

# Filamentous Algae Monitoring Pilot Program: West Virginia Rivers of the Potomac River Basin

Report to the West Virginia Department of Environmental Protection,  
Division of Water and Waste Management

by

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Interstate Commission on the Potomac River Basin

DRAFT

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### **ICPRB Report 12-07**

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# Filamentous Algae Monitoring Pilot Program: West Virginia Rivers of the Potomac River Basin

## Background

Since 2007, the West Virginia Department of Environmental Protection has been observing and evaluating the breadth and causes of filamentous green algae blooms within the state. In the Eastern Panhandle, blooms of filamentous green algae (FGA) have manifested in certain rivers of the Potomac Basin. WVDEP asked the Interstate Commission on the Potomac River Basin (ICPRB) to assist WVDEP in documenting FGA blooms in the West Virginia portions of the South Branch Potomac, Cacapon, and Shenandoah rivers. Following the protocols established for monitoring filamentous algae in other parts of the state, ICPRB collected a suite of water quality parameters and performed monthly algal abundance measures at 13 sites in the three rivers between July and October 2012.

## Collection Methods

The WVDEP filamentous algae monitoring protocols consist of bi-monthly water chemistry samples, monthly quantitative algae coverage estimates, and a qualitative habitat survey. A total of seven visits were made to each sampling site between July and October 2012 (Table 1). Six sampling sites are located on the Cacapon River between Largent and Wardensville, one on the North River at Forks of Cacapon, two on the lower Shenandoah River near the West Virginia state line, and four on the South Branch Potomac, above and below the town of Moorefield, WV (Table 2). Water chemistry parameters included nitrate, nitrite, total phosphorous, dissolved phosphorous, total alkalinity, magnesium, calcium, and total suspended solids. In-situ water quality parameters included water temperature, pH, specific conductivity, dissolved oxygen, and turbidity. The ICPRB field crew consisted of two biologists during routine water chemistry sample rounds, and three on algal measurement rounds. ICPRB staff Adam Griggs was project leader; ICPRB staff Jim Cummins and summer intern Jason Kinder assisted in the project. Sites were generally sampled one river at a time, traveling sequentially either upstream or downstream, depending upon the route. However, sample handling time requirements and available overnight accommodations influenced the final sampling route. Generally, overnight accommodations consisted of camping at grounds along the sample route.

<b>Sampling Round</b>	<b>Sampling Dates</b>
JUL-1	Jul 18-20
AUG-1	Aug 4-5
AUG-2	Aug 16-17
AUG-3	Aug 29-30
SEP-1	Sep 12-13
SEP-2	Sep 25-26
OCT-1	Oct 10-11

**Table 1. Sample rounds and dates.**

Site Name	Site ID	Site Location Description
CA-LRGNT	CA-1	Cacapon River at Rt. 9 in the town of Largent
CA-FRKS	CA-2	Cacapon River at Rt. 127 / Forks of Cacapon
CA-D-CPBRG	CA-3	Cacapon River downstream of Capon Bridge off Cold Stream Road
CA-CAPBRG	CA-4	Cacapon River at Rt. 50 in Capon Bridge
CA-LWR-WARDS	CA-5	Cacapon River at Rt. 259 below Wardensville
CA-UPR-WARDS	CA-6	Cacapon River at Kotz Farm Ford above Wardensville
NO-FRKS	NO-1	North River at Gaston Rd. / Forks of Cacapon
SBR-LWR-TRGH	SB-1	South Branch at Harmison's Landing
SBR-UPR-TRGH	SB-2	South Branch at South Branch Wildlife Management Area
SBR-LWR-MRFLD	SB-3	South Branch at Rt. 220/28 crossing below Moorefield
SBR-UPR-MRFLD	SB-4	South Branch at Fisher Rd above Moorefield.
SHEN-LWR	SH-1	Shenandoah at Rt. 340 near Harper's Ferry
SHEN-UPR	SH-2	Shenandoah at Ann Lewis Road near state line

**Table 2. Sampling site names, abbreviated IDs, and locations.**

#### *Rapid physical habitat assessment*

The WVDEP Filamentous Algae Monitoring Form was completed in the field by the project leader. Global Positioning System (GPS) coordinates were taken using a Garmin Etrex20 on the first and most subsequent field visits. If for any reason the sampling location was moved, the GPS coordinates recorded reflect that change. The photograph recordation form was not used as pictures were being uploaded to a Dropbox® account shared with WVDEP staff. The pictures were arranged in folders according to site and sampling date. A site map was drawn on the first visit indicating the water quality sampling location and algae transect. Precipitation history was not always reported in the field; relevant monthly USGS gage hydrographs are included in Appendix B. Qualitative abundance observations of periphyton, moss, and aquatic vascular plants were made on each site visit. Aquatic vascular plant abundance was interpreted as being submerged aquatic vegetation and ubiquitously occurring water willow was not considered for this parameter.

#### *Filamentous algae abundance measurements*

Percent algae coverage measurements were performed according to Standard Operating Procedures (SOP) provided by WVDEP. Due to the equipment available, length was recorded in meters and depths in inches. All values were appropriately converted to metric scale on the percent algae calculation spreadsheet file, which was modified from that provided by WVDEP to receive the measurements as recorded. The modified percent algae coverage calculation spreadsheets and associated data are provided separately as a Microsoft Excel® file.

#### *In-situ water quality*

Water-chemistry sample bottles were provided pre-fixed by the contracted analysis laboratory. At each sampling location, the large un-fixed TSS/Alkalinity container was used to collect water samples and pour them into the pre-fixed containers. The collection container was rinsed 3 times mid-stream (if possible) and samples were collected facing upstream. Filtering for the dissolved phosphorous sample

was performed using a Nalgene® filter funnel cup, Nalgene® vacuum flask, 47 mm 0.45 µm cellulose-nitrate filter papers and a hand-operated vacuum pump. The vacuum flask and filter apparatus were also rinsed 3 times mid-stream prior to filtering. Otherwise, samples were collected according to WVDEP Standard Operating Procedures.

### *Sample handling*

Water chemistry samples were labeled with a permanent marker and immediately stored on ice. All samples were delivered to Reliance Laboratories in Martinsburg, WV within 48 hours and typically well before the 48-hr hold time for the un-fixed Nitrate/Nitrite samples. Chain-of-custody forms were filled out at the laboratory and a copy was retained for file. On the last sampling round, a complete set of duplicates were collected and the duplicate set was delivered to West Virginia Department of Agriculture office in Moorefield, WV to be picked up by a second water quality laboratory.

### *Completeness*

All 13 stations identified by WVDEP personnel were sampled throughout the study period. In addition, regular photographs and a single water chemistry sample were taken at another site on the Cacapon River, between Capon Bridge, WV and Wardensville, WV. With the exception of the first sampling visit, which required extra time for site establishment, all sites were monitored within a consecutive 2-day period. Water chemistry samples were collected at every visit. On the final sampling round, dissolved phosphorous samples were not collected due to contamination of the filters in the field. In-situ water quality was collected at every site using a Hydrolab DS-5 or a Hydrolab MS-5. The Dissolved Oxygen Sensor on the ICPRB DS-5 was malfunctioning and a loaner multi-parameter sonde (MS-5) was requested from Hach-Hydromet to complete the field season. Algae transects were performed monthly at every site except the two Shenandoah River sites. At the lower Shenandoah Rt. 340 site, river width and hazardous wading conditions prohibited measurements to be performed. At the upper Shenandoah site, river width was problematic but surveys were generally not performed because no filamentous green algae were observed. Occasionally, water clarity or visual surface disturbance due to precipitation prevented performing the visual assessment at certain sites.

## **Data Analysis**

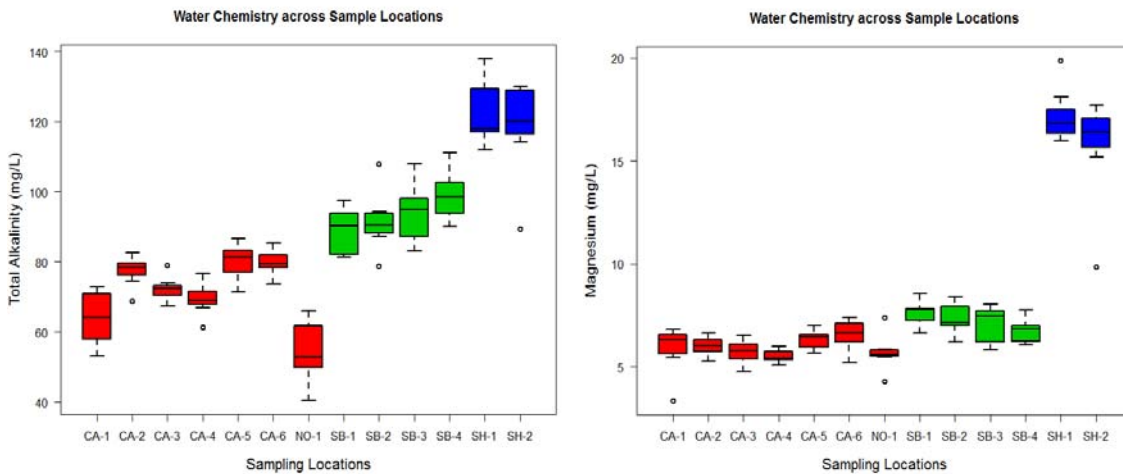
### *Analysis methods*

Data were entered into MS Excel for exploratory analyses. A copy of this dataset is provided electronically to WVDEP along with this report. All analyses were performed using R and analysis scripts are also provided. Water quality parameters were evaluated across station, river system, and sample date using box plots. Basic numerical summaries were used to describe water quality attributes across river basins and a Kruskal-Wallis test was used to look for significant differences between them. Attempts to evaluate stressor-response relationships between the qualitative primary production values and the quantitative algae coverage estimates were explored, but were greatly limited by low sample sizes of the response variables. Associations with a qualitative Sum of Primary Producers variable were also explored by summing the FGA, periphyton, mosses, and aquatic vegetation scores. Quality Assurance concerns were raised about the phosphorus measurements made by Reliance Laboratories

(see below). As a result, results recorded as non-detect (ND) were analyzed as null values in order to control for false negatives. As a result, total phosphorous data used in analyses includes sample duplicate results reported by a second lab during the last sample round. See the project suggestions section below for further details.

*Water chemistry*

Water chemistry parameters differed across sampling stations, river basins, and season. Water chemistry conditions were generally similar within river basin, but differed among certain parameters between river basins. For example, the two Shenandoah sites had overall higher concentrations of total alkalinity, specific conductivity, magnesium, and nitrate compared to the Cacapon and South Branch sites. Cacapon river sites had generally lower concentrations of every measured parameter and lower conductivities compared to the other river basins. The South Branch sites, specifically those below the Moorefield WWTP seemed to have higher calcium and phosphorous concentrations compared to the other river basins (See Figure 1 and Appendix A).



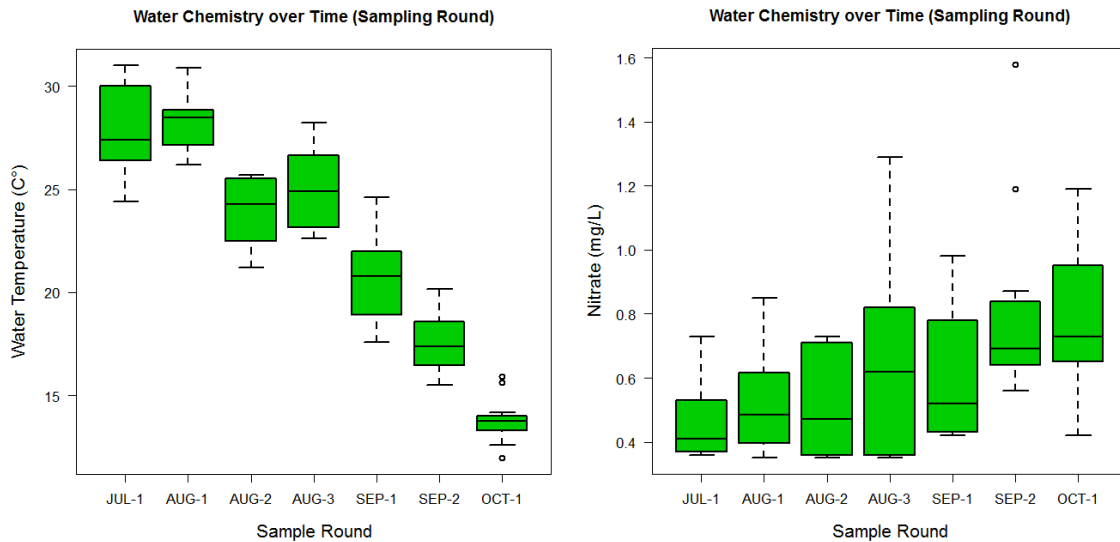
**Figure 1. Total Alkalinity and Magnesium concentrations (mg/L) among the 13 sampling locations.**

The Kruskal-Wallis analysis of variance found that samples collected from the four river basins differed in most water chemistry parameters (Table 3). Water chemistry concentrations also varied over time and displayed somewhat predictable patterns, such as decreasing water temperature over the season. Concentrations of dissolved pollutants such as nitrate generally

Parameter	Cacapon	North	Shenan- doah	South Branch	Chi- square	P value
ALK	73.8	52.83	119.5	93.1	72.8046	1.07E-15
CA	29.3	18.5	38.4	43.8	65.0509	4.89E-14
DO	12.31	11.385	10.905	11.84	7.6964	0.05272
DP	0.02	0.02	0.025	0.055	4.208	0.2399
MG	5.98	5.58	16.65	7.065	56.6967	2.98E-12
NO2	0.14	0.33	0.34	0.267	4.8181	0.1856
NO3	0.43	0.42	0.88	0.73	31.7936	5.79E-07
PH	8.61	8.01	8.75	8.93	24.8685	1.65E-05
SPCOND	187.9	154.25	325.65	256.5	71.2445	2.31E-15
TP	0.02	0.0295	0.02	0.165	11.1268	0.01106
TSS	4	6	7	3.5	8.1195	0.04361
WTEMP	23	22.5	25.7	24.6	4.7668	0.1897

**Table 3. Kruskal-Wallis analysis of variance for the sampled water chemistry among the river basins.**

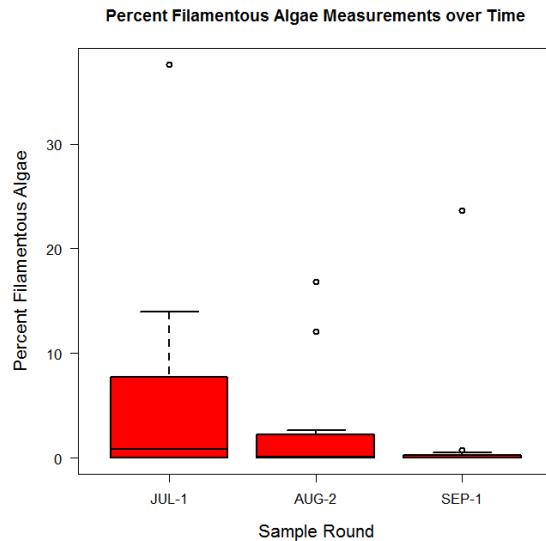
increased over time, possibly due to reduced dilution of pollutants as flows trended downward over the summer season (See Figure 2 and Appendix A, B).



**Figure 2. Water Temperature (C°) and Nitrate (mg/L) over time.**

*Algal measurements and observations*

Filamentous algae were generally most abundant toward the beginning of the sampling season, but fluctuated in abundance from site to site over the remaining period (Figure 3, See Appendix C for representative pictures of each site). The most algae observed in a transect was 37.63% at the Upper Moorefield site on the South Branch on July 18, 2012. Subsequent visits found almost no algae in the channel at this site however an upstream tributary with cattle in the stream was often manifesting floating algal mats. The Lower Moorefield site had the most consistent algae coverage throughout the season, ranging from 12% to 23%. This site also had extreme amounts of submerged aquatic vegetation (SAV). Water milfoil, water stargrass, *Elodea*, and *Hydrilla* were all common with stargrass and milfoil dominating the site throughout the sampling season. SAV beds were extensive and persistent throughout the sampling season (See pictures in Appendix C). Filamentous algae were mostly constricted to an embayment on the river-left bank where it often formed floating mats. Submerged aquatic vegetation was observed at all sites except for the Upper Shenandoah site. This site had light periphyton



**Figure 3. Percent algae coverage estimates over time.**



coverage and other typical primary production communities were also conspicuously rare or absent. The North River site was dominated by a submerged vascular plant of unknown identity. No algae or other SAV species were observed. Towards the end of the sampling season, a brown slime or algae began to manifest on cobble and boulder at many sites. This biofilm was neither filamentous green algae, vascular plant, or moss, and was therefore not captured in the qualitative information on the field monitoring sheet.

## Suggested alterations or additions to the filamentous algae monitoring program

### *Monitoring protocols*

Overall, the filamentous algae monitoring form used in this monitoring program is comprehensive, straightforward, and suits the program well. During completion of the 2012 monitoring season, ideas for possible improvement or clarification were noted. At the bottom of page 2 of the sampling form, the abundance of various primary producer groups are recorded by assigning scores of 0 – 4 for periphyton, filamentous algae (green), aquatic vascular plants, and aquatic mosses. We suggest that the “aquatic vascular plants” entry be clarified as to whether emergent vegetation should be considered along with submerged vegetation types. We also suggest that WVDEP consider submerged vegetation only, as submerged vegetation competes with algae for benthic substrate more often than do littoral emergent plants. Additionally, the ubiquitous emergent water willow (*Justicia americana*) often dominates littoral zones and can inflate the aquatic vegetation score above what should represent the in-stream condition. There were several occasions when non-filamentous green algae were observed. Blue-green algae (cyanobacteria) and possible brown-algae were encountered with fair regularity. We acknowledge that the protocol is designed to capture filamentous green algae, however, observations of algae communities in general may prove important over time in discerning the underlying drivers of filamentous algae blooms. Further, we suggest an attempt to identify algae types whenever possible, either through field-identification or the collection and preservation of samples. Certain genera of algae are readily identifiable in the field, such as *Hydrodictyon sp.* and training or the addition of field-keys could greatly assist in identification (Figure 4).



**Figure 4. *Hydrodictyon sp.* collected at the Upper Moorefield site on the South Branch Potomac.**

The water chemistry parameters collected for the filamentous algae monitoring program are intended to capture ionic composition and nutrient concentrations that may limit or encourage algal growth and largely do so. We suggest that the necessary nitrate species components be sampled, in addition to the nitrate-nitrite which is currently analyzed, to calculate a total nitrogen measure. Total Kjeldahl Nitrogen

(TKN) would measure organic forms of nitrate, ammonia, and ammonium which may be constituents present in the effluent of WWTPs and other sources. Sampling and calculating a TN measure would be an improved measure of overall trophic condition of the sampled waterbodies. In addition, we suggest considering the addition of dissolved organic carbon, which can be a limiting agent of algal production, and heavy metals such as copper or zinc, which can inhibit algal growth even in eutrophic conditions.

### *Sampling logistics*

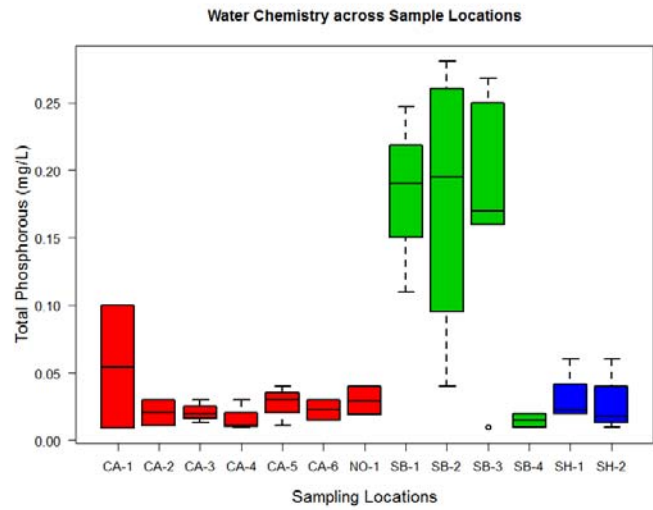
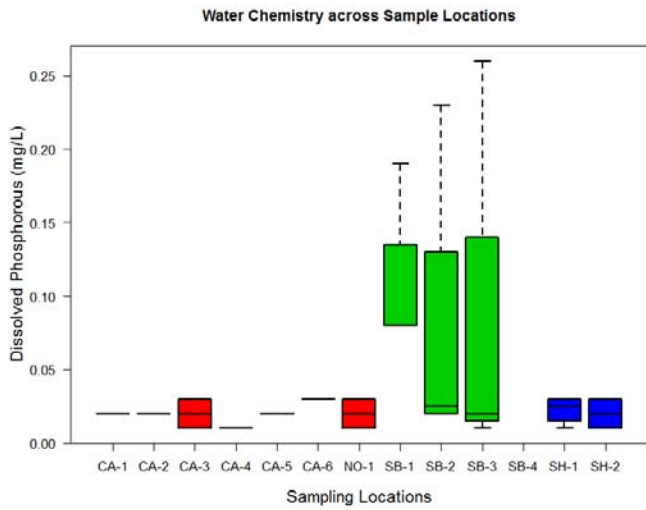
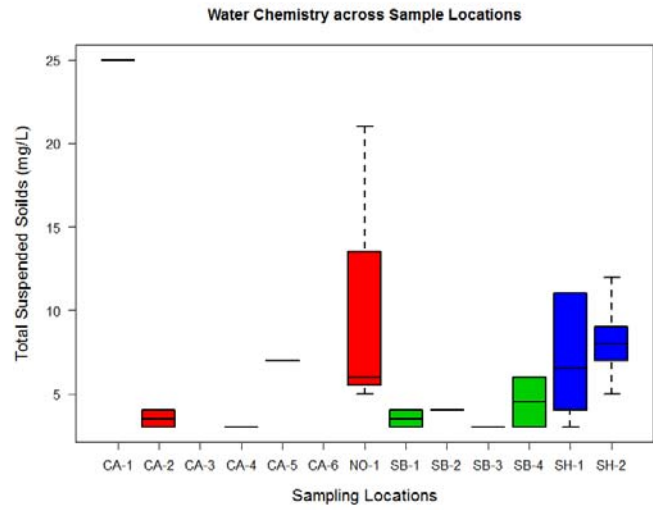
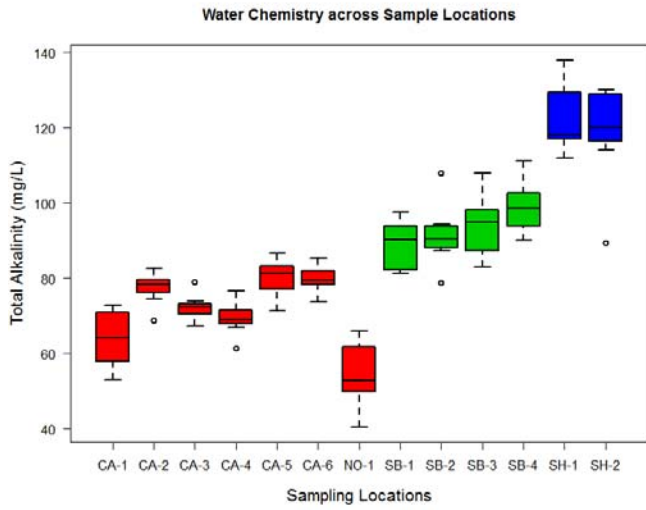
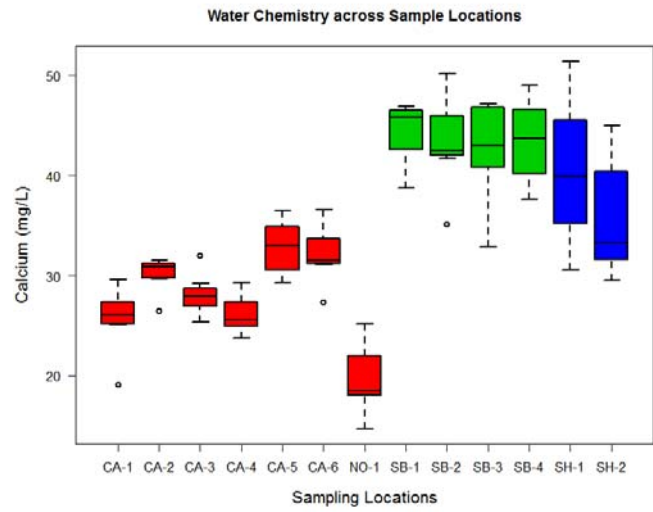
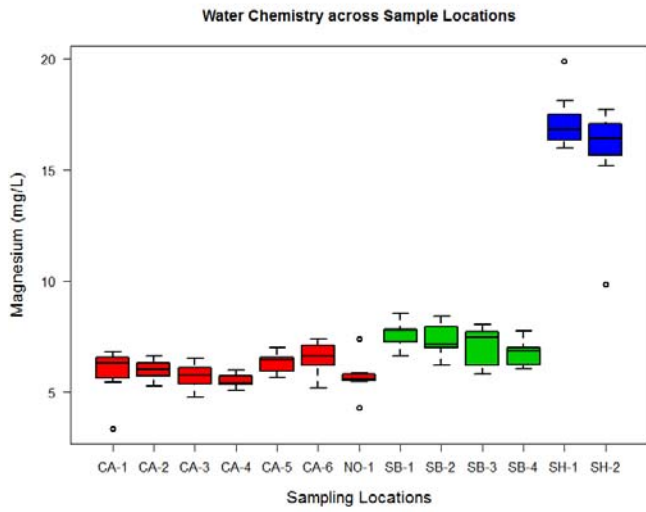
The sampling locations chosen to evaluate algal conditions on the Shenandoah, Cacapon, and South Branch Rivers are both convenient and spatially comprehensive. However, persistent algal blooms on the Cacapon River between Wardensville and Capon Bridge were observed but not captured by the locations currently sampled (Figure 5, Appendix C). We suggest adding a site in this reach to document these persistent blooms. In addition, due to the high nutrients levels observed below the Moorefield, W.Va. WWTP, and only proportional nutrient-assimilation observed between there and Romney, W. Va., we suggest adding sites downstream of Romney to observe any potential algal manifestations in that section of river.

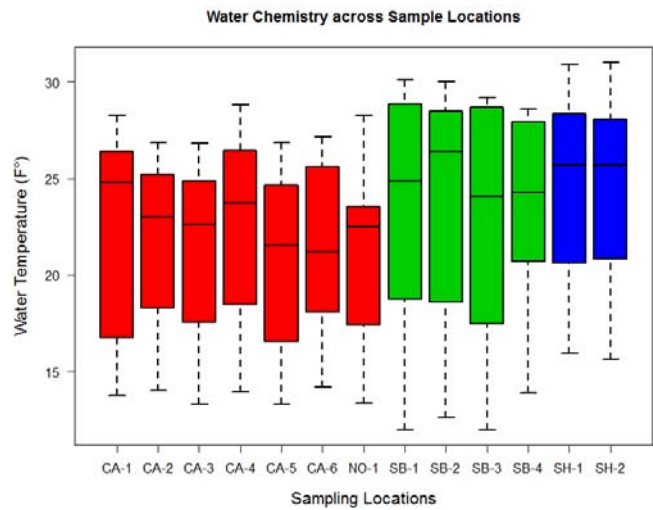
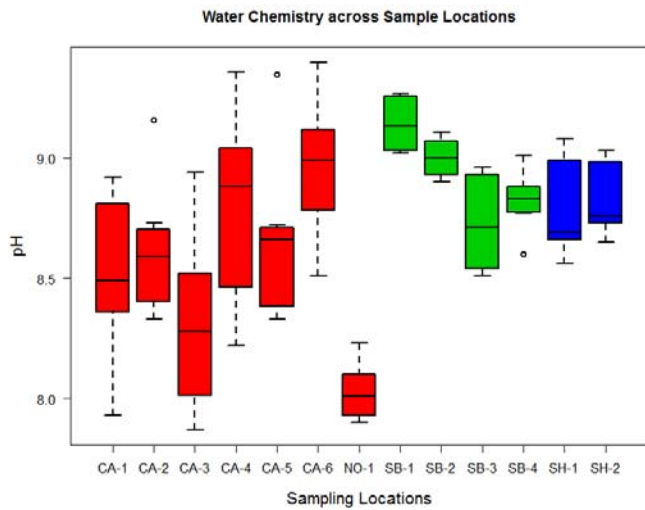
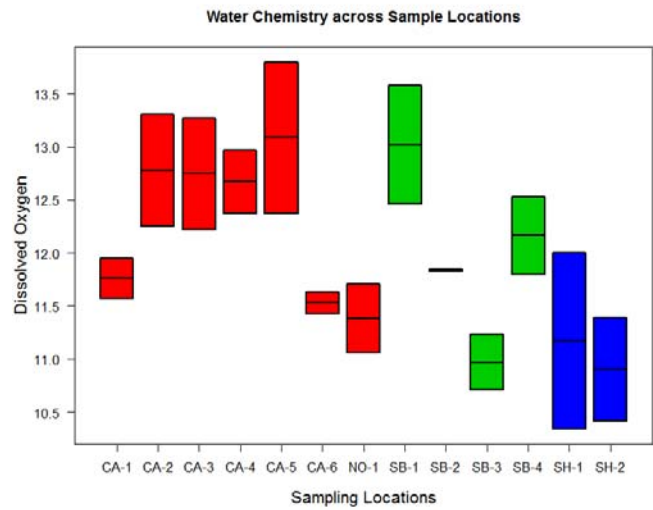
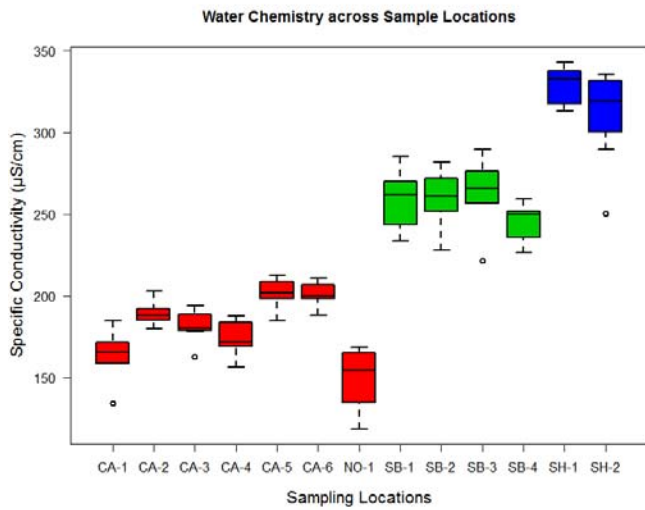
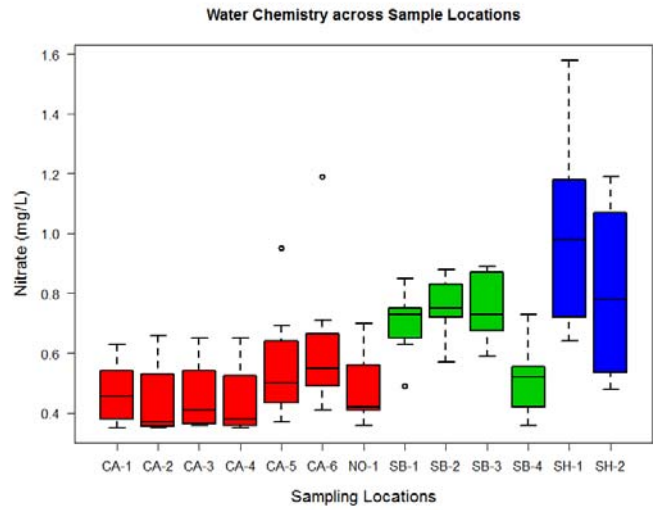
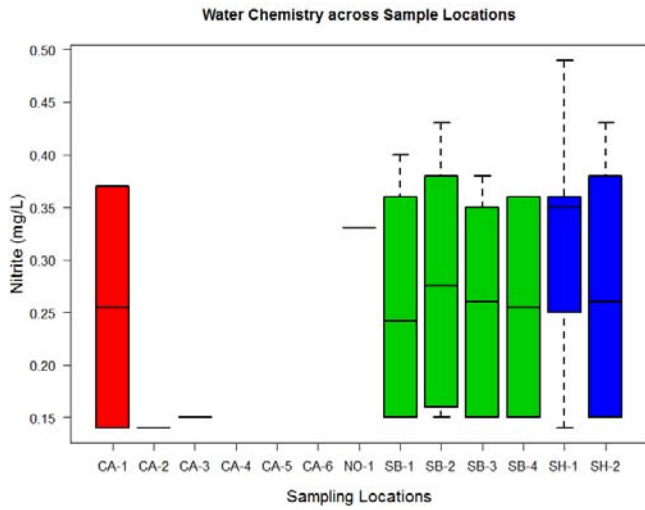
The sampling period for this study extends from June – October, however, due to delays in contracting and securing the required equipment, sampling did not begin until mid-July. Algae abundance seemed to be at a peak during the first sampling round and generally declined throughout the season. We suggest implementing the sampling protocol by June 1 and perhaps as early as May to better capture the manifestation of algal blooms and to document conditions leading to their emergence.



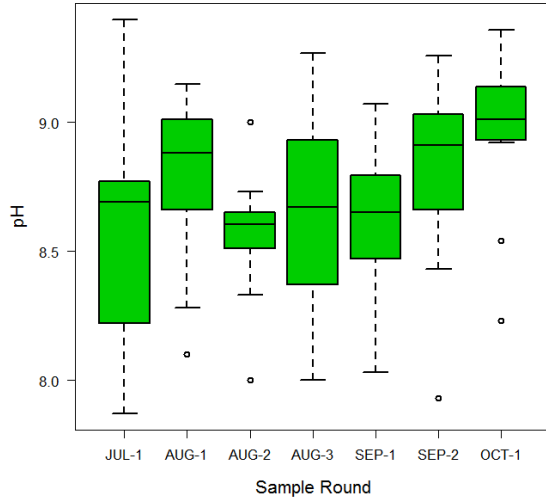
**Figure 5. Filamentous algae on the Cacapon River between Wardensville and Capon Bridge, W.Va.**

# Appendix A Water Chemistry Plots across Space and Time

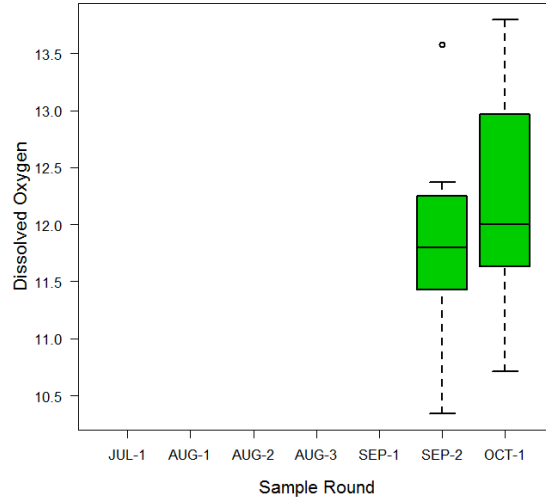




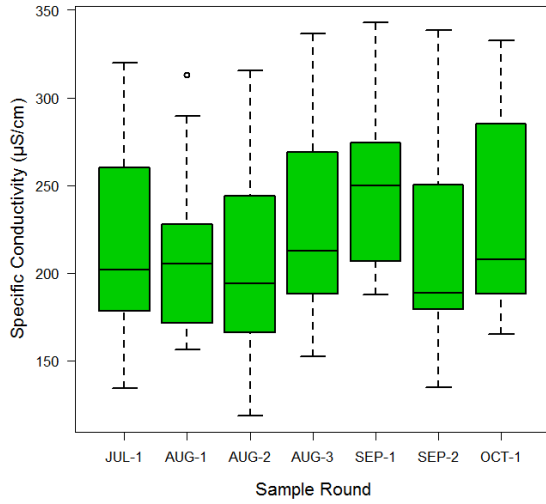
Water Chemistry over Time (Sampling Round)



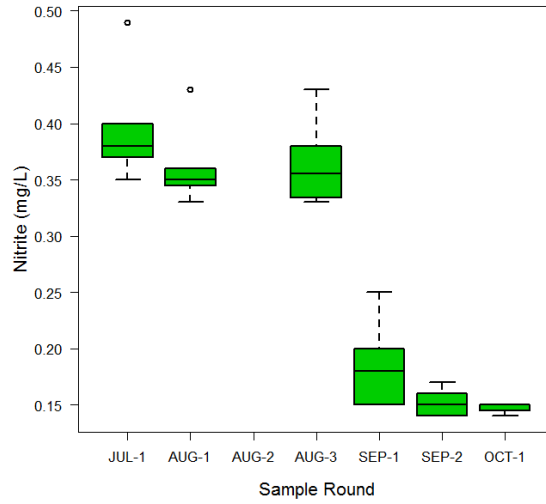
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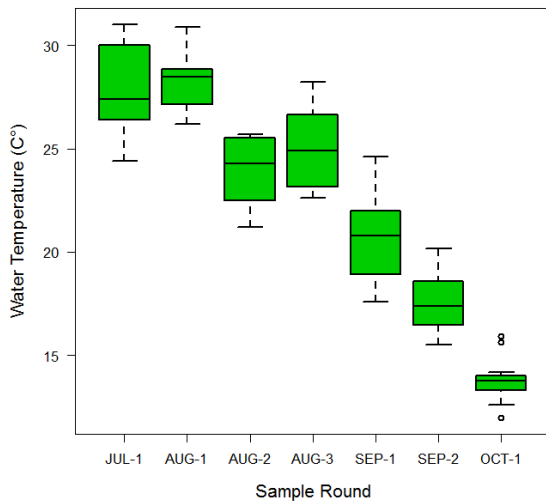
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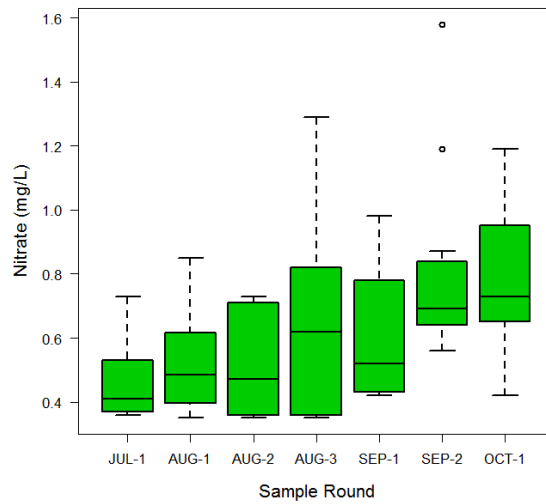
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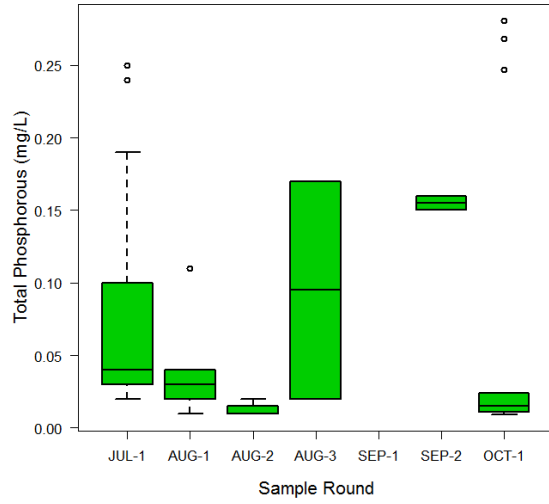
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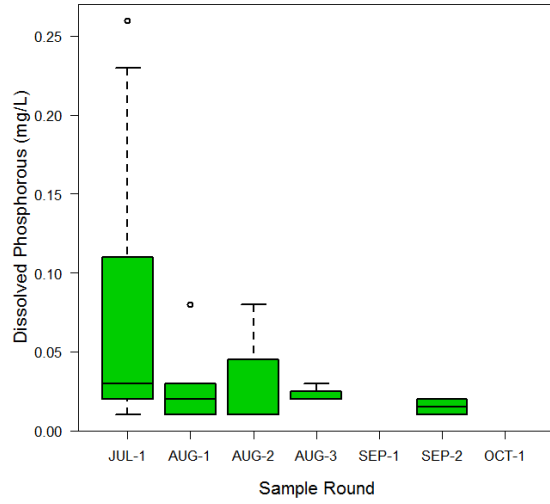
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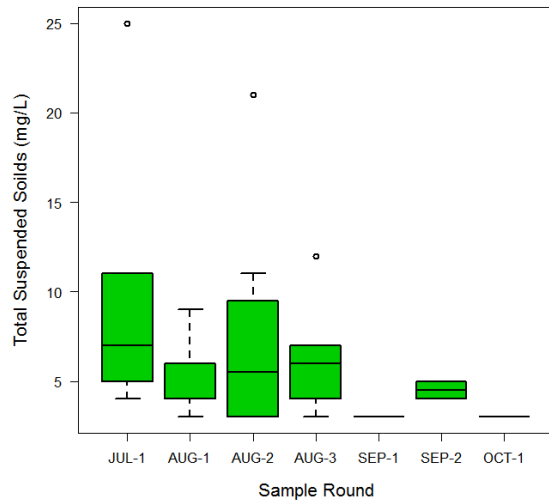
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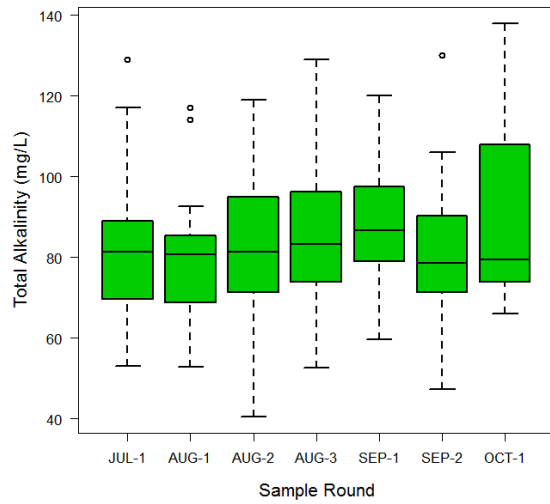
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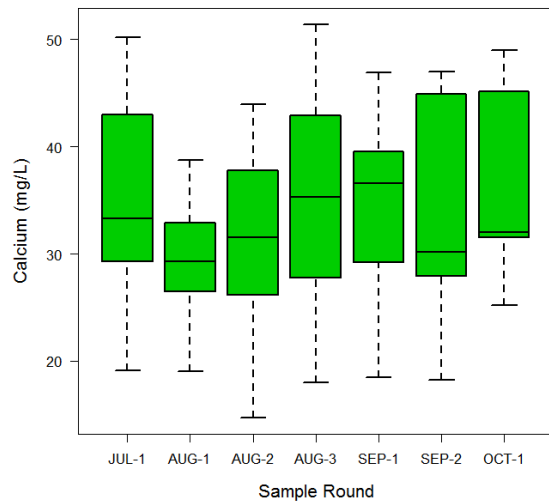
Water Chemistry over Time (Sampling Round)



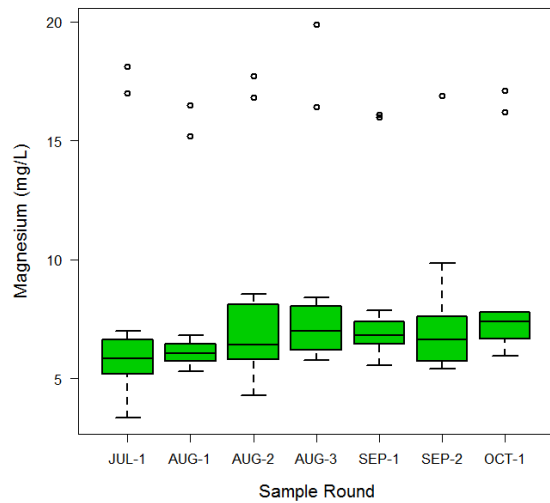
Water Chemistry over Time (Sampling Round)



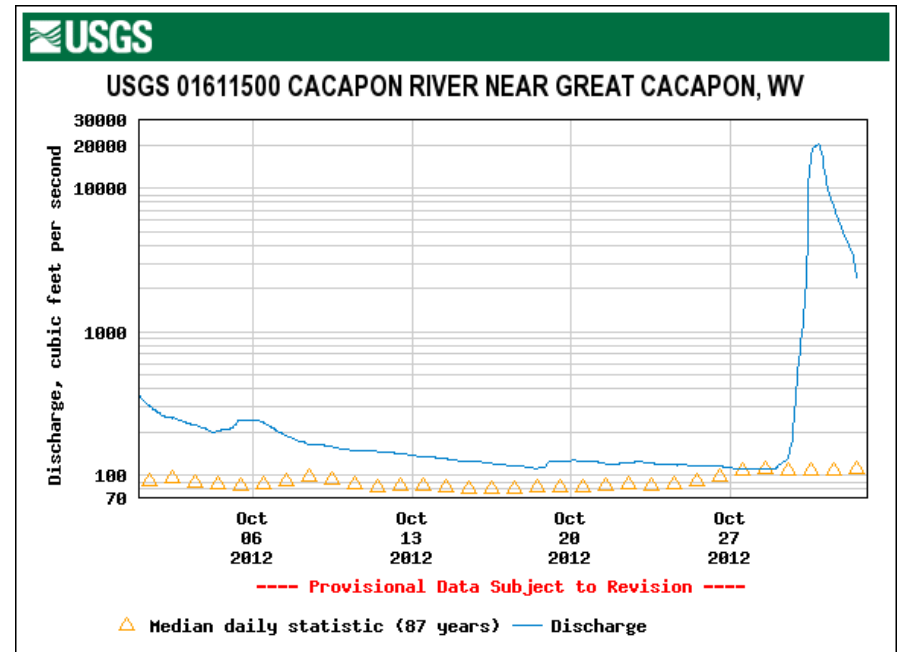
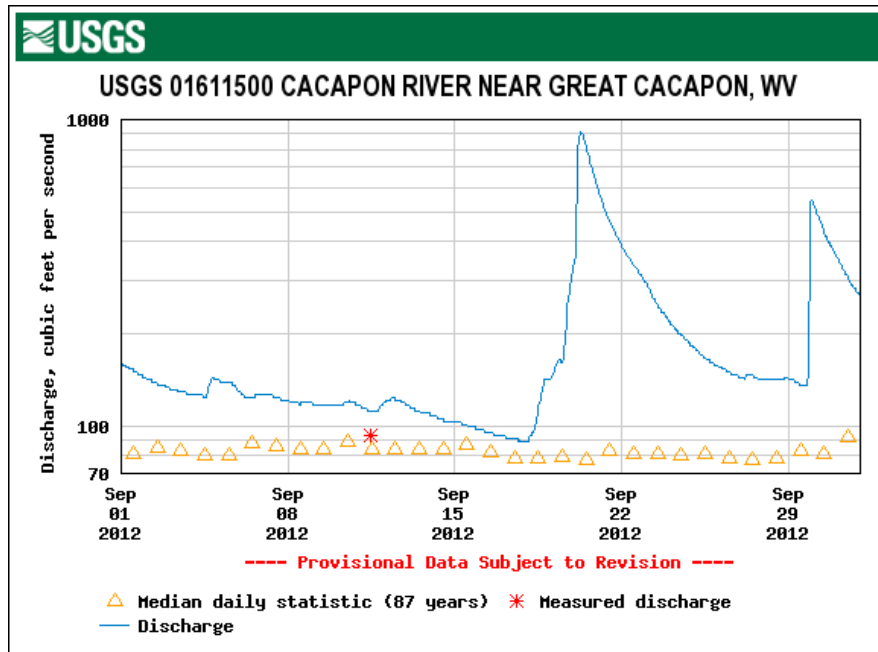
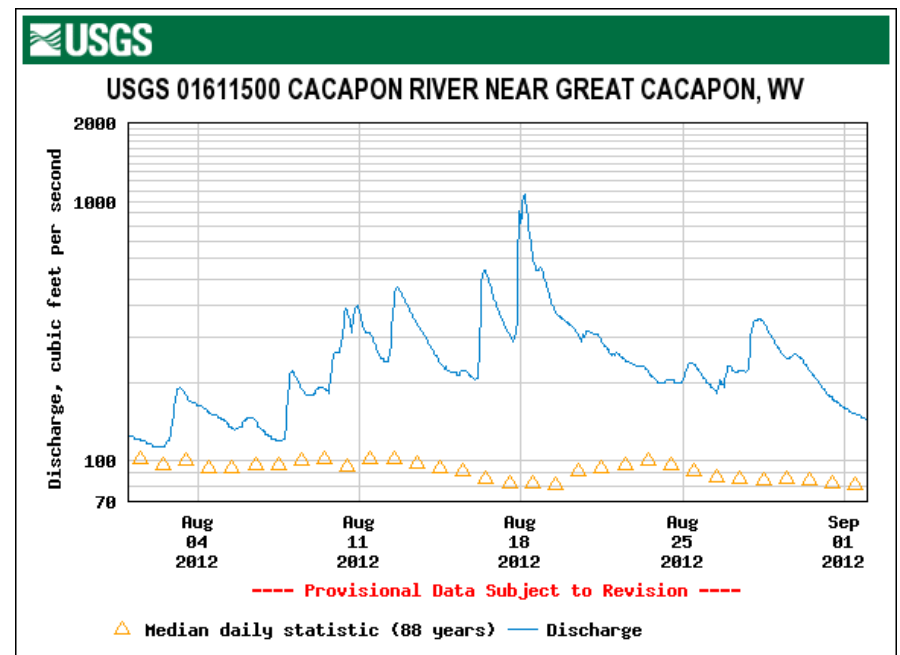
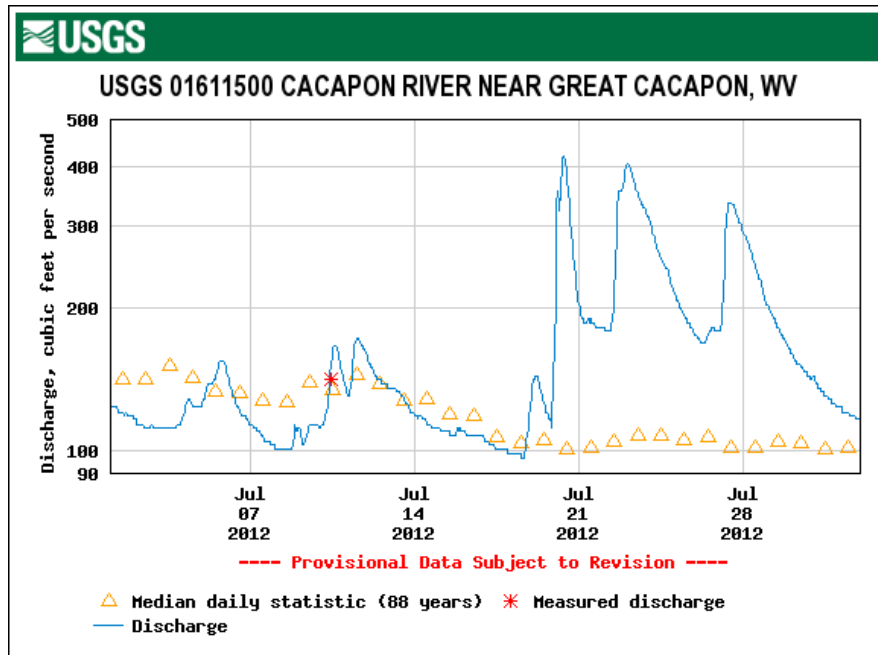
Water Chemistry over Time (Sampling Round)



Water Chemistry over Time (Sampling Round)

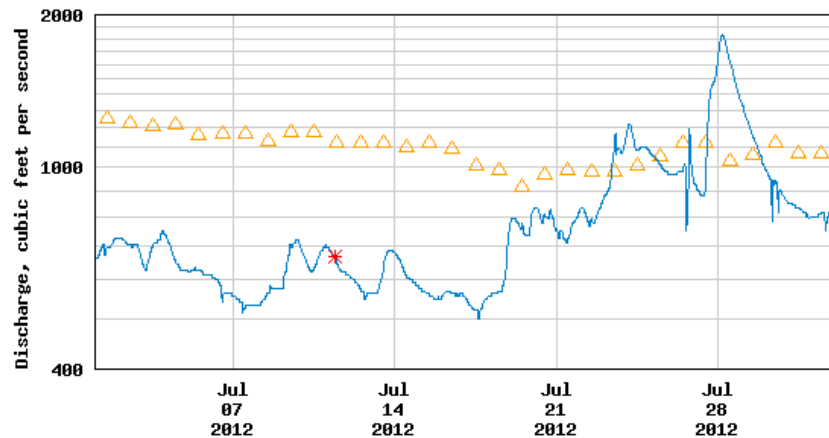


## Appendix B Hydrographs of relevant USGS stream gages over the study period





### USGS 01636500 SHENANDOAH RIVER AT MILLVILLE, WV

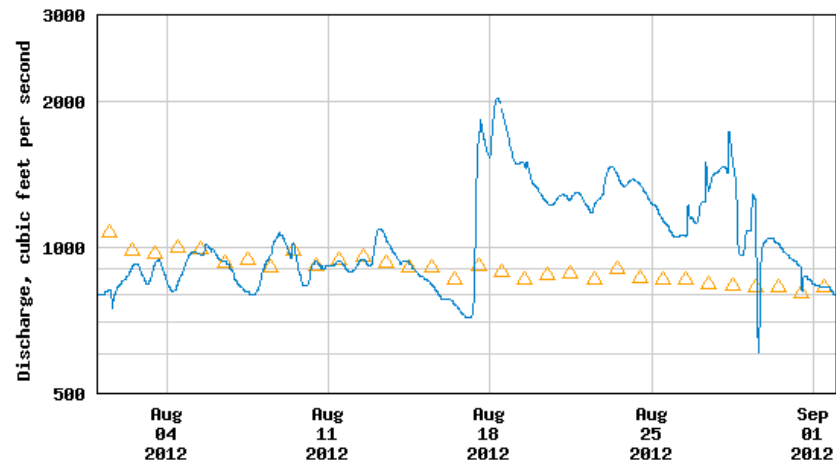


---- Provisional Data Subject to Revision ----

△ Median daily statistic (97 years) \* Measured discharge  
— Discharge



### USGS 01636500 SHENANDOAH RIVER AT MILLVILLE, WV

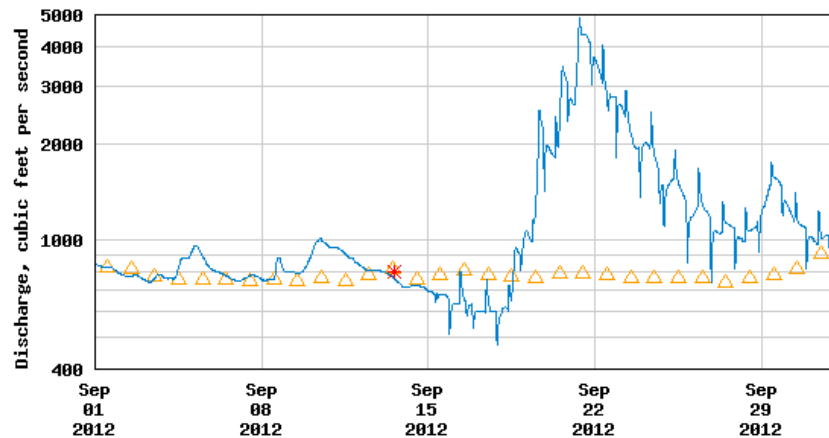


---- Provisional Data Subject to Revision ----

△ Median daily statistic (97 years) — Discharge



### USGS 01636500 SHENANDOAH RIVER AT MILLVILLE, WV

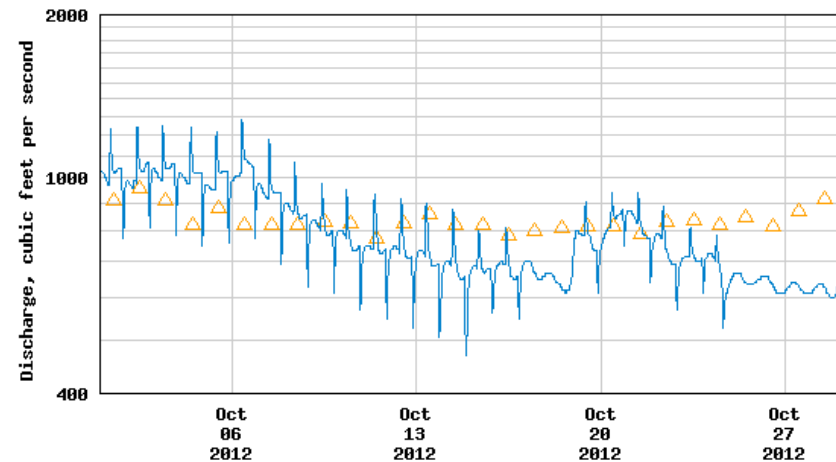


---- Provisional Data Subject to Revision ----

△ Median daily statistic (97 years) \* Measured discharge  
— Discharge



### USGS 01636500 SHENANDOAH RIVER AT MILLVILLE, WV



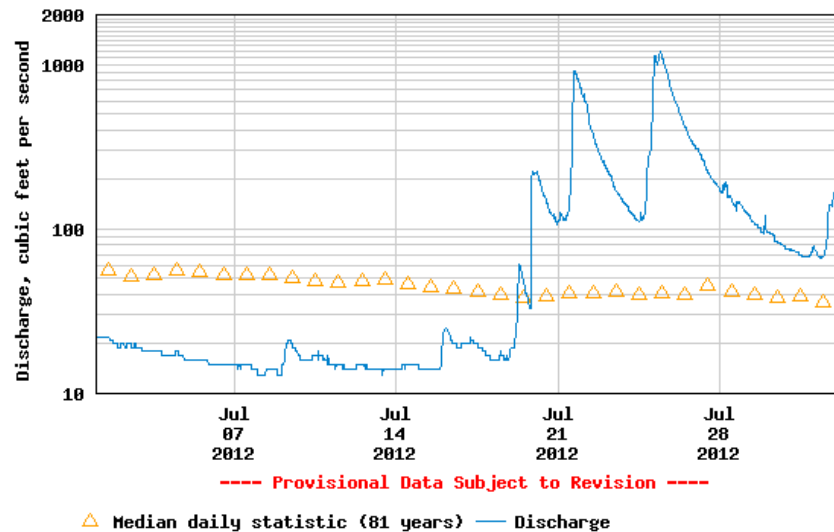
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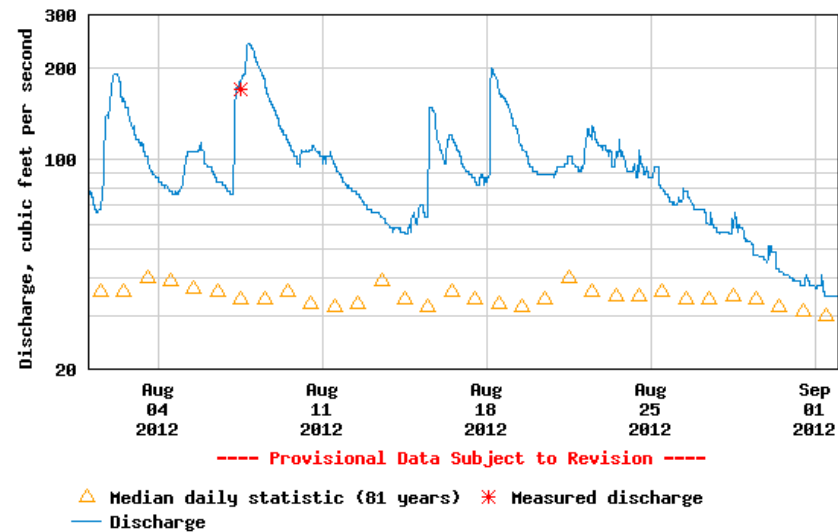




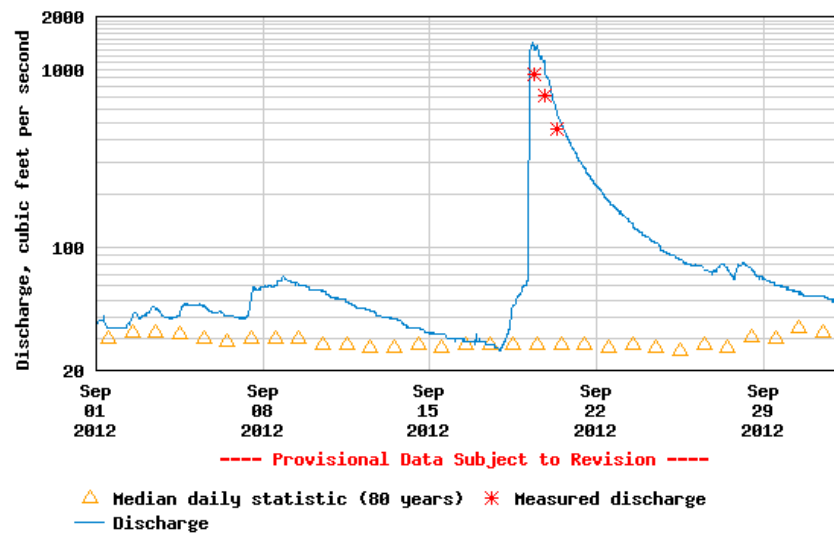
### USGS 01608000 S F SOUTH BRANCH POTOMAC RIVER NR MOOREFIELD, WV



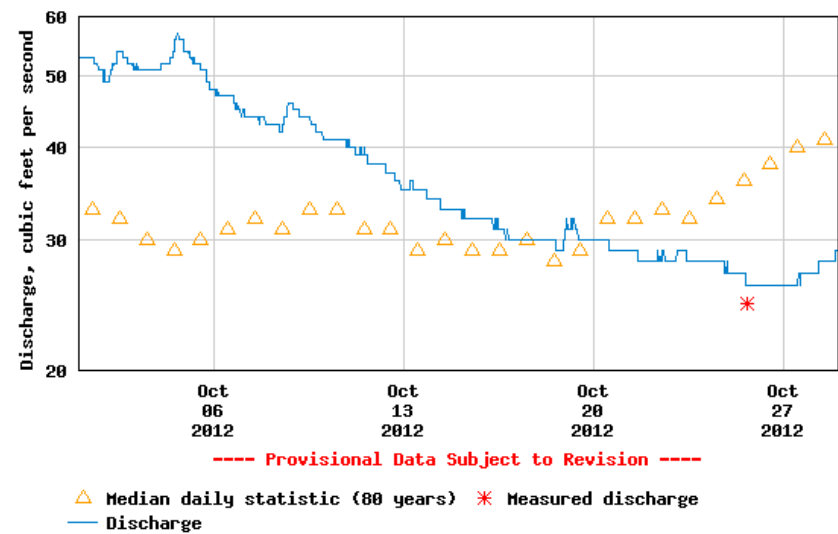
### USGS 01608000 S F SOUTH BRANCH POTOMAC RIVER NR MOOREFIELD, WV



### USGS 01608000 S F SOUTH BRANCH POTOMAC RIVER NR MOOREFIELD, WV



### USGS 01608000 S F SOUTH BRANCH POTOMAC RIVER NR MOOREFIELD, WV



## Appendix C. Representative Photographs and Algal Documentation of the Survey Sites



Shenandoah River at Rt. 340 (Lower)



Filamentous algae observed on emergent vegetation (8/5/2012)



Shenandoah River at Ann Lewis Road (Upper)



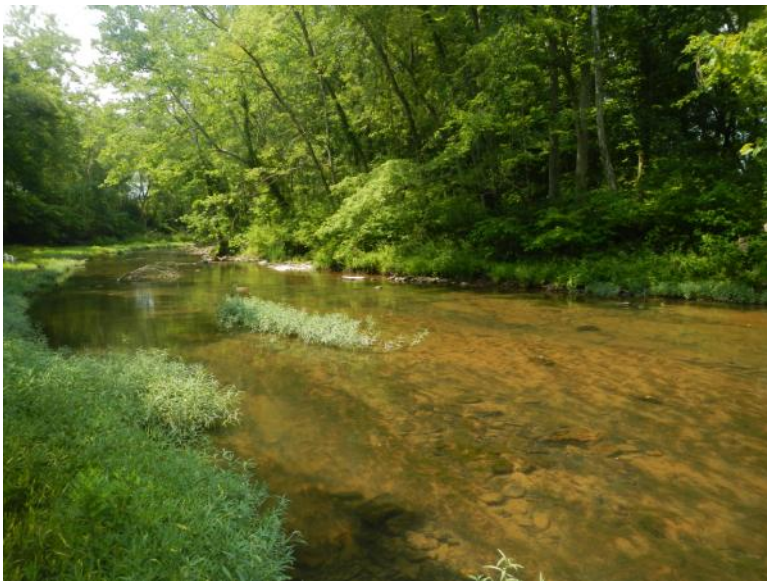
Benthic substrate devoid of algae or SAV



Cacapon River at Largent (Rt. 9)



Patches of *Hydrilla* at bank.



North River at Forks of Cacapon (Gaston Rd.)



The unidentified vascular plant that dominated the site.



Cacapon River at Forks of Cacapon (Rt. 127)



The peak of FGA abundance observed at the site (8/16/2012)



Cacapon River below Capon Bridge (Cold Stream Rd.)



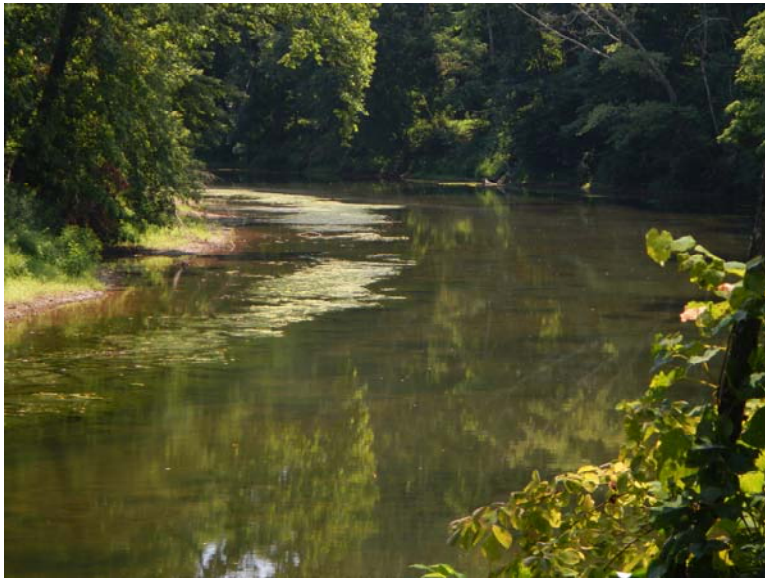
Minor FGA observed on cobble substrate (8/16/2012).



Cacapon River at Capon Bridge (Rt. 9)



Water stargrass and cobble substrate. No FGA observed.



Cacapon River below Camp RimRock (Capon River Rd.)



Persistent benthic and water column algae (8/4/2012)



Cacapon River below Wardensville (Rt. 259)



Abundant periphyton with benthic FGA on cobble (8/4/2012)



Cacapon River above Wardensville (Rt. 48/55/259)



The peak of algae abundance observed (8/4/2012)



South Branch Potomac at Harmison's Landing



Water stargrass beds with minor attached FGA (7/18/2012)



South Branch Potomac at Trough put-in (S. Br. River Rd.)



Water stargrass and periphyton on cobble.



South Branch Potomac below Moorefield (Rt. 28/220)



Extreme SAV coverage by stargrass, milfoil, et al. (7/18/2012)



South Branch Potomac above Moorefield (Fisher Rd.)



Abundant FGA observed on first visit (7/18/2012)