Effects of RSC Restoration on Water Quality & Benthic Macroinvertebrates in North Branch Muddy Creek

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MD DNR

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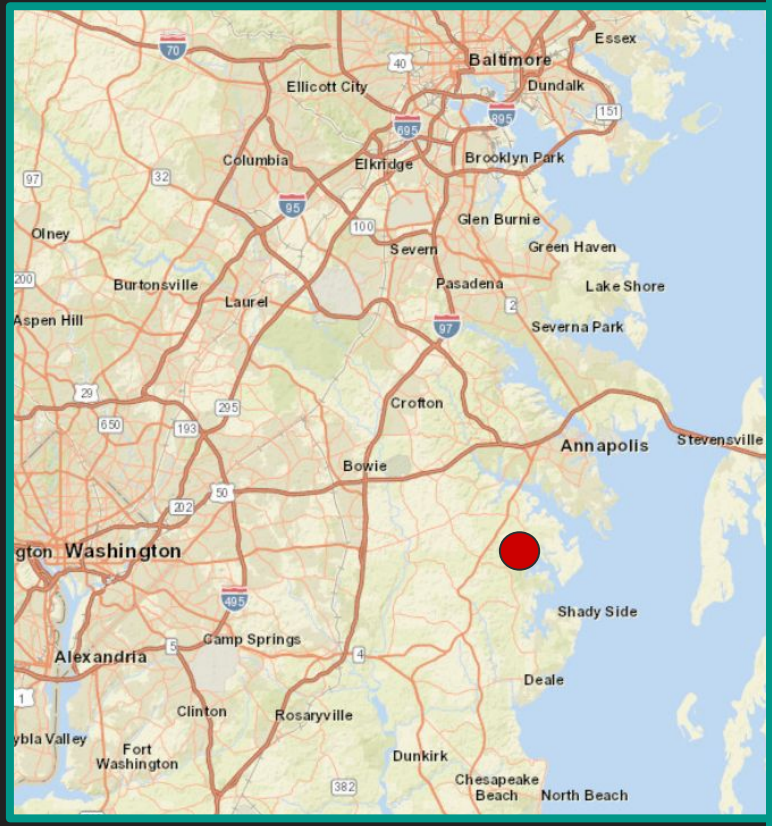
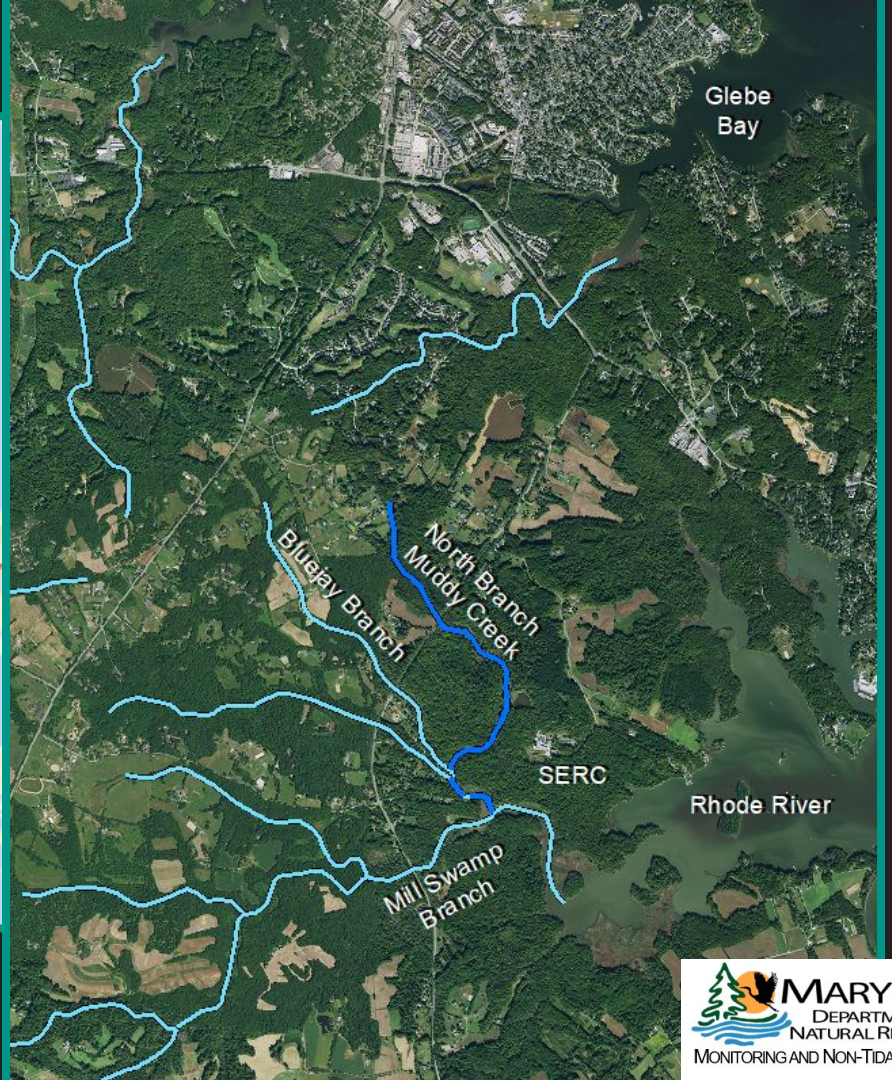
Background





North Branch Muddy Creek
West River Watershed
Smithsonian Environmental Research Center (SERC)
Edgewater, Anne Arundel County, MD

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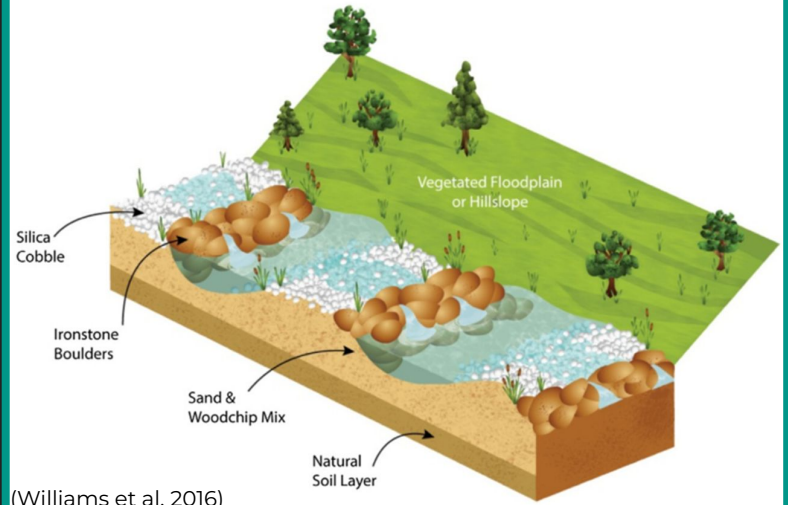
Background

Regenerative Stormwater Conveyance (RSC)

Reconnect to floodplain

Restore riffle-pool sequences

Increase water storage, sediment deposition, nutrient & sediment processing



(Williams et al. 2016)

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Background

Completed February 2016

Funded by Chesapeake and Atlantic Coastal Bays Trust Fund

Restored pool (March 2018)

Restored riffle (March 2018)

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Pre-restoration (2014)

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Methods

Smithsonian Environmental Research Center

Water chemistry monitoring

Flow-weighted composite water samples (March 2015 to December 2020)

Post-restoration DO and temperature monitoring (February 2016 to April 2019)

Maryland Department of Natural Resources

Biological monitoring:
2 years pre-restoration /
6 years post-restoration

Benthic macroinvertebrate annual sampling
(2014 to 2021)

MBSS sampling protocols

Post-restoration DO and temperature monitoring
(June 2019 to July 2021)

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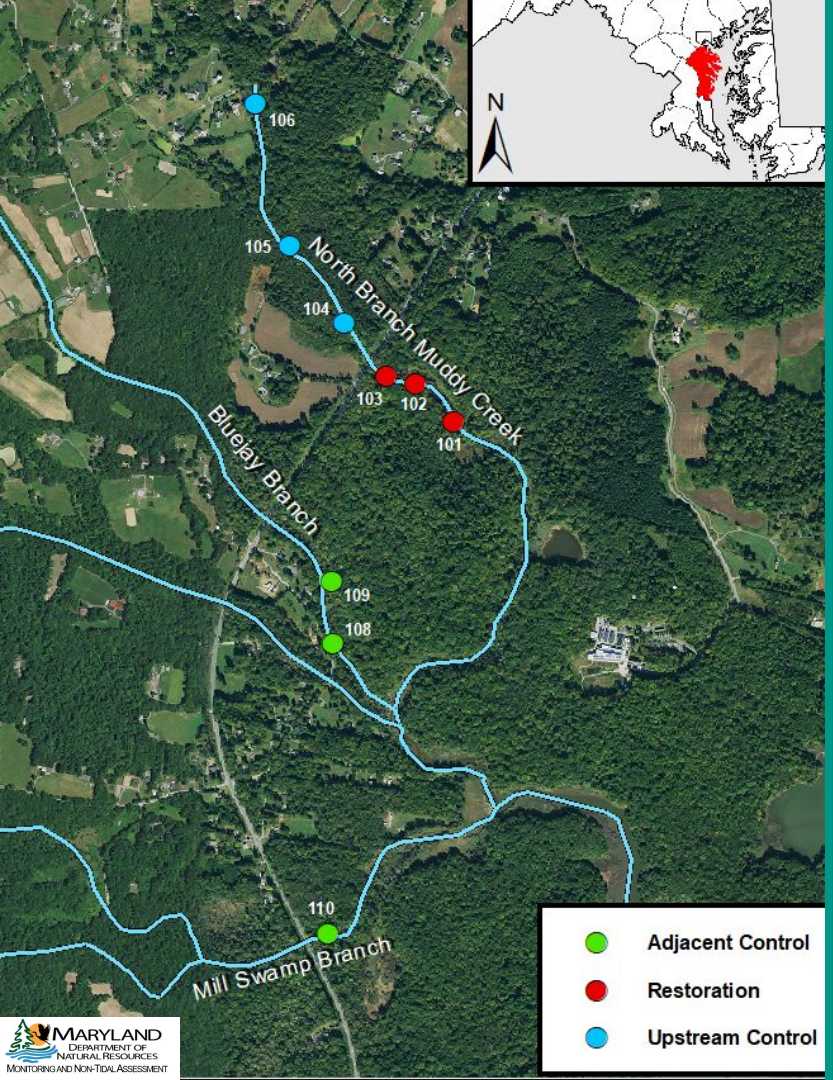
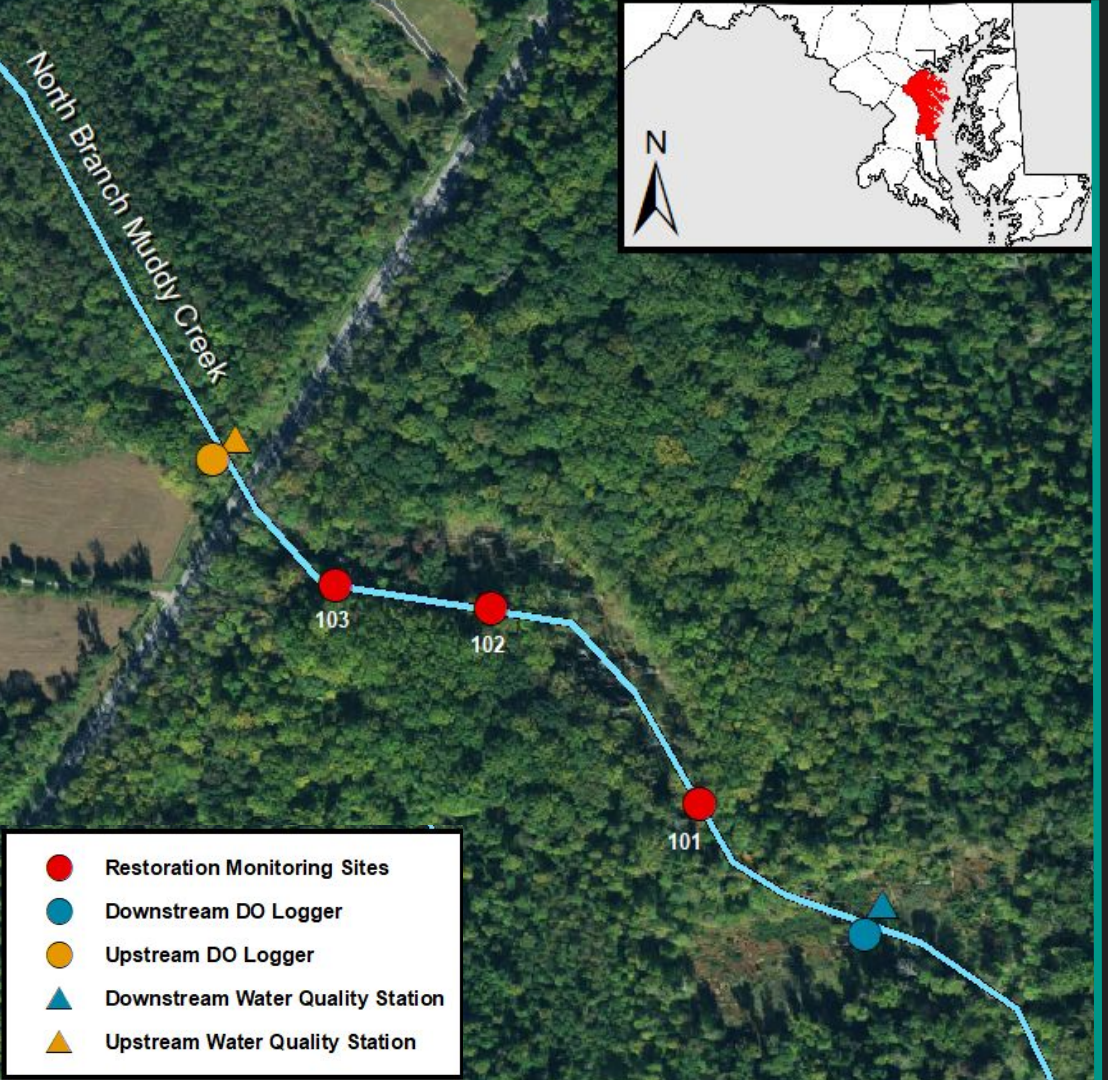


Project sites

Nine total biological monitoring sites



Project sites

Water quality monitoring stations and dissolved oxygen loggers located above and below restoration reach

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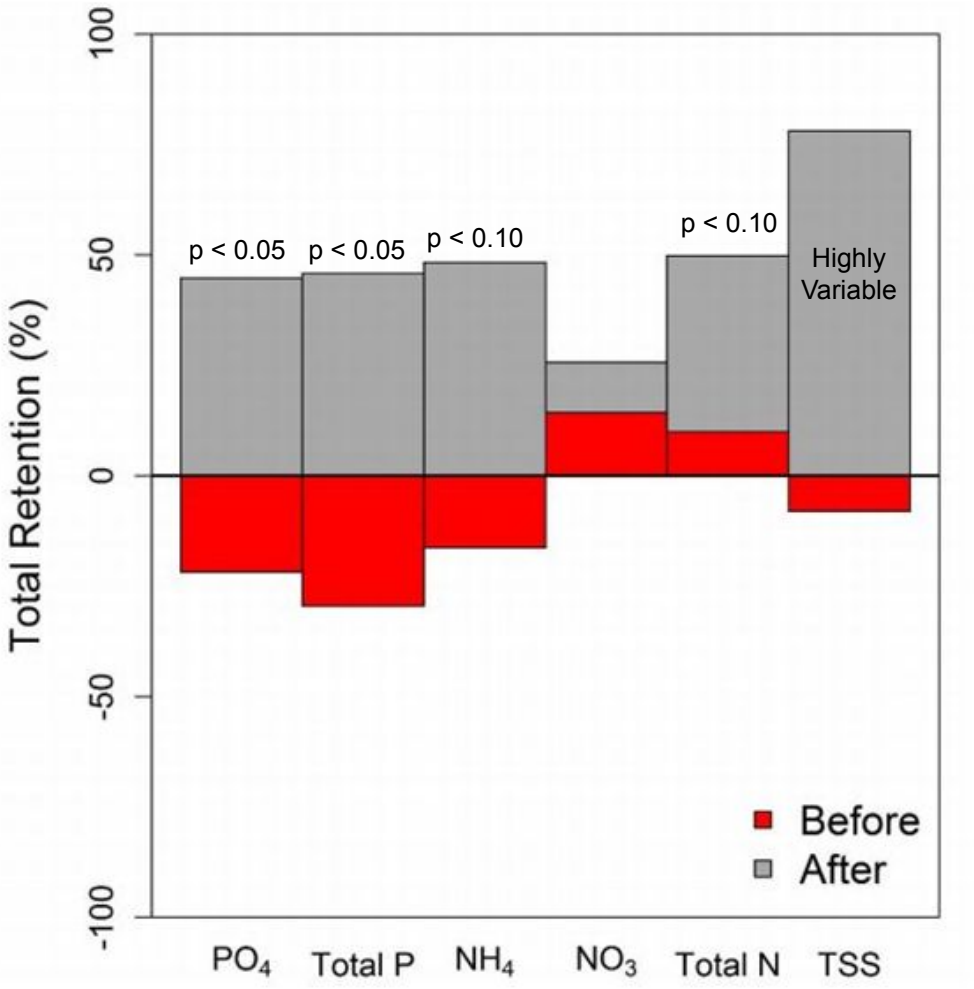
Inflow retention

Large increases in percentages of inputs retained

Only effects on **orthophosphate** and **total phosphorus** retention were statistically significant

Marginally significant reductions in **ammonium** and **total nitrogen**



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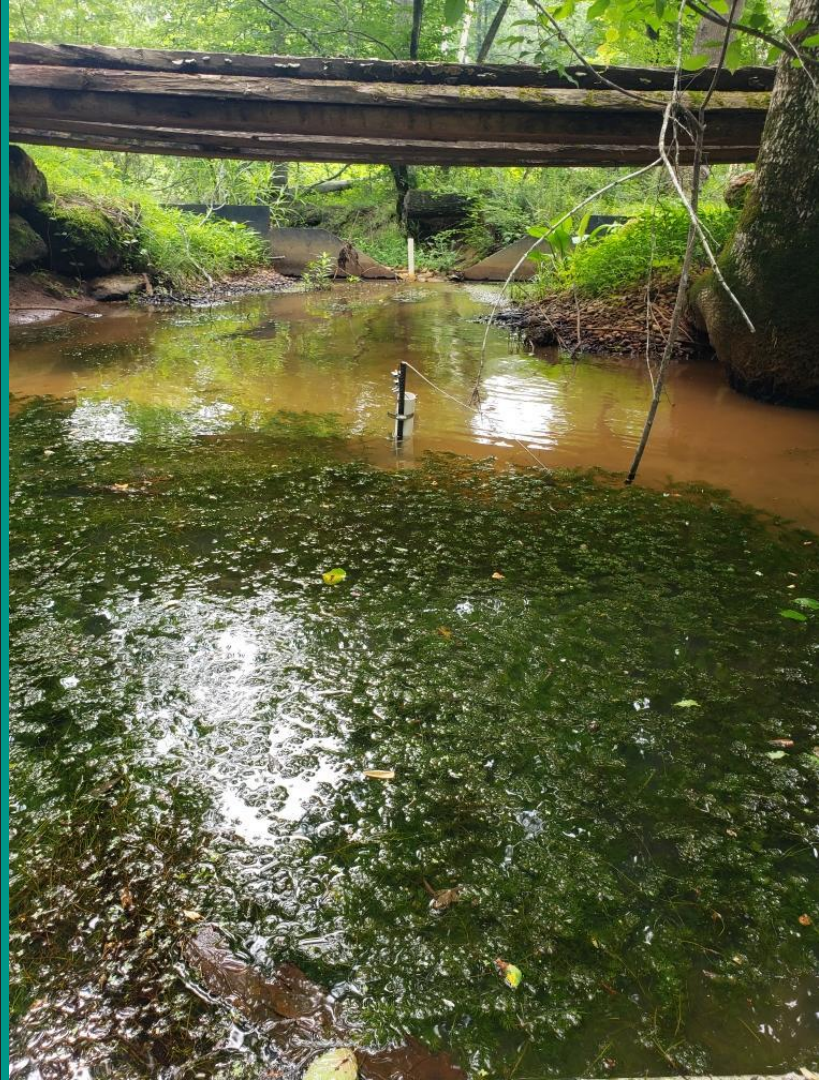
Data from Thompson et al. 2018

Dissolved Oxygen

Mean daily DO concentrations were **significantly lower** at the downstream station compared to the upstream station in 30 of 34 months from 2016 to 2021

Mean daily DO saturation levels were **significantly lower** at the downstream station compared to the upstream station in 19 of 23 months from 2018 to 2021



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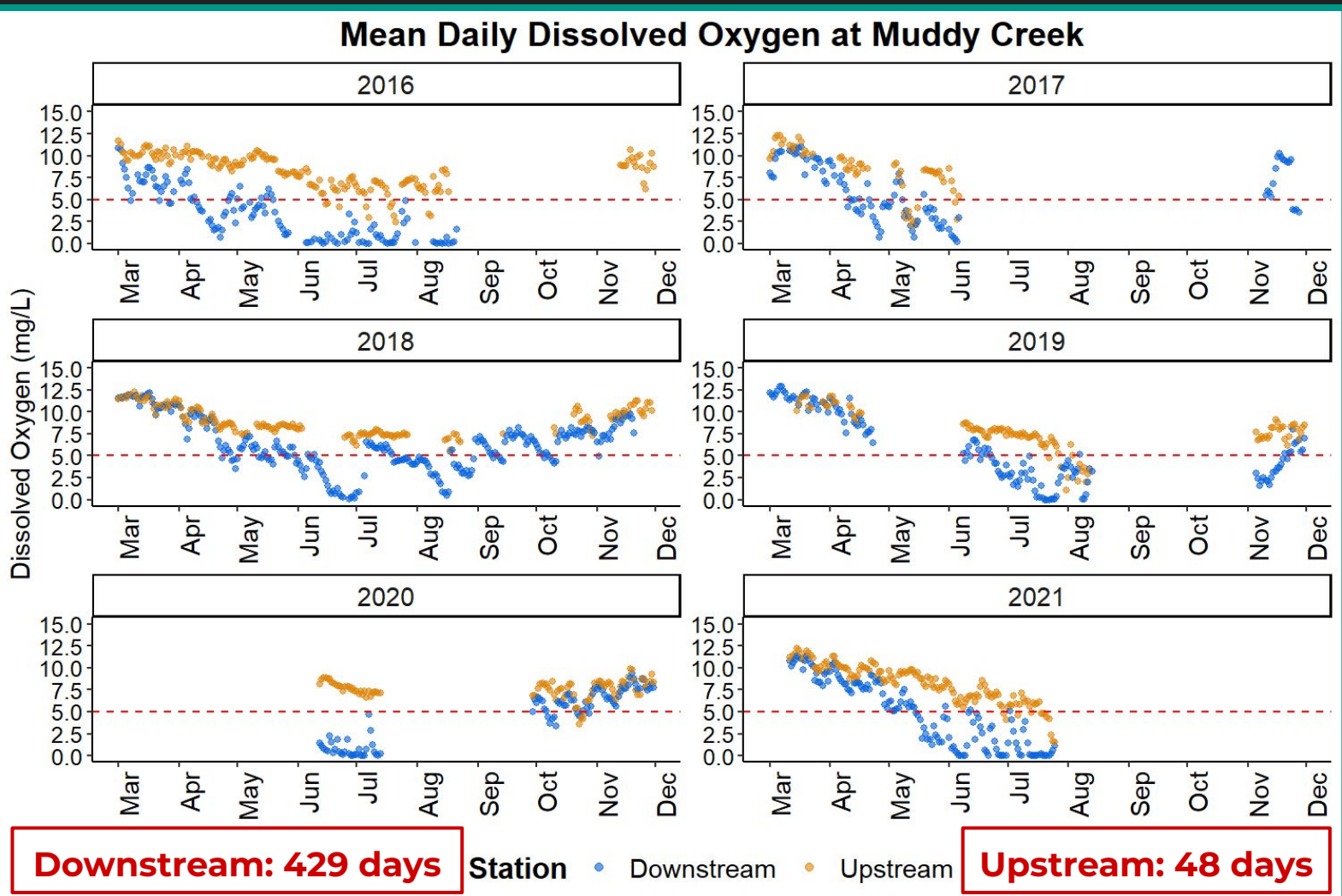
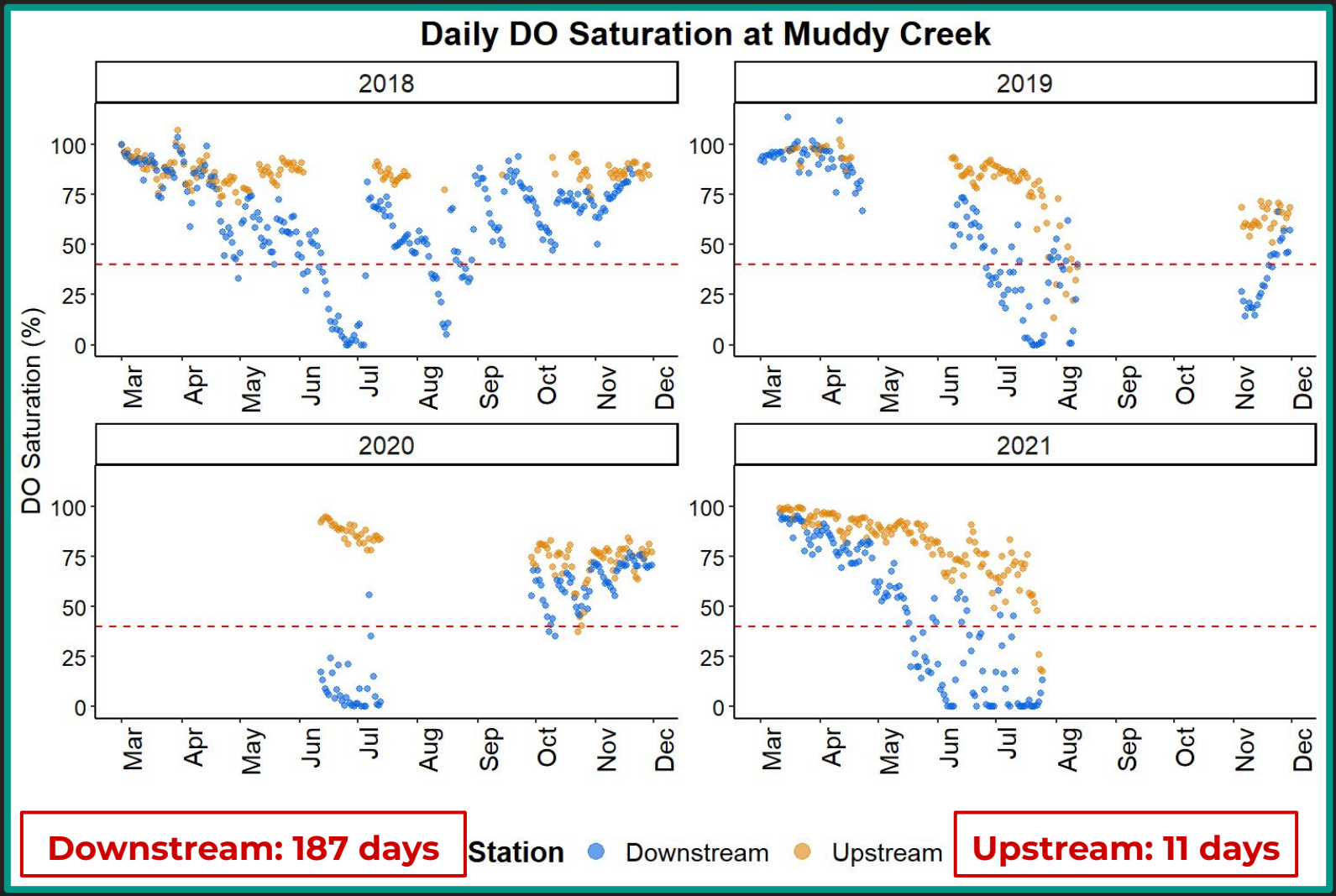
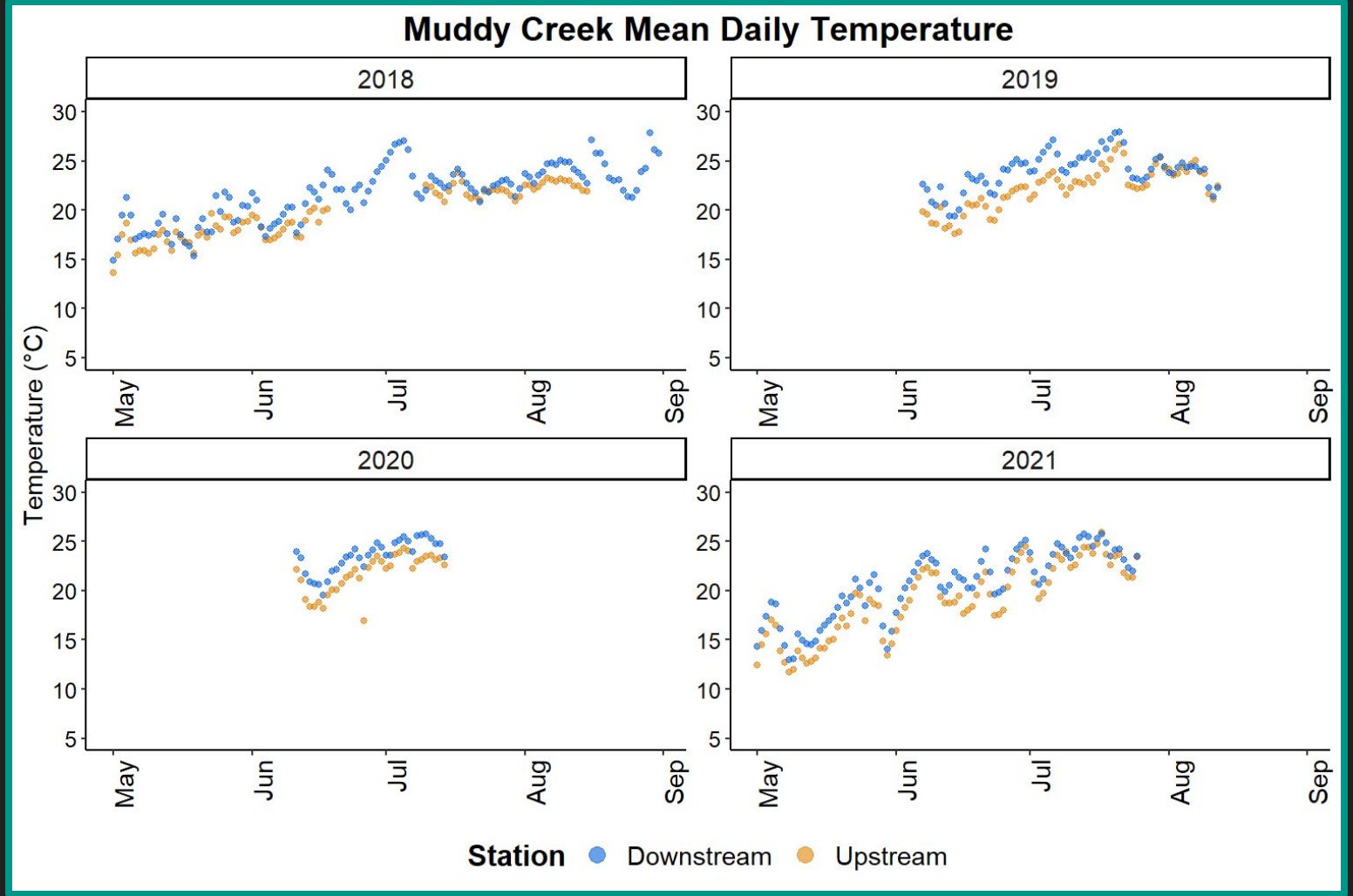

Mean Daily Dissolved Oxygen at Muddy Creek
2016
2017
2018
2019
2020
2021
Dissolved Oxygen (mg/L)
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Downstream: 429 days
Station
Downstream
Upstream
Upstream: 48 days


Daily DO Saturation at Muddy Creek
2018
2019
2020
2021
DO Saturation (%)
100
75
50
25
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Downstream: 187 days
Station
Downstream
Upstream
Upstream: 11 days


Muddy Creek Mean Daily Temperature
2018
2019
2020
2021
Temperature (°C)
30
25
20
15
10
5
May
Jun
Jul
Aug
Sep
Station
Downstream
Upstream

Benthic Macroinvertebrates

Post-restoration decreases

Average BIBI scores

Number of Taxa

Shannon-Weiner Index

Percent Predators

Post-restoration increases

Percent Chironomidae

Percent Collectors

Density

Number of samples

Pre-restoration	N = 6
Post-restoration	N = 18
Upstream Control	N = 24
Adjacent Control	N = 22

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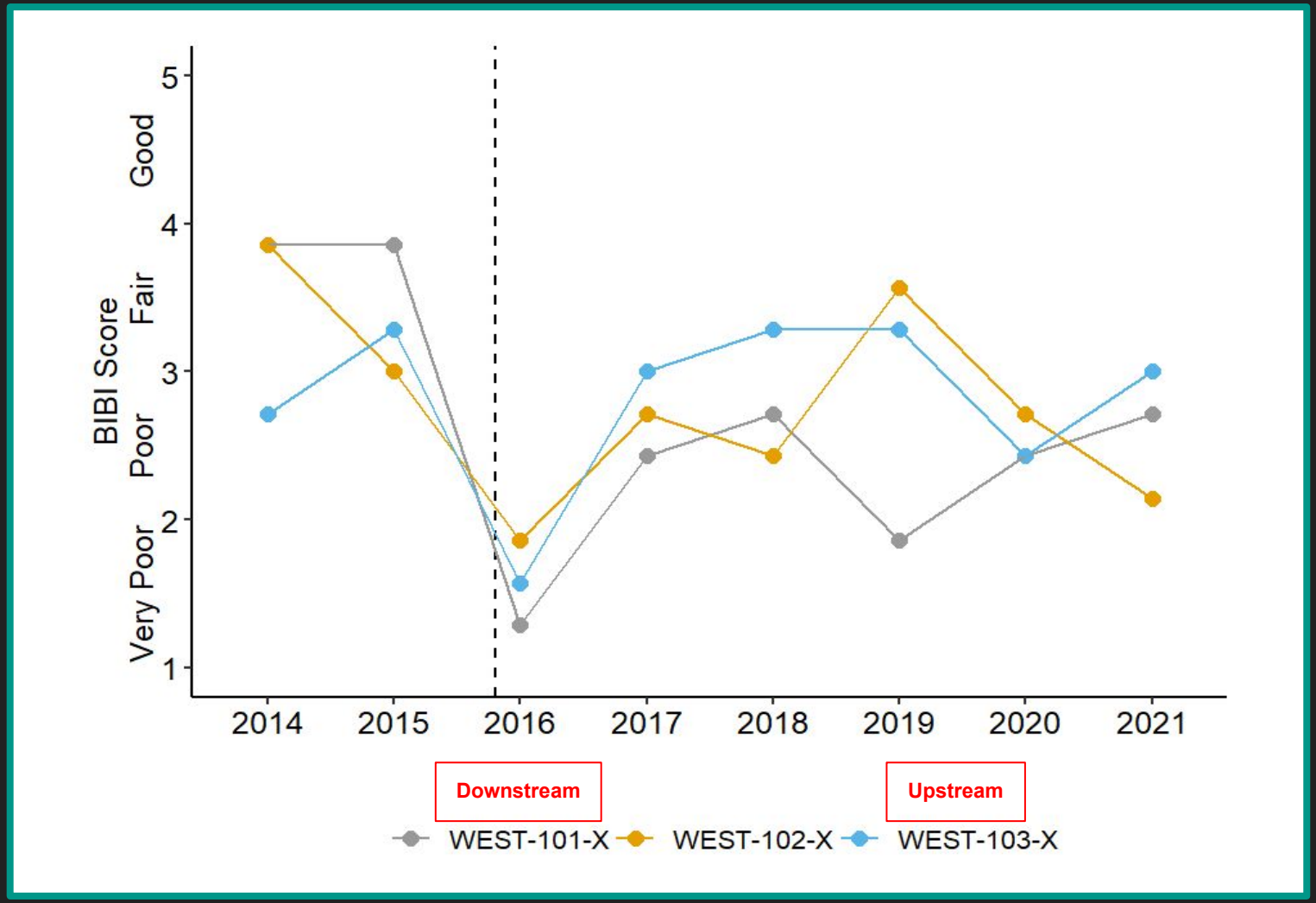
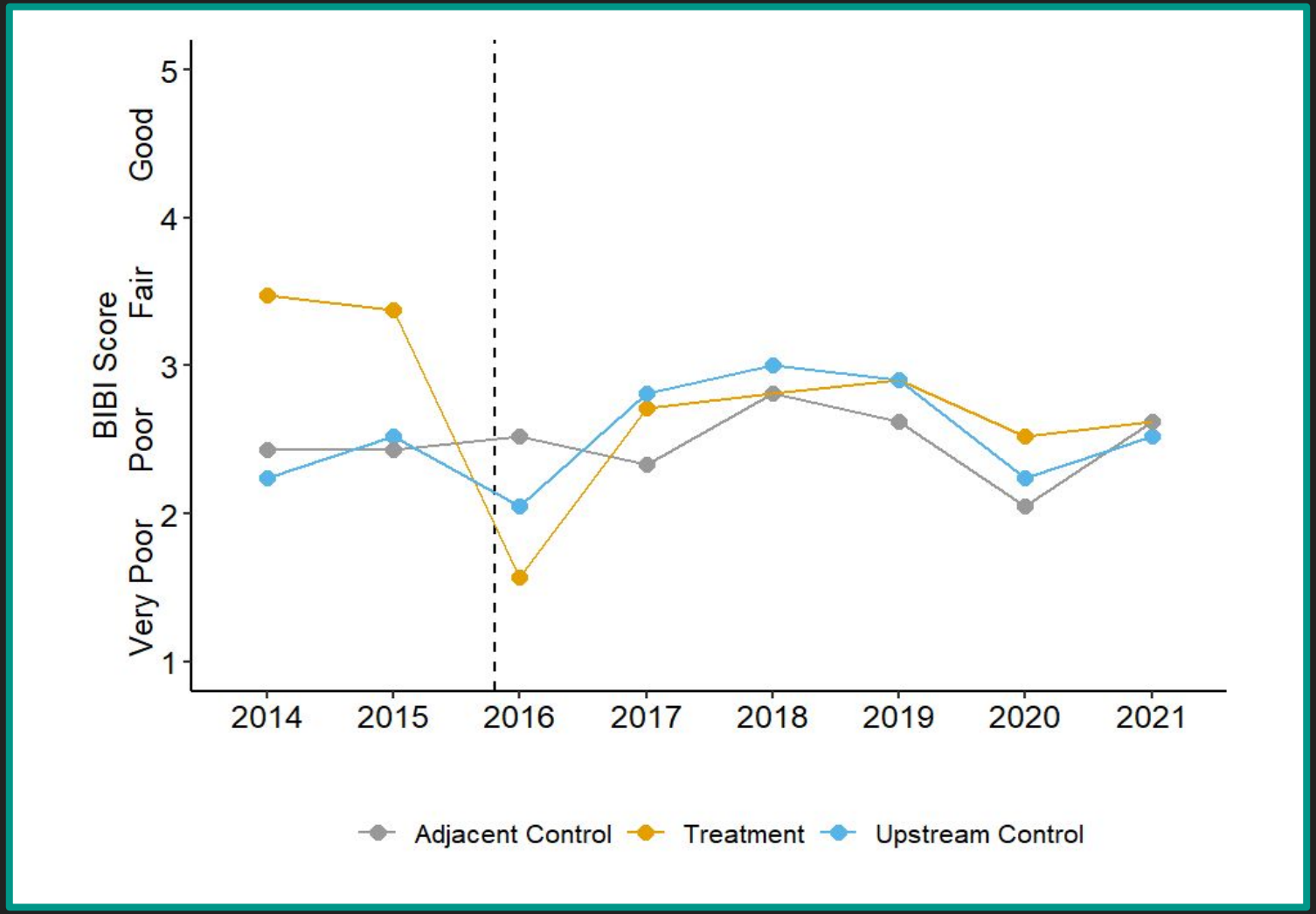
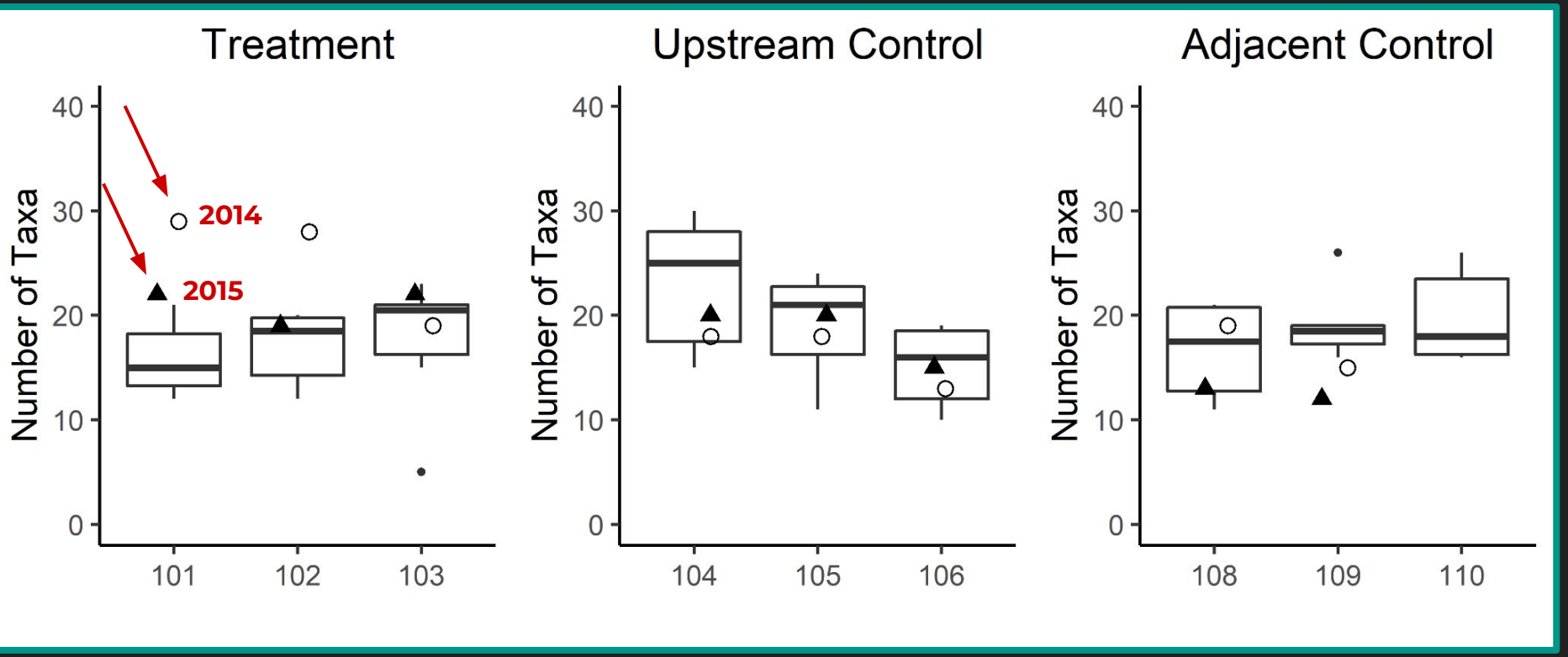
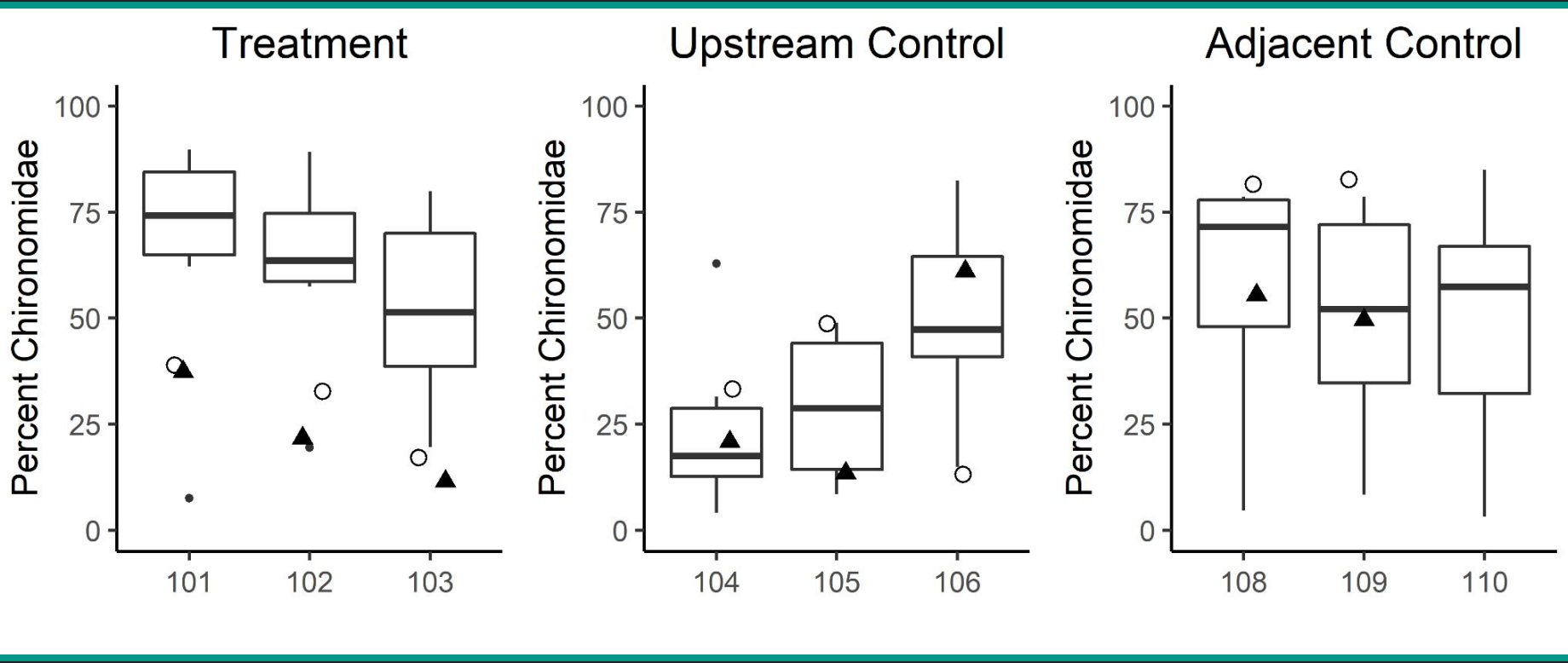
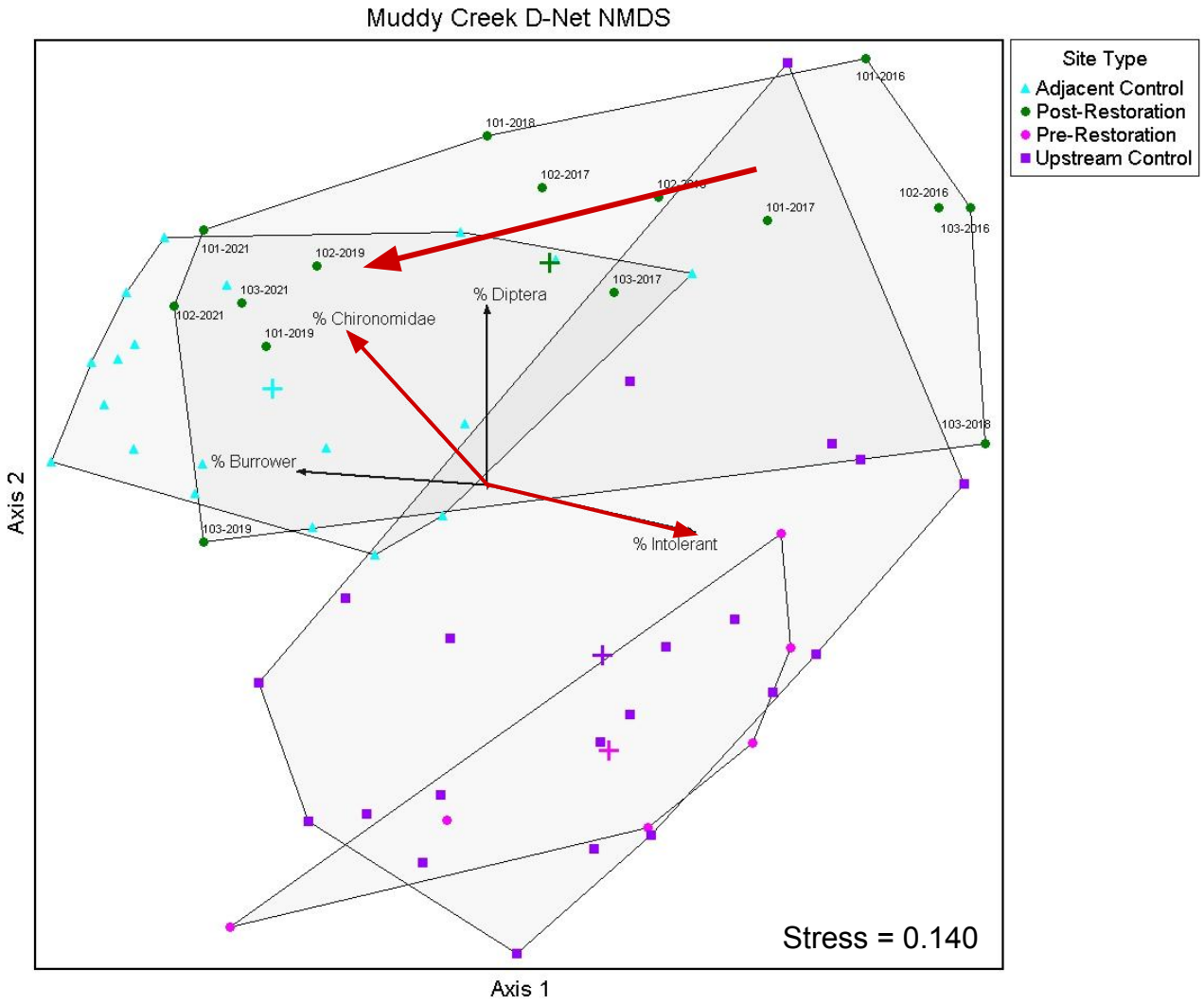

BIBI Score
Good
Fair
Poor
Very Poor
5
4
3
2
1
2014
2015
2016
2017
2018
2019
2020
2021
Downstream
Upstream
WEST-101-X
WEST-102-X
WEST-103-X


BIBI Score
Good
Fair
Poor
Very Poor
5
4
3
2
1
2014
2015
2016
2017
2018
2019
2020
2021
Adjacent Control
Treatment
Upstream Control


Treatment
Upstream Control
Adjacent Control
Number of Taxa
0
10
20
30
40
2014
2015
101
102
103
104
105
106
108
109
110


Treatment
Upstream Control
Adjacent Control
Percent Chironomidae
100
75
50
25
0
101
102
103
104
105
106
108
109
110



Non-metric multidimensional scaling (NMDS)

No significant benthic macroinvertebrate community similarity between **pre-restoration** and **post-restoration** samples

Post-restoration samples shifted to increased similarity with **adjacent control** samples

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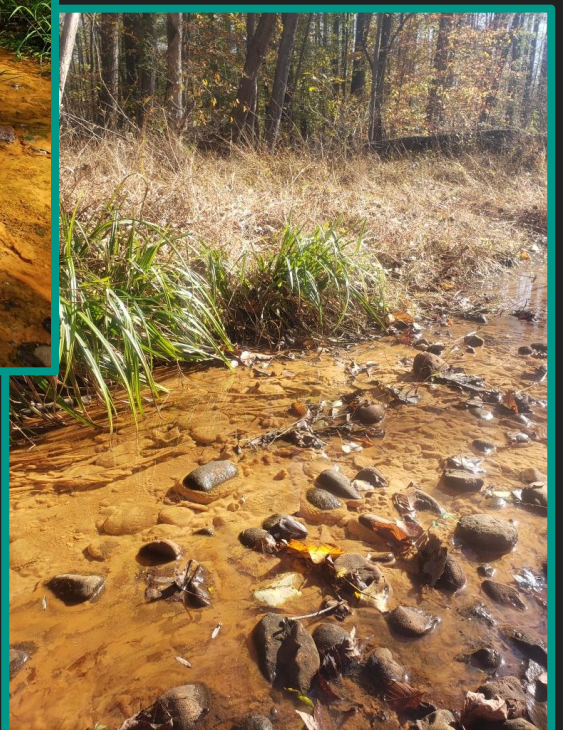
Dissolved oxygen



Large blooms of **iron-oxidizing bacteria** are likely contributing to low DO concentrations downstream

Increased **dissolved organic carbon (DOC)** from decomposing wood chips and trees could contribute to lower DO

Iron flocculation can occur naturally or possibly stem from construction materials or elevated groundwater tables

(Williams et al. 2016, Duan et al. 2019, Fanelli et al. 2019)

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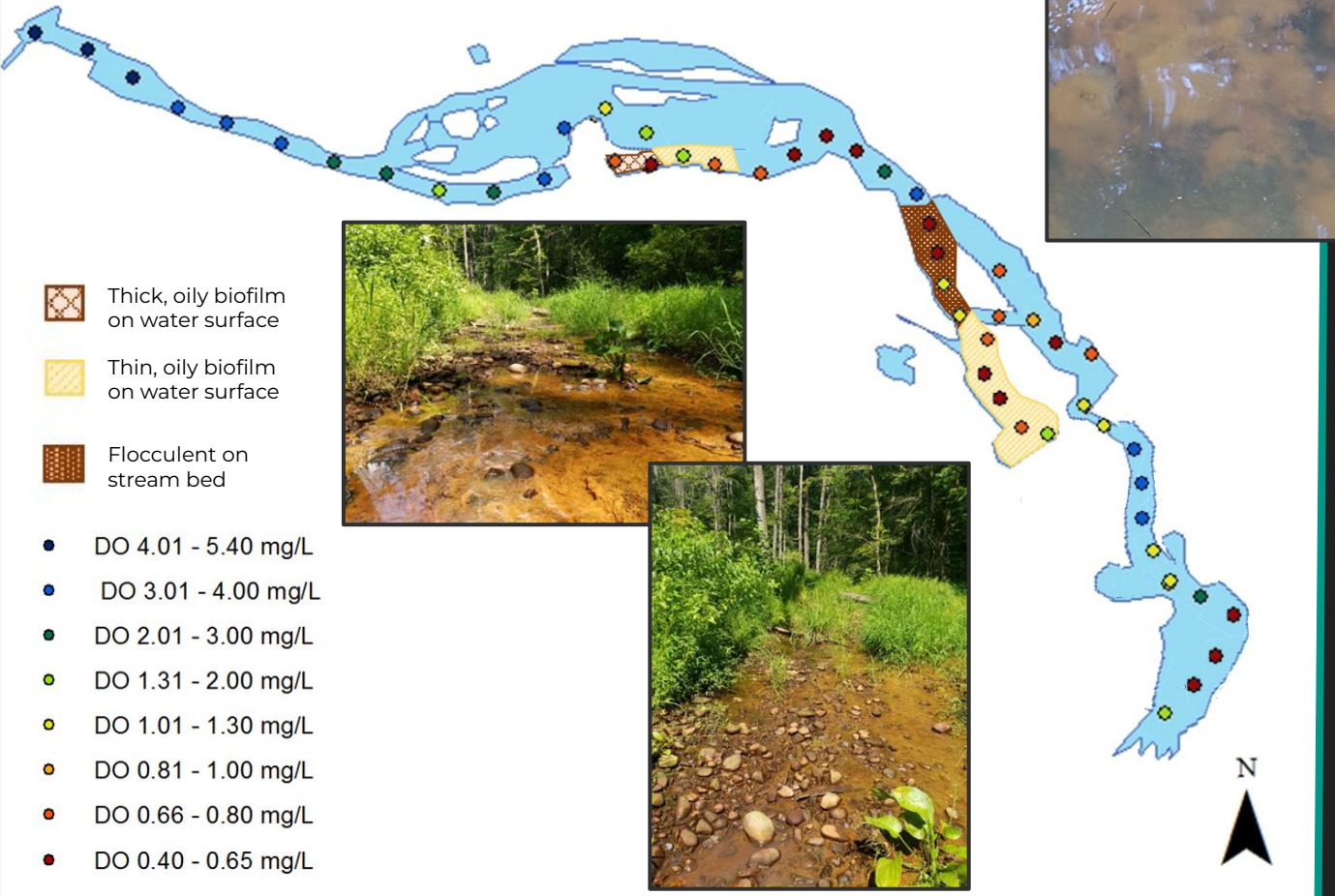
Leptothrix Distributions in Muddy Creek



SERC research showed DO concentrations tended to be lower in 3 major iron flocculent blooms

Credit: Lauren Mosesso (SERC)

Conclusions

Significant reductions of orthophosphate and total phosphorus and marginally significant reductions of ammonium and total nitrogen

Significantly lower mean daily DO concentrations and saturation levels downstream in most months studied

Significantly higher daily mean temperatures downstream for 15 of 25 months

BIBI scores, number of taxa and Shannon-Weiner scores dropped; shift to dominance of tolerant organisms

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References

Duan, S., Mayer, P. M., Kaushal, S. S., Wessel, B. M., & Johnson, T., 2019. Regenerative stormwater conveyance (RSC) for reducing nutrients in urban stormwater runoff depends upon carbon quantity and quality. *Science of The Total Environment*, *652*, 134-146.

Fanelli, R. M., Prestegaard, K. L., & Palmer, M. A., 2019. Urban legacies: Aquatic stressors and low aquatic biodiversity persist despite implementation of regenerative stormwater conveyance systems. *Freshwater Science*, *38*(4), 818-833.

Fleming, E. J., Cetinić, I., Chan, C. S., Whitney King, D., & Emerson, D., 2014. Ecological succession among iron-oxidizing bacteria. *The ISME journal*, *8*(4), 804-815.

Hayer, C. A., Holcomb, B. M., & Chipps, S. R., 2013. Associations between iron concentration and productivity in montane streams of the Black Hills, South Dakota. *The Prairie Naturalist 45*:68–76.

MDE (Maryland Department of the Environment). 2014. Maryland Biological Stressor Identification Process. Baltimore, MD: Maryland Department of the Environment.

Sheldon, S. P., & Wellnitz, T. A., 1998. Do bacteria mediate algal colonization in iron-enriched streams?. *Oikos*, *83*(1), 85-92.

Wellnitz, T. A., Grief, K. A., & Sheldon, S. P., 1994. Response of macroinvertebrates to blooms of iron-depositing bacteria. *Hydrobiologia*, *281*(1), 1-17.

Williams, M. R., Wessel, B. M., & Filoso, S., 2016. Sources of iron (Fe) and factors regulating the development of flocculate from Fe-oxidizing bacteria in regenerative streamwater conveyance structures. *Ecological Engineering*, *95*, 723-737.

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Questions?

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