

**Resource Protection Group, Inc. – Fredericksburg Runoff Monitoring
PROGRESS REPORT
For Period Jan 1, 2021 through Mar 31, 2021**

**Prepared for:
City of Fredericksburg, VA
Resources Protection Group LLC**

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1.0 Objectives

The objectives of the project are:

1. To select five runoff monitoring sites in the City of Fredericksburg that characterize the following land uses: commercial, high density residential, industrial, medium density residential, and transportation.
2. Develop a plan for monitoring and laboratory analysis of collected samples from each site for estimation of event mean concentrations (EMCs) of qualified storm events (minimum of 0.1 in. rainfall, estimated at 24-30 qualifying events per year). This will include specifying, purchasing and installing appropriate sampling equipment, obtaining permissions, providing appropriate security for the equipment, etc.
3. Conduct the monitoring program, collecting samples for analysis of total suspended sediments (TSS), total phosphorus (TP) and total nitrogen (TN).
4. Compare analysis results with current estimates of TSS, TN and TP EMCs in use in the EPA Chesapeake Bay Model and the Virginia Runoff Reduction Method (VRRM). Assess the statistical significance of the differences, and recommend whether additional sampling/analyses and potential revisions to the established EMCs should be conducted.

2.0 Progress during period:

Period includes time from project initiation until March 31, 2021, monitoring spanned from February 1, 2021 to March 31, 2021. Project schedule was delayed due to shutdowns and travel restrictions that occurred due to the pandemic, and difficulty in obtaining permission for some of the monitoring sites, requiring multiple alternatives be identified and assessed. A no cost extension was requested and approved, extending the end date to 8/31/2021. During this period, Virginia Tech:

1. Identified monitoring sites for commercial, medium density residential, and transportation land uses. Procured monitoring equipment. Monitoring equipment installation began in early March, 2020 (medium density residential and commercial, followed by transportation in September, and high density residential in October, and the industrial site on December 15, 2020. Installation was slowed by the pandemic shutdown subsequent restrictions on travel lasting from mid-March until August of 2020.
2. Typical monitoring equipment at each site includes an automatic sampler (ISCO-6712), a flow measurement method (either a Bubbler flow meter (ISCO 730) and a Palmer Bowlus flume or an area velocity flow meter (ISCO 750), a marine battery, and a solar panel to keep the battery charged. The sampler, flow module, a marine battery are typically housed in a reinforced steel tool box, anchored to the ground and painted dark green to resemble a utility box. Several sites also had an integrated rain gage (ISCO 674) upon installation; others were added later. By March, 2021, all sites had an integrated rain gage.
3. Virginia Tech sought and obtained additional funding through Virginia Tech Foundation, extending the monitoring period from 6 to 12 months.

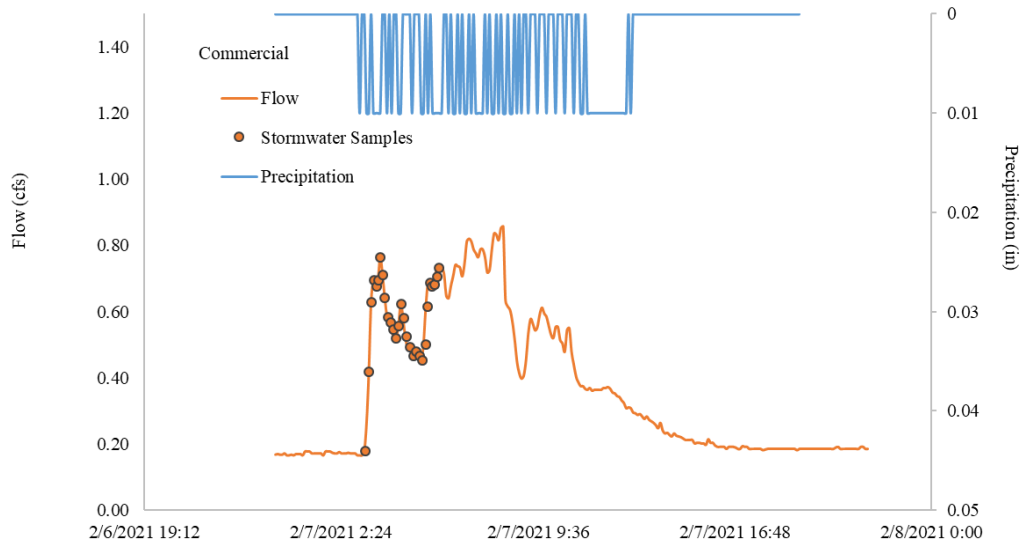
4. Several high density residential monitoring sites were identified, and meetings were held with property managers, seeking permission for use of their site. After three unsuccessful attempts the University of Mary Washington apartments was selected (UMW is a project partner), and permission was successfully obtained. Equipment was installed in October, 2020.
5. Identified several industrial monitoring sites, met with property managers, seeking permission for use of each site. After five unsuccessful attempts, a site in nearby Stafford County was identified. The site is a culvert crossing of a Virginia Dept. of Transportation (VDOT) maintained road; over a dozen industrial properties are tributary to this stream. A VDOT permit was applied for and received on December 15, 2020, which is when the monitoring equipment was installed.
6. Fine tuning of the logic settings of the automatic samplers was conducted to ensure collection of sufficient samples from qualified storms and, from as much of the hydrograph as possible so the sample is truly representative of the land use water quality. Rain gages were installed with sampling equipment at the commercial, industrial, but were late added to the high density residential, transportation, and medium density residential sites as they became available.
7. Obtained the assistance of the University of Mary Washington (UMW) as a subcontractor. UMW will assist with sample collection and processing, after being provided training.
8. Monitoring began in February, 2021. Appendices A-E provide storm reports for commercial, high density residential, industrial, medium density residential, and transportation land uses. Four events were captured (2 in Feb, 2 in March) for the commercial land use, 3 for the medium density residential, and 2 each for the high density residential, transportation, and industrial land use sites. Some sites did not collect a sample as adjustments were still being made to the program logic.
9. The sampler at the Transportation site became nonoperational, requiring replacement (the unit was shipped to the factory for repairs). A Bubbler flow module from high density residential was also found to be needing service, and it, too was shipped to the factory.
10. By March of 2021, all samplers appeared to be fully operational.

3.0 Plans for next quarter

1. To improve the accuracy of flow measurement, a bubbler flow module and 12-inch flume was installed at UMW apartments.
2. The first batch of water samples were sent via courier to the BSE water quality laboratory in Blacksburg, VA. Attached storm reports will be revised with this information as soon as it becomes available.
3. Monitoring is anticipated to conclude by March 1, 2022. Virginia Tech and project partners will discuss an appropriate schedule and project end date.

Appendix A. Individual Storm Reports, commercial land use monitoring

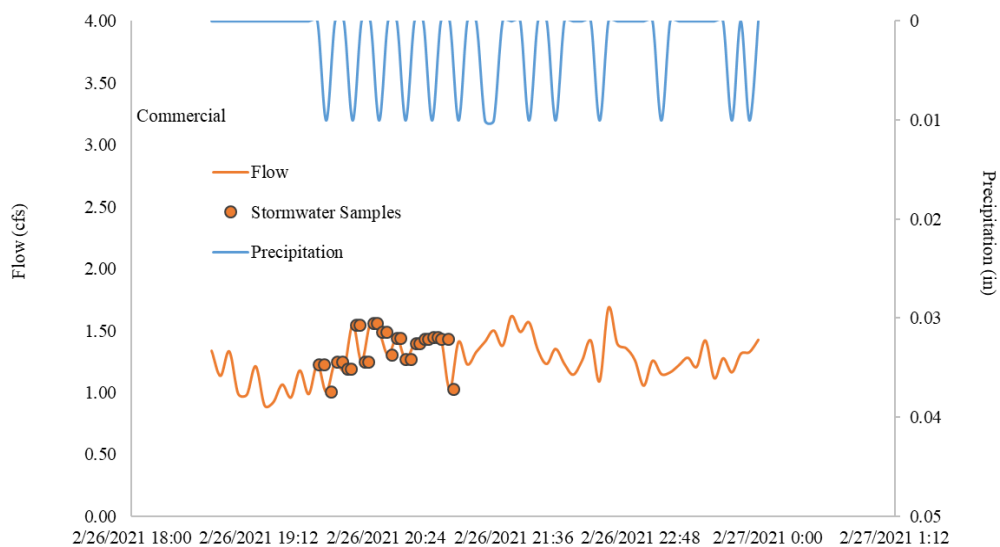
Hydrology	Event Date: 2/7/2021
Total Precipitation (in)	0.68
Duration (minutes)	595
Intensity (in/hr)	0.07
Antecedent Dry periods (day)	2.0
Peak Flow (cfs)	0.76



Analytical Parameter	Event Date: 2/7/2021 EMC (mg L⁻¹)
NH₃	
NH₄	
NH₃-N + NH₄-N	
NO₂	
NO₃	
NO₂-N+ NO₃-N	
TKN	
TN	
PO₄	
TP	
TSS	145.9

Figure A-1. Individual storm report for commercial land use, 2/7/2021.

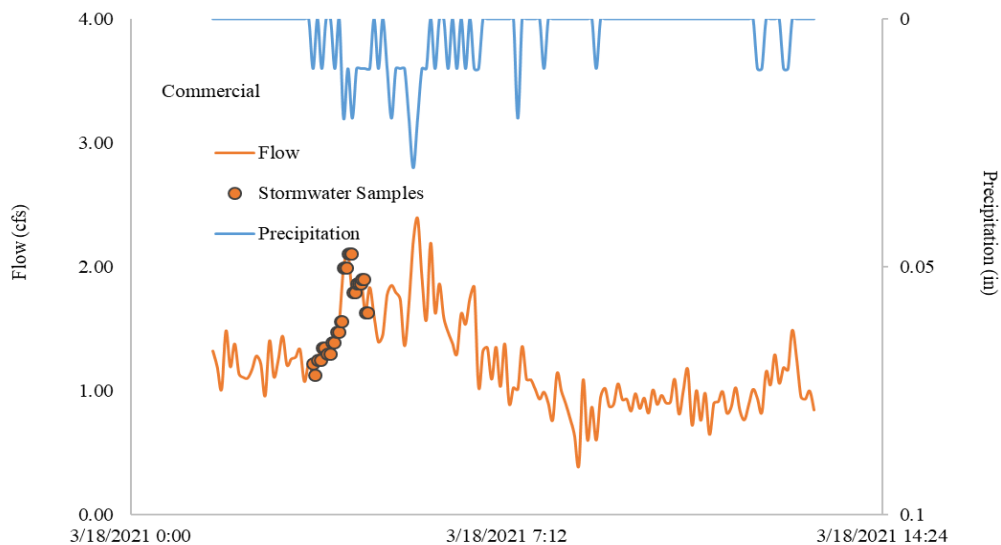
Hydrology	Event Date: 2/26/2021
Total Precipitation (in)	0.14
Duration (minutes)	240
Intensity (in/hr)	0.04
Antecedent Dry periods (day)	3.4
Peak Flow (cfs)	1.56



Analytical Parameter	Event Date: 2/26/2021 EMC (mg L ⁻¹)
NH ₃	
NH ₄	
NH ₃ -N + NH ₄ -N	
NO ₂	
NO ₃	
NO ₂ -N+ NO ₃ -N	
TKN	
TN	
PO ₄	
TP	
TSS	264.5

Figure A-2. Individual storm report for commercial land use, 2/26/2021.

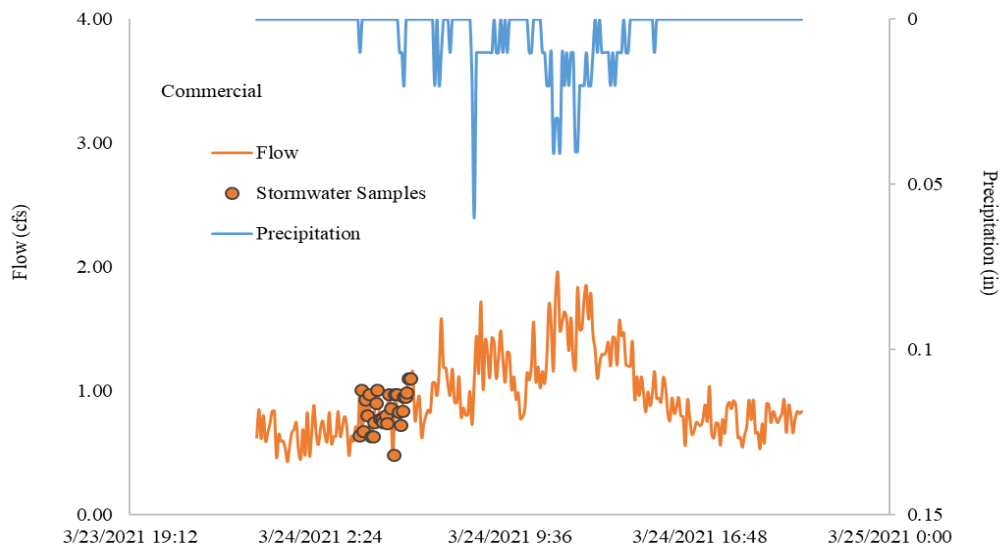
Hydrology	Event Date: 3/18/2021
Total Precipitation (in)	0.42
Duration (minutes)	545
Intensity (in/hr)	0.4
Antecedent Dry periods (day)	16.6
Peak Flow (cfs)	2.11



Analytical Parameter	Event Date: 3/18/2021 EMC (mg L ⁻¹)
NH ₃	
NH ₄	
NH ₃ -N + NH ₄ -N	
NO ₂	
NO ₃	
NO ₂ -N+ NO ₃ -N	
TKN	
TN	
PO ₄	
TP	
TSS	524.0

Figure A-3. Individual storm report for commercial land use, 3/18/2021.

Hydrology	Event Date: 3/24/2021
Total Precipitation (in)	0.98
Duration (minutes)	610
Intensity (in/hr)	0.10
Antecedent Dry periods (day)	5.2
Peak Flow (cfs)	1.10



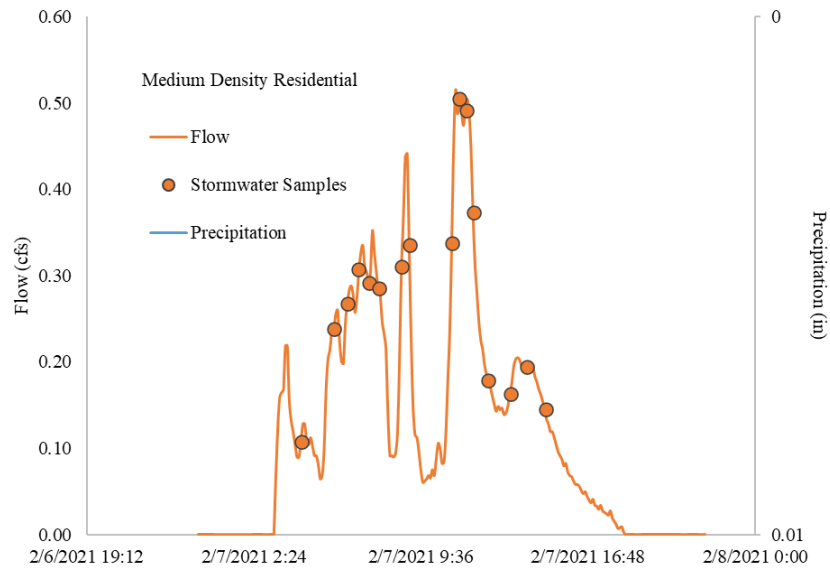
Analytical Parameter	Event Date: 3/24/2021 EMC (mg L ⁻¹)
NH ₃	
NH ₄	
NH ₃ -N + NH ₄ -N	
NO ₂	
NO ₃	
NO ₂ -N+ NO ₃ -N	
TKN	
TN	
PO ₄	
TP	
TSS	148.9

Figure A-4. Individual storm report for commercial land use, 3/24/2021.

Appendix B. Individual Storm Reports, medium density residential land use monitoring

Hydrology	Event Date: 2/7/2021
Total Precipitation (in)	0.68
Duration (minutes)	595
Intensity (in/hr)	0.07
Antecedent Dry periods (day)	2.0
Peak Flow (cfs)	0.51

Precipitation data are adopted from the commercial station.

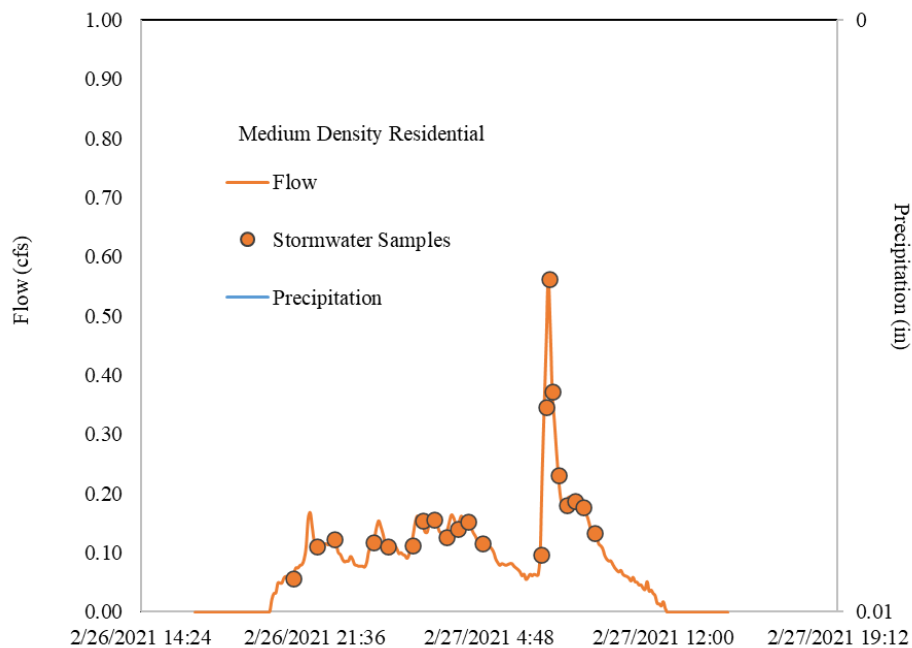


Analytical Parameter	Event Date: 2/7/2021 EMC (mg L⁻¹)
NH₃	
NH₄	
NH₃-N + NH₄-N	
NO₂	
NO₃	
NO₂-N+ NO₃-N	
TKN	
TN	
PO₄	
TP	
TSS	37.2

Figure B-1. Individual storm report for medium density residential land use, 2/7/2021.

Hydrology	Event Date: 2/26/2021
Total Precipitation (in)	0.14
Duration (minutes)	240
Intensity (in/hr)	0.04
Antecedent Dry periods (day)	3.4
Peak Flow (cfs)	0.56

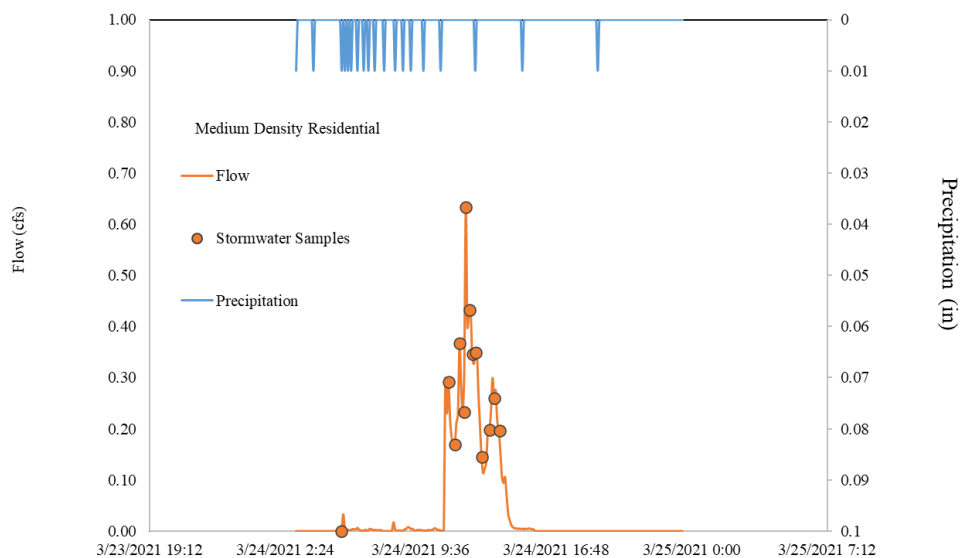
Precipitation data are adopted from the commercial station.



Analytical Parameter	Event Date: 2/26/2021 EMC (mg L ⁻¹)
NH ₃	
NH ₄	
NH ₃ -N + NH ₄ -N	
NO ₂	
NO ₃	
NO ₂ -N+ NO ₃ -N	
TKN	
TN	
PO ₄	
TP	
TSS	68.1

Figure B-2. Individual storm report for medium density residential land use, 2/26/2021.

Hydrology	Event Date: 3/24/2021
Total Precipitation (in)	0.19
Duration (minutes)	960
Intensity (in/hr)	0.012
Antecedent Dry periods (day)	3.6
Peak Flow (cfs)	0.63

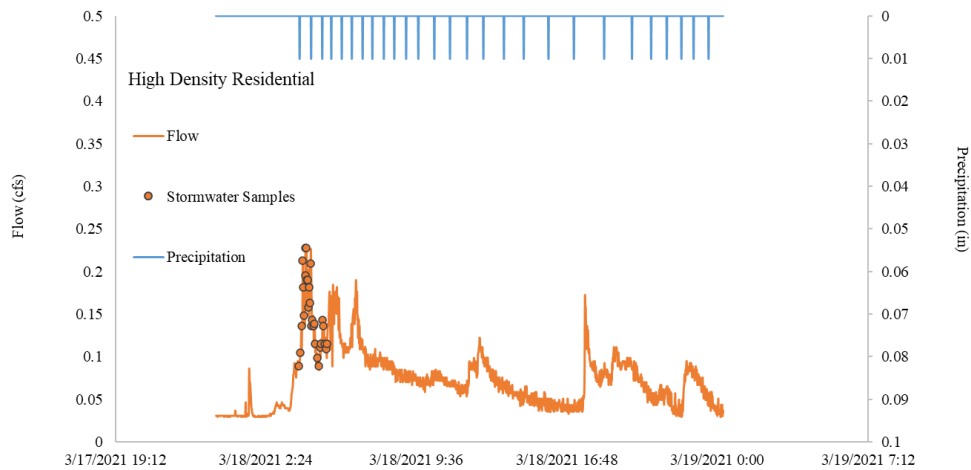


Analytical Parameter	Event Date: 3/24/2021 EMC (mg L ⁻¹)
NH ₃	
NH ₄	
NH ₃ -N + NH ₄ -N	
NO ₂	
NO ₃	
NO ₂ -N+ NO ₃ -N	
TKN	
TN	
PO ₄	
TP	
TSS	45.0

Figure B-3. Individual storm report for medium density residential land use, 3/24/2021.

Appendix C. Individual Storm Reports, high density residential land use monitoring

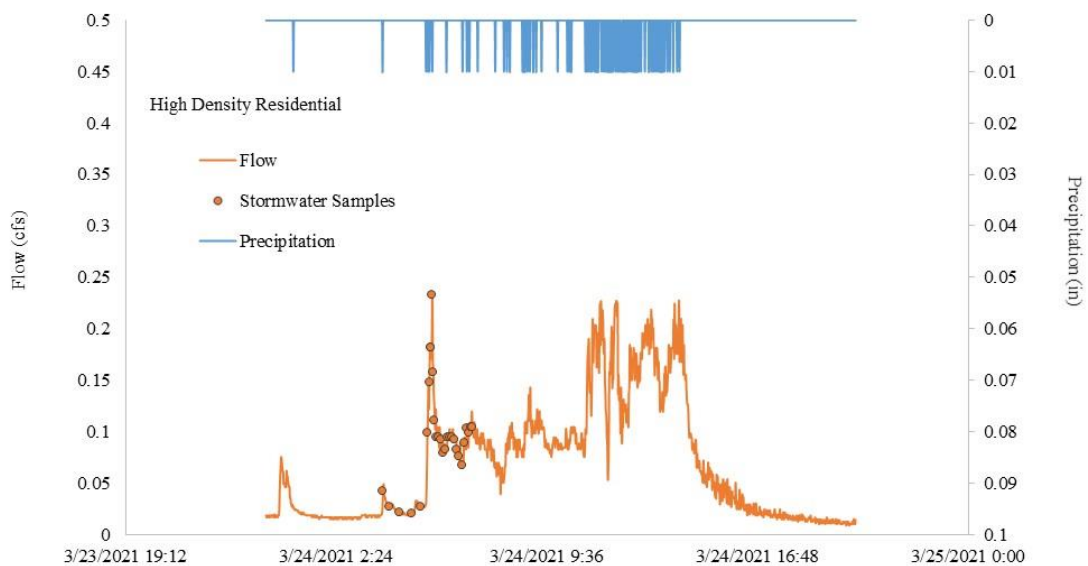
Hydrology	Event Date: 3/18/2021
Total Precipitation (in)	0.27
Duration (minutes)	1175
Intensity (in/hr)	0.014
Antecedent Dry periods (day)	16.7
Peak Flow (cfs)	0.23



Analytical Parameter	Event Date: 3/18/2021
	EMC (mg L⁻¹)
NH₃	
NH₄	
NH₃-N + NH₄-N	
NO₂	
NO₃	
NO₂-N+ NO₃-N	
TKN	
TN	
PO₄	
TP	
TSS	56.1

Figure C-1. Individual storm report for high density residential land use, 3/18/2021.

Hydrology	Event Date: 3/24/2021
Total Precipitation (in)	0.87
Duration (minutes)	792
Intensity (in/hr)	0.066
Antecedent Dry periods (day)	4.5
Peak Flow (cfs)	0.23

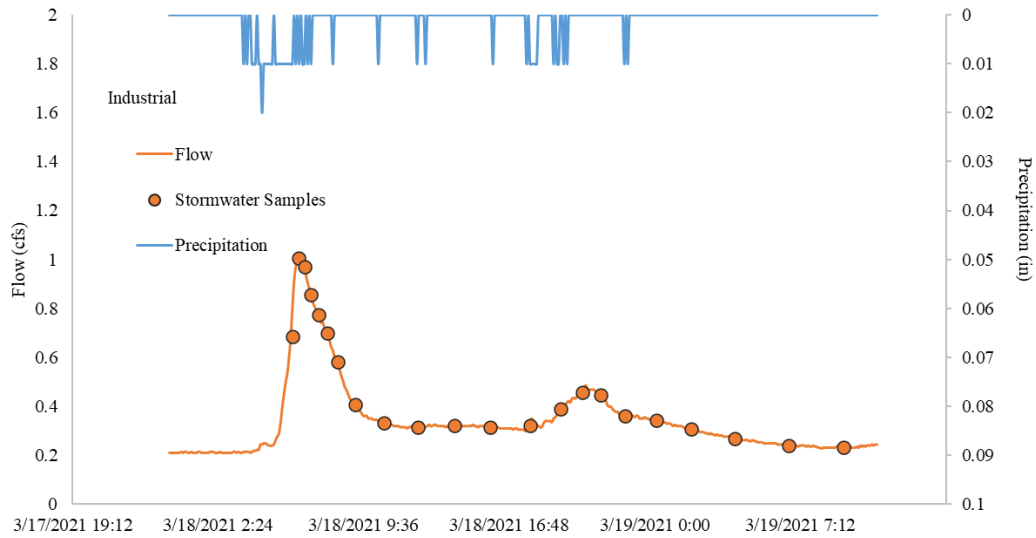


Analytical Parameter	Event Date: 3/24/2021 EMC (mg L ⁻¹)
NH ₃	
NH ₄	
NH ₃ -N + NH ₄ -N	
NO ₂	
NO ₃	
NO ₂ -N+ NO ₃ -N	
TKN	
TN	
PO ₄	
TP	
TSS	13.8

Figure C-2. Individual storm report for high density residential land use, 3/24/2021.

Appendix D. Individual Storm Reports, industrial land use monitoring

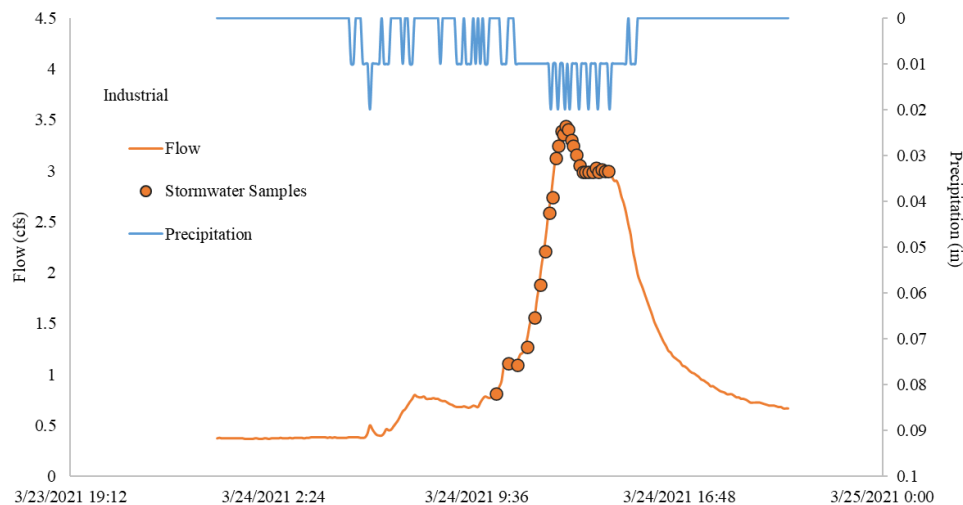
Hydrology	Event Date: 3/18/2021
Total Precipitation (in)	0.5
Duration (minutes)	1140
Intensity (in/hr)	0.026
Antecedent Dry periods (day)	16.8
Peak Flow (cfs)	1.0



Analytical Parameter	Event Date: 3/18/2021 EMC (mg L⁻¹)
NH₃	
NH₄	
NH₃-N + NH₄-N	
NO₂	
NO₃	
NO₂-N+ NO₃-N	
TKN	
TN	
PO₄	
TP	
TSS	11.3

Figure D-1. Individual storm report for industrial land use, 3/18/2021.

Hydrology	Event Date: 3/24/2021
Total Precipitation (in)	0.9
Duration (minutes)	605
Intensity (in/hr)	0.089
Antecedent Dry periods (day)	4.7
Peak Flow (cfs)	3.4

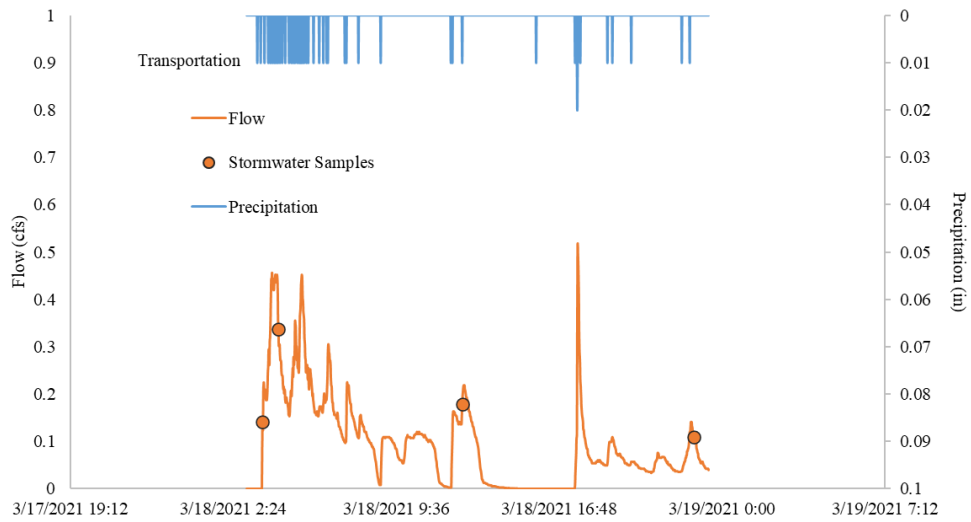


Analytical Parameter	Event Date: 3/24/2021 EMC (mg L ⁻¹)
NH ₃	
NH ₄	
NH ₃ -N + NH ₄ -N	
NO ₂	
NO ₃	
NO ₂ -N+ NO ₃ -N	
TKN	
TN	
PO ₄	
TP	
TSS	43.5

Figure D-2. Individual storm report for industrial land use, 3/24/2021.

Appendix E. Individual Storm Reports, transportation land use monitoring

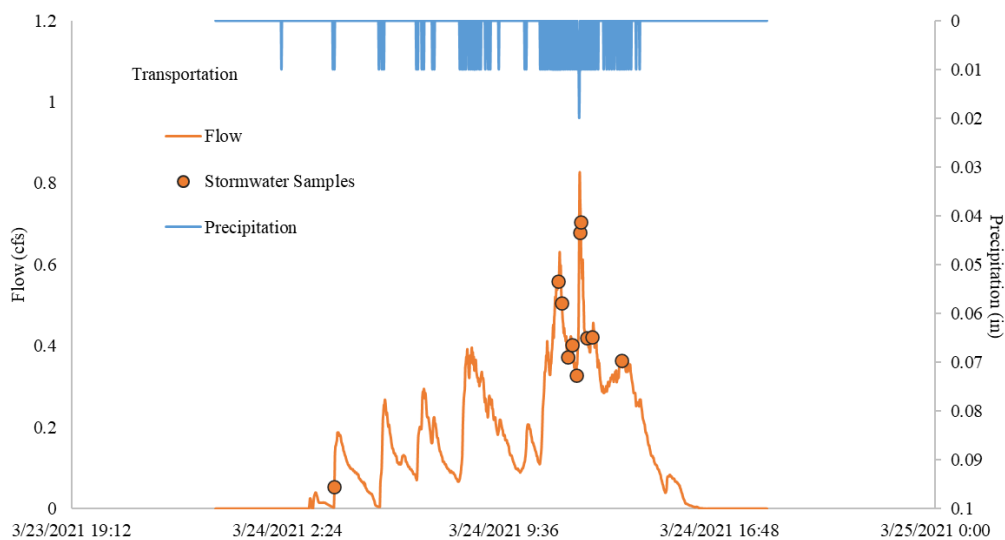
Hydrology	Event Date: 3/18/2021
Total Precipitation (in)	0.54
Duration (minutes)	1146
Intensity (in/hr)	0.028
Antecedent Dry periods (day)	16.8
Peak Flow (cfs)	0.34



Analytical Parameter	Event Date: 3/18/2021
	EMC (mg L⁻¹)
NH₃	
NH₄	
NH₃-N + NH₄-N	
NO₂	
NO₃	
NO₂-N+ NO₃-N	
TKN	
TN	
PO₄	
TP	
TSS	115.5

Figure E-1. Individual storm report for transportation land use, 3/18/2021.

Hydrology	Event Date: 3/24/2021
Total Precipitation (in)	0.95
Duration (minutes)	717
Intensity (in/hr)	0.079
Antecedent Dry periods (day)	5.2
Peak Flow (cfs)	0.7



Analytical Parameter	Event Date: 3/24/2021 EMC (mg L ⁻¹)
NH ₃	
NH ₄	
NH ₃ -N + NH ₄ -N	
NO ₂	
NO ₃	
NO ₂ -N+ NO ₃ -N	
TKN	
TN	
PO ₄	
TP	
TSS	198.7

Figure E-2. Individual storm report for transportation land use, 3/24/2021.