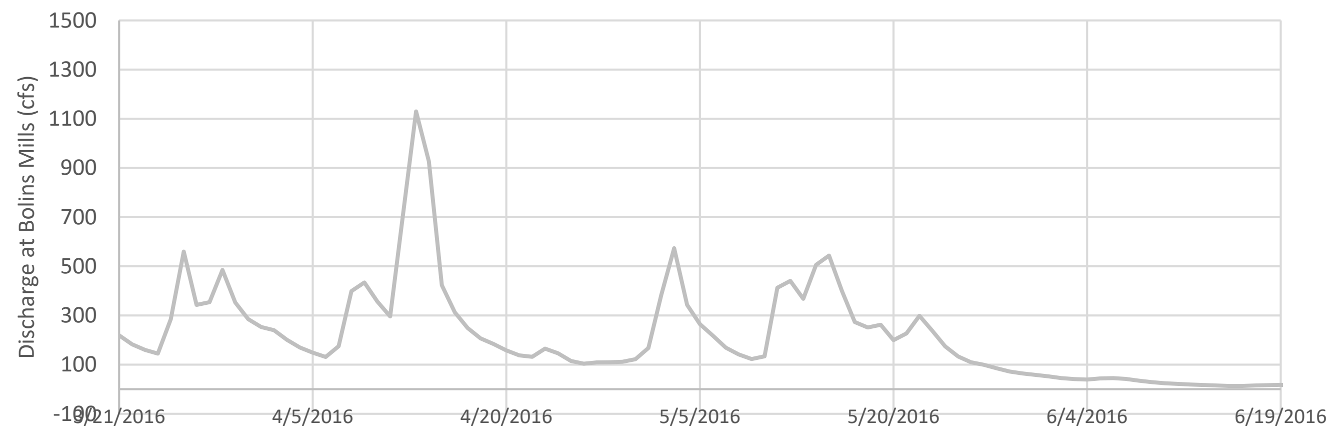
pH
3/21/2016
4/5/2016
4/20/2016
5/5/2016
5/20/2016
6/4/2016
6/19/2016
SpCond
pH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5/20/2016
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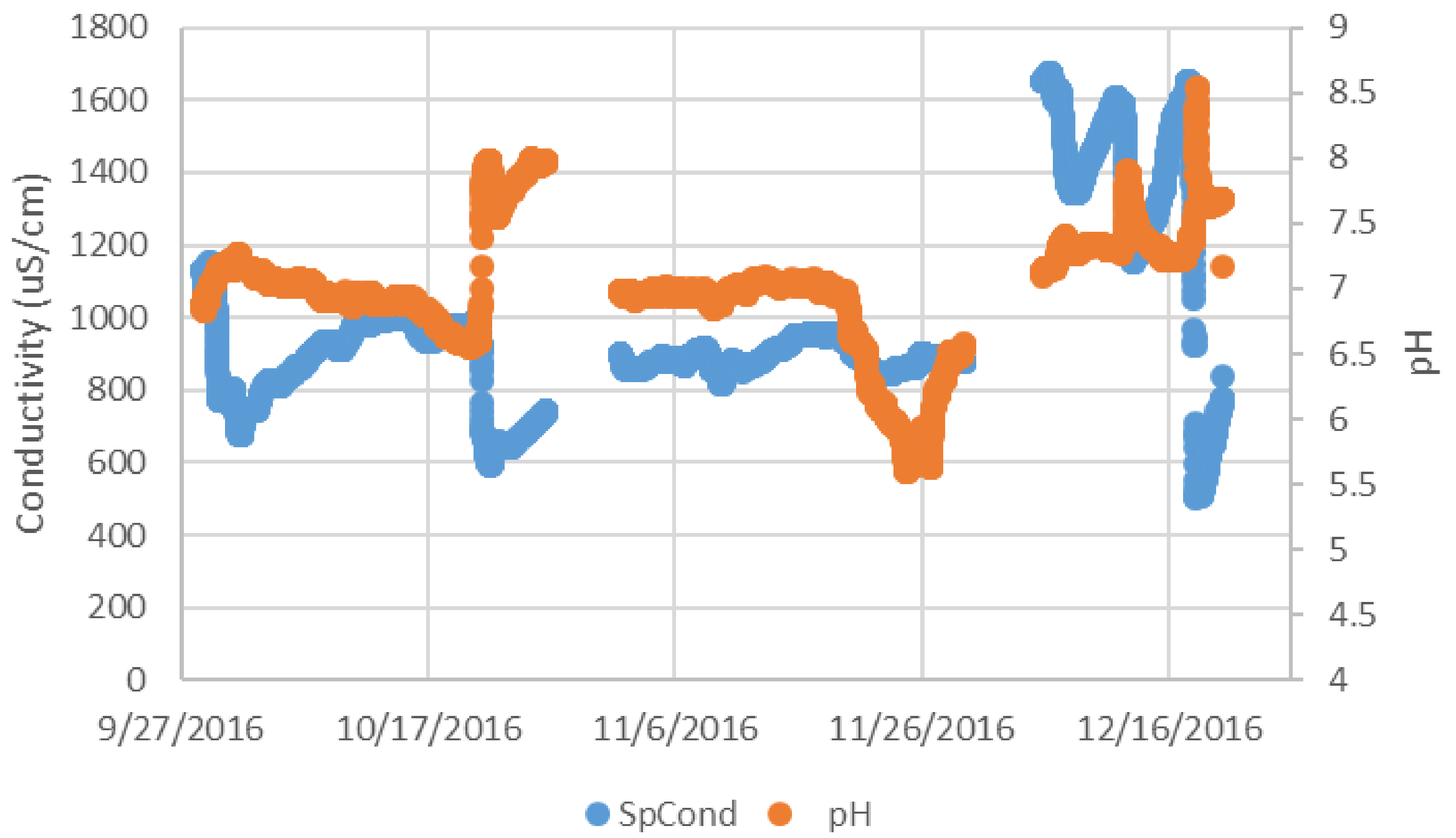

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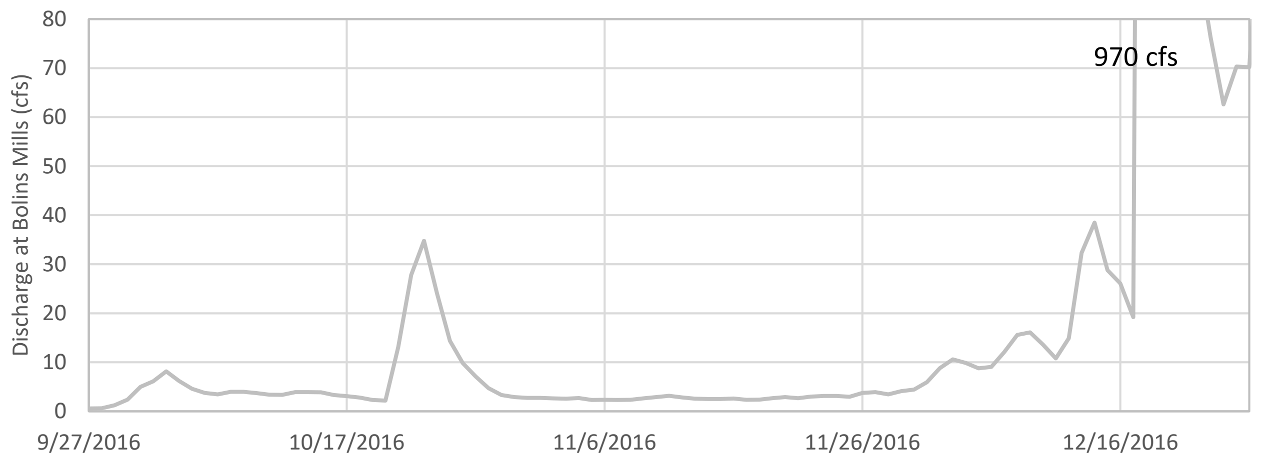
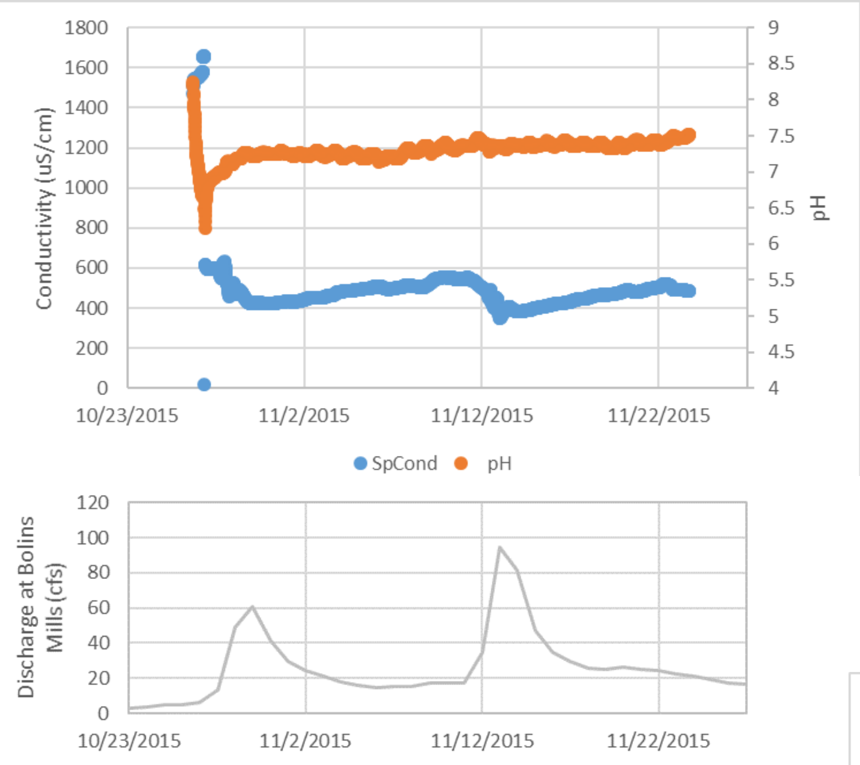
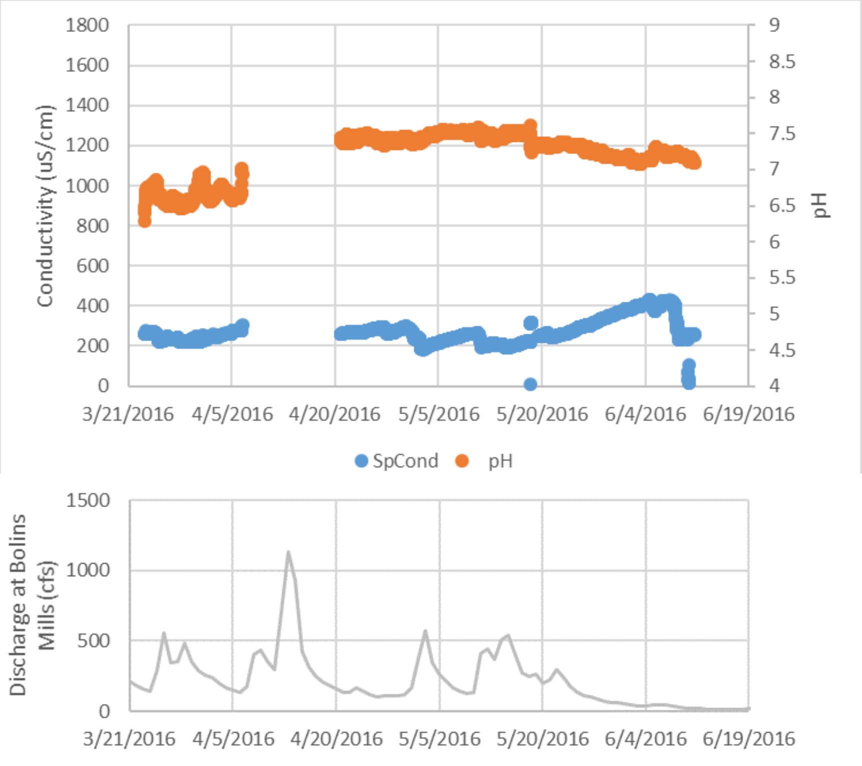
10/17/2016
11/6/2016
11/26/2016
12/16/2016
SpCond
pH

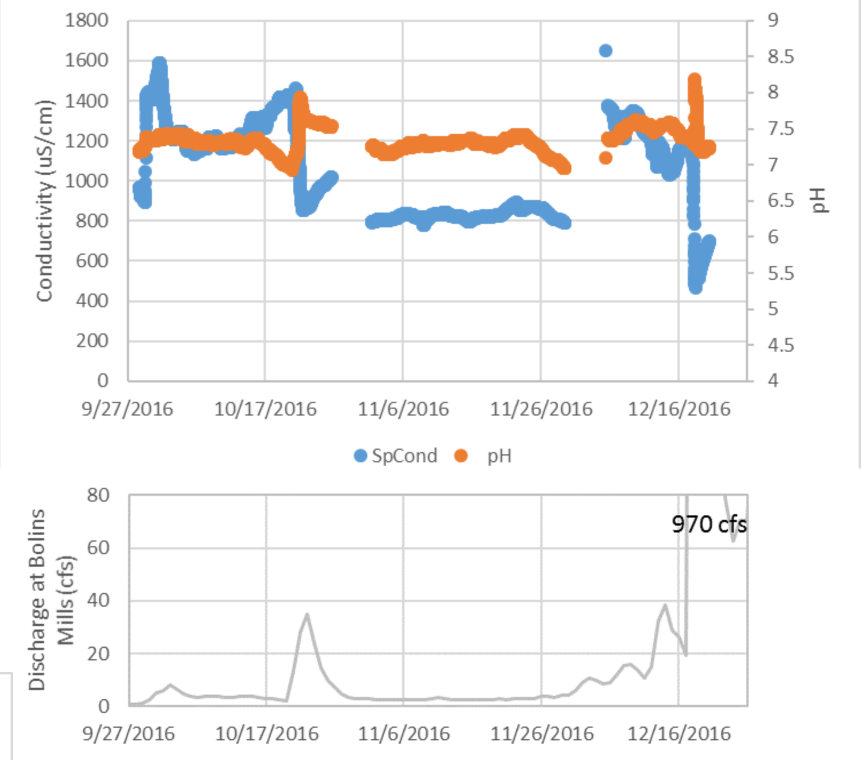


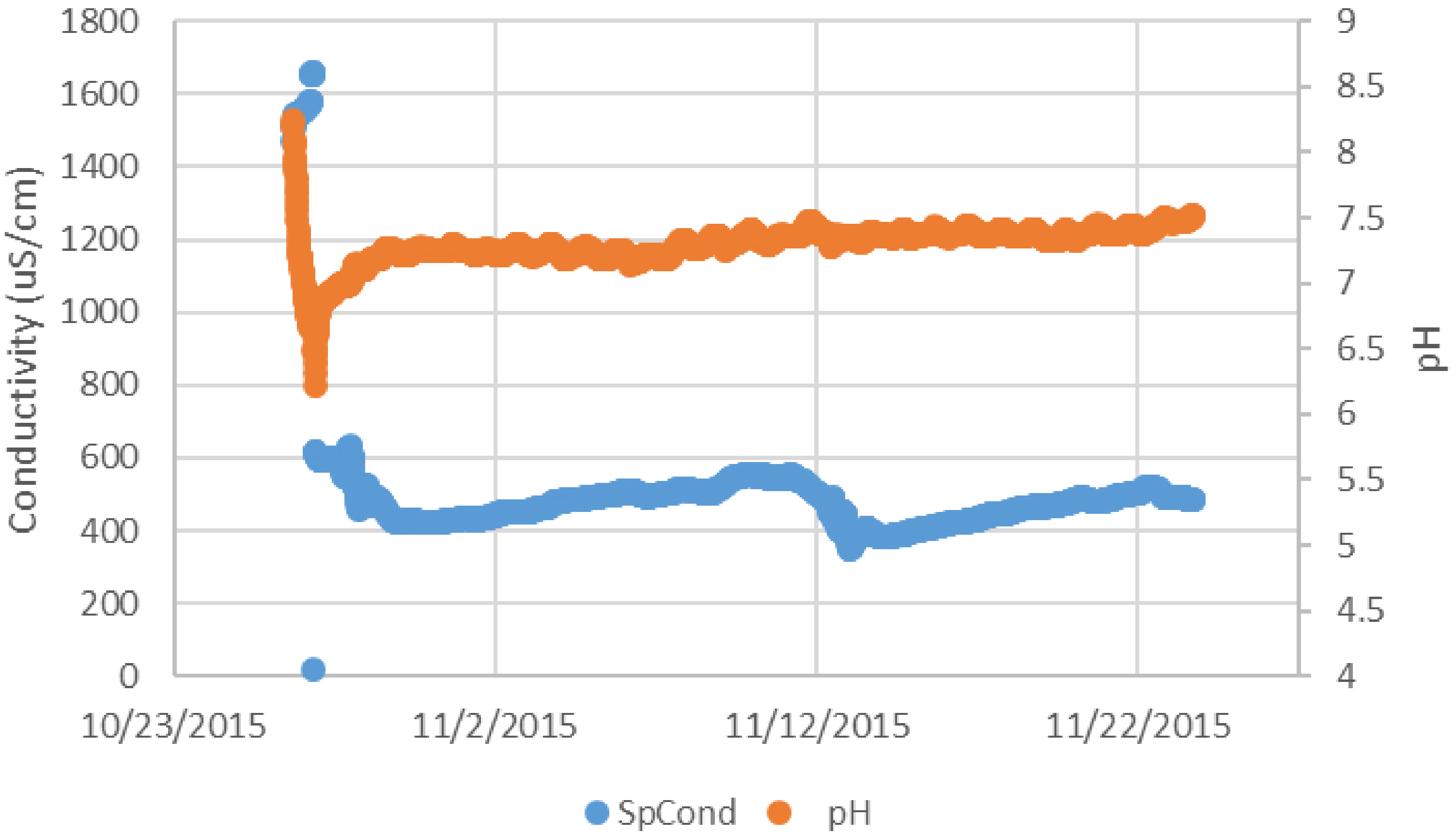
Discharge at Bolins Mills (cfs)
970 cfs
80
70
60
50
40
30
20
10
0
9/27/2016
10/17/2016
11/6/2016
11/26/2016
12/16/2016

Seasonal water quality 11.4 km downstream from doser





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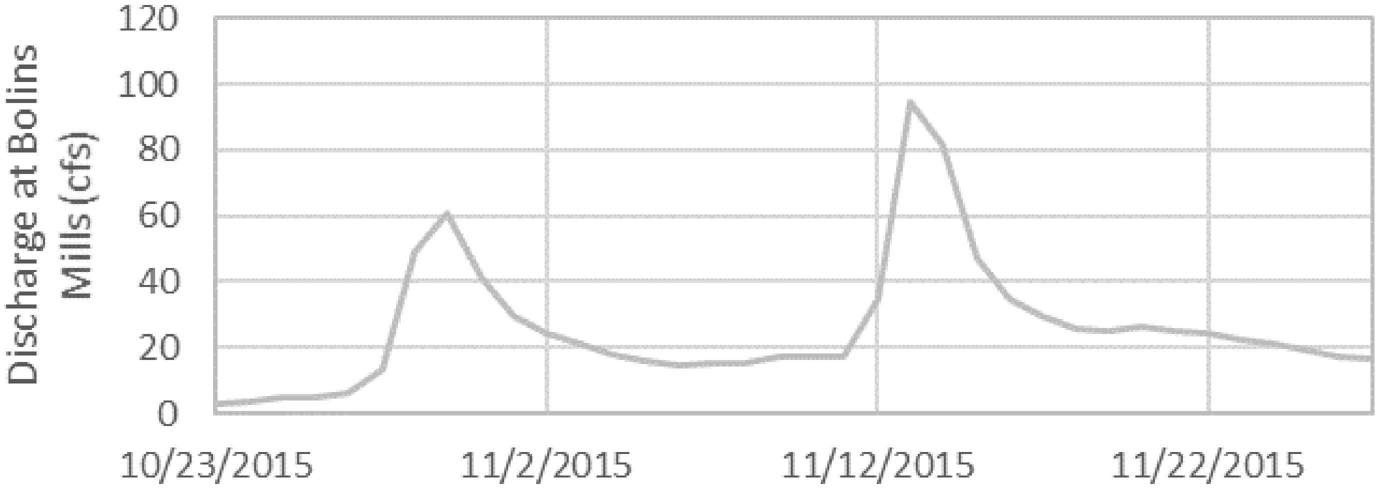
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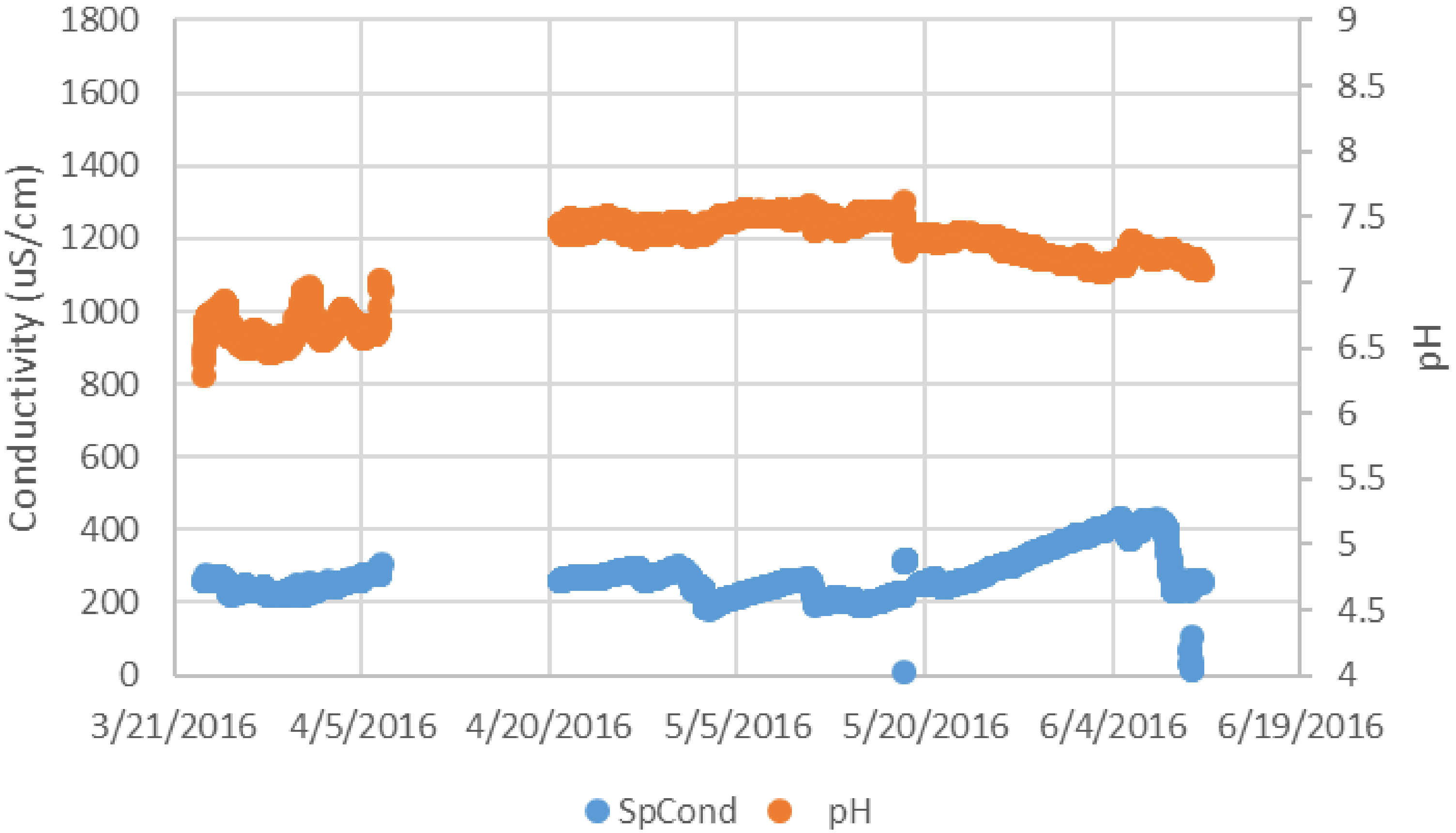
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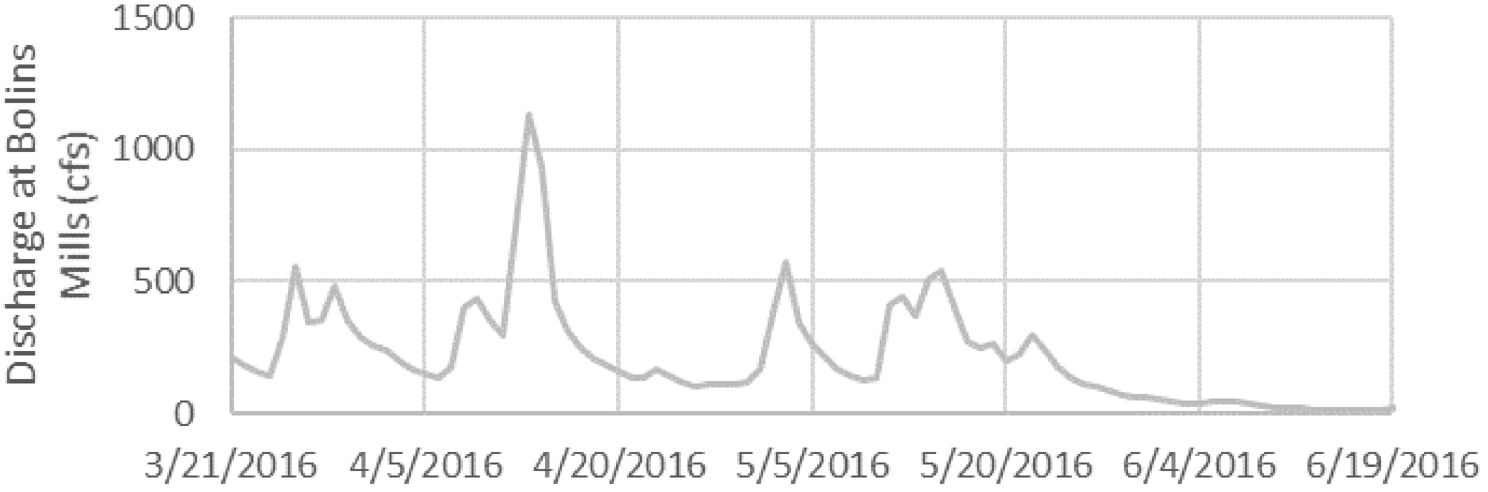
pH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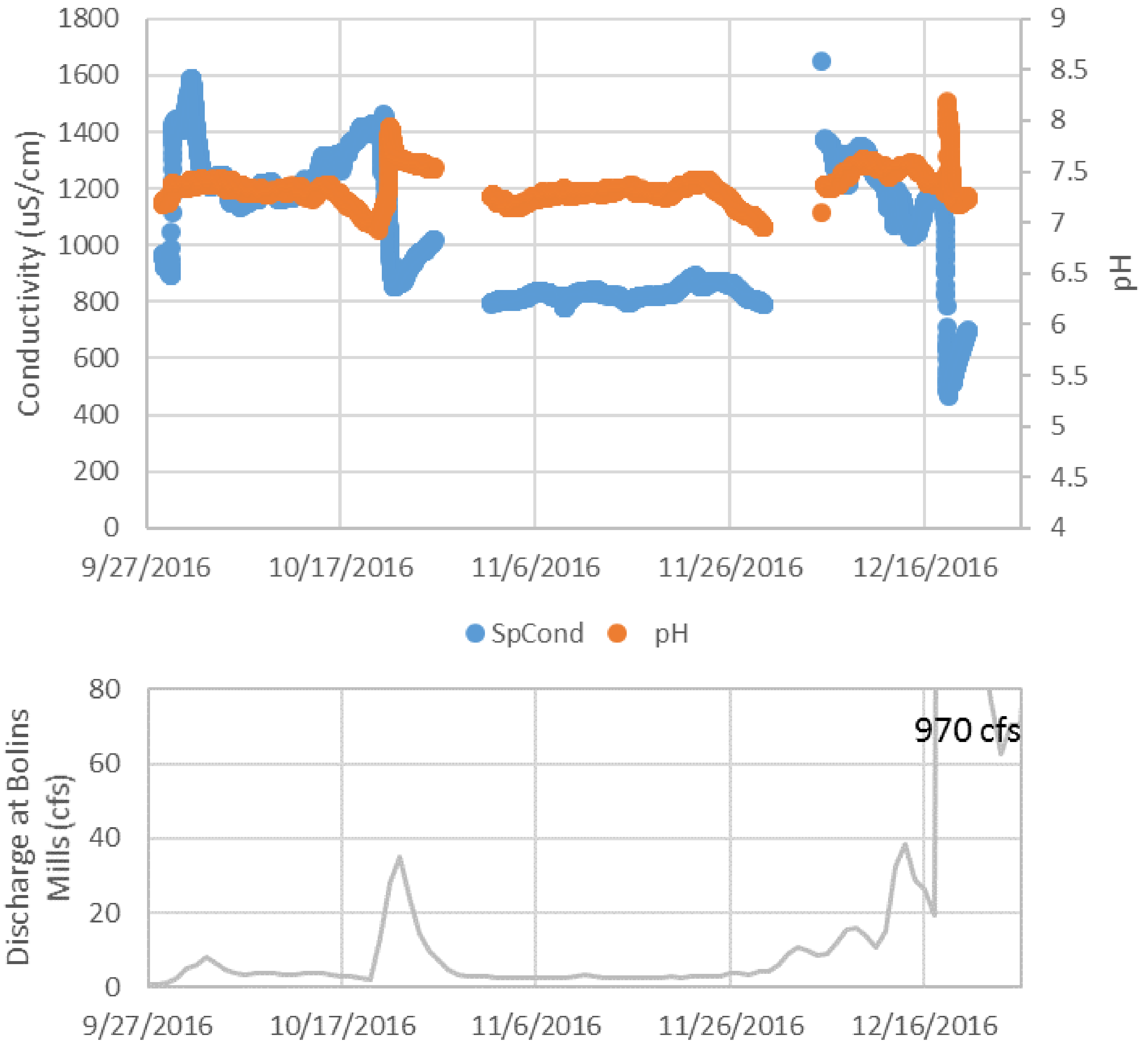

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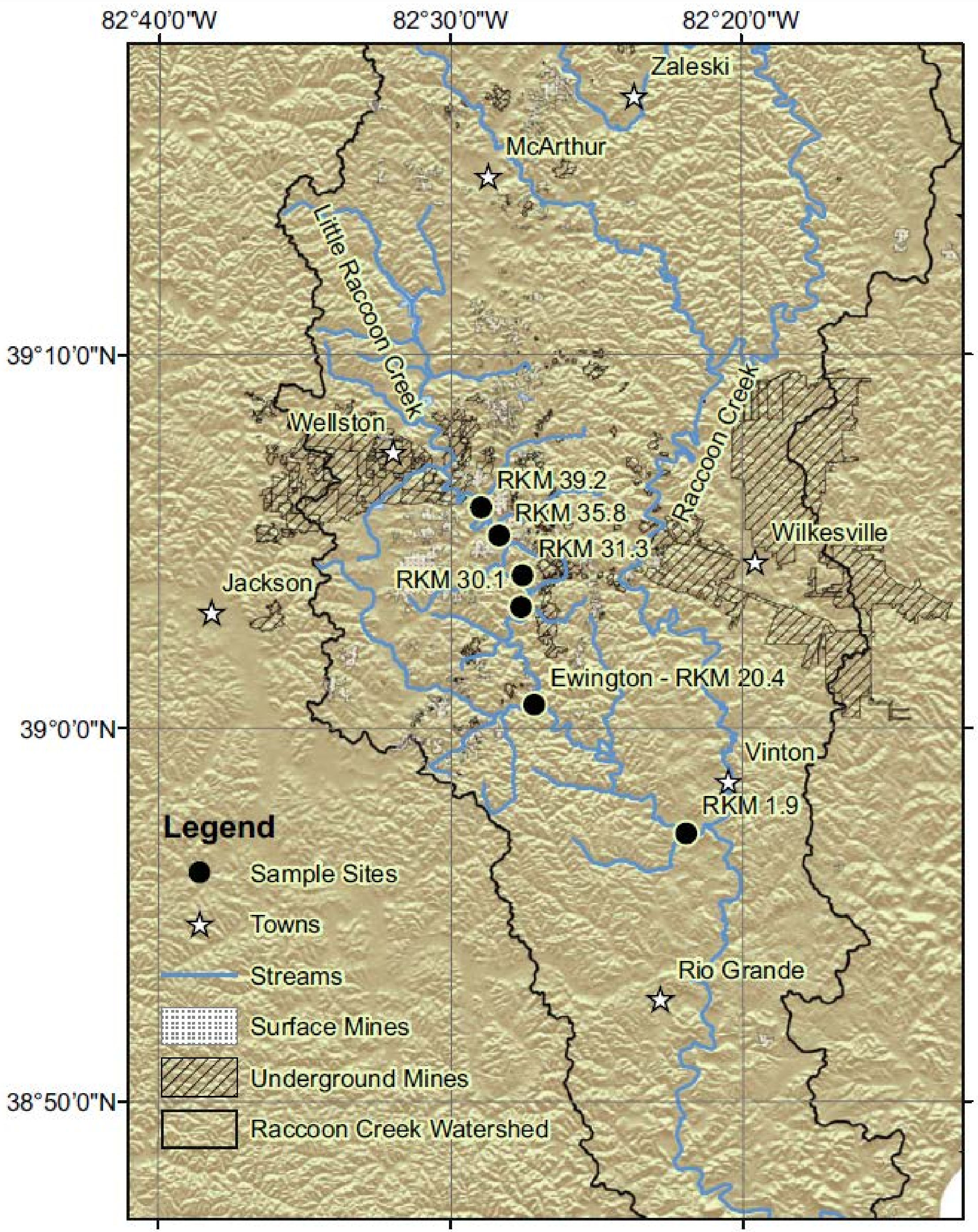
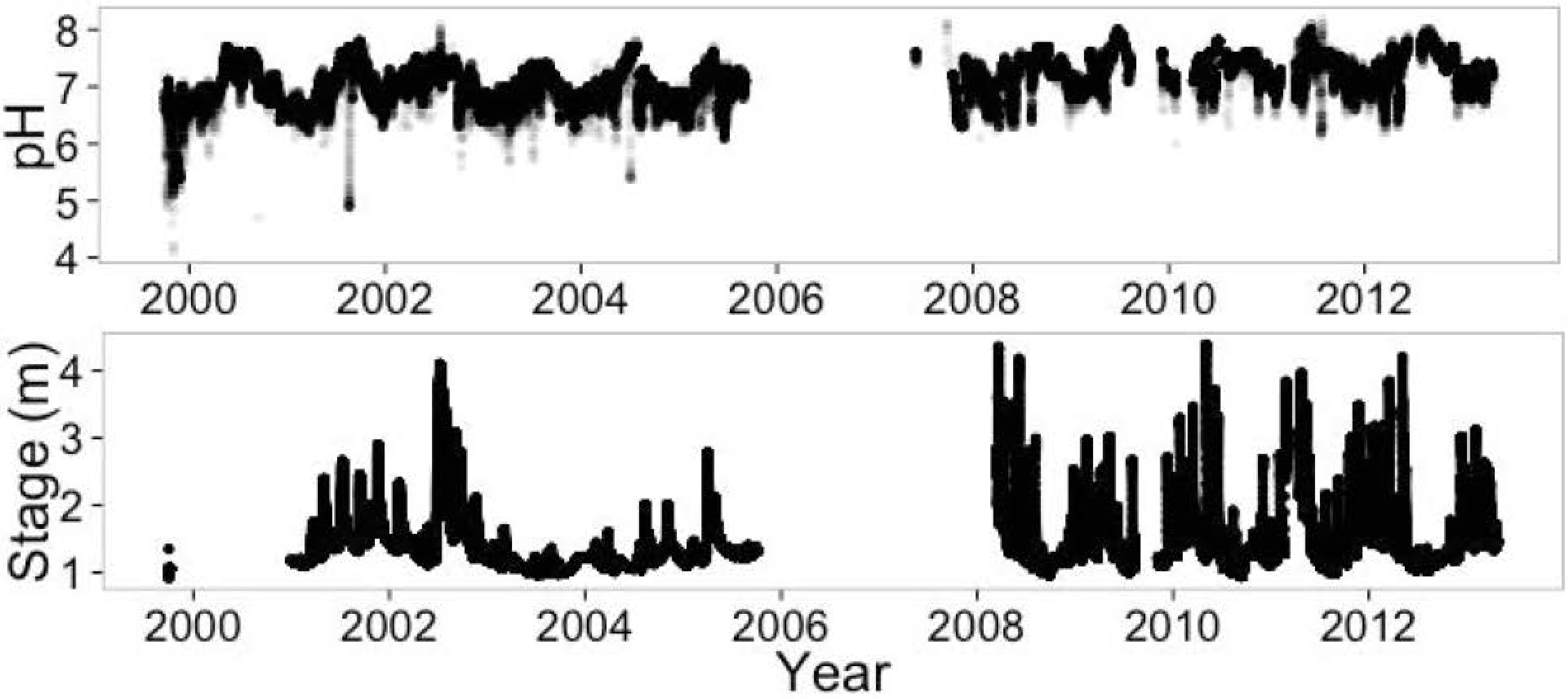
11/6/2016
11/26/2016
12/16/2016

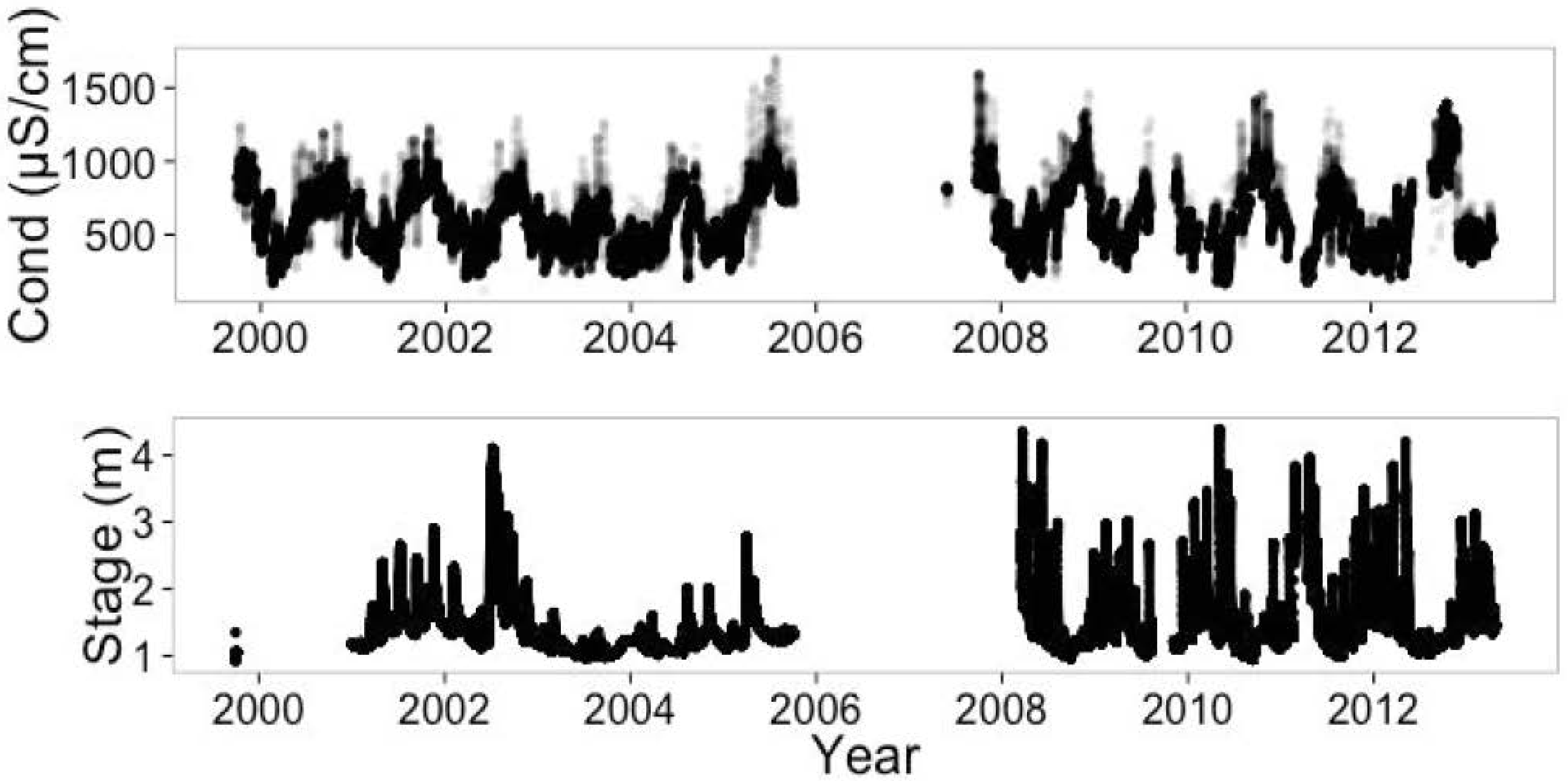
Case study in Little Raccoon Creek – seasonal patterns in pH and conductivity

Little Raccoon Creek





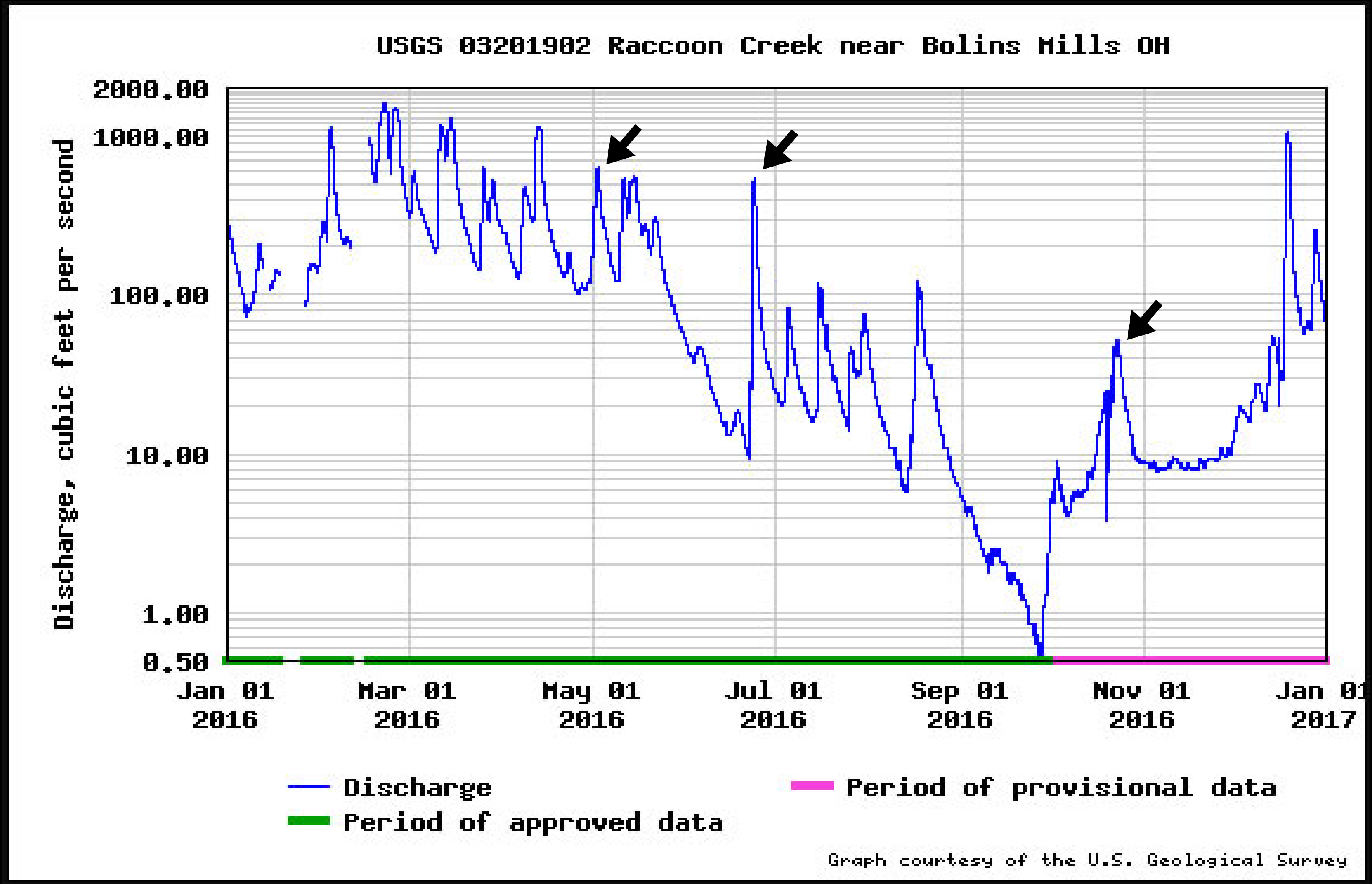
8
7
6
5
4
pH
2000
2002
2004
2006
2008
2010
2012
4
3
2
1
Stage (m)
2000
2002
2004
2006
2008
2010
2012
Year



Cond (μS/cm)
1500
1000
500
2000
2002
2004
2006
2008
2010
2012
Stage (m)
4
3
2
1
2000
2002
2004
2006
2008
2010
2012
Year

Behavior of metals during storm events

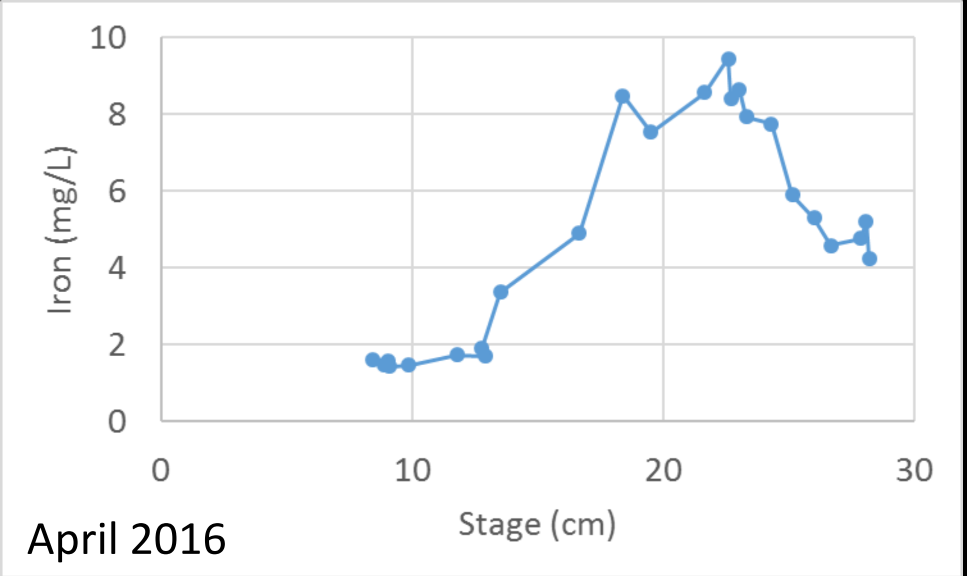
Water Year 2016

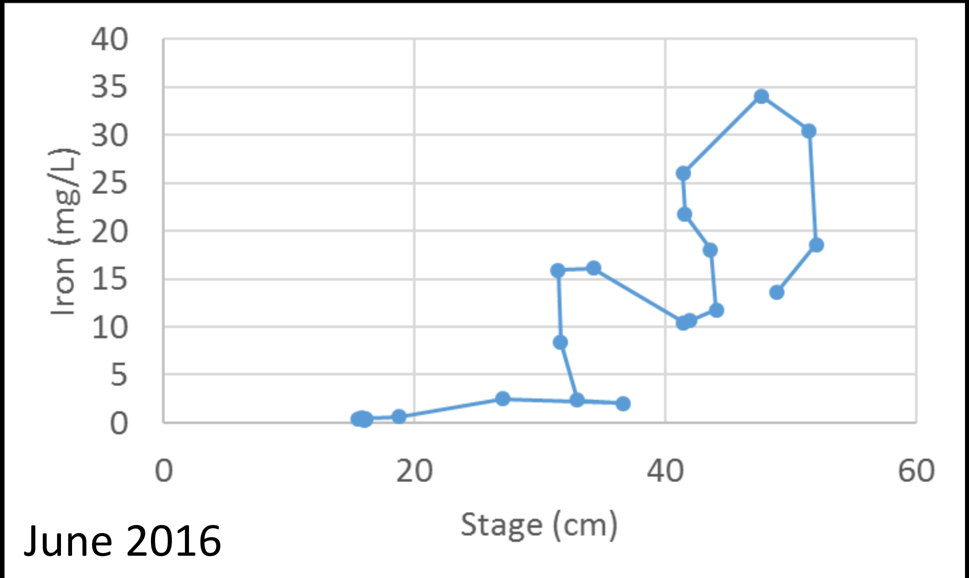


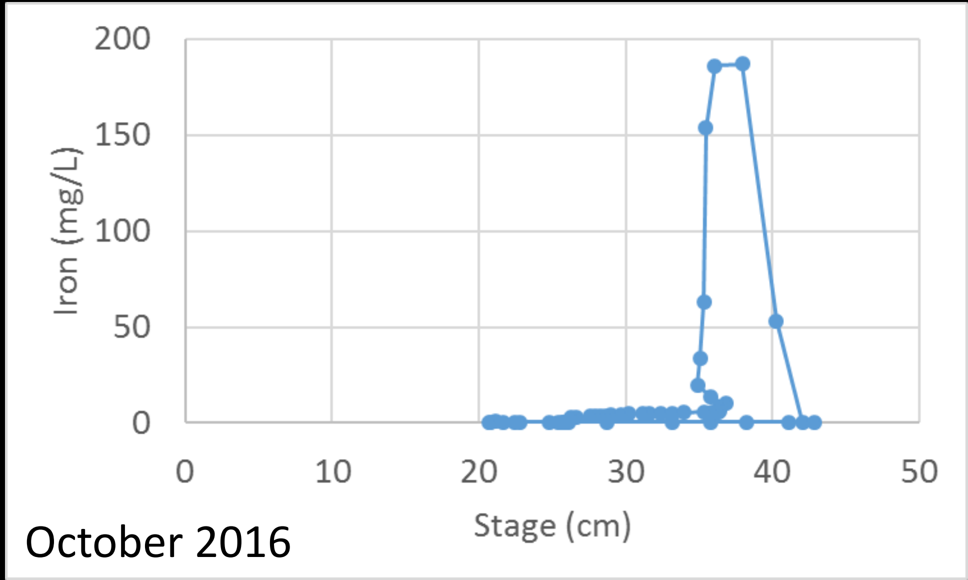
Precipitation Conditions for Each Storm

		Precipitation Data (cm)				Flow Regime		
Storm Date	Season	Total	Max	Min	Std. Dev.	HF039	HF090	Prior Dry Days
4/30/16-5/1/2016	Spring	1.194	0.381	0	0.095	High	High	1
5/20/16-5/21/2016	Spring	1.270	0.533	0	0.131	High	High	2
6/4/16-6/5/2016	Spring	1.067	0.635	0	0.135	High	Low	8
6/22/16-6/23/2016	Spring	5.410	2.337	0	0.540	High	High	5
7/28/16-7/29/2016	Summer	0.508	0.203	0	0.051	High	Low	1
9/28/2016-9/29/16	Summer	0.540	0.200	0	0.047	Low	N/A	9
10/20/2016-10/22/16	Fall	4.470	0.610	0	0.147	High	High	0
12/5/16-12/6/2016	Fall	1.575	0.305	0	0.098	High	Low	0

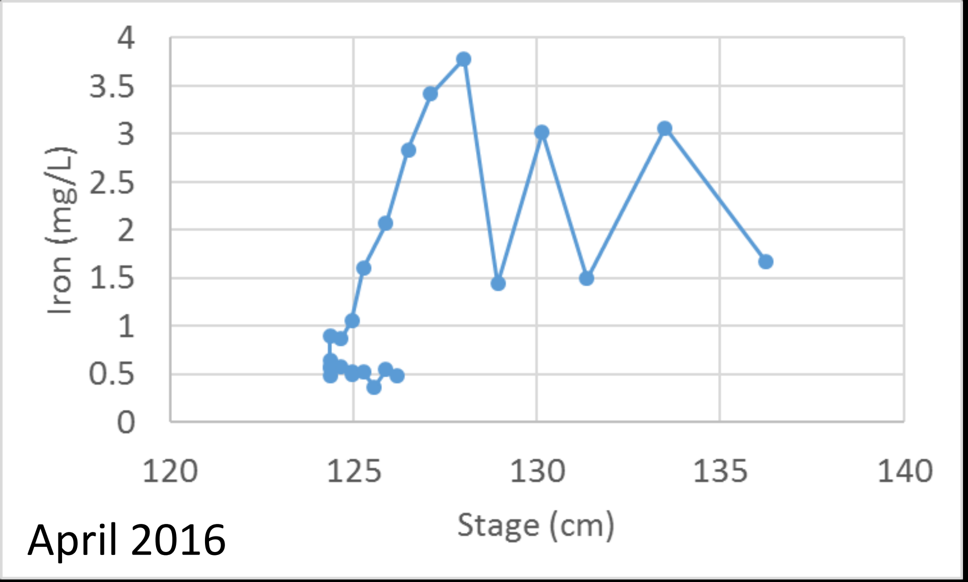
Hysteresis diagrams for metal response to storms

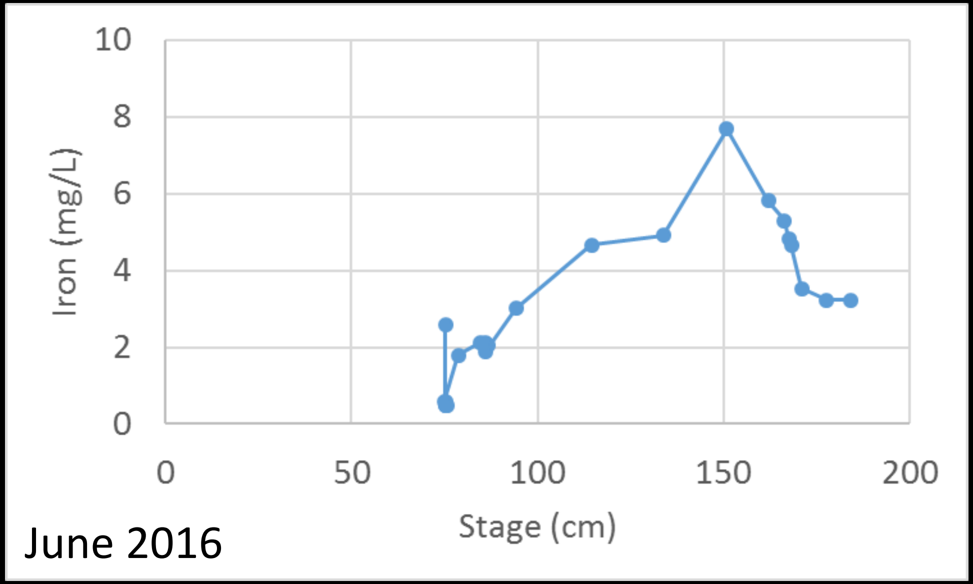


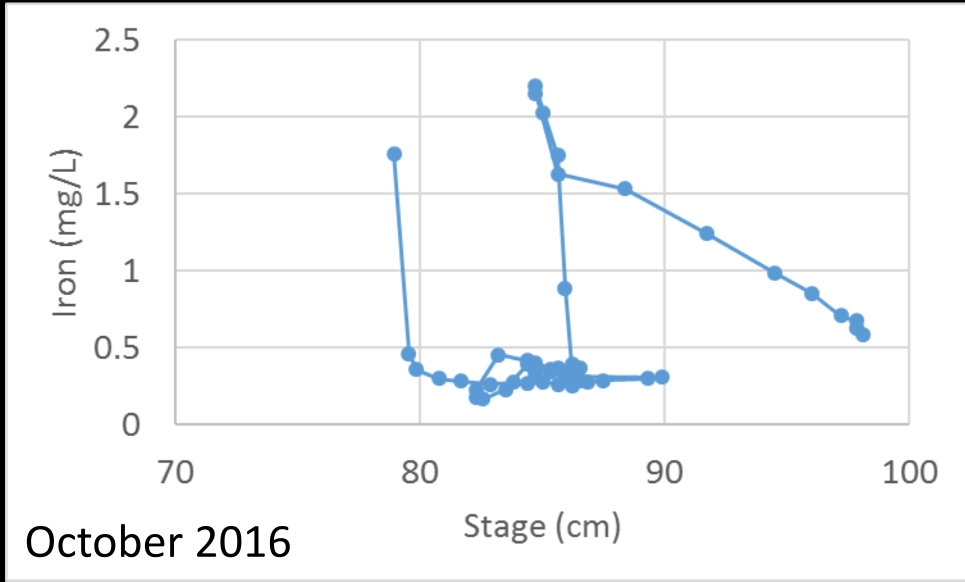




4.5 km downstream of the doser







11.4 km downstream of the doser

Conclusions

- For much of the year, there is a direct relationship between stage and pH and an inverse relationship between stage and conductivity
- Spring storms show significant variability in water quality including an indirect relationship between pH and stage and a direct relationship between stage and conductivity
- Less pronounced response further downstream
- Metal concentrations vary by an order of magnitude between seasons
- Differing patterns of hysteresis between sampling locations

Thanks!

Research Team:

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- Amy Mackey
- Jen Bowman
- Sylvie Wilson
- Bruce Underwood
- Sarah Cornwell

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